VOL.
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ICAR

SIXTH DEANS' COMMITTEE REPORT

(Syllabi of the Undergraduate Programmes in Agriculture and Sciences)

AGRICULTURAL EDUCATION DIVISION
Indian Council of Agricultural Research
Krishi Anusandhan Bhawan-II
Pusa, New Delhi-110012

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(Syllabi of the Undergraduate Programmes
in Agriculture and Sciences)

(Volume-I)

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Indian Council of Agricultural Research
Krishi Anusandhan Bhawan II
Pusa, New Delhi 110012

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कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली–110 001

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Message

Quality human capital is foundational for inclusive development. The release of the 6th Deans' Committee Report marks a critical milestone in the evolution of agricultural education in India. The report reflects a forward-looking, outcome-based, and student-centric approach to curriculum restructuring. It aligns agricultural education with the principles of the National Education Policy (NEP) 2020, emphasizing flexibility, experiential learning, skill orientation, multiple entry-exit options, academic bank of credits, and integration of Indian Knowledge Systems with modern science.

Indian agriculture today stands at the intersection of unprecedented opportunities and complex challenges. Climate change, biodiversity loss, natural resource degradation, food and nutritional security concerns, market volatility, and emerging employment paradigms are reshaping the contours of research, education, and extension. In this dynamic environment, our human capital must be equipped with cutting-edge knowledge, multidisciplinary competencies, entrepreneurial capabilities, and ethical grounding.

The revised curricula thoughtfully incorporate emerging frontiers such as genome editing, artificial intelligence, data science, precision and digital agriculture, drones, robotics, climate-smart agriculture, carbon farming, natural and regenerative agriculture, bioeconomy, and agribusiness management. At the same time, it reinforces strong foundations in basic sciences, soil health, water management, biodiversity conservation, and sustainable farming systems. The Committee's recommendations provide a strong roadmap for building a vibrant, future-ready agricultural education system that continuously upgrades itself to meet the challenges of the 21st century.

I appreciate the Chairman and members of the Sixth Deans' Committee for their dedication, extensive consultations, and forward-looking contributions. I am confident that this revised curriculum for the 13 agriculture and allied disciplines will serve as an important milestone in developing innovative, skilled, and future-ready human resources, and will significantly contribute to India's agricultural transformation in the years ahead.

(M. L. Jat)

Dated the 3rd March, 2026
New Delhi

सत्यमेव जयते

डॉ. हिमांशु पाठक
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Dr HIMANSHU PATHAK
SECRETARY (DARE) & DIRECTOR GENERAL (ICAR)

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Foreword

The Indian Council of Agricultural Research (ICAR) has played the vital role in transforming the agricultural higher education to produce highly skilled human resource equipped with advance knowledge and capable of fulfilling the agricultural needs of the country. National Education Policy (NEP-2020) of India represents a comprehensive and ambitious vision for the future of education in the country. There is an urgent need to revise and align the agricultural education system in the country in line with NEP-2020 norms to build a competent human resource for undertaking education, research and extension activities at diversified, ecologically sustainable and economically viable agricultural and allied sectors with integration of technology and innovation.

The Indian Council of Agricultural Research (ICAR) has been at the forefront of promoting excellence in agricultural education, focusing on the development of a skilled workforce to meet the nation's growing agricultural demands. To ensure that agricultural education stays relevant, the ICAR has regularly revised curricula through various Deans' Committees, with five such committees already having updated the academic standards over the years. These revisions align the education system with both national and international standards ensuring students are prepared for the challenges of modern agriculture.

The Sixth Deans' Committee, constituted in the year 2021, has prudently with congruence of excellence and relevance revised the undergraduate course curriculum, course contents, degree nomenclature including entry-exit options recommending the reforms in admission including lateral entry options and examinations. The committee had updated the course curriculum as per the guidelines of NEP-2020 focussing skill enhancement with integration of digital learning to align with the evolving global requirements and the advent of new technologies with focus on better employability, flexibility in movement from one institution to another, multiple entry and exit options, choice-based credit system. Experiential leaning and entrepreneurship development programs have been included for training student in real work satiations to develop them as future entrepreneurs. Academic Bank of Credits (ABC) introduced to facilitate

movement from one institution to another with credit transfer. Innovative teaching approaches such as online, open distance learning (ODL) and blended learning have been emphasized to merge traditional and non-traditional educational methods. The continuous updating of course curricula based on recent technological advancements ensures that students remain at the cutting edge of agricultural knowledge.

The Council expresses gratitude to Dr. Tej Partap, Chairman of the Sixth Deans' Committee, for his leadership,as well as to the committee members for their efforts in aligning agricultural education with NEP-2020 and global trends. I appreciate the efforts of Dr. R. C. Agrawal, Deputy Director General (Education) and all the committee members to align,update and contextualise the academic pursuits with NEP-2020 guidelines and to prepare this valuable report. Dr. Ajit Singh Yadav, ADG (EQAR & Member Secretary, Sixth Deans' Committee) has rendered untiring efforts in arranging meetings and facilitating the course of deliberations, drafting and compilation of report.

The ICAR shall strive to implement all the recommendations of the report. I hope it will help to achieve our mission to make agricultural education more accessible, affordable, relevant, practical and professional pursuing national and international quality education standards.

(Himanshu Pathak)

Dated: 10 September, 2024
New Delhi

Overview of 6th Deans' Committee Report

Indian Council of Agricultural Research (ICAR) under the Department of Agricultural Research and Education Government of India, is tasked with the responsibility to aid, impart and coordinate agricultural education to develop high-quality human resources in the country. The National Education Policy-2020 (NEP-2020) presents an opportunity for substantial reforms in the education system, including higher agricultural education. Soon after the announcement of the NEP-2020, ICAR formulated a committee and developed the guidelines "Implementation strategy for National Education Policy-2020 in Agricultural Education system" during September, 2021. Accordingly, all the Agricultural Universities (AUs) started implementing various provision of NEP-2020 in their respective AUs. Following the committee's recommendations, the Sixth Deans' Committee was constituted on August 17, 2021 (orders issued on Sep 15, 2021 vide notification *F. No. Edn.5/24/202/EQR/VI Deans).* The 6th Deans' Committee was mandated to revamp the course curriculum, credit framework, and academic standards for agricultural education. This initiative aims to standardize uniform academic structures across the country both in public and private institutions offering undergraduate (UG) programs in agriculture and allied sciences.

To formulate the guidelines, course curriculum & credit framework, and other aspects, series of meetings and consultations (both off-line and on-line) of committee were held and all aspects were discussed in detail taking into consideration of NEP-2020 provisions. The member of the committee consulted the subject specific experts by holding off-line and on-line meeting. A meeting was also organized with CEO, Agriculture Skill Council of India on modalities of integration of vocational courses in the general agriculture education course framework. Further, a meeting with Chairman, UGC was also held to discuss the UG course curriculum of all agriculture and allied science disciplines as per the NEP-2020 and UGC guidelines. The general guidelines, course curriculum and credit framework was also presented in Vice-Chancellor' Conference held at NASC, New Delhi and suggestions were incorporated in the report. The report was also presented in a meeting chaired by Secretary, who attend the meeting DARE & DG ICAR. All Deputy Director General (DDGs) & Assistant Director Generals (ADGs) of education suggested the changes which were incorporated in the report. The report was also sent to all DDGs for their inputs and suggestions. The draft report was sent all Vice-Chancellors of SAUs/CAUs/DUs/CUs with agriculture faculty for taking views/suggestions of faculty and students. In addition, views of foreign experts were also invited on the draft report. The final report on general guidelines, course curriculum, credit framework of all the UG disciplines was prepared in consultation with stakeholders.

Guided by the principles and philosophy of NEP-2020, the committee developed a comprehensive report outlining a restructured course curriculum and credit framework for 13 UG disciplines in agriculture and allied sciences and necessary provisions have been made in the curriculum to enable an individual to study report major and minor courses along with choice of electives. The 13 UG disciplines for which the course curriculum and credit framework restructured were Agriculture, Agricultural Engineering, Biotechnology, Dairy Technology,

Fisheries Science, Food Technology, Forestry, Community Science, Horticulture, Food Nutrition and Dietetics, and Sericulture, along with two new disciplines namely Natural Farming and Agribusiness Management.

Key features of the report include curriculum revision, modification of academic structure of degrees/diplomas/certificates, the introduction of an academic bank of credits (ABC), a multiple entry-and-exit system, flexible course selection, introduction of skill enhancement courses, making internship as part of UG-certificate, UG-diploma and degree requirements, and the incorporation of industry-oriented internships as part of UG requirements. A course entitled "*Deeksharambh*" has been introduced in the first semester for a duration of two weeks to acquaint students to learn from each other's life experiences, traditional values and traditional cultures and values. Common courses have been proposed developing better communication skills and personality development as well as to have a broader view of agriculture and allied sectors. New age courses like artificial intelligence, robotics, machine learning, etc. have been incorporated into the course curricula for preparing student in the era of Digital Technology. Progressive assessment of the student/s is part of course curriculum and the focus is enhancing their critical thinking and creativity rather than rote reading.

During this comprehensive exercise of restructuring the course curriculum and credit framework, the much-needed support, inputs and participation rendered by Hon'ble Vice-Chancellors of SAUs/CAUs/DUs/ CUs with Agriculture Faculty is greatly acknowledged. The support and help extended by all Deputy Director Generals is much appreciated.

I also take this opportunity to express a deep sense of gratitude to Dr. Trilochan Mohapatra, Former Secretary, DARE and Director General, ICAR for his initiatives, guidance and support. I feel extremely happy to take this opportunity to express my deep sense of gratitude to Dr. Himanshu Pathak, Secretary DARE and DG, ICAR for reposing faith in the committee and also constantly providing visionary guidance, cordial support and valuable inputs which helped in completing this task through various stages.

I hope, the educational reforms as suggested by the Sixth Deans Committee shall lead to a complete overhaul, and re-energise the higher agricultural education system to overcome the challenges currently being faced in India and thereby, deliver high quality higher agricultural education with equity and inclusion with focus to make the agricultural graduates as global leaders equipped with skills of better employment.



(R.C.Agrawal)
Deputy Director General (Agricultural Education)

Dated: 10 September, 2024
ICAR, New Delhi

Preface

Enhancing quality of human resource is a pre-requisite for implementing and upgrading research programs, developing technologies, evolving institutional arrangements to face challenges and to harness opportunities in the global perspective. Moreover, in the agriculture and allied sectors, such aspects are still more important due to the rapid changes occurring in challenges as well as in technologies. There is an urgent need of adequate trained manpower, that is professionally competent, socially sensitive and ethically strong to provide the technical backstopping in the changing resource constraints scenario in terms of land and water availability, and sustain agricultural growth with challenges of climatic adversities.

The ICAR having the mandate of guiding, managing and coordinating agricultural education in the country has been working in this regard and the National Agricultural Research, Education and Extension (NAREE) system continues to strive for maintaining and upgrading the quality and relevance of higher agricultural education through the partnership with 76 Agricultural Universities (AUs) comprising State Agricultural Universities (SAUs), ICAR Deemed-to-be-Universities (ICAR DUs), Central Agricultural Universities (CAUs) and Central Universities (CUs) with Agriculture faculty. One such measure that Council has taken periodically is the constitution of Deans' Committee for revising the course curriculum and also to undertake reforms in agricultural education in line with national priority.

National Education Policy (NEP-2020) was launched by the Government of India for transforming India's education system, seeking reforms at school, college, and university levels to build a knowledge-driven society. The NEP-2020 clearly indicates the need for reviving agricultural education which must be aligned with NEP-2020 based on its five pillars, namely, Access, Equity, Quality, Affordability, and Accountability. The NEP-2020 calls for improvement in both the capacity and quality of agricultural education with the aim to develop good, thoughtful, well-rounded, and creative individuals. This policy also focuses on the study of one or more specialized areas of interest at a deep level, and also on developing character, ethical and constitutional values, intellectual curiosity, scientific temper, creativity, spirit of service, and twenty-first century capabilities across a range of disciplines.

This report is the outcome of the Sixth Deans' committee, which was constituted by the Council to restructure course curricula of the UG programs and to align these with the NEP-2020 adopting a bottom-up approach involving all stakeholders. The Committee considered the academic aspects needed to be incorporated for the transformation of agricultural education system so as to prepare the youth to take up the challenges and opportunities in this vital and vibrant field. The main responsibility of the committee was the articulation of the knowledge and skills needed among the graduates and reform the course curricula for technological integration-based innovations for enhancing their skills, entrepreneurship, employment potentials, thus transforming them from job-seekers to job providers.

The report is in two parts. The PART-I comprises general recommendations on curriculum and credits as well as other guidelines on admissions, evaluations, etc., that is applicable to all disciplines and institutions involved in imparting higher agricultural education. The PART-II comprises discipline-wise recommended course curricula of undergraduate programs for thirteen ICAR approved disciplines. As per the provisions of NEP-2020, there are options for multiple entry and exit. Provision has been made for exit after the 1st year for award of UG-Certificate and after 2nd year for award of UG-Diploma after completion of internships at each level. Similarly, entry options for UG-Certificate and UG-Diploma holders have been made in 3rd and 5th semesters, respectively. Choice based skill enhancement courses have been integrated in the course programs. The restructured undergraduate curricula are designed to enable the students to take up entrepreneurship as a career path through several modes of skill development programs as in-plant training, internship, projects and rural agricultural work experience, etc.

Common courses of multi-disciplinary, value-added, and ability enhancement categories as per NEP-2020 guidelines have been recommended for all the disciplines to enhance the communication skills and development of personality of students and to prepare them for collaboration with other sectors to face the next generation challenges from a holistic point of view. Due emphasis has been given for imbibing the traditional knowledge, values and ethics among the students through different courses like the Deeksharambh, NCC, NSS and focus has also been given on health and wellness.

The students will also take online courses, which will be choice based, to groom their passion or strengthen their knowledge and competency in any field beyond the prescribed courses. There are provisions for elective courses, which will also be choice based and the institutions will also have the liberty to develop new elective courses as per local needs and available expertise. As per NEP-2020 guideline, introduction of Academic Bank of Credits (ABC) for the students will be in practice, which can facilitate institutional transfer of students. New age courses like artificial intelligence, robotics, machine learning, nanobiotechnology, renewable energy, information technology etc. have been duly internalized in course curricula.

The committee is grateful to Dr. Himanshu Pathak, Secretary DARE and Director General, ICAR; Dr. Trilochan Mohapatra, former Secretary DARE & DG, ICAR for reposing faith in the Committee and giving opportunity and providing guidance in restructuring the course contents and also for giving their valuable inputs for updating the curricula as per the need of agriculture and allied sectors to face challenges at global level.

The Committee is highly beholden to Dr. R.C. Agrawal, DDG (Agril. Edn.), ICAR for his valued inputs, guidance and constant support. The Committee also puts on record its gratitude to all Deputy Director Generals, ICAR; Vice-Chancellors; Deans and other stakeholders for their constant guidance and support, which were critical in shaping this document and completing this important task. The committee also gratefully acknowledges the contributions of of Dr. P.S. Pandey, Former ADG (EP&HS); Dr. Bimlesh Maan, ADG (EP&HS); Dr. Seema Jaggi, ADG (HRD); Dr. S.K. Sankhyan, Principal Scientists, Dr. Vanita Jain, Dr. Smita Sirohi and Dr. K.P. Tripathi, Principal Scientists of Education Division, ICAR.

The contribution of Subject Matter Specialists as members and special invitees of the Deans' Committee, is gratefully acknowledged.

We also take this opportunity to thank and acknowledge the contributions of Sixth Deans Committee members, namely, Dr. Shanti K. Sharma ADG (Natural Farming); Dr. Sanjaya K. Dash (Agril Engineering); Dr. Jayant Deka (Agriculture); Dr. R. R. B. Singh (Dairy Technology); Dr. R. F. Sutar (Food Technology); Dr. Reeta Raghuvanshi (Food Nutrition and Dietetics); Dr. Meenu Shrivastava (Community Science); Dr. K. T. Parthiban (Forestry); Dr. M.I.S. Gill (Horticulture); Dr. S. Chandrasekhar (Sericulture); Dr. Ramesh Bhat (Biotechnology); Dr. V. R. Kiresur (ABM) and Dr. B. K. Das (Fisheries Science) for their important role in this strenuous task.

The report is expected to stimulate policy innovations and also institutional reforms in academics paving way in building students for more meaningful and satisfying lives and work roles and enabling economic independence of learners capable of global competence. We are confident the guidelines and curriculum in this report would encourage higher agricultural education institutions to shape new generation youth in agriculture and allied fields and motivate all stakeholders, educationists to policy makers in contributing in fulfilling the aspiration of NEW INDIA.

(Ajit Singh Yadav)
Member Secretary
(6th Deans' Committee)

(Tej Partap)
Chairman
(6th Deans' Committee)

ICAR-SIXTH DEANS' COMMITTEE

Task Accomplishment Certificate

The 6th Deans' Committee was set up by ICAR, on the recommendations of the ICAR Expert Committee on Implementation Strategy for executing National Education Policy (NEP-2020) across the 13 disciplines that fall under Agriculture and Allied Disciplines of Agricultural Education system. Under National Education Policy (NEP-2020) regime, ICAR as Professional Standards Setting Body (PSSB) for Agricultural Education in the country, has the primary task of prescribing the course curricula and credit framework that will govern agricultural education in the country. Therefore, as a step towards implementing NEP-2020, ICAR constituted 6th Deans' Committee with a specific mandate of restructuring course curricula and regulations for the degree programs in operation under agricultural education in the country.

The committee members, comprising the Chairman and Deans, representing each academic program, as expert members, held several deliberations and prepared a framework of the restructured academic system, defining credit hours, focus of semesters, integration of skill development opportunities and system of specialization within the degree programs and other provisions of NEP-2020, which will be common to all programs. Thereafter, each Member-Dean, worked with experts within their respective disciplines working across universities/institutions to restructure the course curricula as per NEP-NHEQF, that was considered paramount imperative. Draft notes were circulated among the members and academic experts for their suggestions. Committee also received inputs from ICAR, foreign experts, Vice-Chancellors, DDGs and other stakeholders through the office of Deputy Director General-Agricultural Education. Report of the 6th Deans' Committee is an outcome of these efforts.

This NEP-NHEQF guided restructuring of Undergraduate Programs of Agricultural Science, is expected to help build strong foundation of both knowledge and skills. More emphasis has been given to Skill training and flexibility in choice of courses to adopt the choice-based credit system. It is our belief that the restructured academic programs will help produce new generation of human resources in agricultural domain/disciplines, which will be equipped to meet the needs of new knowledge and skills in agricultural sector.

The committee members draw satisfaction in accomplishing this task and are grateful to ICAR for reposing trust on them to undertake this onerous task, as well as to office of DDG (Agricultural Education) for coordinating the support services during the process. We thank all those academicians across the agricultural education landscape of the country, who were consulted, who offered new ideas, and those who offered constructive criticism. Down the years, we look forward to see the fruits of this work by way of transformed agricultural education system of the country.



(TEJ PARTAP)
Chairman, Sixth Deans' Committee, ICAR

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List of Members of Sixth Deans' Committee

S. No.	Name	Expert
1.	Dr. Tej Partap Former Vice Chancellor, GBPUAT Pantnagar; SKUAST, Srinagar and CSKHPKV, Palampur, HP	Chairman
2.	Dr. Jayant Deka Dean, Faculty of Agriculture, AAU Jorhat, Assam	Member
3	Dr. Sanjaya K Dash Dean, College of Agricultural Engineering and Technology, OUAT, Bhubaneshwar, Odisha	Member
4.	Dr. V R Kiresur, Professor (Agricultural Economics) and Director of Education, UAS, Dharwad, Karnataka	Member
5.	Dr. Ramesh Bhat Professor and Head, Department of Biotechnology, College of Agriculture, UAS, Dharwad, Karnataka	Member
6.	Dr. Meenu Srivastava Former Dean, College of Community Science, MPUAT, Udaipur, Rajasthan	Member
7.	Dr. R R B Singh Vice-Chancellor, Dau Shri Vasudev Chandrakar Kamdhenu Vishwavidyalaya, Durg, Chhattisgarh	Member
8.	Dr. B K Das, Dean, Faculty of Fishery Sciences, WBUAFS, Kolkata, West Bengal	Member
9.	Dr. Rita Singh Raghuvansi Former Dean, College of Home Science, GBPAUT, Pantnagar, Uttarakhand	Member
10.	Dr. R F Sutar Former Dean, Faculty of Food Processing and Bio-Engineering, Anand Agricultural University Anand, Gujarat	Member
11.	Dr. K T Parthiban Dean (Forestry), Forestry College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam, Tamil Nadu	Member
12.	Dr. M I S Gill Dean, College of Horticulture and Forestry, PAU, Ludhiana, Punjab	Member
13.	Dr. S Chandrasekhar Professor and Head, Department of Sericulture, UAS, GKVK, Bellary Road, Bengaluru, Karnataka	Member
14.	Dr. Shanti K Sharma Assistant Director General (HRM), Agril. Education Division, ICAR, KAB-II, New Delhi	Member
15.	Dr. Ajit Singh Yadav Assistant Director General (EQAR), Agril. Education Division, ICAR, KAB-II, New Delhi	Member-Secretary

1. Sixth Deans' Committee: Terms of Reference

1.1 Constitution of Committee for drafting the Implementation Strategy for Higher Agriculture Education

As a follow up to the National Education Policy-2020 (NEP 2020), ICAR, as Professional Standards Setting Body (PSSB) of agricultural education for the NEP-2020, set up a high-level committee comprising the Vice-Chancellors of Agricultural Universities. It was asked to devise a strategy for implementing NEP-2020 in agricultural education. Besides several other recommendations, the high-level committee recommended the constitution of Sixth Deans' Committee for restructuring the course curricula, framed by the Fifth Deans' Committee. Universities have adopted the Fifth Deans' Committee for implementation since 2016. The NEP-2020 required that this course curriculum is restructured to fit into the new academic regime.

1.2 Notification for Setting up the Sixth Deans' Committee

On the Recommendations of ICAR-NEP Implementation Strategy Committee, ICAR constituted the Sixth Deans' Committee on August 17, 2021 (orders issued on Sep 15, 2021) vide notification *F. No. Edn.5/24/202/EQR/VI Deans.* The 6th Deans' Committee was mandated to restructure the existing course curricula so as to enable implementation of NEP-2020 in agricultural education.

1.3 Terms of References of the 6th Deans' Committee

i) Restructuring of all UG Programs, all UG programs to be restructured as per NEP-2020 and NHEQF.

ii) Structure of first year UG Certificate Course, areas, end of course test and criteria for entry into second year Diploma course as per provisions of NEP-2020.

iii) Admission Criteria for UG-Certificate and UG Diploma courses, in view of the multiple entry and exit system provision under NEP-2020.

iv) Guidelines for Entrepreneurship of students.

v) Guidelines on provision for increasing gross enrolment ratio (GER), progressively.

vi) Defining UG and PG degrees for general market needs, as well as for specialist jobs and uniformity in UG and PG degree nomenclature.

vii) Any other point related to NEP-2020.

2. Prologue

2.1 Aim of Restructuring Agricultural Education

Education is at the heart of both personal and community development; its mission is to enable each of us, without exception, to develop all our talents to the full and to realize our creative potential, including responsibility for our own lives and achievement of our personal aim. There is, therefore, every reason to place renewed emphasis on the moral and cultural dimensions, apart from what is taught presently, enabling each person to grasp the individuality of other people and to understand the world's progression towards an uncertain future.

The 21st century is showing all signs of providing unprecedented means for communication and for the circulation and storage of information. Therefore, it will impose on education two demands which at first sight may appear contradictory. Education must transmit, efficiently and on a massive scale, an increasing amount of constantly evolving knowledge and know-how adapted to a knowledge driven civilization, because this forms the basis of the skills of the future. At the same time, it must find and mark the reference points that will make it possible, on the one hand, for people not to be overwhelmed by the flow of information, invading the public and private domains and, on the other hand, to keep the development of individuals and communities as its end in view. Education must, as it were, simultaneously provide maps of a complex world in constant turmoil and the compass that will enable people to find their way in it.

In this view of the future, responses to the demand for traditional education that are essentially quantitatively, and knowledge based are no longer appropriate. It is not enough to supply each student with a store of knowledge to be drawn from the existing one. Instead, everyone must be equipped to seize learning opportunities throughout life, both to broaden her or his knowledge, skills, and attitudes, and to adapt to a changing, complex and interdependent world.

2.2 Four Pillars of Education

The International Commission on Education in its report "Learning: The Treasure Within" (UNESCO, 1996) has defined "why and how" agenda for modifying education for 21st century, globally. It advocated inclusion of the concept of following four pillars of education if education is to succeed in

its task. NEP also has advocated similar perspective of future education system in India. Sixth Deans' Committee would like to lay stress on institutions to reorganize their existing academic system of agricultural education around these four fundamental types of learning. In a way these pillars must remain the pillars of knowledge, throughout a person's life.

1. *Learning to know* -- acquiring the instruments of understanding.
2. *Learning to do* -- to be able to act creatively on one's environment.
3. *Learning to live together* -- so as to participate and cooperate in all human activities.
4. *Learning to be* an essential progression which proceeds from the previous three.

These four paths of knowledge, all form a whole with many points of contact, intersection, and exchange among them.

2.3 Constitution of the report

The report is in two parts. PART-I comprises General Report on curriculum and credits as well as other general guidelines on admissions, evaluations, etc., that is applicable to all disciplines, colleges, universities, institutions, who are involved in imparting higher agricultural education in any of the following ways in the country.

PART-II of the report comprises discipline-wise recommendations, on restructured course curricula of undergraduate degree programs for 13 ICAR approved disciplines, as follows.

1. Agriculture
2. Agricultural Engineering
3. Biotechnology
4. Dairy Technology
5. Fisheries Science
6. Food Technology
7. Forestry
8. Community Science
9. Horticulture
10. Food Nutrition and Dietetics
11. Sericulture
12. Agribusiness Management
13. Natural Farming

3. Executive Summary

New Education Policy-2020 (NEP-2020) of India proposed many changes in the education system of India, including higher agriculture education system. A national level Committee was constituted by ICAR to develop an implementation strategy to comply with various provisions of National Education Policy (NEP-2020). ICAR constituted the Sixth Deans' Committee to restructure the existing course curricula so as to enable implementation of NEP-2020 in agricultural education. As per the NEP-2020 recommendations, the Sixth Deans' Committee has incorporated following several new initiatives in the proposed restructured UG curricula.

3.1 Classification of level of courses with targeted outcomes

The courses have been classified as per the level of teaching and also based on targeted outcome.

- The 1st year of the UG programme (NHEQF Level 4.5) includes the foundation courses, introductory courses and skills enhancement courses/training in the chosen area, ability enhancement courses. It is aimed that student/s will acquire the basic knowledge in respective disciplines and adequate skill in some selected areas, to enable them for employment/ entrepreneurship.
- The 2nd year (NHEQF Level 5) includes the basic core courses and additional skill enhancement in chosen areas/ courses. It is aimed that the student/s will acquire the higher level knowledge in respective disciplines and adequate skills in some selected areas, to enable them employment at middle level/ supervisory level or for entrepreneurship.
- The 3rd year includes the advanced core subjects and their practical applications with an objective that the student will have deeper understanding of the subjects and their major application areas.
- The 4th year (NHEQF Level 6) will have the specialization/ elective courses and advanced skill enhancement through project and internship. The student will acquire advanced knowledge and skill in different areas so as to meet the higher order requirements of the society and industry as well as other prospective employers. It will also enable the graduates to become a job provider rather than a job seeker through establishment of enterprises in concerned fields.

3.2 Multiple Entry and Exit

There is provision of multiple entry and exit at different levels. The student/s will have the option to exit after the 1st year. He/ she/ ze has to complete 10 weeks of internship (10 credits) after 1st year (2 semesters) to be eligible for award of UG-Certificate. The student has another option to exit after the 2nd year. The student has to complete another 10 weeks of internship (10 credits) after 2nd year (4 semesters) to be eligible for award of UG-Diploma.

After four years of study, the student will be awarded UG degree in concerned discipline. No exit after 3 years (6 semesters) is recommended considering the professional nature of the courses.

The lateral entry at 3rd semester will be for the candidates having UG-certificate or those who have completed Diploma (3 years course after 10th) in recognised HAEIs. The lateral entry in 5th semester will be for candidates who have completed UG-Diploma.

3.3 New courses for acquiring advanced knowledge and skill and for strengthening their cultural and ethical values and through choice based programs

3.3.1 Deeksharambh (Induction–cum-Foundation Course)

A course entitled "*Deeksharambh*" (0+2) (Non-gradial) will be offered at the start of first semester for a duration of two weeks. This will create a platform for students to learn from each other's life experiences, help for cultural Integration of students from different backgrounds, know about the operational framework of academic process in university, instilling life and social skills, social awareness, ethics and values, team work, leadership, creativity, etc. It will also help in identifying the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario. There will be sessions by alumni, business leaders, outstanding achievers in related fields, people with inspiring life experiences as well as the University academic and research managers.

3.3.2 Common courses

The following common courses have been proposed to be offered across the disciplines. This will enable the student for better communication skills and personality development as well as to have a broader view of agriculture and allied sectors, which will allow them for future collaboration with other sectors to face the next generation challenges from a holistic point of view.

- Farming based livelihood systems
- Entrepreneurship Development and Business Management
- Agriculture Marketing and Trade
- Communication Skills
- Personality Development
- Environmental Studies and Disaster Management
- Agricultural Informatics and Artificial Intelligence

In addition to these common courses and *Deeksharambh*, the courses such as Physical Education, First Aid, Yoga Practices, Meditation, NCC and NSS have also been made compulsory for students for better social awareness and health of the future generation.

3.3.3 New age courses

New age courses like artificial intelligence, robotics, machine learning, etc. have been incorporated into the course curricula. Besides an array of elective courses have been included so that the student can get deeper knowledge and understanding in the subject of his/her interest. Due emphasis has been given to include the latest topics and subjects in both core and elective courses. Practical exercises and teaching methodology are proposed to make the young generation more imaginative, innovative, ingenious, creative and competent.

3.3.4 Online courses

The students will have to take a minimum of 6-10 credits of online courses, comprising one or more courses, as a partial requirement for the UG programme. The online courses can be from any field such as Basic Sciences, Humanities, Psychology, Anthropology, Economics, Engineering, Business Management, Languages including foreign language, Communication skills/ Music, etc. and can be taken from any online portal. The objective is to allow the students to groom their passion or strengthen their knowledge and competency in any field beyond prescribed courses.

3.3.5 Elective courses

The institutions will offer a bouquet of Elective courses to be offered to the students. The students will have the freedom to choose a subject among these courses. The institutions should develop capabilities to offer maximum of the Elective courses proposed in this report. The institutions will also have the liberty to develop new Elective courses as per local needs and available expertise.

3.4 Imparting Traditional Knowledge, Values and Ethics

Due emphasis has been given for imbibing the traditional knowledge, values and ethics among the students through different courses like the *Deeksharambh*, NCC/ NSS. It is proposed that Study tours shall be conducted across the country to make the student aware about the socio-cultural-economic status of the people of the country and develop respect for their values and ethics.

3.5 Entrepreneurship development as a career path

The restructured undergraduate curricula are designed to enable the students to take up entrepreneurship as a career path. As per NEP- 2020, the curricula in all the disciplines of Agricultural education have been refined and fine-tuned with intensive focus on choice-based skill enhancement programs.

Skill enhancement courses are included in different modes as follows:

- Skill enhancement courses in the 1st year and 2nd year as part of the course programs;
- Internship for exit programs after 1st year/ 2nd year; and
- Advanced skill enhancement through Student READY programs such as in-plant training/ internship/hands-on-training/projects in 4th year.

The skills acquired must make the students proactive, pioneering, prospect oriented during their internship or industrial attachment to serve as apprentices in the relevant field. It will empower them to grasp viable avenues of self-employment and entrepreneurship along with diversified career options in different facets of related domains.

3.5.1 Skill Enhancement Courses

Skill enhancement courses are essential requirements for any programme (UG-Certificate/ UG-Diploma or Degree). These will be choice based; student can choose the areas of skill enhancement from a bouquet of skill enhancement modules offered by the parent institution. The institutions will develop capabilities for offering such courses.

An institution is at liberty to (and in fact, it should) work in partnership with capable organizations/companies/NGOs/progressive entrepreneurs/ farmers for running various skill enhancement programs.

The University/ HAEIs may also formulate and offer courses in any other areas as identified by it, based on institutional expertise/capabilities/resources. In addition, the skill enhancement courses suggested by the UGC (Chapter 6), may also be offered.

3.5.2 Internship

Those students who wish to exit with UG-certificate after one year, has to undergo 10 weeks of internship programme (10 credits) after 1st Year. Similarly, the students who wish to exit with UG-Diploma after 2nd year, has to undergo 10 weeks of internship programme (10 credits) after 2nd Year. The goal of Internship at exit for UG-Certificate and UG-Diploma is to further strengthen skills in the chosen area/ subject.

Internship should be preferably arranged outside of the parent institution at any assigned organization/ industry/research institution/ project or with a progressive farmer/agri enterprise, etc.

3.5.3 Projects

For some disciplines, Projects have been kept as an integral part of the course programme. This will enable the students to develop required competencies and skill in either research or entrepreneurship or potential employment avenues rather than having only mere qualifications. They will be able to choose appropriate career in research or employment/ entrepreneurship, discover their interests, aptitudes and potentialities and maximise their potentialities and self-confidence. It will also add to creativity and critical thinking of the students.

3.6 Introduction of new degree programs

Two new degree programs have been proposed in this report in two important areas.

1. Considering the natural strength of the country and future opportunities, a new UG course on Natural Farming has been included. The syllabus is based on Bhartiya Prakartik Krishi Paddhati (BPKP) in India to enhance production, sustainability, saving of water, improvement in soil health and farm-land ecosystem, and reducing the market inputs. These important aspects of natural farming are considered as cost-effective and suitable for livelihood of large number of farmers and sustainable rural development.
2. A new degree programme on Agribusiness Management has been included. These students are expected to acquire competency and confidence to start their own enterprise, as well as will have adequate competency for getting jobs.

3.7 Light but tight educational programme

As per the norms of the NEP-2020, the programme has been made light but tight for the students. The total credit hours have been kept at 166 considering the specific need of the professional courses, however, in some of the disciplines, viz. Agril Engineering, Food Technology and Dairy Technology, the total credit hours ranged from 172 to 174. At the same time, the students have been given the option of the skill development courses, internship, online courses, etc., which will make their learning experience more pleasurable and learning efficient.

3.8 Progressive evaluation

In the course programme, 20% has been kept for progressive assessment of the student within the semester in form of quizzes/ group assignments. The assessment of the students through quizzes should focus on their critical thinking and creativity rather than rote reading.

The quiz and progressive assessment can also be considered in the form of group assignments (which should encourage creativity, critical thinking and problem-solving attitude).

3.9 Academic Bank of Credit

As per NEP-2020 guidelines, the HAEI will create an Academic Bank of Credits (ABC) of each student and recognise the ABC of a student as per the norms of the HAEI/NEP-2020 recommendations.

3.10 Migration of students from one institution to other

It has been proposed for inter-institutional transfer of students with accumulation of the ABC. The University/ HAEI may admit students either by holding its own admission test or use merit as criteria or by following any of the existing norms of both transferring and accepting Universities/HAEIs. The migration shall be subject to availability of seats at the accepting HAEI. It is recommended to make institutional migration after 4th semester. HAEIs are at liberty to put in place rules/ regulations relaxing/ modifying existing provisions of migration, providing more freedom and ease to students.

3.11 Minimum requirement for establishing colleges for agriculture and allied disciplines

The minimum requirements for establishing colleges for 13 agriculture and allied sciences disciplines shall be as per the ICAR Model Act-2023 and various guidelines and orders being issued by ICAR from time to time.

3.12 Making implementation of the recommendations of the Deans' Committee mandatory

Efforts have been made to improve the quality of agricultural education to make it internationally competitive. Implementation of the recommendations of the Sixth Deans' Committee to be made mandatory for accreditation of academic programs and academic institutions by the National Agricultural Education Accreditation Board (NAEAB) of ICAR.

4. Restructuring of Undergraduate Programmes

4.1 Restructuring of UG Programs

The restructuring has been done based on the following NHEQF levels:

- Year 1, Certificate Course, NEP-NHEQF Level 4.5
- Year-2, Diploma Course, NEP-NHEQF Level 5.0
- Year 4, B.Sc. (Hons.)/ B. F. Sc. (Hons.)/ B. Tech., NEP-NHEQF Level 6.0

The restructured program for the undergraduate agriculture education with multiple entry and exit options is illustrated in Figure 4.1.

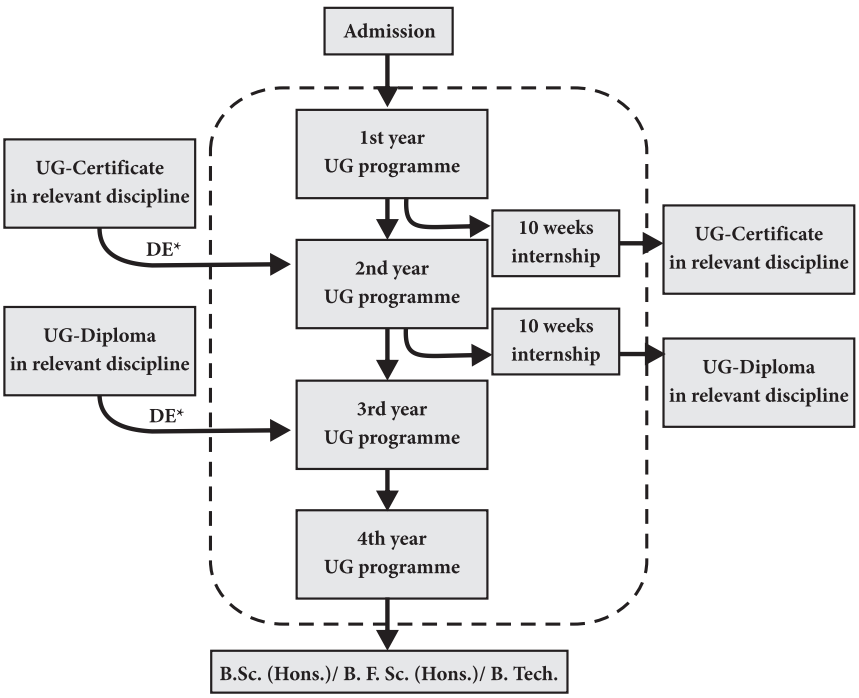


Fig. 4.1 Framework of Undergraduate Programmes
DE* Direct Entry in the respective year

The eligibility for entry into the UG programs will be + 2 Science; the students will be admitted as per norms of ICAR/ SAUs/CAUs. The 1st year of the programme will be having the foundation, introductory and skill enhancement courses. The 2nd year will be having basic core courses with

some more options for skill enhancement. The 3rd year of the programme will have advanced core courses. The 4th year programme will emphasize more on the specialisation and elective courses as well as advanced skill enhancement through internship.

There will be exit options after 1st year and 2nd year for UG-Certificate and UG-Diploma. However, the students opting to exit with UG-Certificate or UG-Diploma will have to take up 10 weeks internship after the 1st year (2 semester) and 2nd year (4 semesters), respectively.

Table 4.1 shows the restructured undergraduate programs for the higher agricultural educational institutions (HAEIs).

Table 4.1 Types of courses and learning outcomes for the restructured undergraduate programs for the HAEIs

Year	Types of courses	Learning outcome	Exit option
YEAR 1 NHEQF Level 4.5	Foundation courses, introductory courses and skills enhancement training/ training in the chosen area, ability enhancement courses	Students will acquire the basic knowledge in respective disciplines and adequate skill in some selected areas, to enable them for employment/ entrepreneurship	A student must complete 10 weeks of internship (10 credits) after 1st year if exit with UG-Certificate is opted
YEAR-2 NHEQF Level 5	Basic core courses and additional skill enhancement in chosen areas/ courses	Students will acquire the higher level knowledge in respective disciplines and adequate skill in some selected areas, to enable them for employment at middle level/ supervisory level or for entrepreneurship	A student must complete 10 weeks of internship (10 credits) after 2nd year if exit with UG-Diploma is opted
YEAR-3	Advanced core subjects and their practical applications	Students will have deeper understanding of the subjects and their major application areas	No exit after 3rd year
YEAR-4 NHEQF Level 6	Specialization/ Elective courses and advanced skill enhancement through project and internship	Students will acquire advanced knowledge and skill in different areas so as to meet the higher order requirements of the society and industry as well as other prospective employers. It will also enable the graduates to become a job provider rather than being a job seeker through establishment of enterprises in concerned fields.	UG degree in concerned discipline

4.2 Credit Hours Allocation

A total of 166-174 credit hours is recommended for the four years of UG programs. The credit distributions for the different courses have been specified for individual disciplines. The general structure is given in Table 4.2.

Table 4.2 General Credits Allocation Scheme of UG Programs (Credit hours)

Semester	Core Courses (Major+ Minor)	Multi-Disciplinary Course (MDC)	Value Added Course (VAC)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)	Internship/ Project/ Student READY	Total Credits	Non-Gradial	Online Courses/ MOOC
I	12	3(2)		1(3) + 2(4)	4	-	22	2(1)	
II	10	3(5)	3(6)	1(3) + 2(7)	4	-	23	-	
Post-II semester						10(12)			
III	16	----		2(8)	2	-	20		
IV	12	3(9)	3 (10)	----	2	-	20	-	10
Post-IV semester						10(13)			
V	21	-	-	-	-	-	21	2(11)	
VI	21	-	-	-	-	-	21	-	
VII	20	-	-	-	-	-	20	-	
VIII	-	-	-	-	-	20	20	-	
Total	112	9	6	8	12	20	167	4	10

(1) Deeksharambh (Induction-cum-Foundation Course) of 2 credits (2 weeks duration).

(2) Farming based Livelihood systems

(3) NCC/NSS; (4) Communication Skills; (5) Entrepreneurship Development and Business Management

(6) Environmental Studies and Disaster Management;

(7) Personality Development; (8) Physical Education, First Aid, Yoga Practices and Meditation.

(9) Agriculture Marketing and Trade; (10) Agricultural Informatics and Artificial Intelligence

(11) Study tour (10-14 days).

(12) Only for those opting for an exit with UG-Certificate. (13) Only for those opting for an exit with UG-Diploma

One multidisciplinary course in Agricultural Engineering discipline is different from the above common courses keeping in view the discipline specific requirement.

Note:

- The credit hours mentioned in the Table 4.2 include both theory and practical.
- The total credit allocation and the allocation for different types of courses including on-line courses for some disciplines such as Agricultural Engineering, Dairy Technology and Food Technology are slightly different than those mentioned in the Table 4.2, so as to accommodate the specific need of these disciplines.
- Also, some minor deviations in the courses and credits allocations are allowed across disciplines considering the specific nature of the courses.
- The three-year course curricula of all disciplines of agricultural and allied sciences do not cover the teaching of elective/ specialized courses, that in fact qualify the students in specializing in

a particular subject in which the student intends to do further studies. These courses have been presently listed under the 7th and 8th semesters (in IV year). Therefore, the Sixth Deans' Committee is of the view that the option of B. Sc. (Hons.) with research may lead to deficiency of the knowledge and learning of the elective / specialized subjects needed for PG studies. For B. Tech. programs, the framework prescribed by AICTE/ UGC may be applicable. Under such circumstances, the Committee recommends that the launching of UG degree with research should be deferred for the time being. ICAR may consider about this aspect along with considering restructuring PG/ Ph.D. programs. Also considering the professional nature of the courses, the exit after at the end of 3rd year (at the end of 6th semester) is not recommended.

- Each class (contact hour) will be of 50 min duration and one practical will be of two contact hours.
- If the student has to take up any deficiency course(s), that has to be satisfactorily completed within the first year.

4.3 Deeksharambh (Introduction- cum-foundation course)

The goal of higher education is to nurture students by blossoming their hidden potentials to pursue the academic and professional studies in a diligent, honest and responsible manner. It is possible by facilitating them to develop a sense of integrity with diverse faculties and build linkages with peers, society and community as a whole and lastly be proficient in earning livelihood independently along with sustaining society and nature.

A course entitled Deeksharambh (0+2) (Non-gradial) will be offered at the start of first semester for a duration of two weeks. This will be a part of first semester for all purposes including the calculation of Net Instruction Days (NIDs).

The goal of Deeksharambh is to inculcate life skills, develop bonding with mentors, peers and seniors, familiarize with institutional academic framework and functioning, It must educate students to explore their potentials and understand the purpose of their life with reference to serving the community, nation and global society.

Often the incoming undergraduate students are influenced by their parents and relatives to join higher studies, without understanding their own interests and talents. Therefore, the very purpose of initiating Deeksharambh: the induction-cum-foundation course is to acclimatize the student with the new surroundings, develop bond with fellow students and teachers. It is the time when a student should become clear as to what he/she/ze is going to study in a particular discipline, or even it is time to quit and join another discipline of his/ her choice. They must develop sensitivity towards various issues of social relevance and imbibe human values to become responsible citizens.

Thus, ensuring a well-designed Induction-cum-foundation program by the institutions shall be designed to become helpful to both teachers and students for setting the pace of productive teaching and learning experiences.

Four Pillars of Deeksharambh

Socializing: Meeting new students, senior students, attend lectures by Eminent People.

Associating: Visits to university / college, visits to Dept./Branch/ Program of study and important places on campus, local area, city and so on.

Acclimatizing with rules and regulations, student support system, etc.

Experiencing: Subject lectures, study skills, small-group activities, physical activity, creative and performing arts, literary activities, universal human values, etc.

Deeksharambh will create a platform for students to:

- learn from each other's life experiences
- help for cultural integration of students from different backgrounds
- know about the operational framework of academic process in university
- instilling life and social skills
- social awareness, ethics and values, team work, leadership, creativity, etc., and
- identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario.

There will be sessions by alumni, business leaders, outstanding achievers in related fields, people with inspiring life experiences as well as the University academic and research managers.

Steps will be taken by the institutions to identify the strength and weakness of students (with remedial measures) and diverse potentialities and to enhance cultural integration of students from different backgrounds.

4.4 Common courses

The following common courses have been proposed to be offered across the disciplines, which in addition to giving the students a broader view of agriculture and allied sectors, will enable them for better communication skills and personality development. Besides, this will also help them to look beyond the boundaries of their own subject/ discipline, and collaborate in future with other sectors to face the next generation challenges from a holistic point of view.

- Farming based livelihood systems
- Entrepreneurship Development and Business Management
- Agriculture Marketing and Trade
- Communication Skills
- Personality Development
- Environmental Studies and Disaster Management
- Agricultural Informatics and Artificial Intelligence

In addition to these common courses and Deeksharambh, the courses such as Physical Education, First Aid, Yoga Practices and Meditation, NCC and NSS have also been made compulsory for students for improving social awareness, ethics, moral values and health of the future generation.

4.5 New age courses

Keeping in view the modern science needs, courses like artificial intelligence, robotics, machine learning, etc. have been incorporated into the course curricula. In addition, an array of elective courses have been included so that the student can get deeper knowledge and understanding in the subject of his interest. Emphasis has also been given to include the latest topics and subjects

in both core and elective courses. Practical exercises and pedagogy are proposed to make the next generation more imaginative, innovative, ingenious, creative and competent.

4.6 Deficiency courses

If the student has to take up any deficiency course(s), it has to be completed within the first year.

4.7 Entrepreneurship development

Entrepreneurship is a key driver of the economy of a nation, which has been encouraged through NEP-2020. Expectation is that an early orientation of the young minds towards skill enhancement and entrepreneurship will inculcate entrepreneurial mind set, allowing them to have first-hand experience of working with institutions, organizations, companies, industrial setup and investors so as to understand their dynamics in the real-world setting.

The restructured undergraduate curricula are designed to enable the students to take up entrepreneurship as a career path. As per NEP-2020, the curricula in all the disciplines of Agricultural education have been refined and fine-tuned with intensive focus on choice-based skill enhancement programs.

Skill enhancement courses are included in following different modes:

- skill enhancement courses in the 1st year and 2nd year as part of the course programs;
- internship for exit programs after 1st year/ 2nd year; and
- advanced skill enhancement through Student READY: RAWE/Experiential Learning/Hands on Training/Skill development/Industrial attachment/In-plant training/student project/Internship etc. in 4th year.

Internship can be seen as a mini capsule of intense learning for a student, a way to apply the theory into practice, expand their knowledge base and a platform to integrate all learnings of formal classroom setup.

Addition of new age courses related to Agriculture, Forestry, Fisheries, Agricultural Engineering, Community Science, Food Nutrition and Dietetics, etc., and incorporation of choice based online courses, which can be taken up from NPTEL, moo KIT, edX, Coursera, SWAYAM or any other portal in open digital learning environment. Practical exercises and teaching methodology are so designed to make the young generation more imaginative, innovative, ingenious, creative and competent.

The skill set acquired must make them proactive, pioneering, prospect oriented during their internship or industrial attachment to serve as apprentices in the relevant field. This will empower them to grasp viable avenues of self-employment and entrepreneurship along with diversified career options in different facets of related domains.

4.7.1 Skill Enhancement Courses

The skill enhancement programs will be choice based; student can choose the areas of skill enhancement from a bouquet of skill enhancement modules offered by the parent institution. The institutions will develop capabilities for offering such courses.

An institution is at liberty to (and in fact, it should) work in partnership with capable organizations/ companies/ NGOs/ progressive entrepreneurs/ farmers for running various skill enhancement programs.

In the report, for each discipline the list of Skill Enhancement Courses (SEC) has been suggested. The University/ HAEIs may also formulate and offer courses in any other areas as identified by it, based on institutional expertise/ capabilities/ resources. In addition, the skill enhancement courses suggested by the UGC, as listed, may also be offered.

The evaluation of the skill enhancement programs will be as per the evaluation criteria of courses with only practical. However, for the internship programs, the evaluation will be done jointly by the host and parent organisations/ institutions.

4.7.2 Internship

The internship proposed under NEP-2020 have been an integral part of agricultural education (as proposed by Fifth Deans' Committee) under the broad category of Student READY programs. It includes various activities such as Experiential Learning/ Hands-on Training, Skill Development Training, Rural Agriculture Work Experience (RAWE), In-Plant Training/ Industrial Attachment and Students' Projects. Therefore, in the recommended structure, the student READY is further strengthened as per NEP-2020 guidelines.

Those students who wish to exit with UG-certificate after one year, has to undergo 10 weeks of internship programme (10 credits) after 1st Year. Similarly, the students who wish to exit with UG-Diploma after second year, has to undergo 10 weeks of internship programme (10 credits) after 2nd Year. The goal of Internship at exit for UG-Certificate and UG-Diploma is to further strengthen skills in the chosen area/ subject.

Internship should be preferably arranged outside of the parent institution at any assigned organization/ industry/ research institution/ project or with a progressive farmer/ agri enterprise, etc.

HAEIs will ensure that the Internship program is aligned with the course that the student has chosen. It is recommended that each HAEI appoints one or more Coordinators for the internship programs. The coordinator must plan/execute/ monitor internship programme implementation at the institution level.

4.7.3 Projects

For some disciplines, projects have been kept as an integral part of the course programme. This will enable the students to develop required competencies and skill in either research or entrepreneurship or potential employment avenues rather than having only mere qualifications, choose appropriate career in research or employment/ entrepreneurship, discover their interests, aptitudes and potentialities and maximise his/ her/ze potentialities and self-confidence. It will also add to creativity and critical thinking of the students. This will also help the students gain research skills and be more innovative in planning, executing, reporting and presenting the things.

4.8 Study tour

There will be a study tour of 10-14 days duration during the 5th semester of the UG programme. The students will preferably visit the leading industries/ enterprises/ institutions/ organisations and

other places of academic interest outside the state (of location of the institution). This, in addition to exposing the students to the indigenous as well as the latest technologies in their related fields, will also help the students to know about the socio-economic-cultural variations within the country. The course will be of 0+2 credits, non-gradial.

4.9 Online courses

The students will have to take a minimum of 6-10 credits of online courses, which will comprise of one or more courses, as a partial requirement for the UG programme.

(As per UGC guideline, a 1- to 3- credit SWAYAM course is expected to be covered in 4-12 weeks' duration including the assessment component, in which it should be 40 hours for 3- credit courses to 80 hours for a 6-credit course for the learning from e-content, reading references material, discussion forum posting and assignment.)

The online courses can be from any field such as Basic Sciences, Humanities, Psychology, Anthropology, Economics, Engineering, Business Management, Languages including foreign language, Communication skills/ Music, etc., and can be taken from NPTEL, mooKIT, edX, Coursera, SWAYAM or any other portal.

The objective is to allow the students to groom their passion or strengthen their knowledge and competency in any field beyond prescribed courses.

The courses will be non-gradial as separate certificates would be issued by institutes offering the courses. These can be taken any time during the duration of UG program, but preferably during the 3rd and 4th years.

The University/ institute will keep a record of such courses registered and completed by each student and will indicate the title of the (successfully completed) courses in final transcript issued to the student.

The requirement of credits for online courses for B. Tech. programs is different due to the specific need of the disciplines.

4.10 Elective courses

The institutions will offer a bouquet of Elective courses to be offered to the students. The students will have the freedom to choose a subject among these courses. The institutions should develop capabilities to offer maximum of the Elective courses proposed in this report. The institutions will also have the liberty to develop and offer more Elective courses relevant to the subject as per local/regional needs and available expertise. The elective courses can be offered from other disciplines in a University/HAEI.

4.11 Imparting traditional knowledge, values and ethics

Due emphasis has been given for imbibing the traditional knowledge, values and ethics among the students through different courses like the Deeksharambh, NCC and NSS. It is proposed the Study tour shall be conducted across the country to be aware about the socio-cultural-economic status of the people of the country and develop respect for their values and ethics.

4.12 Introduction of new degree programs

Among the 13 UG disciplines, two new degree programs have been proposed in the emerging areas. Considering the opportunities natural farming of the country and future opportunities, a new UG course on Natural Farming has been included. The syllabus is based on Bhartiya Prakartik Krishi Paddhati (BPKP) in India to enhance production, sustainability, saving of water, improvement in soil health and farmland ecosystem and reducing the market inputs. As this programme covers important aspects of natural farming which are considered as cost- effective and suitable for livelihood of large number of farmers and sustainable rural development.

Another, new degree programme on Agribusiness Management has also been included. By studying this programme, students are expected to acquire competency and confidence to start their own enterprise, as well as will have adequate competency for getting jobs.

4.13 Light but tight educational programme

The course curriculum of all 13 UG programmes has been made light but tight for the students with total credit hours varying from 166-174 considering the need of the professional courses. Besides, the students have been given the option of the skill development courses, internship, online courses, etc., which will make their learning outcome more employment, oriented and more efficient.

4.14 Moderation of courses at institution level

The following flexibility is allowed to the institutions for offering the courses:

A. Maximum 30% modification in the syllabus for any individual subject. It is recommended the HAEI should consider updating the course curricula around 5% every year. That would enable addition of new contents replacing obsolete/ old contents in the courses.

B. Formulation /addition/ change of Skill Enhancement modules as per needs/ facilities available.

C. Interchange of courses in between semesters within a year (but no change of course shall be normally allowed in between years).

D. Change of maximum two core courses (If any course is removed from the list of core course, it should be kept as elective), However, the total credit hours should not be lower than the prescribed.

E. Inclusion of any number of courses as Electives and freedom to offer the Elective courses.

F. Modification/ change of credit hours for any four courses (however, total credit hours should not differ by more than four).

G. In case the skill enhancement/ internship programs are conducted in collaboration with industry/ other organizations/ agencies, students may be expected to remain out of the campus for a certain period within the semester. In that situation, the timetable should be so adjusted for the remaining part of the net instruction days (NIDs) of the corresponding semester, that each credit has at least 15 contact hours.

4.15 Central Assistance for strengthening higher agricultural education

The central Assistance for strengthening higher agricultural education, as proposed by the Fifth Deans' Committee, may be continued.

4.16 Admission criteria

The eligibility and mode of admission for entry into the UG programs will be as per the prevailing ICAR/ SAU norms.

Agricultural universities/ colleges and other general universities offering agricultural disciplines, will fall under the umbrella of ICAR, as PSSB for agricultural education, as mandated by NEP-2020.

Institutions are at liberty to assess their student intake capacity, and announce the number of seats available in the first semester, and for lateral entries at 3rd semester and 5th semester.

The lateral entry at 3rd semester will be for the candidates having UG-certificate or those who have completed Diploma (3 years course after 10th) in recognised institutions. The lateral entry in 5th semester will be for candidates who have completed UG-Diploma.

There cannot be guarantee for migration to another HAEI. Institutions are at liberty to make their own decisions/ norms/guidelines on the matter of seats and admissions in 3rd and 5th semesters.

4.17 Provision of lateral entry for Diploma holders from recognised institutions

Candidates having a Diploma from polytechnics (after completion of 3 years course after 10th in related disciplines) will be entitled to take admission in the 2nd year (3rd semester) program. The HAEI may admit students either by holding its own admission test or use merit as criteria for by following any of the existing norms of the University/HAEI.

4.18 Migration from one University to other

The UG-Certificate/ UG-Diploma passed candidate from a HAEI will be eligible for admission into any agricultural university/institution in the country at appropriate level, provided the admitting university has provision of seats to admit them.

It is recommended to make institutional migration after 4th semester more convenient. HAEIs are at liberty to put in place rules/ regulations relaxing/ modifying existing provisions of migration, providing more freedom and ease to students. The migration shall be subject to availability of seats at the accepting HAEI.

Provided further, any such rule/ regulation that is notified by UGC regarding changes in admission criteria, migration, etc., these notifications will be considered/ examined by ICAR and re-notified to make them applicable to agricultural education falling under its domain.

4.19 Exit option

There will be three exits during the restructured UG programme.

Exit after 1st year: A student may opt to exit after the 1st year of UG programme. However, he/she has to complete 10 weeks of internship (10 credits) to be eligible for being awarded UG-Certificate degree. (The students going to the higher level need not take 10 weeks internship at this stage.)

Exit after 2nd year: A student may opt to exit after the 2nd year of UG programme. However, he/she has to complete 10 weeks of internship (10 credits) to be eligible for being awarded UG-

Certificate degree. (The students going to the higher level need not take 10 weeks internship at this stage.)

Exit after 4-years programme leading to B.Sc. (Hons.)/ B.F.Sc. (Hons.)/ B. Tech. degree.

4.20 Maximum residential period

Students who exit with a UG-Certificate or UG-Diploma are permitted to re-enter within three academic years and complete the degree programme.

Students may be permitted to take a break from the study during the period of study but the total duration for completing the programme shall not exceed 7 years.

4.21 Examination and Evaluation system

There will be a uniform system of the evaluation and grading to be followed with Grade point average (GPA) system. The following pattern of examination is recommended.

Table 4.3 Evaluation system

Courses detail	Theory	Mid-term	Quiz/progressive assessment	Final Practical
For courses having one credit under practical	40%	15%	15%	30%
For courses having more than one credit under practical	40%	10%	10%	40%
For courses with theory only	50%	30%	20%	-
Courses with practical only	-	30%	20%	50% (Internal)

For the external theory examinations, the question paper will be obtained from external experts. The HoDs of the respective departments will ensure due coverage of the syllabus with the provision of moderation, if necessary. Paper evaluation to be done by a faculty other than the course instructor(s).

The external theory examinations should be of 2 to 2.5 hours duration and the mid-term examinations should be normally of 1-hour duration. The format of assessment and duration of quizzes/ progressive assessment duration will depend upon the course teacher.

Internal practical examination to be conducted by the course instructor and one faculty nominated by the HoD of the concerned department.

The evaluation of the skill enhancement courses will be done as courses with practical only.

Usually for any subject, there will be two quizzes within the semester, one before the mid-term and one after mid-term. There will be provision of corrections in between, i.e. the students scoring lower than 50% marks in any one quiz can opt for appearing for a third quiz to improve their grades. The assessment of the students through quizzes should focus on their critical thinking and creativity rather than rote reading.

The quiz and progressive assessment can also be considered in form of group assignments (which should encourage creativity, critical thinking and problem-solving attitude).

The evaluation of internship will be done both by the parent institute and the host industry/ organisation. It should be 50% weightage for each. The student shall submit a report to the parent

institute and present the learnings before the other students and faculty after the internship programme. The format of evaluation may be developed by the parent institute.

The online/MOOC courses, successfully completed by the student, will be indicated in the transcript with 'Satisfactory' remark.

When students take deficiency course(s), they will be assessed as 'Satisfactory' or 'Un-satisfactory' without any grade points.

The evaluation will be done on a 10-point scale.

10 point = 100 marks

The per cent of marks in a subject will be divided by 10 to obtain the grade point.

The grade point average for a semester will be calculated as follows.

$$GPA = \frac{\sum (Grade\ \ p\ \ \text{int} \times credit\ \ hours)_{in\ \text{one semester}}}{Total\ \ credit\ \ hours\ \text{in the semester}}$$

The Cumulative grade point earned at any stage of the course will be calculated as cumulative grade point average (CGPA) as follows.

$$\text{CGPA} = \frac{\sum (\text{Grade p int} \times \text{credit hours})_{\text{until last semester}}}{\text{Total credit hours until last semester}}$$

If a student passes in a subject in a second attempt, for calculation of CGPA, the grade point for the subject in the second attempt will only be considered. The final CGPA will be named as overall grade point average (OGPA), which will be mentioned in the final transcript of the students.

4.22 Award of Divisions

The award of the divisions will be as follows

Table 4.4 Award of the divisions

OGPA	Division
5 to <6	Pass
6 to <7	II division
7 to<8	I Division
>=8	1st division and distinction

4.23 Uniformity in Nomenclature of Degrees

To ensure hassle free movement of students throughout the country, it is important that nomenclature of degrees awarded is same, across all HAEIs. The nomenclature will be as follows.

a. UG-Certificate with mention of discipline

e.g. UG-Certificate in Agriculture, UG-Certificate in Horticulture, UG-Certificate in Agricultural Engineering

Note: If any institution is at present offering any certificate course of the duration of one year lower, it may continue to do so, but this certificate course will not be considered at par with

the UG-Certificate, if the student has not taken admission through the appropriate entrance examination for entry into the 4-year UG program.

b. UG-Diploma with mention of discipline

e.g. UG-Diploma in Agriculture, UG-Diploma in Horticulture, UG-Diploma in Agricultural Engineering

Note: If any institution is at present offering any Diploma course of two years or less than two years' duration after +2 Science, it may continue to do so, but this diploma course will not be considered at par with the UG-Diploma, if the student has not taken admission through the appropriate entrance examination for entry into the 4-year UG program.

The nomenclature of undergraduate degrees will be as per the recommendations of the 5th Deans' Committee as follows:

B. Sc. (Hons.)/ B. F. Sc. (Hons.)/ B. Tech. followed by discipline

e.g. B. Sc. (Hons.) Agriculture/ B. F. Sc (Hons.)/ B. Tech. (Agricultural Engineering)

The nomenclature of degrees may change in case any such revision is suggested by the UGC.

4.24 Increasing Gross Enrolment Ratio (GER)

Keeping in view the NEP-2020 call for increasing GER, it is recommended that provision is made by institutions to launch stand-alone UG-Certificate and/ or UG-Diploma courses in specific subjects/ disciplines. The entrance examinations for such programs will be separate. The students completing the UG-Certificate will have to appear separate entrance test for continuing to higher level as per University/HAEI norms. Similarly, the students completing the UG-Diploma will have to appear separate entrance test for continuing to higher level as per University/HAEI norms.

4.25 Academic Bank of Credits (ABC)

As per NEP-2020 guidelines, the HAEI will create an Academic Bank of Credits (ABC) of each student and recognise the ABC of a student as per the norms of the HAEI/ NEP-2020 recommendations.

4.26 Blended Learning

Blended learning has gained tremendous popularity as it combines the benefits of traditional classroom teaching with emerging technology and online educational resources to make learning more real-time, contextual, and engaging. This provision will enable blended learning to expand the open /distance learning options and to promote extensive use of technology in learning and skilling. This would help in overcoming the constraints of physical infrastructure and scalability while enhancing access, equity, and affordability and ensuring quality and accountability. The blended learning option shall also enhance accessibility of learning for Divyangs.

4.27 Minimum requirement for establishing colleges for agriculture and allied disciplines

The minimum requirements for establishing colleges for 13 agricultures and allied disciplines shall be as per the ICAR Model Act-2023 and various guidelines and orders being issued by ICAR from time to time.

The new NEP-2020 has been introduced in the country to formalize changes in the system, from school to college/ university level. Keeping in mind the concurrent developing scenario and stakeholders' demands, especially in agriculture education, research and extension systems across the regions, delivery of education content henceforth, will focus on key-concepts, ideas, applications and problem-solving angles so as to empower students to become employment ready.

The Indian Council of Agricultural Research has been declared Professional Standards Setting Body (PSSB) for agriculture and allied subjects under NEP-2020. The Council has been coordinating with all agricultural universities since 1960s or so for addressing the issues of quality agricultural education. Primary focus of national coordination in agricultural education was given to update course curricula periodically and concerned universities to adopt them. As a result of long term persuasions by ICAR and realization of stakeholders' demand, agricultural universities have been implementing ICAR recommended Course Curricula for 13 undergraduate programs, 80 Post Graduate programs and 79 Ph. D. programs.

Later on, it was perceived that merely changing the course curricula would not be sufficient to address the quality education, but a sound framework suggesting minimum requirements for degree programs especially requirements of teaching and non-teaching staff, instructional laboratory and instructional farms and supporting units of the following disciplines are also equally essential:

1. Agriculture
2. Agricultural Engineering
3. Biotechnology
4. Dairy Technology
5. Fisheries Science
6. Food Technology
7. Forestry
8. Community Science
9. Horticulture
10. Food Nutrition and Dietetics
11. Sericulture
12. Agribusiness Management
13. Natural Farming

4.28 Making implementation of the recommendations of the Deans' Committee mandatory

Efforts have been made to improve the quality of agricultural education to make it internationally competitive. Implementation of the recommendations of the Sixth Deans' Committee to be made mandatory for accreditation of academic programs and academic institutions by the National Agricultural Education Accreditation Board (NAEAB).

5. COMMON COURSES

***Deeksharambh* (Induction-cum-Foundation Course)-Non-gradial 2(0+2)**

Objectives

- To give a broad view and application areas of the subject of study
- Helping students from different backgrounds for cultural Integration
- Knowing about the operational framework of academic process in university
- Instilling life and social skills, leadership qualities, team working spirit
- Developing social awareness, ethics and values, creativity
- Helping students to identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario.

Activities

The details of activities/ schedules will be decided by the parent universities. The structure shall include, but not restricted to:

i. Discussions on operational framework of academic process in university, as well as interactions with academic and research managers of the University/institute

ii. Creating awareness on the subject of study, and the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario

iii. Interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences

iv. Group activities to identify the strength and weakness of students (with expert advice for their improvement) as well as to create a platform for students to learn from each other's life experiences

v. Field visits to related fields/ establishments

vi. Sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills

Farming Based Livelihood Systems 3 (2+1)

Objectives

i. To make the students aware about farming-based livelihood systems in agriculture

ii. To disseminate the knowledge and skill how farming-based systems can be a source of livelihood

Theory

Status of agriculture in India and different states, Income of farmers and rural people in India, Livelihood-Definition, concept and livelihood pattern in urban and rural areas, Different indicators to study livelihood systems. Agricultural livelihood systems (ALS): Meaning, approach, approaches and framework; Definition of farming systems and farming based livelihood systems. Prevalent Farming systems in India contributing to livelihood. Types of traditional and modern farming systems. Components of farming system/ farming-based livelihood systems-Crops and cropping systems, Livestock (Dairy, Piggery, Goatry, Poultry, Duckry etc.), Horticultural crops, Agro--forestry systems, Aqua culture Duck/Poultry-cum-Fish, Dairy cum-Fish, Piggery-cum-Fish etc., small, medium and large enterprises including value chains and secondary enterprises as livelihood components for farmers; Factors affecting integration of various enterprises of farming for livelihood. Feasibility of different farming systems for different agro-climatic zones, Commercial farming-based livelihood models by NABARD, ICAR and other organizations across the country; Case studies on different livelihood enterprises associated with the farming. Risk and success factors in farming-based livelihood systems; Schemes and programs by Central and State Government, Public and Private organizations involved in promotion of farming-based livelihood opportunities. Role of farming-based livelihood enterprises in 21st Century in view of circular economy, green economy, climate change, digitalization and changing life style.

Practical

Survey of farming systems and agricultural-based livelihood enterprises, Study of components of important farming- based livelihood models/ systems in different agro-climatic zones; Study of production and profitability of crop based, livestock based, processing based and integrated farming-based livelihood models, Field visit of innovative farming system models. Visit of agri-based enterprises and their functional aspects for integration of production, processing and distribution sectors and Study of agri-enterprises involved in industry and service sectors (Value Chain Models); Learning about concept of project formulation on farming-based livelihood systems along with cost and profit analysis; Case study of Start-Ups in agri-sectors.

Suggested Readings

1. Dixon J, Gulliver A and Gibbon D. 2001. *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World.* FAO and World Bank, Rome, Italy and Washington, DC, USA

2. Ashley C and Carney D. 1999. *Sustainable Livelihoods: Lessons from Early Experience; Department for International Development: London, UK, Volume 7*. [Google Scholar]

3. Reddy S R. 2016. *Farming System and Sustainable Agriculture*. Kalyani Publishers, New Delhi.

4. Walia S S and Walia U S. 2020. *Farming System and Sustainable Agriculture*. Scientific Publishers, Jodhpur, Rajasthan.
5. Carloni A. 2001. *Global Farming Systems Study: Challenges and Priorities to 2030 – Regional Analysis: Sub-Saharan Africa*. Consultation Document, FAO, Rome, Italy
6. Evenson R E. 2000. *Agricultural Producitivity and Production in Developing Countries*. In FAO, The State of Food and Agriculture, FAO, Rome, Italy
7. Agarwal A and Narain S. 1989. *Towards Green Villages: A strategy for Environmentally, Sound and Participatory Rural Development*. Center for Science and Environment, New Delhi, India

Entrepreneurship Development and Business Management 3 (2+1)

Objectives

i. To provide student an insight into the concept and scope of entrepreneurship.
ii. To expose the student to various aspects of establishment and management of a small business unit.
iii. To enable the student to develop financially viable agribusiness proposal.

Theory

Development of entrepreneurship, motivational factors, social factors, environmental factors, characteristics of entrepreneurs, entrepreneurial attributes/competencies. Concept, need and importance of entrepreneurial development. Evolution of entrepreneurship, objectives of entrepreneurial activities, types of entrepreneurs, functions of entrepreneurs, importance of entrepreneurial development, and process of entrepreneurship development. Environment scanning and opportunity identification need for scanning–spotting of opportunity-scanning of environment– identification of product / service – starting a project; factors influencing sensing the opportunities. Infrastructure and support systems- good policies, schemes for entrepreneurship development; role of financial institutions, and other agencies in entrepreneurship development. Steps involved in functioning of an enterprise. Selection of the product / services, selection of form of ownership; registration, selection of site, capital sources, acquisition of manufacturing know how, packaging and distribution. Planning of an enterprise, project identification, selection, and formulation of project; project report preparation; Enterprise management. Production management – product, levels of products, product mix, quality control, cost of production, production controls, material management. Production management–raw material costing, inventory control. Personal management–manpower planning, labour turn over, wages / salaries. Financial management /accounting–funds, fixed capital and working capital, costing and pricing, long term planning and short-term planning, book keeping, journal, ledger, subsidiary books, annual financial statement, taxation. Marketing management- market, types, marketing assistance, market strategies. Crisis management- raw material, production, leadership, market, finance, natural etc.

Practical

Visit to small scale industries/agro-industries, interaction with successful entrepreneurs/ agric-entrepreneurs. Visit to financial institutions and support agencies. Preparation of project proposal for funding by different agencies.

Suggested Readings

1. Charantimath, P M. 2009. *Entrepreneurship Development and Small Business Enterprises.* Pearson Publications, New Delhi.
2. Desai V. 2015. *Entrepreneurship: Development and Management*. Himalaya Publishing House.
3. Desai Vasant. 1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publ. House
4. Grover Indu. 2008. *Handbook on Empowerment and Entrepreneurship*. Agrotech Publishing Academy.
5. Gupta C B. 2001. *Management Theory and Practice.* Sultan Chand & Sons.
6. Khanka S S. 1999. *Entrepreneurial Development*. S. Chand & Co.
7. Mehra P. 2016. *Business Communication for Managers*. Pearson India, New Delhi.
8. Pandey M and Tewari D. 2010. *The Agribusiness Book*. IBDC Publishers, Lucknow.
9. Singh D. 1995. *Effective Managerial Leadership.* Deep & Deep Publ.
10. Singhal R K. 2013. *Entrepreneurship Development & Management*. Katson Books.
11. Tripathi P C and Reddy P N. 1991. *Principles of Management*. Tata McGraw Hill.

Agriculture Marketing and Trade 3 (2+1)

Objectives

i. To understand the fundamentals of agricultural marketing and trade
ii. To analyze the factors influencing supply and demand in agricultural markets
iii. To explore different marketing channels and strategies in agriculture
iv. To examine the role of government policies and regulations in agricultural markets

Theory

Agricultural Marketing: Concepts and definitions of market, marketing, agricultural marketing, market structure, marketing mix and market segmentation, classification and characteristics of agricultural markets; demand, supply and producer's surplus of agri commodities: nature and determinants of demand and supply of farm products, producer's surplus – meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; pricing and promotion strategies: pricing considerations and approaches – cost based and competition based pricing; market promotion – advertising, personal selling, sales promotion and publicity–meaning, merits and demerits; marketing process and functions: Marketing process concentration, dispersion and equalization; exchange functions – buying and selling; physical functions – storage, transport and processing; facilitating functions – packaging, branding, grading, quality control and labelling (Agmark); Market functionaries and marketing channels: Types and importance of agencies involved in agricultural marketing; meaning and definition of marketing channel; number of channel levels; marketing channels for different farm products; Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs; Role of Govt. in agricultural marketing: Public sector institutions-CWC, SWC, FCI, CACP and DMI – their

objectives and functions; cooperative marketing in India; Risk in marketing: Types of risk in marketing; speculation and hedging; an overview of futures trading; Agricultural prices and policy: Meaning and functions of price; administered prices; need for innovations in agricultural price policy; Trade: Concept of International Trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; WTO; Agreement on Agriculture (AoA), and its implications on Indian agriculture; IPR. Role of government in agricultural marketing. Role of APMC and its relevance in the present day context.

Practical

Plotting and study of demand and supply curves and calculation of elasticities; Study of relationship between market arrivals and prices of some selected commodities; Computation of marketable and marketed surplus of important commodities; Study of price behaviour over time for some selected commodities; Construction of index numbers; Visit to a local market to study various marketing functions performed by different agencies, identification of marketing channels for selected commodity, collection of data regarding marketing costs, margins and price spread and presentation of report in the class; Visit to market institutions – NAFED, SWC, CWC, cooperative marketing society, etc. to study their organization and functioning. Application of principles of comparative advantage of international trade.

Suggested Readings

1. Acharya S S and Agarwal N L. 2006. *Agricultural Marketing in India*. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.
2. Chinna S S. 2005. *Agricultural Economics and Indian Agriculture*. Kalyani Pub, N Delhi.
3. Dominic Salvatore. 2017. *Micro Economic Theory (3rd Edn)*. McGrow Hill Education India.
4. Kohls Richard L and Uhl Josheph N. 2002. *Marketing of Agricultural Products*. Prentice-Hall of India Private Ltd., New Delhi.
5. Kotler and Armstrong. 2005. *Principles of Marketing*. Pearson Prentice-Hall.
6. Lekhi R K and Singh Joginder. 2006. *Agricultural Economics*. Kalyani Publishers, Delhi.
7. Memoria C B, Joshi R L and Mulla N I. 2003. *Principles and Practice of Marketing in India*. Kitab Mahal, New Delhi.
8. Pandey Mukesh and Tewari Deepali. 2004. *Rural and Agricultural Marketing*. International Book Distributing Co. Ltd, New Delhi.
9. Sharma R. 2005. *Export Management*. Laxmi Narain Agarwal, Agra.

Agricultural Informatics and Artificial Intelligence 3 (2+1)

Objectives

i. To acquaint students with the basics of computer applications in agriculture, multimedia, database management, application of mobile app and decision- making processes, etc.
ii. To provide basic knowledge of computer with applications in agriculture
iii. To make the students familiar with agricultural-informatics, its components and applications in agriculture and Artificial intelligence

Theory

Introduction to Computers, Anatomy of Computers, Memory Concepts, Units of Memory, Operating System: Definition and types, Applications of MS-Office for creating, Editing and Formatting a document, Data presentation, Tabulation and graph creation, Statistical analysis, Mathematical expressions, Database, concepts and types, creating database, Uses of DBMS in Agriculture, Internet and World Wide Web (WWW): Concepts and components.

Computer programming: General concepts, Introduction to Visual Basic, Java, Fortran, C/ C++, etc. concepts and standard input/output operations.

e-Agriculture, Concepts, design and development, Application of innovative ways to use information and communication technologies (IT) in Agriculture, Computer Models in Agriculture: Statistical, weather analysis and crop simulation models, concepts, structure, inputs-outputs files, limitation, advantages and application of models for understanding plant processes, sensitivity, verification, calibration and validation, IT applications for computation of water and nutrient requirement of crops, Computer-controlled devices (automated systems) for Agri-input management, Smartphone mobile apps in agriculture for farm advice: Market price, postharvest management etc., Geospatial technology: Concepts, techniques, components and uses for generating valuable agri-information, Decision support systems: Concepts, components and applications in Agriculture, Agriculture Expert System, Soil Information Systems etc. for supporting farm decisions. Preparation of contingent crop planning and crop calendars using IT tools, Digital India and schemes to promote digitalization of agriculture in India.

Introduction to artificial intelligence, background and applications, Turing test. Control strategies, Breadth-first search, Depth-first search, Heuristics search techniques: Best-first search, A* algorithm, IoT and Big Data; Use of AI in agriculture for autonomous crop management, and health, monitoring livestock health, intelligent pesticide application, yield mapping and predictive analysis, automatic weeding and harvesting, sorting of produce, and other food processing applications; Concepts of smart agriculture, use of AI in food and nutrition science etc.

Practical

Study of computer components, accessories, practice of important DOS Commands, Introduction of different operating systems such as Windows, Unix/Linux, creating files and folders, File Management. Use of MS-WORD and MS Power-point for creating, editing and presenting a scientific documents, MS- EXCEL-Creating a spreadsheet, Use of statistical tools, Writing expressions, Creating graphs, Analysis of scientific data, Handling macros. MS-ACCESS: Creating Database, preparing queries and reports, Demonstration of Agri-information system, Introduction to World Wide Web (WWW) and its components, Introduction of programming languages such as Visual Basic, Java, Fortran, C, C++, Hands on practice on Crop Simulation Models (CSM), DSSAT/Crop-Info/Crop Syst/ Wofost, Preparation of inputs file for CSM and study of model outputs, computation of water and nutrient requirements of crop using CSM and IT tools, Use of smart phones and other devices in agro-advisory and dissemination of market information, Introduction of Geospatial Technology, Hands on practice on preparation of Decision Support System, Preparation of contingent crop planning, India Digital Ecosystem of Agriculture (IDEA).

Suggested Readings

1. Rajaroman V. 2022. *Fundamentals of Computer*.PH(I)
2. Pearson. 2005. *Introduction to Information Technology*. I. T. L. Education Solutions Limited.
3. C J Date. 2000. *Introduction to Database Management System*. Addison-Wesley.
4. Dhabal Prasad Sethi and Manoranjan. 2017. *Concepts and Techniques of Programming in C*. Techsar Pvt. Ltd.
5. Russell Stuart. 2013. *Artificial Intelligence: A Modern Approach*. Pearson Edition.
6. Nilson N J. 2001. *Principles of Artificial Intelligence*. Narosa.

Environmental studies and disaster management 3 (2+1)

Objective

To expose and acquire knowledge on the environment and to gain the state-of-the-art-skill and expertise on management of disasters.

Theory

Introduction to Environment - Environmental studies - Definition, scope and importance - Multidisciplinary nature of environmental studies - Segments of Environment - Spheres of Earth - Lithosphere - Hydrosphere - Atmosphere - Different layers of atmosphere. Natural Resources: Classification - Forest resources. Water resources. Mineral resources. Introduction to Environment - Environmental studies-Definition, scope and importance -Multidisciplinary nature of environmental studies - Segments of Environment - Spheres of Earth - Lithosphere - Hydrosphere - Atmosphere - Different layers of atmosphere. Natural Resources: Classification - Forest resources. Water resources. Mineral resources Food resources. Energy resources. Land resources. Soil resources. Ecosystems - Concept of an ecosystem - Structure and function of an ecosystem - Energy flow in the ecosystem. Types of ecosystem. Biodiversity and its conservation: Introduction, definition, types. Biogeographical classification of India. Importance and Value of biodiversity. Biodiversity hot spots. Threats and Conservation of biodiversity Environmental Pollution: Definition, cause, effects and control measures of: a. Air pollution. b. Water pollution. c. Soil pollution. d. Marine pollution. e. Noise pollution. f. Thermal pollution. h. light pollution. Solid Waste Management: Classification of solid wastes and management methods, Composting, Incineration, Pyrolysis, Biogas production, Causes, effects and control measures of urban and industrial wastes. Social issues and the Environment: Urban problems related to energy. Water conservation, rain water harvesting, watershed management. Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act. Wildlife Protection Act.

Forest Conservation Act. Human Population and the Environment: Environment and human health: Human Rights, Value Education. Women and Child Welfare. Role of Information Technology in Environment and human health.

Disaster management - Disaster definition - Types - Natural Disasters - Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves. Man Made Disasters - Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest

fire, oil fire, road accidents, rail accidents, air accidents, sea accidents. International and National strategy for disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, community-based organizations and media in disaster management. Central, state, district and local administration in disaster control; Armed forces in disaster response; Police and other organizations in disaster management.

Practical

Visit to a local area to document environmental assets river/forest/grassland/hill/mountain. Energy: Biogas production from organic wastes. Visit to wind mill/hydro power/solar power generation units. Biodiversity assessment in farming system. Floral and faunal diversity assessment in polluted and unpolluted system. Visit to local polluted site - Urban/Rural/ Industrial/Agricultural to study of common plants, insects and birds. Environmental sampling and preservation. Water quality analysis: pH, EC and TDS. Estimation of Acidity, Alkalinity. Estimation of water hardness. Estimation of DO and BOD in water samples. Estimation of COD in water samples. Enumeration of *E. coli* in water sample. Assessment of Suspended Particulate Matter (SPM). Study of simple ecosystem – Visit to pond/river/hills. Visit to areas affected by natural disaster.

Suggested Readings

1. De A K. 2010. *Environmental chemistry. Published* by New Age International Publishers, New Delhi.
2. Dhar Chakrabarti P G. 2011. *Disaster management - India's risk management policy frameworks and key challenges*. Published by Centre for Social Markets (India), Bangalore.
3. Erach Bharucha. *Text book for Environmental studies*. University Grants Commission, New Delhi
4. Parthiban K T, Vennila S, Prasanthrajan M Umesh and Kanna, S. 2023. *Forest, Environment, Biodiversity and Sustainable development.* Narendra Publishing House, New Delhi
5. Prasanthrajan M and Mahendran P P. 2008. *A text book on Ecology and Environmental Science.* ISBN 81-8321-104-6. Agrotech Publishing Academy, Udaipur
6. Sharma P D. 2009. *Ecology and Environment*. Rastogi Publications, Meerat, India
7. Tyler Miller and Scot Spoolman. 2009. *Living in the Environment* (Concepts, Connections, and Solutions). Brooks/cole, Cengage learning publication, Belmont, US

Communication Skills **2 (1+1)**

Objective

To acquire competence in oral, written and non-verbal communication, develop strong personal and professional communication and demonstrate positive group communication.

Theory

Communication Process: The magic of effective communication; Building self-esteem and overcoming fears; Concept, nature and significance of communication process; Meaning, types and models of communication; Verbal and non-verbal communication; Linguistic and non-linguistic barriers to communication and reasons behind communication gap/ miscommunication.

Basic Communication Skills: Listening, Speaking, Reading and Writing Skills; Precis writing/ Abstracting/ Summarizing; Style of technical communication Curriculum vitae/resume writing; Innovative methods to enhance vocabulary, analogy questions.

Structural and Functional Grammar: Sentence structure, modifiers, connecting words and verbals; phrases and clauses; Case: subjective case, possessive case; objective case; Correct usage of nouns, pronouns and antecedents, adjectives, adverbs and articles; Agreement of verb with the subject: tense, mood, voice; Writing effective sentences; Basic sentence faults.

Practical

Listening and note taking; Writing skills: precis writing, summarizing and abstracting; Reading and comprehension (written and oral) of general and technical articles; Micro-presentations and Impromptu Presentations: Feedback on presentations; Stage manners: grooming, body language, voice modulation, speed; Group discussions; Public speaking exercises; vocabulary building exercises; Interview Techniques; organization of events.

Suggested Readings

1. Allport G W. 1937. *Personality: A Psychological Interpretation*. Holt, New York.
2. Brown Michele and Gyles Brandreth. 1994. *How to Interview and be Interviewed*. Sheldon Press. London.
3. Carnegie Dale. 1997. *The Quick and Easy Way to Effective Speaking*. Pocket Books, New York.
4. Francis Peter S J 2012. *Soft Skills and Professional Communication*. Tata McGraw Hill, New Delhi.
5. Kumar S and Pushpa Lata. 2011. *Communication Skills*. Oxford University Press.
6. Neuliep James W. 2003. *Intercultural Communication A Contextual Approach*. Houghton Mifflin Co Boston.
7. Pease Allan. 1998. *Body Language*. Sudha Publications, Delhi.
8. Raman M and Singh P. 2000. *Business Communication*. Oxford University Press.
9. Seely J. 2013. *Oxford Guide to Effective Writing and Speaking*. Oxford University Press.
10. Thomson A J and Martinet A V. 1977. *A Practical English Grammar*. Oxford University

Personality Development 2 (1+1)

Objective

To make students realize their potential strengths, cultivate their inter-personal skills and improve employability.

Theory

Personality Definition, Nature of personality, theories of personality and its types. The humanistic approach - Maslow's self-actualization theory, shaping of personality, determinants of personality, Myers-Briggs Typology Indicator, Locus of control and performance, Type A and Type B Behaviours, personality and Organizational Behaviour.

Foundations of individual behavior and factors influencing individual behavior, Models of individual behavior, Perception and attributes and factors affecting perception, Attribution theory and case studies on Perception and Attribution. Learning: Meaning and definition, theories and principles of learning, Learning and organizational behavior, Learning and training, learning feedback. Attitude and values, Intelligence- types of Intelligence, theories of intelligence, measurements of intelligence, factors influencing intelligence, intelligence and Organizational behavior, emotional intelligence. Motivation- theories and principles, Teamwork and group dynamics.

Practical

MBTI personality analysis, Learning Styles and Strategies, Motivational needs, Firo-B, Interpersonal Communication, Teamwork and team building, Group Dynamics, Win-win game, Conflict Management, Leadership styles, Case studies on Personality and Organizational Behavior.

Suggested Readings

1) Andrews Sudhir. 1988. *How to Succeed at Interviews. (21st Reprint)*. Tata McGraw-Hill, New Delhi.
2) Heller Robert. 2002. *Effective Leadership*. Essential Manager series. DK Publishing.
3) Hindle Tim. 2003. *Reducing Stress. Essential Manager Series*. DK Publishing.
4) Kumar Pravesh. 2005. *All about Self- Motivation*. Goodwill Publishing House, New Delhi.
5) Lucas, Stephen. 2001. *Art of Public Speaking*. Tata - Mc-Graw Hill, New Delhi.
6) Mile D J. 2004. *Power of Positive Thinking*. Rohan Book Company, Delhi.
7) Smith B. 2004. *Body Language*. Rohan Book Company, Delhi.
8) Shaffer D R. 2009. *Social and Personality Development (6th Edn)*. Belmont, CA: Wadsworr

Physical Education, First Aid, Yoga Practice and Meditation 2 (0+2)

Objectives

i. To make the students aware about Physical Education, First Aid and Yoga Practices
ii. To disseminate the knowledge and skill how to perform physical training, perform first aid and increase stamina and general well being through yoga.

Practical

Physical education; Training and Coaching - Meaning and Concept; Methods of Training; aerobic and aerobic exercises; Calisthenics, weight training, circuit training, interval training, Fartlek training; Effects of Exercise on Muscular, Respiratory, Circulatory and Digestive systems; Balanced Diet and Nutrition: Effects of Diet on Performance; Physiological changes due to ageing and role of regular exercise on ageing process; Personality, its dimensions and types; Role of sports in personality development; Motivation and Achievements in Sports; Learning and Theories of learning; Adolescent Problems and its Management; Posture; Postural Deformities; Exercises for good posture.

Yoga; History of Yoga, Types of Yoga, Introduction to Yoga:

- Asanas: Definition and Importance, Padmasan, Gaumukhasan, Bhadrasan, Vajrajasan, Shashankasan, Pashchimotasan, Ushtrasan, Tadasan, Padhastasan, Ardhchandrasan, Bhujangasan, Utanpadasan, Sarvangasan, Parvatasan, Patangasan, Shishupalanasan– left leg-right leg, Pavanmuktasan, Halasan, Sarpasan, Ardhdhanurasan, Sawasan
- Suryanamskar Pranayama (Definition and Importance) Omkar, Suryabhedan, Chandrabhedan, AnulomVilom, Shitali, Shitkari, Bhastrika, Bhramari
- Meditation (Definition and Importance), Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandh
- Mudras (Definition and Importance) Gyanmudra, Dhyanmudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra
- Role of yoga in sports
- Teaching of Asanas – demonstration, practice, correction and practice.

History of sports and ancient games, Governance of sports in India; Important national sporting events; Awards in Sports; History, latest rules, measurements of playfield, specifications of equipment, skill, technique, style and coaching of major games (Cricket, football, table Tennis, Badminton, Volleyball, Basketball, Kabaddi and Kho-Kho) and Athletics

Need and requirement of first aid. First Aid equipment and upkeep. First AID Techniques, First aid related with respiratory system. First aid related with Heart, Blood and Circulation. First aid related with Wounds and Injuries. First aid related with Bones, Joints Muscle related injuries. First aid related with Nervous system and Unconsciousness. First aid related with Gastrointestinal Tract. First aid related with Skin, Burns. First aid related with Poisoning. First aid related with Bites and Stings. First aid related with Sense organs, Handling and transport of injured traumatized persons. Sports injuries and their treatments.

NCC-I **1 (0+1)**

Objectives

i. To develop qualities of character, courage, comradeship, discipline, leadership, secular outlook, spirit of adventure and sportsmanship and the ideals of selfless service among the youth to make them useful citizen.

ii. To create a human resource of organized trained and motivated youth to provide leadership in all walks of life including the Armed Forces and be always available for the service of the nation.

Practical/ Awareness activities

- Aims, objectives, organization of NCC and NCC song. DG's cardinals of discipline.
- Drill- aim, general words of command, attention, stands at ease, stand easy and turning.
- Sizing, numbering, forming in three ranks, open and close order march, and dressing.
- Saluting at the halt, getting on parade, dismissing, and falling out.

- Marching, length of pace, and time of marching in quick/slow time and halt. Side pace, pace forward and to the rear. Turning on the march and wheeling. Saluting on the march.
- Marking time, forward march, and halt. Changing step, formation of squad and squad drill.
- Command and control, organization, badges of rank, honors, and awards
- Nation Building- cultural heritage, religions, traditions, and customs of India. National integration. Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizens. Leadership traits, types of leadership. Character/ personality development. Civil defense organization, types of emergencies, firefighting, protection. Maintenance of essential services, disaster management, aid during development projects.
- Basics of social service, weaker sections of society and their needs, NGO's and their contribution, contribution of youth towards social welfare and family planning.
- Structure and function of human body, diet and exercise, hygiene and sanitation. Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health. Adventure activities. Basic principles of ecology, environmental conservation, pollution and its control.

NCC-II **1 (0+1)**

Objectives

i. To develop qualities of character, courage, comradeship, discipline, leadership, secular outlook, spirit of adventure and sportsmanship and the ideals of selfless service among the youth to make them useful citizen.

ii. To create a human resource of organized trained and motivated youth to provide leadership in all walks of life including the Armed Forces and be always available for the service of the nation.

Practical/ Awareness activities

- Arms Drill- Attention, stand at ease, stand easy. Getting on parade. Dismissing and falling out. Ground/take up arms, examine arms. Shoulder from the order and vice-versa, present from the order and vice-versa. Saluting at the shoulder at the halt and on the march. Short/long trail from the order and vice- versa. Guard mounting, guard of honor, Platoon/Coy Drill.
- Characteristics of rifle (.22/.303/SLR), ammunition, fire power, stripping, assembling, care, cleaning, and sight setting. Loading, cocking, and unloading. The lying position and holding.
- Trigger control and firing a shot. Range Procedure and safety precautions. Aiming and alteration of sight. Theory of groups and snap shooting. Firing at moving targets. Miniature range firing. Characteristics of Carbine and LMG.
- Introduction to map, scales, and conventional signs. Topographical forms and technical terms.
- The grid system. Relief, contours, and gradients. Cardinal points and finding north. Types of bearings and use of service protractor. Prismatic compass and its use. Setting a map, finding north and own position. Map to ground and ground to map. Knots and lashings, Camouflage and concealment, Explosives and IEDs.
- Field defenses obstacles, mines and mine lying. Bridging, waterman ship. Field water

supplies, tracks and their construction. Judging distance. Description of ground and indication of landmarks. Recognition and description of target. Observation and concealment. Field signals. Section formations. Fire control orders. Fire and movement. Movement with/without arms. Section battle drill. Types of communication, media, latest trends and developments.

NSS- I **1 (0+1)**

Objective

Evoking social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skilful in executing democratic leadership, developing skill in programme, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

Practical/ Awareness activities

- Orientation: history, objectives, principles, symbol, badge; regular programs under NSS
- Organizational structure of NSS, Code of conduct for NSS volunteers, points to be considered by NSS volunteers' awareness about health.
- NSS programme activities. Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analyzing guiding financial patterns of scheme, youth programs/ schemes of GoI, coordination with different agencies and maintenance of diary. Understanding youth. Definition, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change.
- Community mobilization. Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership. Social harmony and national integration
- Indian history and culture, role of youth in nation building, conflict resolution and peace-building. Volunteerism and *shramdaan.* Indian tradition of volunteerism, its need, importance, motivation, and constraints; shaman as part of volunteerism
- Citizenship, constitution, and human rights. Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to information. Family and society. Concept of family, community (PRIs and other community-based organizations) and society

NSS-II **1 (0+1)**

Objective

To evoke social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skilled in executing democratic leadership, developing skill in program, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

Practical/ Awareness activities

- Importance and role of youth leadership
- Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership, Life competencies
- Definition and importance of life competencies, problem-solving and decision-making, interpersonal communication. Youth development programs
- Development of youth programs and policy at the national level, state level and voluntary sector; youth-focused and youth-led organizations
- Health, hygiene and sanitation. Definition needs and scope of health education; role of food, nutrition, safe drinking water, water borne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programs and reproductive health. Youth health, lifestyle, HIV AIDS and first aid. Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid. Youth and yoga. History, philosophy, concept, myths, and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method.

6. UGC Skill Courses

UGC recommended list of skill development training areas

In addition to skill development training courses identified by respective universities from respective disciplines of study, such as agriculture, agribusiness, horticulture, forestry, etc. Skill development courses may also be selected by universities from the following list of skill trainings advised in the UGC notification. "Guidelines for the Introduction of Short -Term Skill Development Courses in Higher Educational Institutions". The university/ college may select any number of short-term skill development courses from the broad areas as mentioned below, in which they will have built institutional capacity for training or joined partnership with specialized institution capable of imparting such training program. The courses may be planned as integrated part of the UG-Certificate and UG-Diploma Programmes (after suitable planning of the contents) or they may be offered in stand-alone mode leading to award of certificates on the skill areas.

i. Artificial Intelligence, and machine learning
ii. Artificial Intelligence, and Robotics
iii. IoT (Internet of Things)/ Industrial IoT/Smart Cities
iv. Data Science and Analytics
v. Cloud Computing
vi. Virtual Reality, Augmented Reality and Extended Reality
vii. Cyber Security and Digital Forensics
viii. 5G Connectivity
ix. Digital Fluency/ Digital transformation
x. Industrial Automation and Robotics Process Automation (RPA)
xi. Electronic System Designs/ VLSI Designs
xii. Electronic Manufacturing
xiii. Basic Coding in Computing Languages
xiv. Computer-Aided Design (CAD)/Computer-Aided Manufacturing (CAM)
xv. Mechanical Tooling and Processes/ Mechatronics
xvi. Architectural Drafting, Basic 3D Design
xvii. Building Information Modelling (BIM)
xviii. 3D Printing
xix. Electrician/Electrical and Electronics
xx. Mobile Communication, Mobile Repairing and Basics of DTH Installation

xxi. Digital Marketing - courses in Search Engine Optimization (SEO), social media marketing, content marketing, and e-commerce management

xxii. Health and Wellness - courses focusing on mental health counselling, nutrition and dietetics, and fitness training in response to the growing awareness of personal well-being and holistic health and wellness

xxiii. Financial Technology (FinTech) - courses in digital payments, blockchain technology, digital currencies, and financial regulations

xxiv. Fashion Technology, Fashion design, stitching, etc. (home science colleges)

xxv. Yogic Sciences

xxvi. Soft skills and courses in effective communication, critical thinking and problem-solving, creative thinking and innovation, novel and adaptive thinking, design thinking and mindset, computational thinking, virtual collaboration, cross-cultural competency, new media literacy, team building, etc.

xxvii. Basics of start-ups and Entrepreneurship – leadership, project planning, management, Event Management, marketing, financing, and agri-business entrepreneurship, etc.

The university / college may also offer short-term courses in any other areas identified by it, based on the skill gap studies as well as institutional expertise, e.g. agriculture, horticulture, home science etc. The skill courses run by various Sector Skill Councils can also be adopted.

Syllabi of Different Disciplines

AGRICULTURE

Course Curricula for Undergraduate programme in Agriculture: UG-Certificate in Agriculture; UG-Diploma in Agriculture; B.Sc. (Hons.) Agriculture

INTRODUCTION

Present report is an outcome of the valuable suggestions and recommendations of Sixth Deans' Committee members after having multi-stage in-depth deliberations and discussions in virtual and physical meetings as well as personal communications with the Deans and faculty members of the Agriculture discipline of different SAUs and Central Agricultural Universities, stakeholders from related industries, Government Institutions, alumni and students of the existing course programme across the country.

Restructuring of Undergraduate programme of Agriculture has been carried out as per National Education Policy-2020 guidelines to build among students, a strong foundation of knowledge and increased practical exposure to instil competence and confidence for application of the professional knowledge coupled with hard and soft skills. New scientific advancements in the field of agriculture have been also given due emphasis with inclusion of courses with contents from such areas.

More emphasis has been given on Skill Enhancement Courses, industry attachments, flexibility in choice of courses via electives offered in fourth year and also through online courses along with provision of project work and internship. Provision of UG-Certificate in Agriculture; UG-Diploma in Agriculture and B.Sc. (Hons.) Agriculture degree along with amalgamation of multiple exit and entry options as per NEP-2020 provisions are important changes in the course curriculum.

The detailed report on undergraduate courses of Agriculture viz. UG-certificate in Agriculture; UG-diploma in Agriculture and B.Sc. (Hons.) Agriculture has been prepared with due care and incorporating inputs received from Deans, Heads and faculty members of various departments of agriculture at nationwide level.

HIGHLIGHTS

- The B. Sc. (Hons.) Agriculture programme will be of 177 credits, which will have 167 credits offered by the parent university and 10 credits of online courses taken by the student as per choice in consultation with university/HAEIs.
- After the admission in the college, the students will register for the Foundation programme of 2 weeks' duration in the 1st semester. A course entitled Deeksharambh (0+2) (Non-gradial) will be offered at the start of first semester for two weeks' duration. This will create a platform for students to learn from each other's life experiences, help for cultural integration of students from different backgrounds, know about the operational framework of academic process in university, instilling life and social skills, social awareness, ethics and values, team work, leadership, creativity, etc. It will also help in identifying the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario. There will be sessions by alumni, business leaders, outstanding achievers in related fields, people with inspiring life experiences as well as the university academic and research managers.
- The first year of the course program comprises skill development courses along with other fundamental courses of agricultural science. After satisfactory completion of 42 credits of courses in two semesters of 1st year and subsequent satisfactory completion of 10 credits (10 weeks) of internship, the student will become eligible for the award of UG-Certificate in Agriculture on exit. The students continuing the study further, would not have to attend the internship after 1st year.
- The second year has been designed with the skill development courses, basic courses as well as fundamental courses in agriculture with adequate theory and practical components, enabling the student to get acquainted with the basic principles and applications of agricultural sciences. After satisfactory completion of the courses (84 credits) during first two years and subsequent satisfactory completion of 10 credits (10 weeks) of internship, the student will become eligible for the award of UG-Diploma in Agriculture on exit. The students continuing the study further, would not have to attend the internship after 2nd year.
- During the 5th semester, the students will have a study tour of 10-14 days duration, which will be Non-gradial.
- The third- and fourth- year courses have been designed to impart specialized knowledge to the students in the major disciplines. During the 7th semester, the students will adequately select minimum 20 credits from a basket of elective courses giving an opportunity to them to gain advanced knowledge in frontier areas of agricultural science. The Universities/ HAEIs will have flexibility to include more courses as Electives depending on specific needs and situational variations. The objective is to enable the student to acquire deeper understanding in any particular field.

- In the 8th semester of the course, the major focus has been on strengthening of the knowledge and skill for developing confidence of the students to take entrepreneurship as their future career. For this they will undergo an advanced skill enhancement through Student READY: RAWE/ Industrial Attachment /Experiential Learning / Hands-on Training/ Project Work / Internship. Each student will be attached to a mentor either from the institution or from an organization/ industry. A university or a college will have the freedom to select the options as referred above.
- The students will take a minimum of 10 credits of online courses during four years as a partial requirement for the B.Sc. (Hons.) Agriculture program. The indicative list of courses has been provided; however, online courses can be from any field such as Agriculture and allied sciences, Basic Sciences, Humanities, Psychology, Anthropology, Economics, Business Management, Languages including foreign language, Communication skills/ Music, etc. and can be taken from NPTEL, Mook IT, edX, Coursera, SWAYAM or any other such reputed portal. The objective is to allow the students to groom their passion or strengthen their knowledge and competency in any field beyond prescribed courses. These online courses will be non-gradial and separate certificates would be issued by institute/organization offering the courses. However, the university/ institute will keep a record of such courses registered and completed by each student and indicate the title of the (successfully completed) courses in final transcript issued to the student.
- At each stage of exit (UG-certificate/ UG-Diploma and B.Sc. (Hons.) Agriculture, the students are expected to acquire competency and confidence to get jobs, to face the real challenges in varied jobs and research, as well as to start their own enterprise. The social skills acquired by the students will also make the students more empathetic towards the society and social issues.
- The credits (and contact hours) have been designed in such a way that along with class room teaching, the students will take up NSS/ NCC and Physical Education, Yoga, Meditation etc. in the first year as the case may be. Further, a balance has been made by inclusion of common courses, core courses in basic and applied areas, skill development courses, elective courses in advanced areas, online courses of choice, options for entrepreneurship and skill development to pursue future career. This will increase their acquaintance with the social/ technical problems, improve their analytical ability of the issues/ challenges and enhance their social responsibility.

Entry and Exit Options

The entry and exit options for the B.Sc. (Hons.) in Agriculture are shown in the Figure-1 below.

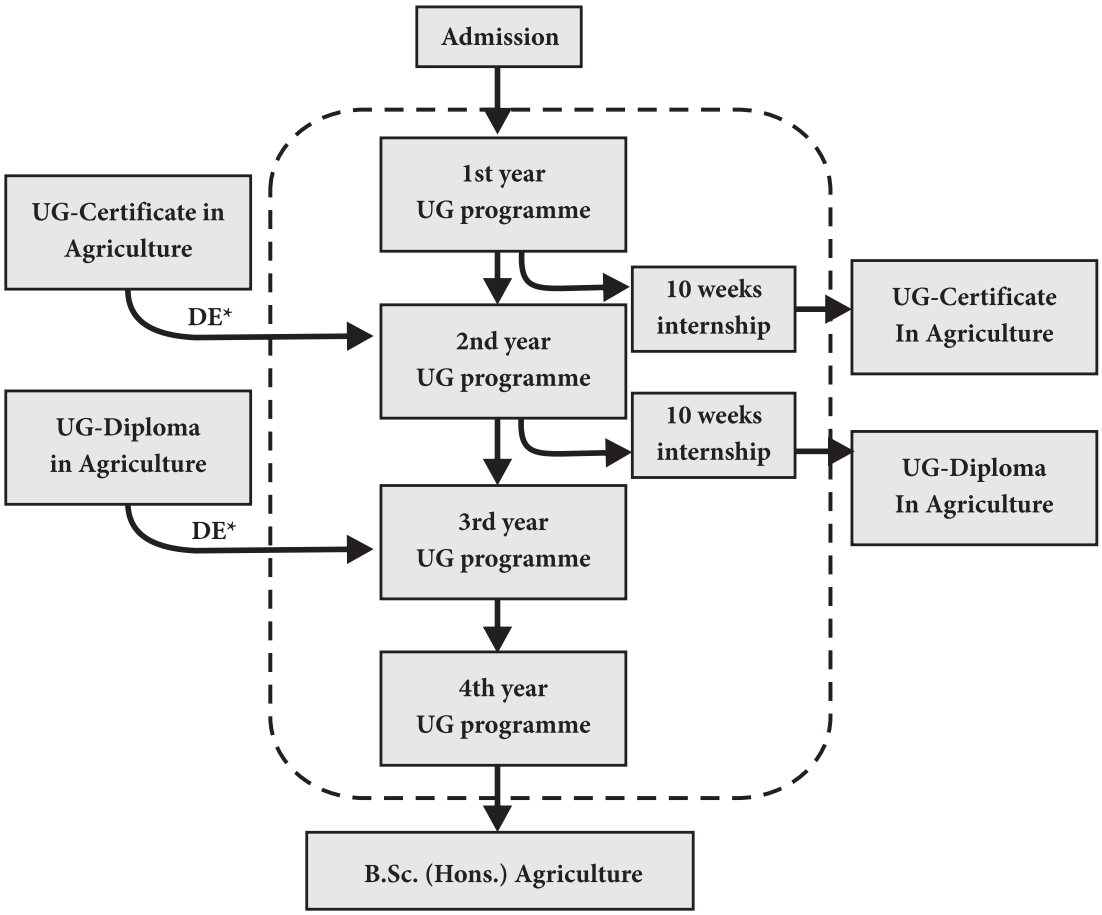


Fig. 1 Entry and Exit options for the UG programme in Agriculture
DE* Direct Entry in the respective year

Exit options

1. **UG-Certificate in Agriculture** (exit after first year and completion of 10 weeks' internship)
2. **UG-Diploma in Agriculture** (exit after second year and completion of 10 weeks' internship)
3. **B.Sc. (Hons.) Agriculture** (on successful completion of four-year degree requirements)

Admission Eligibility for Entry into 1st year UG programme: 10+2 Science from Central/ State Board/University as per ICAR/SAU/HAEI with biology as one subject as per ICAR norms.

Provision for multiple exit and entry into the UG programme in agriculture has been made in the light of NEP-2020. A student may exit after completion of 1st year and 2nd year requirements followed by 10 weeks of internship after 1st year and 2nd year, to get UG-Certificate in Agriculture and UG-Diploma in Agriculture, respectively.

The Universities may consider allowing lateral entry for the candidates having Diploma in Agriculture (as such courses are available in many states and lateral entry is practiced in some Universities). In such cases, the candidates having Diploma in Agriculture (with minimum 3 years course programme after 10th or equivalent) may be allowed admission into the 2nd year of the UG programme, as per the provisions and norms to be notified by the respective AU from time to time.

ACADEMIC PROGRAMME

Semester Wise Course and Credits Allocation

S. No	Course Title	Credit Hours	Total Credit Hours
First year			
I Semester			
1	*Deeksharambh* (Induction-cum-Foundation Course)	(0+2) Non-gradial	**21 (11+10)**
2	Skill Enhancement Course-I*	2 (0+2)	
3	Skill Enhancement Course-II*	2 (0+2)	
4	Communication Skills	2 (1+1)	
5	Farming based Livelihood Systems	3 (2+1)	
6	Rural Sociology and Educational Psychology	2 (2+0)	
7	Fundamentals of Agronomy	3 (2+1)	
8	Fundamentals of Soil Science	3 (2+1)	
9	Fundamentals of Horticulture	3 (2+1)	
10	National Service Scheme (NSS-I)/ National Cadet Corps (NCC-I)	1 (0+1)	
11	Introductory Mathematics (need based)	1 (1+0) Non-gradial	
II Semester			
1	Skill Enhancement Course-III*	2 (0+2)	**21 (10+11)**
2	Skill Enhancement Course-IV*	2 (0+2)	
3	Personality Development	2 (1+1)	
4	Environmental Studies and Disaster Management	3 (2+1)	
5	Soil Fertility Management	3 (2+1)	
6	Fundamentals of Entomology	3 (2+1)	
7	Livestock and Poultry Management	2 (1+1)	
8	Fundamentals of Plant Pathology	3 (2+1)	
9	NCC-II/NSS-II	1 (0+1)	
Post-Semester II (Only for exit option for award of UG-Certificate in Agriculture)			
1	Internship (10 weeks)	10 (0+10)	
Second year			
III Semester			
1	Skill Enhancement Course-V*	2 (0+2)	**21 (9+12)**
2	Entrepreneurship Development and Business Communication	3 (2+1)	
3	Physical Education, First Aid, Yoga Practices and Meditation	2 (0+2)	
4	Principles of Genetics	3 (2+1)	
5	Crop Production Technology-I (*Kharif* Crops)	3 (1+2)	
6	Production Technology of Fruit and Plantation Crops	2 (1+1)	
7	Fundamentals of Extension Education	2 (1+1)	
8	Fundamentals of Nematology	2 (1+1)	
9	Principles and Practices of Natural Farming	2 (1+1)	

IV Semester			
1	Skill Enhancement Course-VI*	2 (0+2)	**21 (11+10)**
2	Agricultural Informatics and Artificial Intelligence	3 (2+1)	
3	Production Technology of Vegetables and Spices	2 (1+1)	
4	Principles of Agricultural Economics and Farm Management	2 (2+0)	
5	Crop Production Technology-II (*Rabi* Crops)	3 (1+2)	
6	Farm Machinery and Power	2 (1+1)	
7	Water Management	2 (1+1)	
8	Problematic Soils and their Management	2 (1+1)	
9	Basics of Plant Breeding	3 (2+1)	
Post-Semester IV* (Only For exit option for UG-Diploma in Agriculture)			
1.	Internship (10 weeks)	10 (0+10)	
Third year			
V Semester			
1	Agriculture Marketing and Trade	3 (2+1)	**22 (13+9)**
2	Introduction to Agro-meteorology	2 (1+1)	
3	Fundamentals of Crop Physiology	3 (2+1)	
4	Pest Management in Crops and Stored Grains	3 (2+1)	
5	Diseases of Field & Horticultural Crops & their Management	3 (2+1)	
6	Crop Improvement (*kharif* Crops) - I	2 (1+1)	
7	Weed Management	2 (1+1)	
8	Ornamental Crops, MAPs and Landscaping	2 (1+1)	
9	Introductory Agroforestry	2 (1+1)	
VI Semester			
1	Fundamentals of Agri Biotechnology	3 (2+1)	**21 (12+9)**
2	Basic and Applied Agricultural Statistics	3 (2+1)	
3	Crop Improvement (*Rabi* Crops) - II	2 (1+1)	
4	Renewable Energy in Agriculture and Allied Sector	2 (1+1)	
5	Dryland Agriculture/Rainfed Agriculture and Watershed Management	2 (1+1)	
6	Agricultural Microbiology and Phyto -remediation	2 (1+1)	
7	Agricultural Finance & Cooperation	2 (1+1)	
8	Essentials of Plant Biochemistry	3 (2+1)	
9	Fundamentals of Seed Science & Technology	2 (1+1)	
Fourth year			
VII Semester			
1	5 Elective Courses (major or minor) each of 4 (3+1) credits for B.Sc. (Hons.) Agriculture degree		**20 (15+5)**
VIII Semester			
1	For B.Sc. (Hons.) Agriculture degree Student READY[RAWE/Industrial Attachment /Experiential Learning/Hands-on Training/Skill Development/Project Work/Internship etc.]		**20 Credits**
		Total	**167**
	****Online Courses**	10	**10**
		Grand Total	**167+10****

* From the basket of Skill Enhancement Course (SEC) modules

Department/section wise course breakup

S. No	Course title	Credit Hours	Total
	Agronomy		
1	Fundamentals of Agronomy	3 (2+1)	**22 (11+11)**
2	Farming based Livelihood Systems	3 (2+1)	
3	Crop Production Technology-I (*Kharif* Crops)	3 (1+2)	
4	Crop Production Technology-II (*Rabi* Crops)	3 (1+2)	
5	Water Management	2 (1+1)	
6	Weed Management	2 (1+1)	
7	Introductory Agro forestry	2 (1+1)	
8	Dryland Agriculture/ Rainfed Agriculture and Watershed Management	2 (1+1)	
9	Principles and Practices of Natural Farming	2(1+1)	
	Soil Science:		
1	Fundamentals of Soil Science	3(2+1)	**8 (5+3)**
2	Soil Fertility Management	3(2+1)	
2	Problematic Soils and their Management	2(1+1)	
	Horticulture		
1.	Fundamentals of Horticulture	3 (2+1)	**9 (5+4)**
2.	Production Technology of Fruit and Plantation Crops	2 (1+1)	
3.	Production Technology of Vegetables and Spices	2 (1+1)	
4.	Ornamental Crops, MAPs and Landscaping	2 (1+1)	
	Genetics and Plant Breeding		
1.	Principles of Genetics	3 (2+1)	**12 (7+5)**
2.	Basics of Plant Breeding	3 (2+1)	
3.	Crop Improvement (*Kharif* Crops) - I	2 (1+1)	
4.	Crop Improvement (*Rabi* Crops)- II	2 (1+1)	
5.	Fundamentals of Seed Science and Technology	2 (1+1)	
	Entomology		
1.	Fundamentals of Entomology	3 (2+1)	**6 (4+2)**
2.	Pest Management in Crops and Stored Grains	3 (2+1)	
	Plant Pathology		
1.	Fundamentals of Plant Pathology	3 (2+1)	**8 (5+3)**
2.	Diseases of Field and Horticultural Crops and their Management	3 (2+1)	
3.	Agricultural Microbiology and Phyto-remediation	2 (1+1)	
	Extension Education		
1.	Rural Sociology and Educational Psychology	2 (2+0)	**8 (5+3)**
2.	Fundamentals of Extension Education	2 (1+1)	
3.	Communication Skills	2 (1+1)	
4.	Personality Development	2 (1+1)	
	Agricultural Meteorology		
1.	Environmental Studies and Disaster Management	3 (2+1)	**5 (3+2)**
2.	Introduction to Agro-meteorology	2 (1+1)	

Agricultural Economics			
1.	Principles of Agricultural Economics and Farm Management	2 (2+0)	**9 (6+3)**
2	Entrepreneurship Development and Business Communication	3 (2+1)	
3	Agricultural Marketing and Trade	2 (1+1)	
4.	Agricultural Finance and Cooperation	2 (1+1)	
Agricultural Statistics			**6 (4+2)**
1.	Agricultural Informatics and Artificial Intelligence	3 (2+1)	
2.	Basic and Applied Agricultural Statistics	3 (2+1)	
3.	Introductory Mathematics	1 (1+0)	Non gradial
Agricultural Engineering			
1.	Farm Machinery and Power	2 (1+1)	
2.	Renewable Energy in Agriculture and Allied Sector	2 (1+1)	**4 (2+2)**
Nematology			
1.	Fundamentals of Nematology	2 (1+1)	**2 (1+1)**
Biochemistry			
1.	Essentials of Plant Biochemistry	3 (2+1)	**3 (2+1)**
Crop Physiology			
1.	Fundamentals of Crop Physiology	3 (2+1)	**3 (2+1)**
Animal Husbandry			
1.	Livestock and Poultry Management	2 (1+1)	**2 (1+1)**
Agricultural Biotechnology			
1.	Fundamentals of Agri Biotechnology	3 (2+1)	**3 (2+1)**
Students' Welfare			
1.	NCC/NSS	1 (0+1)	**1 (0+1)**
2.	NCC/NSS	1 (0+1)	**1 (0+1)**
3.	Physical Education, First Aid, Yoga Practices and Meditation	2 (0+2)	**2 (0+2)**
4.	Study Tour	2 (0+2)	**2 (0+2)** Non gradial
***Elective Courses (Indicative)**			
1	Agri-Business Management	4 (3+1)	**20* (15+5)** 5* Elective Courses
2	Management of Natural Resources	4 (3+1)	
3	Agrochemicals	4 (3+1)	
4	Agricultural Journalism	4 (3+1)	
5	Landscaping	4 (3+1)	
6	Commercial Plant Breeding	4 (3+1)	
7	Food Safety and Standards	4 (3+1)	
8	Bioformulation and Nano formulation	4 (3+1)	
9	Biopesticides and Biofertilizers	4 (3+1)	
10	System Simulation and Agro advisory	4 (3+1)	
11	Hi-tech Horticulture	4 (3+1)	
12	Protected Cultivation	4 (3+1)	
13	Climate Resilient Agriculture	4 (3+1)	
14	Biotechnology of Crop Improvement	4 (3+1)	
15	Geoinformatics and Remote Sensing, Precision Farming	4 (3+1)	
16	Micro-propagation Technologies	4 (3+1)	
17	Commercial Seed Production	4 (3+1)	
18	Principles and Practices of Organic Farming/ Conservation Agriculture	4 (3+1)	
19	Food Science and Nutrition	4 (3+1)	
20	Post-Harvest Technology and Value Addition		

**Skill Enhancement Courses (SECs)			
1.	SEC-I	2 (0+2)	**12 (0+12)**
2.	SEC-II	2 (0+2)	
3.	SEC-III	2 (0+2)	
4.	SEC-IV	2 (0+2)	
5.	SEC-V	2 (0+2)	
6.	SEC-VI	2 (0+2)	

***Host institution may add more courses into this list**
**** SEC will be decided by host institution depending on strength**

List of Courses as per above Categories

Course Category	Course Title	Credit Hours
Induction cum Foundation course	*Deekshaarambh*	2 weeks (Non-gradial)
Common Courses	Farming based Livelihood Systems	3 (2+1)
	Communication Skill	2 (1+1)
	Personality Development	2 (1+1)
	Environmental Studies and Disaster Management	3 (2+1)
	Agricultural Informatics and Artificial Intelligence	3 (2+1)
	Entrepreneurship Development and Business Management	3 (2+1)
	Agricultural Marketing and Trade	3 (2+1)
	NSS/ NCC-I	2 courses each of 1 (0+1) credits
	Physical Education, First Aid and Yoga Practices	2 credits
	Total	**23**
Core Courses	Fundamentals of Agronomy	3 (2+1)
	Crop Production Technology-I (*Kharif* Crops)	3 (1+2)
	Crop Production Technology-II (*Rabi* Crops)	3 (1+2)
	Water Management	2 (1+1)
	Weed Management	2 (1+1)
	Introductory Agroforestry	2 (1+1)
	Dryland Agriculture/Rainfed Agriculture and Watershed Management	2 (1+1)
	Principles and Practices of Natural Farming	2 (1+1)
	Fundamentals of Soil Science	3 (2+1)
	Soil Fertility Management	3 (2+1)
	Problematic Soils and their Management	2 (1+1)
	Fundamentals of Horticulture	3 (2+1)
	Production Technology of Fruit and Plantation Crops	2 (1+1)
	Production Technology of Vegetables and Spices	2 (1+1)
	Ornamental Crops, MAPs, and Landscaping	2 (2+1)
	Principles of Genetics	3 (2+1)
	Basics of Plant Breeding	3 (2+1)
	Crop Improvement (*Kharif* Crops)- I	2 (1+1)

Course Category	Course Title	Credit Hours
	Crop Improvement (*Rabi* Crops)- II	2 (1+1)
	Fundamentals of Seed Science Technology	2 (1+1)
	Fundamentals of Entomology	3 (2+1)
	Pest Management in Crops and Stored Grains	3 (2+1)
	Fundamentals of Plant Pathology	3 (2+1)
	Diseases of Field and Horticultural Crops and their Management	3 (2+1)
	Agricultural Microbiology and Phyto -remediation	2 (1+1)
	Rural Sociology and Educational Psychology	2 (2+0)
	Fundamentals of Extension Education	2 (1+1)
	Introduction to Agro-meteorology	2 (1+1)
	Principles of Agricultural Economics and Farm Management	2 (2+0)
	Agricultural Finance and Cooperation	2 (1+1)
	Basic and Applied Agricultural Statistics	3 (2+1)
	Farm Machinery and Power	2 (1+1)
	Renewable Energy in Agriculture and Allied Sector	2 (1+1)
	Fundamentals of Nematology	2 (1+1)
	Essentials of Plant Biochemistry	3 (2+1)
	Fundamentals of Crop Physiology	3 (2+1)
	Livestock and Poultry Management	2 (1+1)
	Fundamentals of Agri Biotechnology	3 (2+1)
	Total	**92**
Elective Courses	20 credits will be taken from list of choice based course list or department wise courses to be decided by host institution	20
	Total	**20**
Skill Enhancement Courses **(indicative)**	SDC-I (Biofertlizer and Biopesticide Production)	2 (0+2)
	SEC-II (Mushroom Production Technology)	2 (0+2)
	SEC-III (Seed Production Technology)	2 (0+2)
	SEC-IV (Post Harvest Processing Technology)	2 (0+2)
	SEC-V (Beneficial Insect Farming)	2 (0+2)
	SEC-VI (Horticulture Nursery Management)	2 (0+2)
	SEC-VII (Plantation Crops Production and Management)	2 (0+2)
	Total	**12**
Students READY	RAWE/Industrial attachment/Experiential Learning/Hands on training/Project-work/ Internship etc.	20
	Total	**20**

Course Category	Course Title	Credit Hours
Other courses	Remedial course on 1. Mathematics	1 credit Non-Gradial
	Study tour (2 weeks in 5th semester)	2 (0+2) Non-Gradial
	Total of offline course credits	**167**
Online courses	*Online Courses	**10**
	Grand Total	**167+10***

Summary of credit distributions among different categories of courses (Credit hours)

Semester	Core Courses (Major and Minor)	Multi-Disciplinary Course (MDC)	Value Added Course (VAC)	Ability Enhance-ment Course (AEC)	Skill En-hancement Course (SEC)	Internship/ Project/ Student READY	Total Credits	Non gradial	Internship	Online course/ MOOC
I	11	**3**(3)	___	1(4)+2(5)	4		21	2(1)+1(2)	----	**10**(15)
II	11	---	3(6)	1(4)+2(7)	4		21		10(13)	
III	14	3(8)	---	2(9)	2		21		---	
IV	16	---	3(10)	----	2		21		10(14)	
V	19	3(11)	----	----	----		22	2(12)	----	
VI	**21**	_	---	---	---		21		---	
VII	**20**	--	--	---	--		20		--	
VIII		--	--	---	--	20	20			
Total	**112**	**9**	**6**	**8**	**12**	20	**167**	**5**		10

(1) *Deeksharambh* (Induction-cum-Foundation Course) of 2 credits (2 weeks duration).
(2) Remedial Course: Introductory Mathematics 1 credit (non-gradial)
(3) Farming based Livelihood Systems
(4) NCC/NSS
(5) Communication Skills
(6) Environmental Studies and Disaster Management
(7) Personality Development
(8) Entrepreneurship Development and Business Management
(9) Physical Education, First Aid, Yoga Practices & Meditation
(10) Agricultural Informatics and Artificial Intelligence
(11) Agriculture Marketing and Trade
(12) Study Tour (10-14 days)
(13) Only for those opting for an exit with UG-Certificate and
(14) Only for those opting for an exit with UG-Diploma
(15) Online course: student will make his/her own planning and execution of online courses with intimation to the Dean

Summary of Credit Distributions

Type of Courses		Credits
Core courses (Major & Minor)	:	112
Common courses (MDC+VAC+AEC)	:	23
Skill Enhancement Courses (SEC)	:	12
Student READY (RAWE/Industrial Attachment /Experiential Learning/ Hands-on Training/Skill Development/Project Work/Internship etc.)	:	20
**Online Courses/MOOCs	:	10 non-gradial
Total	:	**167+10****

** Massive Open Online Courses

DETAILED SYLLABI

Semester I

Deeksharambh (Induction-cum-Foundation Course)–Non-Gradial 2 (0+2)

The activities to be taken under *Deeksharambh* shall aim at creating a platform for students to

1. Help for cultural Integration of students from different backgrounds
2. Know about the operational framework of academic process in university
3. Instilling life and social skills
4. Social Awareness, Ethics and Values, Team Work, Leadership, Creativity, etc.
5. Identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario.

The details of activities will be decided by the parent universities. The structure shall include, but not restricted to:

i. Discussions on operational framework of academic process in university, as well as interactions with academic and research managers of the University
ii. Interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences
iii. Group activities to identify the strength and weakness of students (with expert advice for their improvement) as well as to create a platform for students to learn from each other's life experiences
iv. Activities to enhance cultural Integration of students from different backgrounds.
v. Field visits to related fields/ establishments
vi. Sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills

Objectives

The activities to be taken under Deeksharambh shall aim at creating a platform for students

Communication Skills 2 (1+1)

Objective

To acquire competence in oral, written and non-verbal communication, develop strong personal and professional communication and demonstrate positive group communication.

Theory

Communication Process**:** The magic of effective communication; Building self-esteem and overcoming fears; Concept, nature and significance of communication process; Meaning, types and models of communication; Verbal and non-verbal communication; Linguistic and non-linguistic barriers to communication and reasons behind communication gap/ miscommunication.

Basic Communication Skills: Listening, Speaking, Reading and Writing Skills; Precis writing/ Abstracting/Summarizing; Style of technical communication Curriculum vitae/resume writing; Innovative methods to enhance vocabulary, analogy questions.

Structural and Functional Grammar**:** Sentence structure, modifiers, connecting words and verbal; phrases and clauses; Case: subjective case, possessive case; objective case; Correct usage of nouns, pronouns and antecedents, adjectives, adverbs and articles; Agreement of verb with the subject: tense, mood, voice; Writing effective sentences; Basic sentence faults;

Practical

Listening and note taking; Writing skills: precis writing, summarizing and abstracting; Reading and comprehension (written and oral) of general and technical articles; Micro-presentations and Impromptu Presentations: Feedback on presentations; Stage manners: grooming, body language, voice modulation, speed; Group discussions; Public speaking exercises; vocabulary building exercises; Interview Techniques; organization of events.

Suggested Readings

1. Napoleon Hill. 2014. *Think and Grow Rich*-Finger Print.
2. Brown Michele and Brandreth Gyles. 1994. *How to Interview and be Interviewed*. Sheldon Press, London.
3. Dale Carnegie. 2018. *The Quick and Easy Way to Effective Speaking*. Finger Print.
4. Francis Peter S J. 2012. *Soft Skills and Professional Communication*. Tata McGraw Hill, New Delhi.
5. Kumar S and Pushpa Lata. 2011. *Communication Skills*. Oxford University Press.
6. Neuliep James W. 2003. *Intercultural Communication A Contextual Approach*. Houghton Mifflin Co Boston.
7. Mark Goulston. 2015. Just Listen. Amacom; Reprint edn. Harper Collins.
8. Raman M and Singh P. 2000. *Business Communication*. Oxford University Press.
9. Seely J. 2013. *Oxford Guide to Effective Writing and Speaking*. Oxford University Press.
10. Partha Sarathi Basu. 2015 Mid-Career Crisis Collins

Farming based Livelihood Systems 3 (2+1)

Objectives

i. To make the students aware about farming-based livelihood systems in agriculture
ii. To disseminate the knowledge and skill how farming-based systems can be a source of livelihood

Theory

Status of agriculture in India and different states, Income of farmers and rural people in India, Livelihood-Definition, concept and livelihood pattern in urban and rural areas, Different indicators to study livelihood systems. Agricultural livelihood systems (ALS): Meaning, approach, approaches and framework, Definition of farming systems and farming based livelihood systems Prevalent Farming systems in India contributing to livelihood. Types of traditional and modern farming systems. Components of farming system/ farming-based livelihood systems- Crops and cropping systems, Livestock (Dairy, Piggery, Goatry, Poultry, Duckry etc.), Horticultural crops, Agro--forestry systems, Aqua culture Duck/Poultry cum

Fish, Dairy cum Fish, Piggery cum Fish etc., Small-, medium- and large- enterprises including value chains and secondary enterprises as livelihood components for farmers, Factors affecting integration of various enterprises of farming for livelihood. Feasibility of different farming systems for different agro-climatic zones, Commercial farming-based livelihood models by NABARD, ICAR and other organizations across the country, Case studies on different livelihood enterprises associated with the farming. Risk and success factors in farming-based livelihood systems, Schemes and programs by Central and State Government, Public and Private organizations involved in promotion of farming-based livelihood opportunities. Role of farming-based livelihood enterprises in 21st Century in view of circular economy, green economy, climate change, digitalization and changing life style.

Practical

Survey of farming systems and agricultural based livelihood enterprises, Study of components of important farming based livelihood models/ systems in different agro-climatic zones, Study of production and profitability of crop based, livestock based, processing based and integrated farming based livelihood models, Field visit of innovative farming system models. Visit of Agri-based enterprises and their functional aspects for integration of production, processing and distribution sectors and Study of agri-enterprises involved in industry and service sectors (Value Chain Models), Learning about concept of project formulation on farming-based livelihood systems along with cost and profit analysis, Case study of Start-Ups in agri-sectors.

Suggested Readings

1. Ashley C and Carney D. 1999. *Sustainable Livelihoods: Lessons from Early Experience*. Department for International Development: London, UK; Volume 7. [Google Scholar]
2. Agarwal A and Narain S. 1989. *Towards Green Villages: A strategy for Environmentally, Sound and Participatory Rural Development*. Center for Science and Environment, New Delhi, India
3. Carloni A. 2001. *Global Farming Systems Study: Challenges and Priorities to 2030 – Regional Analysis: Sub-Saharan Africa*. Consultation Document, FAO, Rome, Italy
4. Dixon J, Gulliver A and Gibbon D. 2001. *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World*. FAO & World Bank, Rome, Italy & Washington, DC, USA
5. Evenson R E. 2000. *Agricultural Productivity and Production in Developing Countries*. In FAO, The State of Food and Agriculture, FAO, Rome, Italy
6. Reddy S R. 2016. *Farming System and Sustainable Agriculture*. Kalyani Publishers, New Delhi.
7. Walia S S and Walia U S. 2020. *Farming System and Sustainable Agriculture*. Scientific Publishers, Jodhpur, Rajasthan.

Rural Sociology and Educational Psychology 2 (2+0)

Objective

To provide knowledge on concept and importance of sociology and rural sociology as well as the relationship with Extension Education

Theory

Extension Education and Agricultural Extension: Meaning, definition, scope, and importance. Sociology and rural sociology: Meaning, definition, scope, importance of rural sociology in Agricultural Extension, and interrelationship between rural sociology and Agricultural Extension. Indian Rural Society: important characteristics, differences and relationship between rural and urban societies. Social Groups: Meaning, definition, classification, factors considered information and organization of groups, motivation in group formation and role of social groups in Agricultural Extension.

Social Stratification: Meaning, definition, functions, basis for stratification, forms of social stratification- characteristics and-differences between class and caste system. Cultural concepts: culture, customs, folkways, mores, taboos, rituals. Traditions: Meaning, definition and their role in Agricultural Extension. Social Values and Attitudes: Meaning, definition, types and role of social values and attitudes in agricultural Extension. Social Institutions: Meaning, definition, major institutions in rural society, functions, and their role in agricultural Extension. Social Organizations: Meaning, definition, types of organizations and role of social organizations in agricultural Extension. Social Control: Meaning, definition, need of social control and means of social control. Social change: Meaning, definition, nature of social change, dimensions of social change and factors of social change. Leadership: Meaning, definition, classification, roles of leader, different methods of selection of professional and lay leaders. Training of Leaders: Meaning, definition, methods of training, Advantages and limitations in use of local leaders in Agricultural Extension, Psychology and educational psychology: Meaning, definition, scope, and importance of educational psychology in Agricultural Extension. Intelligence: Meaning, definition, types, factors affecting intelligence and importance of intelligence in Agricultural Extension. Personality: Meaning, definition, types, factors influencing the personality and role of personality in agricultural Extension. Teaching: Learning process: Meaning and definition of teaching, learning, learning experience and learning situation, elements of learning situation and its characteristics. Principles of learning and their implication of teaching.

Suggested Readings

1. Chitambar J B. 2020. *Introductory Rural Sociology*. (4th Edn.). New Age International Private Limited.
2. Desai A R. 2019. *Rural Sociology in India*. (5th Edition) SAGE Publications India Pvt Ltd.
3. Dahama O P and Bhatnagar O P. 2019. *Education and Communication for Development*. (2nd Edn.). Oxford & IBH Publishing Co. Pvt. Ltd.
4. Ghorpade M B. 1985. *Essential of Psychology*. Bombay Himalaya Publishing House, New Delhi.
5. Ray G L. 2017. Extension Communication and Management. Kalyani Publishers.
6. Sandhu A S. 2020. Textbook on *Agricultural Communication.* (3rd Edn.). Oxford & IBH Publishing Co. Pvt. Ltd.
7. Velusamy R. 2020. Textbook on *Rural Sociology and Educational Psychology*. Daya Publishing House.

Fundamentals of Agronomy 3 (2 +1)

Objective

To impart the basic and fundamental knowledge of Agronomy

Theory

Agronomy and its scope: Definition, meaning and scope of Agronomy; art, science and business of crop production, relation of Agronomy with other disciplines of Agricultural Science, fields crops and classification, importance, ecology and ecosystem. Seeds and sowing: Definitions of crops, variety and seed. Factors affecting crop stands establishment: good quality seed, proper tillage, time of sowing seed rate, depth and method of sowing: broadcasting, drilling, dibbling, transplanting etc. Tillage and tilth: Definition, objectives, types, advantages and disadvantages of tillage including conservation tillage. Crop density and geometry: plant geometry and planting geometry, its effect on growth, yield.

Crop nutrition: Definition of essential nutrients, criteria of essentiality, functional elements, classification of essential nutrients, role of macro and micro nutrients. Nutrient absorption, active and passive absorption of nutrients, forms of plant nutrients absorbed by plants, Combined /un-combined forms. Manures and fertilizers, nutrient use efficiency: Sources of nutrients: Inorganic (fertilizers), organic (manures) and bio-fertilizers; their classification and characteristics, method of preparation and role of organic manures in crop production. Integrated Nutrient Management (INM): Meaning, different approaches and advantages of INM. Green manure- role in crop production: Definition, objectives types of green manuring, desirable characteristics, advantages and limitations of green manuring.

Water management: Water resources of the world, India and the state; Soil Moisture constants: gravitational water, capillary water, hygroscopic water, Soil moisture constants.

Weeds: Definition, importance and basics of classification of weeds and their control. Agro-climatic zones of India and the state, cropping systems: Factors affecting cropping systems, major cropping patterns and systems in the country. Sustainable crop production: Definition, importance and practices, natural resources and conservation pollution and pollutants, Allelopathy: Meaning and importance in crop production, Growth and development of crops: Definition, Meaning and factors affecting growth and development.

Practical

A visit to Instructional Crop farm and study on field crops, Identification of crops, seeds, fertilizers, pesticides, Crops and cropping systems in different Agro-climatic zones of the state, Study of some preparatory tillage implements, Study of inter tillage implements, Practice of ploughing / puddling, Study and practice of inter cultivation in field crops, Numerical exercises on calculation of seed, plant population and fertilizer requirement, Study of yield contributing characters and yield estimation of crops, Identification of weeds in different crops, Seed germination and viability test of seed, Practice on time and method of application of manures and fertilizers.

Suggested Readings

1. Rao V S. 1992. *Principles of Weed Science*. Oxford and IBH Publishing Co. Ltd. New Delhi.
2. Reddy Yellamanda T and Shankar Reddy G H. 1995. *Principles of Agronomy*. Kalyani Publishers, Ludhiana.
3. Reddy S R. 2008. *Principle of Crop Production*, Kalyani Publisher, Ludhiana.
4. William L Donn. 1965. *Meteorology*. McGraw-Hill Book Co. New York.
5. Yawalkar K S and Agarwal J P. 1977. *Manures and Fertilizers*. Agricultural Horticultural Publishing House, Nagpur.

Fundamentals of Soil Science 3 (2+1)

Objective

To impart knowledge on soil genesis, basic soil properties with respect to plant growth

Theory

Soil: Pedological and edaphalogical concepts. Rocks and minerals, weathering, Silicate clays: constitution and properties, sources of charge, ion exchange, cation and anion exchange capacity and base saturation (after buffering capacity), Soil formation, Soil organic matter, Pedogenic processes, Soil colloids: inorganic and organic, Properties of soil colloids and Ion exchange in soils, Soil profile, soil texture, soil structure. Bulk density and particle density, soil consistency, soil temperature, soil air, soil water. Soil reaction and buffering capacity. Soil taxonomy, keys to soil orders. Soils of India.

Practical

Study of general properties of minerals, study of minerals-silicate and non-silicate minerals, study of rocks-igneous, sedimentary and metamorphic rocks; study of a soil profile, collection and processing of soil for analysis, study of soil texture-feel method, mechanical analysis, determination particle density and soil porosity, determination of soil colour, study of soil structure and aggregate analysis, determination of soil moisture, determination of soil moisture constants-field capacity; water holding capacity. Study of infiltration rate of soil, determination of pH and Electrical conductivity of soil.

Suggested Readings

1. Das Dilip Kumar. 2022. *Introductory Soil Science*. Kalyani Publishers.
2. Harry O Buckman and Nyle C. 1996. *The Nature and Properties of Soils*. (11th Edn.). Prentice Hall.
3. Singh S S. 2016. *Soil Fertility and Nutrient Management*. (3rd Edn.). Kalyani Publishers.
4. Tisdale Samual L, Nelson Werner L and Beaton James D. 2016. *Soil Fertility and Fertilizers*. (8th Edn.). Pearson Education.

Fundamentals of Horticulture 3 (2+1)

Objectives

i. To provide knowledge on different branches of horticulture viz. pomology, olericulture, floriculture and landscaping, spices and medicinal plants

ii. To provide knowledge on orchard management, propagation methods, cultural operations and nutrient management of horticultural crops

iii. To provide knowledge on different physiological aspects of horticultural crops

Theory

Horticulture: Its different branches, importance and scope, Horticulture and botanical classification, soil and climate for horticultural crops. Plant propagation: methods and propagation structures, seed dormancy and seed germination, Merits and demerits of sexual and asexual propagation Stock-scion relationship.

Principles of orchard establishment, principles and methods of training and pruning of fruit crops, Juvenility and flower bud differentiation, unfruitfulness in horticultural crops, pollination, pollinizers and pollinators, fertilization and parthenocarpy, importance of bio regulators in horticultural crops, irrigation and its methods, Fertilizer application in horticultural crops.

Practical

Identification and nomenclature of fruit, Layout of an orchard, pit making and system of planting, Nursery raising techniques of fruit crops, Understanding of plant propagation structures, Propagation through seeds and plant parts, Propagation techniques for horticultural crops, Container, potting mixture, potting and repotting, Training and pruning methods on fruit crops, Preparation of fertilizer mixture and application, Preparation and application of PGR, Layout of different irrigation systems, Maturity studies, harvesting, grading, packaging and storage.

Suggested Readings

1. Kumar N. 2023. *Introduction to Horticulture*. (9th Edn.). Science Technology; Medtech Science Press.
2. ICAR. 2024. *Handbook of Horticulture*. Vol.-I & II, ICAR
3. Singh Jitendra. 2025. *Basic Horticulture*. (6th Edn.). Kalyani Publishers.

National Cadet Corps (NCC-1), National Service Scheme (NSS-1) 1 (0+1)

National Cadet Corps- As per government guidelines, for getting B and C certificate in NCC, minimum years of requirement is 2 and 3 years respectively along with 1-2 annual camps

- Aims, objectives, organization of NCC and NCC song. DG's cardinals of discipline.
- Drill- aim, general words of command, attention, stands at ease, stand easy and turning.
- Sizing, numbering, forming in three ranks, open and close order march, and dressing.
- Saluting at the halt, getting on parade, dismissing, and falling out.
- Marching, length of pace, and time of marching in quick/slow time and halt. Side pace, pace forward and to the rear. Turning on the march and wheeling. Saluting on the march.
- Marking time, forward march, and halt. Changing step, formation of squad and squad drill.
- Command and control, organization, badges of rank, honors, and awards
- Nation Building- cultural heritage, religions, traditions, and customs of India. National integration. Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizens. Leadership traits, types of leadership. Character/

personality development. Civil defense organization, types of emergencies, firefighting, protection. Maintenance of essential services, disaster management, aid during development projects.

- Basics of social service, weaker sections of society and their needs, NGO's and their contribution, contribution of youth towards social welfare and family planning.
- Structure and function of human body, diet and exercise, hygiene and sanitation. Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health. Adventure activities. Basic principles of ecology, environmental conservation, pollution and its control.

National Service Scheme (NSS-1)

Evoking social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skilful in executing democratic leadership, developing skill in programme, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

All the activities related to the National Service Scheme are distributed under four different courses viz., National Service Scheme I, National Service Scheme II, National Service Scheme III and National Service Scheme IV; each having one credit load.

The entire four courses should be offered continuously for two years. A student enrolled in NSS course should put in at least 60 hours of social work in different activities in a semester other than five regular one-day camp in a year and one special camp for duration of 7 days at any semester break period in the two years. Different activities will include orientation lectures and practical works. Activities directed by the Central and State Government have to be performed by all the volunteers of NSS as per direction.

Introduction and Basic Components of NSS

- Orientation: history, objectives, principles, symbol, badge; regular programs under NSS
- Organizational structure of NSS, Code of conduct for NSS volunteers, points to be considered by NSS volunteers' awareness about health.
- NSS program activities: Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analyzing guiding financial patterns of scheme, youth program/ schemes of GOI, coordination with different agencies and maintenance of diary. Understanding youth. Definition, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change.
- Community mobilization: Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership. Social harmony and national integration.
- Indian history and culture, role of youth in nation building, conflict resolution and peace-building. Volunteerism and shramdaan. Indian tradition of volunteerism, its need, importance, motivation, and constraints; shaman as part of volunteerism
- Citizenship, constitution, and human rights: Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to

information. Family and society. Concept of family, community (PRIs and other community-based organizations) and society

Introductory Mathematics (Non-gradial) 1 (1+0)

Theory

Algebra: Progressions- Arithmetic, Geometric and Harmonic Progressions. Matrices: Definition of Matrices, Addition, Subtraction, Multiplication, Transpose and Inverse up to 3rd order by adjoint method, Properties of determinants up to 3rd order and their evaluation.

Differential Calculus: Definition - Differentiation of function using first principle, Derivatives of sum, difference, product and quotient of two functions, Methods, Increasing and Decreasing Functions. Application of Differentiation- Growth rate, Average Cost, and Marginal cost, Marginal Cost, Marginal Revenue. Partial differentiation: Homogeneous function, Euler's theorem, Maxima and Minima of the functions of the form $y = f(x)$ and $y = f(x1, x2)$.

Integral Calculus: Integration -Definite and Indefinite Integrals-Methods- Integration by substitution, Integration by parts. Area under simple well-known curves.

Mathematical Models: Agricultural systems-Mathematical models-classification of mathematical models-Fitting of Linear, quadratic and exponential models to experimental data.

Semester-II

Personality Development 2 (1+1)

Objective

To make students realize their potential strengths, cultivate their inter-personal skills and improve employability.

Theory

Personality Definition, Nature of personality, theories of personality and its types. The humanistic approach - Maslow's self-actualization theory, shaping of personality, determinants of personality, Myers-Briggs Typology Indicator, Locus of control and performance, Type A and Type B Behaviours, personality and Organizational Behaviour.

Foundations of individual behavior and factors influencing individual behavior, Models of individual behavior, Perception and attributes and factors affecting perception, Attribution theory and case studies on Perception and Attribution. Learning: Meaning and definition, theories and principles of learning, Learning and organizational behavior, Learning and training, learning feedback. Attitude and values, Intelligence- types of Intelligence, theories of intelligence, measurements of intelligence, factors influencing intelligence, intelligence and Organizational behavior, emotional intelligence. Motivation- theories and principles, Teamwork and group dynamics.

Practical

MBTI personality analysis, Learning Styles and Strategies, Motivational needs, Firo-B, Interpersonal Communication, Teamwork and team building, Group Dynamics, Win-win game, Conflict Management, Leadership styles, Case studies on Personality and Organizational Behavior.

Suggested Readings

1. Andrews Sudhir. 2008. *How to Succeed at Interviews*. McGraw-Hill.
2. George Matthew Adams-2020. You can. Finger Print.
3. Heller Robert. 2002. *Effective Leadership (Essential Manager series)*. Dk Publishing.
4. Hindle Tim. 2009. *Reducing Stress (Essential Manager series*). Dk Publishing.
5. Kumar Pravesh. 2005. *All about Self- Motivation*. New Delhi. Goodwill Publishing House.
6. Lucas Stephen. 2001. *Art of Public Speaking*. New Delhi. Tata - Mc-Graw Hill.
7. Mile D J. 2004. *Power of Positive Thinking*. Delhi. Rohan Book Company.
8. Shaffer D R. 2009. *Social and Personality Development* (6th Edn.). Belmont, CA: Wadswor.
9. Smith B. 2004. *Body Language*. Delhi: Rohan Book Company.

Environmental Studies and Disaster Management 3 (2+1)

Objective

To expose and acquire knowledge on the environment and to gain the state-of-the-art - skill and expertise on management of disasters.

Theory

Introduction to Environment - Environmental studies: Definition, scope and importance - Multidisciplinary nature of environmental studies - Segments of Environment - Spheres of Earth - Lithosphere - Hydrosphere - Atmosphere - Different layers of atmosphere. Natural Resources: Classification - Forest resources. Water resources. Mineral resources Food resources. Energy resources. Land resources. Soil resources. Ecosystems: Concept of an ecosystem - Structure and function of an ecosystem - Energy flow in the ecosystem. Types of ecosystem. Biodiversity and its conservation: Introduction, definition, types. Biogeographical classification of India. Importance and Value of biodiversity. Biodiversity hot spots. Threats and Conservation of biodiversity.

Environmental Pollution: Definition, cause, effects and control measures of: a. Air pollution. b. Water pollution. c. Soil pollution. d. Marine pollution. e. Noise pollution. f. Thermal pollution h. Light pollution. Solid Waste Management: Classification of solid wastes and management methods, Composting, Incineration, Pyrolysis, Biogas production, Causes, effects and control measures of urban and industrial wastes. Social Issues and the Environment: Urban problems related to energy. Water conservation, rain water harvesting, watershed management. Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act. Wildlife Protection Act. Forest Conservation Act. Human Population and the Environment: Environment and human health: Human Rights, Value Education. Women and Child Welfare. Role of Information Technology in Environment and human health.

Disaster management: Disaster definition - Types - Natural Disasters - Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves. Man Made Disasters: Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, road accidents, rail accidents, air accidents, sea accidents. International and National strategy for disaster reduction. Concept of disaster management, national disaster management

framework; financial arrangements; role of NGOs, community-based organizations and media in disaster management. Central, state, district and local administration in disaster control; Armed forces in disaster response; Police and other organizations in disaster management.

Practical

Visit to a local area to document environmental assets river/forest/grassland/hill/ mountain. Energy: Biogas production from organic wastes. Visit to wind mill / hydro power / solar power generation units. Biodiversity assessment in farming system. Floral and faunal diversity assessment in polluted and un polluted system. Visit to local polluted site - Urban/ Rural/Industrial/Agricultural to study of common plants, insects and birds. Environmental sampling and preservation. Water quality analysis: pH, EC and TDS. Estimation of Acidity, Alkalinity. Estimation of water hardness. Estimation of DO and BOD in water samples. Estimation of COD in water samples. Enumeration of *E. coli* in water sample. Assessment of Suspended Particulate Matter (SPM). Study of simple ecosystem – Visit to pond/river/hills. Visit to areas affected by natural disaster.

Suggested Readings

1. Bharucha Erach. 2004. *Textbook for Environmental studies*. University Grants Commission, New Delhi
2. De A K. 2010. *Environmental chemistry*. New Age International Publishers, New Delhi. ISBN:13–978 81 224 2617 5.
3. Dhar Chakrabarti P G. 2011. *Disaster management - India's risk management policy frameworks and key challenges*. Centre for Social Markets (India), Bangalore.
4. Parthiban K T, Vennila Prasanthrajan S, Umesh M and Kanna S. 2023. *Forest, Environment, Biodiversity and Sustainable development*. Narendra Publishing House, New Delhi, India. (In Press).
5. Prasanthrajan M and Mahendran P P. 2008. *A textbook on Ecology and Environmental Science*. ISBN 81-8321-104-6. Agrotech Publishing Academy, Udaipur - 313 002. First Edition: 2008
6. Prasanthrajan M. 2018. *Objective environmental studies and disaster management*. ISBN 9789387893825. Scientific publishers, Jodhpur, India.
7. Sharma P D. 2009. *Ecology and Environment*. Rastogi Publications, Meerut, India.
8. Tyler Miller and Scot Spoolman. 2009. *Living in the Environment (Concepts, Connections, and Solutions)*. Brooks/cole, Cengage Learning publication, Belmont, USA.

Soil Fertility Management 3 (2+1)

Objective

To provide a comprehensive knowledge of soil fertility, plant nutrition, fertilizers, and nutrient management

Theory

History of soil fertility and plant nutrition. criteria of essentiality. role, deficiency and toxicity symptoms of essential plant nutrients, Mechanisms of nutrient transport to plants, factors affecting nutrient availability to plants. Chemistry of macro and micronutrients. Soil fertility evaluation,

Soil testing. Critical levels of different nutrients in soil. Forms of nutrients in soil, plant analysis, rapid plant tissue tests. Indicator plants. Introduction and importance of manures and fertilizers. Fertilizer recommendation approaches.

Integrated nutrient management. Chemical fertilizers: classification, composition and properties of major fertilizers, secondary and micronutrient fertilizers, Complex fertilizers, Customised fertilisers, water soluble fertilizers nano fertilizers Soil amendments, Fertilizer Storage, Fertilizer Control Order. Methods of fertilizer recommendations to crops. Factor influencing nutrient use efficiency (NUE), methods of application under rainfed and irrigated conditions. STCR/RTNM/IPNS, Carbon sequestration and Carbon Trading, Preparation and properties of major manures (FYM, Compost, Vermicompost, Green manuring, Oilcakes).

Practical

Introduction of analytical instruments and their principles, calibration and applications of Coloremetry and flame photometry; Estimation of alkaline hydrolysable N in soils; Estimation of soil extractable P in soils; Estimation of exchangeable K in soils; Estimation of exchangeable Ca and Mg in soils; Estimation of soil extractable S in soils; Estimation of DTPA extractable Zn in soils; Estimation of N in plants; Estimation of P in plants; Estimation of K in plants; Estimation of S in plants.

Suggested Readings

1. Buckman Harry O and Brady Nyle C. 2018. *The Nature and Properties of Soils*. Franklin Classics.
2. Das Dilip Kumar. 2022. *Introductory Soil Science*. Kalyani Publishers, New Delhi.
3. Singh S S. 2011. *Soil Fertility and Nutrient Management*. Kalyani Publishers, New Delhi
4. Tisdale Samuel L, Nelson Werner L and Beaton James D. 2016. *Soil Fertility and Fertilizers*. (8th Edn.). Pearson Education India.

Fundamentals of Entomology 3 (2+1)

Objectives

i. To know the history of entomology, classification of insects and their relationship with other arthropods
ii. To study the various morphological characters of class insect and their importance for classification of insects
iii. To get an idea about the different physiological systems of insects and their roles in growth and development and communications of insects
iv. To study the characteristics of commonly observed insect orders and their economically important families

Theory

History of Entomology in India. Major points related to dominance of Insects in Animal kingdom. Classification of phylum Arthropoda up to classes. Relationship of class Insects with other

classes of Arthropoda. Morphology: Structure and functions of insect cuticle and molting. Body segmentation. Structure of head, thorax and abdomen. Structure and modifications of insect antennae, mouth parts, legs, Wing venation, modifications and wing coupling apparatus. Metamorphosis and diapause in insects. Types of larvae and pupae. Structure and functions of digestive, circulatory, excretory, respiratory, nervous, secretary (Endocrine) and reproductive system, in insects. Types of reproduction in insects. Major sensory organs. Insect Ecology: Introduction, Environment and its components. Effect of abiotic factors and biotic factors. Categories of pests. Systematics: Taxonomy – importance, history and development and binomial nomenclature. Definitions of Biotype, Sub-species, Species, Genus, Family and Order. Classification of class Insecta up to Orders, basic groups of present day insects with special emphasis to orders and families of Agricultural importance like Orthoptera: Acrididae, Tettigoniidae, Gryllidae, Gryllotalpidae; Dictyoptera: Mantidae, Blattidae; Odonata; Isoptera: Termitidae; Thysanoptera: Thripidae; Hemiptera: Pentatomidae, Coreidae, Cimicidae, Pyrrhocoridae, Lygaeidae, Cicadellidae, Delphacidae, Aphididae, Coccidae, Lophophidae, Aleurodidae, Pseudococcidae; Neuroptera: Chrysopidae; Lepidoptera: Pieridae, Papiloinidae, Noctuidae, Sphingidae, Pyralidae, Gelechiidae, Arctiidae, Saturnidae, Bombycidae; Coleoptera: Coccinellidae, Chrysomelidae, Cerambycidae, Curculionidae, Bruchidae, Scarabaeidae; Hymenoptera: Tenthridinidae, Apidae. Trichogrammatidae, lchneumonidae, Braconidae, Chalcididae; Diptera: Cecidomyiidae, Tachinidae, Agromyziidae, Culicidae, Muscidae, Tephritidae.

Practical

Methods of collection and preservation of insects including immature stages; External features of Grasshopper/Blister beetle; Types of insect antennae, mouthparts and legs; Wing venation, types of wings and wing coupling apparatus. Types of insect larvae and pupae; Dissection of digestive system in insects (Grasshopper); Study of characters of orders Orthoptera, Dictyoptera, Odonata, Isoptera, Thysanoptera, Hemiptera, Lepidoptera, Neuroptera, Coleoptera, Hymenoptera, Diptera and their families of agricultural importance. Insecticides and their formulations. Pesticide appliances and their maintenance. Sampling techniques for estimation of insect population and damage.

Suggested Readings

1. Johnson Norman and Triplehorn Charles. 2004. *Borror and DeLong's Introduction to the study of Insects*. (7th Edn.). Brooks/Cole.
2. Odum Eugene P and Barrett Gray W. 2020. *Fundamentals of Ecology*. (5th Edn.). Cangage Learning India.
3. Richards O W and Davies R G. 1977. *IMMS' General Textbook of Entomology*. Chapman and Hall.

Livestock and Poultry Management 2 (1+1)

Objectives

i. To provide basic knowledge to the students about scientific livestock and poultry rearing practices
ii. Entrepreneurship development through Livestock/poultry and Agriculture Integrated Farming System

Theory

Role of livestock in the national economy. Reproduction in farm animals and poultry. Housing principles, space requirements for different species of livestock and poultry. Management of calves, growing heifers and milch animals. Management of sheep, goat and swine. Incubation, hatching and brooding. Management of growers and layers. Important Indian and exotic breeds of cattle, buffalo, sheep, goat, swine and poultry. Improvement of farm animals and poultry. Digestion in livestock and poultry. Classification of feedstuffs. Proximate principles of feed. Nutrients and their functions. Feed ingredients for ration for livestock and poultry. Feed supplements and feed additives. Feeding of livestock and poultry. Introduction of livestock and poultry diseases. Prevention (including vaccination schedule) and control of important diseases of livestock and poultry.

Practical

External body parts of cattle, buffalo, sheep, goat, swine and poultry. Handling and restraining of livestock. Identification methods of farm animals and poultry. Visit to IDF and IPF to study breeds of livestock and poultry and daily routine farm operations and farm records. Judging of cattle, buffalo and poultry. Culling of livestock and poultry. Planning and layout of housing for different types of livestock. Computation of rations for livestock. Formulation of concentrate mixtures. Clean milk production, milking methods. Hatchery operations, incubation and hatching equipment. Management of chicks, growers and layers. Debeaking, dusting and vaccination. Economics of cattle, buffalo, sheep, goat, swine and poultry production

Suggested Readings

1. Banerjee G C. 2019. *A Textbook of Animal Husbandry*. (8th Edn.). Oxford & IBH Publishing, New Delhi.
2. Verma D N. 1999. *A Textbook of Livestock Production Management in Tropic*. Kalyani Publishers

Fundamentals of Plant Pathology 3 (2+1)

Objectives

i. To get acquainted with the role of different microorganisms in the development of plant disease
ii. To get general concepts and classification of plant diseases
ii. To get knowledge of general characteristics of fungi, bacteria, virus, and other microorganisms causing plant diseases
iv. To acquaint the students with reproduction in fungi, and bacteria, causing plant diseases
v. To get acquainted with various plant disease management principles and practices

Theory

Introduction to Plant Pathology: Concept of disease in plants; Different terms used in Plant Pathology, History of Plant Pathology with special references to India; Causes of plant disease: Inanimate and animate causes; Classification of plant disease; Parasitism and pathogenesis; Development of disease in plants: Disease Triangle, Disease cycle; Fungi and their morphology, reproduction and classification of fungi; Bacteria: Morphology, reproduction classification

of phytopathogenic bacteria; Other plant pathogens: Mollicutes; Flagellant protozoa; FVB; Green algae and parasitic higher plants; Viruses and viroids, virus transmission; Principles of Plant disease management: Disease management with chemicals, Host resistance, cultural and biological method of Integrated Disease Management (IDM).

Practical

Study of the microscope; Acquaintance with laboratory material and equipment; Study of different plant disease symptoms; Microscopic examination of general structure of fungi; Simple staining of bacteria: Direct and indirect staining, Gram staining of bacteria; Microscopic examination of fungal diseased specimen; Microscopic examination of bacterial diseased specimen; Preparation of culture media; Isolation of plant pathogens: Fungi, bacteria and viruses; Purification of plant pathogens; Study on plant disease diagnosis: Koch's Postulates, Characteristics, formulation, methods of application and calculation on fungicides.

Suggested Readings

1. Agrios G N. 2010. *Plant Pathology*. Acad. Press.
2. Alexopoulos Constantine J, Mims Charles W and Blackwell Meredith M. 2007. *Introductory Mycology*. (4th Edn.). Wiley India Pvt. Ltd.
3. Dhingra O D and Sinclair J B. 2019. *Basic Plant Pathology Methods*. (2nd Edn.). CRC Press, London.
4. Goto M. 1990. *Fundamentals of Plant Bacteriology*. Academic Press, New York.
5. Hull R. 2002. *Mathew's Plant Virology*. (4th Edn.). Academic Press, New York.
6. Mehrotra R S and Aggarwal A. 2007. *Plant Pathology*. (7th Edn.). Tata Mc Graw Hill Publ. Co. Ltd.
7. Nene Y L and Thapliyal P N. 1993. *Fungicides in Plant Disease Control*. (3rd Edn.). Oxford & IBH, New Delhi.
8. Rajeev K and Mukherjee R C. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.
9. Singh R S. 2008. *Plant Diseases*. (8th Edn.). Oxford & IBH. Pub. Co.
10. Singh R S. 2013. *Introduction to Principles of Plant Pathology*. Oxford and IBH Pub. Co.

National Cadet Corps (NCC-II) 1 (0+1)

- Arms Drill-Attention, stand at ease, stand easy. Getting on parade. Dismissing and falling out. Ground/take up arms, examine arms. Shoulder from the order and vice-versa, present from the order and vice-versa. Saluting at the shoulder at the halt and on the march. Short/ long trail from the order and vice-versa. Guard mounting, guard of honor, Platoon/Coy Drill.
- Characteristics of rifle (.22/.303/SLR), ammunition, fire power, stripping, assembling, care, cleaning, and sight setting. Loading, cocking, and unloading. The lying position and holding.
- Trigger control and firing a shot. Range Procedure and safety precautions. Aiming and alteration of sight. Theory of groups and snap shooting. Firing at moving targets. Miniature range firing. Characteristics of Carbine and LMG.
- Introduction to map, scales, and conventional signs. Topographical forms and technical terms.

- The grid system. Relief, contours, and gradients. Cardinal points and finding north. Types of bearings and use of service protractor. Prismatic compass and its use. Setting a map, finding north and own position. Map to ground and ground to map. Knots and lashings, Camouflage and concealment, Explosives and IEDs.
- Field defenses obstacles, mines and mine lying. Bridging, waterman ship. Field water supplies, tracks and their construction. Judging distance. Description of ground and indication of landmarks. Recognition and description of target. Observation and concealment. Field signals. Section formations. Fire control orders. Fire and movement. Movement with/without arms. Section battle drill. Types of communication, media, latest trends and developments.

National Service Scheme (NSS-II) 1 (0+1)

- Importance and role of youth leadership
- Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership, Life competencies
- Definition and importance of life competencies, problem-solving and decision-making interpersonal communication. Youth development programs
- Development of youth programs and policy at the national level, state level and voluntary sector; youth-focused and youth-led organizations
- Health, hygiene and sanitation. Definition needs and scope of health education; role of food, nutrition, safe drinking water, water borne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programs and reproductive health. Youth health, lifestyle, HIV AIDS and first aid. Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid. Youth and yoga. History, philosophy, concept, myths, and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method.

Post-Semester II (Only for exit option for award of UG-Certificate in Agriculture)

S. No.	Course Title	Credit Hours
SCE 121	Internship (10 weeks)	10 (0+10)

Semester III

Entrepreneurship Development and Business Communication 3 (2+1)

Objectives

i. To provide student an insight into the concept and scope of entrepreneurship

ii. To expose the student to various aspects of establishment and management of a small business unit

iii. To enable the student to develop financially viable agribusiness proposal

Theory

Development of entrepreneurship, motivational factors, social factors, environmental factors, characteristics of entrepreneurs, entrepreneurial attributes/competencies. Concept, need

for and importance of entrepreneurial development. Evolution of entrepreneurship, objectives of entrepreneurial activities, types of entrepreneurs, functions of entrepreneurs, importance of entrepreneurial development, and process of entrepreneurship development. Environment scanning and opportunity identification need for scanning: spotting of opportunity, scanning of environment identification of product / service: starting a project; factors influencing sensing the opportunities. Infrastructure and support systems: good policies, schemes for entrepreneurship development; role of financial institutions, and other agencies in entrepreneurship development. Steps involved in functioning of an enterprise. Selection of the product / services, selection of form of ownership; registration, selection of site, capital sources, acquisition of manufacturing know how, packaging and distribution. Planning of an enterprise, project identification, selection, and formulation of project; project report preparation, Enterprise Management. Production management: product, levels of products, product mix, quality control, cost of production, production controls, Material management. Production management: raw material costing, inventory control. Personal management: manpower planning, labour turn over, wages / salaries. Financial management /accounting: funds, fixed capital and working capital, costing and pricing, long term planning and short-term planning, book keeping, journal, ledger, subsidiary books, annual financial statement, taxation. Marketing management: market, types, marketing assistance, market strategies. Crisis management: raw material, production, leadership, market, finance, natural etc.

Practical

Visit to small scale industries/agro-industries, Interaction with successful entrepreneurs/ agric-entrepreneurs. Visit to financial institutions and support agencies. Preparation of project proposal for funding by different agencies.

Suggested Readings

1. Charantimath P M. 2009. *Entrepreneurship Development and Small Business Enterprises*. Pearson Publications, New Delhi.
2. Desai Vasant. 1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publ. House.
3. Desai V. 2015. *Entrepreneurship: Development and Management*. Himalaya Publishing House.
4. Gupta C B. 2001. *Management Theory and Practice*. Sultan Chand & Sons.
5. Grover Indu. 2008. *Handbook on Empowerment and Entrepreneurship*. Agrotech Public Academy.
6. Khanka S S. 1999. *Entrepreneurial Development*. S. Chand & Co.
7. Mehra P. 2016. *Business Communication for Managers*. Pearson India, New Delhi.
8. Pandey M and Tewari D. 2010. *The Agribusiness Book*. IBDC Publishers, Lucknow.
9. Singh D. 1995. *Effective Managerial Leadership*. Deep & Deep Publ.
10. Singhal R K. 2013. *Entrepreneurship Development & Management*. Katson Books.
11. Tripathi P C and Reddy P N. 1991. *Principles of Management*. Tata McGraw Hill.

Physical Education, First Aid, Yoga Practices and Meditation 2 (0+2)

Objectives

i. To make the students aware about Physical Education, First Aid and Yoga Practices.

ii. To disseminate the knowledge and skill on how to perform physical training, perform first aid and increase stamina and general wellbeing through yoga.

Practical

Physical education; Training and Coaching - Meaning and Concept; Methods of Training; aerobic and aerobic exercises; Calisthenics, weight training, circuit training, interval training, Fartlek training; Effects of Exercise on Muscular, Respiratory, Circulatory and Digestive systems; Balanced Diet and Nutrition: Effects of Diet on Performance; Physiological changes due to ageing and role of regular exercise on ageing process; Personality, its dimensions and types; Role of sports in personality development; Motivation and Achievements in Sports; Learning and Theories of learning; Adolescent Problems and its Management; Posture; Postural Deformities; Exercises for good posture.

- Yoga; History of Yog, Types of Yog, Introduction to Yog.
- Asanas (Definition and Importance) Padmasan,san, Vajrajasan, Shashankasan, Pashchimotasan, Ushtrasan, Tadasan, Padhastasan, Ardhchandrasan, Bhujangasan, Utanpadasan, Sarvangasan, Parvatasan, Patangasan, Shishupalanasan – left leg-right leg, Pavanmuktasan, Halasan, Sarpasan, Ardhdhanurasan, Sawasan
- Suryanamskar Pranayama (Definition and Importance) Omkar, Suryabhedan, Chandrabhedan, Anulom Vilom, Shitali, Shitkari, Bhastrika, Bhramari
- Meditation (Definition and Importance), Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandh
- Mudras (Definition and Importance) Gyanmudra, Dhyanmudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra
- Role of yoga in sports
- Teaching of Asanas – demonstration, practice, correction and practice.

History of sports and ancient games, Governance of sports in India; Important national sporting events; Awards in Sports; History, latest rules, measurements of playfield, specifications of equipment, skill, technique, style and coaching of major games (Cricket, football, table Tennis, Badminton, Volleyball, Basketball, Kabaddi and Kho-Kho) and Athletics

Need and requirement of first aid. First Aid equipment and upkeep. First aid Techniques, First aid related with Respiratory system. First aid related with Heart, Blood and Circulation. First aid related with Wounds and Injuries. First aid related with Bones, Joints Muscle related injuries. First aid related with Nervous system and Unconsciousness. First aid related with Gastrointestinal Tract. First aid related with Skin, Burns. First aid related with Poisoning. First aid related with Bites and Stings. First aid related with Sense organs, Handling and transport of injured traumatized persons. Sports injuries and their treatments.

Principles of Genetics 3 (2+1)

Objective

To make the students acquainted with both principles and practices in the areas of classical genetics, modern genetics, quantitative genetics and cytogenetics.

Theory

Pre and post Mendelian concepts of heredity, Mendelian principles of heredity, Study of model organisms (Drosophila, Arabidopsis, Garden pea, *E. coli*, and mice), Architecture of chromosomes, chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere, special types of chromosomes, Chromosomal theory of inheritance-cell cycle and cell division-mitosis and meiosis. Probabilit and Chi-square. Types of DNA and RNA, Dominance relationships, Epistatic interactions with example, Introduction and definition of cytology, genetics and cytogenetics and their interrelation.

Multiple alleles, pleiotropism and pseudoalleles, Sex determination and sex linkage, sex limited and sex influenced traits, Blood group genetics, Linkage and its estimation, crossing over mechanism, chromosome mapping, Structural and numerical variations in chromosomes and their implications, Use of haploids, dihaploids and double haploids in Genetics, Mutation, classification, Methods of inducing mutations, mutagenic agents and induction of mutation. Qualitative and quantitative traits, Polygenes and continuous variations, multiple factor hypothesis, Cytoplasmic inheritance, Nature, structure and replication of genetic material, Protein synthesis, Transcription and translational mechanism of genetic material, Gene concept: Gene structure, function and regulation.

Practical

Study of microscope, Study of cell structure, Mitosis and Meiosis cell division, Experiments on monohybrid, dihybrid, trihybrid, test cross and back cross, Experiments on epistatic interactions including test cross and back cross, Practice on mitotic and meiotic cell division, Experiments on probability and chi-square test, Determination of linkage and croo-over analysis (through two point test cross data), Study on sex linked inheritance in Drosophila. Study on models on DNA and RNA structures.

Suggested Readings

1. Gardner E J, Simmons M J and Snustad D P. 2006. *Principles of Genetics*. (8th Edn.). John Wiley & Sons.
2. Singh B D. 2022. *Fundamentals of Genetics*. (6th Edn.).Medtech Science Press
3. Sinnott E W, Dunn L C and Dobzhansky Theodosius. 1958. *Principles of Genetics*. McGraw-Hill Inc., US
4. Strickberger M W. 2015. *Genetics*. (3rd Edn.). Pearson Education India

Crop Production Technology-I (*Kharif* Crops) 3 (1+2)

Objectives

i. To impart basic and fundamental knowledge on principles and practices of kharif crop production
ii. To impart knowledge and skill on scientific crop production and management

Theory

Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield of *Kharif* crops. Cereals- rice, maize, sorghum, pearl millet, finger millet and other minor millets, pulses- pigeonpea, mungbean and urdbean; oilseeds- groundnut, soybean, sesame, castor; fibre crops- cotton and jute; forage crops- sorghum, cowpea, cluster bean, maize, guinea and napier.

Practical

Rice nursery preparation, transplanting of rice, sowing of soybean, pigeon pea and mungbean, maize, groundnut and cotton, effect of seed size on germination and seedling vigour of *Kharif* crops, effect of sowing depth on germination of *Kharif* crops, identification of weeds in *Kharif* crops, top dressing and foliar feeding of nutrients, study of yield contributing characters and yield calculation of *Kharif* crops, study of crop varieties and important agronomic experiments at experiential farm, recording biometric observations, Study of forage experiments, morphological description of *Kharif* crops, silage and hay making, visit to research centres of related crops.

***Practical Crop Production- One (1) credit from practical of the course is allotted for Practical Crop Production of selected *kharif* crops covered under this course.**

Suggested Readings

1. Chidda Singh.1997. *Modern Techniques of Raising Field Crops*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Gurarajan B, Balasubramanian R and Swaminathan V. 2018. *Recent Strategies on Crop Production*. (2nd Edn.). Kalyani Publishers, New Delhi.
3. Rajendra Prasad. 2017. *Textbook of Field Crops Production - Commercial Crops (Volume II)*. ICAR Publication.
4. Reddy S R. 2009. *Agronomy of Field Crops*. Kalyani Publishers, New Delhi.
5. Singh S S. 2005. *Crop Management*. Kalyani Publishers, New Delhi.
6. Subhash Chandra Bose M and Balakrishnan V. 2001. *Forage Production*. South Asian Publishers, New Delhi.

Production Technology of Fruit and Plantation Crops 2 (1+1)

Objectives

i. To educate about the different forms of classification of fruit crops
ii. To educate about the origin, area, climate, soil, improved varieties and cultivation practices of fruit and plantation crops
iii. To educate about the physiological disorders of fruit crops, palms and plantation crops

Theory

Production status of fruit and plantation crops: Importance and scope of fruit and plantation crop industry in India; nutritional value of fruit crops; classification of fruit crops; area, production, productivity and export potential of fruit and plantation crops. Crop production techniques in

tropical, sub-tropical and temperate fruit crops: Climate and soil requirements, varieties, propagation and use of rootstocks, planting density and systems of planting: High density and ultra-high density planting, cropping systems, after care – training and pruning; water, nutrient and weed management, fertigation, special horticultural techniques, plant growth regulation, important disorders, maturity indices and harvest, value addition.

Fruit crops: mango, banana, papaya, guava, sapota, citrus, grape, litchi, pineapple, pomegranate, apple, pear, peach, strawberry, nut crops Jackfruit and minor fruits- date, ber, apple, plantation crops-coconut, arecanut, cashew, tea, coffee and rubber.

Crop production techniques in palms and plantation crops: Climate and soil requirements, varieties, propagation, nursery management, planting and planting systems, cropping systems, after care, training and pruning for plantation crops, water, nutrient and weed management, intercropping, multi-tier cropping system, mulching, special horticultural practices, maturity indices, harvest and yield, pests and diseases, processing- value addition

Palms: Coconut, Arecanut, Oil palm and Palmyrah, Plantation crops: Tea, Coffee, Cocoa, Cashewnut, Rubber.

Practical

Propagation techniques, selection of planting material, varieties, important cultural practices for mango, banana, papaya, guava, sapota, grapes, Citrus (mandarin and acid lime), pomegranate, jackfruit, preparation and application of PGR's for propagation, Micro propagation, protocol for mass multiplication and hardening of fruit crops, Identification and description of varieties, mother palm and seed nut selection, nursery practices, seedling selection, fertilizers application, nutritional disorders, pests and diseases of Coconut, Arecanut and cocoa, Tea and coffee, Rubber and cashew, Visit to commercial orchard and plantation industries.

Suggested Readings

1. Banday F A and Sharma M K. 2010. *Advances in temperate fruit production*. Kalyani Publishers, Ludhiana.
2. Bose T K, Mitra S K and Sanyal D. 2001. *Fruits: Tropical and Subtropical (2 volumes)* Naya Udyog, Calcutta.
3. Bose T K, Mitra S K, Farooqi A A and Sadhu M K. (Eds). 1999. *Tropical Horticulture Vol.1*. Naya Prokash, Calcutta.
4. Chadha T R. 2001. *Textbook of temperate fruits*. ICAR, New Delhi
5. Chattopadhyay T K. 2001. *A Text Book on Pomology (4 volumes)*. Kalyani Publishers, Ludhiana.
6. Chattopadhyay T K. 1998. *A Textbook on Pomology (sub-tropical fruits) vol.III*. Kalyani Publishers, Ludhiana.
7. Das B C and Das S N. 2003. *Cultivation of minor fruits*. Kalyani Publishers, Ludhiana.
8. Dhillon W S. 2013. *Fruit production in India*. Narendra Publishing House, New Delhi.
9. Kavino M, Jegadeeswari V, Vijayakumar R M and Balkrishnan S. 2018. *Production Technology of Fruits and Plantation Crops*. Narendra Publishing House.
10. Ponnuswami V, Kumar M, Kumar S Ramesh and Krishnamoorthy C. 2015. *Fruit and Plantation Crops*. Narendra Publishing House.

11. Radha T and Mathew L. 2007. *Fruit crops*. New India Publishing Agency.

12. Sadhu M K and Chattopadhyay P K. 2001. *Introductory Fruit Crops*. Naya Prokash, Calcutta.

13. Sharma A, Kumar P, Tripathi V K. 2024. *Production Technology of Fruits and Plantation Crops*. Elite Publishing House.

14. Singh H P and Mustafa M M. 2009. *Banana – New Innovations*. Westville Publishing House, New Delhi.

15. Singh S P. 2004. *Commercial Fruits*. Kalyani Publishers, Ludhiana.

16. Veeraragavathatham D, Jawaharlal M, Jeeva S, Rabindran R and Umapathy G. 2004. *Scientific fruit culture*. (2nd Edn.). Suri Associates, 1362/4, Velraj Vihar Complex, Thadagam Road, Coimbatore-2 .

Fundamentals of Extension Education **2 (1+1)**

Objectives

i. Classify the types of extension teaching methods

ii. Elaborate the importance and different models of communication

iii. Explain the process and stages of adoption along with adopters' categories

iv. Familiarize with the different types of agriculture and rural development programs launched by govt. of India

v. State the importance of extension education in agriculture

Theory

Education: Meaning, definition and Types; Extension Education: meaning, definition, scope and process; objectives and principles of Extension Education; Extension Programme planning: Meaning, Process, Principles and Steps in Programme Development. Extension systems in India: extension efforts in pre-independence era (Sriniketan, Marthandam, Firka Development Scheme, Gurgaon Experiment, etc.) and post-independence era (Etawah Pilot Project, Nilokheri Experiment, etc.); Reorganised Extension System (T&V system) various extension/ agriculture development programs launched by ICAR/Govt. of India (IADP, IAAP, HYVP, KVK, IVLP, ORP, ND, NATP, NAIP, etc.). Social Justice and poverty alleviation programme: ITDA, IRDP/SGSY/NRLM. Women Development Programme: RMK, MSY etc. New trends in agriculture extension: privatization extension, cyber extension/ e-extension, market-led extension, farmer-led extension, expert systems, etc., Attributes of Innovation, DWCRA, Commodity Interest Groups (CIGs)., Farmers Producer Group (FPG).

Rural Development: concept, meaning, definition; various rural development programs launched by Govt. of India. Community Development: meaning, definition, concept and principles, Philosophy of C.D. Rural Leadership: concept and definition, types of leaders in rural context; Method of identification of Rural Leader. Extension administration: meaning and concept, principles and functions. Monitoring and evaluation: concept and definition, monitoring and evaluation of extension programs; transfer of technology: concept and models, capacity building of extension personnel; extension teaching methods: meaning, classification, individual, group and mass contact methods, ICT Applications in TOT (New and Social Media), media mix

strategies; communication: meaning and definition; Principles and Functions of Communication, models and barriers to communication. Agriculture journalism; diffusion and adoption of innovation: concept and meaning, process and stages of adoption, adopter categories.

Practical

To get acquainted with university extension system. Group discussion- exercise; Identification of rural leaders in village situation; preparation and use of AV aids, preparation of extension literature (leaflet, booklet, folder, pamphlet news stories and success stories); Presentation skills exercise; micro teaching exercise; A visit to village to understand the problems being encountered by the villagers/ farmers; to study organization and functioning of DRDA/PRI and other development departments at district level; visit to NGO/FO/FPO and learning from their experience in rural development; understanding PRA techniques and their application in village development planning; exposure to mass media: visit to community radio and television studio for understanding the process of programme production; script writing, writing for print and electronic media, developing script for radio and television.

Suggested Readings

1. Adivi Reddy A. 2001. *Extension Education*. Sree Lakshmi Press, Bapatla.
2. Dudhani C M, Hirevenkatgoudar L V, Manjunath L, Hanchinal S N and Patil S L. 2004. *Extension Teaching Methods and Communication Technology*. UAS, Dharwad.
3. Jalihal K A and Veerabhadraiah V. 2007. *Fundamentals of Extension Education and Management in Extension*. Concept Publishing Company, New Delhi.
4. Mondal Sagar and Ray G L. 2017. *Text Book on Rural Development, Entrepreneurship and Communication Skills*. (2nd Edn.). Kalyani Publications.
5. Rathore O S, Chauhan M S, Dhakar S D and Ojha S N. 2012. *Handbook of Extension Education*. Agrotech Publishing Academy, Udaipur.
6. Sandhu A S. 1993. *Textbook on Agricultural Communication: Process and Methods*. Oxford and IBH Publishing Pvt. Ltd, New Delhi.
7. Singh A K, Lakhan Singh R and Burman R R. 2006. *Dimensions of Agricultural Extension*. Aman Publishing House, Meerut.

Fundamentals of Nematology 2 (1+1)

Objectives

i. To impart knowledge on history, economic importance of plant parasitic nematodes, morphology, biology, host parasitic relationship of nematodes.

ii. To impart knowledge on nematode pests of different crops of national and local importance and their management.

Theory

Introduction: History of phytonematology, habitat and diversity, economic importance of nematodes. General characteristics of plant parasitic nematodes. Nematode: definition, general morphology and biology. Classification of nematodes up to family level with emphasis on groups containing economically important genera. Classification of nematodes on the basis of feeding/ parasitic habit. Symptomatology, role of nematodes in disease development, Interaction between

plant parasitic nematodes and disease-causing fungi, bacteria and viruses. Nematode pests of crops: Rice, wheat, vegetables, pulses, oilseed and fiber crops, citrus and banana, tea, coffee and coconut. Different methods of nematode management: Cultural methods, physical; methods, Biological methods, Chemical methods, Plant Quarantine, Plant resistance and INM.

Practical

Sampling methods, collection of soil and plant samples; Extraction of nematodes from soil and plant tissues following Cobb's sieving and decanting technique, Baermann funnel technique, Picking and counting of plant parasitic nematode. Identification of economically important plant nematodes up to generic level with the help of keys and description: Meloidogyne, Pratylenchus; Heterodera, Tylenchulus, Xiphinema, and Helicotylenchus etc. Study of symptoms caused by important nematode pests of cereals, vegetables, pulses, plantation crops etc. Methods of application of nematicides and organic amendments.

Suggested Readings

1. Swarup Gopal, Dasgupta D R, Koshy P K. 1986. *Plant Parasitic Nematodes of India: Problems and Progress*. Indian Agricultural Research Institute, New Delhi
2. Walia R K and Bajaj H K. 2020. *Textbook on Introductory Plant Nematology*. (5th Edition) Indian Council of Agricultural Research, New Delhi.
3. Webster J M. 1972. *Economic Nematology*. London New York Academic Press.
4. Zukerman B M, Mai W F and Rohde R A. 1971. *Plant Parasitic Nematodes (Vol-1) : Morphology, Anatomy, Taxonomy and Ecology*. Academic Press.

Principles and Practices of Natural Farming 2 (1+1)

Objectives

i. To provide comprehensive understanding and knowledge to students about natural farming.
ii. To teach students the concept, need and principles of native ecology-based production under natural farming.
iii. To impart practical knowledge of natural farming and related agricultural practices in Indian and global environmental and economic perspectives.

Theory

Indian Heritage of Ancient Agriculture, History of Natural Farming, Importance of natural farming in view of climate change, soil health, water use carbon sequestration, biodiversity conservation, food security and nutritional security, and sustainable development goals (SDGs), Concept of natural farming; Definition of natural farming; Objective of natural farming, Essential characteristics and Principles of natural farming; Scope and importance of natural farming. Main Pillars of natural farming; Methods/ types/schools of natural farming. Characteristics and design of a natural farm, Concept of ecological balance, ecological engineering and community responsibility in natural versus other farming systems, Introduction to concept of ecological, water, carbon and nitrogen foot prints, Concept and evaluation of ecosystem services, integration of crops, trees and animals, cropping system approaches, Biodiversity, indigenous seed production, farm waste recycling, water conservation and renewable energy use approaches on a natural farm, Rearing practices for animals under natural farming, Nutrient management in natural farming and their sources, Insect,

pest, disease and weed management under natural farming; Mechanization in natural farming, Processing, labelling, economic considerations and viability, certification and standards in natural farming, marketing and export potential of natural farming produce and products. Initiatives taken by Government (central/state), NGOs and other organizations for promotion of natural farming and chemical free agriculture, Case studies and success stories in natural farming and chemical free traditional farming, Entrepreneurship opportunities in natural farming.

Practical

Visit of natural farm and chemical free traditional farms to study the various components and operations of natural farming principles at the farm; Indigenous technical knowledge (ITK) for seed, tillage, water, nutrient, insect-pest, disease and weed management; On-farm inputs preparation methods and protocols, Studies in green manuring in-situ and green leaf manuring, Studies on different types of botanicals and animal urine and dung based non-aerated and aerated inputs for plant growth, nutrient, insect and pest and disease management; Weed management practices in natural farming; Techniques of Indigenous seed production- storage and marketing, Partial and complete nutrient and financial budgeting in natural farming; farming; Evaluation of ecosystem services in natural farming (Crop, Field and System).

Suggested Readings

1. Ayachit S M. 2002. *Kashyapi Krishi Sukti (A Treatise on Agriculture by Kashyapa)*. Agri-History Bulletin No.4. Asian Agri-History Foundation.
2. Boeringa R. (Ed.). 1980. *Alternative Methods of Agriculture*. Elsevier, Amsterdam.
3. Dabholkar Shripad A and Prayog Pariwar. 2021. *Plenty for All: Natural Farming A to Z Prayog Pariwar Methodology*. Mehta Publishing House, 1941, Sadashiv Peth, Madiwale Colony, Pune.
4. Faires Nicole. 2016. *The Ultimate Guide to Natural Farming and Sustainable Living: Permaculture for Beginners (Ultimate Guides*). Skyhorse Pub Co Inc.
5. FAO. 2018. *The 10 elements of agro-ecology: Guiding the transition to sustainable food and agricultural system*. FAO. https://www.fao.org/3/i9037en/i9037en.pdf
6. Khurana A and Kumar V. 2020. *State of Organic and Natural Farming: Challenges and Possibilities*. Centre for Science and Environment, New Delhi.
7. Lindenmayer David B, Macbeth Suzannah M, et al. 2022. *Natural Asset Farming: Creating Productive and Biodiverse Farms*. CSIRO Publishing.
8. Malhotra R and Babaji S D. 2020. *Sanskrit Non Translatable- The importance of Sanskritizing English*. Amaryllis, New Delhi India.
9. Nalini S. 1999. *Krishi-Parashara (Agriculture by Parashara)*. Parashara, Brig Sayeed Road, Secunderabad, Telangana: AAHF Classic Bulletin, Asian Agri-History Foundation.
10. Nalini S. 2011. *Upavana Vinoda (Woodland Garden for Enjoyment) by Sarangdhara (13th century CE)*. (AAHF Classic Bulletin 8). Asian Agri-History Foundation, Brig Sayeed Road, Secunderabad, AP (now Telangana), India.
11. Tirado Reyes. 2015. *Ecological Farming – The Seven principles of a food system that has people at its heart*. Baker, M., Kramb, D. [Eds]. Publ. Greenpeace International.
12. Behera U K. 2013. *A Textbook of Farming System*. Agrotech Publishing House, Udaipur.
15. आचार्य देवव्रत 2019 प्राकृतिक कृषि। प्रकाशकः राजभवन शिमला।

Semester IV

Agricultural Informatics and Artificial Intelligence (AI) 3(2+1)

Objectives

i. To acquaint student with the basics of computer applications in agriculture, multimedia, database management, application of mobile app and decision- making processes, etc.

ii. To provide basic knowledge of computer with applications in Agriculture

iii. To make students familiar with Agricultural-Informatics, its components and applications in agriculture

Theory

Introduction to Computers, Anatomy of Computers, Memory Concepts, Units of Memory, Operating System: Definition and types, Applications of MS-Office for creating, Editing and Formatting a document, Data presentation, Tabulation and graph creation, Statistical analysis, Mathematical expressions, Database, concepts and types, creating data base, Uses of DBMS in Agriculture. Internet and World Wide Web (WWW): Concepts and components.

Computer programming: General concepts, Introduction general programming concepts. Concepts and standard input/output operations. e-Agriculture, Concepts, design and development, Application of innovative ways to use information and communication technologies (IT) in Agriculture. Computer Models in Agriculture: Statistical, weather analysis and crop simulation models, concepts, inputs-outputs files, limitation, advantages and application of models for understanding plant processes, sensitivity, verification, calibration and validation, IT applications for computation of water and nutrient requirement of crops, Computer-controlled devices (automated systems) for Agri-input management. Smartphone mobile apps in agriculture for farm advice: Market price, post-harvest management etc. Geospatial technology: Concepts, techniques, components and uses for generating valuable agri-information. Decision support systems: Concepts, components and applications in Agriculture. Agriculture Expert System, Soil Information Systems etc., for supporting farm decisions. Preparation of contingent crop-planning and crop calendars using IT tools. Digital India and schemes to promote digitalization of agriculture in India.

Introduction to artificial intelligence, background and applications, Turing test. Control strategies, Breadth-first search, Depth-first search, Heuristics search techniques: Best-first search, A* algorithm, IoT and Big Data; Use of AI in agriculture for autonomous crop management, and health, monitoring livestock health, intelligent pesticide application, yield mapping and predictive analysis, automatic weeding and harvesting, sorting of produce, and other food processing applications; Concepts of smart agriculture, use of AI in food and nutrition science etc.

Practical

Study of computer components, accessories, practice of important DOS Commands, Introduction of different operating systems such as Windows, Unix/Linux, creating files and folders, File Management .Use of MS-Word and MS Power-point for creating, editing and presenting a scientific documents, MS-EXCEL-Creating a spreadsheet, Use of statistical tools,

Writing expressions, Creating graphs, Analysis of scientific data, MS-ACCESS: Creating Database, preparing queries and reports, Demonstration of Agri- information system, Introduction to World Wide Web (WWW) and its components, Introduction of programming languages such as Visual Basic, Java, Fortran, C, C++, Hands on practice on Crop Simulation Models (CSM), DSSAT/Crop-Info/Crop Syst/ Wofost, Preparation of inputs file for CSM and study of model outputs, computation of water and nutrient requirements of crop using CSM and IT tools, Use of smartphones and other devices in agro-advisory and dissemination of market information, Introduction of Geospatial technology, AR/VR demonstration, Preparation of contingent crop planning, India Digital Ecosystem of Agriculture (IDEA).

Suggested Readings

1. Date C J. 2000. An Introduction to Database Management System. Addison-Wesley.
2. ITL. 2012. Introduction to Information Technology. (2nd Edn.). Pearson Education India.
3. Mahapatra Subrat Kumar, Mishra Prasannajit and Pradhan Jayashankar. 2022 Introductory Agri-Informatics. (2nd Edn.).Jain Brothers Publication..
4. Rajaroman V and Adabala Neeharika. 2014. Fundamentals of Computer. (6th Edn.). PHI Learning.
5. Sethi Dhabal Prasad and Pradhan Manoranjan. 2017. Concepts and Techniques of Programming in C. TechSar Pvt. Ltd.

Production Technology of Vegetables and Spices 2(1+1)

Objectives

i. To educate about the different forms of classification of vegetables
ii. To educate about the origin, area, climate, soil, improved varieties and cultivation practices of vegetables and spices
iii. To educate about the physiological disorders of vegetables and spices

Theory

Importance of vegetables and spices in human nutrition and national economy, kitchen gardening, brief about origin, area, climate, soil, improved varieties and cultivation practices such as time of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders of important vegetable and spices (tomato, okra, brinjal, chili, capsicum, cucumber, bitter gourd , bottle gourd, sweet potato, cassava and moringa, pumpkin, French bean, peas; cole crops such as cabbage, cauliflower, knol-khol; bulb crops such as onion, garlic; root crops such as carrot, radish, beetroot; tuber crops such as potato; leafy vegetables such as amaranth, palak, perennial vegetables, spice crops like turmeric, zinger, garlic, coriander, cumin, black pepper, cardamom, fenugreek, fennel, clove, nutmeg, cinnamon, curry leaf, tamarind and herbal spices.

Practical

Identification of vegetables and spice crops and their seeds. Description of varieties. Propagation methods - rapid multiplication techniques - seed collection and extraction. Nursery raising. Direct seed sowing and transplanting. Study of morphological characters of different

vegetables and spices. Fertilizers applications. Harvesting and post-harvest practices, Economics of vegetables and spices cultivation**,** visit to spice gardens.

Suggested Readings

1. Anant Bahadur and Singh K P. 2014. *Olericulture, Fundamentals of Vegetable Production (Vol.1)*. Kalyani Publishers, Chennai.
2. Fagaria M S, Choudhury B R and Dhaka R S. 2016. *Vegetable Crops Production Technology (Vol. II)*. Kalyani Publishers.
3. Kabir J, Bose T K and Som M G. 2021. *Vegetable crops*. (4th Edn.). Astral Publishing Authors Across the Globe.

Principles of Agricultural Economics and Farm Management 2 (2+0)

Objectives

i. To make students aware of broad areas covered under agricultural economics and farm management
ii. To impart knowledge on judicious use of resources for optimum production

Theory

Economics: Meaning, scope and subject matter, definitions, activities, approaches to economic analysis; micro-and macro-economics, positive and normative analysis. Nature of economic theory; rationality assumption, concept of equilibrium, economic laws as generalization of human behavior. Basic concepts: Goods and services, desire, want, demand, utility, cost and price, wealth, capital, income and welfare. Agricultural economics: meaning, definition, characteristics of agriculture, importance and its role in economic development. Agricultural planning and development in the country. Demand: meaning, law of demand, demand schedule and demand curve, determinants, utility theory; law of diminishing marginal utility, equi-marginal utility principle. Consumer's equilibrium and derivation of demand curve, concept of consumer surplus. Elasticity of demand: concept and measurement of price elasticity, income elasticity and cross elasticity. Production: process, creation of utility, factors of production, input output relationship. Laws of returns: Law of variable proportions and law of returns to scale. Cost: Cost concepts, short run and long run cost curves. Supply: Stock v/s supply, law of supply, supply schedule, supply curve, determinants of supply, elasticity of supply. Distribution theory: meaning, factor market and pricing of factors of production. Concepts of rent, wage, interest and profit. National income: Meaning and importance, circular flow, concepts of national income accounting and approaches to measurement, difficulties in measurement. Population: Importance, Malthusian and Optimum population theories, natural and socio-economic determinants, current policies and programs on population control. Money: Barter system of exchange and its problems, evolution, meaning and functions of money, classification of money, money supply, general price index, inflation and deflation. Economic systems: Concepts of economy and its functions, important features of capitalistic, socialistic and mixed economies, elements of economic planning. Forms of business organizations, international trade and balance of payments. GST and its implication on Indian economy.

Suggested Readings

1. Johl S S and Kapur T R. 2009. *Fundamentals of Farm Business Management*. Kalyani Publishers.
2. Reddy S Subha, Raghu Ram P, Neelakanta T V and Bhvani Devi I. 2004. *Agricultural Economics*. Oxford & IBH publishing Co. Pvt. Ltd.

Crop Production Technology-II (*Rabi* Crops) 3 (1+2)

Objectives

i. To impart basic and fundamental knowledge on principles and practices of *rabi* crop production.
ii. To impart knowledge and skill on scientific crop production and management.

Theory

Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield of *Rabi* crops. Cereals- wheat and barley. Pulses- chickpea, lentil, peas. *Rabi* redgram and, rajmash. Oilseed- rapeseed, mustard, sunflower, safflower; and linseed. Sugar crops-sugarcane and sugar beet. Medicinal and aromatic crops- mentha, lemon grass and citronella. Forage crops –barseem, lucerne and oat; potato, quinoa, tobacco.

Practical

Sowing methods of wheat and sugarcane; identification of weeds in *rabi* season crops; study of morphological characteristics of *rabi* crops; study of yield contributing characters of *rabi* season crops; yield and juice quality analysis of sugarcane; study of important agronomic experiments of *rabi* crops at experimental farms; study of *rabi* forage experiments; oil extraction of medicinal crops; visit to research stations of related crops.

* **Practical Crop Production-One (1) credit from practical of the course is allotted for Practical Crop Production of selected *rabi* crops covered under this course.**

Suggested Readings

1. Gurarajan B, Balasubramanian R and Swaminathan V. 2008. *Recent Strategies on Crop Production*. Kalyani Publishers, New Delhi.
2. Prasad Rajendra. 2002. *Textbook of Field Crops Production*. ICAR, New Delhi.
3. Prasad Rajendra. 2012. *Textbook of Field Crops Production - Foodgrain Crops (Volume I)*. ICAR Publication.
4. Prasad Rajendra. 2017. *Textbook of Field Crops Production - Commercial Crops. (Volume II)*. ICAR Publication.
5. Reddy S R. 2004. *Agronomy of Field Crops*. Kalyani Publishers, Ludhiana.
6. Reddy S R. 2009. *Agronomy of Field Crops*. Kalyani Publishers, New Delhi.
7. Singh Chidda, Singh Rajbir and Singh Prem. 2025. *Modern Techniques of Raising Field Crops*. (4th Edn.). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
8. Singh S S. 2005. *Crop Management*. Kalyani Publishers, New Delhi.
9. Subhash Chandra Bose M and Balakrishnan V. 2001. *Forage Production*. South Asian Publishers, New Delhi.
10. UAS Bangalore. 2011. *Package of Practice*. UAS, Bengaluru.

Farm Machinery and Power 2 (1+1)

Objective

To enable the students to understand the need of farm power, basic principles and parts of IC engine, different tillage, sowing, intercultural, plant protection equipment, working principles of threshers, harvesting of field and horticultural crops.

Theory

Status of Farm Power in India; Sources of Farm Power, I.C. engines, working principles of I C engines; comparison of two stroke and four stroke cycle engines, Study of different components of I.C. engine, I.C. engine terminology and solved problems; Familiarization with different systems of I.C. engines: Air cleaning, cooling, lubrication, fuel supply and hydraulic control system of a tractor; Familiarization with Power transmission system : clutch; gear box, differential and final drive of a tractor; Tractor types; Cost analysis of tractor power and attached implement; Criteria for selection of tractor and machine implements. Familiarization with Primary and Secondary Tillage implement; Implement for hill agriculture; implement for intercultural operations; Familiarization with sowing and planting equipment; calibration of a seed drill and solved examples; Familiarization with Plant Protection equipment; Familiarization with harvesting and threshing equipment.

Practical

Study of different components of I.C. engine. To study air cleaning and cooling system of engine; Familiarization with clutch, transmission, differential and final drive of a tractor; Familiarization with lubrication and fuel supply system of engine; Familiarization with brake, steering, hydraulic control system of engine; Learning of tractor driving; Familiarization with operation of power tiller; Implements for hill agriculture; Familiarization with different types of primary and secondary tillage implements: mould plough, disc plough and disc harrow; Familiarization with seed-cum-fertilizer drills their seed metering mechanism and calibration, planters and trans planter; Familiarization with different types of sprayers and dusters; Familiarization with different inter-cultivation equipment; Familiarization with harvesting and threshing machinery; Calculation of power requirement for different implements.

Suggested Readings

1. Jain S C and Rai C R. 2019. *Farm Tractor Maintenance and Repair*. Standard Publishers, 1705-B, Nai Sarak. Delhi- 110006
2. Ojha T P and Michael A M. 2023. *Principles of Agricultural Engineering (Vol. I)*. (15th Edn.). Jain brothers, 16/893, East Park Road, Karol Bagh, New Delhi -110005.
3. Singh Surendra. 2007. *Farm machinery –Principles and Applications*. ICAR, New Delhi
4. Sahay Jagdiswar. 2020. *Elements of Agricultural Engineering*. Standard Publishers and Distributors Pvt Ltd.

Water Management 2 (1+1)

Objectives

i. To study the important properties of soil affecting water availability to crops and water requirement for optimum growth and development

ii. To study different methods of irrigation and water management practices of both field and horticultural crops and drainage.

iii. To study the soil moisture conservation practices including management of rain water, watershed and command areas.

Theory

Irrigation: definition and objectives; Importance: Function of water for plant growth, water resources and irrigation development for different crops in India; Soil plant water relationships; Available and unavailable soil moisture, distribution of soil moisture, water budgeting, rooting characteristics, moisture extraction pattern, effect of moisture stress on crop growth. Methods of soil moisture estimation, evapotranspiration and crop water requirement; effective rainfall, different approaches of scheduling of irrigation; Methods of irrigation: surface and sub-surface, pressurized methods, viz., sprinkler and drip irrigation, their suitability, merits and limitations, fertigation, economic use of irrigation water; Layout of different irrigation systems, Irrigation efficiency and water use efficiency, conjunctive use of water, irrigation water quality and its management. Water management of different crops (rice, wheat, maize, groundnut, sugarcane, mango, banana and tomato); quality of irrigation water, irrigation management practices for different soils and crops, drip, sprinkler. Layout of underground pipeline system, Irrigation automation, Artificial Intelligence and climate-based irrigation practices and its management.

Practical

Determination of bulk density by field method; Determination of soil moisture content by gravimetric method, tensiometer, electrical resistance block and neutron moisture meter; Determination of field capacity by field method; Determination of permanent wilting point; Measurement of irrigation water by using water measuring devices viz., flumes, weirs, notches, orifices; Calculation of irrigation water requirement (Problems); Determination of infiltration rate; Demonstration of furrow method of irrigation; Demonstration of check basin and basin method of irrigation; Visit to farmers' field and cost estimation of drip irrigation system; Demonstration of filter cleaning, fertigation, injection and flushing of laterals; layout for different methods of irrigation, Erection and operation of sprinkler irrigation system; Measurement of emitter discharge rate, wetted diameter and calculation of emitter discharge variability; Visit to irrigation research centre/ station and visit to command area.

Suggested Readings

1. Carr M K V and Fereres Elias. 2014. *Advances in Irrigation Agronomy*. Cambridge University Press.
2. Michael A M. 2009. *Irrigation Theory and Practice*. (2nd Edn.). Vikas Publishing House Pvt. Ltd.
3. Majumdar Dilip Kumar. 2010. *Irrigation Water Management: Principles and Practice*. Prentice Hall of India Pvt. Ltd.
4. Patil S V and Rajakumar G R. 2016. *Water Management in Agriculture and Horticultural Crops*. Satish Serial Publishing House, Delhi.
5. Rao Y P and Bhaskar S R. 2008. *Irrigation Technology. Theory and Practice*. Agrotech Publishing Academy, Udaipur.

Problematic Soils and their Management 2 (1+1)

Objectives

i. To acquaint the students about various problem soils like degraded soils, acid soils, saline soils, alkali soils, eroded soils, submerged soils, polluted soils. Also to impart knowledge about remote sensing, GIS, Multipurpose tree and Land capability classification

ii. To give hands on training about estimation of various soil and water quality parameters associated with problem soils.

Theory

Soil quality and health, Distribution of Waste land and problem soils in India, Categorization of Problem soils based on properties. Reclamation and management of Acid soils, Saline, Sodic soils, Acid Sulphate soils, Eroded and Compacted soils, polluted soils. Contaminated soils (Pesticide contamination, Heavy metal contamination), Mined soils (Coal mined, Oil mined), Management of Riverine soils, Waterlogged soils, Irrigation water – quality and standards, utilization of saline water in agriculture. Use of Remote sensing and GIS in diagnosis and management of problem soils. Irrigation and water quality. Multipurpose tree (MPT) species, bio remediation through MPTs of soils, land capability and classification, land suitability classification.

Practical

Determination of pHs and EC of saturation extract of problematic soil. Determination of redox potential in soil, Estimation of water soluble and exchangeable cations in soil and computation of SAR and ESP and characterization of problematic soil. Determination of Gypsum requirement of alkali / sodic soil. Determination of lime requirement of acidic soil. Determination of Quality of irrigation water (pH, EC, Ca, Mg, Na, CO_3, HCO_3, Cl, SAR and RSC), Determination of nitrate (NO_3-) from irrigation water, Determination of dissolved oxygen and free carbon dioxide levels in water samples.

Suggested Readings

1. Agarwal R R, Yadav J S P and Gupta R N. 1982. *Saline Alkali soils of India*. ICAR, AGROBIOS (India).
2. Brady Nyle C and Weil Ray R. 2014. *The Nature and Properties of Soils*. Pearson Education Inc., New Delhi.
3. Paul Cirsan J. 1985. *Principles of Remote Sensing*. Longman, New York
4. Indian Society of Soil Science. 2002. *Fundamentals of Soil Science*. IARI, New Delhi.
5. Towhid Osman Khan. 2018. *Management of Soil Problems*. Springer publication
6. Srivastava V C. 2002. *Management of Problem Soils - Principles and Practices*. New Delhi

Basics of Plant Breeding 3 (2+1)

Objective

To acquaint with different techniques ranging from simply selecting plants with desirable characteristics for propagation, to more complex molecular techniques for breeding new varieties, which are higher yielding, resistant to biotic and abiotic stresses for ensuring food security.

Theory

Historical development, concept, nature and role of plant breeding, major achievements and future prospects; Genetics in relation to plant breeding, modes of reproduction and apomixes, self-incompatibility and male-sterility-genetic consequences, cultivar options, Plant genetic resources, its utilization and conservation Domestication, Acclimatization and Introduction. Centres of origin/diversity, Components of Genetic variation. Heritability and genetic advance. Pre-breeding and Universal Plant Breeder's equation. Genetic basis and breeding methods in self-pollinated crops-mass and pure line selection, hybridization techniques and handling of segregating population. Multiline concept, Concepts of population genetics and Hardy-Weinberg Law, Genetic basis and methods of breeding cross-pollinated crops, modes of selection. Population movement schemes- Ear to Row method, Modified Ear to Row, recurrent selection schemes. Heterosis and inbreeding depression, development of inbred lines and hybrids, composite and synthetic varieties. Breeding methods in asexually propagated crops, clonal selection and hybridization. Wide hybridization and pre-breeding. Polyploidy in relation to plant breeding, mutation breeding- methods and uses. Breeding for important biotic and abiotic stresses. Participatory plant breeding. Variety Release and notification. Intellectual Property Rights, Patenting, Plant Breeders and Farmer's Rights.

Practical

Plant Breeder's kit, Study of germplasm of various crops, Study of floral structures of self-pollinated and cross-pollinated crops, Emasculation and hybridization techniques in self and cross pollinated crops, Consequences of inbreeding on genetic structure of resulting populations, Study of male sterility system, Handling of segregating populations, Methods of calculating mean, range, variance, standard deviation, heritability, Designs used in plant breeding experiments, analysis of Randomized Block Design, To work out the mode of pollination in a given crop and extent of natural out-crossing, Prediction of performance of double cross hybrids, Maintenance of breeding records and data collection, Screening tests for biotic and abiotic stresses.

Suggested Readings

1. Allard R W. 1999. *Principles of Plant Breeding* (1st & 2nd Edn.). John Wiley & Sons Inc.
2. Chahal G S and Gosal S S. 2002. *Principles and Procedures of Plant Breeding: Biotechnical and Conventional Approaches*. Alpha Science International Ltd.
3. George Acquaah. 2012. *Principles of Plant Genetics and Breeding*. John Wiley & Sons, Ltd.
4. Sharma J R.1994. *Plant Breeding: Principles & Practices*. Tata McGraw-Hill Pub.
5. Singh B D. 2022. Plant Breeding: Principles and Methods. (12th Edn.). MedTech Science Press.

Post-Semester IV* (Only For exit option for UG-Diploma in Sericulture)

S. No.	Course Title	Credit Hours
SDE 221	Internship (10 weeks)	10 (0+10)

*Mandatory requirement for UG-Diploma.

Semester V

Agriculture Marketing and Trade 3 (2+1)

Objectives

i. To understand the fundamentals of agricultural marketing and trade
ii. To analyze the factors influencing supply and demand in agricultural markets
iii. To explore different marketing channels and strategies in agriculture
iv. To examine the role of government policies and regulations in agricultural markets

Theory

Agricultural Marketing: Concepts and definitions of market, marketing, agricultural marketing, market structure, marketing mix and market segmentation, classification and characteristics of agricultural markets; Demand, supply and producer's surplus of agri commodities: nature and determinants of demand and supply of farm products, producer's surplus – meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; Pricing and promotion strategies: pricing considerations and approaches – cost based and competition based pricing; market promotion – advertising, personal selling, sales promotion and publicity – meaning, merits and demerits; Marketing process and functions: Marketing process concentration, dispersion and equalization; exchange functions – buying and selling; physical functions – storage, transport and processing; facilitating functions – packaging, branding, grading, quality control and labelling (Agmark); Market functionaries and marketing channels: Types and importance of agencies involved in agricultural marketing; meaning and definition of marketing channel; number of channel levels; marketing channels for different farm products; Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs; Role of Govt. in agricultural marketing: Public sector institutions-CWC, SWC, FCI, CACP and DMI – their objectives and functions; cooperative marketing in India; Risk in marketing: Types of risk in marketing; speculation and hedging; an overview of futures trading; Agricultural prices and policy: Meaning and functions of price; administered prices; need for innovations in agricultural price policy; Trade: Concept of International Trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; WTO; Agreement on Agriculture (AoA) and its implications on Indian agriculture; IPR; Role of government in agricultural marketing; Role of APMC and its relevance in the present day context.

Practical

Plotting and study of demand and supply curves and calculation of elasticities; Study of relationship between market arrivals and prices of some selected commodities; Computation of marketable and marketed surplus of important commodities; Study of price behaviour over time for some selected commodities; Construction of index numbers; Visit to a local market to study various marketing functions performed by different agencies, identification of marketing channels for selected commodity, collection of data regarding marketing costs, margins and price spread and presentation of report in the class; Visit to market institutions–NAFED,

SWC, CWC, cooperative marketing society, etc. to study their organization and functioning. Application of principles of comparative advantage of international trade.

Suggested Readings

1. Acharya S S and Agarwal N L. 2006. *Agricultural Marketing in India*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Chinna S S. 2005. *Agricultural Economics and Indian Agriculture*. Kalyani Publications, New Delhi.
3. Kohls Richard L and Uhl Josheph N. 2002. *Marketing of Agricultural Products*. Prentice-Hall of India Private Ltd., New Delhi.
4. Kotler and Armstrong. 2005. *Principles of Marketing*. Pearson Prentice-Hall.
5. Lekhi R K and Singh Joginder. 2006. *Agricultural Economics*. Kalyani Publishers, Delhi.
6. Memoria C B, Joshi R L and Mulla N I. 2003. *Principles and Practice of Marketing in India*. Kitab Mahal, New Delhi.
7. Pandey Mukesh and Tewari Deepali. 2004. *Rural and Agricultural Marketing*. International Book Distributing Co. Ltd, New Delhi.
8. Salvatore Dominic. 2003. *Microeconomics: Theory and Application*. OUP USA.
9. Sharma R. 2005. *Export Management*. Laxmi Narain Agarwal, Agra.

Introduction to Agro-meteorology 2 (1+1)

Objectives

i. To introduce the students to the concept of weather and climate and underlying physical processes occurring in relation to plant and atmosphere

ii. To impart the theoretical and practical knowledge of instruments/equipment used for measurement of different weather variables in an agrometeorological observatory

iii. To study the meteorological aspects of climate change in agriculture and allied activities

Theory

Meaning and scope of agricultural meteorology; Earth atmosphere: its composition, extent and structure; Atmospheric weather variables; Atmospheric pressure, its variation with height; Wind, types of wind, daily and seasonal variation of wind speed, cyclone, anticyclone, land breeze and sea breeze; Nature and properties of solar radiation, solar constant, depletion of solar radiation, short wave, longwave and thermal radiation, net radiation, albedo; Atmospheric temperature, temperature inversion, lapse rate, daily and seasonal variations of temperature, vertical profile of temperature, Application of Thermal time concept and Crop/Pest weather calendar; Energy balance of earth; Atmospheric humidity, concept of saturation, vapour pressure, process of condensation, formation of dew, fog, mist, frost, cloud; Precipitation, process of precipitation, types of precipitation such as rain, snow, sleet, and hail, cloud formation and classification; Artificial rainmaking. Monsoon- mechanism and importance in Indian agriculture; Weather hazards - drought, floods, frost, tropical cyclones and extreme weather conditions such as heat-wave and cold-wave; Agriculture and weather relations; Modifications of crop microclimate, climatic normal for crop and livestock

production. Weather forecasting- types of weather forecast and their uses. Climate change, climatic variability, global warming, causes of climate change and its impact on regional and national agriculture.

Practical

Visit of Agrometeorological Observatory, site selection of observatory, exposure of instruments and weather data recording, Measurement of total, shortwave and long wave radiation, and its estimation using Planck's intensity law, Measurement of albedo and sunshine duration, computation of Radiation Intensity using BSS; Measurement of maximum and minimum air temperatures, its tabulation, trend and variation analysis, Measurement of soil temperature and computation of soil heat flux, Determination of vapor pressure and relative humidity, Determination of dew point temperature, Measurement of atmospheric pressure and analysis of atmospheric conditions, Measurement of wind speed and wind direction, preparation of windrose, Measurement, tabulation and analysis of rain, Measurement of open pan evaporation and evapotranspiration, Computation of PET and AET, Use of synoptic charts, weather reports, weather forecasting-types and methods, crop weather calendar.

Suggested Readings

1. Mahi G S and Kingra P K. 2018. *Fundamentals of Agrometeorology and Climate Change*. Kalyani Publishers.
2. Mavi H S. 1986. *Introduction to Agrometeorology*. Oxford & IBH Pub.
3. Varshneya M C and Pillai P B. 2004. *Textbook of Agricultural Meteorology*. Indian Council of Agricultural Research.
4. Patra Alok Kumar. 2020. *Introduction to Agrometeorology and Climate Change*. New India Publishing Agency.
5. Prasada Rao G S L H V. 2008. *Agricultural Meteorology*. PHI Learning Pvt. Ltd. .

Fundamentals of Crop Physiology 3 (2+1)

Objective

To explain about the basic physiological process of plant viz. plant cell and water relations, mineral nutrition, carbon metabolism, reproductive physiology and plant growth and development

Theory

Definitions of plant physiology and crop physiology; Importance of crop physiology; Relationship of crop physiology with other branches of crop science; Diffusion and osmosis; Physiological roles of water to crop plants; Definition of water potential and components of water potential; Water absorption by plants: Concept of active and passive absorption; Water loss by plants: Types of water loss: transpiration, stomatal physiology and guttation; Water use efficiency; Essential and beneficial elements; Passive and active transport of mineral element; Functions of essential elements; Criteria of essentiality of nutrients; Correction measures for nutrient deficiency symptoms; Foliar nutrition and root feeding – significance; Aeroponics Imbibition; Field capacity, permanent wilting point and available soil moisture; Apoplast, symplast and transmembrane, Ascent of sap – theories and mechanism; Soil-plant-atmospheric continuum.

Significance of transpiration. Stomatal opening and closing mechanisms. Definition of Cavitation and embolism. Antitranspirants - types and examples. Hydroponics and sand culture. Overview of plant cell - organelle and their functions. Brief outline of: Photosynthetic apparatus, pigment system, quantum requirement and quantum yield; Structure of chloroplast, Examples of different photosynthetic pigments (chlorophyll, carotenoids, phycobilins etc.), Difference between chlorophyll a and chlorophyll b, Structure of chlorophyll a and chlorophyll b, Short discussion on quantum requirement and quantum yield, Red drop and Emerson enhancement effect, Pigment system I and II.

Introduction to light reaction of photosynthesis, Light absorption by photosynthetic pigments and transfer of energy. Source of O_2 during photosynthesis: Hill reaction; Brief introduction to cyclic and non-cyclic photo-phosphorylation: production of assimilatory powers; Introduction to C_3, C_4 and CAM pathways: Calvin Cycle, Hatch and Slack Cycle, CAM Cycle; Significance of these pathways (concept of photorespiration, absence of photorespiration in C_4 plant: Productivity of C_4 plant, CAM: an adaptive mechanism); Factors affecting photosynthesis (light, temperature, CO_2, O_2 etc.). Outline of the process of respiration: Definition and importance, Glycolysis, Kreb Cycle and ETC, Factors affecting respiration (O_2, temperature, CO_2 etc.). Terminologies / Definitions: Growth, Development and Differentiation. Measurement of plant growth (fresh weight, dry weight, linear dimension, area etc.). Introduction to CGR, RGR, NAR etc. Photoperiodism: Photoperiodic Classification of plants: Short Day Plant, Long Day Plant, Day Neutral plant etc. Introduction to Photoperiodic induction site of photo-inductive perception, Role of Phytochrome Introduction to Vernalization (What is vernalization, devernalization etc.), Meaning, classification (seasonal, sequential etc), relation with abscission. Physiological and biochemical changes during senescence, Abscission and its significance, Concept of stay green, Hormonal regulation of senescence. Terminologies / Definitions: Plant hormone, Plant growth regulators (PGR), Plant growth inhibitor. Recognized classes of PGR (Auxins, Gibberellins, Cytokinins, Ethylene and Abscisic acid) and their major physiological roles, Agricultural uses of PGRs (IBA, NAA, 2, 4 –D, GAs, Kinetin etc).

Practical

Study on structure and distribution of stomata; Demonstration of imbibition, osmosis, plasmolysis, estimation of water potential, relative water content; Tissue test for mineral nutrients, identification of nutrient deficiency and toxicity symptoms in plant; Identification of nutrients by hydroponics; Estimation of photosynthetic pigments, rate of photosynthesis, respiration and transpiration; Plant growth analysis; Study on senescence and abscission, hormonal regulation of senescence; Demonstration of the effects of different PGRs on plants, Leaf anatomy of C_3 and C_4 plants.

Suggested Readings

1. Devlin Robert M and Witham Francis H. 1983. *Plant Physiology*. (4th Edn.). W. Grant Press.
2. Devlin Robert M, Witham Francis H and Blaydes David F. 2017. *Devlin's Exercises in Plant Physiology*. MedTech Science Press.
3. Salisbury Frank B and Ross Cleon W. 1991. *Plant physiology*. (4th Edn.). Brooks/Cole.

4. Taiz Lincoln, Zeiger Eduardo, Max Møller Ian and Murphy Angus. 2018. *Fundamentals of Plant Physiology*. Sinauer Associates Inc.
5. Taiz Lincoln and Zeiger Eduardo. 2010. Plant Physiology. (5th Edn.) Sinauer Associates.

Pest Management in Crops and Stored Grains 3 (2+1)

Objective

Diagnosis and management of major insect and non- insect pests of crops in field and storage

Theory

General description on nature and type of damage by different arthropod pests; Scientific name, order, family, host range, distribution, biology and bionomics; Nature of damage and management of major insect pests of various field crops, vegetable crops, fruit crops, plantation crops, ornamental crops, spices and condiments. Structural entomology and important household pests, their nature of damage and management. Factors affecting loss of stored grains. Insect pests, mites, rodents, birds and microorganisms associated with stored grains and their management. Storage structures and methods of grain storage and fundamental principles of stored grains management. Management of non insect pest of mites, snails and slugs, Concept of IPM, Practices, scope and limitations of IPM. Classification of insecticides, toxicity of insecticides and formulations of insecticides, Biorational pesticides including insect repellents, antifeedants, Use of drones and AI in pest management,

Practical

Field visit, identification of major insect pests and their damage symptoms. Collection and preservation of major insect pests; collection of damage samples, their identification and herbarium preparation. Methods of monitoring of pest incidence *in situ*. Management strategies of insect pests of different crops. Study on structural entomology and household pests. Storage structures and methods of grain storage. Spraying techniques for selected field and horticultural crops. Vertebrate pest management, Mass multiplication of NPV and entomopathogenic nematodes.

Suggested Readings

1. Athwal A S. 1986. *Agricultural Pests of India and South-East Asia*. Kalyani Publishers.
2. Dhaliwal G S and Arora Ramesh. 2022. *Integrated pest Management Concept and Approaches*. (3rd Edn.). Kalyani Publishers.
3. Prakash Rambhat Thalya and Ravi Chandra. 2022. *Essentials of Pest Management: Key Information on Pest Identification and its Management*. Wings Publication.
4. Sen Somnath and Mohd. Sameer. 2021. *A Textbook of Insect Pest and Disease Management*. S. Kataria & Sons publish.
5. Srivastava K P and Dhaliwal G S. 2010. *A Textbook of Applied Entomology*. Kalyani Publishers.
6. Tarique Hassan Askary. 2022. *Pest Management: Methods, Applications and Challenges*. Nova Science Publishers.

Diseases of Field and Horticultural Crops and their Management 3 (2+1)

Objectives

i. To study the symptoms produced on the host
ii. To study the etiology of the diseases
iii. To know about the disease cycle of the pathogens during pathogenesis
iv. To study the epidemiological factors responsible for disease development
v. To study the management techniques for curbing the major diseases of field and horticultural crops

Theory

Symptoms, etiology, disease cycle, epidemiology and management of major diseases of the following field and horticultural crops: Field crops- Rice (blast, brown spot, sheath blight, false smut, bacterial leaf blight, bacterial leaf streak, tungro, khaira); Wheat (rusts, loose smut, Karnal bunt); Maize (banded leaf and sheath blight, southern and northern blight, downy mildew); Sorghum (smuts, grain mold, anthracnose); Bajra (downy mildew, ergot) and Finger millet (blast, leaf spot); Groundnut (early and late leaf spots, rust, wilt); Soybean (rhizoctonia blight, bacterial spot, seed and seedling rot, mosaic); Grams (Ascochyta blight, wilt, grey mold); Pea (downy mildew, powdery mildew, rust); Black gram and Green gram (web blight, Cercospora leaf spot, anthracnose, yellow mosaic); Sugarcane (red rot, smut, grassy shoot, ratoon stunting, PokahBoeng); Mustard (Alternaria blight, white rust, downy mildew, sclerotinia stem rot) and Sunflower (sclerotinia stem rot, Alternaria blight); Cotton (anthracnose, vascular wilts, black arm). Horticultural crops: Citrus (canker, gummosis) and Guava (wilt, anthracnose); Banana (sigatoka, Panama wilt, bacterial wilt, bunchy top); Papaya (foot rot, leaf curl, mosaic) and Pomegranate (bacterial blight); Apple (scab, powdery mildew, fire blight, crown gall) and Peach (leaf curl); Grapevine (downy mildew, powdery mildew, anthracnose) and Strawberry (leaf spot); Coconut (bud rot, Ganoderma wilt), Tea (blister blight) and Coffee (rust); Mango (anthracnose, malformation, bacterial blight, powdery mildew); Potato (early and late blight, black scurf, leaf roll, mosaic) and Tomato (damping off, wilt, early and late blight, leaf curl, mosaic); Brinjal (phomopsis blight and fruit rot, sclerotinia blight) and Chilli (anthracnose and fruit rot, wilt, leaf curl); Cucurbits (powdery and downy mildew, wilts) and Cruciferous vegetables (Alternaria leaf spot, black rot, cauliflower mosaic); Beans (anthracnose, bacterial blight) and Okra (yellow vein mosaic); Ginger (soft rot), Turmeric (leaf Spot) and Coriander (stem gall); Rose (dieback, powdery mildew, black leaf spot) and Marigold (botrytis blight, leaf spots).

Practical

To study the symptoms of different diseases of field and horticultural crops: Blast and brown spot of rice, sheath blight and bacterial leaf blight of rice, downy mildew and powdery of cucurbits, rhizoctonia and Cercospora leaf spot of green gram / black gram, Alternaria blight and downy mildew of mustard, early blight of late blight of potato and tomato, Phomopsis blight of brinjal, powdery mildew and rust of pea, stem gall of coriander, anthracnose and fruit rot of chilli, taphrina leaf spot of turmeric, red rot of sugarcane, acquaintance with fungicides, antibiotics and biopesticides and their use in management of diseases of horticultural crops.

Identification and histopathological studies of selected diseases of field and horticultural crops covered in theory.

Field visit for the diagnosis of field problems, Collection and preservation of plant diseased specimens for herbarium.

Suggested Readings

1. Agrios George N. 2005. *Plant Pathology*. (5th Edn.). Academic Press.
2. Chaube Hriday and Singh Uma S. 2017. *Plant Disease Management: Principles and Practices*. CRC Press, Taylor and Francis Group.
3. Sharma R C and Sharma J N. 2011. *Integrated Plant Disease Management*. Scientific Publishers (India).
4. Singh R S. 2024. *Plant Diseases*. (11th Edn.). Medtech Science Press.

Crop Improvement (*kharif* crops) – I 2 (1+1)

Objectives

i. To provide knowledge about Self-pollinated and cross pollinated *Kharif* crops
ii. To learn about origin and distribution of *Kharif* crops
iii. To design breeding objectives of major *kharif* crops
iv. To impart information on different crop varieties for *Kharif* season

Theory

Centres of origin, distribution of species, wild relatives in different cereals; pulses; oilseeds; fibres; fodders and cash crops; vegetable and other horticultural crops of *kharif* season; Plant genetic resources, its utilization and conservation, study of genetics of qualitative and quantitative characters; Important concepts of breeding self-pollinated, cross-pollinated and vegetatively propagated crops. Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, adaptability, stability, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional); Hybrid seed production technology in maize, rice, sorghum, pearl millet and pigeopea etc. Ideotype concept, climate resilient crop varieties for future.

Practical

Botany of crops, Floral biology, emasculation and hybridization techniques in different crop species, viz. rice, jute, maize, sorghum, pearl millet, ragi, pigeopea, urdbean, mungbean, soybean, groundnut, sesame, castor, cotton, cowpea, tabacco, brinjal, okra and cucurbitaceous crops. Maintenance breeding of different *kharif* crops. Handling of germplasm and segregating populations by different methods like pedigree, bulk and single seed decent methods; Study of field techniques for seed production and hybrid seed production in *kharif* crops; Estimation of heterosis, inbreeding depression and heritability; Layout of field experiments; Study of quality characters, donor parents for different characters; Visit to seed production plots; Visit to AICRP breeding plots of different crops.

Suggested Readings

1. Chopra V L. 2001. *Breeding field crops – I*. Oxford IBH.
2. Gupta S K. 2008. *Plant Breeding – Theory and Techniques*. Agrobios.
3. Poehlman J M and Barthakur D N. 1969. *Breeding Asian Field Crops*. Oxford & IBH Publishing Company.
4. Ram Hari Har. 2006. *Vegetable Breeding – Principles and Practices*. Kalyani Publishers.
5. Singh C B and Khare D. 2017. *Genetic Improvement of Field Crops*. Scientific publishers.
6. Singh D P. 1991. *Genetics and Breeding of Pulse Crops*. Kalyani Publishers.
7. Sleper D A and Poehlman J M. 2013. *Breeding Field Crops*. Springer Science & Business Media.
8. Yadav Rajendra Kumar. 2022. *Practical Manual on Crop Improvement – I (Kharif crops)*. S.K. Kataria & Sons.

Weed Management 2 (1+1)

Objectives

i. To teach students about principles of weed science
ii. To impart practical knowledge of weed management in field and horticultural crops

Theory

Introduction to weeds, characteristics of weeds, their harmful and beneficial effects on ecosystem. Classification, reproduction and dissemination of weeds, crop-weed completion, factors of competition, factors affecting growth and development. Studies on weed seed bank, weed shifts. Concepts of weed management: physical, cultural, chemical and biological; principles and methods, integrated weed management. Implements for weed control, robotic weed control, weed management in organic/ natural farming. Herbicide classification and properties of important herbicides, concept of adjuvants, surfactants, herbicide formulation and their use, Nano herbicides, precision weed management; Mode of action of herbicides and selectivity phenomenon. Concept of herbicide mixture and utility in agriculture, Herbicide compatibility with agro-chemicals and their application, Herbicide resistance and its management. Weed management in different field and horticultural crops; aquatic weed management, weed management in cropping systems.

Practical

Techniques of weed preservation, weed identification and losses caused by weeds. Biology of important weeds. Study weeds in different situations, Study of herbicide formulations and mixture of herbicide. Study methods of herbicide application, Herbicide application equipment-their parts, use, maintenance and calibration. Weed control implements, Calculation of herbicide doses and requirement, weed control efficiency and weed index, Phytotoxicity of herbicides, Weed management in fallow lands, Management of problem and parasitic weeds.

Suggested Readings

1. Crafts A S and Robbins W W. 1973. *Weed Control*. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
2. Gupta O P. 1984. *Scientific Weed Management*. Today and Tomorrow Printers and Publishers, New Delhi.

3. Gupta O P. 2015. *Modern Weed Management*. Agro Bios (India), Jodhpur.
4. Naidu V S G R. 2012. *Handbook of Weed Identification*. Directorate of Weed Research, Jabalpur.
5. Rajagopal A, Aravindan R and Shanmugavelu K G. 2015. *Weed management of Horticultural Crops*. Agrobios (India), Jodhpur.
6. Ramamoorthy K and Subbian P. 2013. *Predominant Weed Flora in Hill Ecosystems*. Agrobios (India), Jodhpur.
7. Rao V S. 2000. *Principles of Weed Science*. Oxford & IBH Publishing Co., New Delhi.
8. Subramanian S, Mohammed Ali A and Jayakumar R. 1991. *All About Weed Control*. Kalyani Publishers, Ludhiana.
9. Tadulingam C and Venkatnarayana D. 1955. *A Handbook of Some South Indian Weeds*. Government Press, Madras.
10. Thakur C. 1977. *Weed Science*. Metropolitan Book Co. Pvt. Ltd., New Delhi.

Ornamental Crops, MAPs and Landscaping 2 (1+1)

Objectives

i. To educate in detail about origin, area, climate, soil, improved varieties production technology of flowers and MAPs
ii. To educate about concept, designing principles and components of landscaping
iii. To educate about the physiological disorders of commercial flowers
iv. To educate about the post-harvest management and value addition in flower crops and MAP

Theory

Production technology of ashwagandha, costus, isabgol and geranium; Production technology of mint, aloe and ocimum, Coleus, Glory lily, Periwinkle etc.; Production technology of plants like lemongrass, citronella, vetiver and palmarosa etc., Importance and scope of ornamental crops; Importance and scope of medicinal and aromatic plants and landscaping; Principles of landscaping; Landscape uses of trees, shrubs and climbers, Production technology of important cut flowers like rose, gerbera and orchids; Production technology of gladiolus, tuberose and lilium; Production technology of chrysanthemum and carnation; Package of practices for loose flowers like marigold and jasmine under open conditions; Brief concept of Home landscaping, Carpet bedding, Topiary, Bonsai, Lawn, flower arrangement, Herbaceous Border, Hedge, Edge etc.; Processing and value addition imp ornamental crops; Processing and value addition of MAPs produce.

Practical

Identification MAPs and Ornamental plants (trees, shrubs, climbers, seasonal flower and house plants). Propagation of MAP, Bed preparation and planting of MAP; Nursery bed preparation and sowing of seasonal flower seeds; Propagation of ornamental plants by terminal/herbaceous cuttings; Propagation of Anthurium and orchids; Propagation of bougainvillea; Planting of gerbera suckers; Gladiolus corms; Establishment and maintenance of lawn; Preparation of flower preservatives and their use in extending the vase life of cut flowers; Training and pruning of ornamental plants and raising of hedge and edge; Planning and layout of garden.

Suggested Readings

1. Bose T K, Aswath C, Yadav LP, Pal P, Dutta K, Kumar Rajiv and Das P. 2021 (3rd Edn.) *Commercial flowers (Vol-1)*. Astral Publishing Authors Across the Globe.
2. Bose T K, Aswath C, Dutta K, Bhatia Reeta and Shah TN. 2021 (3rd Edn.) *Commercial flowers (Vol-2)*. Astral Publishing Authors Across the Globe.
3. Kumar N, Khader A, Rangaswami P and Irulappan I. 1997. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. Rajalakshmi Publications.
4. Randhawa G S and Mukhopadhyay A. 1998. *Floriculture in India*. Allied Publishers Pvt Ltd.
5. Singh Anil K and Sisodia Anjana. 2017. *Textbook of floriculture and landscaping*. New India Publishing Agency.

Introductory Agroforestry 2 (1+1)

Objectives

i. To study Agro forestry as an alternate system of land use
ii. To study different types of Agro forestry for soil and water conservation.
iii. To study the characteristics of Agro forestry in terms its potential for soil moisture conservation practices

Theory

Agro-forestry: Definition and scope of Agroforestry system, Type of Agroforestry system, potential of Agroforestry in India, Prevailing agroforestry system in India; MPTS- definition, role of MPTS in agroforestry system, its selection for different agroforestry system, MPTS of India, Ecological aspects of Agroforestry system, tree -crop interaction – competition, nutrient recycling; Traditional Agroforestry as a viable choice to conserve Agro biodiversity of India. Management of Agro-forestry system; Role of agroforestry in soil and water conservation; windbreak; Shelterbelt– definition, objectives.; Socio- economic aspects of Agroforestry system; Design and Diagnostic study of agroforetry system; Silviculture: Definition and scope, Propagation of tree species, Regeneration by seed, coppice, root suckers, Transplanting, stump, branch cutting, rhizomes; Nursery bed preparation and management; Cultural practices for bare root and seedling, field handling of nursery stock; Management of tree species; Silviculture of important tree species, choice of species- site factors, root, crown and bole characteristics, phenology, nutritional and water requirement, ground operation, tending, harvesting utility etc. Horticulture and forage crops-based agroforestry models developed by ICAR-IGFRI; Agroforestry models developed by Indian council of Forestry Research and Education.

Practical

Identification of tree species in agro-forestry, Study of tree growth measurement, Study of environmental parameters affecting AF System, Plant propagation methods, Pre-sowing seed treatment, Preparation of nursery bed exercise, practicing propagation techniques for trees, Afforestation method, practical training, pruning, coppicing, pollarding etc. Planting pattern and designs for plantation, natural and artificial regeneration, Design and diagnostic survey of agro-

forestry system, Evaluation of agro-forestry system in different agro climatic zones, Exposure Visit to prevailing agroforestry systems of the state and related important institutions, Virtual visit of agroforestry models developed by ICAR-IGFRI, ICFRE.

Suggested Readings

1. Chundawat D S and Gautham S K. 2017. *Textbook of Agroforestry*. Oxford & IBH Publishing, New Delhi.
2. Divya M P and Parthiban K T. 2005. *A Textbook on Social Forestry and Agroforestry*. Satish Serial Publishing, New Delhi.
3. Nair P K R. 1993. *An Introduction to Agroforestry*. Kluar Academic Publisher
4. Parthiban K T, Krishnakumar N and Karthick M. 2018. *Introduction to Forestry*. Scientific Publisher, Jodhpur. 350p.

Semester VI

Fundamentals of Agricultural Biotechnology 3 (2+1)

Objective

To familiarize the students with the fundamental principles of biotechnology, various developments in biotechnology and its potential applications

Theory

Introduction to Plant Tissue Culture and Genetic Engineering: History; Cellular tot potency and cytodifferentiation; Callus culture, Single-cell/suspension culture and their applications; Organogenesis and somatic embryogenesis; Somaclonal variation and its use in crop improvement; Embryo rescue technique and its significance in hybrid development; *In vitro* fertilization, ovule culture and its significance in hybrid development; Protoplast isolation, culture and regeneration; Somatic hybridization (somatic hybrids and cybrids) and its application in crop improvement; Anther and pollen culture for haploid production; Development of disease-free (virus free) plants through apical meristem culture; Micropropagation technique for the generation of quality planting material; Synthetic seeds and its applications; National certification and Quality management of TC plants-secondary metabolite production- *in vitro* germplasm conservation.

Introduction to Molecular Biology: DNA structure, structure and function; DNA replication, transcription and translation, RNA, types and function; Structure of prokaryotic and eukaryotic gene; Central dogma of life - DNA replication, transcription, genetic codes-translation and protein synthesis; Lac Operon concept - Nucleic acid hybridization; Polymerase chain reaction- DNA sequencing – Sanger method; PCR and its applications.

Introduction to recombinant DNA technology: DNA modifying enzymes and vectors; plant genetic transformation – physical (Gene gun method), chemical (PEG mediated) and Agrobacterium-mediated gene transfer methods; Transgenic and its importance in crop improvement with successful stories; biosafety. Introduction to various molecular markers: RFLP, RAPD, SSR, SNP etc.; Marker-assisted breeding in crop improvement

Practical

Introduction to Plant Tissue Culture Laboratory; Good Laboratory Practices; Media Preparation and sterilization; Glassware sterilization; Micropropagation; Callus induction and culture; Anther culture; Apical meristem culture; Preparation of synthetic seeds; Isolation of plasmid DNA; Quantification of DNA; Agarose Gel Electrophoresis and visualization of plasmid DNA; Restriction digestion of plasmid DNA and agarose gel electrophoresis; Isolation of Plant genomic DNA; PCR amplification of DNA; Gel electrophoresis of amplified DNA; Visit to tissue culture units /biotech labs.

Suggested Readings

1. Bhojwani S S. 1983. *Plant Tissue Culture: Theory and Practice*. Elsevier.
2. Christou P and Klee H. 2004. *Handbook of Plant Biotechnology*. John Wiley & Sons.
3. Lewin B. 2008. *Gene IX*. Peterson Publications/ Panima. W.H. Freeman & Co.
4. Primrose S B. 2001. *Molecular Biotechnology*. Panima.
5. Singh B D. 2007. *Biotechnology: Expanding Horiozon*. Kalyani

Basic and Applied Agricultural Statistics 3 (2+1)

Objective

To provide an idea on statistical concepts of both descriptive and inferential Statistics which will be useful to do statistical analysis.

Theory

Introduction to Statistics and its Applications in Agriculture. Types of Data. Scales of measurements of Data. Summarization of Data. Classification of Data. Frequency Distribution. Methods of Classification. Definition of Grouped and Ungrouped Data. Definition of Class Interval (formula for determining the no. of class interval), Width of CI, Class Limits (Boundaries), Mid Points. Types of Frequency Distribution. Diagrammatic Presentation of Data. Bar Diagrams – Simple, Multiple, Sub-divided and Percentage Bar Diagrams. Pie-diagram. Graphical Presentation of Data – Histogram, Frequency Polygon and Ogives.

Measures of Central Tendency. Requisites for an Ideal Measure of Central Tendency. Different Types of Measure. Arithmetic Mean– Definition, Properties, Merits, Demerits and Uses. A.M. (examples) for Grouped and Ungrouped Data. Step-deviation Method. Weighted Mean. Definition of Geometric Mean and Harmonic Mean. Relationship between A.M., G.M. and H.M. Median- Definition, Merits, Demerits and Uses. Graphical Location of Median. Mode- Definition, Merits, Demerits and Uses. Graphical Location of Mode. Relationship between Mean, Median and Mode.

Measures of Dispersion. Characteristics for an Ideal Measure of Dispersion. Different Types of Measures of Dispersions. Definition of Range, Interquartile Range, Quartile Deviation and Mean Deviation. Standard Deviation- Definition, Properties. S.D. and Variance for Grouped and Ungrouped Data. Variance of Combined Series. Coefficients of Dispersions. Coefficient of Variation.

Measures of Skewness and Kurtosis. Definition of Symmetrical Distribution. Definition of Skewness, Measures of Skewness. Definition of Kurtosis. Measure of Kurtosis. Relationship between Mean, Median and Mode for Symmetrical and Skewed Distribution.

Probability Theory and Normal Distribution. Introduction to Probability. Basic Terminologies. Classical Probability-Definition and Limitations. Empirical Probability- Definition and Limitations. Axiomatic Probability.

Addition and Multiplication Theorem (without proof). Conditional Probability. Independent Events. Simple Problems based on Probability. Definition of Random Variable. Discrete and Continuous Random Variable. Normal Distribution- Definition, Prob. Distribution, Mean and Variance. Assumptions of Normal Distribution. Normal Probability Curve. Correlation and Regression. Definition of Correlation. Scatter Diagram. Karl Pearson's Coefficient of Correlation. Types of Correlation Coefficient. Properties of Correlation Coefficient. Definition of Linear Regression. Regression Equations. Regression Coefficients. Properties of Regression Coefficients. Tests of Significance. Definition. Null and Alternative Hypothesis. Type I and Type II Error. Critical Region and Level of Significance. One Tailed and Two Tailed Tests. Test Statistic. One Sample, Two Sample and Paired t-test with Examples. F-test for Variance. ANOVA and Experimental Designs. Definition of ANOVA. Assignable and Non assignable Factors. Analysis of One-way Classified Data. Basic Examples of Experimental Designs. Terminologies. Completely Randomized Design (CRD). Sampling Theory. Introduction. Definition of Population, Sample, Parameter and Statistic. Sampling Vs Complete Enumeration. Sampling Methods. Simple Random Sampling with Replacement and without Replacement. Use of Random Number Table.

Practical

Diagrammatic and Graphical representation of data. Calculation of A.M., Median and Mode (Ungrouped and Grouped data). Calculation of S.D. and C.V. (Ungrouped and Grouped data). Correlation and Regression analysis. Application of t-test (one sample, two sample independent and dependent). Analysis of variance one-way classification. CRD. Selection of random sample using simple random sampling.

Suggested Readings

1. Agarwal B L. 2006. *Basic Statistics*. New Age International Publishers.
2. Elhance D N, Elhance Veena and Aggarwal B M. 2018. *Fundamentals of Statistics*. Kitab Mahal Publishers.
3. Gupta S C and Kapoor V K. 2021. *Fundamentals of Applied Statistics*. (6th Edn.). Sultan Chand and Sons.
4. Sahu P K. 2010. *Agriculture and Applied Statistics-I*. Kalyani Publishers.
5. Sahu P K and Das A K. 2009. *Agriculture and Applied Statistics-II*. Kalyani Publishers.
6. Singh S P and Verma R P S. *Agricultural Statistics*. Rama Publishing House, Meerut.

Crop Improvement (*Rabi* crops)- II 2 (1+1)

Objective

i. To provide knowledge about self-pollinated and cross-pollinated *rabi* crops
ii. To learn about origin and distribution of *rabi* crops
iii. To design breeding objectives of major *rabi* crops
iv. To impart information on different crop varieties for *rabi* season

Theory

Centres of origin, distribution of species, wild relatives in different cereals; pulses; oilseeds; fibres; fodders and cash crops; vegetable and other horticultural crops; Plant genetic resources, its utilization and conservation, study of genetics of qualitative and quantitative characters; Important concepts of breeding self-pollinated, cross-pollinated and vegetatively propagated crops. Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, adaptability, stability, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional); Hybrid seed production technology in wheat, oat, chickpea, rapeseed and mustard etc. Ideotype concept, climate resilient crop varieties for future.

Practical

Botany of crops, Floral biology, emasculation and hybridization techniques in different crop species, viz. wheat, oat, rapeseed and mustard, pulses, potato, sugarcane, tomato, chilli, onion etc. Study of field techniques for seed production and hybrid seed production in rabi crops; Estimation of heterosis, inbreeding depression and heritability; Study of quality characters, donor parents for different characters; Visit to seed production plots; Visit to AICRP breeding plots of different crops.

Suggested Readings

1. Chopra V L. 2001. *Breeding Field Crops -I*. Oxford & IBH Publishing Company, New Delhi.
2. Gupta S K. 2008. *Plant Breeding – Theory and Techniques*. Agrobios.
3. Poehlman J M and Barthakur D N. 1969. *Breeding Asian Field Crops*. Oxford & IBH Publishing Company, New Delhi.
4. Ram Hari Har. 2006. *Vegetable Breeding – Principles and Practices*. Kalyani Publishers Sleper D A and Poehlman J M. 2013. *Breeding Field Crops*. Springer Science & Business Media.
5. Singh C B and Khare D. 2017. *Genetic Improvement of Field Crops*. Scientific publishers (India).
6. Singh D P. 2014. *Genetics and Breeding of Pulse Crops*. (3rd Edn.). Kalyani Publishers.
7. Yadav Rajendra Kumar. 2022. *Practical Manuals on Crop Improvement-I (Rabi crops)*. S.K. Kataria & Sons. .

Renewable Energy in Agriculture and Allied Sector 2 (1+1)

Objectives

i. To gain the knowledge on different types of materials used in renewable energy
ii. To understand the importance of renewable energy technology and its applications
iii. To train the students on the applications of solar thermal technology

Theory

Classification of energy sources, contribution of these sources in agricultural sector; Familiarization with biomass utilization for biofuel production and their application; Familiarization with types of biogas plants and gasifiers, biogas, bioalcohol, biodiesel and biooil production and their utilization as bioenergy resource; introduction of solar energy, collection and their application; Familiarization with solar energy gadgets: solar cooker, solar water heater, application of solar

energy: solar drying, solar pond, solar distillation, solar photovoltaic system and their application; Introduction of wind energy and their application. Availability of biomass and their application in different places.

Practical

Familiarization with renewable energy gadgets. To study biogas plants, gasifier, production process of biodiesel, briquetting machine, production process of bio-fuels. Familiarization with different solar energy gadgets. To study solar photovoltaic system: solar light, solar pumping, solar fencing, solar cooker and solar drying system. To study solar distillation, solar pond and solar wind hybrid system. Field visit to Solar –Wind farm.

Suggested Readings

1. Kishore V V N. 2008. *Renewable Energy Engineering and Technology: Principles and Practice*. Teri, India.
2. Solanki C S. 2011. *Solar Photovoltaic – Fundamentals, Technologies and Applications*. PHI Learning Pvt. Ltd.
3. Sukhatme S and Nayak J. 2008. *Solar Energy: Principles of Thermal Collection and Storage*. (3rd Edn.). Tata McGraw-Hill.

Dryland Agriculture/Rainfed Agriculture and Watershed Management 2 (1+1)

Objectives

i. To learn about characteristics and conditions of dryland/rainfed agriculture
ii. To gain knowledge about drought and its mitigation
iii. To impart knowledge on water harvesting and watershed management

Theory

Dryland/Rainfed agriculture: Introduction, types and characteristics; History of dryland/ rainfed agriculture in India; Problems and prospects of dryland/rainfed agriculture in India; Soil and climatic conditions prevalent in dry land/rainfed areas; Length of Growing Period (LGP) and Soil Moisture Availability (SMA) and its impact on crop and cropping system; Soil and water conservation techniques; Drought: types, effect of water deficit on physio- morphological characteristics of the plants; Crop adaptation and mitigation to drought; Water harvesting: importance, its techniques, Efficient utilization of water through soil and crop management practices; Crops and cropping systems in dryland/rainfed areas; Management of crops in dry land/rainfed areas; Contingent crop planning for aberrant weather conditions; Concept, history, objective, principles and components of watershed management, factors affecting watershed management. Log term rainfall analysis in relation to simple mathematical models and forecasting the weather abnormalities; Alternate land use system location; regional and crop specific dryland principles and practices for profitable and sustainable dryland farming and allied enterprises.

Practical

Studies on climate classification, studies on rainfall pattern in rainfed areas of the country and pattern of onset and withdrawal of monsoons. Calculation of Length of Growing Period (LGP) and Soil Moisture Availability (SMA) Studies on cropping pattern of different rainfed areas in the country and demarcation of rainfed area on map of India. Interpretation of meteorological data and scheduling of supplemental irrigation on the basis of evapo-transpiration demand of crops. Critical analysis of rainfall and possible drought period in the country. Effective rainfall and its calculation. Studies on cultural practices for mitigating moisture stress including mechanical and agronomic measure. Soil moisture determination under different land situations, Importance of seed priming to mitigate drought. Assessment of meteorological drought. Characterization and delineation of model watershed. Seed treatment, viz., seed hardening and seed priming techniques for all the agricultural crops Field demonstration on soil and moisture conservation measures. Field demonstration on construction of water harvesting structures. Visit to rainfed research station/watershed.

Suggested Readings

1. Lenka D. 2006. *Climate, Weather and Crops in India*. Kalyani Publishers, New Delhi.
2. Mavi H S and Tupper Graeme J. 2005. *Agrometeorology – Principles and applications of climate studies in agriculture*. International Book Publishing Co., Lucknow.
3. Mavi H S. 1994. *Introduction to Agrometeorology*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
4. Nanjappa H V and Ramachandrappa B K. 2007. *Manual on Practical Agricultural Meteorology.* Agrobios India. Jodhpur.
5. Prasad Rao G S L H V. 2008. *Agricultural Meteorology*. Prentice Hall of India Pvt. Ltd., New Delhi.
6. Reddy S R. 1999. *Principles of Agronomy*. Kalyani Publishers, New Delhi.
7. Srivastava A K and Tyagi P K. 2011. *Practical Agricultural Meteorology*. New Delhi Publishing Agency, New Delhi.
8. Yellamanda Reddy T and Sankara Reddi G H. 2010. *Principles of Agronomy*. Kalyani Publishers, New Delhi..

Agricultural Microbiology and Phyto-remediation 2 (1+1)

Objectives

i. To introduce microbiology with specific focus on its significance in agriculture science
ii. To acquaint with the bacterial structure and the function of the different bacterial components
iii. To highlight different fields of microbiology
iv. To highlight the bioremediation of polluted soils using microbial mediators and phytoremediation
v. To introduce the concept of biological control and the role of biopesticides in plant disease management.

Theory

Introduction to Microbiology: Definition, applied areas of Microbiology and Importance of Microbiology. History of Microbiology: Discovery of microorganisms, spontaneous generation theory, Germ theory of diseases, Immunization, fermentation, and origin of life. Bacteria: cell structure, chemoautotrophy, photo autotrophy, growth. Bacterial genetics: Genetic recombination- transformation, conjugation and transduction, genetic engineering. Soil Microbiology: Nutrient mineralization and transformation, Air Microbiology: Phyllosphere microflora, Phylloplane microflora, microflora of floral parts etc. Food Microbiology: Microbial spoilage and principles of food preservations, Food poisoning. Water Microbiology: Types of water, water microorganisms, and microbial analysis of water e.g. coliform test, Purification of water. Industrial Microbiology: Microbial products, Biodegradation, Biogas production, Biodegradable plastics etc. Biological control: Microbial biopesticides for plant disease management Concepts of rhizosphere microbiology-Rhizodeposits -biochemical nature, release mechanism in rhizosphere, function, Carbon flow in rhizosphere, Rhizosphere microbiome-residents and their roles. Potential of plant growth promoting rhizobacteria (PGPR) and endophytes on soil health and sustainability. Bioremediation of polluted soils using microbial mediators. Phytoremediation of polluted soils.

Practical

Study of the microscope; Acquaintance with laboratory material and equipment; Microscopic observation of different groups of microorganisms: moulds (Fungi); Direct staining of bacteria by crystal violet; Negative or indirect staining of bacteria by nigrosin; Gram staining of bacteria; Study of phyllosphere and rhizosphere microflora; Measurement of microorganisms; Preparation of culture media; Isolation and purification of rhizospheric microbes; Isolation and purification of N-fixers; Isolation and purification of Nutrient solubilizers; Isolation and purification of Endophytes.

Suggested Readings

1. Dubey H C. 2007. *A Textbook of Fungi, Bacteria and Viruses*. Vikas Publishing House Ltd., New Delhi.
2. Mukherjee N and Ghosh T. 2004. *Agricultural Microbiology*. Kalyani Publishers, Calcutta
3. Pelczar M J, Chan E C S and Kreig N R. 2002. *Microbiology*. (5th Edn.). Tata McGraw-Hill, New Delhi.
4. Prescott L M. 2002. *Microbiology*. (5th Edition) McGraw-Hill Inc, US.
5. Rangaswami G and Bagyaraj D J. 2005. *Agricultural Microbiology*. Prentice-Hall of India Pvt. Ltd., New Delhi.
6. Salyers A A and Whitt D D. 2001. *Microbiology: diversity, disease, and the environment*. Fitzgerald Science Press, Inc.

Agricultural Finance and Cooperation 2 (1+1)

Objective

To impart knowledge on agricultural finance and financial risk management

Theory

Agricultural Finance- meaning, scope and significance, credit needs and its role in Indian agriculture. Agricultural credit: meaning, definition, need, classification. Credit analysis: 4 R's, and 3C's of credits. Sources of agricultural finance: institutional and non-institutional sources, commercial banks, social control and nationalization of commercial banks. Micro financing including KCC. Lead bank scheme, RRBs, Scale of finance and unit cost. An introduction to higher financing institutions – RBI, NABARD, ADB, IMF, world bank, Insurance and Credit Guarantee Corporation of India. Cost of credit. Recent development in agricultural credit. Preparation and analysis of financial statements – Balance Sheet and Income Statement. Basic guidelines for preparation of project reports. Bank norms – SWOT analysis. Agricultural Cooperation – Meaning, brief history of cooperative development in India, objectives, principles of cooperation, significance of cooperatives in Indian agriculture. Agricultural Cooperation in India- credit, marketing, consumer and multi-purpose cooperatives, farmers' service cooperative societies, processing cooperatives, farming cooperatives, cooperative warehousing; role of ICA, NCUI, NCDC, NAFED. 3 R's, 5 C's and 7 P's of credit. Crop insurance: its scope, significance and limitations and the potential of the newly launched 'Pradhan Mantri Fasal Bima Yojana' (Prime Minister's Crop Insurance Scheme). Successful cooperative systems in Gujarat (AMUL), Tamil Nadu (Aavin), Karnataka (Nandini), Maharashtra and Punjab.

Practical

Optimum allocation of limited amount of capital among different enterprise. Analysis of progress and performance of cooperatives using published data. Analysis of progress and performance of commercial banks and RRBs using published data. Visit to a commercial bank, cooperative bank and cooperative society to acquire first-hand knowledge of their management, schemes and procedures. Estimation of credit requirement of farm business – A case study. Preparation and analysis of balance sheet – A case study. Preparation and analysis of income statement – A case study. Appraisal of a loan proposal – A case study. Techno-economic parameters for preparation of projects. Preparation of Bankable projects for various agricultural products and its value-added products. Seminar on selected topics. Different types of repayment plans.

Suggested Readings

1. Gittinger J P. 1982. *Economic Analysis of Agricultural Projects***.** The Johns Hopkins Univ. Press.
2. Reddy S S and Ram P R. 1996. *Agricultural Finance and Management*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Essentials of Plant Biochemistry 3 (2+1)

Objective

To impart the fundamental knowledge on structure and function of cellular components, biomolecules and the biological processes in plants

Theory

Biochemistry – Introduction and importance, Properties of water, pH and buffer, plant cell and its components. Biomolecules – Structure, classification, properties and function of carbohydrates, amino acids, proteins, lipids and nucleic acids. Vitamins – physiological and metabolic role. Enzymes: General properties; Classification; Mechanism of action; Michaelis and Menten and Line Weaver Burk equation and plots; Introduction to allosteric enzymes, use of enzymes. Metabolic energy and its generation – Metabolism – Basic concepts, Glycolysis, Citric acid Cycle, Pentose phosphate pathway, oxidative phosphorylation, Fatty acid oxidation. Biosynthetic Pathways – Photosynthesis, Gluconeogenesis, nitrogen fixation, fatty acid and starch formation. Regulation of metabolic pathways. Secondary metabolites, Terpenoids, Alkaloids, Phenolic and their applications in food and pharmaceutical industries.

Practical

Preparation of standard solutions and reagents, Determination of pH, Qualitative tests of carbohydrates and amino acids, Quantitative estimation of soluble sugars and starch, Estimation of protein by Kjeldhal method and Lowry's method, Preparation of mineral solution from ash, Estimation of fat by Soxhlet method, Determination of acid value, saponification value and iodine number, Estimation of ascorbic acid, Qualitative/quantitative tests of secondary metabolites.

Suggested Reading

1. Conn Erice, Stumpf Paul, Bruening George and Doi Roy H. 2009. *Outlines of Biochemistry*. (5th Edn.). John Wiley & Sons
2. Goodwin T W and Mercer E I. 2005. *Introduction to Plant Biochemistry*. (2nd Edn.). CBS..
3. Horton Robert, Moran Laurence, Scrimgeour Gray, Perry Marc. 2011. *Principles of Biochemistry*. (5th Edn.). Pearson/Prentice Hall (Can be downloaded)
4. Heldt Hans-Walter and Heldt Fiona. 2005. *Plant Biochemistry*. Elsevier (Can be downloaded)
5. Nelson David L, Cox Michael. 2008. *Lehninger Principles of Biochemistry*. (4th & 5th Edn.). Freeman (Can be downloaded).

Fundamentals of Seed Science and Technology 2 (1+1)

Objectives

i. To impart basic and fundamental knowledge on principles and practices of seed science and technology

ii. To impart practical skills on scientific seed production and post-harvest quality management

Theory

Introduction to seed technology, definition and importance; Seed quality -definition, characters of good quality seed; Causes of deterioration of varietal purity and assessment of genetic purity, different classes of seed. Foundation and certified seed production of important cereals, pulses and oilseed, field inspection, importance and procedures; Post-harvest seed quality management; seed processing procedures, seed drying; Seed treatment, its importance, method

of application and seed packing; seed storage - general principles, stages and factors affecting seed longevity during storage; Seed health management during storage. Seed Certification and legislation; Seed Act and Seed Act enforcement, duty and powers of seed inspector, offences and penalties. Seeds Control Order 1983, basics of seed quality testing; New Seed Bill 2019; Seed quality enhancement techniques.

Practical

Seed Structure, Seed sampling, Physical purity, Moisture determination, Germination test, Seed and seedling vigour test, Seed Viability, Genetic purity test: Grow out test, Field inspection, Seed health testing using blotter and agar plate method. Visit to seed production farms, seed testing laboratories and seed processing plant.

Suggested Readings

1. Agarwal R L. 1995. *Seed Technology*. (2nd Edn.).Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi, India.
4. Bhojwani S S and Bhatnagar S P. 1999. *The Embryology of Angiosperm*. Vikas Publication.
2. Khare D and Bhale M S. 2019. *Seed Technology*. (2nd Revised & Enlarged Edn.). Scientific Publishers, ISBN: 978-81-72338-84-8, New Pali Road, P.O. Box 91, Jodhpur, India
5. McDonald M B Jr and Copeland L O. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.
6. Tunwar N S and Singh S N. 1988. *Indian Minimum Seed Certification Standards*. CSCB, Ministry of Agriculture, New Delhi.
3. Vanangamudi K. 2014. *Seed Technology (An illustrated book)*. New India Publishing Agency, New Delhi, India.

Semester VII

S. No	Course title	Total credits
1	5 Elective Courses each of 4 (3+1) credits/Research Project with related courses*	20
	Total	**20**

* More electives to be included by the universities / institutions, based on the facilities/ expertise available such as nano fertilizers, robotics, use of drones in agriculture, etc.

Elective Course 1

Agri-Business Management 4 (3+1)

Objective

To impart knowledge on understanding the concepts, processes, significance, and role of management and organizational behaviour

Theory

Transformation of agriculture into agribusiness, various stakeholders and components of agribusiness systems. Importance of agribusiness in the Indian economy and New Agricultural Policy.

Distinctive features of Agribusiness Management: Importance and needs of agro-based industries. Classification of industries and types of agro based industries. Institutional arrangement, procedures to set up agro based industries. Constraints in establishing agro-based industries. Agri-value chain: Understanding primary and support activities and their linkages. Business environment: PEST and SWOT analysis. Management functions: Roles and activities, Organization culture. Planning, meaning, definition, types of plans. Purpose or mission, goals or objectives, Strategies, polices procedures, rules, programs and budget. Components of a business plan, Steps in planning and implementation. Organization staffing, directing and motivation. Ordering, leading, supervision, communications, control. Capital management and Financial management of Agribusiness. Financial statements and their importance. Marketing Management: Segmentation, targeting and positioning. Marketing mix and marketing strategies. Consumer behaviour analysis, Product Life Cycle (PLC). Sales and Distribution Management. Pricing policy, various pricing methods. Project Management definition, project cycle, identification, formulation, appraisal, implementation, monitoring and evaluation. Project Appraisal and evaluation techniques.

Practical

Study of agri –input markets: Seed, fertilizers pesticides. Study of output markets: grains, fruits, vegetables, flowers. Study of product market, retails trade commodity trading, and value-added products. Study of financing institutions-Cooperative, Commercial Bank, RRBs, Agribusiness Finance Limited, NABARD. Preparations of projects and Feasibility reports for agribusiness entrepreneur. Appraisal /evaluation techniques of identifying viable project- Non discounting techniques. Case study of agro- based industries. Trend and growth rate of price of agricultural commodities. Net present worth technique for selection of viable project. Internal rate of return.

Suggested Readings

1. Bairwa S L. 2016. *Objective on Fundamentals of Agri-business Management*. Kalyani Publishers
2. Bairwa Shoji Lal, Sen Chandra, Meena L K and Kumari Meera. 2018. *Agribusiness Management Theory and Practices*. Write and Print Publications.
3. Broadway A C and Arif A. 2002. *A textbook of Agri-Business Management*. Kalyani Publishers
4. Kamalvanshi Virender. 2015. *Agribusiness Management*. Random Publications.
5. Nishra Anjan, Biswas Debasish and Giri Arunangshu. 2019. *Agribusiness Management*. Himalaya Publishing House, 220p.

Elective Course 2

Management of Natural Resources 4 (3+1)

Objectives

i. To enlighten about available natural resources and their relationship with crop production
ii. To impart the knowledge of principles and practices of natural resource management

Theory

Introduction to Natural Resource Bases: Concept of resource, classification of natural resources. Factors influencing resource availability, distribution and uses. Interrelationships among different types of natural resources. Concern on Productivity issues. Ecological, social and economic dimension of resource management. Land resources: Land as a resource. Dry land, land use classification, land degradation, man induced landslides, soil erosion and desertification. Landscape impact analysis, wetland ecology and management. Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. Water ecology and management. Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Resource Management Paradigms: Resource management the evolution and history of resource management paradigms. Resource conflicts: Resource extraction, access and control system. Approaches in Resource Management: Ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies. Introduction to soil and water conservation and causes of soil erosion., Definition and agents of soil erosion, water erosion - Forms of water erosion, Gully classification and control measures. Soil loss estimation by universal soil loss equation - Soil loss measurement techniques. Principles of erosion control - Introduction to contouring, strip cropping. Contour bund - Graded bund and bench terracing. Wind erosion - Mechanics of wind erosion, types of soil movement - Principles of wind erosion control and its control measures, Water harvesting techniques - Lining of ponds, tanks and canal systems.

Practical

Identifying natural resources and their utility. Practicing survey - Principles and educating to use pacing technique for measurement. Area calculations through chain survey - GPS demo for tracking and area measurement. Estimation of soil loss and calculation of erosion index. Leveling concepts and practical utility in agriculture. Preparation of contour maps. Concept of vegetative water ways and design of grassed water ways. Wind erosion and estimation process. Different irrigation pumps and their constructional differences. Farm pond construction and its design aspects. Visit to nearby farm pond. Visit to an erosion site. Exposure to strip cropping/contour bunding.

Suggested Readings

1. Misra Harikesh N. (Ed.). 2014. *Managing Natural Resources: Focus on Land and Water*. Prentice Hall India Learning Private Limited, 496p
2. Goel Sushma. 2016. *Management of Resources for Sustainable Development*. The Orient Blackswan.,284p.
3. Lynch Danill R. 2009. *Sustainable Natural Resource Management*. Cambridge University Press.
4. Rathor Vijay Singh and Rathor B S. 2020. *Management of Natural Resource for Sustainable Development*. Daya Publishing House.
5. Upadhyay Arvindrai. 2021. *Natural Resources: Their Conservation and Management*. Aspiration Academy, 320p.
6. Vasudeva Srishti Pal. 2023. *Natural Resource Management for Growth, Development and Sustainability*.Today & Tomorrows Printers and Publishers, 336p.

Elective Course 3

Agrochemicals **4 (3+1)**

Objective

To impart knowledge on different classes of agrochemicals

Theory

An introduction to agrochemicals, their type and role in agriculture, effect on environment, soil, human and animal health, merits and demerits of their uses in agriculture, management of agrochemicals for sustainable agriculture. Herbicides -Major classes, properties and important herbicides. Fate of herbicides. Fungicides- classification –Inorganic fungicides-characteristics, preparation and use of sulphur and copper. Mode of action- Bordeaux mixture and copper oxychloride. Organic fungicides –Mode of action –Dithiocarbamates- characteristics, preparation and use of Zineb and maneb. Systemic fungicides- Benomyl, carboxin, oxycarboxin, Metalaxyl, Carbendazim, characteristics and use. Introduction and classification and insecticides: inorganic and organic insecticides organochorine, Ogranophosphates, Carbamates, Synthetic pyrethriods Neonicotinoids, Biorationals. Insecticide Act and rules, Insecticides banned, withdrawn and restricted use. Fate of insecticides in soil and plant. IGR Biopesticides, Reduced risk insecticides, Botanical, Plant and animal systemic insecticides their characteristics and uses. Fertilizers and their importance. Nitrogenous fertilizers: Feedstocks and Manufacturing of ammonium sulphate, ammonium nitrate, ammonium chloride, urea. Slow release N-fertilizers. Phosphatic fertilizers: feedstock and manufacturing of single superphosphate. Preparation of bone meal and basic slag. Potassic fertilizers: Natural sources of potash, manufacturing of potassium chloride, potassium sulphate and potassium nitrate. Mixed and complex fertilizers: Sources and compatibility-preparation of major, secondary and micronutrient mixtures. Complex fertilizers: Manufacturing of ammonium phosphates, nitrophosphates and NPK complexes. Fertilizer control order. Fertilizer logistic and marketing. Plant bio-pesticides for ecological agriculture, Bio-insect repellent.

Practical

Sampling of fertilizers and pesticides. Pesticides application technology to study about various pesticides appliances. Quick tests for identification of common fertilizers. Identification of anion and cation in fertilizer. Calculation of doses of insecticides to be used. To study and identify various formulations of insecticide available kin market. Estimation of nitrogen in Urea. Estimation of water soluble P2 O5 and citrate soluble P2 O5 in single super phosphate. Estimation of potassium in Muraite of Potash/ Sulphate of Potash by flame photometer. Determination of copper content in copper oxychloride. Determination of sulphur content in sulphur fungicide.

Suggested Readings

1. Biswas D R. 2021. *A Textbook of Fertilizers*. New India Publishing Agency
2. Buchel K H (Ed.). 1992. *Chemistry of pesticides*. John Wiley & Sons
3. Larramendy M L. 2017. *Toxicity and Hazard of Agrochemicals*. INTECH.
4. Panda H. 2022. *The Complete Technology Book on Pesticides, Insecticides, Fungicides and Herbicides (Agrochemicals) with Formulae, Manufacturing Process, Machinery & Equipment Details*. (2nd Revised Edn.). NPCS.
5. Singh A. 2022. *Basics of Agrochemical Formulations*. Brillion Publishing.

Elective Course 4

Agricultural Journalism 4 (3+1)

Objective

To impart knowledge and skill in agricultural journalism

Theory

Journalism – Meaning, nature, importance, and types of journalism. Agricultural Journalism – Meaning, definition, principle, objectives, types, and scope. Similarities and difference between agricultural journalism and other types of journalism. Role of agricultural journalist, Training of agricultural journalist. Qualities of journalist, Role of journalist / journalism in agricultural development and development of newspaper and magazines readers. Newspaper and magazines as communication media: Characteristics, kinds and functions of newspaper and magazines, Characteristics of newspaper and magazines readers. Form, content, style and language of newspaper and magazines, Standard part of newspaper and magazines. The agricultural story: Types of Agriculture stories, subject matter of the agricultural story, structure of the agricultural story. Gathering farm information -Sources of farm information: abstracting from research and scientific materials, interviews, coverage of events. Other sources: electronic media, field study. Success stories-definition, nature, components, guidelines of writing a success story. Writing a news story difference between news and feature story, the principle of writing a news story, Inverted pyramid structure. Organizing the material, treatment of the story, writing the news lead and the body. Readability measure-readability ease score, automated readability index, gunning fog index, How to improve readability of articles and stories. Use of photograph in agricultural journalism-Basic principles of photography – composition, exposure, lens, light. Use of artwork (Graphs, charts maps, etc.). Writing the captions. Editorial mechanism: Copy reading, headline and title writing. Proofreading: definition, signs and symbols of proofreading, level of proofreading, duties of a proof-reader. Layout – meaning, principles of layout and design.

Practical

Practice in writing an agricultural news story. Practice in writing an agricultural feature story. Covering agricultural events for the information collection. Practice in interviewing for the information collection. Abstracting stories from research and scientific materials and wire services. Selecting pictures and artwork for the agricultural story. Practice in editing, copy reading. Practice in headline and title writing. Practising proof reading. Practice in lay outing of newspaper. Testing copy with a readability formula. Visit a publishing office.

Suggested Readings

1. Bhaskaran C, Prakash R and Kishore Kumar N. 2008. *Farm Journalism and Media Management*. Agrotech Publishing Academy.
2. Fleming Carole, Hemmingway Emma and Moore Gillian. 2024. *Introduction to Journalism*. Sage Publications.
3. Jana B L and Mitra K P. 2005. *Farm Journalism*. Agrotech Pub. Academy.
4. Kamath M V. 2009. *Professional Journalism*. Vikas Publishing House.

5. Kamath M V. 2018. *The Journalist's Handbook*. Sangam Books Ltd.
6. Parthasarathy Rangaswami. 1984. *Basic Journalism*. Macmillan India Limited.
7. Prepared You Tube videos.
8. Shrivastava K M. 2003. *News Reporting and Editing*. (Revised Edn.). Sterling Publishers Pvt. Ltd.
9. Singh A K. 2014. *Agricultural Extension and Farm Journalism*. Agrobios (India).

Elective Course 5

Landscaping 4 (3+1)

Objectives

i. To educate the students on designing different styles and types of gardens
ii. To enable the students to identify different ornamental plants and their utilization in landscaping design
iii. To enable students to design landscapes in softwares like AUTOCAD, ARCHCADE etc.

Theory

Importance and scope of landscaping. Principles of landscaping, garden styles and types terrace gardening, vertical gardening, garden components, adornments, lawn making, rockery water garden, walk-paths, bridges, other constructed features etc. Gardens for special purposes. Trees: selection, propagation, planting schemes, canopy management. Shrubs and herbaceous perennials: selection, propagation, planting schemes, architecture. Climber and creepers importance, selection, propagation, planting. Annuals: selection, propagation, planting scheme. Other garden plants: palms, ferns, grasses and cacti succulents. Pot plants: selection, arrangement, management. Bio-aesthetic planning: definition, need, planning. Landscaping of urban and rural areas, Peri-urban landscaping, Landscaping of schools, public places like bus station, railway station, townships, river banks, hospitals, play grounds, airports, industries, institutions, Bonsai principles and management. Lawn: establishment and maintenance. CAD application.

Practical

Identification of trees, shrubs, annuals, pot plants; Propagation of trees, shrubs and annuals; Care and maintenance of plants, potting and reporting; Identification of tools and implements used in landscape design. Training and pruning of plants for special effects. Lawn establishment and maintenance. Layout of formal gardens, informal gardens, special type of gardens (sunken garden, terrace garden, rock garden) and designing of conservatory and lathe house. Use of computer software. Visit to important gardens /parks /institutes.

Suggested Readings

1. Singh Anil K. and Sisodia Anjana. 2017. *Textbook of Floriculture and Landscaping*. New India Publishing Agency.
2. Chandrasekhar Y and Hemla Naik B. 2020. *Principles of Landscape Gardening*. ICAR.
3. Mishra Pragnyashree and Naik Bhimasen. 2022. *Principles of Landscape Architecture*. New India Publishing Agency.

4. Pradhan Sudhir. 2018. *Landscape Gardening*. Scientific Publishers India.
5. Singh Rajaneesh and Singh Brijendra Kumar. 2020. *Introductory Ornamental Horticulture and Landscape Gardening*. Bio-Green Books.

Elective Course 6

Commercial Plant Breeding **4 (3+1)**

Objectives

i. To discuss about hybrid development and various crop improvement aspects of field crops viz., rice, wheat, maize, pearl millet, sorghum, pigeonpea, chickpea, green gram, black gram, lentil, soybean, groundnut, rapeseed-mustard, cotton etc.
ii. To provide understanding on tissue culture and biotechnological approaches as alternative strategies for development of line and cultivars
iii. To impart knowledge on seed production, release and notification of varieties and PPV&FR Act, 2001

Theory

Types of crops and modes of plant reproduction. Line development and maintenance breeding in self- and cross- pollinated crops (A/B/R and two-line system) for development of hybrids and seed production. Genetic test of commercial hybrids. Advances in hybrid seed production of maize, rice, sorghum, pearl millet, castor, sunflower, cotton pigeon pea, Brassica etc. Speed Breeding, Breeding Management systems, High-throughput phenotyping and genotyping platforms, Quality seed production of vegetable crops under open and protected environment. Alternative strategies for the development of the line cultivators: haploid inducer, tissue culture techniques and biotechnological tools. IPR issues in commercial plant breeding: DUS testing and registration of verities under PPV and FR Act. Variety testing, release and notification systems in India. Principles and techniques of seed production, types of seeds, quality testing in self- and cross- pollinated crops.

Practical

Floral biology in self- and cross- pollinated species, selfing and crossing techniques. Techniques of seed production in self- and cross- pollinated crops using A/B/R and two-line system. Learning techniques in hybrid seed production using male- sterility in field crops. Understanding the difficulties in hybrid seed production. Tools and techniques for optimizing hybrid seed production. Concept of rouging in seed production plot. Concept of line its multiplication and purification in hybrid seed production. Role of pollinators in hybrid seed production. Hybrid seed production techniques in sorghum, pearl millet, maize, rice, rapeseed-mustard, sunflower, castor, pigeon pea, cotton and vegetable crops. Sampling and analytical procedures for purity testing and detection of spurious seed. Seed drying and storage structure in quality seed management. Screening techniques during seed processing, viz. grading and packaging. Visit to public private seed production and processing plants.

Suggested Readings

1. Allard R W. *Principles of Plant Breeding*. (1st & 2ndEdn.). John Wiley & Sons.

2. Mangal S K. 2007. *Biotechnology for Agricultural Breeding*. GeneTech Books.
3. Poehlman J M. 2013. Breeding Field Crops. Springer Science & Business Media.
4. Padmalatha H. 2014. *Breeding and Crop Production*. Random Publications.
5. Singh Phundan, Billore Mridula and Singh Monika. 2021. *Commercial Plant Breeding: Objective*. Astral Publishing, 160p.
6. Singh Phundan, Bisen Pratibha, Tiwari Reshu. 2021. *Commercial Plant Breeding at a Glance*. Daya Publishing House.
7. Singh B D. 2022. *Plant Breeding: Principles and Methods*. (12th Edn.). MedTech Science Press.

Elective Course 7

Food Safety and Standards 4 (3+1)

Objectives

i. To develop the skills to convert raw materials into safe, attractive food products
ii. To manage the production of food products
iii. To use scientific knowledge to develop new products

Theory

Food safety –Definition, Importance, Scope and Factors affecting Food Safety. Hazards and Risks, Type of Hazards - Biological, Chemical Physical hazards. Management of hazards – Need. Control of Parameters. Temperature Control. Food Storage. Production Design. Hygiene and Sanitation in Food Service Establishments- Introduction. Sources of contamination and their control. Waste Disposal. Pest and Rodent Control. Personnel Hygiene. Food safety Measures. Food Safety Management Tool- Basic concepts. PRPs, GHPs, GMPs, SSOPs etc. HACCP.ISO series. TQM- concept and need for quality, components of TQM, Kaizen. Risk Analysis. Accreditation and Auditing, Water Analysis, Surface Sanitation and Personal Hygine. Food laws and Standards Indian Food Regulatory Regime, FSSA. Global Scenario CAC. Other laws and standards related to food. Recent concerns -New and Emerging Pathogens. Packaging, Product labelling and Nutritional labelling. Genetically modified food/transgenic. Organic foods. Newer approaches to food safety. Recent Outbreaks. Indian and International Standards for food products.

Practical

Water quality analysis physico – chemical and microbiological. Preparation of different types of media. Microbiological examination of different food samples. Assessment of surface sanitation by swab/rinse method. Assessment of personal hygiene. Biochemical tests for identification of bacteria. Scheme for the detection of food borne pathogens. Preparation of plants for Implementation of FSMS-HACCP, ISO:22000.

Suggested Readings

1. Bernard Davis, Andrew Lockwood, Ioannis Pantelidis, Peter Alcott. 2013. *Food and Beverage Management*. Routledge
2. Cletus Fernandes. 2022. *Safe Food Handling: HACCP booklet for Food Handlers*. Notion Press.

3. Khatekar D S L and Sarkate N R. 2023. *Handbook of Food Safety*. Step Up Academy, 576p.
4. Pulkit Mathur. 2018. *Food Safety and Quality Control*. The Orient Blackswan. 332p.
5. Sharma Avantina. 2017. *Textbook of Food Science and Technology*. (3rd Edn.). CBS Publishers and Distributors Pvt. Ltd.

Elective Course 8

Bioformulation and Nanoformulation 4 (3+1)

Objectives

i. To enable students to acquire expertise and skill to develop bioformulation and Nanoformulation

ii. To know the importance of biopesticides and biofertilizers

iii. To acquaint students about various techniques involved in biofertilizers and biopesticides production

iv. To impart knowledge on essential oils, botanicals, predators, parasitoids, pheromones, and parapheromone and their application in insect pest management

v. To provide concepts on agrochemical formulations with nanoparticles and acquaint them with nanotechnology.

Theory

Introduction and history of biological control of pests and diseases; Microbial biopesticides: the global and Indian market scenario; biopesticides for organic agriculture; Different phytopathogenic biocontrol agents: Mode of action; Different entomopathogenic biocontrol agents: Mode of action; Microbial inoculants as biofertilizer candidates, Production, quality assessment and methods of application of biopesticides and biofertilizers; Regulatory system of biopesticides in India; Formulations of plant essential oils, botanicals, pheromone, and parapheromone and their application in insect pest management; Use of predators and parasitoids for insect pest management; Nanotechnology: its applications in pest and disease diagnosis and management; Nano biopesticides: Concept and importance, different techniques of producing nano biopesticides; Nano Fertilizers: Concept and importance, Types of nano fertilizers; Different techniques of producing nano fertilizers; Green synthesis of nano fertilizers; green slow-release fertilizer composition based on urea-modified hydroxyapatite nanoparticles

Practical

Introduction and acquaintance with biopesticide laboratory; Preparation of culture media; Isolation and purification of bioagent from soil and infected insects; Microscopic study of different microbial bioagents; In vitro assay of microbial bioagents against plant pathogens.

In vitro compatibility study among different microbial bioagents; Mass multiplication of biopesticides; Population enumeration of biocontrol agents in different biopesticides; Preparation of plant extracts and their efficacy test against insect pests; Use of pheromone parapheromone for monitoring and management of insect pests; Bioassay of Entomopathogenic biocontrol agents on insect pests; Preparation of microbial inoculants of biofertilizer microbes; Compatibility of biofertilizer microbes; Preparation of solid and liquid consortia of biofertilizer microbes

Suggested Readings

1. Allhoff Fritz and Lin Patrick (Eds). 2009. *Nanotechnology and Society*. ISBN: 978-1-4020-6208-7 Springer Publications, UK.
2. Baker E F and James R C. 1982. *Biological Control of Plant Pathogens*. American Phytopathological Society.
3. Borkar S G. 2015. *Microbes as Biofertilizers and its Production Technology*. WPI India.
4. Boland G J and David L.1998. *Plant microbe interactions and Biological Control*. Kuykendall Marel Dekker, INC.
5. Ciancia A and Mukerji K J. 2007. *General Concepts of Integrated Pest and Disease Management*. Edited Published by Springer.
6. Cincholkar S B and Mukherji K G. 2007. *Biological Control of Plant Diseases*. Hawarth Food and Agricultural products.
7. Gnanamanickam S S. 2002. *Biological Control of Crop Disease*. Kuykendall Marel Dekker, INC.
8. Ramanujam B and Rabindra R J. 2006. *Current Status of Biological Control of Plant Disease using Antagonistic Organisms in India*. Precision Fototype Services, Bengaluru.
9. Koul Opender Ed. 2019. *Nano-biopesticides Today and Future Perspectives*. Academic Press.
10. Prasad Ram, Kumar Vivek, Kumar Manoj and Choudhary Devendra Eds. 2019. *Nanobiotechnology in Bioformulations*. Kindle Edition
11. Singh S P and Hussanini S S. 1998. *Biological Suppression of Plant Disease, Phytoparasitic Nematodes and Weeds*. Precision Fototype Services, Bengaluru.
12. Shah M A and Ahmad Tokeer. *Nano Science and Technology*. Wiley India.

Elective Course 9

Biopesticides and Biofertilizers 4 (3+1)

Objectives

i. To provide knowledge on principles, methods, and mechanisms of bio-control agents and their use against plant diseases

ii. To provide knowledge on principles, methods, and mechanism of biofertilizers and their use in agriculture

Theory

History and concept of bio pesticides. Importance, scope and potential of bio pesticides. Definitions, concepts and classification of bio pesticides viz. Pathogen, botanical pesticides, and bio rationales. Botanicals and their uses. Mass production technology of bio-pesticides. Virulence, pathogenicity and symptoms of entomopathogenic pathogens and nematodes, Methods of application of bio pesticides. Methods of quality control and Techniques of bio pesticides. Impediments and limitation in production and use of bio pesticides.

Biofertilizers - Introduction, status and scope. Structure and characteristics features of bacterial biofertilizers – Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium and Frankia; Cynobacterial bio fertilizers- Anabaena, Nostoc, Hapalosiphon and fungal biofertilizers – AM mycorrhiza and ectomycorhiza. Nitrogen fixation –Free living and symbiotic nitrogen fixation.

Mechanism of phosphate solubilisation and phosphate mobilization, K solubilisation. Production Technology: Strain selection, sterilization, growth and fermentation, mass production of carrier based and liquid biofertilizers. FCO specifications and quality control of biofertilizers. Application technology for seeds, seedlings, tubers, sets etc. Biofertilizers-Storage, shelf life, quality control and marketing. Factors influencing the efficiency of biofertilizers.

Practical

Isolation and purification of important biopestisides: trichoderma Pseudomonas, Bacillus, Metarhyziumetc. and its production. Identification of important botanicals. Visit to biopesticide laboratory in nearby area. Field visit to explore naturally infected cadavers. Identification of entomopathogenic entities in field condition. Quality control of biopesticides. Isolation and purification of Azospirillum, Azotobactor, Rhizobium, P-solubilizers and cyanobacteria. Mass multiplication and inoculums production of biofertilizers. Isolation of AM fungi- Wet sieving method and sucrose gradient method. Mass production of AM inoculants.

Suggested Readings

1. Boland G J and David L.1998. *Plant Microbe Interactions and Biological Control*. Kuykendall Marel Dekker, INC.
2. Borkar S G. 2015. *Microbes as Biofertilizers and its Production Technology*. WPI India.
3. Ciancia A and Mukerji K J. 2007. *General Concepts of Integrated Pest and Disease Management*. Edited Published by Springer.
4. Cincholkar S B and Mukherji K G. 2007. *Biological Control of Plant Diseases*. Hawarth Food and Agricultural Products.
5. Gehlot Dushyant. 2005. *Organic Farming: Standards, Accreditation, Certification and Inspection*. Agrobios (India).
6. Gnanamanickam S S. 2002. *Biological Control of Crop Disease*. Kuykendall Marel Dekker, INC.
7. Ramanujam B and Rabindra R J. 2006. *Current Status of Biological Control of Plant Disease using Antagonistic Organisms in India*. Precision Fototype Services, Bengaluru.
8. Singh Awani Kr. 2018. *Handbook of Microbial Biofertilizers*. Agrotech Press, Jaipur, India.
9. Singh A K. 2015. *Organic Farming*. New India Publishing Agency, New Delhi.

Elective Course 10

System Simulation and Agro-advisory 4 (3+1)

Objectives

i. To impart the knowledge of statistical and simulation modelling in crop yield estimation
ii. To get acquainted with different weather forecasting techniques and their usability analysis
iii. To study about the preparation and dissemination of agro-advisory bulletin

Theory

System approach for representing soil-plant-atmospheric continuum, system boundaries. Crop models, concepts and techniques, types of crop models, data requirements, relational diagrams. Evaluation of crop responses to weather elements; Elementary crop growth models;

calibration, validation, verification and sensitivity analysis. Potential and achievable crop production- concept and modelling, techniques for their estimation. Crop production in moisture and nutrients limited conditions; components of soil water and nutrients balance. Weather forecasting, types methods, tools and techniques, forecast verification; Value added weather forecast, ITK for weather forecast and its validity; Crop- Weather Calendars; Preparation of agro-advisory bulletin based on weather forecast. Use of crop simulation model for preparation of Agro- advisory and its effective dissemination.

Practical

Preparation of crop weather calendars. Preparation of agro-advisories based on weather forecast using various approaches and synoptic charts. Working with statistical and simulation models for crop growth. Potential and achievable production; yield forecasting, insect and disease forecasting models. Simulation with limitations of water and nutrient management options. Sensitivity analysis of varying weather and crop management practices. Use of statistical approaches in data analysis and preparation of historical, past and present meteorological data for medium range weather forecast. Feedback from farmers about the agro- advisory.

Suggested Readings

1. Bishnoi O P. 2007. Principles of Agricultural Meteorology. Oxford Book Company.
2. Mavi H S. 1986. *Introduction to Agrometeorology*. Oxford & IBH Pub.
3. Prasado Rao G S L H V. 2008. *Agricultural Meteorology*. PHI Learning Pvt. Ltd.
4. Rao V U M, Rao A V M S, Rao G G S N, Ramana Rao B V, Vijaya Kumar P and Venkateswarlu B (Eds.). 2009. *Advances in Plant Atmospheric Interactions*. Central Research Institute for Dryland Agriculture (CRIDA), Santoshnagar, Hyderabad.
5. Varshneya M C and Pillai P B. 2004. *Textbook of Agricultural Meteorology*. ICAR.

Elective Course 11

Hi-tech Horticulture 4 (3+1)

Objectives

i. To educate the students on the latest technology of hi-tech horticulture
ii. To educate students on the concepts and prospects of hi-tech horticulture

Theory

Introduction and importance; Nursery management and mechanization; micro propagation of horticultural crops; Modern field preparation and planting methods; Protected cultivation: advantages, controlled conditions, method and techniques; Micro irrigation systems and its components; EC, pH based fertilizer scheduling; canopy management; high density orcharding; Components of precision farming: Remote sensing; Geographical Information System (GIS); Differential Geo-positioning System (DGPS); Variable Rate Applicator (VRA); application of precision farming in horticultural crops (fruits, vegetables and ornamental crops); mechanized harvesting of produce.

Practical

Types of polyhouses and shade net houses, Intercultural operations, tools and equipment identification and application, Micro propagation, Nursery- portrays, micro-irrigation, EC, pH based fertilizer scheduling, canopy management, visit to hi-tech orchard/nursery.

Suggested Readings

1. Garden Tom. 2021. *Hydroponics for Beginners and Advanced: The Ultimate Hydroponic and Aquaponic Gardening Guide*. Webb Eleanor.
2. Gupta S N. 2025. *Instant Horticulture*. (23rd Edn.). Jain Brothers, 488p
3. More TA. 2020. *Hi-tech Horticulture*. Agrobios
4. Nelson Paul V. 1978. Greenhouse Operation and Management. Reston Publishing Company.
5. Prasad S, Singh Dharam and Bharadwaj R L. 2019. *Hi-Tech Horticulture*. (Pb) Agrobios.

Elective Course 12

Protected Cultivation 4 (3+1)

Objective

To educate students on the scientific and commercial cultivation of important value-added products in protected cultivation

Theory

Protected cultivation- importance and scope, status of protected cultivation in India and World, types of protected structure based on site and climate. Cladding material involved in greenhouse/poly house. Greenhouse design, environment control, artificial lights, Automation. Soil preparation and management, Substrate management. Types of benches and containers, Irrigation and fertigation management. Propagation and production of quality planting material of horticultural crops. Greenhouse cultivation of important horticultural crops-rose, carnation, chrysanthemum, gerbera, orchid, anthurium, lilium, tulip, tomato, bell pepper, cucumber, strawberry, pot plants etc. Cultivation of economically important medicinal and aromatic plants. Off- season production of flowers and vegetables. Insect pest and disease management.

Practical

Raising of seedlings and saplings under protected conditions, Use of portrays in quality planting material production, Bed preparation and planting of crop for production. Inter cultural operations, Soil EC and pH measurement. Regulation of irrigation and fertilizers through drip, fogging and misting.

Suggested Readings

1. Ashok Kumar B, Eggadi Ramesh and Sindhu V. 2022. *Textbook of Protected Cultivation and Precision Farming for Horticultural Crops*. Jain Brothers.
2. Brahma Singh and Balraj Singh. 2014. *Advances in Protected Cultivation*. New India Publishing Agency, 252p.

3. Jha Madan Kumar, Paikra Sujan Singh and Sahu Manju Rani. 2019. *Protected cultivation of Horticultural Crops.* Educreation Publishing.
4. Manjunathaswetha B L, Prabhakar Itigi and Swetha B S. 2020. *Protected Cultivation of Horticulture Crops*. IBPSS.
5. Nelson Paul V. 1978. *Greenhouse operation and management*. Reston Publishing Company.
6. Sagar Maitra, Dinkar J. Gaikwad and Tanmoy Shankar (Eds.). 2021. *Protected Cultivation and Smart Agriculture*. New Delhi Publishers, 263p.

Elective Course 13

Climate Resilient Agriculture 4 (3+1)

Objectives

i. To impart the concept of climate resilient agriculture under the present context of climate change
ii. To study the integrated role of different sectors in building resilience to climate change in agriculture

Theory

Climate change and impacts of climate change on agriculture and food security; crop productivity under different climate change scenarios including extreme events such as drought, flood, pest and disease outbreak etc. Basics of adaption and mitigation in the agricultural sectors; analyzing and assessing climate vulnerability to identify vulnerable sectors and possible adaptation options in agriculture; assessing biophysical and socio-economic impacts on agricultural sector; risk assessment strategies, preparedness for weather and climate risks in agriculture; application of geospatial tools and techniques for sustainable agriculture. Climate resilient agriculture (CRA) – concept, scope and importance with special reference to India, climate resilient technologies for enhancing crop productivity and sustainability – role of weather and climatic information, agro-advisories, ICTs and simulation models; climate resilient agronomic practices – crop/cultivar selection, crop diversification/ crop mixtures; water management practices – rain water harvesting, micro-irrigation, deficit irrigation and drainage management, organic/natural farming, integrated farming systems (IFS); site specific nutrient management (SSNM), conservation agriculture technologies to build soil organic carbon, harnessing microbial biodiversity, biomass recycling; use of renewable sources of energy; climate resilient pest-disease management strategies. Breeding strategies for development of climate change resilient crops and varieties, development of biotic and abiotic stress tolerant/resistant cultivars under changed climatic scenarios including extreme weather events.

Practical

Acquaintance with meteorological instruments including AWS, Statistical techniques to study trend of climatic parameters, Analysis of extreme weather events using non-parametric tests, Building climate change scenarios under different futuristic emission of GHGs, Designing strategies to mitigate the effect of climate change using climate resilient crops/cultivars, Climate resilient technologies and manipulation of cropping patterns, Acquaintance with ICTs for effective

dissemination of local weather information and agro-advisories, Analysing carbon sequestration potential of different agro-ecosystems; Designing climate smart village model considering the availability of resources. Awareness programme on climate change and climate resilient agriculture among farming community.

Suggested Readings

1. Bhan Manish, Tomar Vijay Singh, Agarwal Kamal Kishore, Tomar Sahib Singh and Upadhyaya Sunil Dutta. 2018. *Climate Resilient Agriculture: Adaptation and Mitigation Strategies*. New India Publishing Agency.
2. FAO. 2013. *Climate-Smart Agriculture Sourcebook*. FAO.
3. Prasada Rao G S L H V, Girish Varma G and Beena V. 2017. *Climate Resilient Animal Agriculture*. New India Publishing Agency.
4. Prasada Rao G S L H V, Rao G G S N and Rao V U M. 2010. *Climate Change and Agriculture Over India*. PHI Learning, 352p.
5. Prakash M. 2022. *Climate Smart Agriculture for Sustaining Crop Productivity and Improving Livelihood Security*. Satish Serial Publishing House, 178p.
6. Wahid Hasan, Sachin G. Mundhe, Abdul Majid Ansari and Shivani Kumari. 2022. *Implications for Climate Smart Agriculture*. Bio-Green Books, 357p.

Elective Course 14

Biotechnology of Crop Improvement 4 (3+1)

Objectives

i. To acquaint with biotechnological tools of crop improvement
ii. To know about direct and indirect methods of gene transfer
iii. To introduce about gene editing in plants
iv. To provide knowledge about marker assisted breeding and genomic selection

Theory

Impact of Biotechnology on crop improvement and the perspective of society; Various biotechnological techniques available for crop improvement – Plant Tissue Culture, Genetic Engineering, Genome editing, Marker Assisted breeding and Genomic Selection. Biosafety regulations and their application in Agricultural Biotechnology. Somaclonal variation and its use in crop improvement; embryo culture; anther/pollen culture; somatic embryogenesis; artificial seeds; techniques of protoplast culture, regeneration and somatic cell hybridization, achievements and limitations, utility in the improvement of crop plants. Direct and Indirect methods of gene transfer in plants - Agrobacterium-mediated gene transfer in dicots and monocots; Direct DNA delivery methods (microinjection, particle gun method, electroporation); gene targeting; Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems. Introduction to genome editing – Various tools of genome editing; CRISPR-Cas9 with specific emphasis on Indian regulations; Cloning genomic targets into CRISPR/Cas9 plasmids;

electroporation of Cas9 plasmids into cells; purification of DNA from Cas9 treated cells and evaluation of Cas9 gene editing; in vitro synthesis of single guide RNA (sgRNA); using Cas9/ sgRNA complexes to test for activity on DNA substrates; evaluate Cas9 activity by T7E1 assays and DNA sequence analysis; Applications of CRISPR/cas9 technology in crop plants. Marker Assisted Breeding and Genomic Selection: Introduction to various DNA-based markers and their use in marker-assisted breeding; Foreground Selection, Recombinant Selection and background Selection; Marker-assisted backcross breeding, marker-assisted selection – success stories; Introduction to Genomic Selection.

Practical

Agrobacterium-mediated transformation in Tobacco – preparation of construct, transfer to binary vector, transform Agrobacterium, prepare explant, Inoculation and Co-cultivation, antibiotic based selection of putative transformants, validation using PCR; Genome editing- preparation of CRISPR/CAS construct, direct transfer to plant, analysis of the targets; Planning of a MABB programme – selection of parents, crossing strategies, marker analysis.

Suggested Readings

1. Brown, T A. 2006. *Genomes*. (3rd Edn.). Garland Science Pub, New York.
2. *Gene Cloning and DNA Analysis*. 2010. Retrieved from http://biolab.szu.edu.cn/ otherweb/lzc/ genetic%20engineering/courseware/b1.pdf
3. Green M R and Sambrook J. 2012. *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
4. Kumar Pranav and Mina Usha. 2015. *Biotechnology: A Problem Approach*. Pathfinder Publication.
5. Old R W, Primrose S B and Twyman R M. 2001. *Principles of Gene Manipulation and Genomics*. (7th Edn.). Oxford: Blackwell Scientific Publications.
6. Ram Hari Har. 2019. *Crop Breeding and Biotechnology*. Kalyani Publications.
7. Rastogi S C. 2020. *Biotechnology: Principles and Applications*. Narosa.
8. Sander J D and Joung J K. 2014. *CRISPR-Cas systems for Editing, Regulating and Targeting Genomes*. Nat Biotechnol. 32:347-355.
9. Singh K H, Kumar Ajay and Parmar Nehanjali. 2019. *Agricultural Biotechnology at a Glance*. Sharma Publishers & Distributers.
10. Slater. 2008. *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford**, 400p.**

Elective Course 15

Geoinformatics and Remote Sensing, Precision Farming 4 (3+1)

Objectives

i. Enabling students acquire knowledge on basics of remote sensing technique for precision farming applications

ii. To provide a comprehensive knowledge of remote sensing, precision farming and its benefits in improving crop production and soil health management

Theory

Introduction and history of remote sensing; sources, Principles of remote sensing, propagation of radiations in atmosphere; Interaction with matter; Application of remote sensing techniques land use soil surveys; crop stress and yield forecasting; Advantages and disadvantages of remote sensing; Remote sensing institutes in India; Basic Concepts about geoinformatics.

Data sharing; Expert System: Introduction to expert system, Characteristics and features of expert system, Applications of Expert System, Importance of Expert system, Rule based system architecture; Software Agents; Impact of Block chain and it's concepts; Probability and Statistics: Bayes Theorem, correlation and Covariance, Continuous Random variables and probability distribution function, various forms of distributions, central limit theorem; Basics of Machine Learning: Random forest, SVM, ensemble methods; Basics of Deep learning: various model architectures and it's training aspects; Hyperspectral and Thermal Remote Sensing; Proximal Soil and Crop Sensors.

Practical

Familiarization with different remote sensing equipments and data products, Interpretation of aerial photographs and satellite data for mapping of land resources, Global positioning system (GPS), Basics of Geographic Information System (GIS), Georeferencing of toposheets, Digital soil mapping with different variables, Basics of multivariate data analytics, Principal component analysis and regression applications, clustering methods and geostatistics are essential in agricultural studies.

Suggested Readings

1. Abd El-Kader, Sherine M, Mohammad El-Basioni and Basma M. 2020. *Precision Agriculture Technologies for Food Security and Sustainability*. IGI Global.
2. Adamssen John. 2020. *Artificial Intelligence: Machine Learning, Deep Learning, and Automation Processes*. Efalon Acies.
3. Anji Reddy M. 2008. *Textbook of Remote Sensing and Geographical Information Systems.* (3rd Edn.). BS Publications.
4. Bhunia Gouri Sankar, Chatterjee Uday and Panda Gopal Krishna. 2021. *Advances In Geoinformatics Remote Sensing And GIS: Concept, Principle And Applications*. Today & Tomorrows Printers and Publishers.
5. Chandra A M and Ghosh S K. 2006. *Remote Sensing and Geographic Information System*. Alpha Science.
6. Garg P K. 2019. *Principles and Theory of Geoinformatics*. Khanna Publishers, 296p.
7. Lillesand Thomas M, Kiefer Ralph W and Chipman Jonathan W. 2011. *Remote Sensing and Image Interpretation*. (6thEdn.). Wiley India Pvt. Limited.
8. Satpathy Rabinarayan, Choudhury Tanupriya, Satpathy Suneeta and Nandan Sachi (Eds.). 2021. *Data Analytics in Bioinformatics: A Machine Learning Perspective.* Wiley-Scrivener.
9. Yang Zheng Rong. 2010. *Machine Learning Approaches to Bioinformatics*. World Scientific Publishing Co Pte Ltd.

Elective Course 16

Micro-propagation Technologies 4 (3+1)

Objective

To educate the students about the sterilization techniques for explants, preparation of stocks and working solution, culturing of explants, regeneration of whole plants from different explants and hardening procedures.

Theory

Introduction, History, Advantages and limitations. Types of cultures (seed, embryo, organ, callus, cell); Stages of micro propagation; Axillary bud proliferation (Shoot tip and meristem culture, bud culture); Organogenesis (calluys and direct organ formation); Somatic embryogenesis; Cell suspension cultures; production of secondary metabolites; Somaclonal variation; Cryopreservation.

Practical

Identification and use of equipment in tissue culture Laboratory; Nutrition media composition; Sterilization techniques for media, containers and small instruments; Sterilization techniques for explants; Preparation of stocks and working solution; Preparation of working medium; Culturing of explants: Seeds, shoot tip and single node; Callus induction; Induction of somatic embryos regeneration of whole plants from different explants; Hardening procedures.

Suggested Readings

1. ICAR. 2001. *Handbook of Horticulture*. ICAR.
2. Jha Timir Baran and Ghosh Biswajit. 2016. Plant Tissue Culture: Basic and Applied. (2nd Edn.). Platinum Publishers, 439p.
3. Kumar N. 2020. *Introduction to Horticulture*. Oxford & IBH Publishing Company Pvt Ltd.
4. Singh Jitendra. 2008. *Basics of Horticulture*. Kalyani Publishers.

Elective Course 17

Commercial Seed Production 4 (3+1)

Objective

To introduce the basic principles of planting material production at commercial scale and seed quality evaluation

Theory

General Principles of Seed Production: Raising the seed crop, Introduction, Procurement of a class of Improved seeds, Reporting to Monitoring or certification Agency, Principles and practices of selection of area and agronomic requirement of seed production of field crops, Importance of isolation distance and Rouging, Principles of hybrid seed production in field crops, Principles and practices of selection of area and agronomic requirement of seed production of horticultural

crops, Concept of apomixes, male sterility and self-incompatibility and its application in hybrid seed production of horticultural crops, Farmers participatory seed production.

General Principles of Seed Processing: Introduction, Objectives of Seed Processing, Seed Drying, Principles of Drying, Water vapour equilibrium, Methods of drying seeds, Cleaning and grading, Air and screen machines, Dimensional separators, Density separators, Surface texture separators, Colour separators, Spiral separators, Electric separators, Vibrator separators, Separation based on Affinity to liquids, Seed treatment, Temperature treatment, Chemical treatment, Bagging and Labelling.

General Principles of Seed Testing: Seed testing-Introduction, Procedure of Seed testing, components of seed quality testing genetic, physical, physiological and seed health testing, Seed sampling, Types of seed sampling, Requirements of sampling, Concept of seed viability and vigour; dormancy, types and principles of seed dormancy, Physiological quality of seed, Principles of seed Germination, types of germination, biochemical and genetic basis.

Seed Certification: History, concept and objectives of seed certification; seed certification agency/organization and staff requirement Indian Minimum Seed Certification Standards (I.M.S.C.S.) - general and specific crop standards including GM varieties, field and seed standards.

Seed Industry and Seed Marketing: Introduction, Evolution of the seed industry, Development of the vegetable and Flower seed industry, Seed marketing – concept, definition and purpose, importance and promotion of quality seed, formal and informal seed supply systems, Seed marketing intelligence and product mix, sales promotion, distribution channels, marketing costs and margins; packaging and labelling, Seed Associations, Factors influencing seed marketing, Seed marketing programs, Seed industry organizations, Marketing of public versus private players, Demand and supply of seed; role of seed replacement rate (SRR), seed multiplication ratio (SMR), economics of seed production; determining seed needs, Seed pricing and price policy, seed processing and /packaging, demand forecasting and factors affecting demand for seeds, effect of price and farm income on seed demand, Role of WTO in seed marketing.

Biotechnology in Seed Technology: History of plant tissue culture, Laboratory organization, Composition of nutrient medium, Micro-propagation, Axillary bud proliferation approach, Meristem and shoot tip culture, Bud culture, Advantages of Micro-propagation, Problems associated with micro-propagation, Synthetic seed production, Types of synthetic seeds, methods of development of synthetic seeds, Components of nutrient media for synthetic seed development, Storage of synthetic seeds, Advantages and limitations of synthetic seed production.

Practical

Planning of Seed Production, requirements for different classes of seeds in field crops - unit area and rate

Operation and handling of mechanical drying equipment; effect of drying temperature and duration on seed germination and storability seed processing equipment; seed treating equipment.

Seed production in cross pollinated crops with special reference to land, isolation, Planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony; supplementary pollination, pollen storage, hand emasculation and pollination in tomato, Hybrid seed production in Maize, detasseling in maize, identification of rogues and pollen shedders, Pollen collection, storage, viability and stigma receptivity; gametocide application and visits to seed production plots etc., Visit to seed processing plant and commercial controlled and uncontrolled Seed Stores, Seed industries and local entrepreneurships visit to nearby areas, Different methods of examination of seeds to assess seed-borne microorganisms and to quantify infection percentage, detection of seed-borne fungi, bacteria and viruses, identification of storage fungi, control of seed-borne diseases, seed treatment methods., Maintenance of aseptic conditions and sterilization techniques, Preparation of nutrient stocks for synthetic media, Selection of explants for callus induction, Preparation of MS medium for micro-propagation and Callus induction, Selection of explants for callus induction, Preparation of MS medium for micro-propagation and Callus induction, Inoculation of explants for micro-propagation, Inoculation of explants for callus induction and subsequently regeneration of plantlets from matured seeds of field and horticultural crops, Synthetic seed preparation.

Suggested Readings

1. Agarwal R L. 1997. *Seed Technology*. (2nd Edition) Oxford & IBH Publishing Co. Ltd. New Delhi.
2. Chawla H S. 2008. *Introduction to Plant Biotechnology*. (2nd Edn.). Oxford & IBH Publishing Co. Ltd. New Delhi.
3. Justice O L and Bass L N. 1978. *Principles and Practices of Seed Storage*. Castle House Publ. Ltd.
4. McDonald M B Jr and Copeland L O. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.
5. Singhal N C. 2003. *Hybrid Seed Production in Field Crops*. Kalyani.
6. Thompson J R. 1979. *An Introduction to Seed Technology*. Leonard Hill.
7. Tunwar N S and Singh S N. 1988. *Indian Minimum Seed Certification Standards*. CSCB, Ministry of Agriculture, New Delhi.

Elective Course 18

Principles and Practices of Organic Farming and Conservation Agriculture 4 (3+1)

Objectives

i. To teach the principles of crop production under organic and conservation agriculture situation
ii. To impart practical knowledge of organic and conservation agriculture practices

Theory

Concept of organic farming, principles and its scope in India; Choice of crops and varieties in organic farming; Nutrient management in organic farming and their sources; Fundamentals of insect, pest, disease and weed management under organic mode of production; Operational structure of NPOP; Certification process and crop standards of organic farming; Processing, labelling, economic considerations and viability, marketing and export potential of organic products.

Initiatives taken by Government (central/state), NGOs and other organizations for promotion of organic agriculture. Conservation agriculture: definition, origin, principles, advantages, challenges; Primary practices in conservation agriculture: minimum soil disturbance, crop residue retention, and crop diversification, complementary practices, conservation agriculture vis a vis Climate Smart Agriculture; Organic manures- recommended doses and application in comparison to inorganic fertilizers for major crops.

Practical

Visit of organic farms to study the various components and their utilization; Preparation of enrich compost, vermicompost and their quality analysis; Method of application of bio-fertilizers; Indigenous technology knowledge (ITK) for nutrient, insect-pest and disease management; Studies in green manuring in-situ and green leaf manuring, Studies on different type of botanicals for insect-pest management; Weed management in organic farming; Cost of organic production system; Practices of conservation agriculture.

Suggested Readings

1. Acharya Sankar Kumar, Bera Sreemoyee, Saha Cornea, Kumar Prabhat, Haque Monirul, Chatterjee Riti and Mandal Anwesha. 2022. *Conservation Agriculture Approach and Application*. Scholars World, 292p.
2. Dahama A K. 2003. *Organic Farming for Sustainable Agriculture*. Agrobios (India), Jodhpur.
3. Gaur A C. 2024. *Handbook of Organic farming and biofertilizers*. New India Publishing Agency – NIPA.
4. Palaniappan S P and Annadurai K. 2018. *Organic Farming – Theory and Practice*. Scientific Publishers, Jodhpur.
5. Purohit S S. 2006. *Trends in Organic Farming in India*. AgrosBios (India), Jodhpur.
6. Sathe T V. 2004. *Vermiculture and Organic Farming*. Daya Publishing House, New Delhi.
7. Sharma Arun K. 2001. *Handbook of Organic Farming*. Agrobios (India), Jodhpur.
8. Singh Abhinandan, Ojha Pankaj Kumar and Kumar Rahul. 2018. *Conservation Agriculture Technologies*. Biotech Books.
9. Thampan P K. 1995. *Organic Agriculture*. Peekay Tree Crops Development Foundation, Cochin, Kerala.
10. Thapa U and Tripathy P. 2018. *Organic Farming in India- Problems and Prospects*. Agrotech publishing agency, Udaipur.
11. Veeresh G K. 2006. *Organic Farming*. Foundation Books. New Delhi..

Elective Course 19

Food Science and Nutrition 4 (3+1)

Objective

To impart knowledge on the biochemical aspects of various nutrients and their interactions in foods during processing, storage and deterioration

Theory

Introduction on fundamentals of foods and human nutrition; Basic food groups; Concept of balanced diets; Recommended Daily Allowances (RDA) for various age groups; Biochemical composition, energy and food value of various food grains, fruits and vegetables; Carbohydrates, proteins, fats as nutrients and their interactions; Physio-chemical, functional and nutritional characteristics of essential nutrients- sources and functions, Nutritional requirements, malnutrition, inborn errors of metabolism, deficiency diseases; Digestion, absorption, transport and metabolism of nutrients in human system; Protein quality evaluation. Biochemical and nutritional aspects of vitamins, minerals, nutraceuticals, antioxidant, antinational factors and biochemistry of post-harvest storage, losses during processing. Effect of cooking, processing and preservation on nutrients of different food products, biochemical aspects of food spoilage; Food fads, food safety and quality standards. Enzymes in food industry, food additives, nutritional quality of plant, animal, dairy, marine and fermented products.

Practical

Proximate analysis of foods; calorific value of foods; Estimation of vitamins, phenols and flavonoids, carotenoids, antinutrients like Phytate/ Oxallate, Trypsin and Chymotrypsin inhibitor activities, limiting amino acids in food stuff.

Suggested Readings

1. Damodaran S and Parkin K L (Eds.). 2017. *Fennema's Food Chemistry*. CRC Press
2. Dharmesh Kumar. 2019. *Food Science and Nutrition*. Random Publications.
3. Gibney M J, Lanham-New S A, Cassidy A and Voster H H (Eds.). 2009. *Introduction to Human Nutrition*. Wiley-Blackwell.
4. Rekhi Tejmeet and Yadav Heena. 2014. *Fundamentals of Food and Nutrition*. Elite Publishing House, 257p.
5. Trueman P. 2007. *Nutritional Biochemistry*. MJP Publishers.

Elective Course 20

Post Harvest Technology and Value Addition 4 (3+1)

Objectives

i. To educate about the different pre-harvest, harvest and post-harvest factors affecting the post-harvest life of fruits and vegetables
ii. To educate about preparation techniques of value-added products
iii. To educate about the different dehydration techniques of horticultural crops

Theory

Importance of post –harvest processing of fruits and vegetables, extent and possible causes of post-harvest losses: Pre-harvest factors affecting post-harvest quality, maturity, ripening and changes occurring during ripening; Respiration and factors affecting respiration rate; Harvesting and field handling; Storage (ZECC, cold storage, CA, MA and hypobaric); Value addition concept; Principles and methods of preservation; Intermediate moisture food (jam, jelly, marmalade, preserve, candy) -

concepts and standards; Fermented and non-fermented beverages. Tomato products -concepts and standards; Drying /Dehydration of fruits and vegetables –concept and methods, osmotic drying. Canning – concepts and standards, packaging of products.

Practical

Applications of different types of packing, containers for shelf-life extension. Effect of temperature on shelf life and quality of produce. Demonstration of chilling and freezing injury in vegetables and fruits. Extraction and preservation of pulps and juices. Preparation of jam, jelly, RTS, nectar, squash, osmotically dried products, fruit bar candy and tomato products, canned products. Quality evaluation of products- Physico-chemical and sensory. Visit to processing unit/ industry.

Suggested Readings

1. Aswini Kumar Goel, Rajender Kumar and Satwinder S. Mann. 2007. *Postharvest Management and Value Addition*. Daya Publishing House.
2. Kureel M K, Mandloi D S, Singh K V and Lekhi Rajesh. 2020. *Postharvest Management and Value Addition of Fruits and Vegetables*. Biotech.
3. Qureshi Suja Nabi, Javeed Kounser and Sinha Abhay Kumar. 2018. *Post-Harvest Technology*. Bioscientific Publishers.
4. Sharma S K and Nautiyal M C. 2019. *Post-harvest technology of horticultural crops*. New India Publishing.
5. Sudheer K P and Indira V. 2007. *Postharvest Technology of Horticultural Crops*. New India Publishing Agency. 320p.

Semester VIII

S. No	Course tilte	Total credits
1	For student opting 4 year B.Sc. (Hons.) degree Student READY (RAWE/ Experiential Learning / Hands on Training / Industrial Attachment /Project Work / Internship etc.)	20
	Total	**20**

SKILL ENHANCEMENT COURSE (SEC)

A student admitted into 1st year of B.Sc. (Hons.) Agriculture degree program will take 2 skill enhancement courses each of 2 credits in each semester of first year. Likewise, the student continuing his/her study into 2nd year of B.Sc. (Hons.) Agriculture will take 1 skill enhancement course of 2 credits in each of the 2 semesters of 2nd year.

The student can select these courses from a basket of skill enhancement courses as indicated below or courses offered by a college. The courses may be offered as module of complementing courses to help the student to achieve skill in a specific area of his interest.

The University/HAEIs may offer such skill enhancement courses in which it has strength/ expertise as well as there is prospect of local employment and entrepreneurship development. The

courses included in the list are indicative and the University/HAEIs may add more need-based courses in the list depending on their facilities and expertise available.

Indicative Skill Enhancement Courses

S. No	Course title	Total credits
1	Biofertlizer and biopesticide production	2 (0+2)
2	Production Technology of Bioagents	2 (0+2)
3	Seed Production and Testing Technology	2 (0+2)
4	Mushroom Production Technology	2 (0+2)
5	Soil, Plant and Water Testing	2 (0+2)
6	Post-harvest Processing Technology	2 (0+2)
7	Beneficial Insect Farming	2 (0+2)
8	Plantation Crop Production and Processing	2 (0+2)
9	Poultry Production Technology	2 (0+2)
10	Piggery Production Technology	2 (0+2)
11	Commercial Horticulture	2 (0+2)
12	Floriculture and Landscaping	2 (0+2)
13	Food Processing	2 (0+2)
14	Agriculture Waste Management	2 (0+2)
15	Organic Production Technology	2 (0+2)
16	Commercial Sericulture	2 (0+2)
17	Video Production	2 (0+2)

ONLINE COURSES

The students will have to take a minimum of 10 credits of online courses (as per UGC guidelines for online courses) as a partial requirement for the B.Sc. (Hons.) Agriculture.

The online courses can be from any field such as Basic Sciences, Humanities, Commerce, Business Management, Languages including foreign language, Communication skills, Music, etc. and can be taken from SWAYAM, Diksha, NPTEL, mooKIT, edX, Coursera, or any other portal.

The objective is to allow the students to groom their passion or strengthen their knowledge and competency in any field beyond prescribed courses.

The students will take prior approval of the courses they opt from the concerned Dean/Assoc. Dean/Principal of the Faculty/College/Institute.

The courses will be non-gradial as separate certificates would be issued by the Institute/ University offering the courses.

However, the University/ institute will keep a record of such courses registered and completed by each student and will indicate the title of the (successfully completed) courses in final transcript issued to the student.

Minimum Standards for Establishing a College of Agriculture

- **Degree Nomenclature:** B.Sc. (Hons.) Agriculture

1. Minimum intake (per year): 120

2. Faculty:

A. Core faculty: 23

Agronomy (0+1+3), Agricultural Economics (0+1+1), Agricultural Extension Education (0+1+1), Entomology (0+1+1), Genetics & Plant Breeding (0+1+2), Horticulture (0+1+2), Soil Science (0+1+1), Plant Pathology (0+1+1), Animal Science (0+0+1), Agricultural Engineering (0+0+1), Biochemistry & Physiology (0+0+1)

B. Allied Faculty: Faculty for Mathematics, computer science, Sociology. Psychology, English, Food Science and Technology, Microbiology, Agrometerology and other supporting subjects, if any, shall be adjusted from other colleges, Guest faculty, adjunct faculty and part time faculty.

3. Land requirement(ha): 15

4. Essential Instructional units:

- Farm house/threshing floor/processing centre- 1ha.
- Crop cafeteria- ½ ha.
- Field classroom (2)- 0.1 ha.
- ELP units- vermicomposting, Nursery Polyhouse/Green house/any other for skill development or Enterpreneural mode – 0.5 ha.
- Agronomy (Local Crops), Genetics and Plant Breeding, Soil Science, Physiology, other department – 1 ha.
- Horticulture (orchard) - 1 ha.
- Organic/Natural farming - 0.5 ha.
- Plant Protection practical - 0.5 ha.
- UG practical demonstration - 2 ha.
- Laboratories and instructional facilities as per V Deans' Committee report.
- ELP units to be established under skill development or Entrepreneurial mode- 0.5 ha

5. Divisons/Departments/Sections:

- Agronomy + (Agro-forestry)
- Agricultural Economics + (Basic Economics, Maths & Computer Science and Statistics)
- Agriculture Extension & Communication + (Sociology and Psychology, English)
- Entomology
- Genetics & Plant Breeding + (Seed Science & Technology)
- Horticulture + (Food Science & Technology)
- Soil Science and Agricultural Chemistry + (Microbiology, Agro-meteorology,

Environmental Sciences), Plant Pathology

6. Non- Teaching Staff:

Sl. No.	Divisions/Departments/Sections	Asstt.*	Lab Asstt.	Field Asstt.	Attendant/ Messenger	Total
1.	Agronomy + (Agro-forestry)	1	2	3	-**	6
2.	Agricultural Economics + (Basic Economics,Maths & Computer Science and Statistics)	1	3	-	-	4
3.	Agriculture Extension & Communication +(Sociology and Psychology, English)	1	1	-	-	2
4.	Entomology	1	1	1	-	3
5.	Genetics & Plant Breeding + (Seed Science & Technology)	1	2	2		5
6.	Horticulture + (Food Science & Technology)	1	2	2		5
7.	Soil Science and Agricultural Chemistry + (Microbiology, Agro-meteorology, Environmental Sciences)	1	3	1		5
8.	Plant Pathology	1	2	1		4
9.	Animal Sciences including Fisheries, Dairy Science & Poultry units)	1	1	1		3
10.	Agriculture Engineering + (Farm Management)	1	1	2		4
11.	Biochemistry and Crop Physiology	1	1	-		2
	Total	11	19	13		43

7. Dean's Office:

Sl. No.	Name of the Post	No. of Posts
1.	Dean	01
A. Establishment		
1.	P.A./P.S. to Dean	01
2.	Asstt. Administrative Officer	01
3.	Asstt. Academic Officer	01
4.	Assistant Accounts Officer	01
5.	Assistants (one for each AAO)	03
6.	Steno/Computer Operators	01
7.	Driver	01
8.	Farm Manager (Asstt. Prof.)	01*
9.	Store Keeper	01

*Will be with Engineering/Agronomy.

Utility services like Wireman/Plumber/Janitors/ Attendants/Messengers, Landscaping and Mechanic, etc. tobe outsourced.

Sl. No.	Name of the Post	No. of Posts
B.	**Central Instrumentation Laboratory**	
1.	Instrumentation Asstt. Engineer	01
2.	Instrumentation Technician/Lab Asstt.	01
C.	**Library Staff**	
1.	Asstt. Librarian (Asstt. Prof. cadre)	01
2.	Library Asstt./Clerk	01
3.	Shelf Asstt.	01
D.	**Students Welfare**	
1.	Physical Education (Asstt. Prof.)	01
2.	Attendant	01
E.	Hostel Staff	
1.	Warden	01+01
2.	Care taker/Asstt.	01+01
F.	Estate Branch	
1.	Junior Engineer	01
2.	Security Asstt.	01

8. Dean Office and other associated units

A. Central Facilities

Sl. No.	Details	No. of Rooms	Dimensions (ft)
1.	Dean Office	1	20×24
2.	P.A. Room	1	10×12
3.	Committee Room with video conferencing facility	1	20×30
4.	Assistant Administrative Officer including staff	1	20×12
5.	Assistant Accounts Officer including staff	1	20×12
6.	Assistant Academic Officer including staff	1	20×12
7.	Exam Cell (300 capacity)	1	20×12
8.	Evaluation Room	1	20×36
9.	Faculty Room (Ladies)	1	10×12
10.	Faculty Room (Gents)	1	20×12
11.	Placement Cell	1	20×12
12.	Smart Lecture Halls	5	40×30 (60 capacity)
13.	Exam Hall Cum Auditorium	1	100×50
14.	Library/Book Bank	1	30×72
15.	Common Utility Room	1	20×36
16.	Central Laboratory	1	50×36

Sl. No.	Details	No. of Rooms	Dimensions (ft)
17.	Hostels including Mess, Gym/Indoor, Reading Room,	1 (boys)	150
	Warden Room, Store etc.	1 (girls)	150
18.	Canteen	1	20×12 (kitchen with store) 20×36 Seating
19.	Wash room (with toilet & urinary facilities)	10	20×12 (keeping ladies requirements)
20.	Parking space		As per requirement
21.	Farm stores, threshing yards including implements and tractor sheds		One core complex
22.	Vehicles		
	i.Car		1
	ii. Jeep/Car staff		2
	iii. Bus		1
	iv. Pickup van		1
	v. Motor Bikes		2
	vi. Minibus (30 capacity)		1
	vii. Tractors		2
	Vehicles shed	1	10×80
23.	Drinking water and irrigation facilities		As per requirements

B. Divisions/Departments/Sections – Requirements

Sl. No.	Details	No. of Rooms	Dimensions (in ft)
1.	Office of Head	12	24 × 12 with wash room facility
2.	Faculty Rooms 1+1	12	12 × 10 + 18 × 1224 × 10 depending on the strength of each deptt.
3.	Clerical/technical staff	12	12×10 to 24×10 depending on thestrength of each deptt.
5.	Laboratories	12	30× 60 Larger department will have two
6.	Field/Lab Stores	5	1. Agronomy
			2. Gen. & Pl. Breeding
			3. Soil Sci.
			4. Horticulture
			5. Pests & Chemicals
7.	Green house/poly house/Nursery facilities (Hort. Deptt.)		½ acre

8. Requirements of Lab/field equipment for each Division/Department/Section)

1. Agronomy + (Agroforestry)

1.	Crop Cafeteria	• ½ acre land • small implements like spade, hoe, khurpi, darati etc.
2.	Museum for identification of seeds, fertilizer, weeds, commonly used agro-chemical and medicinal	• Storage bottle • Herbarium posting materialand aromatic plants etc.
3.	Field of sowing method, fertilizer application, irrigation and	• Small equipment/ implement soil productivity and yield estimation
4.	Irrigation water measurement, bulk density etc.	
	Equipment	**Number**
i.	Hot air oven	02
ii.	Moisture box	30
iii.	Moisture meter	05
iv.	Tube Auger	10
v.	Bucket auger	10
vi.	Weighing Balance	01
vii.	Seed Germinator	02
viii.	Conductivity Meter	01
ix.	pH Meter	02
x.	Water Bath	01
xi.	Shaker	01
xii.	Chlorophyl Meter	01
xiii.	Drip and Sprinkler System	03
xiv.	Sprayer	03
xv.	Spring Balance 50 Kg	05
xvi.	Spring Balance 10 Kg	05
xvii.	Top Pan Balance 1 kg capacity	05
xviii.	Top Pan Balance 2 kg capacity	05
xix.	Meter Scale	10
xx.	Tape	05
xxi.	Brix meter	02

2. Agricultural Economics + (Basic Economics, Maths & Computer Science and Statistics)

Sl No.	Items	Nos.
1.	Computers	15
2.	Camera	01
3.	Software	As per requirement

3. Agriculture Extension & Communication + (Sociology and Psychology, English) Audio-visualLab

Sl No.	Items	Nos.
1.	LCD projector	1
2.	Camera (SLR) with zoom, wide-angle, tele-photo lens	1
3.	Video camera with tripod, lighting accessories and editing facility	1
4.	Computers (workstation) with editing softwares	1
5.	Digital voice recorders	5
6.	Audio recording-mixing consoles	1
7.	Computation softwares for statistics	1

4. Entomology

Sl No.	Items	Nos.
1.	Binocular Microscope	20
2.	Insect Box	60
3.	Insect Collection Nets	60
4.	Collection Bottles	60
5.	Insect Collection Big Boxes for Museum (1 for each order)	29
6.	Insecticides for showing students/Representative for each group	As per requirement
7.	Stereomicroscope	01
8.	Electronic Balance	01
9.	Soxhlet Extraction Apparatus	01
10.	Bee keeping equipment	01 Set
11.	Oven	01
12.	Patters Tower	01
13.	Sprayers	01 of each type
14.	Light traps	01 set
15.	Fumigation Chamber	01
16.	Sides/cover slips	as per requirement
17.	pH meter	01
18.	Computer with printer	01 set

5. Genetics & Plant Breeding + (Seed Science & Technology) Genetics

Sl No.	Items	Nos.
1.	Microscope	10
2.	Binocular microscope	10
3.	Electronic Moisture Meter	02
4.	Electronic Balance	02
5.	Seed Germinator	02
6.	Automatic seed/grain counter	01

Biotechnology

Sl No.	Items	Nos.
1.	Hot Air Oven	01
2.	BOD Incubator	01
3.	Fluorescence microscope	01
4.	Centrifuge	01
5.	Growth Chamber	01
6.	Distillation Assembly	01

6. Horticulture + (Food Science & Technology)

a. Labs (Post Harvest)

Sl No.	Items	Nos.
1.	Hand Refractometer	05
2.	Digital Refractometer	02
3.	Oven	01
4.	Refrigerator	01
5.	Electronic Weighing Balance	02
6.	Pan Balance (1 kg & 10 kg. capacity each)	02
7.	Deep Freezer	01
8.	pH Meter	01
9.	Fruit crusher	01
10.	Grinding and Mixing Machine	01
11.	Distillation Assembly	01

b. Lab (UG Lab)

Sl No.	Items	Nos.
1.	Seed Germinator	02
2.	Grafting and budding knife	60
3.	Secateur	60
4.	Saw	05
5.	Loppers	05
6.	Mist Chamber	01
7.	Poly house with drip irrigation system	02
8.	Microscope	02

c. Food Science & Technology

Sl No.	Items	Nos.
1.	Refrigerator	1
2.	Muffle furnace	1
3.	Weighing balance	2
4.	Water bath	2

Sl No.	Items	Nos.
5.	Hot air oven	2
6.	Fruit penetrometer	2
7.	Pulper	1
8.	Juice extractor	1
9.	Crown corking machine	1
10.	Spectrophotometer	1
11.	Microwave oven	1
12.	Baking oven	1
13.	Sieve shaker	1
14.	Poly pouch sealer	1
15.	Crusher	1
16.	Masala grinder	1
17.	Dehydrator	1
18.	Cold room	1
19.	Vacuum pump	1

7. Soil Science and Agricultural Chemistry + (Microbiology, Agro-meteorology, Environmental Sciences)

Sl No.	Items	Nos.
1.	Electronic Top pan balance (0.1 g capacity)	02
2.	Electronic Top pan balance (1 mg capacity)	02
3.	Hot air oven	02
4.	pH Meter	05
5.	EC Meter	05
6.	Flame Photometer	01
7.	Visible spectrophotometer	01
8.	Hot Plate	02
9.	Distilled water unit	02
10.	Water Bath	01
11.	Rotary Shaker	02
12.	Binocular Microscope	20
13.	BOD Incubator	02
14.	Autoclave	02
15.	Laminar Air Flow	01
16.	Microwave oven	01
17.	Digestion block	02
18.	Hydrometer	05
19.	Infiltrometer	02
20.	Hydraulic conductivity meter	01
21.	Atterberg's limitsmeter	05
22.	Nitrogen Analyser	02

8. Agrometeorology

Sl No.	Items	Nos.
1.	Thermometer Max	05
2.	Thermometer Min	05
3.	Digital Anemometer	02
4.	Cup Anemometer	02
5.	Pan Evaporimeter	01
6.	Soil thermometer - 05 cm.	05
7.	10 cm.	05
8.	15 cm.	05
9.	Rain gauge	01
10.	Self-recording Rain gauge	01
11.	Sunshine Recorder	01
12.	Stevenson's Screen	01
13.	Thermograph	01
14.	Hygrograph	01
15.	Soil Heat Flux Plate	01
16.	GPS	10
17.	AWS (optional)	01
18.	Lysimeter (optional)	01
19.	Luxmeter	02
20.	Solar Pyranometer	01

9. Plant Pathology

Sl No.	Items	Nos.
1.	Microscope compound with photo display arrangement	03
2.	Sterobinocular	05
3.	Sample processing Board (Dry preservation of samples)	04
4.	Wet preservation Jars	50
5.	Autoclave	02
6.	Oven	01
7.	Deep Freeze	01
8.	Centrifuge (3000 rpm)	01
9.	Refrigerator	01
10.	Water bath	02
11.	Electronic balance	02
12.	Weighing machine	01
13.	Incubator	02
14.	Occular meter	05
15.	Stage Micrometer	05
16.	Camera Lucida	05

10. Animal Sciences including Fisheries

Sl No.	Items	Nos.
1.	5000/6500 Feed and Forage Analyzer	01
2.	Hand and electric centrifuge	01
3.	Analytical balance	01
4.	Hot air oven	01
5.	Micro kjeldahl N digestion & distillation apparatus	01
6.	Soxhlet unit for fat estimation	01
7.	Hot plate, Fiber Tech.	01
8.	Vacuum pump	01
9.	Willy mill grinder	01
10.	Platform balance (100 kg cap)	01
11.	Gerber centrifuge unit (for milk fat testing)	01
12.	Milk analyzer (automatic)	01
13.	Crude fiber estimation unit	01
14.	Distilled water unit	01

11. Dairy & Poultry

Sl No.	Items	Nos.
1.	Incubator cum hatcher	01
2.	Brooder machine	01
3.	Feeder	01
4.	Waterer	01
5.	Egg candling machine	01
6.	Debeaker	01
7.	Vaccinator	01
8.	Milking machine	As per requirements
9.	Milking bucket	As per requirement
10.	Milking can	As per requirements
11.	Animal and bird identification tools	As per requirement
12.	Chaff cutter	01
13.	Lactometer	01
14.	Castrator	01
15.	Shearer	01
16.	Electric dehorner	01
17.	Artificial vagina	01
18.	Common medication device	01
19.	Cattle crate	01

12. Agriculture Engineering + (Farm Management)

Sl No.	Items	Nos.
1.	Working models of MB plough, Disk plough and indigenous plough	2 sets each
2.	Working model of different harrows	Actual
3.	Seed drill	01
4.	Different types of threshing drums	As per requirement
5.	Working models of reaper and mowers	02
6.	Different types of sprayers and dusters	As per
7.	Cut model of CI & SI engine	requirement 01
8.	Cut model of Tractor	01

13. Central Library and Information System

Sl No.	Items	Nos.
1.	Internet Server	01
2.	Intranet Server	01
3.	Computers for Reading Hall	20
4.	Heavy Duty Photocopiers	02
5.	Computerized Issue and Catalogue Systems	02
6.	Wi-Fi facility in college/library/hostels	As per requirement
7.	CCTV monitoring system for library	01
8.	RFID and Access Control System (Optional)	01
9.	Broadband Internet Connectivity with minimum speed of	1Gbps

HORTICULTURE

Course Curricula for Undergraduate program in Horticulture: UG-Certificate (Horticulture); UG-Diploma (Horticulture); B.Sc. (Hons.) Horticulture

INTRODUCTION

Horticulture, viewed as one of the promising option for crop diversification in agriculture, has a great significance especially as the fruits and vegetables are important components of diet required to meet the nutritional needs of the masses. Equally important is the commercial cultivation of flowers and landscape gardening/ architecture. In the current scenario of need for diversified agriculture, the sustainable horticulture is only possible if the trained workforce, especially graduates/ postgraduates in horticulture are readily available. The need based up-gradation of course curriculum, especially with a focus on skill enhancement of graduates is required. The skill empowerment along with the sound theoretical knowledge of the subject is the basic requirement of a trained graduate. That is the essence of NEP 2020 and has been embedded in all the Undergraduate degree programs through formation of 6th Deans' Committee and its subsequent discussions on developing need/ skill-based course curriculum in different subjects including Horticulture. Apart from skill enhancement, the other provisions of NEP–2020 especially multiple entry and exit options have been taken into consideration in restructured course curriculum of B. Sc. (Hons.) Horticulture degree program. There is provision of exit after 1st year and 2nd year and the students thus will be entitled for UG Certificate in Horticulture and UG Diploma in Horticulture, respectively. Likewise, entry options have been provided for the degree after 4 year. The value-added courses (VAC) and ability enhancement courses (AEC) along with choice-based skill enhancement courses (SEC) have also been added in the proposed course curriculum.

The course curriculum in Horticulture has been restructured based on the elaborate discussion among the members of 6th Deans' Committee as well as the subject experts from different Universities/ Institutes imparting horticulture degrees, representing different regions of the country. The discussion to improve course curriculum

has been made among the faculty of all the three disciplines of horticulture namely fruits, vegetables and flowers.

The sketch of semester wise courses I to VIII, along with detailed course contents are presented in the following text.

HIGHLIGHTS

- The whole course program of B.Sc. (Hons.) Horticulture will be of 167+10*(*MOOCs) with a total of 177 credit hours.
- More weightage has been given to skill enhancement courses in first two years. Students have been given flexibility and choice in selection of skill enhancement courses from a basket of multiple skill enhancement modules offered in all the four semesters of first two years.
- Students will be given 12 credits of skill-based courses so that they acquire enough knowledge and skill through hands-on training in related domain to get UG-certificate by the end of first year and UG-Diploma at the end of second year if they opt to exit.
- In first year, after completing the course requirement, there is provision of extra 10-credit Internship of two months' period for Industry exposure/ Hands on training in related domain of skill acquired to get first-hand experience to become eligible for the award of UG Certificate on exit. Similarly, internship is necessary for those exiting after 2 years with UG-diploma. Students will complete requirement of given course credits plus 10 weeks Internship each in first and second year.
- These students are expected to acquire competency and confidence to start their own enterprise and have adequate competency for getting jobs.
- More emphasis has been given in proper amalgamation of theory and practical to provide them hard core knowledge of Horticulture discipline.
- 10 non-credit courses have been made compulsory are at the discretion of students. Students have the choice of MOOCs to enhance their knowledge and competency beyond prescribed courses. Student also have flexibility to complete these non credit courses of 10 credits throughout the span of the degree program preferably in 3rd and 4th year.
- On successfully completing the four years' degree requirement, the student will be given undergraduate degree of B.Sc. (Hons.) Horticulture.
- During the 5th semester, the students will have to undertake study tour of 10-14 days' duration, which will be counted as 2 credits (Non-gradial).
- The elective courses will be offered in 7th semester. The students can choose any one of the electives and pursue in total of minimum 20 credits in the semester.
- The Universities/HAEIs will have flexibility to include more courses as electives depending on specific needs and situational variations. The objective is to enable the student to acquire deeper understanding in any particular field.
- Any individual course can also be modified maximum up to 30% with approval from competent authority of the University.

Entry and Exit Options

The entry and exit options for the B. Sc. (Hons.) Horticulture programme are shown in the Figure. 1 below:

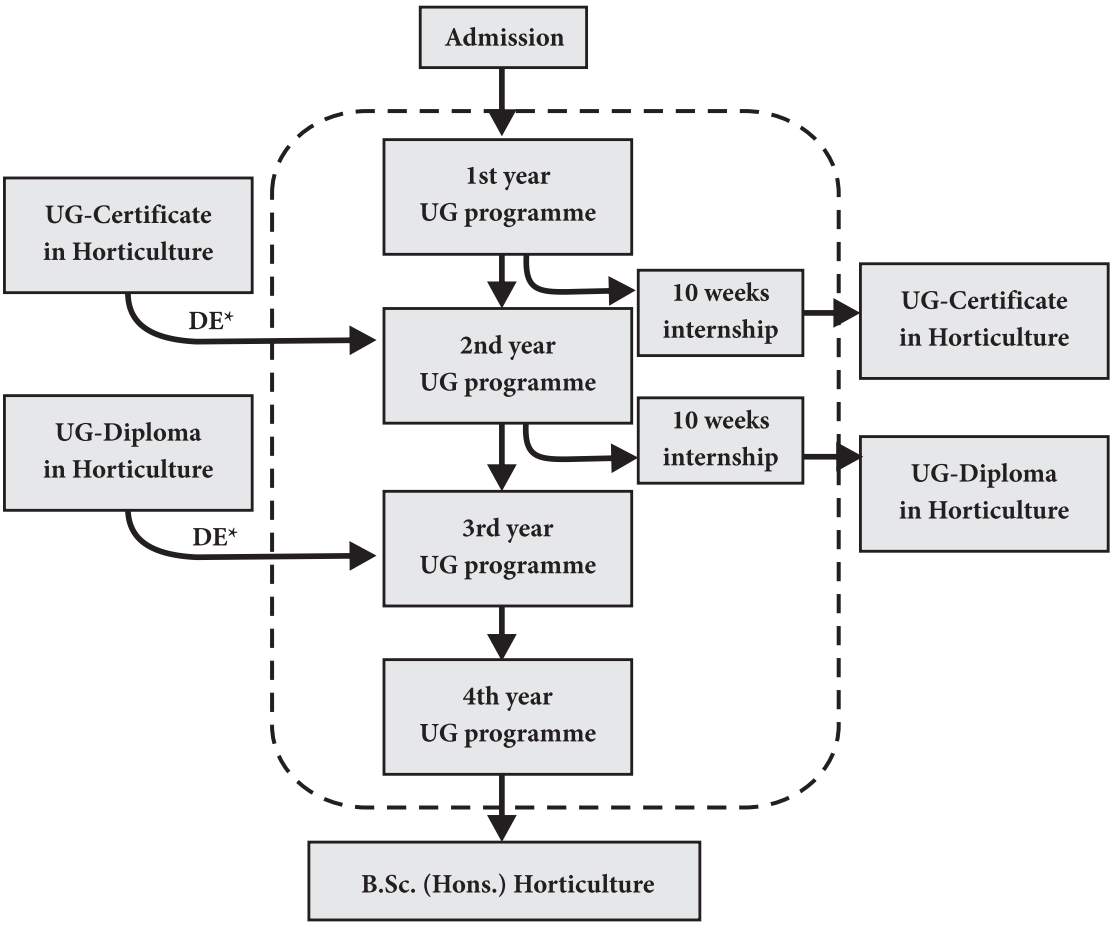


Fig. 1 Entry and Exit options for the UG program in Horticulture

DE*: Direct Entry in the respective year

Exit options

1. UG-Certificate in Horticulture- (exit after first year and completion of 10 weeks internship)
2. UG-Diploma in Horticulture- (exit after second year and completion of 10 weeks internship)
3. B. Sc. (Hons.) Horticulture- (on successful completion of four-year degree requirements)

Admission Eligibility Criteria for Entry into 1st year UG Programme: 10+2 Science with PCM/ PCB/Agriculture/ Horticulture or as per norms of SAUs/ICAR/HAEI

ACADEMIC PROGRAM

Semester wise course distribution

Semester	Course Title	Credit Hours	Total Credits
First Year			
I semester			
1	Deeksharambh (Induction cum Foundation Course)	2 (0+2) NG Non-gradial	**21 (8+13) + 2 (Non-gradial)**
2.	Fundamentals of Horticulture	3 (2+1)	
3.	Plant Propagation and Nursery Management of Fruit and Plantation crops	3 (1+2)	
4.	Commercial production of Flower crops	3 (1+2)	
5.	Farming Based Livelihood Systems	3 (2+1)	
6.	Sprinkler and Micro irrigation systems	2 (1+1)	
7.	Communication Skills	2 (1+1)	
8.	Skill Enhancement Courses (SEC-I)*	4 (0+4)	
9.	NCC-I/NSS-I	1 (0+1)	
II Semester			
1.	Introduction to Major Field crops	3 (2+1)	**22 (10+12)**
2.	Commercial Production of Spices and Plantation crops	3 (2+1)	
3.	Plant Propagation and Nursery Management in Vegetables, Flowers and Medicinal crops	3 (1+2)	
4.	Personality Development	2 (1+1)	
5.	Entrepreneurship Development and Business Management	3 (2+1)	
6.	Environmental Studies and Disaster Management	3 (2+1)	
7.	Skill Enhancement Courses (SEC-II)*	4 (0+4)	
8.	NCC-II/NSS-II	1 (0+1)	
Post-II Semester			
1.	Internship (for 10 weeks-only for exit option for award of UG-Certificate)	10 (0+10)	
Second Year			
III Semester			
1.	Fundamentals of Soil Science	3 (2+1)	**20 (11+9)**
2.	Commercial Fruit Production	4 (3+1)	
3.	Precision Farming and Protected Cultivation	3 (2+1)	
4.	Seed Production of Vegetable, Tuber and Spice crops	3 (2+1)	
5.	Disease Management in Horticulture crops	3 (2+1)	
6.	Physical Education, First Aid,Yoga Practices and Meditation	2 (0+2)	
7.	Skill Enhancement Courses (SEC-III)*	2 (0+2)	

Semester	Course Title	Credit Hours	Total Credits
IV Semester			
1.	Commercial Vegetable Production	4 (3+1)	**22 (13+9)**
2.	Farm Power and Machinery for Horticulture	3 (2+1)	
3.	Agricultural Informatics and Artificial Intelligence	3 (2+1)	
4.	Urban and Peri Urban Horticulture	2 (1+1)	
5.	Agriculture Marketing and Trade	3 (2+1)	
6.	Pest Management of Horticulture crops	3 (2+1)	
7.	Introductory Agrometeorology and Climate Change	2 (1+1)	
8.	Skill Enhancement Courses (SEC-IV)*	2 (0+2)	
Post-IV semester			
1.	Internship (for 10 weeks-only for exit option for award of UG-Diploma)	10 (0+10)	
Third Year			
V Semester			
1.	Fundamentals of Plant Breeding	3 (2+1)	**20 (12+8) + 2 (Non gradial)**
2.	Growth and Development of Horticultural crops	3 (2+1)	
3.	Soil Fertility and Nutrient Management	3 (2+1)	
4.	General Microbiology	3 (2+1)	
5.	Information and Communication Technology in Horticulture	3 (1+2)	
6.	Introductory Crop Physiology	2 (1+1)	
7.	Basic Statistics and Experimental Designs	3 (2+1)	
8.	Education Tour (10-14 days)	2 (0+2) Non-gradial	
VI Semester			
1.	Introductory Agroforestry	3 (2+1)	**22 (13+9)**
2.	Laboratory Techniques for Horticultural crops	2 (0+2)	
3.	Principles of Biochemistry	3 (2+1)	
4.	Dryland Horticulture	3 (2+1)	
5.	Economics and Marketing	3 (2+1)	
6.	Principles and Practices of Natural Farming	2 (1+1)	
7.	Horticulture Based Integrated Farming System	3 (2+1)	
8.	Processing and Value Addition of Horticulture crops	3 (2+1)	
Fourth Year			
VII Semester			
1.	**Elective Courses**- Students will opt one of the elective discipline and accordingly the courses offered by University may be taken		**20**
	Fruit Science	20	
	Vegetable Science	20	
	Floriculture and Landscaping	20	

Semester	Course Title	Credit Hours	Total Credits
	VIII Semester		
1.	Student READY (RAWE/Industrial Attachment /Experiential Learning/Hands-on Training/Skill Development/Project Work/ Internship etc.)	20 (0+20)	**20**
		Grand total	**MOOCs 167 +10****

* From the basket of Skill Enhancement Course (SEC) modules

Non gradial courses- *Deeksharambh* (0+2); Education Tour (0+2)

**MOOCs (Massive open online courses)

Department/ section wise course breakup

	Foundation course	
	Course Title	**Credits**
1.	*Deeksharambh* (Induction-Cum-Foundation Course (2 weeks)	2 (0+2)

Skill Enhancement Courses (SEC)		**Credits**
1.	Mushroom Cultivation	2 (0+2)
2.	Apiculture	2 (0+2)
3.	Orchard Floor Management	2 (0+2)
4.	Landscape Gardening	2 (0+2)
5.	Packing and Packaging of Horticultural Crops	2 (0+2)
6.	Farm Machinery	2 (0+2)
7.	Introduction to Forestry	2 (0+2)
8.	Installation, Operation and Maintenance of Micro-irrigation System	2 (0+2)
9.	Computer Programming and Data Structures	2 (0+2)
10.	Turf and Turf Management	2 (0+2)
11.	Post-Harvest Management of Horticultural Produce	2 (0+2)
12.	Nursery Production in Horticulture crops	2 (0+2)
13.	Seed Production techniques in Vegetable crops	2 (0+2)
14.	Sericulture	2 (0+2)

Note: The University/ Institute may offer more Skill Enhancement courses relevant to the region and the subject.

Core (Major/ Minor Course)

Fundamentals of Horticulture	3 (2+1)
Plant Propagation and Nursery Management of Fruit and Plantation crops	3 (1+2)

Plant Propagation and Nursery Management in Flowers and Medicinal and crops	3 (1+2)
Growth and Development of Horticulture crops	3 (2+1)
Commercial Fruit Production	4 (3+1)
Commercial Vegetable Production	4 (3+1)
Commercial Production of Flower crops	3 (1+2)
Dry land Horticulture	3 (2+1)
Urban and Peri Urban Horticulture	2(1+1)
Sprinkler and Micro Irrigation systems	2 (1+1)
Laboratory Techniques for Horticulture crops	2 (0+2)
Processing and Value Addition of Horticulture crops	3 (2+1)
Farm Power and Machinery for Horticulture	3 (2+1)
Pest management of Horticulture crops	3 (2+1)
Disease Management of Horticulture crops	3 (2+1)
Information and Communication Technology in Horticulture	3 (1+2)
Commercial production of spices and plantation crops	3 (2+1)
Precision farming and protected cultivation	3 (2+1)
Horticulture based integrated farming system	3 (2+1)
Seed production of vegetables, tuber and spice crops	3 (1+2)
Soil Fertility and Nutrient Management	3 (2+1)
Fundamentals of Soil Science	3 (2+1)
Introduction to Major Field crops	3 (2+1)
Fundamentals of Plant Breeding	3 (2+1)
Introductory Agroforestry	3 (2+1)
Introductory Agrometeorology and Climate Change	2 (1+1)
Economics and Marketing	3 (2+1)
Introductory Crop Physiology	2 (1+1)
Principles of Biochemistry	3 (2+1)
General Microbiology	3 (2+1)
Basic Statistics and Experimental Designs	3 (2+1)
Principles and Practices of Natural Farming	2 (1+1)

Elective courses

Fruit Science	
Production Technology of Tropical Fruit crops	3 (2+1)
Production Technology of Sub tropical and temperate Fruit crops	3 (2+1)

Breeding of Fruit crops	3 (2+1)
Canopy Management in Fruit crops	3 (2+1)
Biotechnological Approaches and Micropropagation in Fruit crops	3 (2+1)
Production Technology of Arid Fruit crops	3 (2+1)
Postharvest Management for Fruit crops	2 (1+1)
Vegetable Science	3 (2+1)
Production Technology of Warm Season Vegetable crops	3 (2+1)
Production Technology of Cool Season Vegetable crops	3 (2+1)
Production Technology of Tuber crops	3 (2+1)
Breeding of Vegetable crops	3 (2+1)
Biotechnological approaches and Micropropagation in Vegetable crops	3 (2+1)
Postharvest Management of Vegetable crops	3 (2+1)
Protected cultivation of Vegetable crops	2 (1+1)
Floriculture and Landscaping	
Turf Management	2 (1+1)
Protected Cultivation of Flower crops	3 (2+1)
Value Addition in Floriculture	3 (2+1)
Breeding of Ornamental crops	3 (2+1)
Principles of Landscape Architecture	3 (2+1)
Commercial Floriculture and Landscaping	3 (2+1)
Postharvest handling of Floriculture crops	3 (2+1)

Note: The University/ Institute may offer more electives/courses relevant to the subject.

Multidisciplinary Courses (MDC)

Farming Based Livelihood Systems	3 (2+1)
Entrepreneurship Development and Business Management	3 (2+1)
Agriculture Marketing and Trade	3 (2+1)

Value Added Courses (VAC)

Environmental Studies and Disaster Management	3 (2+1)
Agriculture Informatics & Artificial Intelligence	3 (2+1)

Ability Enhancement Courses (AEC)

Communication Skills	2 (1+1)
Personality Development	2 (1+1)
Physical Education, First Aid, Yoga & Meditation	2 (0+2)
NCC/NSS	2 (0+2)

Summary of Credit distribution of different categories of courses (Credit hours)

Semester	Core Courses (Major+ Minor)	Multi-Disciplinary Course (MDC)	Value Added Course (VAC)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)	Internship/ Project/ Student READY	Total Credits	Non-Gradial	Internship	Online Courses/ MOOC
I	11	3[2]		1[3] + 2[4]	4	-	21	2[1]		
II	9	3[5]	3[6]	1[3] + 2[7]	4	-	22	-	10[12]	
III	16	--		2[8]	2	-	20	-		
IV	14	3[9]	3[10]	----	2	-	22	-	10[13]	**10**
V	20	-	-	-	-	-	20	2[11]		
VI	22	-	-	-	-	-	22	-		
VII	20	-	-	-	-	-	20	-		
VIII	-	-	-	-	-	20	20	-		
Total	**112**	**9**	**6**	**8**	**12**	**20**	**167**	**4**		**10**

[1] *Deeksharambh* (Induction-cum-Foundation Course) of 2 credits (2weeks duration)
[2] Farming based Livelihood systems
[3] NCC/NSS
[4] Communication Skills
[5] Entrepreneurship Development and Business Management
[6] Environmental Studies and Disaster Management
[7] Personality Development
[8] Physical Education, First Aid, Yoga Practices & Meditation
[9] Agriculture Marketing and Trade
[10] Agricultural Informatics & Artificial Intelligence
[11] Study tour (10-14 days)
[12] Only for those opting for an exit with UG-Certificate
[13] Only for those opting for an exit with UG-Diploma

Summary of Credit Distribution

Type of courses	Credits
Core courses (major and minor/s)	112
Common courses (MDC+VAC+AEC)	23
Skill Enhancement Courses (SEC)	12
Internship / Student READY	20
Non-Gradial Courses [*Deeksharambh* and Educational Tour]	4*
Online Courses / MOOCs	10**
Total	167 + 10**

*Non-Gradial ** Online courses

Detailed Syllabi
Semester I

***Deeksharambh* (Induction-cum-Foundation Course)** **0+2 (NG)**

The activities to be taken under *Deeksharambh* shall aim at creating a platform for students to

1. Helpings in for cultural Integration of students from different backgrounds
2. Know about the operational framework of academic process in the University
3. Instilling life social skills
4. Social awareness, ethics and values, team work, leadership, creativity, etc.
5. Identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario.

The details of activities will be decided by the Universities. The structure shall include, but not restricted to:

i. Discussions on operational framework of academic process in university, as well as interactions with academic and research managers of the University

ii. Interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences

iii. Group activities to identify the strength and weakness of students (with expert advice for their improvement) as well as to create a platform for students to learn from each other's life experiences

iv. Activities to enhance cultural Integration of students from different backgrounds.

v. Field visits to related fields/ establishments

vi. Sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills

Fundamentals of Horticulture **3 (2+1)**

Objectives

i. To provide knowledge of horticulture in a brief and prescribed manner

ii. To familiarize students with principles and practices of management for Horticultural crops

Theory

Scope and importance, classification of horticultural crops and nutritive value, area and production, exports and imports, fruit and vegetable zones of India and of different states, nursery techniques and their management, soil and climate, vegetable gardens, nutrition and kitchen garden and other types of gardens – principles, planning and layout, management of orchards, planting systems and planting densities. Methods of pruning and training of fruit crops, types and use of growth regulators in horticulture, water management– irrigation methods, merits and demerits, weed management, fertility management in horticultural crops-manures and fertilizers, different methods of application, cropping systems, intercropping, multi-tier cropping, mulching– objectives,

types merits and demerits, Classification of bearing habits of fruit trees, factors influencing the fruitfulness and unfruitfulness. Rejuvenation of old orchards, top working, frameworking, principles of organic and Natural farming, market chain management.

Practical

Features of orchard, planning and layout of orchard, tools and implements, identification of various horticultural crops, layout of nutrition garden, preparation of nursery beds for sowing of vegetable/ flower seeds, digging of pits for fruit plants, planting systems, training and pruning of orchard trees, preparation of fertilizer mixtures and field application, preparation and application of growth regulators, layout of different irrigation systems, identification and management of nutritional disorder in fruits and vegetable crops, maturity standards, harvesting, grading, packaging and storage.

Suggested Readings

1. Chattopadhyay T K. 2013. *A Textbook on Pomology Vol I-IV*. Kalyani Publications. New Delhi.
2. Kumar Prasad. 2014. *Principles of Horticulture.* (2nd Edn.). Agrobios India.
3. Misra Kausal Kumar and Kumar Rajesh 2014. *Fundamentals of Horticulture*. Biotech Books.
4. Peter K V. 2009. *Basics Horticulture*. New India Publishing Agency.
5. Salunkhe D K and Kadam S S. 2013. *A Handbook of Fruit Science and Technology*. CRC Press.
6. Singh Jitendra. 2011. *Basic Horticulture.* Kalyani Publications. New Delhi.
7. Singh Neeraj Pratap. 2005. *Basic concepts of Fruit Science.* (1st Edn.). IBDC Publishers.

Plant Propagation and Nursery Management of Fruit and Plantation Crops 3 (1+2)

Objectives

i. To know different methods of propagation techniques
ii. Horticultural significance of specialized vegetative structures
iii. To study the different types of plant propagation methods and structures

Theory

Status and importance of plant propagation and nursery production in fruits and plantation crops. Sexual and asexual methods of propagation, their advantages and disadvantages. Apomixes, seed dormancy, types of dormancy and methods to overcome seed dormancy. Use of vegetative propagation methods viz. division, cutting, layering, budding and grafting. Propagation structures in nursery production: Mist chamber, humidifiers, greenhouses, glasshouses, cold frames, hot beds and poly-houses. Use of growth regulators in nursery production. Components of a nursery, maintenance of mother trees and seed gardens, collection of scion-wood, and bud wood certification. Growing medium and containers used for nursery production. Role of tissue culture techniques viz. micropropagation, micrografting and meristem culture. Nursery registration act. Management of insect-pests and diseases in nursery. Cost of establishment of a modern nursery.

Practical

Selection of site, soil sterilization and preparation of beds for nursery raising. Preparation of growing media and use of different nursery containers for containerized nursery production in fruits

and plantation crops. Seed treatments for breaking dormancy and prevention of nursery diseases. Sowing of seed, raising and maintenance of rootstock/ seedlings. Practicing different vegetative propagation methods, viz. cutting, layering, grafting and budding. Preparation of plant growth regulators for seed germination and vegetative propagation. Digging, labelling and packing of field grown nursery plants. Familiarisation with propagation structures mist chamber, greenhouse, glasshouse, polyhouse and net house; and their maintenance. Micropropagation and hardening of plants. Tissue culture media preparation, explant preparation, *in vitro* culturing and shoot tip culture, primary and secondary hardening of tissue culture plants. Maintenance of nursery records. Identification and management of insect-pests and diseases in nursery. Project formulation for small and high-tech nurseries. Nursery Accreditation.

Suggested Readings

1. Davies F T, Geneve R L and Wilson S B 2018. *Hartmann and Kester's Plant Propagation Principles and Practices.* (9th Edn.). Pearson. USA.
2. ICAR 2019. *Handbook of Horticulture.* (2nd Edn.). ICAR Vol I, II. New Delhi.
3. Peter K V. 2002. *Plantation crops*. National Book Trust India, New Delhi.
4. Sharma R R and Krishna Hare. 2017. *Textbook of Plant Propagation and Nursery Management*. C B S Publishers. New Delhi.
5. Sharma R R and Srivastava Manish. 2004. *Plant Propagation and Nursery Management*. IBDC Publishers. New Delhi

Commercial Production of Flower Crops 3 (1+2)

Objectives

Imparting knowledge about climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, nutritional and irrigation requirements, intercultural operations, weed management, physiological disorders, postharvest management, plant protection measures of major flower crops.

Theory

Scope and importance of flower cultivation. Soil, climate, varieties, propagation, special intercultural operations, fertilizers requirement, irrigation, use of growth regulators, weed management, plant protection measures, harvesting, grading, packaging, and storage of rose, jasmine, carnation, chrysanthemum, gladiolus, marigold, tuberose and cut foliage crops under open/partial shade. Seed production of flowering annuals.

Practical

Introduction of flower crops. Identification of commercial varieties, propagation techniques, bed preparation, soil decontamination, planting and layout, training, pruning, staking, growing media, potting and repotting. Containers for growing flowers for exhibition. Fertilizer calculations and application, growth regulator application. Weed management and plant protection measures. Special horticultural practices in cut flower and cut foliage crops. Determination of harvest indices, harvesting methods and postharvest handling. Commercial Standards, Packing methods. Project preparation. Visit to commercial flower market and progressive growers having high-tech farms.

Suggested Readings

1. Arora J S. 2016. *Introductory Ornamental Horticulture*. Kalyani Publishers.
2. Aswath C, Bose T K, Dutta K, Reeta Bhatia and Saha T N. 2021.*Commercial Flowers. (Vol. II)*. Daya Publishing House, New Delh.
3. Bose T K, Maiti R G, Dhua R S, Das P. 1999. *Floriculture and Landscaping. (Vol.I)*. Calcutta: Naya Prokash.
4. Purohit S S and Bhardwaj Prasad R A. 2016. *Textbook of Production Technology of Vegetable and Flower Crops*. Agrobios (India).
5. Randhawa, G. S. and Mukhopadhyay Amitabha. 1986. *Floriculture in India*. Allied Publishers, 660p.
6. Singh A K. 2006. *Flower Crops: Cultivation and Management*. New India Publishing, Gardening, 480p.
7. Vishnu Swarup .1967. *Garden Flowers: Buy Garden Flowers*. National Book Trust, India, 261p.

Farming Based Livelihood Systems 3 (2+1)

Objectives

i. To make the students aware about farming-based livelihood systems in agriculture
ii. To disseminate the knowledge and skill how farming-based systems can be a source of livelihood

Theory

Status of agriculture in India and different states, Income of farmers and rural people in India, Livelihood-Definition, concept and livelihood pattern in urban and rural areas, Different indicators to study livelihood systems. Agricultural livelihood systems (ALS): Meaning, approach, approaches and framework, Definition of farming systems and farming based livelihood systems Prevalent Farming systems in India contributing to livelihood. Types of traditional and modern farming systems. Components of farming system/ farming based livelihood systems- Crops and cropping systems, Livestock, (Dairy, Piggery, Goatry, Poultry, Duckry etc.), Horticultural crops, Agro--forestry systems, Aqua culture Duck/Poultry cum Fish, Dairy cum Fish, Piggery cum Fish etc., Small, medium and large enterprises including value chains and secondary enterprises as livelihood components for farmers, Factors affecting integration of various enterprises of farming for livelihood. Feasibility of different farming systems for different agro-climatic zones, Commercial farming- based livelihood models by NABARD, ICAR and other organizations across the country, Case studies on different livelihood enterprises associated with the farming. Risk and success factors in farming-based livelihood systems, Schemes and programs by Central and State Government, Public and Private organizations involved in promotion of farming based livelihood opportunities. Role of farming-based livelihood enterprises in 21st Century in view of circular economy, green economy, climate change, digitalization and changing life style.

Practical

Survey of farming systems and agriculture-based livelihood enterprises, Study of components of important farming based livelihood models/ systems in different agro-climatic zones, Study of

production and profitability of crop based, livestock based, processing based and integrated farming based livelihood models, Field visit of innovative farming system models. Visit of Agri-based enterprises and their functional aspects for integration of production, processing and distribution sectors and Study of agri-enterprises involved in industry and service sectors (Value Chain Models), Learning about concept of project formulation on farming- based livelihood systems along with cost and profit analysis, Case study of Start-Ups in agri-sectors.

Suggested Readings

1. Agarwal A and Narain S. 1989. *Towards Green Villages: A strategy for Environmentally, Sound and Participatory Rural Development, Center for Science and Environment*, New Delhi, India.
2. Ashley C and Carney D. 1999. *Sustainable Livelihoods: Lessons from Early Experience; Department for International Development: London*. UK, Vol. 7. [Google Scholar]
3. Carloni A. 2001. *Global Farming Systems Study: Challenges and Priorities to 2030 – Regional Analysis: Sub-Saharan Africa, Consultation Document*. FAO, Rome, Italy.
4. Dixon J, Gulliver A and Gibbon D. 2001. *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World.* FAO and World Bank, Rome, Italy and Washington, DC, USA
5. Evenson R E. 2000. Agricultural Productivity and Production in Developing Countries. In: FAO, The State of Food and Agriculture, FAO, Rome, Italy.
6. Reddy S R. 2016. *Farming System and Sustainable Agriculture*. Kalyani Publishers, New Delhi.
7. Walia S S and Walia U S. 2020. *Farming System and Sustainable Agriculture*. Scientific Publishers, Jodhpur, Rajasthan.

Sprinkler and Micro irrigation Systems 2 (1+1)

Objectives

To acquaint the students with the basic knowledge of modern irrigation systems

Theory

Sprinkler irrigation: adaptability, types, problems and prospects. Sprinkler/micro sprinkler irrigation system design: steps, layout, selection, design of lateral, sub-main and main pipeline, selection of pump and power unit. Performance evaluation of sprinkler irrigation system: uniformity coefficient and pattern efficiency. Micro irrigation system: types, merits and demerits, components. Design of drip irrigation system: general considerations, wetting patterns, irrigation requirement, emitter selection, hydraulics and design steps. Steps for proper operation of a drip irrigation system. Maintenance of micro irrigation system: clogging, filter cleaning, flushing and chemical treatment. Fertigation: advantages, limitations, methods, fertilizers solubility and their compatibility, precautions, frequency, duration and injection rate. Economics: Cost estimation of sprinkler and micro irrigation system.

Practical

Study of different components, design and installation of sprinkler irrigation system. Determination of precipitation pattern, discharge and uniformity coefficient. Study of different components, design and installation of drip irrigation system. Determination of pressure

discharge relationship and emission uniformity for emitter. Study of different types of filters and determination of filtration efficiency. Determination of rate of injection and calibration for chemigation / fertigation. Design of irrigation and fertigation schedule for crops. Field visit to micro irrigation system and evaluation of drip system. Cost economics of sprinkler and drip irrigation system.

Suggested Readings

1. Biswas R K. 2015. *Drip and Sprinkler Irrigation.* New India Publishing Agency.
2. Goyal M R. 2016. *Micro Irrigation Management Technological Advances and Their Applications - Innovations and Challenges in Micro Irrigation*. CRC Press.
3. James L G. 1993. *Principles of Farm Irrigation System Design*. Krieger publishing Company, Malabar, Florida.
4. Mane M S and Ayare B L. 2019. *Principles of Sprinkler Irrigation*. Jain Brothers, N. Delhi. (4th Edn.).
5. Mane M S and Ayare B L. 2019. *Principles of Drip Irrigation*. Jain Brothers, New Delhi.

Communication Skills 2 (1+1)

Objectives

i. To acquire competence in oral, written and non-verbal communication
ii. To develop strong personal and professional communication and demonstrate positive group communication

Theory

Communication Process: The magic of effective communication; Building self-esteem and overcoming fears; Concept, nature and significance of communication process; Meaning, types and models of communication; Verbal and non-verbal communication; Linguistic and non-linguistic barriers to communication and reasons behind communication gap/ miscommunication.

Basic Communication Skills: Listening, Speaking, Reading and Writing Skills; Precis writing/ Abstracting/Summarizing; Style of technical communication Curriculum vitae/resume writing; Innovative methods to enhance vocabulary, analogy questions.

Structural and Functional Grammar: Sentence structure, modifiers, connecting words and verbals; phrases and clauses; Case: subjective case, possessive case; objective case; Correct usage of nouns, pronouns and antecedents, adjectives, adverbs and articles; Agreement of verb with the subject: tense, mood, voice; Writing effective sentences; Basic sentence faults.

Practical

Listening and note taking; Writing skills: precis writing, summarizing and abstracting; Reading and comprehension (written and oral) of general and technical articles; Micro-presentations and Impromptu Presentations: Feedback on presentations; Stage manners: grooming, body language, voice modulation, speed; Group discussions; Public speaking exercises; vocabulary building exercises; Interview Techniques; organization of events.

Suggested Readings

1. Brown Michele and Gyles Brandreth. 1994. *How to Interview and be Interviewed*. Sheldon Press, London.
2. Carnegie Dale. 1997. *The Quick and Easy Way to Effective Speaking*. Pocket Books, New York.
3. Francis Peter S J. 2012. *Soft Skills and Professional Communication*. Tata McGraw Hill, New Delhi.
4. Kumar S and Pushpa Lata. 2011. *Communication Skills*. Oxford University Press.
5. Neuliep James W. 2003. *Intercultural Communication A Contextual Approach*. Houghton Mifflin Co Boston.
6. Pease Allan. 1998. *Body Language*. Sudha Publications. Delhi.
7. Raman M and Singh P. 2000. *Business Communication*. Oxford University Press.
8. Seely J. 2013. *Oxford Guide to Effective Writing and Speaking*. Oxford University Press.
9. Thomson A J and Martinet A V. 1977. *A Practical English Grammar*. Oxford University

National Cadet Corps (NCC-I) 1 (0+1)

- Aims, objectives, organization of NCC and NCC song. DG's cardinals of discipline.
- Drill- aim, general words of command, attention, stands at ease, stand easy and turning.
- Sizing, numbering, forming in three ranks, open and close order march, and dressing.
- Saluting at the halt, getting on parade, dismissing, and falling out.
- Marching, length of pace, and time of marching in quick/slow time and halt. Side pace, pace forward and to the rear. Turning on the march and wheeling. Saluting on the march.
- Marking time, forward march, and halt. Changing step, formation of squad and squad drill.
- Command and control, organization, badges of rank, honors, and awards
- Nation Building- cultural heritage, religions, traditions, and customs of India. National integration. Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizens. Leadership traits, types of leadership. Character/ personality development. Civil defense organization, types of emergencies, firefighting, protection. Maintenance of essential services, disaster management, aid during development projects.
- Basics of social service, weaker sections of society and their needs, NGO's and their contribution, contribution of youth towards social welfare and family planning.
- Structure and function of human body, diet and exercise, hygiene and sanitation. Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health. Adventure activities. Basic principles of ecology, environmental conservation, pollution and its control.

National Service Scheme (NSS-I) 1 (0+1)

Evoking social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skillful in executing democratic leadership, developing skill in program, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

All the activities related to the National Service Scheme are distributed under four different courses viz., National Service Scheme I, National Service Scheme II, National Service Scheme III and National Service Scheme IV each having one credit load. The entire four courses should be offered continuously for two years.

A student enrolled in NSS course should put in at least 60 hours of social work in different activities in a semester other than five regular one-day camp in a year and one special camp for duration of 7 days at any semester break period in the two years. Different activities will include orientation lectures and practical works. Activities directed by the Central and State Government have to be performed by all the volunteers of NSS as per direction.

Introduction and Basic Components of NSS

- Orientation: history, objectives, principles, symbol, badge; regular programs under NSS
- organizational structure of NSS, Code of conduct for NSS volunteers, points to be considered by NSS volunteers' awareness about health.
- NSS program activities. Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analyzing guiding financial patterns of scheme, youth program/ schemes of GOI, coordination with different agencies and maintenance of diary. Understanding youth. Definition, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change.
- Community mobilization. Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership. Social harmony and national integration
- Indian history and culture, role of youth in nation building, conflict resolution and peace-building. Volunteerism and *shramdaan*. Indian tradition of volunteerism, its need, importance, motivation, and constraints; shaman as part of volunteerism
- Citizenship, constitution, and human rights. Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to information. Family and society. Concept of family, community (PRIs and other community-based organizations) and society.

Semester II

Introduction to Major Field Crops 3 (2+1)

Objectives

i. To provide in-depth understanding about crop response to variable agronomic factors

ii. To inculcate the skill of raising field crops with appropriate agronomic practices for higher productivity

Theory

Classification and distribution of field crops, definition, concept and principles of multiple cropping, mixed cropping, intercropping, relay and alley cropping, crop rotation. Economic importance, soil and climatic requirement, varieties, cultural practices for raising major cereals (rice,

wheat, maize), pulses (gram, soybean, arhar moong), oilseeds (rapeseed and mustard, sunflower, groundnut), cash crops (cotton, sugarcane) and fodder crops (sorghum, *bajra*, berseem, oats). Principles and practices of green manuring.

Practical

Identification of crop plants, seeds, weeds. Preparation of cropping scheme. Method of sowing, fertilizer and herbicide application in field crops. Calculation of fertilizer and herbicide dose.

Suggested Readings

1. Anonymous. 2023. Package of Practices for *Kharif* Crops.
2. Anonymous. 2023 Package of Practices for *Rabi* Crops.
3. Reddy T Y and Reddy G H S. 2020. *Principles of Agronomy*. Kalyani Publishers, Ludhiana.
4. Singh Chidda. 2020. *Modern Techniques of Raising Field Crops*. Oxford and IBH Publication.

Commercial Production of Spices and Plantation Crops 3 (2+1)

Objectives

To inculcate the skill of raising spices and plantation crops with appropriate agronomic practices for higher productivity

Theory

Present status and importance of spice crops, soil and climate requirements, commercial varieties, site selection, layout, sowing time and methods, nutritional and irrigation requirements, intercropping, weed control, physiological disorders, harvesting, post-harvest management and plant protection measures of the following crops: Black pepper, turmeric, ginger, garlic, clove, cinnamon, fenugreek, cumin, ajowain, coriander, fennel, cardamom, Vanilla, betelvine and celery.

Area, production and export potential of plantation crops, varietal wealth, cultivation systems, multitier cropping, high density planting, nutritional and irrigation requirements, weed management, training and pruning, physiological disorders, maturity indices, harvesting, postharvest management and plant protection measures of the following crops: Coffee, tea, cashew, rubber, coconut, arecanut, cocoa and oil palm.

Practical

Identification of seeds and plants, propagation, nursery raising, field layout, planting methods, cultural practices, harvesting and handling, visit to fields and marketing centres.

Suggested Readings

1. Kumar N. 2018. *Introduction to Spices Plantation Crops medicinal and aromatic plants*. Oxford and IBH publishing Co. Pvt. Ltd, New Delhi.
2. Peter K V. 2002. *Plantation Crops*. National Book Trust of India, New Delhi.
3. Pruthi J S .1998. *Major Spices of India Crop Management and Post Harvest Technology ICAR*-Krishi Anusandhan Bhavan, Pusa, New Delhi.

Plant Propagation and Nursery Management in Vegetables, Flowers and Medicinal Crops 3 (1+2)

Objectives

i. Study of biology and types of propagation, tissue culture and physiology of seed, seed storage and dormancy

ii. Knowledge of nursery management, nursery establishment and nursery techniques for plant propagation

iii. Propagation from specialized structures in major vegetable, flower crops, medicinal and aromatic plants

Theory

Nursery management practices for vegetables, flowers and medicinal crops, Biology of plant propagation, Sexual and Asexual plant propagation, physiology of seed, seed storage and dormancy, physiology of cutting, layering, grafting, budding. Tissue culture, Maintenance of elite germplasm and mother stock. Propagation from specialized modified plant parts, crop specific plant propagation practices in commercial vegetables and flowers. Nursery techniques and crop specific propagation methods of medicinal crops.

Practical

Identification of planting material, commercial varieties of vegetable, flowers and medicinal crops. Propagation and multiplication, seed production. Potting, repotting and maintenance of houseplants. Practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking. Harvesting techniques. Crop-specific plant propagation practices. Visit to local nurseries and florist centers. Marketing requirements and strategies for sale of important crops.

Suggested Readings

1. Hartmann and Kester. 2002. *Plant Propagation: Principles and Practices*. (7th Edn.) Prentice Hall.

2. Kumar Tarai Ranjan. 2020. *Plant Propagation and Nursery Management*. New India Publishing Agency.

Personality Development 2 (1+1)

Objective

To make students realize their potential strengths, cultivate their inter-personal skills and improve employability.

Theory

Personality Definition, Nature of personality, theories of personality and its types. The humanistic approach - Maslow's self-actualization theory, shaping of personality, determinants of personality, Myers-Briggs Typology Indicator, Locus of control and performance, Type A and Type B Behaviours, personality and Organizational Behaviour.

Foundations of individual behavior and factors influencing individual behavior, Models of individual behavior, Perception and attributes and factors affecting perception, Attribution theory and case studies on Perception and Attribution. Learning: Meaning and definition, theories and

principles of learning, Learning and organizational behavior, Learning and training, learning feedback. Attitude and values, Intelligence- types of Intelligence, theories of intelligence, measurements of intelligence, factors influencing intelligence, intelligence and Organizational behavior, emotional intelligence. Motivation- theories and principles, Teamwork and group dynamics.

Practical

MBTI personality analysis, Learning Styles and Strategies, Motivational needs, Firo-B, Interpersonal Communication, Teamwork and team building, Group Dynamics, Win-win game, Conflict Management, Leadership styles, Case studies on Personality and Organizational Behavior.

Suggested Readings

1. Andrews Sudhir. 1988. *How to Succeed at Interviews. (21st Reprint).* Tata McGraw-Hill, New Delhi.
2. Heller Robert. 2002. *Effective Leadership*. Essential Manager Series. DK Publishing.
3. Hindle Tim. 2003. *Reducing Stress.* Essential Manager Series. DK Publishing.
4. Kumar Pravesh. 2005. *All about Self- Motivation*. Goodwill Publishing House, New Delhi.
5. Lucas Stephen. 2001. *Art of Public Speaking*. Tata - Mc-Graw Hill, New Delhi.
6. Mile D J. 2004. *Power of Positive Thinking*. Rohan Book Company, Delhi.
7. Smith, B. 2004. *Body Language*. Rohan Book Company, Delhi.
8. Shaffer D R. 2009. *Social and Personality Development. (6th Edn.).* Belmont, CA: Wadswor.

Entrepreneurship Development and Business Management 3 (2+1)

Objectives

i. To provide student an insight into the concept and scope of entrepreneurship

ii. To expose the student to various aspects of establishment and management of a small business unit

iii. To enable the student to develop financially viable agribusiness proposal

Theory

Development of entrepreneurship, motivational factors, social factors, environmental factors, characteristics of entrepreneurs, entrepreneurial attributes/competencies. Concept, need for and importance of entrepreneurial development. Evolution of entrepreneurship, objectives of entrepreneurial activities, types of entrepreneurs, functions of entrepreneurs, importance of entrepreneurial development, and process of entrepreneurship development. Environment scanning and opportunity identification need for scanning–spotting of opportunity-scanning of environment– identification of product / service – starting a project; factors influencing sensing the opportunities. Infrastructure and support systems- good policies, schemes for entrepreneurship development; role of financial institutions, and other agencies in entrepreneurship development. Steps involved in functioning of an enterprise. Selection of the product / services, selection of form of ownership; registration, selection of site, capital sources, acquisition of manufacturing know how, packaging and distribution. Planning of an enterprise, project identification, selection, and formulation of project; project report preparation, Enterprise Management. Production

management – product, levels of products, product mix, quality control, cost of production, production controls, Material management. Production management – raw material costing, inventory control. Personal management – manpower planning, labour turn over, wages / salaries. Financial management /accounting – funds, fixed capital and working capital, costing and pricing, long term planning and short-term planning, book keeping, journal, ledger, subsidiary books, annual financial statement, taxation. Marketing management- market, types, marketing assistance, market strategies. Crisis management- raw material, production, leadership, market, finance, natural etc.

Practical

Visit to small scale industries/agro-industries specific to horticulture-base, Interaction with successful entrepreneurs/ horti-entrepreneurs. Visit to financial institutions and support agencies. Preparation of project proposal for funding by different agencies.

Suggested Readings

1. Charantimath P M. 2009. *Entrepreneurship Development and Small Business Enterprises*. Pearson Publications, New Delhi.
2. Desai V. 2015. *Entrepreneurship: Development and Management*. Himalaya Publishing House.
3. Desai Vasant. 1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publ. House
4. Gupta C B. 2001. *Management Theory and Practice*. Sultan Chand and Sons.
5. Indu Grover. 2008. *Handbook on Empowerment and Entrepreneurship*. Agrotech Public Academy.
6. Khanka S S. 1999. *Entrepreneurial Development*. S. Chand and Co.
7. Mehra P. 2016. *Business Communication for Managers. Pearson India*. New Delhi.
8. Pandey M and Tewari D. 2010. *The Agribusiness Book*. IBDC Publishers, Lucknow.
9. Singh D. 1995. *Effective Managerial Leadership*. Deep and Deep Publ.
10. Singhal R K. 2013. *Entrepreneurship Development and Management*. Katson Books.
11. Tripathi P C and Reddy P N. 1991. *Principles of Management*. Tata McGraw Hill.

Environmental Studies and Disaster Management 3 (2+1)

Objectives

i. To expose and acquire knowledge on the environment
ii. To gain the state-of-the-art - skill and expertise on management of disasters

Theory

Introduction to Environment - Environmental studies - Definition, scope and importance - Multidisciplinary nature of environmental studies - Segments of Environment - Spheres of Earth - Lithosphere - Hydrosphere - Atmosphere - Different layers of atmosphere. Natural Resources: Classification - Forest resources. Water resources. Mineral resources Food resources. Energy resources. Land resources. Soil resources. Ecosystems - Concept of an ecosystem - Structure and function of an ecosystem - Energy flow in the ecosystem. Types of ecosystem. Biodiversity and its

conservation: Introduction, definition, types. Biogeographical classification of India. Importance and Value of biodiversity. Biodiversity hot spots. Threats and Conservation of biodiversity.

Environmental Pollution: Definition, cause, effects and control measures of: (a) Air pollution. (b) Water pollution. (c) Soil pollution. (d) Marine pollution. (e) Noise pollution. (f) Thermal pollution. (g) light pollution. Solid Waste Management: Classification of solid wastes and management methods, Composting, Incineration, Pyrolysis, Biogas production, Causes, effects and control measures of urban and industrial wastes. Social Issues and the Environment: Urban problems related to energy. Water conservation, rain water harvesting, watershed management. Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act. Wildlife Protection Act. Forest Conservation Act. Human Population and the Environment: Environment and human health: Human Rights, Value Education. Women and Child Welfare. Role of Information Technology in Environment and human health.

Disaster management - Disaster definition - Types - Natural Disasters - Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves. Man Made Disasters - Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, road accidents, rail accidents, air accidents, sea accidents. International and National strategy for disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, community-based organizations and media in disaster management. Central, state, district and local administration in disaster control; Armed forces in disaster response; Police and other organizations in disaster management.

Practical

Visit to a local area to document environmental assets river/forest/grassland/hill/mountain. Energy: Biogas production from organic wastes. Visit to wind mill / hydro power / solar power generation units. Biodiversity assessment in farming system. Floral and faunal diversity assessment in polluted and un polluted system. Visit to local polluted site - Urban/Rural/Industrial/Agricultural to study of common plants, insects and birds. Environmental sampling and preservation. Water quality analysis: pH, EC and TDS. Estimation of Acidity, Alkalinity. Estimation of water hardness. Estimation of DO and BOD in water samples. Estimation of COD in water samples. Enumeration of *E. coli* in water sample. Assessment of Suspended Particulate Matter (SPM). Study of simple ecosystem – Visit to pond/river/hills. Visit to areas affected by natural disaster.

Suggested Readings

1. De A K. 2010. *Environmental chemistry. Published* by New Age International Publishers, New Delhi. ISBN:13–978 81 224 2617 5. 384pp.
2. Dhar Chakrabarti P G. 2011. *Disaster management - India's risk management policy frameworks and key challenges. Published.* Centre for Social Markets (India), Bangalore. 36pp.
3. Erach Bharucha, *Text book for Environmental studies*. University Grants Commission, New Delhi.
4. Parthiban K T. Vennila S, Prasanthrajan M and Umesh Kanna S. 2023 *Forest, Environment, Biodiversity and Sustainable Development.* Narendra Publishing House, New Delhi, India.
5. Prasanthrajan M and Mahendran P P. 2008. *A text book on Ecology and Environmental Science.1st edn. ISBN 81-8321-104-6*. Agrotech Publishing Academy, Udaipur - 313002.

6. Prasanthranjan M. 2018. *Objective Environmental Studies and Disaster Management, ISBN 9789387893825*. Scientific Publishers, Jodhpur, India. 146p.

7. Sharma P D. 2009. *Ecology and Environment.* Rastogi Publications, Meerut, India.

8. Tyler Miller and Scot Spoolman. 2009. *Living in the Environment (Concepts, Connections, and Solutions)*. Brooks/cole, Cengage learning publication, Belmont, USA.

National Cadet Corps (NCC-II) 1 (0+1)

- Arms Drill- Attention, stand at ease, stand easy. Getting on parade. Dismissing and falling out. Ground/take up arms, examine arms. Shoulder from the order and vice-versa, present from the order and vice-versa. Saluting at the shoulder at the halt and on the march. Short/long trail from the order and vice- versa. Guard mounting, guard of honor, Platoon/Coy Drill.
- Characteristics of rifle (.22/.303/SLR), ammunition, fire power, stripping, assembling, care, cleaning, and sight setting. Loading, cocking, and unloading. The lying position and holding.
- Trigger control and firing a shot. Range Procedure and safety precautions. Aiming and alteration of sight. Theory of groups and snap shooting. Firing at moving targets. Miniature range firing. Characteristics of Carbine and LMG.
- Introduction to map, scales, and conventional signs. Topographical forms and technical terms.
- The grid system. Relief, contours, and gradients. Cardinal points and finding north. Types of bearings and use of service protractor. Prismatic compass and its use. Setting a map, finding north and own position. Map to ground and ground to map. Knots and lashings, Camouflage and concealment, Explosives and IEDs.
- Field defenses obstacles, mines and mine lying. Bridging, waterman ship. Field water supplies, tracks and their construction. Judging distance. Description of ground and indication of landmarks. Recognition and description of target. Observation and concealment. Field signals. Section formations. Fire control orders. Fire and movement. Movement with/without arms. Section battle drill. Types of communication, media, latest trends and developments.

National Service Scheme (NSS-II) 1 (0+1)

- Importance and role of youth leadership
- Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership, Life competencies
- Definition and importance of life competencies, problem-solving and decision-making, interpersonal communication. Youth development programs
- Development of youth programs and policy at the national level, state level and voluntary sector; youth-focused and youth-led organizations
- Health, hygiene and sanitation. Definition needs and scope of health education; role of food, nutrition, safe drinking water, water borne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programs and reproductive health. Youth health, lifestyle, HIV AIDS and first aid. Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid. Youth and yoga. History, philosophy, concept, myths, and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method.

Post-Semester II (Only for exit option for award of UG-Certificate in Agriculture)

S. No.	Course Title	Credit Hours
INT	Internship (10 weeks)	10 (0+10) *

*Mandatory Internship with horticulture based industries to get certificate after 1 Year exit.

Semester III

Fundamentals of Soil Science 3 (2+1)

Objective

To make the students aware about the importance of soil in relation to soil formation, texture, structure, water, temperature, aeration, nutrient availability, and soil microbiology, soil survey

Theory

Composition of earth's crust, soil as a natural body – major components. Eluviation, Illuviation formation of various soils. Physical parameters; texture – definition, methods of textural analysis, stock's law, assumption, limitations, textural classes, use of textural triangle; absolute specific gravity/particle density, definition, apparent specific gravity/bulk density – factors influencing, field bulk density. Relation between BD (bulk density), AD – practical problems. Pore space – definition, factors affecting capillary and non-capillary porosity, soil colour – definition, its significance, colour variable, value hue and chroma. Munsell colour chart, factors influencing, parent material, soil moisture, organic matter, soil structure, definition, classification, clay prism like structure, factors influencing genesis of soil structure, soil consistency, plasticity, Atterberg's constants. Soil air, air capacity, composition, factors influencing, amount of air space, soil air renewal, soil temperature, sources and distribution of heat, factors influencing, measurement, chemical properties, soil colloids, organic, humus, inorganic, secondary silicate, clay, hydrous oxides. Ion exchange, cation-anion importance, soil water, forms, hygroscopic, capillary and gravitational, soil moisture constants, hygroscopic coefficient, wilting point, field capacity, moisture equivalent, maximum water holding capacity, energy concepts, PF scale, measurement, gravimetric – electric and tensiometer methods – pressure plate and pressure membrane apparatus–Neutronprobe–soilwatermovement–classification–aerialphotography– satellite of soil features – their interpretation; soil orders; land capability classification; soil of different eco-systems and their properties, Rock and Minerals classification, Pedogenic process. Objectives of soil science research institute in India (NBSS and LUP, ISSS, LTFE and NSSTL). Management of Soil Crusting, Soil Compaction and Soil Compression. Soil Biology benefits and harmful effects. Methods and objective of soil survey, Remote sensing application in soil and plant Studies, Soil degradation.

Practical

Collection and preparation of soil samples as per protocols for horticultural crops, estimation of moisture, EC, pH and bulk density. Textural analysis of soil by Robinson's pipette method. Description of soil profile in the field. Quantification of minerals and their abundance. Determination of Soil colour using Munsell Chart. Estimation of water holding capacity and hydraulic conductivity of soils. Estimation of Infiltration rate using double ring infiltrometer method. Estimation of soil moisture using gypsum block and neutron probe method. Soil compaction measurement with Pentrometer. Determination of pore space of soil. Determination of field capacity and permanent

wilting point of soil. Determination of soil water potential characteristic curves by tensiometer and pressure plate apparatus. Aggregate size distribution analysis of soil. Air capacity of soil by fieldmeth Nursery raising/procurement and transplanting, management and maintenance of the crop, postharvest handling, quality control and marketing.

Suggested Readings

1. Das D K. 2011. *Introductory Soil Science (3rd Revised Edn.)*. Kalyani Publishers, Ludhiana.
2. Fundamentals of Soil Science by Indian Society of Soil Science Second Revised Edition 2009. Indian Society of Soil Science. New Delhi.
3. Nyle C Brady and Weil Ray R. 2016. The Nature and Properties of Soils (15th Edn.). Prentice Hall of India Pvt Ltd. New Delhi.
4. Sharma Pradeep K. 2017. Introduction to Soil Physics First Edition Westville Publishing House. New Delhi.
5. Saha A K. 2008. Text Book of Soil Physics. (Reprint). Kalyani Publishers. Ludhiana.
6. Sehgal J A. 2005. Textbook of Paedology Concepts and Applications. Kalyani Publishers. Ludhiana.

Commercial Fruit Production 4 (3+1)

Objective

To acquaint the students with the cultivation techniques for commercially important tropical, sub-tropical and temperate fruit crops

Theory

Area, production and export potential, varieties, soil and climate requirements, propagation techniques, planting density and systems, training and pruning, high density planting, ultra-high density planting, mechanization, management of water, nutrient and weeds, Physiological disorders, Special production problems, insect-pests, diseases and their control measures. Post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage of the following crops: mango, banana, citrus, guava, litchi, grapes, papaya, pineapple, ber, aonla, pomegranate, sapota, jamun, date palm, apple, pear, peach, plum, cherry, almond, apricot, walnut, kiwifruit, hazelnut, chestnut, pecan nut, plantation crops (coconut, cashew nut, tea, coffee, cocoa, arecanut, palmyrah palm and strawberry.

Practical

Description and identification of varieties of horticultural crops. Training and pruning, application of manure, fertilizer and irrigation, weed control, maturity standards, harvesting, handling, grading and packaging of fruits. Visit to commercial orchards.

Suggested Readings

1. Bal J S. 2014. Fruit Growing. Kalyani Publishers.
2. Chattopadhyay T K. 2012. A Textbook on Pomology Vol I-IV. Kalyani Publishers
3. George Acquaah. 2002. Horticulture Principles and Practices. Prentice Hall.
4. ICAR Handbook of Horticulture Vol I-II. ICAR Publication.
5. Singh Ranjit. 1992. *Fruits.* New Book Trust. New Delhi. 303p.

Precision Farming and Protected Cultivation 3 (2+1)

Objective

The students will learn about the basics of cultivation of plants under protected conditions

Theory

Precision farming vis a vis horticultural crops– laser levelling, mechanized direct seed sowing; seedling and sapling transplanting, site specific input application. Protected cultivation technology: Introduction, techniques of protected cultivation, types of Green Houses, Plant response to Greenhouse environment, Planning and design of greenhouses, Design criteria of greenhouse for cooling and heating purposes. Green house equipment, materials of construction for traditional and low-cost green houses. Irrigation systems used in protected cultivation, Typical applications, passive solar green house, hot air greenhouse heating systems, greenhouse drying. Cost estimation and economic analysis. Choice of crops for cultivation under protected structures, problems/constraints of greenhouse cultivation and future strategies. Growing media, soil culture, type of soil required, drainage, flooding and leaching, soil pasteurization in peat moss and mixtures, rock wool and other inert media, nutrient film technique (NFT)/ hydroponics.

Practical

Laser levelling procedure and field visit. Study and field visit for mechanized direct seed sowing and transplanting in horticultural field. Study of different types of greenhouses based on shape, construction and cladding materials. Studies on different environment control parameters in greenhouses. Estimation of drying rate of horticultural products inside greenhouse. Testing of soil and water to study its suitability for growing crops in protected structures. The study of fertigation requirements for greenhouse crops and estimation of E.C and pH in the fertigation solution. The study of various growing media used in raising of greenhouse crops and their preparation and pasteurization/sterilization. Visit to commercial protected cultivation structures. Economics of protected cultivation.

Suggested Readings

1. Brahma S. 2019. *Precision Farming and Protected Cultivation*. NIPA, New Delhi.
2. Michael A M. 2008. *Irrigation Theory and Practices*. Vikas Publishing House Pvt. Ltd., New Delhi.
3. Kumar S 2002. *Precision Farming and Protected Cultivation: Concepts and Applications*. Narendra Publishing House, New Delhi.

Seed Production of Vegetable, Tuber and Spice Crops 3 (2+1)

Objectives

i. Students will acquire skill for certification and storage of seed production of vegetable, tuber and spice crops

ii. Students will be trained for on-farm operations of different seed multiplication activities of vegetable, tuber and spice crops.

Theory

Introduction and history of seed industry in India. Definition of seed, classes-types of seed. Differences between grain and seed. Importance and scope of vegetable seed production in India. Principles of vegetable seed production. Role of temperature, humidity and light in vegetable seed production, land requirements, climate, season, planting time, nursery management, seed rate, rouging, seed extraction and storage, packaging and labelling of cole crops, root vegetables, solanaceous vegetables, cucurbits, okra, leafy vegetables, bulb crops, tuber crops like potato, spice crops like coriander, fenugreek, leguminous vegetables and exotic vegetables. Seed germination and purity analysis. seed priming and pelleting, Field and seed standards. Seed drying and extraction. Seed legislation.

Practical

Study of seed structure, colour size, shape and texture. Field inspection of seed crops. Practices in rouging. Harvesting and seed extraction. Germination and purity analysis. Methods of seed production, Seed certification in cole crops, root vegetables, bulb crops, solanaceous vegetables, cucurbits, okra, leafy vegetables, leguminous vegetables and exotic vegetables. Seed processing machines. Visit to seed production units

Suggested Readings

1. Arya Singh P. 2003. *Vegetable seed Production Principles*. Kalyani Publishers. Ludhiana.
2. Hazra P and Som M G. 2009. *Vegetable Seed Production and Hybrid Technology.* Kalyani Publishers, Ludhiana.
3. Kulkarni G N. 2002. *Principles of Seed Technology.* Kalyani Publishers, Ludhiana.
4. Ram H H, Upadhyay R, Dubey R K and Mandal B C. 2017. *Vegetable Seed Production- Principles and Practices*. Kalyani Publishers, Ludhiana.
5. Singh S P. 2001. *Seed Production of Commercial Vegetables*. Agrotech Publishing, Udaipur

Disease Management in Horticulture crops 3 (2+1)

Objectives

i. To identify various pathogen structures and diagnose the diseases of horticultural crops in field
ii. To understand the disease cycle and epidemiology of various diseases of horticultural crops
iii. To give an overview of various disease management methods (cultural, physical biological, chemical)

Theory

Etiology, symptoms, mode of spread, epidemiology and integrated management of the diseases under protected conditions and of fruits, plantation, medicinal, aromatic, vegetables, ornamental, and spice crops *viz* mango, litchi, banana, grape, citrus, guava, sapota, papaya, jack fruit, pineapple, pomegranate, ber, apple, pear, peach, plum, almond, walnut, strawberry, tomato, brinjal, chilli, bhindi, cabbage, cauliflower, radish, knol-khol, pea, beans, beet root, onion, garlic, fenugreek, ginger,

potato, areca nut, coconut, oil palm, coffee, tea, cocoa, cashew, rubber, betel vine, senna, neem, hemp, belladonna, pyrethrum, camphor, costus, crotalaria, datura, dioscorea, mint, opium, *Solanum khasianum*, Tephrosia, turmeric, pepper, cumin, cardamom, nutmeg, coriander, clove, cinnamon, jasmine, rose, crossed, tuberose, gerbera, anthurium, geranium, marigold, gladiolus. Important post-harvest diseases of fruit, plantation, medicinal, aromatic, vegetables, ornamental and spice crops and their management. Etiology, symptoms and integrated management of important plant parasitic nematodes of fruits – (tropical, sub-tropical and temperate) vegetables, tuber, ornamental, spice and plantation crops. Role of nematodes in plant disease complex.

Practical

Observations of disease symptoms, identification of casual organisms and host parasite relationship of important diseases of fruits, plantation, medicinal, aromatic, vegetables, ornamental and spice crops. Collection and preservation of diseased plant specimen.

Suggested Readings

1. Gupta S K and Thind T S. 2018. *Disease Problems in Vegetable Production*. Scientific Publishers India, 586p.
2. Gupta S K, Sharma R C and Sharma M. 2017. *Diseases of Vegetable. Ornamental and Spice crops*. Scientific Publishers India.
3. Mehrotra R S and Aggarwal A. 2003. *Plant Pathology. (2nd Edn.)*. Tata Mc Graw Hill Publication Com Ltd, P.846.
4. Pathak V N 1989. *Diseases of fruit crops*. Oxford and IBH Publication Comp. New Delhi, 309p.
5. Rangaswami G and Mahadevan A 2002. *Diseases of Crop Plants in India (4th Edn.)*. Prentice Hall of India Pvt Ltd. New Delhi, 536p.
6. Singh R S. 1987. *Diseases of Vegetable Crops (2nd Edn.)*. Oxford and IBH Publication, New Delhi.
7. Singh R S 2018. *Plant Diseases (10th edn.)* Oxford and IBH Publication, New Delhi, 821p.
8. Singh R S 2018. *Diseases of Fruit Crops (2nd Edn.)*. Med Tech. New Delhi, 281p.

Physical Education, First Aid, Yoga Practices and Meditation 2 (0+2)

Objectives

i. To make the students aware about Physical Education, First Aid and Yoga Practices

ii. To disseminate the knowledge and skill how to perform physical training, perform first aid and increase stamina and general wellbeing through yoga

Practical

Physical education; Training and Coaching - Meaning and Concept; Methods of Training; aerobic and aerobic exercises; Calisthenics, weight training, circuit training, interval training, Fartlek training; Effects of Exercise on Muscular, Respiratory, Circulatory and Digestive systems; Balanced Diet and Nutrition: Effects of Diet on Performance; Physiological changes due to ageing and role of regular exercise on ageing process; Personality, its dimensions and types; Role of sports in personality development; Motivation and Achievements in Sports; Learning and Theories of learning; Adolescent Problems and its Management; Posture; Postural Deformities; Exercises for good posture.

Yoga; History of Yoga, Types of Yoga, Introduction to Yoga,

- Asanas (Definition and Importance) Padmasan, Gaumukhasan, Bhadrasan, Vajrajasan, Shashankasan, Pashchimotasan, Ushtrasan, Tadasan, Padhastasan, Ardhchandrasan, Bhujangasan, Utanpadasan, Sarvangasan, Parvatasan, Patangasan, Shishupalanasan – left leg-right leg, Pavanmuktasan, Halasan, Sarpasan, Ardhdhanurasan, Sawasan
- Suryanamskar Pranayama (Definition and Importance) Omkar, Suryabhedan, Chandrabhedan, AnulomVilom, Shitali, Shitkari, Bhastrika, Bhramari
- Meditation (Definition and Importance), Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandh
- Mudras (Definition and Importance) Gyanmudra, Dhyanmudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra
- Role of yoga in sports
- Teaching of Asanas – demonstration, practice, correction and practice.

History of sports and ancient games, Governance of sports in India; Important national sporting events; Awards in Sports; History, latest rules, measurements of playfield, specifications of equipment, skill, technique, style and coaching of major games (Cricket, football, table Tennis, Badminton, Volleyball, Basketball, Kabaddi and Kho-Kho) and Athletics Need and requirement of first aid. First Aid equipment and upkeep. First AID Techniques, First aid related with respiratory system. First aid related with Heart, Blood and Circulation. First aid related with Wounds and Injuries. First aid related with Bones, Joints Muscle related injuries. First aid related with Nervous system and Unconsciousness. First aid related with Gastrointestinal Tract. First aid related with Skin, Burns. First aid related with Poisoning. First aid related with Bites and Stings. First aid related with Sense organs, Handling and transport of injured traumatized persons. Sports injuries and their treatments.

Semester IV

Commercial Vegetable Production 4 (3+1)

Objective

Student shall gain expertise on commercial cultivation of vegetable crops

Theory

Importance of Olericulture. Vegetable gardens. Vegetable classification, area, production and varieties. Package of practices of tomato, brinjal, chillies, capsicum, moringa and okra. Cucurbitaceous vegetables- cucumber, ridge gourd, ash gourd, snake gourd, bottle gourd, bitter gourd, pumpkin and melons. Cole crops - cabbage, cauliflower and knol-khol. Bulb crops - onion and garlic. Beans and peas - French beans, cluster beans, dolichos beans, peas and cowpea. Tuber crops - potato, sweet potato, tapioca, colocasia, yams. Root crops - carrot, radish, turnip and beet root. Leafy vegetables – broccoli, lettuce, spinach, chinese cabbage and asparagus.

Practical

Identification of vegetable crops and seeds; Planning, layout and maintenance of kitchen garden; Direct sowing of vegetables, Bed preparation and method of nursery sowing; Transplanting of vegetable seedlings; Method of fertilizer application and calculation of different fertilizer doses; Intercultural operations in vegetable crops, Harvesting, grading and packaging of vegetable crops, Economics of vegetable crops, Visit to commercial vegetable farms.

Suggested Readings

1. Bose T K. and Som M G. 2003. *Vegetable Crops. Vol I, II, III.* Naya Prokash.
2. Dhaliwal M S 2014. *Handbook of Vegetable Crops*. Kalyani Publishers.
3. Fageria M S, Choudhary B R and Dhaka R S. 2016 *Vegetable Crops: Production Technology. Vol II*. Kalyani Publishers.
4. Hazra P. and Som M G. 2009. *Technology for Vegetable Production and Improvements*. Naya Prokash. 395p.
5. ICAR *Handbook of Horticulture. 2019.* Vol 1-II, ICAR Publication.

Farm Power and Machinery for Horticulture 3 (2+1)

Objective

To acquaint students of the tools available at his disposal for doing the work in horticulture (mechanical power source: engines/ tractors; machines and tools for harvesting the horticultural produce: tillage equipment, planting equipment, plant care equipment)

Theory

Basic concepts of various forms of energy; Tractors, power tillers and their types and uses Introduction about IC Engines: Basic principles of operation of compression, ignition and spark ignition engines; two stroke and four stroke engines; Crank system, valve system, fuel supply system, cooling and lubrication systems; power transmission systems; broad understanding of performance and efficiency. Tillage: objectives, method of ploughing. Primary tillage implements: construction and function of improved indigenous ploughs, mould board ploughs, disc and rotary ploughs, offset rotavators. Secondary tillage implements construction and function of cultivators, harrows, levellers, ridgers and bund formers. Adjustments affecting performance in tillage equipment. Calculation of bite length of rotavator. Post-hole digger. Introduction about planting and transplanting equipment: potato planters, small seed planter, nursery sowing machinery, vegetable transplanters, plastic mulch and drip laying machinery. Introduction about intercultural machinery. Sprayers: Types, working principle, manual and tractor operated, gun-type and boom type. Special purpose sprayers: aero-blast sprayers, electrostatic sprayers, sprayer calibration and nozzle spacing. Safety features and safe use, shrub cutters, pick positioner; grafting, pruning and training tools and equipment; sweep, rotary weeders, tractor operated pruners. Crop harvesting equipment: potato diggers, fruit-pluckers, seed extraction machine.

Practical

Calculation on force, power and energy. IC engines – showing the components of dismantled engines. Familiarization with engine systems Primary and secondary tillage implements: hitching,

adjustments and operations. Operation of post hole digger. Operation of planting and transplanting machinery. Operation of vegetable transplanter, plastic mulch and drip laying machinery. Operation of Inter-culture equipment including offset rotavator in orchard; calibration of plant protection equipment, calculation of dilution ratio and operation; operation of power weeder, shrub cutter. Operation of crop harvesting equipment and seed extraction machine. Operation of shrub cutters, fruit-pluckers, pick positioner.

Suggested Readings

1. Sahay Jagdishwar. 2006. *Elements of Agricultural Engineering*. Standard Publishers Distributors.
2. Kepner R A, Bainer R and Barger E L. 1978. *Principles of Farm Machinery*. Avi Publishing Company.
3. Michael A M and OjhaT P. 1978. *Principles of Agricultural Engineering*. Jain Bros.
4. Culpin C. 1938. *Farm Machinery.* C. Lockwood & Son Limited.
5. Rodichev V and Rodicheva G. 1989.*Tractors and Automobiles*. Mir Publishers, Moscow.

Agricultural Informatics and Artificial Intelligence 3 (2+1)

Objectives

i. To acquaint students with the basics of computer applications in agriculture, multimedia, database management, application of mobile app and decision- making processes, etc.
ii. To provide basic knowledge of computer with applications in agriculture
iii. To make the students familiar with agricultural-informatics, its components and applications in agriculture.

Theory

Introduction to Computers, Anatomy of Computers, Memory Concepts, Units of Memory, Operating System: Definition and types, Applications of MS-Office for creating, Editing and Formatting a document, Data presentation, Tabulation and graph creation, Statistical analysis, Mathematical expressions, Database, concepts and types, creating database, Uses of DBMS in Agriculture, Internet and World Wide Web (WWW): Concepts and components. Computer programming: General concepts, Introduction to Visual Basic, Java, Fortran, C/ C++, etc. concepts and standard input/output operations.

e-Agriculture, Concepts, design and development, Application of innovative ways to use information and communication technologies (IT) in Agriculture, Computer Models in Agriculture: Statistical, weather analysis and crop simulation models, concepts, structure, inputs-outputs files, limitation, advantages and application of models for understanding plant processes, sensitivity, verification, calibration and validation, IT applications for computation of water and nutrient requirement of crops, Computer-controlled devices (automated systems) for Agri-input management, Smartphone mobile apps in agriculture for farm advice: Market price, postharvest management etc., Geospatial technology: Concepts, techniques, components and uses for generating valuable agri-information, Decision support systems: Concepts, components and applications in Agriculture, Agriculture Expert System, Soil Information Systems etc. for supporting farm decisions.

Preparation of contingent crop-planning and crop calendars using IT tools, Digital India and schemes to promote digitalization of agriculture in India.

Practical

Study of computer components, accessories, practice of important DoS Commands, Introduction of different operating systems such as Windows, Unix/ Linux, creating files and folders, File Management. Use of MS-Word and MS Power-point for creating, editing and presenting a scientific document, MS- EXCEL - Creating a spreadsheet, Use of statistical tools, Writing expressions, Creating graphs, Analysis of scientific data, Handling macros. MS-ACCESS: Creating Database, preparing queries and reports, Demonstration of Agri- information system, Introduction to World Wide Web (WWW) and its components, Introduction of programming languages such as Visual Basic, Java, Fortran, C, C++, Hands on practice on Crop Simulation Models (CSM), DSSAT/ Crop-Info/Crop Syst/ Wofost, Preparation of inputs file for CSM and study of model outputs, computation of water and nutrient requirements of crop using CSM and IT tools, Use of smart phones and other devices in agro-advisory and dissemination of market information, Introduction of Geospatial Technology, Hands on practice on preparation of Decision Support System, Preparation of contingent crop planning, India Digital Ecosystem of Agriculture (IDEA).

Suggested Readings

1. Dhabal Prasad Sethi and Manoranjan. 2017. *Concepts and Techniques of Programming in C*. Techsar Pvt. Ltd.
2. RajaromanV. 2015. Fundamentals *of Computer*. PHI Learning.
3. *Introduction to Information Technology* .2005. Pearson Education India.
4. Date C. J. 2000. *Introduction to Database Management System*. Addison-Wesley.
5. Mahapatra, Subrat K et al. 2022. *Introductory Agri Informatics.* Jain Brothers Publication.

Urban and Peri urban Horticulture 2 (1+1)

Objectives

1. To acquaint the students about the unban and peri-urban horticulture and its types.
2. To impart the knowledge about the cultivation practices of horticultural crops in urban and peri-urban areas.

Theory

Introduction to urban and peri-urban horticulture: Definition, importance, characteristics and scope. Types of urban and peri-urban gardens and their characteristics: Terrace gardening, vegetable gardening, container gardening, rooftop gardens, community gardens, vertical gardens, hydroponics and aeroponics. Selection of site, planting material, media (soil and soilless) preparation and nutrient management for cultivation of vegetables, herbs, fruits, flowers and ornamental plants. Protected cultivation in urban and peri-urban areas. Making and maintenance of lawns. Interior and exterior landscaping in urban and peri-urban households. Water and waste management, waste water recycling and its use in landscaping. Insect-pest and disease management in urban horticulture.

Practical

Site selection and layout of various urban and peri-urban gardens. Preparation of growing media and potting mixtures. Types of containers, nursery raising and planting for rooftop gardens. Irrigation and nutritional management in urban and peri-urban horticulture. Visit to fruit nutrition garden, vegetable kitchen garden and public gardens.

Suggested Readings

1. Alka Singh, Patel N L and Ahlawat T R. 2016. *Handbook of Urban and Periurban Horticulture (*1st Edn.). Ambica Publisher.
2. Sumangla H P, Malhotra S K and Chowdappa P. 2013. *Urban and Peri-urban Horticulture- A Perspective.*

Agriculture Marketing and Trade 3 (2+1)

Objectives

i. To understand the fundamentals of agricultural marketing and trade
ii. To analyze the factors influencing supply and demand in agricultural markets
iii. To explore different marketing channels and strategies in agriculture
iv. To examine the role of government policies and regulations in agricultural markets

Theory

Agricultural Horticultural Produce Marketing: Concepts and definitions of market, marketing, agricultural marketing, market structure, marketing mix and market segmentation, classification and characteristics of agricultural markets; demand, supply and producer's surplus of agri commodities: nature and determinants of demand and supply of farm products, producer's surplus – meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; pricing and promotion strategies: pricing considerations and approaches – cost based and competition based pricing; market promotion – advertising, personal selling, sales promotion and publicity – meaning, merits and demerits; marketing process and functions: Marketing process concentration, dispersion and equalization; exchange functions – buying and selling; physical functions – storage, transport and processing; facilitating functions – packaging, branding, grading, quality control and labelling (Agmark); Market functionaries and marketing channels: Types and importance of agencies involved in agricultural marketing; meaning and definition of marketing channel; number of channel levels; marketing channels for different farm products; Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs; Role of Govt. in agricultural marketing: Public sector institutions- CWC, SWC, FCI, CACP and DMI – their objectives and functions; cooperative marketing in India; Risk in marketing: Types of risk in marketing; speculation and hedging; an overview of futures trading; Agricultural prices and policy: Meaning and functions of price; administered prices; need for innovations in agricultural price policy.

Trade: Concept of International Trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; WTO; Agreement on Agriculture (AoA) and its implications on Indian agriculture; IPR. Role of government in agricultural marketing. Role of APMC and its relevance in the present-day context.

Practical

Plotting and study of demand and supply curves and calculation of elasticities; Study of relationship between market arrivals and prices of some selected commodities; Computation of marketable and marketed surplus of important commodities; Study of price behaviour over time for some selected commodities; Construction of index numbers; Visit to a local market to study various marketing functions performed by different agencies, identification of marketing channels for selected commodity, collection of data regarding marketing costs, margins and price spread and presentation of report in the class; Visit to market institutions –NAFED, SWC, CWC, cooperative marketing society, etc. to study their organization and functioning. Application of principles of comparative advantage of international trade.

Suggested Readings:

1. Acharya S S and Agarwal N L. 2006. *Agricultural Marketing in India*, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Chinna S S. 2005. *Agricultural Economics and Indian Agriculture*. Kalyani Pub, New Delhi.
3. Dominic Salvatore. 2009. *Micro Economic Theory*. Oxford University Press.
4. Kohls Richard L and Josheph Uhl N. 2002. *Marketing of Agricultural Products*. Prentice-Hall of India Private Ltd., New Delhi.
5. Kotler and Armstrong, 2005, *Principles of Marketing* Pearson Prentice-Hall.
6. Lekhi R K and Jogindr Singh. 2006. *Agricultural Economics*. Kalyani Publishers, Delhi.
7. Memoria C B, Joshi R L and Mulla N I. 2003. *Principles and Practice of Marketing in India*. Kitab Mahal, New Delhi.
8. Pandey Mukesh and Tewari Deepali. 2004. *Rural and Agricultural Marketing*. International Book Distributing Co. Ltd, New Delhi.
9. Sharma R. 2005. *Export Management*. Laxmi Narain Agarwal, Agra.

Pest Management of Horticulture Crops 3 (2+1)

Theory

Classification of insect-pests. Dynamics of EIL and ETL. Methods of pest control - host plant resistance, cultural, mechanical, physical, legislative, biological and chemical control. Recent technologies for insect-pest management. Insecticides, classification, formulations, first aid and antidotes. IPM – importance and principles. Scientific name, order, family, host range, distribution, biology, ecology, nature of damage and management of important insect-pests of various fruit (tropical, sub-tropical and temperate), vegetable, ornamental, plantation, spice, medicinal, aromatic crops and under protected conditions. Pest surveillance. Storage insects – Scientific name, order, family, host range, distribution, biology, ecology, nature of damage and management of important insect-pests attacking stored fruit, vegetable, plantation, ornamental, spice, medicinal and aromatic crops' produce and their processed products. Insecticides residue problems in fruit, vegetable, plantation, ornamental, spice, medicinal and aromatic crops and their maximum residue limits (MRLs). Waiting periods for insecticides on various crops.

Practical

Identification of insect-pests of various fruit, vegetable, plantation, ornamental, spice, medicinal and aromatic crops in field and their produce during storage, and their symptoms of damage. Identification of biocontrol agents and natural enemies. Insecticide formulations. Pesticide application appliances. Calculation of insecticide quantity for preparing spray material.

Suggested Readings

1. Dhaliwal G S and Arora Ramesh. 2003. *Integrated Pest Management Concepts and Approaches*. CABI.
2. Atwal A S and Dhaliwal G S. 2015. *Agricultural Pests of South Asia and their Management*. Kalyani Publishers.
3. Dhaliwal G S, Singh Ram and Chillar B S. 2008. *Essentials of Agricultural entomology*. Kalyani Publishers.
4. Atwal A S and Bains S S. 2011. *Applied Animal Ecology*. Kalyani Publishers.

Introductory Agrometeorology and Climate Change 2 (1+1)

Objective

Training graduate students with respect to management the climate aberration for sustainable crop production

Theory

Agrometeorology – definition, scope. Earth atmosphere - its composition, extent and structure. Atmospheric weather variables. Elements and factors of weather and climate. Atmospheric pressure. Wind, types, daily and seasonal variation. Cyclone, anticyclone. Land and sea breeze. Solar radiation - solar constant, depletion, short and long wave, thermal radiation, net radiation, albedo. Atmospheric temperature, inversion, lapse rate, daily and seasonal variations, vertical profile. Energy balance of earth. Atmospheric humidity, saturation, vapor pressure, condensation. Dew, fog, mist, frost. Precipitation, process, types. Cloud formation and classification. Artificial rainmaking. Monsoon - mechanism and importance in Indian agriculture. Weather hazards. Agriculture and weather relations. Modifications of microclimate. Climatic normal for crop and livestock production. Weather forecasting – types and applications. Climate change and impacts on agriculture.

Practical

Visit to agrometeorological observatory. Site selection of observatory and exposure of instruments and weather data recording. Measurement of total, short and long wave radiations and their estimation using Planck's intensity law. Measurement of albedo and sunshine duration, computation of radiation intensity using BSS. Measurement of maximum and minimum air temperatures, tabulation, trend and variation analysis. Measurement of soil temperature and computation of soil heat flux. Determination of vapor pressure and relative humidity. Determination of dew point temperature. Measurement of atmospheric pressure and analysis of atmospheric conditions. Measurement of wind speed and wind direction, preparation of wind rose. Measurement, tabulation and critical analysis of rainfall. Computation of drought indices. Measurement of open pan evaporation and evapotranspiration. Computation of PET and AET.

Suggested Readings

1. Avi H S. 1985. *Introduction to Agrometeorology*. Oxford and IBH Publishing Co., New Delhi.
2. Lenka D. 2006. *Climate, Weather and Crops in India*. Kalyani Publishers, New Delhi.
3. Mavi H S and Tupper G J. 2005. *Agrometeorology – Principles and Applications of Climate Studies in Agriculture*. International Book Publishing Co., Lucknow.
4. Mavi H S 1994. *Introduction to Agrometeorology.* Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
5. Nanjappa H V and Ramachandrappa B K. 2007. *Manual on Practical Agricultural Meteorology*. Agrobios India. Jodhpur.
6. Pattersen S. 1958. *Introduction to Meteorology*. Mc. Graw Hill Book Co. Inc., New York
7. Prasad Rao G S L H V. 2008. *Agricultural Meteorology*. Prentice Hall of India Pvt. Ltd., New Delhi.
8. Srivastava A K and Tyagi P K. 2011. *Practical Agricultural Meteorology*. New Delhi Publishing Agency, New Delhi.
9. Yellamanda Reddy T and Sankara Reddi G H. 2010. *Principles of Agronomy*. Kalyani Publishers, New Delhi.

Post-Semester II (Only for exit option for award of UG-Certificate in Agriculture)

S. No.	Course Title	Credit load
1.	Internship (10 weeks)	**10 (0+10) ***

*Mandatory Internship to get Diploma after 2 Year exit.

Semester V

Fundamentals of Plant Breeding 3 (2+1)

Theory

Historical development, concept, nature and role of plant breeding. Major achievements and future prospects. Genetics in relation to plant breeding. Modes of reproduction. Male sterility - genetic consequences and cultivar options. Domestication, acclimatization and introduction. Centres of origin/diversity. Components of genetic variation, heritability and genetic advance. Genetic basis and breeding methods in self-pollinated crops - mass and pure line selection, hybridization techniques and handling of segregating population. Multiline concept. Concepts of population genetics and Hardy-Weinberg Law. Genetic basis and methods of breeding cross - pollinated crops. Modes of selection. Population improvement schemes - ear to row method, modified ear to row, recurrent selection schemes. Heterosis and inbreeding depression. Development of inbred lines and hybrids, composite and synthetic varieties. Breeding methods in asexually propagated crops - clonal selection. Wide hybridization and pre-breeding. Polyploidy in relation to plant breeding. Mutation breeding - methods and uses. Breeding for important biotic and abiotic stresses. Introduction to biotechnological tools - DNA markers and marker assisted selection. Participatory plant breeding. Plant Breeders' and Farmers' Rights.

Practical

Plant breeder's kit. Study of germplasm of various crops. Study of floral structure of self-pollinated and cross pollinated horticultural crops. Emasculation and hybridization techniques

in self and cross-pollinated horticultural crops. Consequences of inbreeding on genetic structure of resulting populations. Study of male sterility system. Handling of segregation populations. Maintenance of breeding records and data collection. Methods of calculating mean, range, variance, standard deviation, heritability. Designs used in plant breeding experiments, analysis of Randomized Block Design. Working out the mode of pollination in a given crop and extent of natural out-crossing. Prediction of performance of double cross hybrids.

Suggested Readings

1. Chahal G S and S S. Gosal 2001. *Principles and Procedures of Plant Breeding*.
2. Fehr W R. 1987 Principles of Cultivar Development –Theory and Practice.
3. Poehlman J M and Sleper DA.1995. Breeding Field Crops.
4. Singh B D 2011. A text book in Plant Breeding. Kalyani Publishers. Ludhiana.
5. Singh B D. 2008. Plant Breeding – Principles and Methods.

Growth and Development of Horticulture crops 3 (2+1)

Objectives

i. To understand the physiology of canopy management, flowering, fruit setting and seed development in horticultural crops
ii. To impart basic knowledge on the natural phytohormones and their specific functions in controlling the growth and developments
iii. To impart basic knowledge on the natural phytohormones and their specific functions in controlling the growth and developments
iv. To understand the usage of synthetic growth regulators and their applications for overall manipulation of growth and development in horticultural crops

Theory

Growth and development-definitions, components, photosynthetic productivity, Canopy photosynthesis and productivity, leaf area index (LAI) - optimum LAI in horticultural crops, canopy development; different stages of growth, growth curves, Crop development and dynamics (Case studies of annual/perennial horticultural crops), growth analysis in horticultural crops. Plant bio-regulators- auxin, gibberellin, cytokinin, ethylene inhibitors and retardants, basic functions, biosynthesis, role in crop growth and development, propagation, flowering, fruit setting, fruit thinning, fruit development, fruit drop, and fruit ripening. Flowering-factors affecting flowering, physiology of flowering, photoperiodism-long day, short day and day neutral plants, vernalization and its application in horticulture, pruning and training physiological basis of training and pruning-source and sink relationship, translocation of assimilates. Physiology of seed development and maturation, seed dormancy and bud dormancy, causes and breaking methods in horticultural crops. Physiology of fruit growth and development, fruit setting, factors affecting fruit set and development, physiology of ripening of fruits-climatic and non-climacteric fruits. Physiology of fruits under post-harvest storage.

Practical

Estimation of photosynthetic potential of horticultural crops, leaf area index, growth analysis parameters including harvest index, bioassay of plant hormones, identification of synthetic plant hormones and growth retardants, preparations of hormonal solution and induction of rooting in cuttings, ripening of fruits and control of flower and fruit drop. Important physiological disorders and their remedial measures in fruits and vegetables, seed dormancy, seed germination and breaking seed dormancy with chemicals and growth regulators.

Suggested Readings

1. Jain V K. 2006. *Fundamentals of Plant Physiology (9th Edn.)*. S, Chand and Co., New Delhi, India.
2. Mohr H and Schopfer P. 1995. *Plant Physiology. Springer-Verlag*, Berlin, Germany.
3. Richard P Marini: *Physiology of Pruning Fruit Trees.* http://pubs.ext.vt.edu/422/422-025/422-025.htmlTOC.
4. Salisbury F B and Ross C W. 1992. *Plant Physiology (4th Edn.)*. Wadworth Publishing Co., California, USA.
5. Taiz L and Zeiger E. 2003. *Plant Physiology (3rd Edn.)*. Sinaure Associates, Inc., Publishers, Massachusetts, USA.

Soil Fertility and Nutrient Management 3 (2+1)

Objective

To acquaint students with the basic knowledge of soil fertility and nutrient management, as to understand the key factors affecting plant growth and development.

Theory

Plant nutrients - classification and sources; Essential and beneficial elements, criteria of essentiality, forms of nutrients in soil, mechanisms of nutrient transport to plants, factors affecting availability of major, secondary and micro-nutrients to plants. Measures to overcome deficiency and toxicities. Soil fertility- different approaches for soil fertility evaluation; Soil testing for available nutrients for different horticultural crops; Critical levels of different nutrients in soil. Plant analysis- total and rapid tissue tests- critical levels of nutrients in plants; DRIS method; Deficiency symptoms-indicator plants. Biological method of soil fertility evaluation. Soil test-based fertilizer recommendations to crops. Site-specific and plant need-based nutrient management. Factors influencing nutrient use efficiency (NUE) in respect of N, P, K, S, Fe and Zn fertilizers. Source, method and scheduling of nutrients for different soils and crops grown under rainfed and irrigated conditions. Integrated plant nutrient supply system and its management. Soil quality in relation to sustainable agriculture-acid, salt affected and calcareous soils, characteristics, nutrient availabilities, Reclamation- mechanical, chemical and biological methods.

Practical

Analytical Instruments- principles, calibration and applications; Estimation of available nitrogen, available phosphorus, available potassium and available sulphur in soil; Estimation of exchangeable calcium and magnesium in soil, Estimation of available micronutrients in soils;

Preparation of plant samples for analysis; Estimation of nitrogen, phosphorus and potassium in plants.

Suggested Readings

1. Aggarwal J P, Yawalkar K S and Bokde S. 2011. *Manures and Fertilizers* (11th Edn.). Agri Horticultural Publishing House. Nagpur.
2. Basak Ranjan Kumar. 2016. *Fertilizers: A Text Book,* (4th Edn.). Kalyani Publishers. Ludhiana.
3. Brady N C. 1999. *Nature and Properties of Soils* (10th Edn.). Paperback.
4. Das P C. 2015. *Manures and Fertilizers* (3rd Edn.). Kalyani Publishers. Ludhiana.
5. Goswami N N. 2009. *Fundamentals of Soil Science* (2nd Edn.). ISSS New Delhi.
6. Kanwar J S. 1976. *Soil Fertility Theory and Practice.* ICAR, New Delhi.
7. Soil Science an Introduction. 2015. Indian Society of Soil Science. New Delhi.
8. Tisdale S L, Nelson W L and Beaton J D. 1985. *Soil Fertility and Fertilizers* (4th Edn.). Mac Millan Publishing Company. New York.

General Microbiology 3 (2+1)

Objective

To provide knowledge about general concepts of microbiology.

Theory

Evolution and scope of microbiology. History of microbiology. Microbial classification, nomenclature and identification. Taxonomic groups. General methods of classifying bacteria. Microscopy and microscopes: Smears and staining. Morphology and fine structure of bacteria. Cultivation of bacteria, nutritional requirements. Nutritional classification of bacteria; Phototrophs, chemotrophs, autotrophs and heterotrophs; Obligate parasites; Bacteriological media, Growth of bacteria, Reproduction of bacteria; Introduction to fungi, algae and protozoa and virus, Microbiology of water and food Nutrient transport phenomenon: Passive diffusion, facilitated diffusion; Group translocation, active transport. Metabolism in bacteria –ATP generation Microbial genetics; Bacterial recombination; Bacterial conjugation, transduction; Bacterial transformation; Mutations: Types of mutations, mutagenesis; Mutation rate, repair of mutations; Phenotypes of bacterial mutants; Designation of bacterial mutants; Destruction of microorganisms: Physical agents and chemical agents; Chemotherapeutic agents and chemotherapy; Characteristics of antibiotics; Mode of action of antibiotics; Pure culture: Methods of isolation of pure cultures; Maintenance and preservation of pure cultures; Culture collections.

Practical

Microscopy; Micrometry; Cleaning and sterilization of glassware and acquainting with equipment used in microbiology; Preparation of nutrient agar media and techniques of inoculation; Staining methods (monochrome staining, Gram staining, negative staining, capsule-staining, flagella staining and endospore staining); Pure culture techniques (streak plate/pour plate/spread plate); Identification procedures (morphology and cultural characteristics); Growth characteristics of fungi: Determination of microbial numbers, direct plate count, generation time; Factors influencing growth: pH, temperature, growth curves for bacteria.

Suggested Readings

1. Dubey R C and Maheshwari D K. 2013. *A Textbook of Microbiology*. S Chand Publishing, New Delhi.
2. Gerard J T, Berdell R F and Christine L C. 2014. *Microbiology: An Introduction.* (12th Edn.). Prentice-Hall, NY, USA.
3. Johanne M W, Linda M S and Woolverton C J. 2013. *Prescott's Microbiology.* (9th Edn.). McGraw-Hill Higher Education, NY, USA.
4. Pelczar M J, Chan ECS and Noel R K. 1998. *Microbiology.* (5th Edn.). Tata McGraw-Hill Education, New Delhi.
5. Purohit S S. 2001. *Microbiology-Fundamentals and Applications*. Agrobios, New Delhi.
6. Sharma P D. 1999. *Microbiology. Rastogi Publications*. Meerut, India.
7. Tauro P, Kapoor K K and Yadav K S. 2002. *Introduction to Microbiology*. New Age International (P) Limited Publications, New Delhi, India.

Information and Communication Technology in Horticulture 3 (1+2)

Objective

To learn basics of computing and its practical use in communication

Theory

IT and its importance. IT tools, IT-enabled services and their impact on society; Introduction to Computers, hardware and software; input and output devices; word and character representation; features of machine language, assembly language, high-level language and their advantages and disadvantages; Operating Systems, definition and types, Applications of Word Processing / Spreadsheet /Presentation /Databases for document creation and Editing, Data presentation, interpretation and graph creation, statistical analysis, mathematical expressions, Database concepts and types, uses of DBMS in Horticulture; Introduction to Local area network (LAN), Wide area network (WAN), Internet and World Wide Web, HTML and IP and Video conferencing, Introduction to e- Horticulture, concepts and applications, Use of ICT in Horticulture.

Practical

Practice with latest operating system for creating Files, Folders, File Management. Use of Word Processing/ Spreadsheet/ Presentation/ Databases with latest software packages; Creating a spreadsheet, Use of statistical tools, writing expressions, creating graphs, analysis of scientific data. Creating Database, preparing queries and reports, creation and operation of E mail account; Demonstration of Horti-information system using Mobile Apps. Internet applications: Web browsing, handling of audio-visual equipment. Planning, preparation, presentation of posters, charts. Introduction of Geospatial Technology of generating valuable information for horticultural. Hands on Decision Support System. Preparation of contingent horticultural crop planning.

Suggested Readings

1. Comer Douglas E. 2018. *The Internet Book: Everything You Need to Know about Computer Networking and how the Internet Works.* Chapman and Hall/CRC.
2. Crowther R, Joe L, Ash Blue, and Wanish G. 2014. *HTML5 in Action* (1st Edn.). Manning Publication Co.

Introductory Crop Physiology 2 (1+1)

Objectives

i. To study different physiological plant aspects such as water uptake and movement in horticultural plants, nutrient absorption, assimilation

ii. To study factors affecting photosynthesis and its importance in plants

Theory

Water Relations in Plants: Role of water in plant metabolism, osmosis inhibition, diffusion, water potential and its components, measurement of water potential in plants, absorption of water, mechanism of absorption and ascent of sap. Stomata: Structure, distribution, classification, mechanism of opening and closing of stomata. Osmotic pressure, guttation, stem bleeding; transpiration methods and mechanism and factors affecting transpiration. Drought: Different types of stresses; water, heat and cold tolerance; mechanism of tolerance. Plant Nutrition: Essentiality, mechanism of absorption and its role in plant metabolism. Biological Nitrogen Fixation. Photosynthesis, structure and function of chloroplast, dark and light reactions, cyclic and on-cyclic electron transfer, CO_2 fixation – C3, C4 and CA metabolism, advantages of C4 pathway. Photorespiration and its implications, factors affecting photosynthesis. Mode of herbicide action, Secondary metabolites and plant defense.

Practical

Measurement of water potential, osmosis, root pressure, structure of the stomata, distribution, opening and closing of the stomata, measurement, transpiration and calculation of transpiration pull demonstration. Importance of light and chlorophyll in photosynthesis, pigment identification in horticultural crops, measurement of relative water content (RWC), studying plant movements.

Suggested Readings

1. Bendre A M and Pande P C. 2009. *Introductory Botany*. Rastogi publication, Meerut.
2. Bhatia K N. 2015. *Plant Physiology*. Trueman Book Company, Jalandhar.
3. Dutta A C. 2013. *A Textbook of Botany.* Oxford University Press, Oxford Lecture Schedule.
4. Gardner F P, Pearce R Band Mitchell R L. 2003. *Physiology of Crop Plants*. Scientific Publishers, Jodhpur.
5. Jain V K. 2019. *Fundamentals of Plant Physiology*. S Chand Publishers, New Delhi.

Basic Statistics and Experimental Designs 3 (2+1)

Objectives

i. To understand the analytical techniques for data analysis and interpretation

ii. To help students to compete for various competitive examinations

Theory

Definition of statistics, its use and limitations. Variable statistics, types and sources of data, classification and tabulation of data. Construction of frequency distribution tables – graphic presentation of data, simple, multiple component and percentage, bar diagram, pie diagram,

histogram, frequency polygon and frequency curve, cumulative frequency curve. Measures of central tendency: mean, median, mode, geometric mean, harmonic mean, percentiles and quartiles for raw and grouped data, Measures of dispersion: range, quartile deviation, mean deviation, standard deviation for raw and grouped data, coefficient of variation. Skewness and kurtosis. Probability-definition, additive and multiplicative law for two events, Normal distribution and its properties. Introduction of sampling. basic concepts, sampling vs. Complete enumeration parameter and statistic. Sampling techniques (simple random sampling: lottery method and random number table method). Tests of significance, Null hypothesis, Alternate hypothesis, Type I and II Error, one and two tail tests, level of significance and confidence interval. Large sample tests for mean (Single sample and two samples), Student's t-test for single sample, two samples and paired t-test, F-test, Chi-square test for application of attributes (contingency table) and test for goodness to fit of Mendalian ratios, Yates' correction for continuity. Correlation-scatter diagram and Karl Pearson coefficient of correlation for ungrouped data and its testing. Linear regression and its properties. Inter-relation between 'r' and the regression coefficient, Introduction to design of experiment- Basic principles of experimental design-replication, randomization and local control, Analysis of variance (ANOVA) and its assumptions, analysis of Completely Randomized Design (CRD), Randomized Block Design (RBD) and Latin Square Design (LSD), Comparisons based on means-critical difference.

Practical

Construction of frequency distribution tables and frequency curves, Measures of central tendency: mean, median, mode, geometric mean, harmonic mean, percentiles and quartiles. Measures of dispersion: range, quartile deviation, mean deviation, standard deviation for raw and grouped data, coefficient of variation. Skewness and kurtosis. Probability. Large sample tests for mean, Student's t-test, F-test and Chi-square test, Correlation coefficient 'r' and its testing, Fitting of regression equations, Analysis of CRD, RBD and LSD.

Suggested Readings

1. Bansal M L, Singh Sukhminder, Singh Tejinderpal and Jindal Rakesh Kumar. 2014. *Statistical Methods for Research Workers*. (4th Edn.). Kalyani Publishers.
2. Chandal S R S. 2014. *A Handbook of Agricultural Statistics*. Achal Prakashan Mandir.
3. Gupta S P. 2021. *Statistical Methods.* Sultan Chand and Sons.
4. William G Cochran and George W Snedecor. 2014. *Statistical Methods.* (8th Edn.). Wiley India Pvt Ltd.

Semester-VI

Introductory Agroforestry 3 (2+1)

Objective

To develop skill and expertise on forestry, agroforestry models, wood-based industries, and nursery raising practices of important tree species

Theory

Forestry–Introduction, related definitions. Objective of silviculture. Forest classification. Indian Forest Policies. Artificial and natural regeneration–objectives, choice between natural and artificial regeneration. Coppicing, pollarding, root suckers. Forest mensuration – objectives,

instruments for diameter, height and age measurement. Tree stem form, form factor, form quotient. Measurement of volume of felled and standing trees.

Agroforestry–definition, objectives and potential. Distinction between agroforestry and social forestry. Choice of species with respect to site/economic uses and constraints on tree growing. Agroforestry systems, sub-systems and practices, shifting cultivation, taungya, home gardens, alley cropping, intercropping, wind breaks, shelterbelts and energy plantations. Planning for agroforestry–constraints, diagnosis and design methodology, selection of tree - crop species for agroforestry. Agroforestry projects – national and overseas. National Agroforestry Policy 2014. MPTs (*Azadirachta indica, Acacia* species, Bamboos, *Dalbergia sissoo*, *Eucalyptus* species, *Grewia optiva*, *Gmelina arborea*, *Leucaena leucocephala, Melia* species, *Populus deltoides*, *Tectona grandis*, etc.) – nursery and planting management practices.

Major wood-based industries in India – Timber, panel, plywood, paper and pulp, match, etc. – Raw material requirements and their procurement. Economics and marketing of products raised in agroforestry systems.

Practical

Identification of seeds and seedlings of tree species. Diameter measurements of forked, buttressed, fluted and leaning trees. Height measurement of standing trees by shadow method, single pole method and hypsometer. Volume measurement of logs using various formulae. Nursery practices for *Azadirachta indica, Acacia* species, Bamboos, *Dalbergia sissoo*, *Eucalyptus* species, *Grewia optiva*, *Gmelina arborea*, *Leucaena leucocephala, Melia* species, *Populus deltoides*, *Tectona grandis*, etc. Layout of agroforestry plantation and study the compatibility of MPTs with agricultural crops. Visit to social forestry/agroforestry plantations and nearby forest-based industries.

Suggested Readings:

1. Chundawat D S and S K Gautham. 2017. *Textbook of Agroforestry.* Oxford and IBH Publishing, (ISBN: 9788120408326).
2. Nair PKR, Kumar B M and V D Nair. 2021. *An Introduction to Agroforestry – Four Decades of Scientific Developmen*ts. Springer Cham
3. Parthiban K T, Umarani R, Kanna S U, Sekar I, Rajendran P and Durairasu P. 2014. *Industrial Agroforestry - Perspectives and Prospective.* Scientific Publishers, Jodhpur.
4. Tejwani K G. 2001. *Agroforestry in India*. Concept Publishing Company.

Laboratory Techniques for Horticulture crops 2 (0+2)

Objectives

i. To impart practical training for the analysis of physio-chemical attributes of fruit.

ii. To acquaint students with operating of various labware and equipment's

Practical

Safety measures and maintenance of laboratory. Acquaintance with the laboratory equipment's used for quality analysis of fruits and vegetables. Preparation of different standard solutions. Sampling procedures for quantitative analysis. Determination of physiological loss in weight,

specific gravity, fruit size, shape, juice content, firmness and fruit colour. Assessment of textural properties of harvested produce. Determination of biochemical components in horticultural produce viz. TSS, pH, acidity, sugars, carbohydrates, total antioxidants, starch index (SI), ascorbic acid, chlorophyll, anthocyanin, and carotenoids, phenols. Leaf nutrient analysis using Kjeldahl apparatus, spectrophotometer, flame photometer and atomic absorption spectrophotometer. Compilation and analysis of data and interpretation of results.

Suggested Readings

1. AOAC International. 2003. Official Methods of Analysis of AOAC International. (17th Edn.). Gaithersburg MD USA Association of Analytical Communities USA.
2. Rangana S 2001. *Handbook of Analysis and Quality Control for Fruits and Vegetable Products.* (2nd Edn.). Tata McGraw Hill. New Delhi.
3. Linskens H F and Jackson J F 1995. Fruit Analysis Springer.
4. Leo M L 2004. Handbook of Food Analysis (2nd Edn.). Vols I-III, USA.
5. Sarkar A K and Mahapatra 2015. Plant Nutrient Disorders Diagnosis and Management. New India Publishing Agency. New Delhi, India.

Principles of Biochemistry 3 (2+1)

Objective

To learn about the basic concepts of biochemistry

Theory

Recapitulation of basic chemistry and biology. Water, pH and buffers. Acid-base balance. Cellular constituents and their structure and function, amino acid and proteins, carbohydrates, lipids and bio-membranes, nucleic acids. Dissolved molecules– vitamins and minerals. Enzymes-function, properties and mechanism. Metabolism of cellular constituents, basic concepts of bioenergetics. Carbohydrate metabolism-glycolysis and glycogenolysis, HMP pathway, TCA cycle and gluconeogenesis. Electron transport chain. Photosynthesis. Lipid metabolism-β-oxidation, ketone bodies, fatty acid synthesis. Amino acid metabolism - general reactions of nitrogen assimilation and excretion. Biosynthesis of DNA, RNA and protein- replication, transcription, translation and genetic code. Regulation of gene expression.

Practical

Preparation of buffers and pH determination. Preparation of colloids. Qualitative and quantitative tests of carbohydrates, lipids and proteins. Tests of enzyme action- potato oxidase, urease, salivary amylase. Paper chromatography of amino acids or carbohydrates ascending and descending. Determination of starch and sugar. Analysis of proximate constituents in food.

Suggested Readings

1. Eric E. Conn, Paul K. Stumpf, George Brueninh and Roy H. Doi. 2009 Outlines of Biochemistry-(5th Edn.). John Wiley & Sons. 712p.
2. Satyanarayana U and Chakrapani U. 2013. *Biochemistry* (4th Edn.). Elsevier India.

3. David L. Nelson and Michael M. Cox. 2017. *Lehninger. Principles of Biochemistry.* (7th Edn.). WH Freeman.

Dryland Horticulture 3 (2+1)

Objectives

i. To acquaint the students with the soil and climatic features of the dry land areas
ii. To impart the knowledge about the soil and water conservation technologies for dry land areas
iii. To impart the knowledge about the production technologies for fruit crops of dry land areas

Theory

Definition, importance and limitation of dry land horticulture, present status and future scope. Constraints encounter in dry lands. Agro-climatic features in rainfed areas, scarce water resources, high temperature, soil erosion, run-off losses etc. Techniques and management of dry land horticulture. Watershed development, soil and water conservation methods-terraces, contour bunds etc. Methods of control and impounding of run-off water-farm ponds, trenches, macro catch pits etc. In-situ water harvesting methods, micro catchment, different types of tree basins etc. Methods of reducing evapotranspiration, use of shelter belts, mulches, anti-transpirants, growth regulators, organic amendments etc. water use efficiency-need based, economic and conjunctive use of water, micro irrigation systems and fertigation etc. Water quality: characterization and use in horticultural crops. Selection of plants having drought resistance. Special techniques, planting and after care-use of seedling races, root stocks, in-situ grafting, deep pitting/planting, canopy management etc. Characters and special adaptation of crops: ber, aonla, annona, jamun, wood apple, bael, pomegranate, carissa, date palm, phalsa, fig, west Indian cherry and tamarind.

Practical

Rainfall patterns. Contour bunding/trenching, micro catchments; rainfall erosivity and soil erodibility indices, measurement of runoff, soil loss and their control. Study of evapotranspiration, mulches and micro irrigation systems. Special techniques of planting and aftercare in dry lands. Morphological and anatomical features of drought tolerant fruit crops.

Suggested Readings

1. Chundawat B S. 1990. *Arid Fruit Culture*. Oxford and IBH, New Delhi.
2. Jatav M K, Saroj P L and Sharma B D. 2019. *Dryland Horticulture*. New India Publishing Agency. https://www.perlego.com/book/1975613/dryland-horticulture-pdf ISBN 10.1201/9781003245902.
3. Rathore R S, Singh R P, Singh P K and Singh P S 2020. *Dryland Horticulture Cultivation and Management*. Publisher AGROBIOS (INDIA) ISBNs: 978-81-943776-5-8. 340p.
4. Singh Jitendra. 2022. *Drylands Horticulture*, ISBN: 9789355400048. Kalyani Publishers.

Economics and Marketing 3 (2+1)

Objectives

i. To introduce the student about the concepts, subject matter and importance of study of economics.
ii. To make the student understand about the terms - goods, service, value, price, wealth, welfare.
iii. To impart knowledge to the student about the concept of wants, utility and consumer surplus.
iv. To expose the students to the laws of marginal utility and their importance.
v. To provide an overview to the students about the concept of demand, kinds of demand and law of demand.
vi. To aware the student about the concept of supply, law of supply and price determination of commodity under equilibrium condition.
vii. To aware the student about factors of production and their characteristics
viii. To provide an overview to the student about the Gross Value Added.
ix. To expose the students to the concept of marketing, market, price spread, marketing efficiency, integration, marketing functions, classification of markets and marketing channels.
x. To aware the students about the market intelligence, constraints in marketing of horticultural produce.
xi. To impart knowledge to the student about Basic guidelines for preparation of project reports, Bank norms, Insurance, SWOT analysis, crisis management.

Theory

Economics–Terms and definitions; Consumption, demand, price and supply; Factors of production; Gross Value Added. Role of Biotechnology/horticulture Sector in National GVA. Marketing – definition; Marketing process; Need for marketing; Role of marketing; Marketing functions; Classification of markets; Marketing of various channels; Price spread; Marketing efficiency; Constraints in marketing of horticultural produce; Market intelligence. Basic guidelines for preparation of project reports; Bank norms; Insurance; SWOT analysis; Crisis management.

Practical

Techno-economic parameters for preparation of projects; Preparation of bankable projects for various biotechnology/horticultural products and value-added products; Identification of marketing channel; Calculation of price spread; Identification of market structure; Visit to different markets, market institutions; Study of SWC, CWC and STC; Analysis of information of daily prices; Marketed and marketable surplus of different commodities.

Suggested Readings

1. Acharaya S S and Aggarwal N L.1987. *Agricultural Marketing in India.* Oxford and IBH.
2. Gupta R D. 2006. *Elementary Economic Theory*. Kalyani Publishers.
3. Dewett K K, Navalur M H. 2010. *Modern Economic Theory*. S. Chand Publishing.
4. Dewett K K and Verma J D.1973. *Elementary Economic Theory*. S Chand and Company.
5. Reddy Subba S, Raghu Ram P, Neelkanta T V and Bhawani Sastry Devi.2020. *Agricultural Economics.* CBS Publishers and Distributors Pvt. Ltd.

Principles and Practices of Natural Farming 2 (1+1)

Objectives

i. To teach students the concept, need and principles of native ecology-based production under natural farming
ii. To impart practical knowledge of natural farming and related agricultural practices in Indian and
iii. To global environmental and economic perspectives.

Theory

Indian Heritage of Ancient Agriculture, History of Natural Farming, Importance of natural farming; Definition; Objective of natural farming, Essential characteristics and Principles of natural farming; Scope and importance of natural farming. Main Pillars of natural farming; Methods/ types/ schools of natural farming. Introduction to concept of ecological, water, carbon and nitrogen foot prints, Concept and evaluation of ecosystem services, Rearing practices for animals under natural farming**,** Nutrient management in natural farming and their sources, Insect, pest, disease and weed management under natural farming; Mechanization in natural farming, Processing, labelling, economic considerations and viability, certification and standards in natural farming, marketing and export potential of natural farming produce and products. Initiatives taken by Government (central/state), NGOs and other organizations for promotion of natural farming and chemical free agriculture, Case studies and success stories in natural farming and chemical free traditional farming, Entrepreneurship opportunities in natural farming.

Practical

Visit of natural farm and chemical free traditional farms to study the various components and operations of natural farming principles at the farm; Indigenous technical knowledge (ITK) for seed, tillage, water, nutrient, insect-pest, disease and weed management; On-farm inputs preparation methods and protocols, Studies in green manuring *in-situ* and green leaf manuring, Studies on different types of botanicals and animal urine and dung based non-aerated and aerated inputs for plant growth, nutrient, insect and pest and disease management; Weed management practices in natural farming; Techniques of indigenous seed production, storage and marketing, Partial and complete nutrient and financial budgeting in natural farming; Evaluation of ecosystem services in natural farming (Crop, Field and System).

Suggested Readings

1. Ayachit S M. 2002. *Kashyapi Krishi Sukti (A Treatise on Agriculture by Kashyapa).* Brig Sayeed Road, Secunderabad, Telangana: Asian Agri-History Foundation 4: 205.
2. Boeringa R. (Ed.). 1980. *Alternative Methods of Agriculture*. Elsevier, Amsterdam, 199 pp.
3. Dabholkar Shripad A. 2021. Plenty For All: Natural Farming A To Z Prayog Pariwar Methodology Prayog Pariwar.
4. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.

5. Ecological Farming -The seven principles of a food system that has people at its heart. May 2015, Greenpeace.
6. Faires Nicole. 2016. *The Ultimate Guide to Natural Farming and Sustainable Living: Permaculture for Beginners* (Ultimate Guides).
7. INFRC. 1988. *Guidelines for Nature Farming Techniques.* Atami, Japan. 38 p.
8. Khurana A and Kumar V. 2020. *State of Organic and Natural Farming: Challenges and Possibilities, Centre for Science and Environmen*t, New Delhi.
9. Malhotra R and Babaji S D. 2020. *Sanskrit Non-Translatable- The importance of Sanskritizing English.* Amaryllis, New Delhi India.
10. Nalini S. 1996. *Vrikshayurveda* (The Science of Plant Life) by Surapala. AAHF Classic Bulletin 1. Asian Agri-History Foundation, Brig Sayeed Road, Secunderabad, AP (now Telengana), India. 94p.
11. Nalini S. 1999. *Krishi-Parashara* (Agriculture by Parashara) by Parashara. Brig Sayeed Road, Secunderabad, Telangana: AAHF Classic Bulletin, Asian Agri-History Foundation. 104p.
12. Nalini S. 2011. *Upavana Vinoda (Woodland Garden for Enjoyment) by Sarangdhara (13th Century CE): AAHF Classic Bulletin 8. Asian Agri-History Foundation*. Brig Sayeed Road, Secunderabad, AP (now Telangana), India. 64p.
13. Prathapan Paramu. 2021. *Natural Farming Techniques: Farming without Tilling*. Bookventure.
14. Reyes Tirado. 2015. *Ecological Farming- The Seven Principles of a Food System that has People at its Heart. Greenpeace Research laboratorie*s. University of Exeter, Ottho Heldringstraat.
15. UK Behera. 2013. *A text Book of Farming System*. Agrotech Publishing House, Udaipur.
16. कम लागत प्राकृतिक खेतीः आचार्य देवव्रत, 166p.

Horticulture Based Integrated Farming System **3 (2+1)**

Objective

To familiarize the students for farm management to deliver more sustainable agriculture

Theory

Farming System-scope, importance, concept and factors affecting types of farming system. Farming system components and their maintenance. Evolution and diversity of farming systems; Stone age survival to swidden farming, Nomadic pastoralism and agro-pastoralism in warm and cold deserts of India. Horticulture crop based livestock farming, subsistent livelihoods in rain-fed areas of India. Industrial and semi-industrial agriculture- agro-enterprises, agribusiness systems, their produce for marketing grains, vegetables, fruits, flowers, fibre crops, medicinal and aromatic plants. Value addition for income enhancement. Integrated farming system-objectives, characteristics and its advantages and disadvantages. Site specific development of IFS model for different agro-climatic zones, resource use efficiency and optimization techniques in relation to horticulture crops. Resource cycling and flow of energy in different horticulture-based farming system and environment. Sustainable livelihood horticulture- problems and its impact on horticulture. Indicators of soil health and environment for horticulture- based

IFS. Vertical farming definition, their scope and objectives; multilayer farming, hydroponics, aeroponics-their definition, requirements, advantages, disadvantages and opportunities; Site specific horticulture- based IFS models; horticulture and vegetable intercropping systems; high density plantation; bankable IFS models; rooftop farming; Farm typology. Visit of horticulture based IFS model in different agro-climatic zones of nearby states University/ institutes and farmers' field.

Practical

Preparation of horticulture based cropping scheme and integrated farming system models for irrigated, rainfed and dryland situations. Preparation of enriched farmyard manure and vermicompost. Visit to urban waste recycling unit and model farmers' field. Preparation of farm lay out plans. Estimating horticulture crop yields. Energy budgeting in different horticulture crops. EC/pH/TDS of water; Hydroponics nutrient management, Designing of polyhouse, Net house and tunnel house; Mushroom farming and its various types; Seeding with soilless media. C-sequestration, budgeting, footprints. Organic fertigation in orchards; use of biorationales. Working out ecological optimum zones. Project making exercises for establishment of horticulture-based production models under different situation.

Processing and Value Addition of Horticulture crops 3 (2+1)

Objectives

i. To make the students familiarize with the principles of food preservation and processing
ii. To develop the skill set in students for value addition of horticultural produce by application of suitable food processing methods

Theory

Importance and scope of fruit and vegetable processing industry in India. Food pipeline-losses in postharvest, processing and distribution systems. Losses in post-harvest operations. Unit operations in food processing-pasteurization, sterilization, blanching, canning, and bottling. Principles and guidelines for selecting the location and establishment of processing units. Principles and methods of preservation by heat, low temperature, sugar and salt, chemicals. Methods of fruit juice extraction, preparation of RTS, cordials, nectars, squashes, syrups, candies, crystallized fruits, preserves, jam, jelly, marmalade, fermented beverages, vinegar, pickles, chutneys and sauces. Tomato and mushroom products, freezing of fruits and vegetables. Drying of fruits and vegetables. Processing of plantation crops, their products, spoilage in processed foods, quality control of processed products, Government policy on import and export of processed fruits. Food laws.

Practical

Equipment used in food processing units. Canning of fruits and vegetables. Preparation and quality evaluation of squash, RTS, syrup, jam, jelly, marmalade, candies, preserves, chutneys. Dehydration of fruits and vegetables, tomato products, refrigeration and freezing, cut out analysis of processed foods. Visit to food processing units.

Suggested Readings

1. Fellows P J. 2005. *Food Processing Technology: Principles and Practice.* CRC Press, Woodhead Publishing Ltd.
2. Girdhari Lal, Siddappa G S and Tandon G L. 1967. *Preservation of Fruits and Vegetables*. Indian Council of Agricultural Research, New Delhi.
3. Kureel M K. 2020. *Postharvest Management and Value Addition of Fruits and Vegetables*. Bio-Green Books.
4. Potter Norman N. 2013. *Food Science*. Springer Science and Business Media.
5. Srivastava R P and Kumar Sanjeev. 2019. *Fruit and Vegetable Preservation – Principles and Practices.* CBS Publishers and Distributors Pvt Ltd.

Semester VII

ELECTIVE COURSES

A.	Fruit Science	Credits
1.	Production Technology of Tropical Fruit crops	3 (2+1)
2.	Production Technology of Sub tropical and Temperate Fruit crops	3 (2+1)
3.	Breeding of Fruit Crops	3 (2+1)
4.	Canopy Management in Fruit Crops	3 (2+1)
5.	Biotechnological Approaches and Micro-propagation in Fruit Crops	3 (2+1)
6.	Production Technology of Arid Fruit Crops	3 (2+1)
7.	Postharvest Management of Fruit Crops	2 (1+1)
B.	**Vegetable Science**	
1.	Production Technology of Warm Season Vegetable Crops	3 (2+1)
2.	Production Technology of Cool Season Vegetable Crops	3 (2+1)
3.	Production Technology of Tuber Crops	3 (2+1)
4.	Breeding of Vegetable Crops	3 (2+1)
5.	Biotechnological approaches and Micropropagation in Vegetable Crops	3 (2+1)
6.	Postharvest Management of Vegetable Crops	3 (2+1)
7.	Protected cultivation of Vegetable Crops	2 (1+1)
C.	**Floriculture and Landscaping**	
1.	Turf management	2 (1+1)
2.	Protected Cultivation of Flower Crops	3 (2+1)
3.	Value Addition in Floriculture	3 (2+1)
4.	Breeding of Ornamental Crops	3 (2+1)
5.	Principles of Landscape Architecture	3 (2+1)
6.	Commercial Floriculture and Landscaping	3 (2+1)
7.	Postharvest handling of Floricultural Crops	3 (2+1)

Note: The University/ Institute may offer more electives/courses relevant to the subject.

A. Fruit Science

Production Technology of Tropical Fruit crops 3 (2+1)

Objectives

i. To teach students origin, systematics, genetic resources, botany and production of tropical fruit crops

ii. To impart adequate knowledge and skill tothe students for commercial cultivation of tropical fruit crops

Theory

Importance, scope and commercial importance of tropical fruits. Distribution of tropical zones in the world and India. Origin, systematics, distribution, genetic resources, and eco-physiological requirements. Major species, commercial varieties and rootstocks. Propagation, planting, training and pruning. Nutrient and water management. crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques. Physiological disorders, major pests and diseases and their management. Industrial and export potential, Agri. Export Zones (AEZ) and industrial support. Fruit crops- mango, papaya, pineapple, banana, avocado, sapota, guava, jackfruit, tamarind, annonas and minor fruits of tropics viz. carambola, mangosteen, pashion fruit, bilimbi, rambutan, longan and durian.

Practical

Description and identification of species and varieties of tropical fruits. Propagation and nursery management of tropical fruit crops. Leaf sampling and nutrient analysis. Rejuvenation of old and unproductive trees. Identification and management of nutritional disorders, insect-pest and diseases. Maturity standards, harvesting, grading, packaging and storage. Visit to commercial orchards.

Suggested Readings

1. Bartholomew D P, Paull R E and Rohrbach K G. 2002. *The Pineapple: Botany, Production, and Uses*. CAB International.
2. Bose T K and Parthasarathy V A. 2022. *Fruits: Tropical and Subtropical.* (14th Edn.). Daya Publishing House, New Delhi.
3. Chattopadhyay T K. 2013. *A Textbook on Pomology Vol I-II*. Kalyani Publications. New Delhi.
4. ICAR. 2019. *Handbook of Horticulture (Vol I-II)*. ICAR Publications, New Delhi.
5. Mitra S K. 2021. *Guava: Botany, Production and Uses*. CAB International.
6. Paull R E and Duarte O. 2011. *Tropical Fruits (Vol. I-II).* CAB International.
7. Robinson J C and Saúco V G. 2010. *Bananas and Plantains*. CAB International.

Production Technology of Sub-tropical and Temperate Fruit Crops 3 (2+1)

Objectives

i. To familiarize the students about cultural and management practices of fruit crops

ii. To impart a comprehensive knowledge and skills on quality production of fruit crops

Theory

Importance, scope and commercial importance of sub-tropical and temperate fruits. Distribution of sub-tropical and temperate zones in the world and India. Origin, systematics, distribution, genetic resources, and eco-physiological requirements. Major species, commercial varieties and rootstocks. Propagation, planting and HDP, training and pruning and orchard floor management. Nutrient and water management, flowering and fruit set, compatibility, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques. Physiological disorders, major pests and diseases and their management. Industrial and export potential, Agri. Export Zones (AEZ) and industrial support. Fruit crops- citrus, grapes, pomegranate, litchi, loquat, grapes, litchi, pomegranate, apple, pear, peach, plum, apricot, cherries, berries, persimmon, kiwifruit, walnut, almond, pecan nut, hazelnut, chestnut, strawberry.

Practical

Description and identification of varieties based on flower and fruit morphology of sub-tropical and temperate fruits. Canopy management. Selection of site and planting system, Mulching, Manure and fertilizer application including bio-fertilizers in fruit crops. Preparation and application of growth regulators. Crop regulation, maturity indices, ripening of fruits, grading and packaging. Production economics of sub-tropical and temperate fruits. Visit to commercial orchards and diagnosis of maladies.

Suggested Readings

1. Chadha K L and Shikhamany S D 1999. *The Grape - Improvement, Production and Post-Harvest Management.* Malhotra Book Depot, New Delhi.
2. Chattopadhyay T K. 2013. *Text book on Pomology (Temperate Fruits), Vol. IV*. Kalyani Publishers, New Delhi.
3. Chattopadhyay T K. 2013. *Text book on Pomology (Sub Tropical Fruits), Vol. III.* Kalyani Publishers, New Delhi.
4. Dhillon WS. 2013. *Fruit Production in India*. Narendra Publishing House, New Delhi.
5. Jackson D. Thiele G, Looney N E and Morley-Bunker M. 2011. *Temperate and Subtropical Fruit Production*. CAB International.
6. ICAR. 2019. *Handbook of Horticulture (Vol I and II).* ICAR Publications, New Delhi.
7. Sandhu S and Gill B S. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi.
8. Sharma R R and Krishna H. 2018. *Textbook of temperate fruits*. CBS Publishers and Distributors Pvt. Ltd., New Delhi.

Breeding of Fruit Crops 3 (2+1)

Objectives

i. To provide knowledge about the breeding objectives and methods of fruit breeding in a prescribed manner
ii. To familiarize students with latest principles and practices of crop improvement in different fruit crops

Theory

Fruit breeding-history, importance in fruit production; Major problems in fruit breeding; Plant genetic resources, their conservation and utilization in fruit crops; Breeding objectives for improvement of commercial fruits (mango, citrus, guava, banana, grapes, strawberry, litchi, sapota, pomegranate, pineapple, papaya, apple, pear, peach, plum, cherry, kiwifruit, walnut, apricot, plantation crops-coconut, cocoa, tea, arecanut, coffee), their distribution, domestication and adaptation; Incompatibility, sterility, parthenocarpy and apomixes; Breeding methods- introduction, colonal selection, hybridization, mutation breeding, polyploid manipulation; Rootstock breeding and improvement of quality traits; Breeding for insect-pest and disease resistance and abiotic stresses; Biotechnological interventions in fruit crop improvement.

Practical

Tools and equipment of use in fruit breeding; Studies on bearing habits and flower structure; in-vitro pollen germination test and determination of pollen viability; Methods of emasculation and pollination; Hybrid seed collection, extraction and storage; hybrid seed germination; Raising and evaluation of segregating populations; Induction of mutations through use of physical/chemical mutagens; Polyploidy manipulation; Hand on practice of Emasculation and pollination in major crops of the region.

Suggested Readings

1. Badenes M L and Byrne D H. 2012. *Fruit Breeding.* Springer Science, New York.
2. Dinesh M R. and Sankaran M. 2022. *Fruit Breeding and Genetics*. New India publishing Agency, New Delhi
3. Kumar N. 2014. *Breeding of Horticultural Crops: Principles and Practices*. NIPA, New Delhi.
4. Ray P K. 2002. *Breeding Tropical and Subtropical Fruits.* Narosa Publ. House, New Delhi.
5. Ghosh S N, Verma M K and Thakur A. 2018. *Temperate Fruit Crop Breeding: Domestication to Cultivar Development.* NIPA, New Delhi.

Canopy management in Fruit Crops 3 (2+1)

Objectives

i. To provide knowledge about manipulation of plant growth and development by employing different training and pruning procedures

ii. To familiarize student with scientific principles of tree growth, physiology and understanding of tree response to various pruning cuts.

Theory

Introduction and importance of canopy management, objectives of canopy management, importance and factors affecting canopy development. Canopy types, tree architecture and different conventional and trellis training systems. Canopy manipulation for optimum utilization of light and its interception. Dwarfing physiology and high-density planting. Physical manipulation and growth regulation: Canopy management through rootstock and scion. Effect of thinning and heading cuts on branch growth. Canopy management through plant growth regulators, training and pruning

and management practices. Canopy development and management in relation to growth, flowering, fruiting and fruit quality in different deciduous and evergreen fruits.

Practical

Study of different types of canopies, training of plants for different canopy types, Canopy development through pruning, study of different trellis training systems, development of effective canopy with support system, study on effect of different canopy types on production and quality of fruits understanding bearing behaviour and canopy management in different fruits, use of plant growth regulators, effect of pruning on light interception and fruit quality. Canopy management practices in different deciduous and evergreen fruits.

Suggested Readings

1. Bakshi J C, Uppal D K and Khajuria H N. 1988. *The Pruning of Fruit Trees and Vines*. Kalyani Publishers, New Delhi.
2. Chadha K L and Shikhamany S D.1999.*The Grape: Improvement, Production and Post-harvest Management*. Malhotra Publishing House, Delhi.
3. Iyer CPA and Kurian R M. 2006. *High Density Planting in Tropical Fruits: Principles and Practices.* IBDC Publishers, New Delhi.
4. Pradeep Kumar, T. 2008. Management of Horticultural Crops. NIPA, New Delhi.
5. Singh G. 2010. *Practical Manual on Canopy Management in Fruit Crops. Dept. of Agriculture and Co-operation.* Ministry of Agriculture (GoI), New Delhi.
6. Srivastava K K. 2012. *Canopy Management in Fruits.* ICAR, New Delhi.

Biotechnological Approaches and Micro propagation in Fruit Crops 3 (2+1)

Objectives

i. To provide knowledge about the biotechnological interventions and micropropagation methods in a prescribed manner

ii. To familiarize students with biotechnological tools in fruit crops to enhance yield, biotic and abiotic stress management and improved quality traits to a considerable extent

Theory

Introduction, history and basic principles of biotechnology; Physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture; *In vitro* culture and hardening: callus culture – types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis; Hardening and ex-vitro establishment of tissue cultured plants; Transgenics and Gene Technologies; Somatic cell hybridization, construction and identification of somatic hybrids and cybrids, wide hybridization; *In-vitro* pollination and fertilization, haploids, in vitro mutation, artificial seeds, cryopreservation: *In- vitro* selection for biotic and abiotic stress; use of molecular markers and genomics; Gene silencing, gene tagging, gene editing, achievements of biotechnology in fruit crops.

Practical

An exposure to low cost, commercially operated and privately-owned tissue culture laboratories; Tasks include preparing media, inoculating explants for clonal multiplication, inducing and culturing callus, and regenerating plantlets from callus; Methods for sub-culturing on anther,

ovule, embryo culture, and somaclonal variation; *In vitro* mutant selection against abiotic stress; Protoplast culture and fusion process. Development of large-scale mass multiplication; Project development for the establishment of a commercial tissue culture laboratory.

Suggested Readings

1. Bajaj YPS. 1989. *Biotechnology in Agriculture and Forestry. Vol. V, Fruits.* Springer, USA.
2. Brown T A. 2001. *Gene Cloning and DNA Analysis and Introduction*. Blackwell Publishing, USA.
3. Chahal G S and Gosal S S. 2010. *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches.* Narosa, New Delhi.
4. Keshavachandran R, Nazeem P A, Girija D, John P S and Peter K V. 2007. *Recent Trends in Biotechnology of Horticultural Crops. Vols. I, II.* NIPA, New Delhi.
5. Miglani G S. 2016. *Genetic Engineering – Principles, Procedures and Consequences*. Narosa Publishing House, New Delhi.

Production Technology of Arid Fruit Crops 3 (2+1)

Objectives

i. To impart basic knowledge about the arid fruit crops
ii. To familiarize students with the latest developments and trends in production technology of important arid fruit crops

Theory

Importance, scope and limitations of arid and semi-arid zones, Distribution of Agro-climatic arid and semi-arid zones, soil and water conservation methods-terraces, contour bunds etc. Methods of control and impounding of run-off water - farm ponds, trenches, macro catch pits etc. *In-situ* water harvesting methods, micro catchment, different types of tree basins etc. Methods of reducing evapotranspiration, use of shelter belts, mulches, anti transpirants, growth regulators, etc. micro systems of irrigation etc. Characteristic feature of arid fruit crops, bearing habit, flowering and fruit set, improved varieties, planting techniques, propagation, canopy management, nutrient and weed management, Special production problems, insect-pests, diseases and their control measures, Post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage of the following crops: ber, aonla, pomegranate, jamun, bael, date palm, phalsa, fig, custard apple, karonda, prickly pear, lasora, sea buckthorn, pistachio and wood apple

Practical

Identification of various arid fruit crops, Planning and layout of orchards, propagation methods in arid fruit crops, training and pruning of orchard trees, preparation of fertilizer mixtures and field application, leaf sampling and nutrient analysis, preparation and application of growth regulators, layout of different irrigation systems, Identification and management of nutritional disorders, insect-pest and disease management, maturity standards, harvesting, grading, packaging and storage.

Suggested Readings

1. Chattopadhyay T K 2013. *A Textbook on Pomology Vol I-IV.* Kalyani Publications. New Delhi.

2. Hiwale S 2015. *Sustainable Horticulture in Semiarid Drylands*. Springer.
3. ICAR 2019. *Handbook of Horticulture (Vol I and II).* ICAR Publications. New Delhi.
4. Krishna H and Sharma R R 2017. *Fruit Production- Minor Fruits.* Daya Publishing House, Delhi.
5. Peter K V 2010. *Underutilized and Underexploited Horticultural Crops.* NIPA, New Delhi.
6. Saroj P L and Awasthi O P. 2005. *Advances in Arid Horticulture, Vol II: Production Technology of Arid and Semiarid Fruits.* IBDC, Lucknow.
7. Sontakke M B. 2014. *Production and Management of Fruit Crops in Arid/Drylands*. Agrotech Publishing Academy, Udaipur (Rajasthan).

Postharvest Management of Fruit crops 2 (1+1)

Objectives

i. To provide knowledge about various physico-chemical changes occurring during postharvest life of fruits

ii. To familiarize students with various techniques to minimize postharvest losses and maintain the postharvest quality of fruits

Theory

Importance and scope. Maturity indices, harvesting practices and grading. Influence of pre-harvest practices. Physiology and biochemistry of fruit ripening, ethylene evolution and its management. Pre-cooling. Factors leading to post-harvest losses. Treatments prior to transportation viz. chlorination, waxing, chemicals, natural plant products, hot-water, vapour heat treatment, sulphur fumigation and irradiation. Fruit packaging and transport. Methods of storage.

Practical

Analyzing maturity stages of commercially important fruit crops, harvesting methods, pre-cooling methods, grading. Components of cold and ripening chambers. Ripening of fruits. Pre-harvest and post-harvest application of growth substances, fungicides, nutrients, waxes and hot water treatments. Improved packing and storage of important horticultural commodities, Physiological loss in weight of fruits. Estimation of quality characteristics viz; TSS, titratable acidity, firmness, Vitamin C, sugars in stored fruits.

Suggested Readings

1. Kader A A. 2002. *Postharvest Technology of Horticultural Crops. (3rd Edn.). University of California.* Agricultural and Natural Resources.
2. Wills R, McGlasson B, Graham D and Joyce DC. 2007. *An Introduction to the Physiology and Handling of Fruits, Vegetables and Ornamentals*, CAB International
3. Saraswathy S, Preethi T L, *Balasubramanyam S, Suresh J, Revathy N and Nararajan S. 2010. Postharvest Management of Horticultural Crops*. Agrobios publication, Jodhpur.
4. Verma L R and Joshi V K. 2000. *Postharvest Technology of Fruits and Vegetables. Vol I,* II. Indus Publishing Company.

B. Vegetable Science

Note: ***The University/ Institute may offer more electives/courses relevant to the subject.***

Production Technology of Warm Season Vegetable Crops 3 (2+1)

Objectives

To impart knowledge and skills for production of warm season vegetable crops

Theory

Introduction, nutritional value, origin, botany and taxonomy, important countries and states growing vegetables along with area, climate and soil requirements, commercial varieties/hybrids, sowing/ transplanting time, seed rate, seed treatment, nutritional and irrigation requirements, chemical weed control, mulching, physiological disorders, harvesting techniques, postharvest management, plant protection measures and seed production of warm season vegetable crops i.e. solanaceous crops, okra, cucurbitaceous crops, cowpea, sweet potato, cluster beans, amaranth, basella, moringa, tapioca. Poly-house, net- house and low tunnel technology for off-season production of summer vegetables

Practical

Seed extraction, sowing practices, nursery management, Use of growth regulators, grafting technique, water and nutrient management. Drip irrigation, fertigation, weed management and mulching. Identification of physiological disorders, pests, diseases and nutrient deficiencies. Study of maturity indices. Forcing techniques for raising summer vegetables. Visit to vegetable nursery unit/ protected cultivation unit.

Suggested Readings

1. Bose T K, Kabir J, Maity T K, Parthasarathy VA and Som M G. 2003. *Vegetable crops. Vols. I-III.* Naya Udyog.
2. Dhaliwal M S. 2017. *Handbook of Vegetable Crops*. Kalyani publishers, Ludhiana
3. Hazra P. 2016. *Vegetable Science. (2nd Edn.).* Kalyani publishers, Ludhiana.
4. Hazra P. 2019. *Vegetable Production and Technology.* New India Publishing Agency, New Delhi.
5. ICAR. 2002. Hand Book of Horticulture. ICAR.
6. Thamburaj S and Singh N (Eds). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.

Production Technology of Cool Season Vegetable Crops 3 (2+1)

Objective

To impart knowledge and skills for production of cool season vegetable crops

Theory

Introduction, nutritional value, origin, botany and taxonomy, important countries and states growing vegetables along with area, climate and soil requirements, commercial varieties/hybrids evolved by private and public sector, sowing/ transplanting time, seed rate and seed treatment,

nutritional and irrigation requirements, chemical weed control, mulching, physiological disorders, harvesting techniques, postharvest management, plant protection measures and seed production of potato, cole crops; cabbage, cauliflower, knolkhol, broccoli, brussels' sprout, chinese cabbage, root crops; carrot, radish, turnip, beet root, bulb crops; onion and garlic, peas and beans, green leafy cool season vegetables.

Practical

Seed extraction, sowing practices, nursery management, Use of growth regulators, grafting technique, water and nutrient management. Drip irrigation, fertigation, weed management and mulching. Identification of physiological disorders, pests, diseases and nutrient deficiencies. Study of maturity indices. Forcing techniques for raising cool season vegetables. Visit to vegetable nursery unit/ protected cultivation unit. Layout of kitchen garden.

Suggested Readings

1. Bose T K, Kabir J, Maity T K, *Parthasarathy VA and Som M G. 2003. Vegetable Crops. Vols. I-III*. Naya Udyog.
2. Dhaliwal M S. 2017. *Handbook of Vegetable Crops*. Kalyani publishers, Ludhiana
3. Hazra P. 2016. *Vegetable Science* (2nd Edn.). Kalyani publishers, Ludhiana.
4. Hazra P. 2019. *Vegetable Production and Technology.* New India Publishing Agency, New Delhi.
5. ICAR. 2002. *Hand Book of Horticulture*. ICAR.
6. Thamburaj S and Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.

Production Technology of Tuber Crops 3 (2+1)

Objective

To impart knowledge and skill for production of tuber crops and their management

Theory

Origin, area, production, economic importance and export potential of tropical, sub-tropical and temperate tuber crops; description of varieties and hybrids. Climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems. Harvesting practices yield; economic of cultivation. Postharvest handling and storage, marketing. Crops to be covered-potato, sweet potato, arrow root, cassava, colocasia, xanthosoma, amorphophallus, dioscorea, Jerusalem artichoke, horse radish, coleus and yam bean and other under exploited tuber crops.

Practical

Identification and description of potato and tropical, sub-tropical and temperate tuber crops; planting systems and practices; field preparation and sowing/planting. Top dressing of fertilizers and interculture and use of herbicides and growth regulators; identification of nutrient deficiencies, physiological disorders; harvest indices and maturity standards, postharvest handling and storage, marketing. Seed collection, working out cost of cultivation.

Suggested Readings

1. Dhaliwal M S. 2008. *Handbook of Vegetable Crops*. Kalyani Publishers. Ludhiana
2. ICAR. 2002. *Hand Book of Horticulture*. ICAR.
3. Thamburaj S. 2014. *Text Book of Vegetable, Tuber Crops and Spices*. ICAR, New Delhi.
4. Umashankar. 2008. *Indian Vegetables.* Anmol Publications. Pvt. Ltd., New Delhi.

Breeding of Vegetable Crops 3 (2+1)

Objectives

i. To make students well verse with the plant genetic resources and their utilization in improvement of vegetable crops

ii. To impart knowledge and skill regarding breeding procedures of self-pollinated, often cross pollinated, cross-pollinated and vegetatively propagated vegetable crops

Theory

Definition and history of vegetable breeding. Origin, distribution, wild relatives and breeding objective of different vegetable crops viz. tomato, brinjal, chilli, muskmelon, watermelon, cucumber, bitter gourd, pumpkin, squashes, onion, garlic, carrot, radish, cauliflower, cabbage, pea, okra and potato. Plant genetic resources, their utilization and conservation. Breeding procedures of self-pollinated, often cross pollinated, cross-pollinated and vegetatively propagated vegetable crops. Conventional and modern techniques for improvement of vegetable crops. Breeding for biotic, abiotic stress tolerance and quality in vegetable crops. Genetic mechanisms for exploitation of heterosis in vegetable crops.

Practical

Study of inflorescence and flower structures. Practice for emasculation and artificial pollination. Distinguished morphological characteristics of released varieties/hybrids. Layout of field experiments. Estimation of heterosis. Handling of germplasm and segregating populations by different methods like pedigree, bulk and single seed decent methods. Visit to vegetable seed production field.

Suggested Readings

1. Allard R W. 1960. *Principle of Plant Breeding*. John Willey and Sons, USA.
2. Kalloo G. 1988. *Vegetable Breeding (Vol. I, II, III)*. CRC Press, Fl, USA.
3. Kole C R. 2007. *Genome Mapping and Molecular Breeding in Plants-Vegetables*. Springer, USA.
4. Peter KV and Pradeep Kumar T. 1998. *Genetics and Breeding of Vegetables*. ICAR, New Delhi, p. 488.
5. Prohens J and Nuez F. 2007. *Handbook of Plant Breeding-Vegetables (Vol I - II)*. Springer, USA.
6. Ram H H. 2019. *Vegetable Breeding: Principles and Practices*. Kalyani Publishers.
7. Singh B D. 2007. *Plant breeding- principles and methods.* (8th Edn.). *Kalyani Publishers*, New Delhi.
8. Singh Ram J. 2007. *Genetic Resources, Chromosome Engineering, and Crop Improvement-Vegetable Crops (Vol. III)*. CRC Press, Fl, USA.
9. Swarup V. 2016. *Vegetable Science and Technology in India*. Kalyani Publishers.

Biotechnological Approaches and Micropropagation in Vegetable Crops 3 (2+1)

Objective

To educate students about latest biotechnical advancements in vegetables

Theory

Concepts and applications of plant biotechnology. Introduction to recombinant DNA methods: physical, chemical and Agrobacterium mediated gene transfer methods; Transgenics and its importance in crop improvement; PCR techniques and its applications; DNA markers and their application - RFLP, RAPD, AFLP, CAPS, SSR etc. Marker Assisted Breeding in crop improvement; Biotechnology regulations. Plant Cell and Tissue Culture - organ culture, embryo culture, cell suspension culture, protoplast culture, callus culture, anther culture, pollen culture, ovule culture and their applications; Micro-propagation methods; organogenesis and embryogenesis, Synthetic seeds and their significance; Embryo rescue and its significance. Somatic hybridization and cybrids. Soma-clonal variation and its use in crop improvement. Cryo-preservation. Application of *in-vitro* techniques.

Practical

Preparation of solution, pH and buffers. Sterilization techniques. Composition of various tissue culture media and preparation of stock solutions for MS nutrient medium. Callus induction from various explants and plant regeneration. Micro-propagation, hardening and acclimatization. Demonstration on isolation of DNA and PCR technique. Demonstration of gel electrophoresis techniques and DNA finger printing.

Suggested Readings

1. Bajaj YPS (Ed.). 1987. *Biotechnology in Agriculture and Forestry. Vol. XIX*. Hitech and Micropropagation. Springer.
2. Chadha K L, Ravindran P N and Sahijram L (Eds). 2000. *Biotechnology of Horticulture and Plantation Crops*. Malhotra Publ. House.
3. Debnath M. 2005. *Tools and Techniques of Biotechnology. Pointer Publication*. New Delhi. Horticultural Sciences–Vegetable Science
4. Keshavachandran R. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. New India Publ. Agency.
5. Keshavachandran R and Peter K V. 2008. *Plant Biotechnology; Tissue Culture and Gene Transfer*. Orient and Longman, USA.
6. Keshavachandran R. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. New-India Publication Agency, New Delhi.
7. Parthasarathy V A, Bose T K, Deka P C, Das P, Mitra S K and Mohanadas S. 2001. *Biotechnology of Horticultural Crops. Vols. I-III. Naya Prokash. Pierik RLM. 1987. In-vitro Culture of Higher Plants.* Martinus Nijhoff Publ.
8. Prasad S. 1999. *Impact of Plant Biotechnology on Horticulture.* (2nd Edn.). Agro Botanica.
9. Rout G R and Peter K V. 2018. *Genetic Engineering of Horticultural Crops*. Academic Press Elsevier, USA.

10. Sharma R. 2000. *Plant Tissue Culture*. Campus Books.
11. Singh B D. 2010. *Biotechnology- Expanding Horizons*. Kalyani Publishers, New Delhi.
12. Vasil T K, Vasi M, While DNR and Bery H R. 1979. *Somatic Hybridization and Genetic Manipulation in Plants, Plant Regulation and World Agriculture*. Planum Press.

Postharvest Management of Vegetable Crops 3 (2+1)

Objective

To understand pre- and post-harvest factors responsible for deterioration in vegetable crops

Theory

Determination of maturity in different vegetable crops, assessment of post-harvest losses, pre-harvest methods and practices affecting post-harvest shelf life of vegetables, mechanized harvesting of vegetables, pre-cooling of vegetables using different techniques, post-harvest chemical and non-chemical treatments to enhance shelf life, sorting and grading for packaging, ripening of vegetables, packaging of vegetables including latest techniques like MAP, storage of vegetables including latest techniques like CA storage, food safety and quality, non-destructive methods of quality analysis, quality of raw material for processing, transportation and destination handling, marketing, treatments before shipment and storage, fresh-cut vegetables.

Practical

Practices in judging the maturity of vegetables, harvesting methods and tools. Methods used for pre-cooling and their efficiency measurements. Post-harvest chemical treatments to extend shelf life. Sorting and grading methods. Ripening techniques used in climacteric vegetables. Traditional and latest safe storage techniques. Respiration measurements in harvested produce. Field visit to post-harvest and processing industry.

Suggested Readings

1. Chadha K L and Pareek O P. 1996. *Advances in Horticulture. Vol. IV.* Malhotra Publ. House.
2. Chattopadhyay S K. 2007. *Handling, Transportation and Storage of Fruit and Vegetables*. Gene Tech Books, New Delhi.
3. Haid N F and Salunkhe S K. 1997. *Postharvest Physiology and Handling of Fruits and Vegetables*. Grenada Publ.
4. Mitra S K. 1997. Postharvest Physiology and Storage of Tropical and Sub-tropical Fruits. CABI.
5. Paliyath G, Murr DP, Handa AK and Lurie S. 2008. Postharvest Biology and Technology of Fruits, Vegetables and Flowers. Wiley-Blackwell, ISBN: 9780813804088.
6. Ranganna S. 1997. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. Tata McGraw-Hill.
7. Stawley J K. 1998. *Postharvest Physiology of Perishable Plant Products*. CBS Publishers.
8. Sudheer K P and Indira V. 2007. *Postharvest Technology of Horticultural Crops*. New India Publ. Agency.

9. Thompson A K. 2014. *Fruit and Vegetables: Harvesting, Handling and Storage (Vol. I, II)* Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.
10. Verma L R and Joshi V K. 2000. *Postharvest Technology of Fruits and Vegetables: Handling, processing, fermentation and waste management*. Indus Publishing Company, New Delhi, India. ISBN 8173871086.
11. Willis R, McGlassen W B, Graham D and Joyce D. 1998. *Postharvest: An Introduction to the Physiology and Handling of Fruits, Vegetables and Ornamentals*. CABI.
12. Wills RBH and Golding J. 2016. *Postharvest: An Introduction to the Physiology and Handling of Fruit and Vegetables.* CABI Publishing, ISBN 9781786391483.
13. Wills RBH and Golding J. 2017. *Advances in Postharvest Fruit and Vegetable Technology*, CRC Press, ISBN 9781138894051

Protected Cultivation of Vegetable Crops 2 (1+1)

Objective

To provide technical know-how to students for raising vegetables under protected structures

Theory

Protected cultivation- importance, scope and constraints, status of protected cultivation in India and world. Soil/substrate preparation and management. Classification and types of protected structures. Irrigation and fertigation management. Propagation and production of quality planting material of horticultural crops. Greenhouse cultivation of important horticultural crops viz., tomato, bell pepper, cucumber, lettuce, brinjal. Off season production of vegetables. Hydroponics, aeroponics system of cultivation, Insect pest and disease management. Use of protected structures for seed production; Economics of greenhouse crop production

Practical

Identification of different protected structures, Use of pro-trays in quality planting material production, Identification of different growing media/ substrates, Raising of seedlings and saplings under protected cultivation, Bed preparation, planting and intercultural operations for crop production, Estimation and management of soil EC, Estimation and management of pH in media/ substrates, Scheduling of irrigation in different horticultural crops, Fertilizer management through drip irrigation, Control of disease and insect pests in protected structures, fumigation techniques. Visit to commercial protected cultivation units.

Suggested Readings

1. Chandra S and Som V. 2000. *Cultivating Vegetables in Green House*. Indian Horticulture 45:17-18.
2. Parvatha RP. 2016. *Sustainable Crop Protection under Protected Cultivation*. E-Book Springer. Prasad S and Kumar U. 2005. *Greenhouse Management for Horticultural Crops*. (2nd Edn.). A Grobios.
3. Singh B. 2005. *Protected Cultivation of Vegetable Crops*. Kalyani publishers, New Delhi.
4. Singh D K and Peter K V. 2014. *Protected Cultivation of Horticultural Crops* (1st Edn.). New India Publishing Agency, New Delhi.

5. Singh S, Singh B and Sabir N. 2014. *Advances in Protected Cultivation*. New India Publishing Agency, New Delhi.
6. Tiwari G N. 2003. *Green house Technology for Controlled Environment*. Narosa Publ. House.

C. Floriculture and Landscaping

Note: ***The University/ Institute may offer more electives/courses relevant to the subjects.***

Turf Management 2 (1+1)

Objectives

1. To impart hands-on training on practical aspects of turf management practices
2. To impart entrepreneurial skills in turf establishment

Theory

History, present status and prospects of turf industry; basic requirements, site selection and evaluation, concepts of quality of soil pertaining to turf grass establishment, criteria for evaluation of turf quality. Types, species, varieties, important breeders, grasses for different locations and conditions and their compatible groupings as per climatic conditions; Turfing for roof gardens. Turf establishment methods such as seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, instant turfing (portable), hydro-seeding, Turf management – Irrigation, drainage, nutrition, special practices like aerating, rolling, coring, dethatching, verti-cutting, soil topdressing, use of plant growth regulators and micronutrients, Turf mowing – mowing equipment, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs, standards for turf, use of recycled water etc., Making of different sports arenas: Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, residential and public parks, turfing of Govt. and Corporate office gardens, turf colourants.

Practical

Identification of turf grasses and turf machinery, Soil preparation, turf establishment methods, provision of drainage, Layout of macro and micro irrigation systems, Water and nutrient management, Special practices – mowing, raking, rolling, soil top dressing, weed management, Biotic and abiotic stress management, Project preparation for turf establishment, Visit to parks and golf courses, corporate, Govt. organizations, Rejuvenation of lawns, Turf economics.

Suggested Readings

1. Jankiram T, Namita and Jain Ritu. 2015. Introduction to Turfgrasses. (1st Edn.). Westville Publishing House.
2. Nick E. 2016. Christians Fundamentals of Turfgrass Management. (5th Edn.) Aaron J. Patton, Quincy D. Law. Wiley
3. Tiwari A K, Singh, K P, Shephalika Amrapali, Girish, K S and Singh Premjit. 2015. *Lawn Management*. ICAR-Directorate of Floricultural Research, Pune-411005 (Maharashtra), India 1-48.

Protected Cultivation of Flower Crops 3 (2+1)

Objectives

i. To enable regulation of flowering under protected cultivation

ii. To impart skills in formulating the project on protected cultivation of flower crops

Theory

Prospects and types of protected structures: Prospects of protected floriculture in India; Types of protected structures – Glasshouse/polyhouse, shade net houses, mist chambers, lath houses, orchidarium, fernery, rain shelters etc. Principles of designing and erection of protected structures; Low cost/Medium cost/High-cost structures; Structural components; Suitable flower and foliage plants for protected cultivation. Microclimate management and manipulation of temperature, light, humidity, air and CO_2; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation, containers and substrates, media, soil decontamination, layout of drip and fertigation system, water and nutrient management, IPM and IDM, Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation. Automation in greenhouses, sensors, solar greenhouses and retractable greenhouses, Export standards, MDH guidelines for erection of protected structure, APEDA regulations for export. Crops: Rose, Chrysanthemum, Carnation, Gerbera, Orchids, Anthuriums, Lilium, Alstromeria, etc.

Practical

Study of various protected structures, Design, layout and erection of different types of structures, Practices in preparatory operations, growing media, soil decontamination techniques, Microclimate management, Practices in drip and fertigation techniques, special horticultural practices, Determination of harvest indices and harvesting methods, Postharvest handling, packing methods, Economics of cultivation, Project preparation, Project Financing guidelines, Visit to commercial greenhouses.

Suggested Readings

1. Tyagi S and Sahay S 2020. *Protected Cultivation of Flowers.* NIPA, New Delhi.
2. Singh Mahesh Chand and Sharma, K K. 2024. *Protected Cultivation: Structural Design, Crop Management, Modelling and Automation.* CRC Press.

Value Addition in Floriculture 3 (2+1)

Objectives

i. To study different methods of value addition like drying, flower arrangements, oil extraction, etc.

ii. To prepare value added products from flower crops

Theory

Scope and prospects of value addition, Types of value-added products, techniques of value addition including tinting. Value addition in loose flowers and product development- Gulkhand,

floral tea, rose oil, rose water, Pankhuri, floral dyes, rose sherbet, floral ice creams, sweets, etc. Flower arrangement, styles, ikebana schools (ikenobo, ohara, sogetsu etc), Ikebana- moribana, nagiere, contemporary style. Dry flowers– Identification and selection of flowers and plant parts; tips for collecting dry flower making, selection of stages for picking of flowers for drying, Techniques in dry flower making – Drying, glycerising, bleaching, dyeing, embedding, pressing; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; petal embedded handmade papers. Post drying management including moisture, pests and molds. Essential oils; Selection of species and varieties (including nonconventional species), extraction methods, Packing and storage, Aromatherapy. Types of pigments, carotenoids, anthocyanins, chlorophyll, betalains; Significance of natural pigments as nutraceuticals, Extraction methods and applications in food, pharmaceutical and poultry industries. Synthetic and Natural dyes, dying techniques, colour retention.

Practical

Practices in preparation of different type of flower arrangements including bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands with fresh flowers, Techniques in flower arrangement and floral decoration, Identification of plants for dry flower making, Practices in dry flower making; Preparation of dry flower baskets, bouquets, potpourri, wall hangings, button holes, greeting cards, wreaths, etc. Essential oil extraction units, Extraction of pigments, Visit to dry flower units, Economics of value-added products.

Suggested Readings

1. De L C. 2019. *Value Addition in Flowers and Orchids*. New India Publishing Agency.
2. Gupta Sachi, Pathak Sanjay and Yadav Atul. 2019. *Advances and Value Addition in Flower Crops.* Weser Books.

Breeding of Ornamental Crops 3 (2+1)

Objectives

i. To teach the students crop specific breeding
ii. To teach the students about the varieties evolved in flower crops through various methods and institutions

Theory

Origin, evolution, distribution, introduction, domestication and conservation of ornamental crops. Unit II: Introduction and initiatives in IPR and PBR of ornamental crops. Breeding objectives, reproductive barriers (Male sterility, incompatibility) in major ornamental crops. Inheritance of important traits, Genetic mechanisms associated with flower colour, size, form, doubleness, fragrance, plant architecture, post-harvest life, abiotic and biotic stress tolerance/ resistance. Breeding methods suitable for sexually, asexually propagated flower crops, self- and cross- pollinated crops- pedigree selection, backcross, clonal selection, polyploidy and mutation breeding, heterosis and F1 hybrids. Role of biotechnology in improvement of flower crops including somaclonal variation, in vitro mutagenesis, genetic engineering, molecular markers etc., Crops- rose, chrysanthemum, carnation, gerbera, gladiolus, orchids, anthurium, lilium, marigold, jasmine, tuberose, dahlia,

gaillardia, crossandra, aster etc., Flowering annuals: petunia, zinnia, snapdragon, stock, pansy, calendula, balsam, dianthus etc. Important ornamental crops like aglaonema, diffenbachia, hibiscus, bougainvillea, tecoma, kalanchoe etc.

Practical

Floral biology of important ornamental crops, Cytology and cytogenetics. Selfing and crossing procedures for important ornamental crops. Evaluation of hybrid progenies. Induction of mutants through physical and chemical mutagens. *In vitro* selection, genetic engineering. Induction of polyploidy. DUS testing.

Suggested Readings

1. De L C. 2019. *Ornamental Crop Breeding.* Aavishkar Publishers and Distributors, Jaipur, Rajasthan.
2. Singh B D. 2006. *Plant Breeding: Principles and Methods*. Kalyani Publishers, New Delhi.

Principles of Landscape Architecture 3 (1+2)

Objectives

i. To familiarize students with basics of Auto-CAD software
ii. To impart skills in preparation of garden designs

Theory

Historical Importance of Indian gardens, Gardens of ancient world, Definitions, Famous gardens of India and abroad, formal, informal, free style and wild gardens, basic themes of gardens viz. circular, rectangular and diagonal themes, Steps in preparation of garden design. Use of Auto CAD in designing gardens. Factors affecting landscape design viz. initial approach, view, human choice, simplicity, topography etc., Principles of Landscape gardens viz. Axis, rhythm, balance, texture, form, mass effect, focal point, mobility, emphasis, unity and harmony etc. Elements of landscape gardens. Bio-aesthetic planning, definition, objectives, Planning and designing of home gardens, colonies, countryside planning, urban landscape, Development of institutional gardens, planning and planting of avenues, beautifying schools, railway stations, factories, bus stands, air ports corporate buildings, river banks, play grounds.

Practical

Study of gardens, tools and implements. Use of drawing equipment, graphic symbols and notations in landscaping designing, Study and designing of different styles of gardens, Study and designing of gardens based on different themes, Designing gardens using Auto-cad, Designing gardens for home, traffic islands, schools and colleges, public buildings, factories, railway stations, air ports, religious places, play grounds, corporate buildings/ malls. Designing and planting of avenues for state and National highways, Design and establishment of Japanese, English and Mughal gardens. Visit to public, institutional and botanical gardens.

Suggested Readings

1. Arora J S. 2010. *Introductory Ornamental Horticulture*. (6th Edn.). Kalyani Publishers. 230p.
2. Randhawa G S and Mukhopadhyay A. 2001. *Floriculture in India*. Allied Publishers. 660p.

Commercial Floriculture and Landscaping 3 (2+1)

Objectives

i. To learn about production technology, propagation, and cultural practices and packaging and marketing of various flower crops
ii. To learn generating the planting material and their practical use in different landscaping projects

Theory

Scope, importance and export potential of floriculture, environment factors influencing plant growth and flower production in cut flowers and cut greens. Production technology including varieties, propagation, soil, nutrition, disease and pests of important cut flowers. Post harvest handling, grading and packing cut flowers, pot and bedding plants. Flower seed production. Cost of production of commercially important flowers. History of gardening, characteristics of Hindu, Mughal, Japanese and English gardens. Principle groups of plants like trees, shrubs, climbers, shade loving plants, ground covers, their analysis and use in landscape composition. Principles of art and landscaping. Preparation of landscape plans for homes, farm complexes, small parks and institutions. Development and maintenance of rock, water and terrace gardens. Bonsai and dish gardens, project formulation and evaluation.

Practical

Preparation of plans and laying out of gardens. Identification of planting material and commercial varieties of flowers. Seed collection, germination tests and storage. Harvesting and handling of cut flowers. Judging of flowers and pot plants. Visit to local nurseries and florist centers.

Suggested Readings

1. Arora, J.S. 2010. *Introductory Ornamental Horticulture*. Kalyani Publishers. (6th Edn.). 230p.
2. Randhawa, G. S. and Mukhopadhyay, A. 2001. *Floriculture in India*. Allied Publishers. 660p.

Postharvest Handling of Floriculture crops 3 (2+1)

Objectives

i. To teach the students about various factors leading to postharvest losses in flowers
ii. To acquaint the students about various technologies (like conditioning, grading, storage, packaging etc) used in postharvest management of flowers
iii. To provide hand on training to students for postharvest handling of commercial flowers

Theory

Importance of Postharvest Technology in Floricultural crops, Physiology of flowering in relation to photoperiodism, temperature and other environmental factor. Structural, biochemical,

metabolic and hormonal changes during flower senescence. Factors affecting postharvest quality of flowers- pre harvest, harvest and postharvest. Causes of decline in post-harvest life of flowers. Floral preservatives - holding, pulsing and budding. Plant hormones and their role in postharvest management of flowers. Storage, its types and factors affecting storage. Grading of different flowers. Packaging – passive and active. Importance of cool chain in transportation of cut flowers. Physiological disorders of flowers. Latest approaches to improve postharvest life of flowers. Postharvest handling of commercial flowers- Rose, Chrysanthemum, Gladiolus, Lilium Tuberose and marigold.

Practical

Photoperiodism and vernalization in flowering. Membrane integrity and water relation during senescence. Harvest and postharvest factors affecting postharvest quality of flowers. Preparations of different solutions. Holding and pulsing solutions. Wet and dry storage. Grading of flowers. Types of packaging. Physiological disorders of flowers and their remedial measures. Postharvest handling of commercial flowers- Rose, Chrysanthemum, Gladiolus, Lilium Tuberose and marigold.

Suggested Readings

1. Bhattacharjee S K and De L C. 2004. *Advances in Ornamental Horticulture. Vol. V*. Pointer Publishers, Jaipur.
2. Bose T K and Yadav L P. 1989. *Commercial Flowers*. Naya Prokash, Kolkata.
3. Bose T K, Maiti R G, Dhua, R S and Das P. 1999. *Floriculture and Landscaping*. Naya Prokash.
4. Larson, RA and Armitage A M. 1992. *Introduction of Floriculture.* International Book Distributing Co., Lucknow, India.
5. Nowak, J and Rudnicki, R M. 1990. *Postharvest Handling and Storage of Cut Flowers, Florist Greens, and Potted Plants*. Timber Press, USA. 210p.

Semester VIII

SKILL ENHANCEMENT COURSES (SEC)

S. No.	Course Title	Credit Hours
	First Year	
SEC-I (any of two courses can be selected)		
1.	Mushroom Cultivation	2 (0+2)
2.	Apiculture	2 (0+2)
3.	Orchard Floor Management	2 (0+2)
4.	Landscape Gardening	2 (0+2)
SEC- II (any of two courses can be selected)		
5.	Packing and Packaging of Horticulture Crops	2 (0+2)
6.	Farm Machinery	2 (0+2)
7.	Introduction to Forestry	2 (0+2)
8.	Installation, Operation and Maintenance of Micro-irrigation System	2 (0+2)

S. No.	Course Title	Credit Hours
	Second Year	
SEC- III (any of one course can be selected)		
9.	Computer Programming and Data Structures	2 (0+2)
10.	Turf and Turf Management	2 (0+2)
11.	Post-harvest management of Horticulture Produce	2 (0+2)
SEC- IV (any of one course can be selected)		
12.	Nursery Production in Horticulture Crops	2 (0+2)
13.	Seed Production techniques in Vegetable Crops	2 (0+2)
14.	Sericulture	2 (0+2)

1. Mushroom Cultivation (0+2)

Current status and scope of mushroom cultivation in India and Punjab, Important features of edible fungi, Nutritional and medicinal value of mushrooms, Preparation of media, Tissue culture preparation, Sub-culturing for culture maintenance and its preservation, Spawn preparation techniques, Collection of wild mushroom flora, Raw material formulations for Agaricus bisporus (button mushroom), Composting (long method and short method), Casing preparation, Crop management practices, Mushroom farm design and infrastructure required for commercial unit, Cultivation techniques of *Pleurotus florida* (dhingri), *Lentunus edodes* (shiitake), *Calocybe indica* (milky) and *Volvoriella volvacea* (paddy straw) mushrooms, Marketing of mushrooms, Mushroom diseases and their control, Preparation of value added products from mushrooms, Economics of mushrooms, Exposure visit to commercial farms.

2. Apiculture (0+2)

Identification of honeybee species and castes. Hive and other apicultural appliances. Examination of honeybee colonies. Recording of colony performance. Bee pasturage. Migratory routes and migration of colonies. Seasonal management of honeybee colonies. Selection of honeybee colonies for improving bee health and colony productivity. Mass queen bee rearing techniques. Identification of bee enemies and diseases and their management. Foraging and communication behaviour in honeybees. Honey extraction, processing and packaging. Collection of other hive products.

3. Orchard Floor Management (0+2)

Layout of different systems of orchards and Fruit Nutrition Garden. Soil management practices: clean cultivation, sod culture, sod mulch, intercropping, cover cropping and mixed cropping. Use of mulch materials: organic and inorganic, moisture conservation and weed control. Layout of various irrigation systems, surface irrigation: Flood system, basin system, modified basin system, furrow method, sub-surface irrigation systems: drip irrigation and its components, overhead irrigation: sprinkler system, fertigation, Different methods of application of manure and fertilizers, use of organic manures, Biofertilizers, Green manuring and bio-agents. Visit to orchards of Progressive fruit growers.

4. Landscape Gardening (0+2)

Identification and use of garden tools and equipment. Study of growth characters, identification and classification of ornamental trees, shrubs, climbers, ground covers and indoor plants. Making and maintenance of edge, hedge and topiary. Establishment and maintenance of a lawn. Bonsai making. Art principles of landscaping. Formal and informal gardens. Planning, designing and establishment of garden features. Landscape design process: Landscape drafting tools. Dimensioning, graphic symbols and notations. Site analysis and landscape designing of residential, public buildings and religious places. Landscape planning of roads and roundabouts. Visit to community parks and Institutional gardens.

5. Packing and Packaging of Horticulture crops (0+2)

Different packaging and cushioning materials used for horticultural produce. Packaging technology for retail marketing- vacuum, shrink wrap, cling pack. Concept of active and passive packaging. Important physical parameters of different packaging materials. Determination of gas permeability and water vapour permeability of packaging materials. Designing of retail packaging boxes. Different type of damages occurring in horticultural crops during transportation. Packaging technology for domestic and export of commercial horticultural crops. Controlled and modified atmospheric packaging for shelf-life enhancement. Visit to commercial pack house. Visit to fruits and vegetables market.

6. Farm Machinery (0+2)

Familiarization with different makes and models of agricultural tractors. Identification of various functional systems including air supply, fuel, cooling, transmission, steering and hydraulic systems. Maintenance points to be checked before starting a tractor. Familiarization with controls on a tractor. Safety rules and precautions to be observed while driving a tractor. Practice of driving a tractor and with tillage tools (Primary/Secondary tillage implements) and their adjustment in the field. Field patterns while operating a tillage implement. Hitching and de-hitching of mounted and trailed type implements to the tractor. Practice for driving of a trailed type of trolley: forward and in reverse direction. Familiarization with different types of sprayers. Operation of tractor operated boom and orchard sprayers. Calibration of a sprayer. Nozzle spacing on a boom, pressure setting of a nozzle. Use of Pick Positioner. Use of drones for spraying. Familiarization with tractor operated tree pruners.

7. Introduction to Forestry (0+2)

Identification of important farm grown trees, tree seeds and seedlings. Site selection for tree nursery and layout of nursery. Propagation methods, plantation establishment, plantation management, pest and diseases management and harvesting for various wood-based industries. Height measurement, diameter measurement and Volume estimation in trees - Identification of wood and non - wood forest products - Visit to Agroforestry plantations. Visit to Pulp and Paper, Matchwood, Energy, plywood industries to study the production, processing and marketing.

8. Installation, Operation and Maintenance of Micro-Irrigation System (0+2)

Micro-irrigation system installation: installation of filters and fertigation equipment, installation of main and sub mains, laying of laterals, punching of laterals, and fixing of emitters, operation of micro-irrigation systems(drip/sprinkler). Maintenance of micro-irrigation system: filter cleaning, maintenance of fertigation equipment, chemical treatment, sub-main and lateral/ bi-wall flushing. Introduction to automated irrigation system in open field and greenhouse- sensors for soil moisture, temperature, light control devices, timing devices, fertigation systems, solenoid

devices, remote controlled valves system.

9. Computer Programming and Data Structures (0+2)

Introduction to high level languages; structure programming, C programming, a simple C programming, execution of a 'C' program, program and instruction; Familiarizing with Turbo C IDE; Building an executable version of C program; Study of different operators such as arithmetic, relational, logical, assignment, increment and decrement, conditional, bitwise and special operators, precedence of arithmetic operators; Debugging a C program; Developing and executing simple programs; Creating programs using decision making statements such as if, go to and switch; Developing program using loop statements while, do and for; Using nested control structures; Familiarizing with one and two dimensional arrays; Using string functions; Creating user defined functions; Developing structures and union; Using local, global and external variables; Using pointers; Developing linked lists in C language; Inserting an item in Linked List; Deleting an item in Linked List; Implementing Stacks; Implementing push/pop functions; Creating queues, Insertion/ Deletion in queues.

10. Turf and Turf Management (0+2)

Site analysis for turf establishment. Field preparation and layout for turf making. Identification and classification of turf grasses. Turf establishment methods. Sod production. Turf irrigation management. Nutrient management in turf grasses. Special practices in turf management. Rejuvenation of old and withered turf. Equipment for turf management. Selection and maintenance of grasses for Golf course and Cricket ground. Turfing for roof top gardens. Applications and use of Turf growth regulators (TGRs). Identification of seasonal turf grass weeds. Integrated approaches for turf weed management. Identification and management of Turfgrass diseases, insect-pests, abiotic stress disorders and nutrient deficiencies.

11. Post-harvest management of Horticulture Produce (0+2)

Layout and planning of postharvest experiments, Maturity and harvesting of horticulture produce. Judging maturity by different methods. Harvesting tools. Objective measurement of colour, texture and dry matter. Components and equipment used in Postharvest laboratory, Different types of cleaning agents and washing methods for horticultural produce. Layout of packhouse and General packhouse operation. Sorting, surface sanitizing and drying of fruit. Postharvest treatments for shelf-life extension of fruits and vegetables. Packing of fruits in different packaging materials, preparation of different coating materials and their method of applications. Pre-cooling of horticultural produce. Ripening technology for horticultural crops. Significance of sorting and grading in horticulture produce: Types of grading system and standards. Cold-chain management. Storage requirements. Commercial technologies for processing of horticultural produce.

12. Nursery Production in Horticulture crops (0+2)

Layout of model nursery, Tools and equipment-identification and application. Different methods of breaking seed dormancy stratification, scarification and use of plant growth regulators. Extraction and storage of healthy seeds, seed bed preparation, Identification and raising of rootstocks for different fruit plants, soil solarization, preparation of potting mixtures. Selection of healthy scion wood, practices in different methods of plant propagation like cutting, layering, budding and grafting in fruit plants. Micropropagation-explant preparation, media preparation, culturing–meristem tip culture, axillary bud culture, micro-grafting and hardening of plants. Nursery management practices

i.e. weed control, irrigation, nutrition, removal of sprouts etc. Protection of nursery plants against adverse climatic conditions. Protected structures. Diagnosis and control of important diseases and pests in the nursery, lifting and packing of nursery plants, Visit to commercial tissue culture laboratories and accredited nurseries.

13. Seed Production techniques in Vegetable crops (0+2)

Vegetable seed industry in India, Floral biology, pollination and breeding behaviour of important vegetable crops, Categories of seeds and their maintenance, Characteristics of quality seed, Agronomical principles and methods of seed production in important vegetable crops, Use of growth regulators and chemicals in vegetable seed production, Methods of hybrid seed production, Seed harvesting, extraction, curing, drying, grading, packaging and storage, Seed sampling and seed testing (genetic purity, seed viability, seedling vigour, germination, physical purity), Visit to seed processing units, seed testing laboratory and seed production farms.

14. Sericulture (0+2)

Mulberry varieties, Host plants of non-mulberry silkworms, Preparation of land, planting material and planting of mulberry, Pruning, harvesting and storage of mulberry, Mulberry pests and diseases, Identification of cocoons of important breeds, External morphology of life stages egg, larva, pupa and moth of *Bombyx mori* L. Study of silk glands and digestive system of *Bombyx mori* L. Disinfectants- rearing bed and general disinfectants, Grainage techniques. Study of rearing house plan and equipment's for shoot feeding and shelf rearing. Methods of Incubation of silkworm eggs and brushing. Identification of silkworm settling for moult, at moult, out of moult, Feeding, bed cleaning and spacing, Identification and picking of ripe silkworms, mounting, types of mountages, cocoon harvesting and grading, Pests and diseases of mulberry silkworm, Single cocoon reeling, study of reeling equipment.

ONLINE COURSES

- The students will choose 10 credit online (as per UGC guidelines for online courses) as a partial requirement for the for the B. Sc (Hons) Horticulture degree program. These can be taken any time during the whole span of the degree program as per choice of students.
- The online courses can be from any field such as Horticulture, Basic Sciences, Humanities, Economics, Business Management, Languages including foreign language, Communication Skills/ Music, etc. and can be taken from NPTEL, mooKIT, edX, Coursera, SWAYAM or any other portal.
- The objective is to allow the students to groom their passion or strengthen their knowledge and competency in any field beyond prescribed courses.
- The courses will be non-gradial as separate certificates would be issued by institutes offering the courses.
- The MOOC courses taken by the student will be separately registered/ approved at the University level.
- The University/ institute will keep a record of such courses registered and completed by each student and will indicate the title of the (satisfactorily completed) courses in final transcript issued to the student.

Minimum Standards for Establishing a College of Horticulture

- **Degree Nomenclature:** B. Sc. (Hons.) Horticulture

1. Minimum intake (per year): 120

2. Faculty: A. Core faculty: 27

Fruit Science (0+1+3), Vegetable Science (0+1+3), Floriculture and Landscape Architecture (0+1+2), Post Harvest Technology (0+1+2),Plant Protection (0+1+2), Basic Sciences (0+1+2), Natural Resources Management(0+1+3), Social Sciences (0+1+2)

B. Allied faculty: Faculties for Mathematics, computer science, Sociology, Psychology, English, Food Science and Technology, Microbiology, Agrometerology and other supporting subjects, if any, shall be adjusted from other colleges, Guest faculty, adjunct faculty and part time faculty.

3. Land requirement (ha): 15

4. Essential Instructional units:

- Horticultural crop museum- 1 ha
- Botanical garden (Germplasm centre/ Mother plant)- 1 ha
- Nursery- (2) / Polyhouses(6) / shadehouses(6) / Glass houses(2) / Potting shade (2) / Scion bank (1) / Root stock block (1)
- Orchards (Important crops)- 6 ha
- Farm office unit- 1 ha
- Laboratories and instructional facilities as per V Deans' Committee report.
- ELP units to be established under skill development or Entrepreneurial mode- 0.5 ha

5. Divisons/Departments/Sections:

- Fruit Science
- Vegetable Science
- Floriculture and Landscape Architecture
- Postharvest Technology
- Plant protection
- Basic Sciences
- Natural Resource Management
- Social Science

6. Non-Teaching Staff:

S. No.	Non-teaching staff	Required
a)	Assistant Registrar/Administrative Officer	01
b)	Superintendent (Administration)	01
c)	Assistant Comptroller	01

d)	Assistant Engineer (Civil)	01
e)	Assistant Medical Officer	01
f)	Junior Engineer (Electrical)	01
g)	Lab Technician	01
h)	Library Assistant	02
i)	Lab Assistant	08
j)	Field assistant	08
k)	Shelf assistant	02
l)	Assistant-cum-Computer Operator	06
m)	Driver	06
n)	Tractor Driver	02
o)	Cook	04
p)	Care taker	03
q)	Plumber	01
r)	Electrician	01
s)	Bus helper	02
t)	Sports helper	02
u)	Gardener	06
v)	Janitor	02
w)	Office Attender	06
x)	Watchman	06
y)	Nurse (Female + Male)	02
	Total	**76**

7. Floor Space Civil StructuresCollege Main Building

S. No.	Details	No. of rooms	Dimensions (ft)
1.	UG Class Rooms	05	70 students seating capacity
2.	PG Class Rooms	12	30 seating capacity
	UG Labs	08	50 capacity with HOD and faculty chambersand store room attached
3.	PG Labs	12	25 capacity/separate lab/department where PG programme offered)
4.	Seminar Hall	01	150 seating capacity
5.	Examination Hall	01	150 seating capacity
6.	Computer Laboratory	02	50 seating capacity (UG) + 25 capacity for (PG)

7.	Central Instrumentation room	01	40 × 40
		(only for PG)	
8.	Dean's Room and Office	02	20 × 24
9.	PA's room	20 × 12	
10.	Mini Meeting Room	01	20 × 48(attached to Dean Chamber)
11.	Academic Unit	01	20 × 12
12.	Administration Unit	01	20 × 12
13.	Accounts unit	01	20 × 12
14.	External Examination Unit	01	20 × 12
15.	Student Welfare Unit	01	20 × 12
16.	Days scholar lounge	02	1 for Boys and 1 for Girls
17.	Placement / Counselling cell	01	20 × 12
18.	Language Lab	01	20 × 20
19.	General Store	01	20 × 12
20.	Postharvest Technology Pilot plant	01	separate building shed for processing, value addition, packaging and dispatch

Library

S. No.	Details	No. of Rooms
1.	Staff room (Assistant Librarian)	01
2.	Stack room (borrowing)	01
3.	Reference Hall / Journal section	01
4.	Book bank	01
5.	E-resource Centre	01
6.	Photo-copying room	01
7.	Reading Hall for students	01
8.	Reading Hall for Staff - (Small)	01
9.	**Auditorium**	01(optional 400 - 500 capacity)

Hostels and Guest House

UG Boys Hostel - 01: (150 capacity, 3 students per room) (Min. room size of 5m × 4m)

UG Girls Hostel - 01: (150 capacity, 3 students per room) (Min. room size of 5m × 4m)

PG Boys Hostel - 01: (50 capacity, Single bed) (Min. room size of 3m × 4m)

PG Girls Hostel - 01: (50 capacity, Single bed) (Min. room size of 3m × 4m)

International hostel - 01: (25 capacity, single bed room 25 for Ph.D. with Kitchen and Wash room attached) (Min. room size of 5m × 4m)

Vehicle parking sheds – 02: (Two wheeler) one each attached to Boys & Girls hostel

Farm / Orchard office

a. Farm Manager Office
b. Seed processing + Storage unit
c. Farm store
d. Threshing yard
e. Workers rest shed
f. Maintenance cell / Estate Branch
g. Implement Shed
h. Tractor Shed
i. Meteorological unit
j. Farm fencing

Vehicle parking shed (four & two wheeler + 2 buses)Generator Shed / Battery Room

Guest Houses: 01 (10 VIP Suits + 20 Double bed rooms)

Farmers Training hostel (Men): 20 rooms with five beds each & attached bath room

Farm Women Hostel: 20 rooms with five beds each & attached bath room

Sports & Welfare

1.	Four hundred meters track with pavilion & Gallery	– 01
2.	Courts - Volley ball	- 02
	Basket ball	- 02
	Kabbadi	- 01
	Kho-Kho	- 01
	Tennis	- 01
3.	Indoor games facilities	
	Table tennis	- 02 (each for boys and girls hostel)
	Shuttle badminton	- 02 (each for boys and girls hostel)
	Gymnasium	- 02 (each for boys and girls hostel)
4.	Canteen	- 02 (Staff + student)
5.	Dispensary (10 beds)	- 01
6.	Stationery & Xerox point	-01
7.	Bank & ATM	- 01
8.	Other utilities unit	- 04 to 06
Research-cum-Instructional Farm		
(Total area 40 ha/100 acres for UG additional 20 ha/50 acres for PG)		
1.	Crop Museum	- Tech Demo Plot unit
2.	Botanical Garden	- 04 ha (Germplasm Centre cum Mother plant block)

3.	Nursery	- Polyhouses (6), shade houses (6), Glass house (2), Potting shed (2), Scion banks of important crops (1),Root stock block (1)
4.	Structures of	- Naturally ventilated - single span, multi span, medium, cost, various types high cost, and climate control structure with fan and pad system.
5.	Bio-agents production units	- 02
6.	IFS model	- 01
7.	Experiential Learning Modules	- 04
8.	Composting unit and vermicomposting	- 04
Irrigation, Water harvesting facilities		
1.	Bore wells / Lift Irrigation / Water treatment plant	
2.	Farm pond and watershed unit/ Heavy duty system RO & storage units – 02	
3.	Over head tank	
4.	Ground water sump	
5.	Irrigation network to farm	
6.	Roof water harvesting facility and collection pond/tank	
7.	Spent water treatment units, incinerator	
8.	Hydrological field lab	
9.	Drip/Sprinkler irrigation system	

Farm Machinery

1.	Tractors	
2.	Tractor drawn water tank, trailer and other	- 02
	tractor bound land preparation, spraying, harvesting, Equipment, with a workshop	- 01 Set
3.	Power tiller	- 02
4.	Mini Tractor	- 01
5.	Power shears	- 02
6.	Weed cutter	- 01
7.	Laser leveler	- 01
Mobility		
8.	Bus (60 seater)	- 01
9.	Minibus (40 seater)	- 01
10.	Car	- 01
11.	Jeep	- 01
12.	Multipurpose utility van	- 01
13.	Motor Cycle	- 02

8. Laboratory Equipment

a) Equipment for UG laboratory

S. No.	Particulars	Quantity
1.	Weigh balance (0.001g)	8
2.	Weigh balance (0.01g)	8
3.	Weigh balance (0.1g)	8
4.	Weigh balance (60g)	2
5.	Single distillation unit	6
6.	pH meter	8
7.	EC Bridge	8
8.	Digital refractrometer	3
9.	Digital varnier calipers	2
10.	Compound microscope	25
11.	Hot air over	10
12.	Magnetic stirrer (liter)	8
13.	Micro oven (25 lt)	8
14.	Refrigerator (320 lt)	8
15.	Water bath with shaker (20 lt)	8
16.	Power pack - small	2
17.	Horizontal gel unit – medium	2
18.	Digital thermometer and hygrometer	8
19.	Liquid nitrogen container – 7 lt	4
20.	Air conditioner – 2 tone	8
21.	Online UPS – 10 volts	8
22.	Digital camera – 14m pix	8
23.	vortex	8
24.	Hot plate – 5 lt	8
25.	Seed analyzer	1
26.	Seed coating machine	1
	Total	**178**

b) Equipments for centralized laboratory

S. No.	Particulars	Quantity
1.	Seed germinator	2
2.	Electrical conductivity	1
3.	Double distillation unit	5
4.	Lab microscope	3
5.	Stereo zoom microscope	2

6.	Fluorescent microscope	1
7.	Orbital shatter (8500ml conical flask cap)	4
8.	UV vis spectrophotometer	2
9.	Refrigerated centrifuge	2
10.	Microtome	1
11.	Vertical gel unit (dual unit max)	3
12.	Micro pipette (10 1, 100 1, 1000 1, 5000 1)	3
13.	BOD incubators	4
14.	Laminar air flow chamber	2
15.	Deep freezer vertical (-20°C, 275 lt)	4
16.	Autoclave (vertical) 250 lt	3
17.	Nitrogen distillation unit	2
18.	Fib estimation unit	2
19.	Flame ohoto meter	2
20.	Ultra pure water purification system	2
21.	Thermocycler unit	2
22.	Gel documentation unit	2
23.	Air conditioner – 2 ton	3
24.	Online UPS – 10 volts	2
25.	Growth chamber	2
26.	SPAD	2
27.	Chromatographic system (TLC HPLC)	1
28.	Colour meter	1
29.	Texture analyzer	1
30.	Company analyzer	1
31.	Leaf area meter	1
32.	AAS	1
33.	Cultured trollies – 4	4
34.	Visco meter	1
35.	Cold store cum ripening chamber	1
36.	Water activity meter	1
	Total	**76**

c) Laboratory equipment required for PG

Equipment	Quantity
Magnetic stirrer	9
Vernier caliper (digital)	10
Refractometers (digital)	4

Pressure testers	4
Top pan balance	10
Humidifier	2
Plant press	8
Altimeter	4
Lux meter	4
Thermo hydrographs	8
Seed drier	2
Bee hives	20
Honey extractor with wax meter	2
Microscope with computer attachment	1
Tensio meter with digital sensors	24
Soil thermometers	24
Suction pump	2
Soil testing units	3
Oil extraction operators	2
Leaf scan meter	1
Root length scanner	1
Silva compass	2
Clinometer	2
Range finder	1
Fillescope	2.0
Digital planni meters	2
Increment stem boner – 12", 16", 20" and 25"	24
High limb chain saw	4
Wheeler penda	1
Abney's level	2
Wood moisture meter	1
Hot and cold press	1
Strength testing apparatus	1
Wood working machine	1
Wood grinder	1
Boiler	1
Hedge cutter	4
Gas liquid chrometaography	1
CO2 analyzer	1
Canopy analizer	1
Ultra centrifuge	1
Soil moisture pans	2

Cold rooms	2
Air curtain door	1
Aluminum calipers	10
Brine meter	1
Brine hydrometer	1
Digital seed hunter	2
Digital pycnometer	1
Digital immerse tester/penetrometer	1
Cushocton silt sampler	1
GPS	1
Leet converter	5
Hygrometer	1
Infra red thermometer	1
Moisture meter	1
Ozone generator	1
Psychrometer	1
Soil colour charts	2
Seed combined	5
Soxhlet apparatus	2
Surfuzing equipment	1
Viscocity meter	1
Turbidity meter	1
Water bath	3
Willing mill	2
Wind tunnel	1
Bomb calorimeter	1
Chlorophyll meter	1
Cobous meter	1
Work station	1
Total	**263**

d) Equipment for postharvest management lab

S. No.	Equipment	Quantity
1.	Walk in cool chamber	01
2.	Grading and packaging unit including shrink and vacuum packaging machine	-
3.	Bunch cutting machine / fruit harvesters	-
4.	Hydraulic fruit harvester	1
5.	Bunch tying machine	1

6.	Bundling machine for bunching	1
7.	Heat sealing machine	1
8.	Strapping machine for cartons	1
9.	Turgidity machine	1
10.	Refrigerated van	1
11.	Ripening chamber	1
12.	Conditioning godown	1
13.	Pre cooling chamber	-
14.	Cooling chamber	-
15.	Zero energy cool chamber	-
16.	Seed germinator	-
17.	Freeze drier	1
	Total	**11**

Equipment for fruits and vegetables processing and preservation lab

S. No.	Equipment	Quantity
A.	**Measuring instruments**	
1.	Weighing scale – platform type	1
2.	Counter weight scale with pan indicator and weights	1
3.	Jam boiling thermometer	2
4.	Gelly thermometer	2
B.	**Preparation, cutting, slicing, cubing, dicing equipment**	
1.	Working table with stainless steel top	2
2.	Stainless steel knives for cutting, coaring, pitting, peeling etc.	2 sets
3.	Fruits / vegetable slicer (1HP)	1
4.	Slicer with circular cutting knife	1
5.	Fruits / vegetable slicer (0.5 HP)	1
6.	Papaya cutter – 1 HP	1
7.	Papaya slicer	1
8.	Carrot slicer	1
9.	Cherry peeler	1
10.	Lemon or orange halving machine	1
11.	Pineapple slicer – 2 HP	1
12.	Pineapple coarer	5
13.	Pineapple cutting knives	10
14.	Dicing and cubing machine	1
15.	Mango cutter	1
16.	Mushroom knives	10
17.	Scooping knife	10
18.	Lemon quartering machine	1

C.	**Washing equipment**	
1.	Fruits and vegetables washer	1
2.	Rotary type fruits/vegetables washing machine	1
3.	Bottle washer	1
4.	Empty can washer and sterilizer (power type)	1
D.	**Graders**	
1.	Fruit grader	1
2.	Pea grader (1.5hp)	1
E.	**Dryer/Dehydrator**	
1.	Tray dryer (40 trays)	1
2.	Cabinet tray dryer (24 trays)	
3.	Vegetable dryer	1
4.	Dryer/dehydrator/heater	1
5.	Drying oven	1
F.	**Blanchers**	
1.	Blancher (0.5hp)	1
2.	Steam blancher	1
G.	**Peelers/sheller**	
1.	Potato peeler (0.5hp)01	1
2.	Papaya peeler	1
3.	Lye peeler	1
4.	Pea sheller	1
H.	**Kettler**	
1.	Steam jacketed kettle	1
2.	SS trays	10
I.	**Grinders/pulverizer**	
1.	Mini pulverizer	1
2.	Orange peel shedding machine	1
J.	**Juice extractor/fruit mills/pulpers**	
1.	Mini pulper (1hp)	1
2.	Pulper (twin)/mango pulper	1
3.	Hydro extractor	1
4.	Oil type hydraulic juice press (power operated)	1
5.	Apple/fine apple/carrot juicer	1
6.	Fruit mill/custer	1
7.	Hand basnet press	2
8.	Hammer mill	1
9.	Apple/pear crusher	1
K.	**Sterilizer/mixture/pasteurizers**	
1.	Juice pasteurizer	1
2.	homogenizer	1

3.	Storage and mixing	4
4.	Sterilization tony	1

Canning equipment including canning retort/ pressure boxes, reforming unit, double seaming machine, hand cane seamer, cane opener lid embossing machine, steam checking gauge, vacuum tester, flame rectifier, etc. Complete set

S. No.	Equipment	Quantity
M.	**Filling & packaging equipment**	
1.	Vacuum filling machine	1
2.	Crown corking machine	1
3.	Cup filling and reeling machine	1
4.	PP cap seeling machine	1
5.	Pouch filling and sealing machine	1
6.	Shrink packaging machine	1
N.	**Miscellaneous**	
1.	Mixi	2
2.	Filter press (1hp)	1
3.	Steam generator/ mini boiler	1
4.	Pea pricking machine	1
5.	Roasting machine	1
6.	Pickle mixture	1
7.	centrifuge	1
8.	Straight line exhaust box	1
9.	Portable strimer	1
	Total	**120**

Campus shall be properly laid out depending on the location with proper Master plan.

1. With proper approach roads to various structures with street light (solar) facility for important roads.
2. All round the campus there shall be a proper fence or compound with tall growing trees to serve aswind break or shelter belts besides compound wall to ladies hostel.
3. Around main building and hostel building proper landscape gardening shall be established.
4. All along important roads, selected ornamental trees/useful trees shall be planted.
5. Each major department should have Research block of 4 hectare - Germplasm unit, evaluation/ trialblock, Field laboratory, farm store etc.
6. Intercom network
7. Solar lighting
8. Solar water heating system
9. Underground electricity supply system (24hrs line)
10. General security system/ office
11. All buildings with fire / electricity alarm and safety systems.

    Proper storage systems and use of harmful chemicals insecticides and pesticides, etc.

SERICULTURE

Course Curricula for Undergraduate program in Sericulture: UG- Certificate in Sericulture; UG- Diploma in Sericulture; B.Sc. (Hons.) Sericulture

INTRODUCTION

Sericulture is an agro-based industry. It involves cultivation of host plants and rearing of silkworms for the production of cocoons to produce raw silk. The major activities of sericulture comprise food-plant cultivation to feed the silkworms, which spin silk cocoons, and reeling the cocoons for unwinding the silk filament for processing and weaving to produce the valuable products.

Silk is the most elegant textile in the world with unparalleled grandeur, natural sheen, and inherent affinity for dyes, high absorbance, lightweight, soft touch and high durability. Because of these unique features, silk is known as the "Queen of Textiles" all over the world. Besides, it stands for livelihood opportunity for millions, owing to its high employment potential, low capital requirement, and remunerative nature of its production. The very nature of this industry, with its rural based on-farm as well as off-farm activities and enormous employment generation potential has attracted the attention of the planners and policymakers to recognize the industry among one of the most appropriate avenues for socio-economic development of a largely agrarian Indian economy.

The sericulture industry provides employment to approximately 8.7 million persons in rural and semi-urban areas in India. India has the unique distinction of being the only country producing all the five known commercial silks, namely, Mulberry, Tropical Tasar, Oak Tasar, Eri, and Muga, of which Muga, which is produced only in India with its golden yellow glitter, is a prerogative of India. In India, because of the prevalence of favourable climatic conditions, sericulture is being practiced in five states, viz., Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal, and Jammu and Kashmir.

The present report is an outcome of the valuable suggestions and recommendations of Sixth Deans' Committee members after having multistage in-depth deliberations and discussions in virtual meetings with the members of four sub-groups representing departments/divisions of Sericulture Science, Stakeholders from related universities, sericulture experts, and also passed out undergraduate students of the existing degree program across the nation.

Restructuring of undergraduate programs in Sericulture has been carried out as per NEP–2020 guidelines to build among students a strong foundation

of knowledge with increased practical exposure and skill development to build competence and confidence for the application of the gained knowledge.

More emphasis has been given on basic skill enhancement courses, exposure visits and case studies, industry attachments, flexibility in choice of courses via electives offered in the fourth year and also through online courses, along with provision of advanced skill development through project work or experiential learning, etc., with amalgamation of multiple exit and entry options as per NEP.

The details of the course structure for the Undergraduate courses in Sericulture (UG-Certificate, UG-Diploma, B.Sc. (Hons.) Sericulture) have been prepared after having multistage in-depth deliberations and discussions. It is expected that the course curriculum will strengthen the knowledge and skill base of the students and meet the expectations of the NEP 2020 towards making India a knowledge superpower and realizing the dream of *Atmanirbhar Bharat*.

HIGHLIGHTS

- The whole course work of 4 years undergraduate program in Sericulture will be of 178 credits, which will have 168 credits offered by the parent university and 10 credits of online courses to be taken by the student as per his/ her/choice.
- After the admission of students in the university, the students will register for the Foundation course, at the start of the first semester, which will be of 2 weeks duration.
- The course will include discussions on the operational framework of the academic process in the university, sessions from alumni, business leaders, academic and research managers and classes on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills.
- Steps will be taken to identify the strengths and weaknesses of students (with remedial measures) along with diverse potentialities and to enhance cultural integration of students from different backgrounds. It will also create a platform for students to learn from each other's life experiences.
- Student will have to do common courses under categories like multi-disciplinary, value added, ability enhancement courses etc. NSS/NCC will be of 2 credits.
- The first two years of the course program are dedicated to skill development in the Sericulture discipline through skill enhancement courses along with basic and fundamental courses.
- The skill enhancement courses (SEC) of 12 credit hours will be offered during the first and second year of the degree program with full flexibility to the student as per NEP 2020 guidelines.
- There are four different SEC modules of 12 credit hours, each to be offered one in each semester in a sequential manner, like SEC module-1 (0+4) in first semester, SEC module-2 (0+4) module in second semester, SEC module-3 (0+2) in third semester and SEC module-4 (0+2) module the in fourth semester.

- The students will have flexibility and choice in selection of a skill development area from a basket of SEC modules offered by the parent institute. Each of the SEC module offers skill development areas related domains of Sericulture for the students. After a one-week common orientation on different skill enhancement modules, students will take up one module as per the local needs and gain complete hands-on experience in the selected module.
- In addition, Universities/HAEIs may also offer courses in any other areas as identified by them, based on institutional expertise/capabilities/resources.
- In the first year, after satisfactory completion of 45 credits of courses in two semesters and subsequent satisfactory completion of 10 credits (10 weeks) of industry/institute training/ internship, the student will become eligible for the award of UG-Certificate in Sericulture on exit. The students continuing the study further would not have to attend the internship after first year.
- The second year has been designed with the practical exposure as well as some part of the fundamental courses related to Sericulture with adequate theory and practical components, enabling the student to get acquainted with the basic principles and applications of Sericulture. After satisfactory completion of 40 credits of courses in third and fourth semesters and subsequent satisfactory completion of 10 credits (10 weeks) of industry/institute training/ internship, the student will become eligible for the award of UG-Diploma in Sericulture on exit.
- The students continuing the study further would not have to attend the internship after second year. These students will acquire distinct knowledge, skill, competency and confidence to start their own enterprise and can also get good jobs as per their merit.
- The Sericulture courses in the third year have been designed to impart hardcore knowledge of the subject to the students. There will no exit option after third year.
- During the fifth semester, the students will have a study tour/ industry visit of 10-14 days duration, which will be counted as 2 credits (non-gradial).
- The fourth-year course program has been meticulously designed not only to impart specialized knowledge to the students in the selected major discipline but also to prepare the students to take up either research or employment or entrepreneurship as their future career.
- In order to inculcate experiential learning habits in students, Student READY (Rural Entrepreneurship Awareness Development Yojana) Program which include Rural Agriculture Work Experience (RAWE)/in-plant training/industrial attachment/experiential learning. hands-on-training/internship and student projects.
- Students opting for the degree leading to B.Sc. (Hons) Sericulture will study Electives as major/ minors. There will be adequate choice of electives/ specialization courses for the students in the seventh semester. The students can choose major/ minor courses from the list of courses offered by the university in the related disciplines.

- The students will also have choice to take 10 credits of online courses either from MOOC/ Swayam/ NPTEL/ mooKIT/ edX/ Coursera or any other portal accepted by the University during the third and fourth year as a partial requirement for the degree of B.Sc. (Hons.) Sericulture.
- The online courses may relate to the main discipline or from any other discipline like social science, psychology, anthropology, economics, business management, agriculture, language/humanity, music, etc. The objective is to allow the students to groom their passion and strengthen their knowledge and competency based on their choice.
- These online courses will be non-gradial and a separate certificate would be issued by the institute/university offering the courses. However, the university/ institute will keep a record of such courses registered and completed by each student and will indicate the title of the successfully completed courses in the final transcript issued to the student.
- After satisfactory completion of the fourth year course requirements, the student will become eligible for the award of degree in B. Sc. (Hons.) Sericulture.
- At each stage of exit (UG-Certificate/ UG-Diploma/ B.Sc. (Hons.) Sericulture), the students are expected to acquire competency and confidence to get jobs, to face the real challenges in varied jobs and research, as well as to start their own consultancy/ enterprise.
- The social skills acquired by the students will also make the students more empathetic towards the society and social issues.
- The Universities will have flexibility to include more courses as electives depending on specific needs and situational variations. The objective is to enable the student to acquire deeper understanding in any particular field.
- The core and elective courses can also be modified by a maximum of 30% with approval from the competent authority of the university.
- It is recommended that each HAEI appoint a Coordinator for the internship program. The coordinator must plan /monitor internship programe implementation in the university, as per detailed guidelines prescribed by UGC. Read more details of guidelines in the UGC notification on Internship, 2023.

Entry and Exit Options

The entry and exit options for the B. Sc. (Hons.) Sericulture programme are shown in the Figure. 1 below:

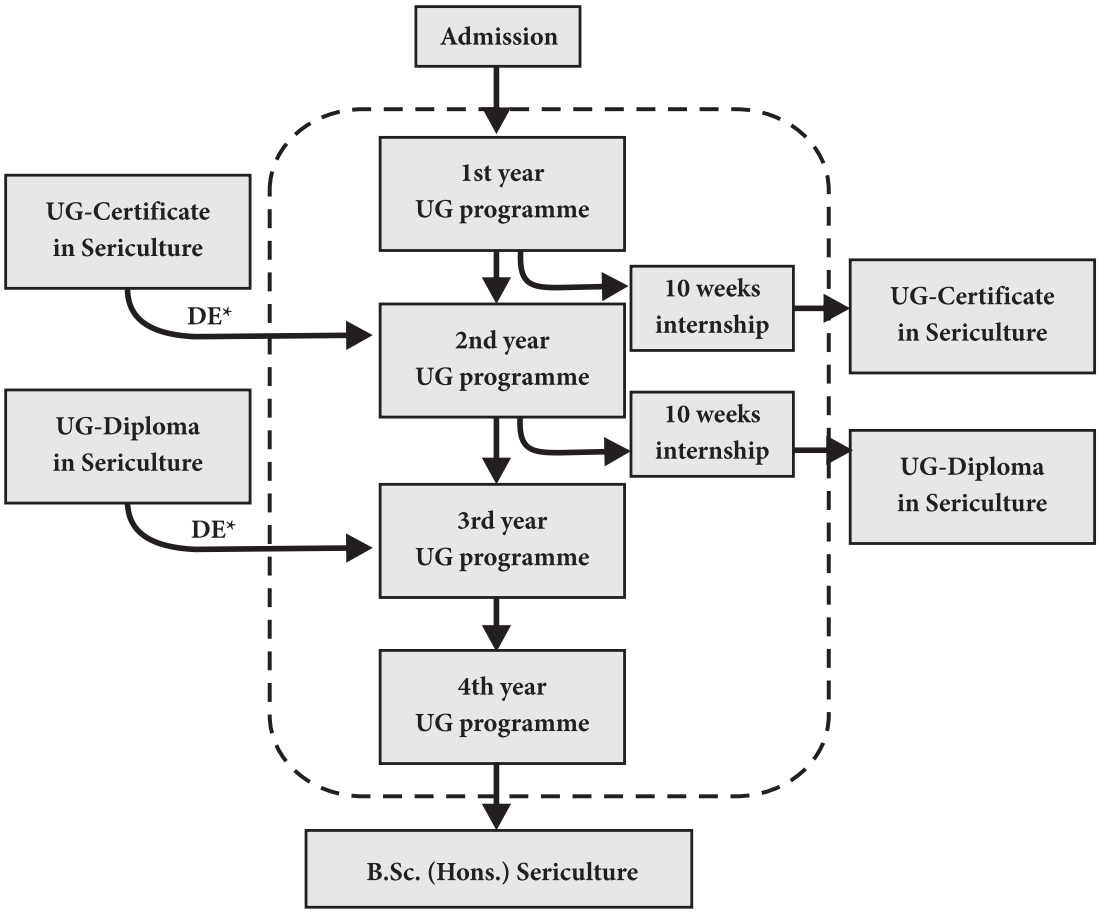


Fig. 1. Entry and Exit options in UG Program in Sericulture

DE* Direct Entry in the Respective Year

Exit Options

- **UG-Certificate** in Sericulture (exit after first year and completion of 10 weeks' internship)
- **UG-Diploma** in Sericulture (exit after second year and completion of 10 weeks' internship)
- **B.Sc. (Hons.)** Sericulture (on successful completion of four-year degree requirements)

Admission Eligibility: 10+2 Science with Biology or Mathematics as one subject/Agriculture from recognized Cenral/State Board or as per the criteria decided by the ICAR/ SAU/HAEI.

The Universities may also consider allowing lateral entry for the candidates having Diploma in Sericulture from Polytechnic colleges or other institutions approved by UGC/ICAR as per the provisions to be notified by the respective AU from time to time.

ACADEMIC PROGRAM

Semester wise course distribution

Sl. No.	Course Title	Credit Hours	Total Credit hours
	First Year		
	Semester I		
1.	Deeksharambh (Induction-cum-Foundation Program) (2 weeks)	2(0+2) Non-gradial	**22 (11+11)**
2.	Leaf Production Technology of Host Plants of Silkworms	3 (2+1)	
3.	Silkworm Seed Production Technology	3 (2+1)	
4.	Mulberry Silkworm Rearing Technology	3 (2+1)	
5.	Raw Silk Production Technology	3 (2+1)	
6.	Farming Based Livelihood System	3 (2+1)	
7.	National Cadet Corps (NCC-I)/National Service Scheme (NSS-I)	1 (0+1)	
8.	Communication Skills	2 (1+1)	
9.	SEC 1: Skill Enhancement Courses*	4 (0+4)	
	Semester II		
1.	Diseases of Silkworm and their Management	3 (2+1)	**23 (11+12)**
2.	Pests of Host Plants of Silkworms and their Management	2 (1+1)	
3.	Pests of Silkworm and their Management	3 (2+1)	
4.	Bivoltine Silkworm Rearing	2 (1+1)	
5.	Personality Development	2 (1+1)	
6.	Environmental Studies and Disaster Management	3 (2+1)	
7.	National Cadet Corps (NCC-II)/National Service Scheme (NSS-II)	1 (0+1)	
8.	Entrepreneurship Development and Business Management	3 (2+1)	
9.	SEC 2: Enhancement Courses**	4 (0+4)	
	Post-Semester II (Only for exit option for award of UG-Certificate in Sericulture)		
1.	Internship (10 weeks)	10 (0+10)	
	Second Year		
	Semester III		
1.	Botany and Cytology of Host Plants of Silkworm	3 (2+1)	**20 (11+9)**
2.	Genetics and Breeding of Host Plants of Silkworms	3 (2+1)	
3.	Cytology and Genetics of Silkworm	2 (2+0)	
4.	Fundamentals of Entomology and Nematology	3 (2+1)	
5.	Fundamentals of Genetics	2 (1+1)	
6.	Fundamentals of Agronomy	3 (2+1)	
7.	Physical Education, First Aid, Yoga Practices and Meditation	2 (0+2)	
8.	SEC 3: Skill Enhancement Course***	2 (0+2)	

Sl. No.	Course Title	Credit Hours	Total Credit hours
	Semester IV		
1.	History, Development and Organization of Sericulture Industry	2 (1+1)	**20 (11+9)**
2.	Morphology and Systematics of Silkworms	3 (2+1)	
3.	Silkworm Anatomy and Physiology	3 (2+1)	
4.	Water Management	2 (1+1)	
5.	Agricultural Statistics	2 (1+1)	
6.	Agricultural Marketing and Trade	3 (2+1)	
7.	Agricultural Informatics and Artificial Intelligence	3 (2+1)	
8.	SEC 4: Skill Enhancement Course****	2 (0+2)	
	Post-Semester IV* (Only For exit option for UG-Diploma in Sericulture)		
1.	Internship (10 weeks)	10 (0+10)	
	Third Year		
	Semester V		
1.	Silkworm Breeding	3 (2+1)	**22 (13+9)**
2.	Vanya Sericulture	2 (1+1)	
3.	Fundamentals of Soil Science	2 (1+1)	
4.	Fundamental of Extension Education	3 (2+1)	
5.	Mechanization in Sericulture	2 (1+1)	
6.	Seri Biotechnology	2 (1+1)	
7.	Physics and Chemistry of Fibres	2 (2+0)	
8.	Fundamentals of Crop Physiology	2 (1+1)	
9.	Introduction to Agrometeorology	2 (1+1)	
10.	Essentials of Plant Biochemistry	2 (1+1)	
11.	Educational and Study tour (10-14 days)	2 (0+2) Non-gradial	
	Semester VI		
1.	Experimental Techniques in Sericulture Research	2 (1+1)	**21 (11+10)**
2.	Silk Throwing Dyeing and Weaving	3 (2+1)	
3.	Spun Silk Technology	1 (0+1)	
4.	Apparels in Sericulture Industry	1 (0+1)	
5.	Agricultural Marketing and Trade	2 (0+2)	
6.	Introduction to Agro Forestry	2 (1+1)	
7.	Bio Formulation and Nano Technology	2 (1+1)	
8.	Renewable Energy in Agriculture and Allied Sector	3 (2+1)	
9.	Fundamentals of Agricultural Economics	2 (2+0)	
10.	Fundamentals of Plant Pathology	3 (2+1)	

Fourth Year			
Semester VII			
Elective subject***			
Elective - I Host Plant Production Technology	Techniques in Host Plants Improvement	5 (2+3)	**20 (8+12)**
	Techniques in Host Plants Production	5 (2+3)	
	Techniques in Host Plants Protection	5 (2+3)	
	Value Addition to Host Plants By products	5 (2+3)	
Elective - II Cocoon Crop Production Technology	Techniques in Silkworm Crop Improvement	5 (2+3)	**20 (8+12)**
	Techniques in Silkworm Cocoon Production	5 (2+3)	
	Techniques in Silkworm Crop Protection	5 (2+3)	
	Value Addition to Silkworm Rearing By products	5 (2+3)	
Elective - III Silk Product Science Technology	Techniques in Raw Silk Production	5 (2+3)	**20 (8+12)**
	Techniques in Spun Silk Technology	5 (2+3)	
	Techniques in Post Reeling Technology	5 (2+3)	
	Value Addition of Silk Industry By-products	5 (2+3)	
VIII Semester			
I.	Student READY (RAWE/Industrial Attachment / Experiential Learning/Hands-on Training/Skill Development/Project Work/Internship etc.)	20 (0+20)	**20 (0+20)**

*From the basket of available SEC-I modules

**From the basket of available SEC-II modules

***From the basket of available SEC-III modules

****From the basket of available SEC-IV modules

***** The student will take anyone elective as per choice

****** The University can develop their own SEC modules considering the local needs & available facilities.

Skill Enhancement Courses (SEC)

Sl. No	SEC	Course Title	Credit Hours
1.	**SEC-I**	Mulberry Leaf Production Technology	4 (0+4)
2.		Silkworm Egg Production Technology	4 (0+4)
3.	**SEC-II**	Silkworm Rearing Technology	4 (0+4)
4.		Silk Reeling Technology	4 (0+4)
5.	**SEC-III**	Raw Silk Processing	2 (0+2)
6.		Weaving Technology	2 (0+2)
7.		Seri Clinic	2 (0+2)
8.	**SEC-IV**	Value Addition in Sericulture	2 (0+2)
9.		Entrepreneurship and Business Development in Sericulture	2 (0+2)

Foundation Courses/ Ability Enhancement Courses, etc.			
1.	Deeksharambh	2 (0+2) (NG)*	23 (13+10)
2.	Farming Based Livelihood System	3 (2+1)	
3.	Communication Skills	2 (1+1)	
4.	Personality Development	2 (1+1)	
5.	Environmental Studies and Disaster Management	3 (2+1)	
6.	Entrepreneurship Development and Business Management	3 (2+1)	
7.	Agricultural Marketing and Trade	3 (2+1)	
8.	Agricultural Informatics and Artificial Intelligence	3 (2+1)	
9.	Physical Education, First Aid, Yoga Practices & Meditation	2 (1+1)	
10.	NSS/ NCC - I	1 (0+1)	
11.	NSS/ NCC - II	2 (0+2)	
12.	Educational Tour	(0+2) NG*	
Elective courses			
1.	Elective Course-I	20 (8+12)	20 (8+12)
2.	Elective Course-II		
3.	Elective Course-III		
Skill Enhancement Courses			
1.	Skill Enhancement Course I	4 (0+4)	12 (0+12)
2.	Skill Enhancement Course II	4 (0+4)	
3.	Skill Enhancement Course III	2 (0+2)	
4.	Skill Enhancement Course IV	2 (0+2)	
In-plant training/ Internship			
1.	Internship only for exit option with UG-Certificate	10 (0+10)*	20 (0+20)
2.	Internship only for exit option with UG-Diploma	10 (0+10)*	
Project Work/ Internship			
1.	Student READY: Experiential Learning/Internship RAWE In-Plant Training/Industrial Attachment Student Project	20 (0+20) 8 6 4 2	20 (0+20)
On-line courses			
1.	Online course	10 (0+10)*	10 (0+10)
			167+4+10

1.	**Department of Host Plant Production**	
S. No.	**Course Title**	**Credit hours**
1	Leaf Production Technology of Host Plants of Silkworms	3 (2+1)
2	Pests of Host Plants of Silkworm and Their Management	2 (1+1)

3	Mechanization in Sericulture	2 (1+1)
4	Experimental Techniques in Sericulture Research	2 (1+1)
	Elective Courses	
5	Techniques in Host Plants Production	5 (2+3)
6	Techniques in Host Plants Protection	5 (2+3)
7	Value Addition to Host Plants By products	5 (2+3)
	Skill Enhancement Courses	
8	Mulberry Leaf Production Technology	4 (0+4)
9	Silkworm Egg Production Technology	4 (0+4)

2.	**Department of Sericulture Crop Improvement**	
S. No.	**Course Title**	**Credit hours**
1	Botany and Cytology of Host Plants of Silkworms	3 (2+1)
2	Genetics and Breeding of Host Plants of Silkworms	3 (2+1)
3	Cytology and Genetics of Silkworms	2 (2+0)
4	Silkworm Breeding	3 (2+1)
5	Seri Biotechnology	2 (1+1)
	Elective Courses	
6	Techniques in Host Plants Improvement	5 (2+3)
7	Techniques in Silkworm Crop Improvement	5 (2+3)

3.	**Department of Cocoon Crop Production**	
S. No.	**Course Title**	**Credit hours**
1	Silkworm Seed Production Technology	3 (2+1)
2	Mulberry Silkworm Rearing Technology	3 (2+1)
3	Diseases of Silkworm and Their Management	3 (2+1)
4	Pests of Silkworm and their Management	3 (2+1)
5	Bivoltine Silkworm Rearing	2 (1+1)
6	History, Development and Organization of Sericulture Industry	1 (1+0)
7	Morphology and Systematics of Silkworm	3 (2+1)
8	Silkworm Anatomy and Physiology	3 (2+1)
9	Vanya Sericulture	2 (1+1)
	Elective Courses	
10	Techniques in Silkworm Cocoon Production	5 (2+3)
11	Techniques in Silkworm Crop Protection	5 (2+3)
12	Value Addition to Silkworm Rearing By products	5 (2+3)

	Skill Enhancement Courses	
13	Silkworm Rearing Technology	4 (0+4)
14	Seri Clinic	2 (0+2)
15	Value Addition in Sericulture	2 (0+2)
16	Entrepreneurship and Business Development in Sericulture	2 (0+2)

4.	**Department of Silk Product Science**	
S. No.	**Course Title**	**Credit hours**
1	Raw Silk Production Technology	3 (2+1)
2	Physics and Chemistry of Fibres	2 (2+0)
3	Silk Throwing Dyeing and Weaving	3 (2+1)
4	Spun Silk Technology	1 (0+1)
5	Apparels in Sericulture Industry	1(0+1)
	Elective Courses	
6	Techniques in Raw Silk Production	5 (2+3)
7	Techniques in Spun Silk Technology	5 (2+3)
8	Techniques in Post Reeling Technology	5 (2+3)
9	Value Addition of Silk Industry By-products	5 (2+3)
	Skill Enhancement Courses	
10	Silk Reeling Technology	4 (0+4)
11	Raw Silk Processing	2 (0+2)
12	Weaving Technology	2 (0+2)

Credits Allocation Scheme of UG Sericulture Programs (Credit Hours)

Semester	Core Courses (Major+ Minor)	Multi-Disciplinary Course (MDC)	Value Added Course (VAC)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)	Internship/ Project/ Student READY	Total Credits	Non-Gradial	Internship	Online Courses/ MOOC
I	12	$3^{(2)}$		$1^{(3)} + 2^{(4)}$	4	-	22	$2^{(1)}$		
II	10	$3^{(5)}$	$3^{(6)}$	$1^{(3)} + 2^{(7)}$	4	-	23	-	$10^{(12)}$	
III	16	----		$2^{(8)}$	2	-	20			
IV	12	$3^{(9)}$	$3^{(10)}$	----	2	-	20	-	$10^{(13)}$	**10**
V	22	-	-	-	-	-	22	$2^{(11)}$		
VI	21	-	-	-	-	-	21	-		
VII	20	-	-	-	-	-	20	-		
VIII	-	-	-	-	-	20	20	-		
Total	**113**	**9**	**6**	**8**	**12**	**20**	**168**	**4**		**10**

[1] *Deeksharambh* (Induction-cum-Foundation Course) of 2 credits (2 weeks duration)
[2] Farming based Livelihood systems
[3] NCC/NSS[4] Communication Skills; [5] Entrepreneurship Development and Business Management
[6] Environmental Studies and Disaster Management;
[7] Personality Development; [8] Physical Education, First Aid, Yoga Practices and Meditation
[9] Agriculture Marketing and Trade; [10] Agricultural Informatics and Artificial Intelligence
[11] Study tour (10-14 days).
[12] Only for those opting for an exit with UG-Certificate [13] Only for those opting for an exit with UG-Diploma

SUMMARY OF CREDIT DISTRIBUTIONS

Type of courses		Credits hours
Core Courses (Minor and Major)	:	113
Skill Enhancement Courses	:	12
Multidisciplinary/Common Courses (MDC, VAC and AEC)	:	23
Internship/ In-plant training (Student READY)	:	20
Online courses/ MOOC (non – gradial) *	:	10
Total	:	**168+10***

Semester I

Deeksharambh (Induction-cum-Foundation Course)- Non-gradial 2 (0+2)

The activities to be taken under *Deeksharambh* shall aim at creating a platform for students to

1. Help with cultural integration of students from different backgrounds
2. Know about the operational framework of the academic process in the University
3. Instill life and social skills
4. Social awareness, ethics and values, team work, leadership, creativity, etc.
5. Identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenarios.

The details of activities will be decided by the parent universities. The structure shall include, but not restricted to:

i. Discussions on the operational framework of the academic process in the University, as well as interactions with academic and research managers of the University

ii. Interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences

iii. Group activities to identify the strengths and weaknesses of students (with expert advice for their improvement) as well as to create a platform for students to learn from each other's life experiences

iv. Activities to enhance cultural integration of students from different backgrounds.

v. Field visits to related fields/ establishments

vi. Sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills

Leaf Production Technology of Host Plants of Silkworms 3 (2+1)

Objective

To understand the cultivation practices of host plants of mulberry, tasar, eri and muga silkworms

Theory

Introduction, climatic requirements, sexual and asexual methods of propagation, mulberry varieties, nursery techniques in mulberry propagation, pruning, irrigation schedules. Green manuring, manurial and fertilizer schedules. Weed control practices. Harvesting under different planting system of mulberry. Leaf preservation. Mulberry cultivation under rainfed condition and irrigated condition. Tree mulberry plantation, precision farming in mulberry and chawki / young age mulberry plantation. Cultivation and propogation of host plants of eri silkworms: castor, tapioca and kesaru. Cultivation and propogation of host plants of tropical tasar silkworms: Asan, Arjun and sal. Temperate tasar / oak tasar silkworms: *Quercus serrata* and *Quercus incana*. Cultivation and propogation of host plants of muga silkworms - som and soalu.

Practical

Study of primary and secondary tillage implements, soil sampling technique. Nursery bed preparation and raising of seedling through sexual propogation and saplings through asexual propogation in mulberry. Identification of mulberry varieties. Manures and fertilizer application. Planting methods. Irrigation methods, pruning methods, weed management. Harvesting and preservation of mulberry leaves. Identification of host plants of Eri silkworm, host plants of tasar silkworms and host plants of muga silkworms. Cultivation of primary host plants of eri silkworms. Cultivation of primary host plants of tasar silkworms and cultivation of secondary host plants of muga silkworms. Herbarium preparation for the host plants and weeds. Collection of insect pests of host plants and disease specimens of host plants.

Suggested Readings

1. Rangaswami G and Manjeet S Jolly. 1976. *E-manual 1- Mulberry Cultivation*. 149p. FAO, Rome.
2. Anonymous. 2007. *Tasar culture – Principles and Practices*, Vol.1. *Tasar silkworm host plants – Production, Protection and improvement.*
3. Anonymous. 2003. *Sericulture Buisness manual – A user's guide. Vol. 1.*
4. Ganga G and Sulochanachetty J. 2019 *Introduction to sericulture*. 328p. Oxford and IBH Publishing.
5. Minamizawa K. 1997. *Moriculture, Science of Mulberry Cultivation*. Oxford and IBH Publishing Co. Pvt. Ltd. pp 235-285.
6. Ramakrishna Naika, Venkataravana P and Sunil kumar T. 2024. *Sericulture cultivation, processing and marketing*. 293 p. Daya Publishing House. Delhi.
7. Patnaik R K. 2017. *Mulberry cultivation*. 255 p. Biotech books.
8. Kamal Jaiswal, Snil, P Trivedi, B N Pandey and R K Khatri. 2009. *Moriculture*. APH publishing corporation, New Delhi.

9. Sathe T V and A D Jadhav. 2012. *Sericulture & pest management*. DAYA publishing house, New Delhi.
10. Ganga G. 2005. *Comprehensive Sericulture (Vol. I).* Oxford & IBH Publishing Co. Pvt. Ltd.
11. Madan Mohan Rao M. 2005. *Comprehensive Sericulture Manual.* B. S. Publications.
12. Savithri G, Sujathamma P and Neeraja P. 2016. *Sericulture industry*: An overview, Agrobios (India).
13. Ganga G and Sulochana Chetty. *An Introduction to Sericulture*, pp 25-79. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.

Silkworm Seed Production Technology 3 (2+1)

Objective

To study the importance of quality silkworm seed production and silkworm seed production organization structure in sericulture industry

Theory

Importance of quality silkworm seed in sericultural industry. Embryology of *Bombyx mori*, *Samia ricini, Antheraea assamensis* and *Antheraea mylitta*. Morphological and biochemical changes in eggs of different silkworms during embryogenesis. Seed areas, special features of seed areas and seed cocoon transaction. Seed organization in India and abroad. Three tier system of egg production (P3, P2 and P1). Special features of parental silkworm rearing, Basic seed and Industrial seed and standards for the same. Hill amelioration, marketing of seed cocoons, grainage techniques and steps in hybrid DFL preparation. Small scale production of hibernating and non-hibernating eggs in loose form and on egg sheets. Methods of termination of hibernation, acid treatment for hibernating eggs. Egg borne diseases and methods of elimination. Pebrine disease management at various levels. Incubation and preservation of DFLs till disposal. Standards for quality eggs. Preservation and handling of eggs, different hibernation schedules. Cost structure of a model grainage and a private grainage. Economics of egg production, cost of production. Management of industrial grainages. Maintenance of records in grainages. Enumeration of Seed LegislationAct.

Practical

Methods of embryo testing and preparation of permanent slides**.** Grainage plan and equipments, different grainage operations. Procurement, transportation and preservation of seed cocoons. Sexing, moth emergence, pairing, depairing, preparation of eggs on cards and in loose forms. Identification of good, dead, unfertile and hibernated eggs. Mother moth examination, disinfection of eggs. Acid treatment for hibernating eggs. Preparation of hybrid eggs. Visit to local grainages.

Suggested Readings

1. Narasimhanna M N. 1998. *Manual on Silkworm Egg Production*. 189p. Central Silk Board, Bengaluru.
2. Jayant Jayaswal K, Giridhar J, Somi Reddy H and Jagadish Prabhu. 2008, *Silkworm Seed Production*. 131p. Central Silk Board, Bengaluru.
3. Singh Tribhuwan, Bhat Madan Mohan and Khan Mohammad Ashraf. 2010. *Silkworm Egg Science*. 290p. Daya Publishing House, Delhi.

4. Singh Tribhuwan and Berra Saratchandra. 2004. *Principles and Techniques of Silkworm Seed Production*. 231p. Discovery Publishing House, New Delhi.
5. Ganga G. *Comprehensive Sericulture (Vol. II)*. Oxford & IBH Publishing Co.Pvt.Ltd. New Delhi.
6. Naika Ramakrishna, Venkataravana P and T Sunil Kumar. 2024. *Sericulture Cultivation, Processing and Marketing*. 293p. Daya Publishing House, Delhi.

Mulberry Silkworm Rearing Technology 3 (2+1)

Objective

To improve quality and quantity of cocoon production through induction of modern rearing technology in Sericulture.

Theory

Introduction: sericulture, components and importance of sericulture. Morphology and biology of silkworm *Bombyx mori*. Classification of silkworm races. Characters of races of silkworm. Planning of silkworm rearing. Different types of silkworms rearing houses. Silkworm rearing appliances. Disinfection. Egg incubation and methods. Brushing and types of brushing. Environmental requirements for different stages of silkworm. Rearing methods of young age and late age silkworm. Chawki Rearing Centres (CRC) and their management. Feeding of silkworm. Bed cleaning and methods of bed cleaning. Spacing management during silkworm rearing. Moulting (Ecdysis) care. Mounting of silkworms and mountages. Quality cocoon harvest and assessment of cocoons quality. Nutritional requirement of silkworm *Bombyx mori*. Role of artificial diet for Chawki rearing. Importance of juvenile hormone analogues in practical sericulture. Diseases and pests of silkworm and their management. Maintenance of rearing records.

Practical

Life cycle of silkworm *Bombyx mori*. Study of plan for rearing house- chawki and late-age silkworm rearing house. Study of different rearing equipment/appliances. Disinfectants and their applications. Study of egg incubation methods and black boxing. Study of brushing of silkworms and selection of leaf for different instars. Study of bed cleaning methods and moulting worms and management. Study of different types of chawki and late-age silkworm rearing methods. Study of shoot feeding method and shelf rearing method. Role of environmental factors, micro and macro-nutrients on growth and development of silkworms. Identification of ripe worms and methods of mounting. Study of fortification of mulberry leaves and artificial diet in silkworm rearing. Study of use of juvenile hormone analogues on silkworm rearing. Harvesting of cocoons, transportation and marketing of cocoons. Study of natural enemies of silkworms. Study on maintenance of rearing records. Visit to Chawki Rearing Centers. Visit to farmer's mulberry garden, rearing house and cocoon market.

Suggested Readings

1. Ananthanarayanan. 2008. *Silkworm Rearing*. 266p. Biotech Books, New Delhi.
2. Anonymous. 1975. *Textbook of Tropical Sericulture*. 594p. Japan Overseas Co-operation Volunteers, Japan.
3. Aruga H. 1994. *Principles of Sericulture*. 376p. Oxford and IBH, New Delhi.

4. Dandin S B and Giridhar K. 2010. *Handbook of Sericulture Technologies*. Central Silk Board, Bangalore.
5. Dandin S B, Rajan R K, Mishra R K, Singh G B and Das P K. 2022. *A Model for Commercial Chawki Rearing*. 28p. Central Silk Board, Bangalore.
6. Datta R K. 1992. *Guidelines for Bivoltine Rearing*. 24p. Central Silk Board, Bangalore.
7. Forth H D. 1991. *Fundamentals of Soil Science*. 645p. John Wiley and Sons, New York.
8. Ganga G and Sulochana Chetty J. 2010. *An Introduction to Sericulture*. 302p. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
9. Ganga G. 2003. *Comprehensive Sericulture Vol. II - Silkworm Rearing and Silk Reeling*. 429p. Oxford and IBH, New Delhi.
10. Govindaiah, Gupta V P, Sharma D D, Rajadurai S and Nishitha Naik V. 2005. *Textbook on Mulberry Crop Protection*. 247p. Central Silk Board, Bangalore.
11. Govindan R, Narayanaswamy T K and Devaiah M C. 1998. *Principles of Silkworm Pathology*. 420p. Seri Scientific Publishers, Bangalore.
12. Jolly M S. 1987. *Appropriate Sericulture Techniques*. 215p. Central Sericultural Research and Training Institute, CSB, Mysore.
13. Krishnaswami S, Narasimhanna M N, Suryanarayan, S K and Kumararaj S. 1979. *Silkworm Rearing,* FAO Manual, Vol. II. pp99-129. FAO, Rome.
14. Muzafar Ahmad Bhat, Abdul Aziz, Suraksha Chanotra, Shamim Ahmed Bandey, Zafar Iqbal Bhuroo and Mohammad Azam. 2020. *A Textbook on Introduction to Sericulture and Soil Science*. 425p. IP Innovative Publication, New Delhi.
15. Narayanaswamy K C and Devaiah M C. 1998. *Silkworm Uzi Fly*. 232p. Zen Publishers, Bengaluru.
16. Nataraju B, Sathyaprasad K, Manjunath D and Aswani Kumar C. 2005. *Silkworm Crop Protection*. pp 1-324. Central Silk Board, Bangalore.
17. Rajan R K, Akiyoski Muroga and Datta R K. 1996. *Manual of Young Silkworm Rearing*. 24p. Central Silk Board, Bangalore.
18. Savithri G, Sujathamma P and Neeraja P. 2016. *Sericulture Industry : An Overview*. 194p. Agrobios (India) Publications, Rajasthan.
19. Sengupta K. 1989. *A Guide for Bivoltine Sericulture*. 42p. Central Sericultural Research and Training Institute, Mysore.
20. Singh R N and Saratchandra B. 2011. *Sericulture Entomology*. 493p. APH Publishing Co-operations, New Delhi.
21. Singh R N, Samson M V and Datta R K. 2000. *Pest Management in Sericulture*. 327p. Indian Publishers New Delhi.
22. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture*. 209p. Central Silk Board, Bangalore.

Raw Silk Production Technology **3 (2+1)**

Objectives

i. To understand the processing of cocoon for reeling a silk yarn
ii. To acquaint with the skills of cocoon reeling and raw silk production

Theory

Introduction - world raw silk production and present silk production in India, cocoon formation, physical characteristics of mulberry cocoon- colour, shape, wrinkles etc. Cocoon markets - its functions, method of transaction, method of fixing the cocoon price. Transportation of cocoons-care and handling. Cocoon testing and grading. Cocoon sorting - manual and mechanical method. Different types of defective cocoons. Mulberry silk reeling process - steps involved in silk reeling, cocoon stifling and methods, storage of stifled cocoons - sun drying, steam stifling, hot air drying. Cocoon cooking and its systems - open pan, two pan, three pan, pressurized cooking method/circular cocoon boiling machine, mechanical cooking, brushing methods. Evolution of reeling machines. General principles in reeling, different reeling machines - charakha, improved charakha, cottage basin/domestic basin, multiend reeling machine, semi automatic and automatic reeling machine. Re-reeling and lacing, silk examination, skeining, book and bale making, storage and selling raw silk, silk exchange. Physical properties of Tasar, Muga, eri cocoon. Tasar cocoon reeling - stifling, cooking, reeling machines. Muga cocoon reeling - stifling, cooking, reeling machines. Eri cocoon cooking, spinning methods, Filature water engineering. Marketing of silk, silk exchanges and price stabilization of silk. Objectives and advantages of raw silk testing and grading. Qualities of silk, major and minor characters of quality silk, equipments and facilities required for silk testing, silk testing and conditioning houses, BIS and ISA specifications of testing and grading of silk, condition test, winding test, size test, strength test, evenness, cleanness and neatness tests, cohesion test, standard tables for grading of silk.

Practical

Cocoon testing – tactile and mechanical tests. Fixing up of cocoon price based on the test results. Cocoon sorting – manual and identification of different defective cocoons and working out the defective cocoon per cent and deciding the cocoon price. Steam generation units – Boilers. Cocoon stifling by steam and hot air oven method and conditioning for reeling. Cooking and brushing of steam stifled cocoons – open pan method. Cocoon reeling in multiend reeling machine. Croissure formation and reeling path. Putting the knot for the broken yarn. Casting of brushed cocoons to the end. Maintaining the continous reeling speed. Reeling of cocoons (crossreed and bivoltine). Reel permeation by soaking method. Re-reeling in closed type re-reeling machine. Lacing of re-reeled silk. Examination of re-reeled silk yarn and small skein making using skeining machine. Book and bale making and submission of skein. Marketing of reeled raw silk in silk exchange.

Suggested Readings

1. Anonymous. 2003. *Seri Business Manual*. 112p. CSB, Bangalore
2. Anonymous. 2013. *Vanya Silks*. 155p. CSB, Bangalore
3. Krishnaswami S, Madhava Rao N R, Suryanarayan S K and Sundaramurthy T S. 1972. *Sericulture Manual 3 - Silk Reeling*. 112p. FAO, Rome.
4. Mahadevappa V G, Haliyal, D G Shankar and Ravindra Bhandiwad. 2000. *Mulberry Silk reeling Technology*. 227p. Oxford & IBH Publishing Company.
5. Tammanna N and Sonuwalker. 1993. *Handbook of Silk Technology*. Wiley Eastern.
6. Yong-woo Lee. 2005. *Silk Reeling and Testing Manual*. 130p. National Sericulture and Entomology Institute, Seoul, Republic of Korea.
7. Ananthanarayanan S K. 2008. *Silk Reeling*. 266p. Biotech books, Delhi.

Farming Based Livelihood Systems 3 (2+1)

Objectives

i. To make the students aware about farming based livelihood systems in agriculture

ii. To disseminate the knowledge and skill how farming based systems can be a source of livelihood

Theory

Status of agriculture in India and different states, Income of farmers and rural people in India, Livelihood - Definition, concept and livelihood pattern in urban and rural areas, Different indicators to study livelihood systems. Agricultural livelihood systems (ALS): Meaning, approach, approaches and framework. Definition of farming systems and farming based livelihood systems. Prevalent Farming systems in India contributing to livelihood. Types of traditional and modern farming systems. Components of farming system/ farming based livelihood systems - Crops and cropping systems, Livestock, (Dairy, Piggery, Goatry, Poultry, Duckry etc.), Horticultural crops, Agro--forestry systems, Aquaculture, Duck/Poultry cum Fish, Dairy cum Fish, Piggery cum Fish etc. Small, medium and large enterprises including value chains and secondary enterprises as livelihood components for farmers, Factors affecting integration of various enterprises of farming for livelihood. Feasibility of different farming systems for different agro-climatic zones, Commercial farming based livelihood models by NABARD, ICAR and other organizations across the country. Case studies on different livelihood enterprises associated with the farming. Risk and success factors in farming based livelihood systems, Schemes and programs by Central and State Government, Public and Private organizations involved in promotion of farming based livelihood opportunities. Role of farming based livelihood enterprises in 21st century in view of circular economy, green economy, climate change, digitalization and changing life style.

Practical

Survey of farming systems and agricultural based livelihood enterprises, Study of components of important farming based livelihood models/ systems in different agro-climatic zones, Study of production and profitability of crop based, livestock based, processing based and integrated farming based livelihood models. Field visit of innovative farming system models. Visit of Agri-based enterprises and their functional aspects for integration of production, processing and distribution sectors and Study of agri-enterprises involved in industry and service sectors (Value Chain Models). Learning about concept of project formulation on farming based livelihood systems along with cost and profit analysis. Case study of Start-Ups in agri-sectors.

Suggested Readings

1. Agarwal A and Narain S. 1989. *Towards Green Villages: A Strategy for Environmentally, Sound and Participatory Rural Development*. Center for Science and Environment, New Delhi, India.

2. Ashley C and Carney D. 1999. *Sustainable Livelihoods: Lessons from Early Experience.* Department for International Development, London, UK. Volume 7. [Google Scholar].

3. Bhatt B P, Abhay Kumar, P K Thakur, Amitava Dey Ujjwal Kumar, Sanjeev Kumar, B K Jha, Lokendra Kumar, K N Pathak, A Hassan, S K Singh, K K Singh and Singh K M. *Livelihood*

Improvement of Underprivileged Farming Community: Some Experiences from Vaishali, Samastipur, Darbhanga and Munger Districts of Bihar. ICAR Research Complex for Eastern Region ICAR Parisar, P.O. Bihar Veterinary College, Patna, Bihar.

4. Carloni A. 2001. *Global Farming Systems Study*: Challenges and Priorities to 2030 – Regional Analysis: Sub-Saharan Africa. Consultation Document, FAO, Rome, Italy.
5. Dixon J, Gulliver A and Gibbon D. 2001. *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World*. FAO and World Bank, Rome, Italy and Washington, DC, USA.
6. Evenson R E. 2000. *Agricultural Producitivity and Production in Developing Countries'*. FAO, The State of Food and Agriculture, FAO, Rome, Italy.
7. Panwar. 2020. *Integrated Farming System Models for Agricultural Diversification, Enhanced Income and employment.* Indian Council of Agricultural Research, New Delhi.
8. Reddy S R. 2016. *Farming System and Sustainable Agriculture*. Kalyani Publishers, New Delhi.
9. Singh J P. 2015. *Region Specific Integrated Farming System Models*. ICAR-Indian Institute of Farming Systems Research, Modipuram.
10. Walia S S and U S Walia. 2020. *Farming System and Sustainable Agriculture*. Scientific Publishers, Jodhpur, Rajasthan.

National Cadet Corps (NCC-I) 1 (0+1)

Objectives

i. To develop qualities of character, courage, comradeship, discipline, leadership, secular outlook, spirit of adventure and sportsmanship and the ideals of selfless service among the youth to make them useful citizen.

ii. To create a human resource of organized trained and motivated youth to provide leadership in all walks of life including the Armed Forces and be always available for the service of the nation.

Practical/ Awareness activities

- Aims, objectives, organization of NCC and NCC song. DG's cardinals of discipline.
- Drill - aim, general words of command, attention, stands at ease, stand easy, and turning.
- Sizing, numbering, forming in three ranks, open and close order march, and dressing.
- Saluting at the halt, getting on parade, dismissing, and falling out.
- Marching, length of pace, and time of marching in quick/slow time and halt. Side pace, pace forward and to the rear. Turning on the march and wheeling. Saluting on the march.
- Marking time, forward march, and halt. Changing step, formation of squad and squad drill.
- Command and control, organization, badges of rank, honours, and awards.
- Nation Building - cultural heritage, religions, traditions, and customs of India. National integration. Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizens. Leadership traits, types of leadership. Character/ personality development. Civil defense organization, types of emergencies, firefighting, protection. Maintenance of essential services, disaster management, aid during development projects.

- Basics of social service, weaker sections of society and their needs, NGO's and their contribution, contribution of youth towards social welfare and family planning.
- Structure and function of human body, diet and exercise, hygiene and sanitation. Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health. Adventure activities. Basic principles of ecology, environmental conservation, pollution and its control.

National Service Scheme (NSS-I) **1 (0+1)**

Objectives

i. To evoke social consciousness among students through various activities viz., working together, constructive, and creative social work.

ii. To be skillful in executing democratic leadership, developing skill in program.

iii. To be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

Practical/ Awareness activities

- Orientation: history, objectives, principles, symbol, badge; regular programs under NSS.
- Organizational structure of NSS, code of conduct for NSS volunteers, points to be considered by NSS volunteers', awareness about health.
- NSS program activities. Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analyzing guiding financial patterns of scheme, youth program/ schemes of GoI, coordination with different agencies and maintenance of diary. Understanding youth. Definition, profile, categories, issues and challenges of youth; and opportunities for youth who are the agents of social change.
- Community mobilization. Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership. Social harmony and national integration.
- Indian history and culture, role of youth in nation building, conflict resolution and peace-building. Volunteerism and shramdaan. Indian tradition of volunteerism - its need, importance, motivation, and constraints; shaman as part of volunteerism.
- Citizenship, constitution, and human rights. Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights, and rights to information. Family and society. Concept of family, community (PRIs and other community-based organizations) and society.

Communication Skills **2 (1+1)**

Objective

To acquire competence in oral, written and non-verbal communication, develop strong personal and professional communication and demonstrate positive group communication.

Theory

Communication Process: The magic of effective communication; Building self-esteem and overcoming fears; Concept, nature and significance of communication process; Meaning, types and models of communication; Verbal and non-verbal communication; Linguistic and non-linguistic barriers to communication and reasons behind communication gap/ miscommunication.

Basic Communication Skills: Listening, speaking, reading and writing skills; Precis writing/ Abstracting/Summarizing; Style of technical communication; Curriculum vitae/resume writing; Innovative methods to enhance vocabulary, analogy questions.

Structural and Functional Grammar: Sentence structure, modifiers, connecting words and verbals; Phrases and clauses; Case: subjective case, possessive case, objective case; Correct usage of nouns, pronouns and antecedents, adjectives, adverbs and articles; Agreement of verb with the subject: tense, mood, voice; Writing effective sentences; Basic sentence faults.

Practical

Listening and note taking; Writing skills: precis writing, summarizing and abstracting; Reading and comprehension (written and oral) of general and technical articles; Micro-presentations and Impromptu Presentations: Feedback on presentations; Stage manners: grooming, body language, voice modulation, speed; Group discussions; Public speaking exercises; Vocabulary building exercises; Interview Techniques; Organization of events.

Suggested Readings

1. Carnegie Dale. 2018. *The Quick and Easy Way to Effective Speaking*. Fringer Print.
2. Francis Peter S J. 2012. *Soft Skills and Professional Communication*. Tata McGraw Hill, New Delhi.
3. Hill Napolean. 2014. *Think & Grow Rich*. Finger Print Publishing, New Delhi.
4. Kumar S and Pushpa Lata. 2011. *Communication Skills*. Oxford University Press.
5. Mehra Shital Kakkar. 2020. *Executive Presence*. Harper Business, New Delhi.
6. Murphy Joseph. 2020. *The Power of Your Subconscious Mind*. Srishti Publishers Distribution, New Delhi.
7. Neuliep James W. 2003. *Intercultural Communication: A Contextual Approach*. Houghton Mifflin Co, Boston.
8. Raman M and Singh P. 2000. *Business Communication*. Oxford University Press.
9. Seely J. 2013. *Oxford Guide to Effective Writing and Speaking*. Oxford University Press.

SEC-I

Mulberry Leaf Production Technology 4(0+4)

Objectives

i. To acquaint with the skills for quality leaf production
ii. Maximization of profit in mulberry leaf production

Practicals

Identifying characters of mulberry varieties. Prepartion of cuttings for raising saplings. Raising of mulberry saplings in tubes / polythene bags and in nursery bed by VAM inoculation. Raising of Kissan nursery. Scheduling of activities for mulberry cultivatin under rainfed condition. Scheduling of activities for mulberry cultivation under iirigated condition. Observing and recording mulberry growth and yield in different systems of planting – row system, kolar system and Indo-Japanese, 3M plantation. Raising mulberry garden exclusively for chawki silkworm rearing. Integrated nutrent management- Inorganic fertilizer and application. Organic farming – preparation of compost, vermicompost, biofertilizer, bio-organic formaulations - jeevamrutha, panchagavya. Enrichment of compost, vermicompost. Application of foliar spray in mulberry – nutrient, triacontanol, seriboost. Weed and their management – mechanical control, tillage, hoeing, digging, mulching, chemical control, merits and demerits. Mechanization of mulberry cultivation and its importance. Mulberry based integrated farming system – Features of IFS. Mixed farming, intercropping. Identification of pests of mulberry and its managment - Foliar, stem, root. Identification of diseases of mulberry by the symptoms – Foliar, stem, root. Integrated pest and disease management in mulberry. Utility of biocontrol agents in mublerry field. Maintenance of cultivation sheet and farm records. Economics of mulberry leaf production. Estimating the brushing capaciity for leaf production.

Suggested Readings

1. Choudhury P C and Giridhar K. 1987. *Mulberry Cultivation "Appropriate Sericulture Techniques"*. pp 18-34. International Centre for Training and Research Tropical Sericulturis. Manandwadi Road
2. Minamizawa K. 1997. *Moriculture, Science of Mulberry Cultivation*. pp 235-285. Oxford and IBH Publishing Co. Pvt. Ltd.
3. Rajanna L Das, P K Ravindran, S Bogesha, K Mishra R K, Singhvi N R, Katiyar R S and Jayaram H. 2005. *Mulberry Cultivation and Physiology*. CSB.

Silkworm Egg Production Technology 4 (0+4)

Objectives

i. Developing skill competency of the student in silkworm seed production, quality assessment of seed cocoon and producing disease free laying
ii. Developing the technical skill in handling diapause and non-diapause egg
iii. Training the students to detect the defective eggs through predictive test
iv. Building scientific skill in students to produce disease free layings

Practical

Study of characteristics of important parental breeds of *Bombyx mori* L. Silkworm embryo testing and preparation of slides. Study of procurement, transportation and preservation of seed cocoons. Study of moth emergence, coupling, decoupling and oviposition. Preparation of hibernating eggs and non-hibernating eggs on egg cards. Preparation of loose eggs of mulberry silkworm,

Bombyx mori L. Brine treatment for loose eggs of *Bombyx mori* L. Termination of hibernation in eggs of *Bombyx mori* L. through chemical methods. Studyof preliminary examination and mother moth examination for pebrine detection. Influence of mating duration on fecundity in *Bombyx mori* L. Effect of re-use of male moths on fecundity and hatching in silkworm. Influence of refrigeration of polyvoltine eggs of *Bombyx mori* L. on hatching.

Suggested Readings

1. Narasimhanna M N. 1998. *Manual on Silkworm Egg Production*. CSB, Bengaluru.
2. Jayant Jayaswal, K Giridhar, J Somi Reddy and H Jagadish Prabhu. 2008. Silkworm Seed Production. Central Silk Board, Bengaluru.
3. Tribhuwan Singh, Madan Mohan Bhat and Mohammad Ashraf Khan. 2010. *Silkworm Egg Science*. Daya Publishing House, Delhi.

Semester II

Diseases of Silkworm and their Management 3 (2+1)

Objectives

i. To Students needs to be acquiring the skills, knowledge and experiences the management of silkworm diseases.
ii. To acquaint the knowledge of silkworm diseases.
iii. To formulate and execute the management practices for silkworm diseases according to season.
iv. To assess the cocoon crop loss due to silkworm diseases.
v. To mitigate the probable unforeseen risks during silkworm crop period.

Theory

Introduction and importance of silkworm diseases. Nature and extent of damages caused to sericulture due to biotic and abiotic factors. Infectious and non-infectious diseases of silkworms including non-mulberry silkworms. Koch's postulates. Non-infectious diseases including physical and chemical injuries, nutritional and genetic disorders. Important infectious diseases: Pebrine – Causal agents, life cycles, incubation periods, symptoms, diagnosis, seasonal factors, epizootiology, prevention and control; Flacheire – Causal agents, life cycles, incubation periods, symptoms, diagnosis, seasonal factors, epizootiology, prevention and control; Muscardines – Causal agents, life cycles, incubation periods, symptoms, diagnosis, seasonal factors, epizootiology, prevention and control; Grasserie (BmNPV) – Causal agents, life cycles, incubation periods, symptoms, diagnosis, seasonal factors, epizootiology, prevention and control; CPV – Causal agents, life cycles, incubation periods, symptoms, diagnosis, seasonal factors, epizootiology, prevention and control; IFV – Causal agents, life cycles, incubation periods, symptoms, diagnosis, seasonal factors, epizootiology, prevention and control; DNV – Causal agents, life cycles, incubation periods, symptoms, diagnosis, seasonal factors, epizootiology, prevention and control. Cross infectivity of pathogens to silkworms. Impact of insect crop pests on silkworm. Impact of biological pest control on sericulture. Infectivity techniques. Determination of LC50 and ET50. Disinfection and hygiene, disinfectants and their mode of action.

Practicals

Study of gross pathology of different diseases. Causal agents of infectious disease and symptoms. Isolation and culturing of silkworm pathogens. Koch's postulates. Preparation of permanent slides. Infectivity techniques. Cross infectivity. Histopathological techniques. Patho-physiological techniques. Determination of LC_{50} and $ET_{50.}$ Effect of different insecticides on silkworms. Silkworm breeds and instars susceptibility. Preventive measures of infectious diseases. Disinfection and hygiene.

Suggested Readings

1. Ananthanarayanan. 2008. *Silkworm Rearing*. 266p. Biotech Books, New Delhi.
2. Anonymous. 1975. *Textbook of Tropical Sericulture*. 594p. Japan Overseas Co-operation Volunteers, Japan.
3. Aruga H. 1994. *Principles of Sericulture*. 376p. Oxford and IBH, New Delhi.
4. Dandin S B and Giridhar K. 2010. *Handbook of Sericulture Technologies*. 427p. Central Silk Board, Bangalore.
5. Dandin S B, Rajan R K, Mishra R K, Singh G B and Das P K. 2022. *A Model for Commercial Chawki Rearing*. 28p. Central Silk Board, Bangalore.
6. Datta R K. 1992. *Guidelines for Bivoltine Rearing*. 24p. Central Silk Board, Bangalore.
7. Forth H D. 1991. *Fundamentals of Soil Science*. 645p. John Wiley and Sons, New York.
8. Ganga G and Sulochana Chetty J. 2010. *An Introduction to Sericulture*. 302p. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
9. Ganga G. 2003. *Comprehensive Sericulture Vol. II - Silkworm Rearing and Silk Reeling*. 429p. Oxford and IBH, New Delhi.
10. Govindaiah, Gupta V P, Sharma D D, Rajadurai S and Nishitha Naik V. 2005. *Textbook on Mulberry Crop Protection*. 247p. Central Silk Board, Bangalore.
11. Govindan R, Narayanaswamy T K and Devaiah M C. 1998. *Principles of Silkworm Pathology*. 420p. Seri Scientific Publishers, Bangalore.
12. Jolly M S. 1987. *Appropriate Sericulture Techniques*. 215p. Central Sericultural Research and Training Institute, CSB, Mysore.
13. Krishnaswami S, Narasimhanna M N, Suryanarayan, S K and Kumararaj S. 1979. *Silkworm Rearing,* pp 99-129. FAO Manual, Vol. II. FAO, Rome.
14. Muzafar Ahmad Bhat, Abdul Aziz, Suraksha Chanotra, Shamim Ahmed Bandey, Zafar Iqbal Bhuroo and Mohammad Azam. 2020. *A Textbook on Introduction to Sericulture and Soil Science*. 425p. IP Innovative Publication, New Delhi.
15. Narayanaswamy K C and Devaiah M C. 1998. *Silkworm Uzi Fly*, 232 p. 232p. Zen Publishers, Bengaluru.
16. Nataraju B, Sathyaprasad K, Manjunath D and Aswani Kumar C. 2005. *Silkworm Crop Protection*. pp 1-324. Central Silk Board, Bangalore.
17. Rajan R K, Akiyoski Muroga and Datta R K. 1996. *Manual of Young Silkworm Rearing*. 24p. Central Silk Board, Bangalore.
18. Savithri G, Sujathamma P and Neeraja P. 2016. *Sericulture Industry: An Overview*. 194p. Agrobios (India) Publications, Rajasthan.

19. Sengupta K. 1989. *A Guide for Bivoltine Sericulture*. 42p. Central Sericultural Research and Training Institute, Mysore.
20. Singh R N and Saratchandra B. 2011. *Sericulture Entomology*. 493p. APH Publishing Co-operations, New Delhi.
21. Singh R N, Samson M V and Datta R K. 2000. *Pest Management in Sericulture*. 327p. Indian Publishers New Delhi.
22. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture*. 209p. Central Silk Board, Bangalore.

Pests of Host Plants of Silkworm and their Management **2 (1+1)**

Objectives

i. Students need to acquire the skills, knowledge and experiences on insect pests of host plants of silkworms
ii. To impart knowledge on insect pests of silkworm host plants.
iii. To acquaint and enlisting the reasons responsible for insect attack to silkworm hosts.
iv. To study management of silkworm host plant pests.
v. To impart skills on production of natural enemies of pests of silkworm host plants.

Theory

Definition of pest, Classification of insect pests and status of pest, Causes for pest outbreak. Pest residue, Biotic potential, Environmental resistance, Concepts and Principles of crop pest management. Insect pest of mulberry (Defoliators and Sucking Pests) and their management. Non insect pests of mulberry (Mites, Snails and slugs) and their management. Insect pest of *Terminalia* spp., Sal, Som and their management. Insect pest of oak and their management. Insect pest of ber, castor and their management. Definition of pesticide, Classification of insecticides (based on mode of action, Mode of entry, Chemical nature). Formulation, objectives of formulation. Advantages and disadvantages of different formulations. Safe period, Safer methods of application of insecticides and and Pesticide residue problems.

Practicals

Types of damage to plants by different insects, Concept of pest, their classification, reasons for insects assuming pest status. Study of defoliating and sucking pests of mulberry. Visit to mulberry and non mulberry plots to study the nature and symptoms of pest damage. Study of pests of *Terminalia* spp and Sal, *Shorea robusta.* Study of pests of Ber*, Zizyphus jujuba*, Oak, Som, and Castor. Pesticidal formulations and method of application. List of commonly used pesticides and related useful information.

Suggested Readings

1. Khan Mohammad Ashraf, Madan Mohan Bhat and Tribhuwan Singh. 2011. *Silkworm Crop Protection*. 224p. Daya Publishing House, New Delhi.
2. Sathe T V and Jadhav A D. 2012. *Sericulture and Pest Management*. 197p. Daya Publishing House, New Delhi.

3. Singh R N and Beera Saratchandra. 2011. *Sericulture Entomology*. 493p. APH Publishing Corporation, New Delhi.
4. Singh R N, Samson M V and Datta R K. 2000. *Pest Management in Sericulture*. 387p. Indian Publisher and Distributions, New Delhi.

Journals:

1 Annual Review of Entomology.
2 Journal of Economic Entomology.
3 Journal of Medical Entomology.
4 Environmental Entomology.
5 Medical and Veterinary Entomology.
6 Ecological Entomology.
7 Systematic Entomology.
8 Physiological Entomology.

Online Sources:

- www.cabi.in/
- www.karnataka.gov.in/kssrdi/
- www.tnau.ac.in/

Pests of Silkworm and their Management **3 (2+1)**

Objectives

i. To acquire the skills, knowledge and experiences the management of silkworm pests.
ii. To impart the knowledge of different silkworm pests.
iii. To formulate and execute the management practices for mitigate the silkworm pest infestation.
iv. To assess the cocoon crop loss due to silkworm pest infestation.
v. To mitigate the probable unforeseen risks during silkworm crop period.

Theory

Introduction, Glossary, Classification minor and major pests. Concepts of Pest management, Economic Injury Level (EIL) and Economic threshold level (ETL). Classification of pests based on occurrence, level of infestation, extent of loss and site of preference. Importance of silkworm pests including insect and non-insect pests. Tachnid fly, Exorista sp. of silkworm: classification, distribution, occurrence, nature of damage and alternative hosts. External morphology of different stages of silkworm uzi fly. Uzi fly behaviour in relation to emergence, mating, oviposition and flight. Uzi fly management through physical and mechanical practices. Uzi fly management through chemo-sterilization, biological control and genetic control. Uzi fly integrated pest management (IPM) practices. Importance of cocoon pests in grainages viz., dermestid beetles, earwigs, ants and mites, their biology and nature of damage. Grainage pest management through physical, mechanical and chemical means and integrated management of the pest. Occurrence, nature of damage, prevention and control of other pests of silkworm like Pantatomid bug (Canthecons sp.), Praying mantid (Hierodula sp.), Red ant (Oecophylla sp.), Braconid fly (Apantdes sp.). Occurrence and nature of damage caused by non-insect pests like rats, squirrels, lizards, mites, nematodes, snakes, birds, etc.

Practicals

Major pests of mulberry silkworm, *Bombyx mori* L. Minor pests of mulberry silkworm, *Bombyx mori* L. Study of life cycle of silkworm uzi fly, *Bombyx mori* L. Estimation of the incidence of uzi fly in silkworm crop. Study of management of Indian uzi fly by through physical and mechanical practices. Study of management of Indian uzi fly by chemo-sterilization, biological control and genetic control. Study of management of Indian uzi fly by use of bio-pesticides. Study of biology and management of dermestid beetle. Study of biology and management of ants. Study of non mulberry silkworms pests and their management. Study of non-insect pests like rats, squirrels, lizards, mites, nematodes, snakes, birds, etc. Identification and collection of pests and affected specimens. Visit to Seri-agro-ecosystems (farmer's field). Visit to R and D institute. Presentations.

Suggested Readings

1. Ananthanarayanan. 2008. *Silkworm Rearing*. 266p. Biotech Books, New Delhi.
2. Anonymous. 1975. *Textbook of Tropical Sericulture*. 594p. Japan Overseas Co-operation Volunteers, Japan.
3. Aruga H. 1994. *Principles of Sericulture*. 376p. Oxford and IBH, New Delhi.
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12. Jolly M S. 1987. *Appropriate Sericulture Techniques*. 215p. Central Sericultural Research and Training Institute, CSB, Mysore.
13. Krishnaswami S, Narasimhanna M N, Suryanarayan, S K and Kumararaj S. 1979. *Silkworm Rearing,* pp 99-129. FAO Manual, Vol. II. FAO, Rome.
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15. Narayanaswamy K C and Devaiah M C. 1998. *Silkworm Uzi Fly*, 232 p. 232p. Zen Publishers, Bengaluru.
16. Nataraju B, Sathyaprasad K, Manjunath D and Aswani Kumar C. 2005. *Silkworm Crop Protection*. pp 1-324. Central Silk Board, Bangalore.
17. Rajan R K, Akiyoski Muroga and Datta R K. 1996. *Manual of Young Silkworm Rearing*. 24p. Central Silk Board, Bangalore.
18. Savithri G, Sujathamma P and Neeraja P. 2016. *Sericulture Industry: An Overview*. 194p. Agrobios (India) Publications, Rajasthan.

19. Sengupta K. 1989. *A Guide for Bivoltine Sericulture*. 42p. Central Sericultural Research and Training Institute, Mysore.
20. Singh R N and Saratchandra B. 2011. *Sericulture Entomology*. 493p. APH Publishing Co-operations, New Delhi.
21. Singh R N, Samson M V and Datta R K. 2000. *Pest Management in Sericulture*. 327p. Indian Publishers New Delhi.
22. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture*. 209p. Central Silk Board, Bangalore.

Journals:

- Bulletin of Indian Academy of Sericulture, CSTRI, Berhampore
- Indian Silk, CSB, Bengaluru
- Journal of Sericultural Science of Japan, Japan
- Seridoc, CSRTI (CSB), Mysore
- Sericologia, ISC, Bengaluru
- Korean Journal of Sericulture, Korea
- Indian Journal of Sericulture, CSRTI (CSB), Mysore
- And other Periodicals, Journals, Reports, Brochures, etc.

Online Sources:

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/
- www.tnau.ac.in/
- www.csrtimys.res.in/

Bivoltine Silkworm Rearing **2 (1+1)**

Objectives

i. To acquire the skills and knowledge about the bivoltine silkworm rearing
ii. To impart with the knowledge on bivoltine silkworm rearing
ii. To formulate and execute the silkworm rearing plan by assessing the available resources and season
iv. To acquaint with and enlisting the pros and cons involved in the bivoltine rearing
v. To assess the prevailing market prices and select suitable market for sale of cocoons
vi. To mitigate the probable unforeseen risks during silkworm crop period

Theory

Importance of Bivoltine sericulture; JICA method of mulberry cultivation and silkworm rearing; Popular bivoltine races; Importance of disinfection; Disinfection at three levels – rearing house, surroundings, entrance, rotary mountage; Incubation of loose eggs in incubation frames and black boxing; Brushing with double net; Selection of leaf for Chawki rearing; Transferring of larvae to rearing trays, bed cleaning, care during moulting and distribution of chawki larvae; Late age silkworm rearing, silkworm rearing house, shoot rearing stand, hygiene maintenance,

transportation and preservation of mulberry shoots, nylon net for uzi fly prevention, space requirement according to instar wise; Mounting of larvae, jobrai method of collection of mature larvae mounting of worms to rotary mountage; Harvesting of cocoons, sorting, packing and marketing; Economics of bivoltine silkworm rearing.

Practicals

Raising mulberry garden as per JICA recommendations which includes INM, IPM, IDM practices, weed management, pruning and harvesting; Rearing of bivoltine silkworm races as per JICA specifications which includes disinfection of silkworm rearing house and appliances; Incubation of eggs, black boxing; Selection and harvesting of leaf for chawki rearing; brushing of layings; Bed cleaning, care during moulting and distribution of chawki larvae; Late age silkworm rearing, silkworm rearing house, shoot rearing stand, hygiene maintenance, transportation and preservation of mulberry shoots, nylon net for uzi fly prevention, space requirement according to instar wise; Mounting of larvae, jobrai method of collection of mature larvae mounting of worms to rotary mountage; Harvesting of cocoons, sorting, packing and marketing; Working out the economics of mulberry cultivation and bivoltine silkworm rearing.

Suggested Readings

1. Ananthanarayanan. 2008. *Silkworm Rearing*. 266p. Biotech Books, New Delhi.
2. Anonymous. 1975. *Textbook of Tropical Sericulture*. 594p. Japan Overseas Co-operation Volunteers, Japan.
3. Aruga H. 1994. *Principles of Sericulture*. 376p. Oxford and IBH, New Delhi.
4. Dandin S B and Giridhar K. 2010. *Handbook of Sericulture Technologies*. 427p. Central Silk Board, Bangalore.
5. Dandin S B, Rajan R K, Mishra R K, Singh G B and Das P K. 2022. *A Model for Commercial Chawki Rearing*. 28p. Central Silk Board, Bangalore.
6. Datta R K. 1992. *Guidelines for Bivoltine Rearing*. 24p. Central Silk Board, Bangalore.
7. Forth H D. 1991. *Fundamentals of Soil Science*. 645p. John Wiley and Sons, New York.
8. Ganga G and Sulochana Chetty J. 2010. *An Introduction to Sericulture*. 302p. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
9. Ganga G. 2003. *Comprehensive Sericulture Vol. II - Silkworm Rearing and Silk Reeling*. 429p. Oxford and IBH, New Delhi.
10. Govindaiah, Gupta V P, Sharma D D, Rajadurai S and Nishitha Naik V. 2005. *Textbook on Mulberry Crop Protection*. 247p. Central Silk Board, Bangalore.
11. Govindan R, Narayanaswamy T K and Devaiah M C. 1998. *Principles of Silkworm Pathology*. 420p. Seri Scientific Publishers, Bangalore.
12. Jolly M S. 1987. *Appropriate Sericulture Techniques*. 215p. Central Sericultural Research and Training Institute, CSB, Mysore.
13. Krishnaswami S, Narasimhanna M N, Suryanarayan, S K and Kumararaj S. 1979. *Silkworm Rearing,* pp 99-129. FAO Manual, Vol. II. FAO, Rome.
14. Muzafar Ahmad Bhat, Abdul Aziz, Suraksha Chanotra, Shamim Ahmed Bandey, Zafar Iqbal Bhuroo and Mohammad Azam. 2020. *A Textbook on Introduction to Sericulture and Soil Science*. 425p. IP Innovative Publication, New Delhi.
15. Narayanaswamy K C and Devaiah M C. 1998. *Silkworm Uzi Fly*, 232 p. 232p. Zen Publishers, Bengaluru.
16. Nataraju B, Sathyaprasad K, Manjunath D and Aswani Kumar C. 2005. *Silkworm Crop Protection*. pp 1-324. Central Silk Board, Bangalore.

17. Rajan R K, Akiyoski Muroga and Datta R K. 1996. *Manual of Young Silkworm Rearing*. 24p. Central Silk Board, Bangalore.
18. Savithri G, Sujathamma P and Neeraja P. 2016. *Sericulture Industry: An Overview*. 194p. Agrobios (India) Publications, Rajasthan.
19. Sengupta K. 1989. *A Guide for Bivoltine Sericulture*. 42p. Central Sericultural Research and Training Institute, Mysore.
20. Singh R N and Saratchandra B. 2011. *Sericulture Entomology*. 493p. APH Publishing Co-operations, New Delhi.
21. Singh R N, Samson M V and Datta R K. 2000. *Pest Management in Sericulture*. 327p. Indian Publishers New Delhi.
22. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture*. 209p. Central Silk Board, Bangalore.

Journals:

- Bulletin of Indian Academy of Sericulture, CSTRI, Berhampore
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- Journal of Sericultural Science of Japan, Japan
- Seridoc, CSRTI (CSB), Mysore
- Sericologia, ISC, Bengaluru
- Korean Journal of Sericulture, Korea
- Indian Journal of Sericulture, CSRTI (CSB), Mysore
- And other Periodicals, Journals, Reports, Brochures, etc.

Online Sources:

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/
- www.tnau.ac.in/
- www.csrtimys.res.in/

Personality Development 2 (1+1)

Objective

To make students realize their potential strengths, cultivate their inter-personal skills and improve employability.

Theory

Personality definition, Nature of personality, theories of personality and its types. The humanistic approach - Maslow's self-actualization theory, shaping of personality, determinants of personality, Myers-Briggs Typology Indicator, Locus of control and performance, Type A and Type B behaviours, Personality and organizational behaviour.

Foundations of individual behaviour and factors influencing individual behaviour, Models of individual behaviour, Perception and attributes and factors affecting perception, Attribution theory and case studies on perception and attribution. Learning: Meaning and definition, theories and principles of learning, Learning and organizational behaviour, Learning and training, Learning feedback. Attitude and values, Intelligence- types of Intelligence, theories of intelligence, measurements of intelligence, factors influencing intelligence, intelligence and Organizational

behaviour, emotional intelligence. Motivation - theories and principles, teamwork and group dynamics.

Practical

MBTI personality analysis, Learning styles and strategies, Motivational needs, Firo-B, Interpersonal communication, Teamwork and team building, Group dynamics, Win-win game, Conflict management, Leadership styles, Case studies on personality and organizational behaviour.

Suggested Readings

1. David R Shaffer. 2008. *Social and Personality Development* (6th Edn.). 622p. Wadsworth Publishing Company, Belmont, CA 94002, US.
2. Heller and Robert. 1999. *Effective Leadership*. 72p. Essential Manager Series, DK Publishing, Noida, UP.
3. Hindle and Tim. 2002. *Reducing Stress*. 72p. Essential Manager Series, DK Publishing, Noida, UP.
4. Mile D J. 2004. *Power of Positive Thinking*, Rohan Book Company, Delhi.
5. Pravesh Kumar. 2008. *All About Self- Motivation*. 144p. Goodwill Publishing House, New Delhi.
6. Smith B. 2004. *Body Language*. 63p. Rohan Book Company, Delhi.
7. Stephen E Lucas. 2011. *Art of Public Speaking*. 480p. Tata McGraw-Hill Education, New Delhi.
8. Sudhir Andrews. 2008. *How to Succeed at Interviews*. 292p. Tata McGraw-Hill Education, New Delhi.

Environmental Studies and Disaster Management 3 (2+1)

Objective

To expose and acquire knowledge on the environment and to gain the state-of-the-art-skill and expertise on management of disasters.

Theory

Introduction to Environment. Environmental studies - Definition, scope and importance, Multidisciplinary nature of environmental studies, Segments of environment, Spheres of Earth - Lithosphere - Hydrosphere - Atmosphere - Different layers of atmosphere. Natural Resources: Classification, Forest resources, Water resources, Mineral resources, Food resources, Energy resources, Land resources, Soil resources. Ecosystems - Concept of an ecosystem, Structure and function of an ecosystem, Energy flow in the ecosystem, Types of ecosystem. Biodiversity and its conservation: Introduction, definition, types. Biogeographical classification of India. Importance and Value of biodiversity. Biodiversity hot spots. Threats and Conservation of biodiversity.

Environmental Pollution: Definition, cause, effects and control measures of Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, light pollution. Solid Waste Management: Classification of solid wastes and management methods, Composting, Incineration, Pyrolysis, Biogas production, Causes, effects and control measures of

urban and industrial wastes. Social Issues and the Environment: Urban problems related to energy. Water conservation, rain water harvesting, watershed management. Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act. Human Population and the Environment: Environment and human health, Human rights, Value education, Women and child welfare, Role of Information Technology in environment and human health.

Disaster management: Disaster definition, Types. Natural Disasters - Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves. Man Made Disasters - Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, road accidents, rail accidents, air accidents, sea accidents. International and National strategy for disaster reduction. Concept of disaster management, national disaster management framework, financial arrangements, role of NGOs, community-based organizations and media in disaster management. Central, state, district and local administration in disaster control; Armed forces in disaster response; Police and other organizations in disaster management.

Practical

Visit to a local area to document environmental assets (river/forest/grassland/hill/mountain). Energy: Biogas production from organic wastes. Visit to wind mill / hydro power/solar power generation units. Biodiversity assessment in farming system. Floral and faunal diversity assessment in polluted and unpolluted system. Visit to local polluted site - Urban/Rural/Industrial/Agricultural to study of common plants, insects and birds. Environmental sampling and preservation. Water quality analysis: pH, EC and TDS. Estimation of Acidity, Alkalinity. Estimation of water hardness. Estimation of DO and BOD in water samples. Estimation of COD in water samples. Enumeration of *E. coli* in water sample. Assessment of Suspended Particulate Matter (SPM). Study of simple ecosystem – Visit to pond/river/hills. Visit to areas affected by natural disaster.

Suggested Readings

1. De A K. 2010. *Environmental Chemistry*. 384p. New Age International Publishers, New Delhi.
2. Dhar Chakrabarti P G. 2011. *Disaster Management - India's Risk Management Policy Frameworks and Key Challenge*. 36p. Centre for Social Markets (India), Bengaluru.
3. Erach Bharucha. 2013. *Textbook for Environmental Studies for Undergraduate Studie*. 324p. University Grants Commission, New Delhi.
4. Parthiban K T, Vennila S, Prasanthrajan M and Umesh Kanna S. 2003. *Forest, Environment, Biodiversity and Sustainable Development*. Narendra Publishing House, New Delhi (In Press).
5. Prasanthrajan M and Mahendran P P. 2008. *A Textbook on Ecology and Environmental Science,*. 288p. Agrotech Publishing Academy, Udaipur.
6. Prasanthrajan M. 2018. *Objective Environmental Studies and Disaster Management.* 146p. Scientific Publishers, Jodhpur, India.
7. Sharma P D. 2011. *Ecology and Environmen*. 240p. Rastogi Publications, Meerut, India.

8. Tyler Miller G and Scott E Spoolman. 2008. *Living in the Environment (Concepts, Connections, and Solutions*. 828p. Brooks/cole, Cengage Learning Publication, Belmont, USA.

National Cadet Corps (NCC-II) 1(0+1)

- Arms Drill - Attention, stand at ease, stand easy. Getting on parade. Dismissing and falling out. Ground/take up arms, examine arms. Shoulder from the order and vice-versa, present from the order and vice-versa. Saluting at the shoulder at the halt and on the march. Short/long trail from the order and vice- versa. Guard mounting, guard of honor, Platoon/Coy Drill.
- Characteristics of rifle (.22/.303/SLR), ammunition, fire power, stripping, assembling, care, cleaning, and sight setting. Loading, cocking, and unloading. The lying position and holding.
- Trigger control and firing a shot. Range Procedure and safety precautions. Aiming and alteration of sight. Theory of groups and snap shooting. Firing at moving targets. Miniature range firing. Characteristics of Carbine and LMG.
- Introduction to map, scales, and conventional signs. Topographical forms and technical terms.
- The grid system. Relief, contours, and gradients. Cardinal points and finding north. Types of bearings and use of service protractor. Prismatic compass and its use. Setting a map, finding north and own position. Map to ground and ground to map. Knots and lashings, Camouflage and concealment, Explosives and IEDs.
- Field defenses obstacles, mines and mine lying. Bridging, waterman ship. Field water supplies, tracks and their construction. Judging distance. Description of ground and indication of landmarks. Recognition and description of target. Observation and concealment. Field signals. Section formations. Fire control orders. Fire and movement. Movement with/without arms. Section battle drill. Types of communication, media, latest trends and developments.
- Importance and role of youth leadership: Meaning, types and traits of leadership, qualities of good leaders, importance and roles of youth leadership
- Life competencies: Definition and importance of life competencies, problem-solving and decision-making, interpersonal communication
- Youth development programs: Development of youth programs and policy at the national level, state level and voluntary sector; youth-focused and youth-led organizations
- Health, hygiene and sanitation: Definition needs and scope of health education; role of food, nutrition, safe drinking water, water borne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programs and reproductive health. Youth health, lifestyle, HIV AIDS and first aid. Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid
- Youth and yoga: History, philosophy, concept, myths, and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method

Entrepreneurship Development and Business Management 3 (2+1)

Objectives

i. To provide student an insight into the concept and scope of entrepreneurship.

ii. To expose the student to various aspects of establishment and management of a small business unit.

iii. To enable the student to develop financially viable agribusiness proposal.

Theory

Development of entrepreneurship, motivational factors, social factors, environmental factors, characteristics of entrepreneurs, entrepreneurial attributes/competencies. Concept, need for and importance of entrepreneurial development. Evolution of entrepreneurship, objectives of entrepreneurial activities, types of entrepreneurs, functions of entrepreneurs, importance of entrepreneurial development, and process of entrepreneurship development. Environment scanning and opportunity identification need for scanning–spotting of opportunity-scanning of environment– identification of product / service – starting a project, factors influencing sensing the opportunities. Infrastructure and support systems - good policies, schemes for entrepreneurship development, role of financial institutions, and other agencies in entrepreneurship development. Steps involved in functioning of an enterprise. Selection of the product / services, selection of form of ownership, registration, selection of site, capital sources, acquisition of manufacturing know how, packaging and distribution. Planning of an enterprise, project identification, selection and formulation of project, project report preparation, enterprise management. Production management – product, levels of products, product mix, quality control, cost of production, production controls, material management. Production management – raw material costing, inventory control. Personal management – manpower planning, labour turn over, wages / salaries. Financial management /accounting – funds, fixed capital and working capital, costing and pricing, long term planning and short-term planning, book keeping, journal, ledger, subsidiary books, annual financial statement, and taxation. Marketing managemen t- market, types, marketing assistance, market strategies. Crisis management - raw material, production, leadership, market, finance, natural etc.

Practical

Visit to small scale industries/agro-industries, Interaction with successful entrepreneurs/ agric-entrepreneurs. Visit to financial institutions and support agencies. Preparation of project proposal for funding by different agencies.

Suggested Readings:

1. Poornima M C. 2018. *Entrepreneurship Development and Small Business Enterprises*. (3rd Edn.). 432p. Pearson Educations, New Delhi.
2. Desai V and Kaur K. 2015. *Entrepreneurship: Development and Management*. 481p. Himalaya Publishing House Pvt. Ltd., Bengaluru.
3. Desai V. 2011. *Small Scale Industries and Entrepreneurship*. 570p. Himalaya Publishing House Pvt. Ltd., Bengaluru.
4. Gupta C B. 2021. *Management Theory and Practice*. 650p. Sultan Chand and Sons, Delhi.
5. Indu Grover. 2008. *Handbook on Empowerment and Entrepreneurship*. 192p. Agrotech Public Academy, Udaipur.
6. Khanka S S. 1999. *Entrepreneurial Development*. 794p. S Chand and Co. New Delhi.
7. Mehra P. 2016. *Business Communication for Managers*. 432p. Pearson Education India, New Delhi.
8. Pandey M and Tewari D. 2010. *The Agribusiness Book*. 581p. CBS Publishers & Distributor Pvt. Ltd., New Delhi.
9. Singh D. 1995. *Effective Managerial Leadership*. 171p. Deep and Deep Publications, New Delhi.

10. Singal R K. 2013. *Entrepreneurship Development and Management*. 300p. S K Kataria and Sons, Delhi.
11. Tripathi P C, Reddy P N and Ashish Bajpai. 2021. *Principles of Management* (7th Edn.). 560p. Tata McGraw Hill, Noida, Uttar Pradesh.

SEC-II

Silkworm Rearing Technology 4 (0+4)

Objectives

i. Enhancement of rearing skill of the students for cocoon production
ii. To improve quality and quantity of cocoon production through induction of modern rearing technology in Sericulture

Practical

Life cycle of silkworm *Bombyx mori*. Study of plan for rearing house - chawki and late-age silkworm rearing house. Study of different rearing equipment/appliances. Disinfectants and their applications. Study of egg incubation methods and black boxing. Study of brushing of silkworms and selection of leaf for different instars. Study of bed cleaning methods and moulting worms and management. Study of different types of chawki and types of late-age silkworm rearing methods. Study of shoot feeding method and shelf rearing method. Role of environmental factors, micro- and macro-nutrients on growth and development of silkworms. Identification of ripe worms and methods of mounting. Study of fortification of mulberry leaves and artificial diet in silkworm rearing. Study of use of juvenile hormone analogs on silkworm rearing. Harvesting of cocoons, transportation and marketing of cocoons. Study of natural enemies of silkworms. Study on maintenance of rearing records. Visit to chawki rearing centers. Visit to farmers mulberry garden, rearing house and cocoon market

Suggested Readings

1. S B Dandin and K Giridhar. 2014. *Handbook of Sericulture Technologies*. CSB.
2. G Ganga and Sulochana Chetty. 2022. *An Introduction to Sericulture.* CSB.
3. FAO Manual on Sericulture.
4. B Nataraju, K Sathyprakash, D Manjunath and C Aswani Kumar. 2005. *Silkworm Crop Protection.*
5. *Intensive Bivoltine Sericulture Technology Package*. CSR&TI, Mysore.

Silk Reeling Technology 4 (0+4)

Objectives

i. To practice cocoon reeling
ii. To develop with the skills of cocoon reeling in multiend reeling machine

Practical

Crossbreed cocoon reeling in multiend reeling machine by floating system – Basket method of steam stifling, cocoon cooking and brushing by open (single) pan method. Practicing the reeling path in multiend reeling machine with 150 -200 rpm reeling speed. Putting the tavellette

croissure and maintaining a rawsilk denier of 20/22d. Reel permeation by soaking method and re-reeling by closed type re-reeling machine with 200-250 rpm speed, lacing, silk examination and skeining.

Bivoltine cocoon reeling in multiend reeling machine by sunken system – hot air stifling by batch method using hot air oven or ushnakoti. Partial drying or complete drying of cocoons. Pressurised cooking by circular cocoon cooking unit, brushing by individual mechanical bushing unit, reeling cocoons in sunken system in multiend reeling machine. Putting the tavellette croissure and maintaining a rawsilk denier of 20/22d. Reel permeation by soaking method and re-reeling by closed type re-reeling machine with 200-250 rpm speed, lacing, silk examination and skeining.

Dupion silk reeling using the double and reelable defective cocoons in charaka and producing raw silk yarn of above 60D. Working out the economics of crossbreed, bivoltine and dupion raw silk production.

Suggested Readings

1. Anonymous. 2003. *Seri Business Manual*. CSB.
2. Anonymous. 2003. *Vanya Silks*. CSB.
3. Krishnaswami S, Madhava Rao N R, Suryanarayan S K and Sundaramurthy T S. 1972. *Sericulture Manual 3- Silk Reeling*. FAO. Rome,
4. Mahadevappa, V G Haliyal, D G Shankar and Ravindra Bhandiwad. *Mulberry silk reeling technology*.
5. Tammanna N and Sonuwalker. *Handbook of Silk Technology*.
6. Yong-woo Lee. *Silk Reeling and Testing Manual*. National Sericulture and Entomology Institute, Seoul, Republic of Korea.

Post-Semester II (Only for exit option for award of UG-Certificate in Sericulture)

S. No.	Course Title	Credit Hours
SCE 121	Internship (10 weeks)	10 (0+10)

Student taking various modules will get a Certificate with Nomenclature as follows-

Nomenclature of Certificate	Module taken	
	Semester-I	Semester-II
UG Certificate in Sericulture	SEC – 1	SEC – 2

Semester III

Botany and Cytology of Host Plants of Silkworms 3 (2+1)

Objectives

i. To study the botanical classification and cytological details of hosts plants of mulberry
ii. To understand the breeding systems of different hosts plants of different silkworm, basic cell program, cell life cycle, seed formation anatomy of plants and cytological details like chromosomal number and their behavior during division, ploidy level, etc.

Theory

Taxonomy, systematics and botanical description of mulberry, mulberry silk worm host plant. Taxonomy, systematics and botanical description of Terminalia and Quercus, host plants of tasar silk worm. Taxonomy, systematics and botanical description of Som and Soalu, host plants of Muga silkworm. Taxonomy, systematics and botanical description of castor, tapioca and kessaru, host plants of Eri silkworm. Poly embryonic seed in mulberry. Mitosis and karyo morphological studies in host plants of silkworms. Micro and mega sporogenesis and fertilization in mulberry. Fruit seed development and parthenocarpy in mulberry.

Practical

Botanical description of mulberry. Botanical description of Terminalia and Quercus. Botanical description of Som and Soalu. Botanical description of castor, tapioca and kessuru. Anatomy of root, stem, leaf, fruit and seed in mulberry. Micro and mega sporogenesis and fertilization in mulberry. Squashing and smearing techniques in mulberry. Karyo morphology and idiogram in some host plants of silkworms.

Suggested Readings

1. Chakraborti S P, Choudhuri S Roy and Bindroo B B. 2013. *A textbook on Mulberry Breeding and Genetics*. 193p. Kalyani Publishers, New Delhi.
2. Amitabha Sarkar. 2015. *Mulberry Breeding*. 208p. Kalyani Publishers, New Delhi.
3. Sarkar D D. 1998. *The Silkworm Biology, Genetics and Breeding*. 338p. Vikas Publishing House Pvt. Ltd., New Delhi.
4. Singh B D. 2012. *Fundamental of Genetics*. 719p. Kalyani Publishers, New Delhi.
5. Tazima Y. 1964. *The Genetics of Silkworm*. 253p. Logos Press Ltd., London.
6. Gardner E J, Simmous M J and Snustad D P. 1991. *Principles of Genetics*. 649p. John Willey and Sons Inc., New York.
7. Anonymous. 1987. *FAO Manual on Sericulture.* 150p. CSB, Bangalore.
8. Anonymous. 2006. *Wild Silks of India (Vol. I). An Introduction to Vanya Silks.* pp 86-111. CSB, Bangalore.

Genetics and Breeding of Host Plants of Silkworms 3 (2+1)

Objectives

i. To study the breeding methods that can be employed for improvement of host plants of silk worm.

ii. Studying the flower biology, modes of reproduction, principles, methods of breeding specifically can be adopted for specific host plants of silk worm.

Theory

Germplasm sources, geographical distribution and exploration. Centres involved in crop improvement program of host plants of silkworms. Conservation and role of germplasm in crop improvement. Inheritance of economic characters (quantitative and qualitative characters). Breeding methods for self- and cross-pollinated crops. Objectives and pre-requisites of mulberry breeding.

Methods of breeding, viz., introduction and acclimatisation, methods of selection in mulberry. Hybridization, heterosis breeding, backcross, population improvement, mutation breeding, polyploid breeding. Breeding for resistance to biotic and abiotic factors - drought, diseases, pests, salinity and alkalinity. Breeding for leaf quality. Evaluation and statistical approach for yield test in mulberry. Varietal multiplication and dissemination.

Practical

Procedure for mass and pedigree selection, and its uses in mulberry improvement. Techniques of hybridization in mulberry and its appliances necessary for breeding. Procedure for collection of pollen and artificial pollination in mulberry, details of recording data. Procedure for induction of polyploidy in mulberry-treatment with colchicine. Different techniques of induction of mutation.

Suggested Readings

1. Chakraborti S P, Choudhuri S Roy and Bindroo B B. 2013. *A textbook on Mulberry Breeding and Genetics*. 193p. Kalyani Publishers, New Delhi.
2. Amitabha Sarkar. 2015. *Mulberry Breeding*. 208p. Kalyani Publishers, New Delhi.
3. Sarkar D D. 1998. *The Silkworm Biology, Genetics and Breeding*. 338p. Vikas Publishing House Pvt. Ltd., New Delhi.
4. Singh B D. 2012. *Fundamental of Genetics*. 719p. Kalyani Publishers, New Delhi.
5. Tazima Y. 1964. *The Genetics of Silkworm*. 253p. Logos Press Ltd., London.
6. Gardner E J, Simmous M J and Snustad D P. 1991. *Principles of Genetics*. 649p. John Willey and Sons Inc., New York.
7. Anonymous. 1987. *FAO Manual on Sericulture*. 150p. CSB, Bangalore.
8. Anonymous. 2006. *Wild Silks of India (Vol. I). An Introduction to Vanya Silks.* pp 86-111. CSB, Bangalore.

Cytology and Genetics of Silkworm 2 (2+0)

Objectives

i. General objectives of the course study of cell and its components.
ii. To know number of Chromosomes in different species of Silkworms and identification.

Theory

History of cytology and genetics. Basic terminology of cytology and genetics. Biology of the silkworm *Bombyx mori.* Cell and types of cells. Cell cycle (Mitosis and Meiosis). Chromosome and structural models of chromosomes. Structure and chemical composition of nucleic acids. Mendels laws of inheritance. Genetic interactions and its methods. Concepts of crossing over and types crossing over. Linkage and chromosomal maps. Concept and principles of maternal inheritance in silkworm. Qualitative and quantitative characters in silkworm. Concepts of genotype, phenotype. Concepts, heritability and genetic advance. Hereditary traits of silkworms at different stages. Conservation strategies of genetic Stocks of silkworms. Genetic basis of hormonal mechanism in silkworm. Sex determination in silkworms.

Suggested Readings

1. Chakraborti S P, Choudhuri S Roy and Bindroo B B. 2013. *A textbook on Mulberry Breeding and Genetics*. 193p. Kalyani Publishers, New Delhi.
2. Amitabha Sarkar. 2015. *Mulberry Breeding*. 208p. Kalyani Publishers, New Delhi.
3. Sarkar D D. 1998. *The Silkworm Biology, Genetics and Breeding*. 338p. Vikas Publishing House Pvt. Ltd., New Delhi.
4. Singh B D. 2012. *Fundamental of Genetics*. 719p. Kalyani Publishers, New Delhi.
5. Tazima Y. 1964. *The Genetics of Silkworm*. 253p. Logos Press Ltd., London.
6. Gardner E J, Simmous M J and Snustad D P. 1991. *Principles of Genetics*. 649p. John Willey and Sons Inc., New York.
7. Anonymous. 1987. *FAO Manual on Sericulture.* 150p. CSB, Bangalore.
8. Anonymous. 2006. *Wild Silks of India (Vol. I). An Introduction to Vanya Silks.* pp 86-111. CSB, Bangalore.

Fundamentals of Entomology and Nematology 3 (2+1)

Objectives

i. To acquire the skills, knowledge and experiences on Entomology and Nematology.
ii. To gain knowledge on insects and nematodes.
iii. To acquaint about the reasons responsible for insect dominance in animal kingdom.
iv. To study morphology, anatomy and taxonomy of insects in relation to silkworm. To impart dissection skills.

Theory

Definition and need to study Entomology, Position of insects in the animal kingdom and general organisation of phylum arthropoda. Characters of Class Insecta, Dominance of insects in the Animal kingdom: Factors responsible for dominance. General morphology of insects: Body division and segmentation, History of Entomology in India. Structure and functions of body wall and its appendages, moulting process, Segmentation of the body. Structure of Insect – Head - areas and sutures, Appendages of the head. Structure and types of antenna – modifications of insect antennae with examples. Johnston's organ – location and function, General structure of typical biting and chewing type of an insect: mouth parts – types of mouth parts. Structure of thorax-Leg structure and its modification with examples. Wings: Structure of typical wing, wing venation, modifications and wing coupling mechanisms. Structure of abdomen and its appendages – non-reproductive appendages and Reproductive appendages, structure of male and female genetalia and structure of sting in bees. Sensory organs in insects – structure and function. Insect communication: Sound production, light production, honey bee dances, insect pheromones. Metamorphosis, types of insect metamorphosis and diapause in insects. Types of larvae and pupae, Head glands, Digestive system of insects. Circulatory system – Functions of haemolymph, Respiration in insects (Ventilation), Excretory system, Nervous system, Reproductive system, types of reproduction in insects. Definition of Taxonomy, systematics, classification and its importance, Brief history of classification, Nomenclature definition, objectives, guidelines Binomial nomenclature as indicated

by ICZN. Definitions of Biotypes, species, sub species, genus, family, order, tribe, hierarchy, Taxonomic categories; type concept in nomenclature, general classification of Insects up to orders. General classification of insects – phylogeny of insects, Study of apterygotan orders - Collembola, Protura, Diplura, Thysanura Ephemeroptera and Odanata. Study of the representatives of the orders Blattodea, Mantodea Isoptera and Orthoptera Hemiptera and suborder: Homoptera. Study of the insect orders – Neuroptera, Siphonaptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera. Introduction, History and characteristics of Plant parasitic nematodes, economic importance of nematodes in mulberry. Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology. Nematode habitats and diversity- plant, animal and human. Nematode morphology and and anatomy of plant parasitic nematodes, stages of nematodes. Broad classification of nematodes. Reproduction of nematodes. Types of parasitism; nature of damage, symptomatology; interaction of plant-parasitic nematodes with other organisms. Importance of nematodes in international trade and quarantine. Useful nematodes. Principles and practices of nematode management. Integrated nematode management.

Practical

Study of the phylum Arthropoda, Insect collection and preservation, Study of the class Insecta. Study of the antennae, legs, and wings of insects. Internal anatomy of the cockroach, morphology of honey bees and house fly, morphological variations in insects with special reference to the mouth parts. General classification of the class Insecta – study of sub class Apterygota, Ephemeroptera, Odanata, Plecoptera, Orthoptera and Phasmida Hemiptera and suborder: Heteroptera. Neuroptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera. Equipment's used in nematology laboratory. Studies on kinds of nematodes - free-living, animal, insect and plant parasites. Nematode extraction from soil, extraction of migratory endoparasites, staining for sedentary endoparasites. Examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology. Study of perennial pattern in Root knot nematodes.

Suggested Readings

1. Bhat Muzafar Ahmad , Abdul Aziz, Suraksha Chanotra, Shamim Ahmed Bandey, Zafar Iqbal Bhuroo and Mohammad Azam. 2020. *A Textbook on Introduction to Sericulture and Soil Science*. 425p. IP Innovative Publication, New Delhi.
2. Chapman R F. 1998. *The Insects - Structure and Function*. Cambridge University Press, UK.
3. Metcalf C L and Flint W P. 1990. *Fundamentals of Insect Life*. McGraw Hill Publishing Company Ltd., New Delhi.
4. Richards O W and Davies R G. 1997. *Imm's General Textbook of Entomology* (Vol. I - II). Hall and Oxford Publication.
5. Romoser W S and Stoffolano J G. 1994. *The Science of Entomology.* Wm. C. Brown Publishers, Oxford, England.
6. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture*. 209p. Central Silk Board, Bengaluru.

Journals

1. Annual Review of Entomology.
2. Journal of Economic Entomology.

3. Journal of Medical Entomology.
4. Environmental Entomology.
5. Medical and Veterinary Entomology.
6. Ecological Entomology.
7. Systematic Entomology.
8. Physiological Entomology.

Online Sources

- www.cabi.in/
- www.karnataka.gov.in/kssrdi/
- www.tnau.ac.in/

Fundamentals of Genetics 2 (1+1)

Objectives

i. To educate students about genes, genetic variations and heredity in organisms
ii. To develop knowledge on mendelian principles of heredity and medelian exceptions
iii. To impart knowledge on qualitative and quantitative traits inheritance
iv. To impart knowledge on application of probability and chi-square to solve genetic problems
v. To impart understand the concepts of linkage, genetic map, gene and gene regulations (Lac and Tryp operons)

Theory

Pre- and Post-Mendelian concepts of heredity. Mendelian principles of heredity. Probability and Chi-square. Types of dominance, epistatic interactions with examples. Multiple alleles, pleiotropism, Blood group genetics. Sex determination and sex linkage, sex limited and sex influenced traits. Linkage and its estimation, crossing over mechanisms, chromosome mapping. Mutation, classification, mutagenic agents and induction of mutation. Qualitative and Quantitative traits; Polygenes and continuous variations, multiple factor hypothesis. Cytoplasmic inheritance. Protein synthesis, Transcription and translational mechanism of genetic material. Gene concept: gene structure, function and regulation, Lac and Trptophan operons.

Practicals

Solving problems on monohybrid, dihybrid, trihybrid. Solving problems on epistatic interactions including test cross and back cross. Concepts of probability and Chi-square test and their application in genetics. Detection and estimation of linkage through two-point test cross and three-point test cross data. Solving problems of sex linkage.

Suggested Readings

1. Benjamin A P. 2012. *Genetics: A Conceptual Approach*. 400p. W.H. Freeman and Company, New York, US.
2. Gardner E J, Simmons M J and Snustad D P. 2006. *Principles of Genetics*. (8th Edn.). 700p. John Wiley and Sons, Inc., Oxford, England.

3. Robert H Tamarin. 2017. *Principles of Genetics*. (7th Edn.). 300p. McGraw Hill Education, New York.
4. Singh B D. 1992. *Fundamentals of Genetics*. 696p. Kalyani Publishers, New Delhi.
5. Singh Phundan. 2023. *Elements of Genetics. (*6th Edn.). 426p. Kalyani publishers, New Delhi.
6. Stansfield W D. 1991. *Theory and Problems of Genetics. (*3th Edn.). 457p. Schaum's Outline Series, McGraw Hill Inc., New York.
7. Strickberger M W. 1995. *Genetics. (*3th Edn.). 864p. Prentice Hall India Learning Private Limited, New Delhi.

Fundamentals of Agronomy 3 (2+1)

Objective

To study in detail about the cultivation techniques required for efficient crop production from sowing to harvest.

Theory

Agriculture: definition, meaning, importance and scope of agriculture. History of agriculture development in India and Karnataka. Agriculture as an art, science and business of crop production, Agronomy- definition, meaning and its scope, factors affecting crop production. Agrarian classification of crops, seeds and sowing, soil and its components. Soil fertility, soil productivity and their management practices. Tillage and tilth. Crop density and geometry. Crop nutrition, manures and fertilizers, nutrient-use efficiency. Growth and development of crops, concept of ideotypes. Cropping systems: definition, principles and types of cropping system. Agro-climatic zones of India and Karnataka. Crop adaptation and distribution, crop management technologies in problematic areas. Irrigation: Introduction, Importance, definition and objectives, methods of irrigation. Weeds: definition, classification and characteristics, crop weed competition, concepts of weed management – principles and methods. Herbicides – classification, selectivity and resistance, Methods of application. Allelopathy, types of allelopathy.

Practical

Identification of crops, seeds and fertilizers. Classification of field crops, tillage implements. Study and practice of different methods of ploughing, Study of different methods of sowing. Study of seed drills, intercultural implements. Study of fertilizers, manures and green manures. Calculation of fertilizers and seed rates. Study on seed germination and plant population. Preparation of FYM and compost. Participation in ongoing field operations, study and identification of dry land and waste land weeds. Study of agro-climatic zones of Karnataka and India. Study and identification of garden land, wet land and aquatic weeds. Calculation of herbicide doses and their spray. Herbarium, preparation of herbariums of different weeds.

Suggested Readings

1. Chaudhary J P. 2016. *Fertilizers and Manures*. 659p. Rama Publishing House, Meerut, UP.
2. Nandeha K L and Nirjharnee N. 2017. *Fundamentals of Agronomy*. 383p. Kushal Publications and Distributors, Varanasi, UP.

3. Panda S C. 2006. *Cropping and Farming Systems*. 460p. Agrobios (India) Private Limited, Jodhpur, Rajasthan.
4. Reddy S R. 2014. *Introduction to Agronomy and Principles of Crop Production*. 298p. Kalyani Publishers, New Delhi.
5. Yellamanda Reddy T and Shankar Reddy G H. 2016. *Principles of Agronomy*. 650p. Kalyani Publishers, New Delhi.

Physical Education, First Aid, Yoga Practices and Meditation 2 (0+2)

Physical education; Training and coaching - Meaning and concept; Methods of training; Aerobic and anaerobic exercises; Calisthenics, weight training, circuit training, interval training, Fartlek training; Effects of Exercise on muscular, respiratory, circulatory and digestive systems; Balanced Diet and Nutrition: Effects of diet on performance; Physiological changes due to ageing and role of regular exercise on ageing process; Personality, its dimensions and types; Role of sports in personality development; Motivation and achievements in sports; Learning and theories of learning; Adolescent problems and its management; Posture; Postural deformities; Exercises for good posture.

Yoga; Introduction to Asanas, Pranayama, Meditation and Yogic Kriyas; Role of yoga in sports; Teaching of Asanas – demonstration, practice, correction and practice.

Governance of sports in India; Important national sporting events; Awards in Sports; History, latest rules, measurements of playfield, specifications of equipment, skill, technique, style and coaching of major games (Cricket, Football, Table Tennis, Badminton, Volleyball, Basketball, Kabaddi and Kho-Kho) and Athletics

Need and requirement of first aid. First Aid equipment and upkeep. Handling and transport of injured traumatized persons. Emergency procedure for suffocation, demonstration of artificial respiration. Treatment of injuries (wounds and bleeding)–methods of dressing and bandages; first-aid procedure for injured bones. Handling unconsciousness; Treatment of burns and scalds. Emergency procedure for poisoning with special references to snakebite injuries to muscles and joints and treatments. Sports injuries and their treatments.

SEC-III

Raw Silk Processing 2 (0+2)

Objectives

i. To understand the processing of raw silk yarn for weaving a fabric
ii. To develop the skills of raw silk processing for fabric production

Practicals

Twisting of raw silk (Throwster's unit) - Soaking of raw silk, winding, doubling – making different plys of silk yarn, mixing up of the yarns and twisting. Different types of twist – S twist, Z twist and production of different types of yarns. Steaming and Re-reeling. Maintenance of working condition of throwsters unit. Working out tho economics of cost of production of twisted yarn. Wet processing of twisted silk yarn - Degumming – methodology. Dyeing of yarn – different types of dyes, methods of dyeing and its application for silk dyeing. Warp making – different methods of

warping – ball warping, drum warping. Weft yarn prepartion. Working out the economics of silk warping. Visit to throwsters unit and warp making units.

Suggested Readings

1. Anonymous. 2003. *Seri-Business Manual* (Vol. III). Industrial Sector, CSB, Bangaluru.
2. Kanwar Varinder Pal Singh. 2004. *Elementary Idea of Textile Dyeing, Printing and Finishing*. 186p. Kalyani Publishers, New Delhi.

Weaving Technology 2 (0+2)

Objective

To impart the knowledge of weaving preparatory and waving technology of warp and weft winding machines, weaving and basic motions of weaving.

Practicals

Introduction to the weaving; Selection of raw silk, procurement, preparation of raw silk yarn; Arrangement of looms; Pit loom, Frame loom, Power loom; Self designed; Jacquard looms, Dobby operation. Weaving of the fabric, Designing of the fabric, Plain or designed weaving, Zari work, Hand working on plain fabrics; Normal finish packaging of sarees, dress material Starch, Chemical finishing of the fabric tautening, ironing. Marketing of the fabric, project preparation and calculation of B/C ratio in weaving.

Suggested Readings

1. Anonymous. 1975. *Textbook of Tropical Sericulture*. 594p. Japan Overseas Co-operation volunteers, Japan.
2. Anonymous. 2000. *Do's and Don'ts of Silk Twisting and Weaving Industry Part – II (Weaving)*. 35p. Central Silk Board, Bengaluru.
3. Aruga H. 1994. *Principles of Sericulture*. 376p. Oxford and IBH, New Delhi.
4. Bhattacharya M and Mahadevappa D. 2002. *Silk Weaving*. 376p. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
5. Ganga G and Sulochana Chetty J. 1991. *An Introduction to Sericulture*. 176p. Oxford and IBH, New Delhi.
6. Ganga G. 2003. *Comprehensive Sericulture. Volume 2, Silkworm Rearing and Silk Reeling*. 429p. Oxford and IBH, New Delhi.
7. Goswami B C, Martindale J G and Scardino F L. 2010. *Textile Yarns: Technology, Structure and Applications*. 565p. Wiley India Edition, New Delhi.
8. Jolly M S. 1987. *Appropriate Sericulture Techniques*. 215p. Central Sericultural Research and Training Institute, CSB, Mysore.
9. Mishra S P. 2006. *A Textbook of Fibre Science and Technology*. 336p. New Age International Publishers, New Delhi.
10. Reddy D N R, Shylaja T A and Narayanaswamy K C. 2000. *Reshmae Vasthra Vinyasa*. 78p. CVG Publicaions, Bengaluru.
11. Sengupta K. 1989. *A Guide for Bivoltine Sericulture*. 42p. Central Sericultural Research and Training Institute, Mysore.

12. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture*. 209p. Central Silk Board, Bengaluru.

Journals

- Bulletin of Indian Academy of Sericulture, CSTRI, Berhampore
- Indian Silk, CSB, Bengaluru
- Journal of Sericultural Science of Japan, Japan
- Seridoc, CSRTI (CSB), Mysore
- Sericologia, ISC, Bengaluru
- Korean Journal of Sericulture, Korea
- Indian Journal of Sericulture, CSRTI (CSB), Mysore
- And other Periodicals, Journals, Reports, Brochures, etc.

Online Sources:

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/
- www.tnau.ac.in/
- www.csrtimys.res.in/
- www.nift.ac.in/

Seri-Clinic 2 (0+2)

Objective

To provide knowledge and expertise for setting up Seri-Clinic

Practicals

Soil health diagnosis, INM practices to improve the soil and plant health, Identification of deficiency symptoms in mulberry and non-mulberry and acquainting with remedial measures, Diagnosis of pest and diseases of silkworm and acquainting with remedial measures, Survey of problematic mulberry and non-mulberry garden and rearing houses and find out the remedies for the cause, Assessment of quality of the inputs, leaf and DFL's., Assessment of toxicity, their nature, level and suggest remedies, Development of INM, IPM and IDM schedules for management of nutrition and pest and diseases in mulberry.

Suggested Readings

1. Anonymous. 1975. *Textbook of Tropical Sericulture*. 594p. Japan Overseas Co-operation volunteers, Japan.
2. Anonymous. 2000. *Do's and Don'ts of Silk Twisting and Weaving Industry Part – II (Weaving)*. 35p. Central Silk Board, Bengaluru.
3. Aruga H. 1994. *Principles of Sericulture*. 376p. Oxford and IBH, New Delhi.
4. Bhattacharya M and Mahadevappa D. 2002. *Silk Weaving*. 376p. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
5. Ganga G and Sulochana Chetty J. 1991. *An Introduction to Sericulture*. 176p. Oxford and IBH, New Delhi.

6. Ganga G. 2003. *Comprehensive Sericulture. Volume 2, Silkworm Rearing and Silk Reeling*. 429p. Oxford and IBH, New Delhi.
7. Goswami B C, Martindale J G and Scardino F L. 2010. *Textile Yarns: Technology, Structure and Applications*. 565p. Wiley India Edition, New Delhi.
8. Jolly M S. 1987. *Appropriate Sericulture Techniques*. 215p. Central Sericultural Research and Training Institute, CSB, Mysore.
9. Mishra S P. 2006. *A Textbook of Fibre Science and Technology*. 336p. New Age International Publishers, New Delhi.
10. Reddy D N R, Shylaja T A and Narayanaswamy K C. 2000. *Reshmae Vasthra Vinyasa*. 78p. CVG Publicaions, Bengaluru.
11. Sengupta K. 1989. *A Guide for Bivoltine Sericulture*. 42p. Central Sericultural Research and Training Institute, Mysore.
12. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture*. 209p. Central Silk Board, Bengaluru.

Journals

- Bulletin of Indian Academy of Sericulture, CSTRI, Berhampore
- Indian Silk, CSB, Bengaluru
- Journal of Sericultural Science of Japan, Japan
- Seridoc, CSRTI (CSB), Mysore
- Sericologia, ISC, Bengaluru
- Korean Journal of Sericulture, Korea
- Indian Journal of Sericulture, CSRTI (CSB), Mysore
- And other Periodicals, Journals, Reports, Brochures, etc.

Online Sources:

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/
- www.tnau.ac.in/
- www.csrtimys.res.in/

Semester IV

History, Development and Organization of Sericulture Industry **2 (2+0)**

Objectives

i. To understand the history and organizational setup of sericulture industry in India.
ii. To develop the technical knowledge on role and responsibilities of sericultural organization.
iii. To understand International silk policy, export, import and development of sericultural industry.

Theory

Introduction, definition of sericulture, importance of sericulture, advantages of sericulture in Indian context. Brief mention about four major types of silks in India with their scientific

names and primary host plants. Leading silk producing countries in the world and states in India, traditional sericultural districts in Karnataka. History of sericulture in China and its spread to Korea, Japan, Europe and India. Development of Sericulture in India with special reference to south India. National and International Organizations related to sericulture, their role in development of sericulture industry, different developmental projects in sericulture, main objectives of NSP. Central Silk Board, its function, different regional offices of CSB and their role in sericulture development, training facilities in CSB. Organizational setup of State Departments of Sericulture and KSSR&DI. Cocoon markets and their mode of functioning. Quality control and marketing of silk, objectives of silk exchange, role of KSMB in Sericulture development, role of export import policy in price stabilization. Development of Sericultural Education in India. Voluntary Organizations and their role in development of sericulture, development through social, organizational and technical aspects

Suggested Readings

1. Abdul Aziz and Hanumanthappa HG. 1985. *Silk Industry Problems and Prospects*. 129p. Ashish Publishing House, New Delhi.
2. Anonymous. 2007. *Sericulture and Silk Industry Statistics*. 96p. Central Silk Board, Bengaluru.
3. Ganga G. 2003. *Comprehensive Sericulture (Vol. II)*. pp 1-16. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
4. Ganga G and Sulochana Chetty J. 2001. *An Introduction to Sericulture*. pp 1-23. Ashish Publishing House, New Delhi.
5. Hanumappa H G. 1993. *Sericulture Society and Economy*. 140p. Himalaya Publishing House, Bombay.
6. Koshy T D. 2001. *Silk Production and Export Management*. 656p. APH Publishing Corporation, New Delhi.
7. Sanjay Sinha. 1990. *Development of Indian Silk*. 103p. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
8. Vekata Narasaiah P. 1992. *Sericulture in India*. 214p. Ashish Publishing House, New Delhi.

Morphology and Systematics of Silkworms 3 (2+1)

Objectives

i. To identify the sericigenous fauna
ii. To understand the basic principles of morphology
iii. To understand the basic principles of systematics
iv. To Understanding the type concept
v. To establish confidence in systematics and morphology of sericigenous insects

Theory

Introduction to morphology, why to study morphology. Definitions and its relation to Anatomy, Physiology and Ecology. Systematics, Taxonomy, Classification, Class, Order, Genera, Species. Objectives of systematic, classification and taxonomy. Functions of systematics, Zoological nomenclature, objectives of ICZN. Law of priority – Homonyms, Synonyms. Type

concepts: Types at species level- Holotype, Syntype, Lectotype, Paralectotype and Allotype. Levels of taxonomy/Classification of Mulberry silkworm, Tropical Tasar, Temperate tasar, Eri and Muga silk silkworm. General insect morphology: Metamorphosis, life cycle. Integument-Basement membrane, Epidermis and cuticle, composition of cuticle, Cuticular modifications: 1. Cellular membrane, 2. Apodeme and Apophysis. External processes: 1. Acellular: spicules, small spines, cuticular hairs, corrugations and ridges; 2. Cellular processes: Unicellular (Setae) and Multi-cellular (spines, spurs). Cuticular modifications (forms of spine and spurs) in lepidopteran larvae: simple primary hairs, chalaza, scoli, vericule, verruca. General insect morphology: The head, head segmentation. Procephalon, Gnathocephalon. Orientation of the Head: Prognathus, Hypognathus, Opisthognathus. Structure of the head, regions of the head, Head appendages. General insect morphology: Thorax: Segmentation in the thorax. Thoracic appendages – Legs, The wings (Generalized insect wing). Wing coupling and types. General insect morphology: Abdomen: Segmentation of the abdomen, abdominal appendages, pre-genital appendages, collembolan appendages, larval leg and gills like appendages, genital appendages (male and female genitalia). Chaetotaxy: primary setae, secondary setae, nomenclature of setae, setal map, setal arrangement in silkworm. Arrangement of primary setae in the first instar of mulberry silkworm. Morphology of eggs of silkworms: Structure, morphology and follicular imprints of Mulberry silkworm, temperate and tropical tasar, eri and muga silkworms. Morphology of *Bombyx mori* L. larvae, head, thorax, abdomen and its appendages, larval marking, moulting and mounting, life cycle. Morphology of mulberry silkworm pupa, adult, differentiation of sex, cocoon characters. Morphology of tropical and temperate silkworm – larval characters, developmental morphology: prothoracic hood, marking on the anal flap and claspers, larval lines, tubercles, setae (body setae, tubercular setae, shining spots). Morphology of cocoons, pupae, adult- wings, wing venation, ocellus, scales on different parts of tropical and temperate silkmoth. Morphology of Muga, *Antheraea assamensis* – larval characters, developmental morphology of prothoracic hood, marking on the anal flap and claspers, tubercles, pupa, cocoon and adult – ocellus, wing venation. Morphology of Eri, Samia ricini larval characters, developmental morphology of prothoracic hood, marking on anal flap and claspers, tubercles, pupa, cocoon and adult –wing venation.

Practical

Good Laboratory Practices. Study of collection and preservation of insect specimens. Study of classification of insects and silkworm. Study of insect antennae and mouth parts. Study of insect legs and wings. Study of immature stages of insects. Study of *Bombyx mori* L. egg. Study of head and its appendages of *Bombyx mori* L. larva. Study of thorax and abdomen and their appendages of *Bombyx mori* L. larva. Study of morphology of *Bombyx mori* L. cocoon and pupa. Study of morphology of adult *Bombyx mori* L. (head, thorax, abdomen and appendages). Study of adult *Bombyx mori* L. (legs, wings and scales). Study of taxonomy of Antheraea. Study of morphology of *Antheraea mylitta* (tropical tasar). Study of morphology of *Antheraea assamensis* (muga). Study of morphology of *Samia ricini* (eri).

Suggested Readings

1. Dilip De Sarkar. 1998. *The Silkworm – Biology, Genetics and Breeding*. pp 1-338. Vikas Publishing House Pvt. Ltd., New Delhi.
2. IMMS A D. 1961. *General Textbook of Entomology. (9th Edn.)*. Rev. by O.W. Richards and R.G. Davies, Bombay.

3. Saxena A B. 1996. *Development of Behaviour in Insects*. Anmol Publications Pvt. Ltd., New Delhi.
4. Saxena A B. 1996. *Principles of Insect Morphology*. Anmol Publications Pvt. Ltd., New Delhi.
5. Saxena A B. 1996. *Ecology of Insects*. Anmol Publications Pvt. Ltd., New Delhi.

Silkworm Anatomy and Physiology 3 (2+1)

Objectives

i. To understand the basic principles of anatomy
ii. To provide information on silk production among various sericigenous insects, their evolution and differences

Theory

Introduction - meaning of the terms anatomy and physiology, a list of visceral organs in silkworm with their function. Anatomy of digestive system of mulberry silkworm and cross-section through fore gut, mid gut and rectum. Digestive system of silk moth. Physiology of digestion-glands associated with digestion, digestive enzymes, digestion and absorption. Anatomy of circulatory system - organs of circulation (Diaphragms and sinuses, Dorsal blood vessel in silkworm and silk moth and Accessory pulsatory organs). Silkworm blood - plasma and haemocytes and their functions, circulation of blood, pulsation and reversal of pulsation. Anatomy of respiratory system components of insect respiratory system (spiracles, trachea, tracheoles and end cells), types of respiratory system based on the number of functional spiracles, respiratory system in silkworm and adult. Physiology of respiration - amount of respiration, respiratory co-efficient and respiratory hindrances in silkworm. Metabolism of carbohydrates (glycolysis, Kreb's cycle and ETC), lipids and proteins. Anatomy of Excretory system organs of excretion, integument, tracheal system and malpighian tubules. Accessory organs of excretion (nephrocytes, fat bodies and oenocytes). Malpighian tubules in silkworm as a principle excretory organ, modification in silk moths. Physiology of excretion - generalizations on the activity of malpighian tubules, formation of uric acid and urea in silkworm. Nervous system - general aspects (neuron; types of neurons). Nervous system in silkworm - central nervous system and visceral or sympathetic nervous system. Modifications in the central nervous system of adults. Sense organs visual organs (simple and compound eyes), mechanoreceptors (Trichoid sensilla, chordotonal organs and multipolar stretch receptors), auditory organs (Tympanal organs, auditory hairs, Johnston's organs and pilifer of choerocampine hawk moths) and chemoreceptors. Physiology of nervous system (conduction of stimulus - resting potential and action potential). Anatomy of reproductive system - Gonads in larval stage, male and female reproductive systems, cross-section of a testis and structure of a typical spermatic tube. Structure of an ovariole. A brief on spermatogenesis and oogensis. Kinds of eggs in lepidopterans. Endocrine system, Nuerosecretory cells, Corpora cardiac, Corpora allata. Prothoracic glands and Sub-esophageal glands, their secretions and functions. Exocrine glands silk glands, scent glands and accessory gland of reproductive system. Muscular system - categories of muscles (skeletal and visceral), muscles in silkworm. Hormonal mechanism of moulting, physiology of diapause (classification based on occurrence - obligatory' and facultative: based on stage - embryonic, larval, pupal and imaginal). Physiological changes during onset of diapauses and termination of diapauses. Effect of photo period and temperature on occurrence of diapauses. Host preference and Stimuli (olfactory and gustatory) of feeding artificial diets for silkworm composition, advantages and limitations, substitution of food plants. Application of juvenile hormones (JH) in sericulture,

JH Analogues (JHAs). Techniques of application, effect of JHAs on silk production, limitations. Anti-juvenile hormones and their effects. Nutritional requirement of silkworm - amino acids, lipids, carbohydrates, vitamins, minerals and water Anatomy of digestive system, respiratory system, reproductive system and nervous system in *Antheraea mylitta* and *Samia ricini.*

Practicals

Study of mouth parts in *Bombyx mori* L. Study of the digestive system in the larvae of *Bombyx mori* L. Study of circulatory system in *Bombyx mori* L. larva. Study of digestive system in the adult of *Bombyx mori* L. Study of respiratory system in the larva of *Bombyx mori* L. Study of respiratory system in the adults of *Bombyx mori* L. Study of central nervous system in the larva of *Bombyx mori* L. Study of central nervous system in the adult of *Bombyx mori* L. Study of excretory system in the larvae of *Bombyx mori* L. Study of female reproductive system in *Bombyx mori* L. Study of male reproductive system in mulberry silk moth. Study of internal organs of larva of tropical/temperate tasar silk worm *Antherea mylitta* D. Study of internal organs of larva of tropical/temperate tasar silk worm *Antherea mylitta* D. Study of internal organs of larva of eri silk worm *Samia ricini* Boisduval. Study of internal organs of eri silk moth *Samia ricini* Boisduval.

Suggested Readings

1. Ather H Siddiqi.1982. *Experimental Physiology*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
2. Beck S D. 1963. *Animal Photoperiodism*. Holt, Holt Library of Science Series, New York.
3. Beck S D. 1980. *Insect Photoperiodism*. Academic Press, New York.
4. Gilmour D. 1961. *Biochemistry of Insects*. Academic Press, New York.
5. Goldsmith M R and František Marec. 2010. *Molecular Biology and Genetics of the Lepidoptera*. CRC Press Taylor and Francis Group, Broken Sound Parkway NW, USA.
6. Govindan Bhaskaran, Stanley Friedman and Rodriguez J G. 1981. *Current Tropics in Insect Endocrinology and Nutrition*. Plenum Press, New York and London.
7. Morohoshi S. 2000. *Development Physiology of Silkworms*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
8. Saxena A B. 1996. *Hormones of Insects*. Anmol Publications Pvt. Ltd., New Delhi.
9. Sturnikov V A. 1976. *Control of Silkworm Development and Sex*. MIR Publishers, Moscow.
10. Wigglesworth V B. 1956. *Insect Physiology*. (5th Edn.). 741p. Rev, Methuen, London.

Water Management 2 (1+1)

Objectives

i. To study the fundamental concept about scientific management irrigation water to achieve higher water productivity
ii. To acquaint about the fundamental principles of water management along with various irrigation practices at the field level

Theory

Introduction - definitions, objectives of irrigation and water management, importance of irrigation water, terminologies used in water management and irrigation. History of irrigation in

India. Water resources - distribution of water resources, rainfall, reservoirs and tanks, underground water resources, irrigated area in India and Karnataka under the tanks, reservoirs and wells and hydrological cycle. Exploitation of Water Resources - dams, canals, underground, lift irrigation and waste water use systems. Soil water relations - physical nature and characteristics of soil - adhesion, cohesion, capillarity, porosity, bulk density and particle density; effective root zone depth; nature of soil water - hygroscopic, capillary and gravitational water, soil moisture constants, infiltration, expression of soil moisture, soil moisture tension and potentials, expression of soil moisture and their mutual relations, hysteresis, hydro dynamics, assessment of soil moisture by directs methods - gravimetric, volumetric, rapid moisture meter and sulphuric acid method; Indirect methods – tensiometer, gypsum block/ resistance block meter and neutron moisture meter. Plant Water Relations - importance of water in plants, critical stages, effects of excess and deficit moisture on plant growth and water availability and nutrient uptake. Assessment of Water Requirement (WR) - components and components of water requirement - water supplied and water demand, factors influencing water requirement, methods to estimate water requirement - lysimeter, Estimation of ET losses, soil moisture depletion, field experimentation technique, water balance method, drum culture technique, expressions of water requirement. Methods of irrigation - classification, principles, suitability, advantages and disadvantages of surface irrigation methods - flooding, border strip, check basin, ridges and furrow and sub-surface irrigation methods. Sprinkler irrigation method - types of sprinkler irrigation, components, advantages and disadvantages, water distribution pattern and wetting area based on wind speed. Drip irrigation method- differences between sprinkler and drip irrigation methods, types of drip irrigation, components, advantages and disadvantages, water distribution pattern, pitcher irrigation, cablegation, fertigation and suitability of irrigation methods. Irrigation efficiency - conveyance, application of water, storage of water in soil profile, distribution of water, Water Use Efficiency (WUE) - types and methods to improve WUE. Assessment of Irrigation Requirement (IR) - meaning, net irrigation requirement, gross irrigation requirement and relationship between IR and WR. Quantitative estimation of irrigation water - units of water measurement - direct methods - volume time relation, velocity area, tracer method, current meter, coordinate method. Indirect methods - weirs, orifices and parshall flume, duty of water. Suitability of land water for irrigation – Suitability of land – Physical assessment: texture, water holding capacity, non-capillary pores and permeability, degree of slope, direction of slope, depth of water table. Chemical assessment: soluble salt content, exchangeable sodium, pH. Quality of irrigation water - total soluble salts, sodium adsorption ratio; effects of poor quality of water on crop performance, Irrigation management in problematic areas – poorly drained area, saline and alkaline lands. Scheduling of irrigation - definition, approaches to scheduling - Feel and appearance method, plant / crop indices, indicator plants, critical stage approach, soil moisture depletion approach, IW / CPE ratio approach, stress degree day (SDD) concept. Irrigation control structure and water conveyance methods - unlined and lined open channels, pipes, drop structures, check gates, chute spillways, turn outs, flumes and culverts. Irrigation practices for some important crops - paddy, closed and wide spaced crops, plantation and orchard crops and nurseries, suitable irrigation practice for different methods of mulberry cultivation. Drainage - surface and sub-surface methods.

Practical

Soil moisture determination by direct methods. Study and installation of tensiometer. Study and installation of gypsum block resistance moisture meter. Determination of bulk density. Determination of maximum water holding capacity. Determination of field capacity.

Determination of permanent wilting point. Determination of infiltration rate. Study of capillarity in soil. Study of methods of water flow measurement. Study and use of weirs and orifices. Study and use of parshall flume. Study of surface and sub-surface irrigation methods. Study of sprinkler irrigation. Study of drip irrigation. Study of water requirement calculation for mulberry. Study of on-farm irrigation structures. Study of drainage structures. Practice of numerical examples and conversions.

Suggested Readings

1. Mukund Joshi and Prabhakar Setty T K. 2013. *Irrigation and Water Management*. 275p. Kalyani Publishers, New Delhi.
2. Reddy S R and Reddy G K. 2016. *Irrigation Agronomy*. 256p. Kalyani Publishers, New Delhi.
3. Darra B L and Raghuvanshi C S. 1990. *Irrigation Management*. 466p. Atlantic Publishers and Distributors, New Delhi.
4. Dilipkumar Mujumdar. 2014. Irrigation Water Management: Principles and Practices. 487p. Prentice Hall India Learning Private Limited, New Delhi.
5. Michael A M. 2007. *Irrigation: Theory and Practice*. 477p. Vikas Publishing House Pvt. Limited, New Delhi.
6. Premjit Sharma. 2008. *Agricultural Water Management*. 302p. Daya Publishing House, Delhi.

Agricultural Statistics 2 (1+1)

Objective

To impart knowledge about the basic concepts of statistics and familiarize the students about application of statistics in the field of Agriculture.

Theory

Introduction to Statistics and its Applications in Agriculture, Classification and Frequency Distributions of Data, Diagrammatic Representation of Data: Bar and and Pie diagrams, Graphical Representations of Data: Histogram, Frequency Polygon, Frequency curve and Cumulative frequency curve (Ogives). Measures of Central Tendency: Concepts and and Definition, Characteristics of ideal Average, Arithmetic Mean, Median, Mode, Quartiles, Deciles and and Percentiles (both for Ungrouped and Grouped data), Geometric Mean and Harmonic Mean (Ungrouped data). Measures of Dispersion: Concepts and and Definition, Types of Measures of Dispersion: Range, Quartile deviation, Absolute Mean Deviation from mean and median, Standard Deviation and Variance, and Co-efficient of dispersion (both for Ungrouped and Grouped data). Moments, Measures of Skewness and Kurtosis (both for Ungrouped and Grouped data). Concept of Set Theory: Permutation and and Combinations. Theory of Probability: Concept and and Definition, Addition and Multiplication rules (without proof). Theoretical Probability distributions: Binomial, Poisson and Normal Distribution, their Properties and and Applications.

Simple Correlation Analysis: Definition, Measures of Correlation: Scatter diagram, Karl Pearson product moment and Spearman's rank correlation coefficients and their properties. Simple Linear Regression Analysis: Definition, Fitting of simple linear regression equations Y on X and X on Y, Properties of regression coefficient, interrelation between correlation and regression.

Introduction to Sampling Theory: Sampling versus Complete Enumeration, Methods of Sampling, Type of Sampling- Simple Random Sampling (with and without replacement), Use of Random Number Tables for selection of Simple Random Sample, Concept of Sampling distribution and standard error, Concept of systematic, stratified and cluster sampling along with their advantage and disadvantages.

Test of Significance: Introduction, Null and Alternative hypothesis, Types of Errors, Level of significance, Degrees of freedom, Critical and Acceptance regions. Large sample tests: Z-Test for Means - One and Two Sample Means for Known and Unknown population variance. Small sample test: Student t-test for Means - One and Two sample means, Paired t-test and F-test for two population variances. Chi-Square test: Test for Goodness of Fit, Test for independence of attributes for rXc contingency table, 2x2 contingency table with Yates correction, and test for single population variance.

Introduction to Analysis of Variance and its Assumptions, Analysis of Variance for One and Two Way Classification. Concept of design of experiments: Basic Principle of Experimental Design: Randomization, Replication and Local control, Basic Designs: CRD and RCBD their advantages and disadvantages.

Practicals

Construction of Frequency Distribution tables. Diagrammatic presentation of data: Bar diagrams and and pie diagrams. Graphical Representation of Data: Histogram, Frequency polygon, Frequency curve and Cumulative frequency curve (Ogives). Computation of Measures of Central Tendency: Arithmetic Mean, Median, Mode, Quartiles, Deciles and and Percentiles (both for Ungrouped and Grouped data), Geometric Mean and Harmonic Mean (Ungrouped data). Computation of Measures of Dispersion: Range, Quartile deviation, Absolute Mean Deviation, Standard Deviation and Variance and Co-efficient of dispersion (both for Ungrouped and Grouped data). Computation of Moments, Measures of Skewness and Kurtosis (both for Ungrouped and Grouped data), Problems on permutation and combination. Problems on Simple Probability, Addition and Multiplication rules. Computation of probabilities using Binomial, Poisson and Normal Distributions. Computation of Correlation Coefficient: Karl Pearson product moment and Spearman's rank correlation coefficients. Fitting of Simple Linear Regression Equations Y on X, and X on Y. Use of Random Number Tables for selection of Simple Random Sample. Problems on Large sample tests: Z-Test for Means - One and Two sample means for known and unknown population variance. Problems on Small sample tests: Student t-test for Means - One and Two sample means, Paired t-test, and F-test two population variances. Problems on Chi-Square test: Test for Goodness of Fit, Test for independence of attributes for rXc contingency table, 2x2 contingency table with Yates correction and test for single population variance. Problems on Analysis of Variance for One and Two Way Classified data. Problems on CRD and RCBD.

Suggested Readings

1. Bansil P C. 2021. *Agricultural Statistics in India.* (4th Edn.). 786p. CBS Publishers and Distributors Pvt. Ltd., New Delhi.
2. Chandel S R S. 2014. *Handbook of Agricultural Statistics*. 542p. Achal Prakashan Mandir, Jodhpur, Rajasthan.
3. Gangai Selvi R and Kailasam C. 2017. *Applied Statistics*. 215p. Kalyani Publishers, New Delhi.

4. Gupta S C and Kapoor V K. 2007. *Fundamentals of Applied Statistics*. 502p. Sultan Chand & Sons, New Delhi.
5. Majumder A and Sahu P K. 2018. *Statistical Methods*. 225p. Kalyani Publishers, New Delhi.
6. Rangaswamy R. 1995. *A Textbook of Agricultural Statistics*. 495p. New Age International (P) Ltd., New Delhi.
7. Vijay Katyal and Gangawar B. 2011. *Statistical Methods for Agricultural Field Experiments*. 158p. New India Publishing Agency, Delhi.

Agricultural Marketing and Trade 3 (2+1)

Objectives

i. To understand the fundamentals of agricultural marketing and trade
ii. To analyze the factors influencing supply and demand in agricultural markets
iii. To explore different marketing channels and strategies in agriculture
iv. To examine the role of government policies and regulations in agricultural markets

Theory

Agricultural Marketing: Concepts and definitions of market, marketing, agricultural marketing, market structure, marketing mix and market segmentation, classification and characteristics of agricultural markets; demand, supply and producer's surplus of agri-commodities: nature and determinants of demand and supply of farm products, producer's surplus – meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; pricing and promotion strategies: pricing considerations and approaches – cost based and competition based pricing; market promotion – advertising, personal selling, sales promotion and publicity – meaning, merits and demerits; marketing process and functions: Marketing process concentration, dispersion and equalization; exchange functions – buying and selling; physical functions – storage, transport and processing; facilitating functions – packaging, branding, grading, quality control and labelling (Agmark); Market functionaries and marketing channels: Types and importance of agencies involved in agricultural marketing; meaning and definition of marketing channel; number of channel levels; marketing channels for different farm products; Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs; Role of Govt. in agricultural marketing: Public sector institutions- CWC, SWC, FCI, CACP and DMI – their objectives and functions; cooperative marketing in India; Risk in marketing: Types of risk in marketing; speculation and hedging; an overview of futures trading; Agricultural prices and policy: Meaning and functions of price; administered prices; need for innovations in agricultural price policy; Trade: Concept of International Trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; WTO; Agreement on Agriculture (AoA) and its implications on Indian agriculture; IPR. Role of government in agricultural marketing. Role of APMC and its relevance in the present day context.

Practical

Plotting and study of demand and supply curves and calculation of elasticities; Study of relationship between market arrivals and prices of some selected commodities; Computation of

marketable and marketed surplus of important commodities; Study of price behaviour over time for some selected commodities; Construction of index numbers; Visit to a local market to study various marketing functions performed by different agencies, identification of marketing channels for selected commodity, collection of data regarding marketing costs, margins and price spread and presentation of report in the class; Visit to market institutions –NAFED, SWC, CWC, cooperative marketing society, etc. to study their organization and functioning. Application of principles of comparative advantage of international trade.

Suggested Readings

1. Acharya S S and Agarwal N L. 2006. *Agricultural Marketing in India*. 506p. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Chinna S S. 2017. *Agricultural Economics and Indian Agriculture*. (4th Edn.). 345p. Kalyani Publishers, New Delhi.
3. Dominic Salvatore. 2003. *Micro Economic Theory*. (4th Edn.). 283p. Oxford University Press, USA.
4. Kohls Richard L and Uhl Josheph N. 2001. *Marketing of Agricultural Products*. 554p. Prentice-Hall of India Private Ltd., New Delhi.
5. Kotler P, Armstrong G and Gary M A. 2010. *Principles of Marketing*. (13th Edn.). 613p. Prentice-Hall of India Private Ltd., New Delhi.
6. Lekhi R K and Joginder Singh. 2018. *Agricultural Economics*. 594p. Kalyani Publishers, New Delhi.
7. Memoria C B, Joshi R L and Mulla N I. 2003. *Principles and Practice of Marketing in India*. 860p. Kitab Mahal, New Delhi.
8. Pandey, Mukesh, Tewari and Deepali. 2004. *Rural and Agricultural Marketing*. 480p. International Book Distributing Co. Ltd, New Delhi.
9. Sharma R. 2005. *Export Management*. 402p. Laxmi Narain Agarwal, Agra.

Agricultural Informatics and Artificial Intelligence 3 (2+1)

Objectives

i. To acquaint students with the basics of computer applications in agriculture, multimedia, database management, application of mobile app and decision-making processes, etc.
ii. To provide basic knowledge of computer with applications in Agriculture.
iii. To make the students familiar with Agricultural-Informatics, its components and applications in agriculture.

Theory

Introduction to Computers, Anatomy of Computers, Memory Concepts, Units of Memory, Operating System: Definition and types, Applications of MS-Office for Creating, Editing and Formatting a document. Data presentation, Tabulation and graph creation, Statistical analysis, Mathematical expressions. Database: concepts and types, creating database, Uses of DBMS in Agriculture. Internet and World Wide Web (WWW): Concepts and components.

Computer programming: General concepts, Introduction to Visual Basic, Java, Fortran, C/C++, Concepts and standard input/output operations.

e-Agriculture, Concepts, design and development, Application of innovative ways to use information and communication technologies (IT) in Agriculture, Computer Models in Agriculture: Statistical, weather analysis and crop simulation models, concepts, structure, input-output files, limitation, advantages and application of models for understanding plant processes, sensitivity, verification, calibration and validation, IT applications for computation of water and nutrient requirement of crops, Computer-controlled devices (automated systems) for Agri-input management, Smartphone mobile apps in agriculture for farm advice: Market price, postharvest management etc., Geospatial technology: Concepts, techniques, components and uses for generating valuable agri-information, Decision support systems: Concepts, components and applications in Agriculture, Agriculture Expert System, Soil Information Systems etc. for supporting farm decisions. Preparation of contingent crop-planning and crop calendars using IT tools, Digital India and schemes to promote digitalization of agriculture in India.

Introduction to artificial intelligence, background and applications, Turing test. Control strategies, Breadth-first search, Depth-first search, Heuristics search techniques: Best-first search, A* algorithm, IoT and Big Data; Use of AI in agriculture for autonomous crop management, and health, monitoring livestock health, intelligent pesticide application, yield mapping and predictive analysis, automatic weeding and harvesting, sorting of produce, and other food processing applications; Concepts of smart agriculture, use of AI in food and nutrition science etc.

Practical

Study of computer components, accessories, practice of important DoS Commands, Introduction of different operating systems such as Windows, Unix/ Linux, creating files and folders, File Management. Use of MS-WORD and MS Power-point for creating, editing and presenting a scientific document, MS-EXCEL - Creating a spreadsheet, Use of statistical tools, Writing expressions, Creating graphs, Analysis of scientific data, Handling macros. MS-ACCESS: Creating Database, preparing queries and reports, Demonstration of Agri-information system, Introduction to World Wide Web (WWW) and its components, Introduction of programming languages such as Visual Basic, Java, Fortran, C, C++, Hands on practice on Crop Simulation Models (CSM), DSSAT/Crop-Info/Crop Syst/ Wofost, Preparation of inputs file for CSM and study of model outputs, computation of water and nutrient requirements of crop using CSM and IT tools, Use of smart phones and other devices in agro-advisory and dissemination of market information, Introduction of Geospatial Technology, Hands on practice on preparation of Decision Support System, Preparation of contingent crop planning, India Digital Ecosystem of Agriculture (IDEA).

Suggested Readings

1. Date C J. 1999. *Introduction to Database Management System*. (7th Edn.). 938p. Pearson Education India, New Delhi.
2. Dhabal Prasad Sethi and Manoranjan P. 2020. *Concepts and Techniques of Programming in C*. 416p. Dreamtech Press Books, New Delhi.
3. Pearson. 2012. *Introduction to Information Technology*. (2th Edn.). 788p. Pearson Education India, New Delhi.
4. Rajaraman V and Neeharika A. 2015. *Fundamentals of Computer*. (6th Edn.). 421p. PHI Learning Pvt. Ltd., New Delhi.
5. Subrat Kumar M, Prasannajit M and Jayashankar P. 2022. *Introductory Agri Informatics*. (2th Edn.). 198p. Jain Brothers Publication, Bangalore, Karnataka.

SEC-IV

Value Addition in Sericulture 2 (0+2)

Objectives

i. To make the students aware about all seri-by-products and its utilization

ii. To understand the best utilization of by-products generated at each stage of sericultural activity and their value addition

Practicals

Importance and scope of by-product utilization in sericulture, Value addition during host plant cultivation: kisan nursery, composting, vermicomposting, bio-digester, bio gas production, livestock production, pisciculture, mushroom cultivation. Mulberry as feed for poultry, piggery and other livestock's. Use of mulberry fruits in preparation of jam, jelly and wine. Value addition during silkworm rearing –silkworm litter as livestock feed; as an organic manure, raw material for biogas production, mushroom culture, poultry feed, fish feed, silkworm excreta: chlorophyll extraction. Pupal oil extraction and its uses, pupal powder as animal feed and manure. Flimsy cocoons and waste cocoons for spun silk production and quilting purpose. Silkworm pupa in human consumption-commercialized products and locally prepared dishes. Preparation of handicrafts, toys, wall plates, garlands, greeting cards, etc., from pierced/ cut cocoons. Sericin for medicine, cosmetics, artificial membranes and plastic industry and other uses of silk.

Suggested Readings

1. Anonymous. 2002. *Silk Weaving*, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
2. Bernard P Corbman. 1983. *Textiles: Fiber to Fabric*. (6th Edn.). 594p. Mc. Graw Hill International Editions, Home Economic Series, Singapore.
3. Dandin S B and Gupta V P. 2002. *Advances in Indian Sericulture Research*, CSR&TI, Mysore.
4. Dandin S B, Jayant, Jayaswal and Giridhar K (Eds.). 2003. *Handbook of Sericulture Technologies,* CSB, Bengaluru.
5. Govindan R, Chinnaswamy K P, Krishnaprasad N K and Reddy D N R. 2000. *Non-Mulberry Sericulture, Silk Technology and Sericulture Economics and Extension,* Vol. III– Proceedings of NSTS – 1999. UAS, Bengaluru.
6. Sanjay, Sinha. 1990. *The Development of Indian Silk*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
7. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture*. CSB Bengaluru.

Entrepreneurship and Business Development in Sericulture 2 (0+2)

Objectives

i. To be able to understand the entrepreneurial opportunities in sericulture.

ii. Enables them to understand the resource management in various activities of sericulture for earning more profit.

Practical

Concept of entrepreneur, Entrepreneurship development, Characteristics of entrepreneurs; SWOT analysis and and achievement motivation, Government policy and programs and institutions for entrepreneurship development, Impact of economic reforms on Agribusiness/ Agrienterprises, Entrepreneurial development process; Import, export and international issues; Business leadership skills; Developing organizational skill (controlling, supervising, problem solving, monitoring and and evaluation), Developing managerial skills, Business leadership skills (Communication, direction and motivation skills), Problem solving skill, Supply chain management and Total quality management, Project planning formulation and report preparation; Financing of enterprise, Opportunities for agri-entrepreneurship and rural enterprise. Entrepreneurship development in different areas of Sericulture: Entrepreneurship development in mulberry cultivation - kisan nursery, composting, vermicomposting, bio-digester, bio-gas production, livestock production, mushroom cultivation and silage production. Entrepreneurial development in silkworm-egg production, Chawki rearing and cocoon production. Entrepreneurship development in silk reeling and post reeling activities: Entrepreneurship development in silk reeling – establishment of reeling units, twisting and dying units, weaving units. Entrepreneurship development in seri-inputs, manufacture/ production, marketing/ custom hiring of sericulture material/equipment.

Value addition to by-products in sericulture: Value addition to mulberry- mulberry as fuel, green manure, fodder, live fencing material, wind breaks. Mulberry fruits and their use in pickle, jam, jelly, beverage/wine preparation. Mulberry as medicine, mulberry in agriculture and sports industry, mulberry in biogas production, mulberry as shade and avenue tree. Processing of mulberry leaves for tea preparation and food products. Medicinal value of mulberry. Value addition during silkworm rearing –silkworm litter as livestock feed; as an organic manure, raw material for biogas production, mushroom raising, poultry feed, fish feed, silkworm excreta in cosmetic industry. Silkworm in human consumption. Value addition to by-products of silk reeling: Pupal oil extraction and its uses, pupal powder as animal feed and manure. Flimsy cocoons and waste cocoons used as raw material in spun silk industry and quilting purpose. Silkworm pupa in human consumption-commercialized products and locally prepared dishes. Preparation of handicrafts, toys, wall plates, garlands, greeting cards, etc., from waste cocoons. Sericin in medicine, cosmetics, artificial membranes and plastic industry and other uses of silk.

Suggested Readings

1. Anonymous. 2002. *Silk Weaving*, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
2. Anonymous. 2002. *Colours from Nature – Silk Dyeing Using Natural Dyes (Vol. I & II).* Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
3. Bernard P. Corbman. 1983. *Textiles: Fiber to Fabric*. (6th Edn.). 594p. Mc. Graw – Hill International Editions, Home Economic Series, Singapore.
4. Charles J Huber. 1929. *The Raw Silk Industry of Japan.* The Silk Association of America, Inc., New York.
5. Dandin S B and Gupta V P. 2002. *Advances in Indian Sericulture Research*, CSR&TI, Mysore.
6. Dandin S B, Jayaswal J and Giridhar K (Eds.). 2003. *Handbook of Sericulture Technologies*, CSB, Bengaluru.
7. Datta R K. 1996. Global Silk Scenario – 2001. *Proceedings of the International Conference on Sericulture – 1994,* Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.

8. Govindan R, Chinnaswamy K P, Krishnaprasad N K and Reddy D N R. 2000. *Non-Mulberry Sericulture, Silk Technology and Sericulture Economics and Extension,* Vol. III– *Proceedings of NSTS – 1999,* UAS, Bengaluru.
9. Sinha S. 1990. *The Development of Indian Silk,* Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
10. Tazima Y. 1978. *The Silkworm: An Important Laboratory Tool,* Kodansha Ltd., Tokyo.
11. Tripurari Sharan. 1984. *Sericulture and Silk Industry,* Published by Y.K. Sharma, Consortium on Rural Technology, Delhi.
12. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture,* CSB, Bengaluru.
13. Yasuji Hamamura. 2001. *Silkworm Rearing on Artificial Diet,* Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
14. Yonemura M and Rama Rao N. 1925. *Handbook of Sericulture,* Mysore Government Branch Press.

Journals

- Bulletins of Sericultural Experimental Station – Suginami, Tokyo, Japan.
- Journal of Sericultural Science of Japan – Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- Sericologia – ISC, Bengaluru.
- Indian Journal of Sericulture – CSR and TI, Mysore.
- Journal of Sericulture and Technology – NASSI, Bengaluru.
- Indian Silk – Central Silk Board, Bengaluru.
- Bulletin of Indian Academy of Sericulture - Bhubneswar, Odisha.
- Reshme Krishi (Kannada) – Department of Sericulture, Government of Karnataka, Bengaluru.

Websites

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in/
- www.csrtimys.res.in/

Post-Semester IV* (Only For exit option for UG-Diploma in Sericulture)

S. No.	Course Title	Credit Hours
SDE 221	Internship (10 weeks)	10 (0+10)

*Mandatory requirement for UG-Diploma.

On exit, the students will be eligible to be awarded UG-Diploma in Sericulture.

A student studying any one of the following modules will get a Diploma in Sericulture

Nomenclature of Diploma	Module taken	
	Semester-III	Semester-IV
UG Diploma in Sericulture	SEC-3	SEC-4

Semester - V

Silkworm Breeding 3 (2+1)

Objectives

i. To study the fundamental concept about silkworm races, silkworm breeding and strategies for future sericulture development.

ii. To study the concept of non-conventional silkworm breeding methodology and skill development in germplasm management.

Theory

History of silkworm breeding in Japan, China and and India, Origin and differentiation of silkworm breeds, Genealogy of silkworm races, CSR breeds and Hybrids: Characters and requirements for cocoon production, Analysis of accomplishment of silkworm breeding in India and causes for non exploitation of native silkworm breeds. Principles and objectives of silkworm breeding, Hardy Weinberg's Law of Equilibrium of gene and genotype frequencies, Factors disturbing the equilibrium in random populations: Migration, Mutation, Random drift, Selection and Inbreeding, Systems of mating: Random mating, Genetic assortative mating, Genetic dissortative mating, Phenotypic assortative mating and Phenotypic dissortative mating, Objectives of silkworm breeding. Activities of silkworm Breeding Program: Creation of variation, Selection, Evaluation, Multiplication and Distribution. Maintenance of silkworm germplasm bank: Definition of Germplasm, Importance of maintenance of silkworm germplasm bank/station, Objectives of germplasm station, Activities of germplasm stations, Collection: Definition, Criteria/Procedure for collection of germplasm, Proforma for collection of silkworm breeds, Maintenance of germplasm: Care taken during maintenance, Rearing schedule, Incubation and Black boxing, Pattern of Brushing, Method of rearing, Selection of cocoons, Egg Production, Passport Description of Germplasm: Name and Number of the Accession/Genotype, Donor, Place of Origin, Classification/Category of germplasm based on origin (Indegenous, Exotic) and need (Breeds in current use, Obsolete breeds, Breeding material, Other collection). Maintenance and multiplication of silkworm breeds/stocks, Maintenance of silkworm breeds/stocks - Procedure for Multivoltines and Bivoltines and Maintenance of Breeder's stock, Maintenance of Parental stocks, 3- tier multiplication of parental stocks of silkworms. Genetic Basis of silkworm breeding program s, Hybridizarion: Meaning and Objectives, Types and Pre-requisites and Procedure/Steps in silkworm Hybridization Program, Choice of parental material, Crossing and hybridization, Precautions during hybridization, Concept and handling of filial generations (F_1), Handling of Second filial (F_2) and subsequent generations: Pedigree method, Mass/bulk method, Comparison of Pedigree and Mass/Bulk Methods, Consequences and problems in hybridization. Preserving the variability, Minimizing Inbreeding depression. Heterosis breeding: Heterosis, Meaning of Heterosis, Effects of Heterosis (Biological, Physiological), Classification of Heterosis, Causes of Heterosis, Biochemical basis. Breeding methods to exploit Heterosis, Measurement of Heterosis: Relative Heterosis, Heterobeltiosis, Standard Heterosi. Commercial exploitation of Heterosis and manifestation of Heterosis. Silkworm Improvement through Selection Breeding, Mass selection/ Bulk Method: Definition, Procedure of mass selection, Merits and demerits. Pureline selection: Definition, Characters of pureline, Uses of the pureline, Procedure for pureline selection, Advantages and disadvantages of pureline selection. Back cross (BC) breeding: Definition of Backcross, Requirements for BC breeding program, Application of BC method, Genetic consequences of BC

method, Procedure for BC method and Merits and demerits of BC and a few accomplishments. Line breeding: Definition of line breeding and inbreeding, Criteria for line breeding, Procedure for Line/ inbreeding and Effects of line/inbreeding. Parthenogenesis in silkworms: Definition and history, Classification of parthenogenesis, Methods of induction of parthenogenesis, Characteristic features of parthenogenetic individuals. Mutation breeding in silkworm improvement: Definition and historical account of mutation breeding, classification of mutations, mutagens and their classification, effects of mutagens, molecular basis of mutations, mechanism of action of mutagens, procedure for mutation breeding to improve polygenic traits in silkworms, handling mutated population and methods of measurement of mutation frequency and application, limitations and achievements of mutation breeding. Polyploidy breeding in silkworm improvement: Definition, occurrence and origin of polyploids, Types of polyploids, Production of polyploids in silkworms and characters of polyploids. Breeding for stress tolerance (Biotic: Disease and Abiotic: Temperature) in silkworms: Definition of disease, Disease development, Concept of disease escape and disease resistance, Mechanism of disease resistance: Mechanical, Hyper sensitivity, Antibiosis, Nutritional, Genetic basis of disease resistance and Approaches for disease resistance breeding in silkworms. Sex limited breeding in silkworm, *Bombyx mori* L. Techniques for breeding of auto sexing races in silkworms, Concepts of Breeding of non-mulberry silkworm, Authorization of silkworm breeds and their hybrids, AISRCC (All India Sericulture Research Co-ordination committee) norms of authorization, JICA (Japanese International Co-operation for Agriculture) Race Authorization committee.

Practicals

Study of breed characteristics of mulberry and non-mulberry silkworm. Procedure and maintenance of silkworm germplasm bank. Procedure for hybridization in silkworms. Assessment of variability (ANOVA). Genetic analysis of qualitative and quantitative traits. Estimation of heterosis. Diallel (partial and complete) and three-way cross analysis. Line X Tester analysis.

Suggested Readings

1. Mal Reddy N and Kalpana G V. 2005. *Silkworm Breeding and Genetics*, Central Silk Board, Bengaluru.
2. Dilip De Sarkar. 1998. *The Silkworm - Biology, Genetics and Breeding*. Vikas Publishing House Pvt. Ltd., New Delhi.
3. Sreerama Reddy G. 1998. *Sikworm Breeding*, Oxford and IBH Publishing Co Pvt. Ltd., New Delhi and Calcutta.
4. Tazima Y. 1964. *Genetics of Silkworm*, Academic Press, London.

Vanya Sericulture 2 (1+1)

Objectives

i. To enlighten about various types of silk producing insects and their production techniques
ii. To provide basic and applied aspects of non-mulberry sericulture

Theory

Introduction to vanya sericulture- Importance of vanya silks. Global production of vanya silks, their scope and impact on the socio-economic conditions of tribal's. Status of vanya silks in India- Production trends. Distribution of Vanya Silk Yielding (Sericigenous) Insects and Non

Insects and their Classification Plant Origin- Silk Cotton Fiber and Floss Silk, Animal Origin - Insect origin- Commercially Exploited- Tasar, Eri and Muga, Insect origin – Commercially less Exploited – Anaphae, Fagara, Coan, Non-insect origin – Mussel and Spider silk. Different types of votinism of tropical and temperate tasar, eri and muga silkworms– Univoltine, Bivoltine, Trivoltine and Multivoltine. Characteristic features of different stages of tropical and temperate tasar, eri and muga silkworms - Egg, Larva, pupa, cocoon and adult. Traditional methods of tropical and temperate tasar silkworm rearing – traditional rearing practices by the tribals Improved methods of tropical and temperate tasar silkworm rearing. Indoor rearing (Chawki silkworm) – Bottle rearing, Picture rearing, Pit rearing, Box rearing. Advantages and disadvantages of different indoor rearing techniques. Outdoor rearing – Nylon net enclosure method, Maintenance of outdoor rearing – Feeding and its frequency, Moulting, and mounting management and care during Moulting and mounting and Harvesting of cocoons. Egg production technology of topical and temperate tasar silkworms Selection of seed cocoons, Emergence of moths and Synchronization, Pairing and de-paring of moths - Different techniques, Oviposition and care during oviposition, Handling of eggs after egg laying – collection of eggs, washing, drying, packing and mother moth examination. Eri silkworm rearing Traditional eri silkworm rearing practices, Improved methods of eri silkworm rearing – Bunch rearing and tray rearing, Maintenance of rearing – Feeding and its frequency, bed cleaning and methods, spacing of worms, Moulting and mounting management and care during Moulting and mounting, Methods of eri silkworm mounting – Bamboo basket, split bamboo, Jali and mat mounting and Harvesting of cocoons. Egg production techniques in eri silkworm Selection of seed cocoons, Emergence of moths and Synchronization, Pairing and de-paring of moths - Different techniques, Oviposition and care during oviposition, Handling of eggs after egg laying – collection of eggs, washing, drying, packing and mother moth examination. Traditional methods of muga silkworm rearing Traditional muga silkworm rearing practices, Improved methods of muga silkworm rearing – outdoor rearing techniques, Maintenance of rearing – Feeding and its frequency, Moulting and mounting management and care during Moulting and mounting and Harvesting of cocoons. Egg production techniques in muga silkworm Concept of Pre-seed and seed crop in muga culture, Selection of seed cocoons, Emergence of moths and Synchronization, Pairing and de-paring of moths - Different techniques, Oviposition and care during oviposition, Handling of eggs after egg laying – collection of eggs, washing, drying, packing and mother moth examination. Natural enemies and other problems in vanya silk cocoon production Insect and non-insect pests of vanya silkworm and their management, Diseases of vanya silkworm and their management, Other problems in vanya sericulture sector – natural calamities, forest policies, marketing of cocoons etc.. Marketing of vanya silk (Tasar, Eri and Muga) products (Cocoon, raw silk and silk fabrics). Economics of Tasar, eri and muga culture. Recent Developments in Non-Mulberry Sericulture New Projects, Other Agencies Involved In Vanya Sector – NGOs Etc., Value Addition to Non-Mulberry Sericulture By-products.

Practical

Study on Vanya silkworms. Study on Insect and Non Insect Sericigenous Species. Study of life stages of eri silkworm, tasar and muga silkworms. Host plants of eri silkworm and their pests and diseases. Study on food plant production technology of Eri Silkworm *Samia cynthia ricini*. Grainage operations in *Samia cynthia ricini* Boisduval. Rearing of Eri Silkworm *Samia cynthia ricini* on Primary Host Plants and diseases and pests of eri silkworm. Spinning, harvesting and grading of eri silk cocoons. Economics of ericulture. Host plants of tasar silkworms and their pests and diseases.

Study on food plant production technology of tasar silkworm. Study of Rearing Tasar Silkworm on Primary Host Plants and Pests and Diseases of Tasar Silkworm. Host plants of muga silkworms and their pests and diseases. Study on Host Plant production technology of Muga Silkworm. Study of Rearing Muga Silkworm Antheraea assamensis and Pests and Diseases of Muga Silkworm.

Suggested Readings

1. Jolly M S, Sen S K and Ahsan M M. 1974. *Tasar Culture*, Ambika Publishers, Bombay.
2. Jolly M S, Sen S K, Sonwalkar T N and Prasad G K. 1979. *Sericulture Manual - 4 – Non-Mulberry Silks*, Agriculture Service Bulletin, FAO, Rome.
3. Sannappa B, Jayaramaiah M, Govindan R and Chinnaswamy K P. 2002. *Advances in Ericulture,* Seri Scientific Publishers, Bengaluru.
4. Sarkar D C. 1980. *Ericulture in India*, Central Silk Board, Bengaluru.

Fundamentals of Soil Science 2 (1+1)

Objectives

i. To enable the students to familiarize with the soil formation and its properties
ii. To study the soil pedolgy and soil physics

Theory

Soil Science: definition, introduction, importance, scope and branches. Soil: definition, Soil a natural body, edaphalogical and pedological concepts of soil, components of soil. Minerals: definition, occurrence, classification of minerals based on abundance, specific gravity, mode of origin and chemical composition, study of silicate and non-silicate minerals (types and their composition). Rocks: definition, formation, occurrence and classification of rocks based on mode of origin. Igneous rocks, Sedimentary rocks and Metamorphic rocks, their classification. Weathering of rocks and minerals: definition, types - physical, chemical and biological weathering, factors influencing weathering, products of weathering, weathering sequence. Soil formation: factors of soil formation, active factors like climate, organisms and passive factors like parent materials, topography and time. Pedogenic processes of soil formation: basic/ fundamental processes and specific pedogenic processes. Soil profile: master horizons, transitional horizons and subordinate horizons. Soil physical properties: Soil texture- definition, soil separates (USDA and ISSS) and their properties. Particle size analysis – Stoke's law; derivation, assumptions and limitation of Stoke's law. Textural classes. Soil structure: classification based on types, class and grade, importance, mechanism of aggregate formation, factors affecting soil structure and evaluation of soil structure. Management of soil structure. Soil density: particle density, bulk density; their relationships, factors influencing soil density and importance. Soil porosity: definition, types of pores, factors affecting porosity and importance. Soil colour: Attributes (hue, value and chroma), importance, factors affecting soil colour. Soil consistency: forms (Hard, soft, plastic and sticky consistency), factors affecting consistency, Atterberg's limits, and significance. Soil air: composition, importance, mechanism of gaseous exchange and management. Soil temperature: Source, amount, factors influencing soil temperature, flow of heat, thermal properties of soil and its importance/management in plant growth. Soil water: classification, soil moisture constants, movement and availability of soil water, infiltration, percolation and hydraulic conductivity. Soil Organisms: Macro and Microorganisms

(Beneficial and Harmful organisms). Soil survey: types, methods and purpose of soil survey. Soil classification: USDA system of classification (Soil taxonomy); salient features, structure of soil taxonomy, formative elements and their meaning, epipedons, endopedons, soil moisture and soil temperature regimes, keys to soil orders and salient characteristics of Inceptisols, Entisols, Alfisols and Vertisols. Soils of India and Karnataka.

Practical

Study of silicate minerals. Study of non-silicate minerals. Study of igneous rocks. Study of sedimentary rocks. Study of metamorphic rocks. Study of soil sampling tools and collection of representative soil samples. Study of soil profile. Determination of soil density, moisture content and porosity. Study of soil texture by feel and bouyoucos method. Studies of capillary rise phenomenon of water in soil column and water movement in soil. Determination of soil colour Demonstration of heat transfer in soil. Study of soil map.

Suggested Readings

1. Saha Arun Kumar. 2004. *Textbook of Soil Physics,* Kalyani Publishers, New Delhi.
2. Baruah T C and Barthakar H P. 1997. *A Textbook of Soil Analysis*, Vikas Publishing House Pvt Ltd, New Delhi.
3. Brady N C and Weil R. 2001. *Nature and Properties of Soil*. (13th Edn.). Macmillan Co., New York.
4. Sarkar Dipak. 2003. *Fundamentals and Applications of Pedology,* Kalyani Publishers, New Delhi.
5. Das Dilip Kumar. 1996. *Introductory Soil Science,* Kalyani Publishers, New Delhi.
6. Ghildayal B P and Thripathi R P. 1987. *Soil Physics,* Wiley Eastern Ltd, New Delhi.
7. Sekhon G S. 2002. *Fundamentals of Soil Science,* ISSS, IARI, New Delhi.
8. Sehgal J. 1996. *Pedology: Concepts and Applications*, Kalyani Publishers, New Delhi.

Fundamentals of Extension Education 3 (2+1)

Objective

To understand the importance and concept of extension education and different rural development programs.

Theory

Education: Meaning, definition and and types; Extension education - meaning, definition, scope and process. Objectives and principles of extension education. Extension program planning – Meaning, Process, Principles and steps in program development. Extension systems in India: Extension efforts in pre-independence era (Sriniketan, Marthandam, Firka development Scheme, Guragaon Experiment) and Post-independence era (Etawah Pilot Project, Nilokheri Experiment). Agriculture development programs launched by ICAR/ Govt. of India (IADP, IAAP, HYVP, KVK, IVLP, ORP, ND, NATP, NAIP). New trends in agriculture extension: Privatization of extension, cyber extension/ e-extension, market-led extension, farmer-led extension, expert systems. Rural development: Concept, meaning, definition; various rural development programs launched by Govt. of India. Community Development- meaning, definition, concept and and Principles, Philosophy of C.D. Rural leadership: Concept and definition, types of leaders in rural context; extension

administration: meaning and concept, principles and functions. Monitoring and evaluation: Concept and definition, monitoring and evaluation of extension programs; transfer of technology: concept and models, capacity building of extension personnel. Communication: Meaning, definition, Basic elements of communication and their characteristics, Principles and functions of communication. Communication models- Aristotle, Shanon Weaver, Berlo's, Sachramm, Leagan's, Rogers and Shoemaker and Lasswell model. Types and barriers to communication. Scope and importance of communication. Diffusion and adoption of innovations - Concepts and meaning, definition, attributes of innovation, models, adoption process and stages of adoption and factors influencing adoption process. Innovation Decision Process - elements, adopter categories and their characteristics. Extension teaching methods- Meaning, definitions, functions and classification. Factors influencing the selection of extension teaching methods and combination (Media Mix) of teaching methods. Individual contact methods-farm and home visit, result demonstration, field trials - meaning, objectives, steps, merits and demerits. Group contact methods-group discussion, general meeting, method demonstration, field trips and study tour - meaning, objectives, steps, merits and demerits. Mass contact methods - newspaper, campaign, exhibition, kisan mela, radio and television - meaning, importance, steps, merits and demerits. Application in TOT (New and social media), Definition, concept, ICAR projects, National demonstrations, ORP, KVKs, Lab to Land program, constraints in TOT, models of transfer of Technology, farming system research extension model, IPM-FFs model, decentralized extension, ATMA model, model developed by IRI New Delhi, farming system research / extension, ICT applications in TOT (New and social media), media mix strategies. Capacity building of extension personnel and farmers-meaning, definition types of training, difference between capacity building and training, methods of capacity building, different methods of training, training to farmers, farm women and rural youth FTC and KVK. Agriculture Journalism – functions of Journalism, different sources of information and importance of journalism in agricultural development, news and factors influencing effectiveness of news.

Practical

To get acquainted with university extension system. Group discussion –exercise; handling and use of audio visual equipments and digital camera and LCD projector; preparation and use of AV aids. Preparation of extension literature- leaflet, booklet, folder, pamphlet news stories and success stories. Presentation skills exercise; micro teaching exercise. A visit to village to understand the problems being encountered by the villagers/farmers. To study organization and functioning of DRDA and other development departments at district level. Visit to NGO and learning from their experience in rural development. Understanding PRA techniques and their application in village development planning; exposure to mass media. Simulated exercises on communication. identifying the problems fixing the priorities and selecting the most important problem for preparation of a project. Developing a project based on identified problem in a selected village. Organization of group discussion and method demonstration. Visit to KVK/ FTC. Planning and writing of scripts for radio and television. Audio visual aids, meaning, importance and classification. Selection, planning, preparation, evaluation and presentation of visual aids. Audio visual aids – meaning, importance and classification. Visit to community radio and television studio for understanding the process of program production. Planning and preparation of visual aids- posters, charts, overhead projector (OHP), transparencies, power point slides. Planning and preparation of agricultural information materials-leaflet, folder, pamphlet. New stories and success stories field diary and lab record, indexing, footnote and bibliographic procedure. Handling of public address equipment

(PAE) system. Still camera, video camera and liquid crystal display (LCD) projector. Development of schedules, questionnaires and field visits for data collection.

Suggested Readings

1. Advi Reddy A. 1977. *Extension Education,* Sree Lakshmi Press, Bapatla (A.P).
2. Benor D and Baxter M. 1984. *Training and visit Extension,* The World Bank Washington.
3. Berlo D K. 1960. *The Process of Communication*, Holt, Rinehart Winston Inc., New York.
4. Bhaskaran S. 2014. *Entrepreneurship Development and Management*, Aman Publishing House, Meerut.
5. Debabrata Das Gupta. 2012. *AGROBIOS (INDIA*). Agro House, behind Nasrani Cinema, Chopasani Road, Jodhpur.
6. Dhama O P and Bhatnagar O P. 1985. *Education and Communication for Development*, Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.
7. M V Srinivasa Reddy. 2021. *Fundamentals of Agricultural Extension Education*, Brillion Publishers, New Delhi.
8. Ray G L. 1991. *Extension Communication and Management*, Naya Prakash, Calcutta.
9. Rogers E M. 2003. *Diffusion of Agril*, Innovations, Free Press, New York.
10. Sagar Mondal. 2017. *Fundamentals of Agricultural Extension Education*, Kalyani Publishers, Delhi.
11. Sandhu A S. 2003. *Agricultural Communication Process and Methods,* Oxford and IBH Publishing, Co. Pvt. Ltd.
12. Supe S V. 1987. *An introduction to Extension Education*, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Mechanization in Sericulture 2 (1+1)

Objectives

i. To study the mechanization related to mulberry cultivation and cocoon production and post cocoon production process.
ii. To acquire a practical knowledge on primary stage of repair and maintenance of machineries.
iii. To study the tillage, intercultural and other machineries used for mulberry cultivation.
iv. To study the different machineries/handtools/systems used in rearing house for cocoon production.
v. To acquire a knowledge about machineries/ tools involved in post cocoon production process.
vi. To obtain a knowledge about repair and maintenance of machineries.

Theory

Status of farm power in India, Sources, importance and scope of mechanization. Different tillage, intercultural and other machineries used for mulberry cultivation. Different machineries/ handtools / instruments/ systems used in rearing house for cocoon production. Different types of mountages and mounting sheds. Cocoon driers. Cocoon sorting machines-riddling-deflossing machines. Cocoon cooking, brushing machines and Boilers. Filature and cotton basin units. Working of reeling and re-reeling machines, types, suitability and their testing. Silk twisting and throwing equipment. Non-mulberry cocoon reeling machines. Primary repair and maintenance of machineries used for mulberry cultivation.

Practicals

Familiarization with operation of tillage, intercultural and other machineries. Determination of different measures of mulberry cultivation machineries. Operation and installation of systems/ instruments used in rearing house for cocoon production. Study of mountages and mounting sheds, revolving mountages- cocoon stifling structures. Study the operation of cocoon driers. Familiarization with cocoon sorting machines-riddling-deflossing machines. Familiarization with cocoon cooking and brushing machines. Familiarization and operation of reeling machines. Familiarization with cottage basin and filature basins. Familiarization with automatic reeling machines, re-reeling machines. Familiarization with silk twisting and throwing equipment. Familiarization with repair and maintenance of machineries. Visit to reeling units.

Suggested Readings

1. B B Bindroo and Satish Verma. 2014. *Sericulture Technologies Developed by CSRTI, Mysore* (http://www.csrtimys.res.in/sites/default/files/ebooks/2014-1.pdf).
2. Krishnaswami S, Narasimhanna M N, Suryanarayan S K, Kumararaj S. 1973. *Sericulture manual (v.) 2.: Silkworm rearing*. FAO Agricultural Services Bulletin (FAO) Eng v. 15(2).
3. Satish Verma, S B Dandin. 2006. *Mechanisation in Sericulture*, Published by CSRTI, Mysore (http://www.csrtimys.res.in/sites/default/files/ebooks/2006-2.pdf)

Seri Biotechnology 2 (1+1)

Objectives

i. To understand the principles and applications of biotechnology.
ii. To provide information on various applications of biotechnology in sericulture.

Theory

Introduction to Biotechnology. Principles and methods of plant tissue culture techniques. Micro propagation in mulberry. Secondary metabolites and their applications. Recombinant DNA technology – Principles and applications in sericulture, PCR Techniques and their types. Restriction Enzymes, Vectors, Host and steps in gene cloning and expression. Transgenic- Methods of Gene Transformation (Agrobacterium and Ballistic Gene gun method). Molecular markers and their application in sericulture. Introduction to Genome Mapping. CRISPR-Cas9 technology and its application in sericulture. Introduction to Bioinformatics. Principles, Methods and Applications of gene sequencing. Gene silencing and its importance in sericulture. BmNPV vector and its applications.

Practical

Requirements for Plant Tissue Culture Lab. Techniques in Plant Tissue Culture- Sterilization Techniques, Plant Tissue Culture Media, Preparation of MS Medium. Micro-propagation in Mulberry. Genomic DNA Isolation in mulberry and silkworm. Study of Gel Electrophoresis. Study of Polymorphism in PCR based molecular markers. Gene Transformation Techniques- Agrobacterium mediated transformation and Ballistic Gene gun method. An overview of Bioinformatics tools. Visit to Biotechnology Laboratory.

Suggested Readings

1. Venkatesh Kumar R. 2011. *Applications of Biotechnology in Sericulture*. 300p. Studium Press India Pvt. Ltd.

2. Rajendra Kumar Yadav. 2021. *Handbook of Agricultural Biotechnology*. 775p. Bhavya Books.
3. Singh B D. 2023. *Biotechnology Expanding Horizons*. 938p. MedTech Sciencepress; Fifth Edition, Ansari Road, Daryaganj, New Delhi.

Physics and Chemistry of Fibres 2 (2+0)

Objectives

i. To understand the properties of different textile fibres.
ii. To enable differentiate in between natural and synthetic fibres.

Theory

Introduction, History and classification of fibres. General properties of fibres and essential properties of fibre forming polymer. Common properties of natural fibres – plant, animal and mineral fibres and synthetic/artificial fibre. Physical properties of fibres – length, width, ratio, translucency, luster, resiliency, pliability, elasticity. Chemical properties of fibres – reaction to acids, alkalies, salts. Study of plant based or cellulosic fibres – Cotton, flax/linen, hemp, ramie, sisal, abaca, pina, kapok, coir, jute. Study of regenrated cellulosic fibres – Rayon, acetate, triacetat fibres. Study of animal or protein fibre – wool, silk, spider. Hair fibres – camel, vicuna, Guancco, Llama, Aplaca, mohair, angora, quivit, human hair. Minor hair fibres – camel, common rabbit. Study of regenerated protein fibre – casein, ardil and vicara. Study of mineral and inorganic and and high-performance fibres – asbestos – glass fibres, carbon fibres, silicon carbide fibres, stainless steel fibres. Study of synthetic fibres – Nylon, polyester, poly acryl, vinylon (poly vinyl) vinilidene chloride, polyethylene, polypropylene, poly urethane.

Suggested Readings

1. Arindum Basu. 2015. *Advances in Silk Science and Technology*. (Illustrated Edn.). 298p. Woodhead Publishing Ltd; Illustrated edition.
2. Barker A F. 2015. *Handbook of Textiles*. 375p. Abhishek Publications.
3. Mishra S P. 2005. *A Textbook of Fibre Scence and Technology*. 368p. A New age International Publishers.
4. Susma Gupta. 2004. *Textbook of Clothing and Textile*, Kalyani Publishers. New Delhi.
5. Sushma Gupta, Neeru Garg, Jaspreet Kaur and Lotika Gupta. 2018. *Textbook of Clothing, Textiles and Laundry*. 368p. Kalyani Publishers.

Fundamentals of Crop Physiology 2 (1+1)

Objectives

i. To learn the basic functioning of plants.
ii. To understand water and nutrient uptake and functioning mechanisms in plants; mechanism of CO_2 fixation in plants; plant growth and development as influenced by plant growth hormones; mechanism of stress adaptation by plants.

Theory

Introduction: Importance of physiology in various fields of agriculture. Plant-water relations: Structure of water, functions and properties of water. Importance of water for plant

growth and development. Water movement in plants, concept of diffusion, osmosis and imbibition. Concept of water potential: Definition, components of water potential in plant cell and soils. Water in soil; forms of water in soil and available water. Concepts of water saturation, field capacity, wilting point. Water absorption. Symplastic and apoplastic movement of water in plants. Internal and external factors influencing water absorption in plants. Translocation of water: Theories explaining ascent of sap (water translocation). Soil-plant-atmosphere continuum; Internal and external factors influencing water translocation in plants. Transpiration: Definition, types of transpirations in plants, significance of transpiration; Transpiration in relation to crop productivity. Transpiration ratio. Stomatal physiology: Structure of Stomata, types and stomatal movement. Theories explaining the stomatal movement. Factors affecting transpiration rate. Concept of cavitation. Water use efficiency and its relevance. Water use efficiency in C3, C4 and CAM plants. Anti-transpirants- Definition, different types of Anti-transpirants with examples. Mineral Nutrition: Definition, importance of plant nutrients, Arnon's criteria of essentiality. Classification of essential nutrients based on requirements, Physiological role and Biochemical functions and based on mobility in phloem. Mechanisms of ion uptake: Theories explaining ion uptake, Passive and active ion uptake, membrane transporters and carriers. Photosynthesis: definition, structure of chloroplast and its function. Photochemical and biochemical reactions and their importance for photosynthesis. Mechanism of carbon fixation in C3, C4 and CAM plants. Steps in carbon fixation: Chemo-osmotic theory and ATP production. Kranz leaf anatomy in C4 plants and its relevance. Difference between C3, C4 and CAM pathways. Internal and external factors influencing photosynthesis in plants. Phloem loading and unloading; difference between apoplastic and symplastic phloem loading. Photorespiration; significance and steps involved in photorespiration. Respiration: definition and significance of respiration, structure of mitochondria and its function. Respiratory substrates and Respiratory quotient, types of respiration, Steps in aerobic respiration. Anaerobic respiration/ fermentation. Alternative respiration /pentose phosphate pathway. Cyanide resistance respiration in plants. Internal and external factors influencing rate of respiration in plants. Relationship between respiration, photosynthesis and yield. Plant growth and development: Definition. Plant growth pattern and growth curve. Determinate and indeterminate growth habits. Monocarpic and polycarpic species with examples. Growth and yield parameters and their measurements; Measurement and Formulae used for determining Leaf Area Index (LAI), Leaf area duration (LAD), Specific leaf area (SLA), Crop Growth rate (CGR), Net assimilation rate (NAR), Relative growth rate (RGR), Harvest Index (HI). Plant growth regulators and Hormones: Endogenous and exogenous (synthetic) growth regulating substances. Discovery and site of synthesis of different plant hormones. Synthetic growth regulating substances, growth retardants, growth inhibitors, pinching agents, male sterility. Importance of plant growth regulators in modulating crop growth. Physiological importance of different plant hormones such as Auxin, Gibberellin, Brassinosteroid, cytokinin, ABA, ethylene etc., Biosynthesis and mode of action of plant hormones, applications of plant growth regulators in agriculture, horticulture and industry. Stress Physiology: Acclimation and adaptation mechanisms. Plants response to stress. Strategies adopted by plants to overcome stress effects. Drought tolerance traits and their relevance.

Practical

Preparation of standard solutions, units of concentration and dilution. Methods of measuring water status in plant tissue. Determination of stomatal frequency and index. Measurement of

stomatal conductance and transpiration. Extraction, separation and quantification of photosynthetic pigments. Measurement of water use efficiency at single leaf level. Measurement of photosynthetic rate. Measurement of respiration rate. Measurement of growth and yield parameters. Deficiency symptoms of nutrients and their identification. Growth hormone bioassay. Effect of moisture stress on seed germination and seedling vigour.

Suggested Readings

1. Frank B Salisbury and Cleon W Ross. 2004. *Plant Physiology.* (4th Indian Edn.). 682p.
2. Malcolm B Wilkins. 1987. *Advanced Plant Physiolog*. 528p. Longman, New edition.
3. Ray Noggle G and Fritz G J. 1986. *Introduction to Plant Physiology.* (2th Edn.). 640p. Prentice Hall India Learning Private Limited; 2nd edition.
4. Robert M Devlin and Francis H Witham. 1983. *Plant Physiology*. 320p. Medtech, Division of Scientific International.
5. Taiz L and Zeiger E. 2002. *Plant Physiology.* (3rd Edn.). John Wiley & Sons Inc., Hoboken, New Jersey.
6. William G Hopkins. 1986. *Introductory Plant Physiology*. J. Wiley, New York.

Introduction to Agrometeorology 2 (1+1)

Objectives

i. Enables the application of meteorological information to agriculture
ii. To study the weather and its uses in crop production
iii. To learn about climate to enhance or expand agricultural crop production

Theory

Agricultural meteorology, meaning, scope and importance in crop production. Earth Atmosphere-composition-vertical layers of atmosphere based on temperature difference. Climate and weather-factors affecting climate and weather, Atmospheric weather variables. Atmospheric pressure, its variation with height. Wind, types of wind, daily and seasonal variation of wind speed, cyclone, anticyclone, land breeze and sea breeze. Solar radiation, Nature and properties, solar constant, depletion of solar radiation, short wave, longwave and thermal radiation, net radiation, albedo. Light, light intensity, quality, direction and duration, effect of light on crop production. Atmospheric temperature, temperature inversion, lapse rate, diurnal and seasonal variation in air temperature, Isotherm. Heat unit, definition and its use, heat and cold waves, role of temperature in crop production. Energy balance of earth. Atmospheric humidity, concept of saturation, vapor pressure, Absolute humidity, Relative humidity, Specific humidity. Cloud formation and classification. Condensation, Process of condensation, formation of dew, fog, mist, frost, cloud. Precipitation, process of precipitation, types such as rain, snow, sleet, and hail. Artificial rainmaking. Cold and warm cloud seeding, Monsoon- mechanism and importance in Indian agriculture. Weather hazards - drought, floods, frost, tropical cyclones and extreme weather conditions such as heat-wave and cold-wave. Weather forecasting- types of weather forecast and their uses.

Practical

Visit of Agrometeorological Observatory. Selection of site for Agrometeorological observatory, exposure of instruments and weather data recording. Measurement of total, shortwave and longwave

radiation, and its estimation using Planck's intensity law. Measurement of albedo and sunshine duration. Computation of radiation intensity using Bonnel sphere spectrometer. Measurement of maximum and minimum air temperatures. Tabulation, trend and variation analysis in maximum and minimum temperature. Measurement of soil temperature and computation of soil heat flux. Determination of vapour pressure and relative humidity. Measurement of atmospheric pressure and analysis of atmospheric conditions. Measurement of wind speed and wind direction. Measurement, tabulation and analysis of rainfall. Measurement of open pan evaporation and evapotranspiration. Computation of potential and actual evapotranspiration.

Suggested Readings

1. Khan Naushd and Dubey Digvijay. 2021. *Climate Science*. 300p. Bhavya Books, New Delhi.
2. Mahi H S. 2003. *Introduction to Agrometerology*, Kalyani Publishers, New Delhi.
3. Reddy S R. 2016. *Principles of Agronomy*, Kalyani Publishers, New Delhi.
4. Yellamandareddy T and Shankar Reddy G H. 2016. *Principles of Agronomy*, Kalyani Publishers, New Delhi.

Essentials of Plant Biochemistry 2 (1+1)

Objectives

i. This course aims to provide an in depth understanding of the metabolism of macro and micronutrients and of the role of nutrition in influencing cell growth, development and maintenance of body functions. Students will be able to understand the biochemical pathways in normal and diseased conditions.

ii. To understand the relationship of chemical and physiological functions of various specialized cells of the body to their roles in metabolism and nutrition.

iii. To describe the major pathways of energy metabolism, how they are regulated, modified during different physiological states and their consequences.

iv. To understand the biochemical aspects of nutrients and utilization of nutrients in the body.

Theory

Introduction to biochemistry: The plant cell and its sub cellular organelles-nucleus, endoplasmic reticulum, Golgi apparatus, vacuoles, mitochondria, chloroplasts, micro bodies, oleosomes, cytoskeleton, cell wall and their functions. Biomolecular components of plant cells: Carbohydrates - Definition and classification. Monosaccharides - stereochemistry, nomenclature, cyclic forms. Mutarotation, reactions of monosaccharides. Di-andoligo-saccharides. Plant polysaccharides, structure and role; Amino acids and proteins: Importance of proteins in living systems. Diverse roles of proteins. Amino acids, the subunits of proteins. Classification, structures and chemical reactions. Protein amino acids. The peptide bond. Biological role of peptides. Protein classification. Structure of proteins - primary, secondary, tertiary and quaternary structures. Properties of proteins. Denaturation of proteins; Lipids: Classification. Fatty acids - their classification and structures. Chemical properties, Triglycerols, waxes, phospholipids, sphingolipids, terpenes and sterols. Their structures and functions; Enzymes: Classification and nomenclature. Factors that influence enzyme activity. Immobilization and industrial applications; Nucleic acids: RNA and DNA. The constituents of nucleic acids, structures of purines and

pyramidines. Nucleosides, nucleotides. DNA-its structure. Types of RNA, their characteristics and role. Cloverleaf structure of tRNA. Metabolism of Biomolecules: An overview of metabolism, catabolism and anabolism-their general characteristics; Carbohydrate metabolism; Glycolysis-Pathway of glucose in the cytosolic glycolytic sequence. Energetics of glycolysis; TCA cycle-a mitochondrial reaction cycle. Oxidation of Pyruvate via TCA cycle. Energetics of TCA cycle; Electron transport and oxidative phosphorylation-the components of the electron transport chain. ATP synthesis coupled to electron transport; The pentose phosphate pathway-reactions. Role of pentose phosphate pathway; Lipid metabolism: β-Oxidation of fatty acids and its energetics. Amino acid metabolism: Removal of amino group of amino acids by deamination and transamination. Decarboxylation of amino acids. Secondary metabolites: Phenolics: Different classes of phenolics and their functions; Polyphenols: the tannins-classification of tannins. Phenolics and tannins as antinutritional factors. Roles of phenolics and tannins in disease/pest resistance of plants; Alkaloids: Definition and occurrence of some common alkaloids of plants. Role of alkaloids as defense compounds; Terpenoids: Nomenclature, classification and occurrence. Functions of terpenoids. Carotenoids-their distribution and functions in higher plants.

Practical

Estimation of total sugars by Phenol-Sulfuric acid method. Estimation of protein by Lowry's Method. Protein denaturation: Heat, pH, Precipitation of protein with heavy metals. Extraction of oil from oil seeds. Estimation of crude fat. Estimation of iodine number of an oil. Estimation of saponification value of an oil or fat. Determination of ascorbic acid. Determination of chlorophylls. Determination of phenols. Assay of enzyme. Extraction of nucleic acids and quantification. Paper chromatography for separation of sugars. Quantitative and qualitative determination of sugars.

Suggested Readings

1. Albert L Lehninger. 2004. *Biochemistry*. 1052p. Kalyani Publishers, New Delhi.
2. Rajan Katoch. 2017. *Fundamentals of Plant Biochemistry and Biotechnology*. 217p. Kalyani Publishers, New Delhi.
3. Eric E Conn, Paul K stumpf, George Bruening and Roy H Doi. 2007. *Outline of Biochemistry.* (5th Edn.). 693p. John wiley & sons, Singapore.
4. Wilson K and Walker J M. 1994. *Principles & Techniques of Practical Biochemistry*. 574p. Cabridge University Press.

Semester VI

Experimental Techniques in Sericulture Research 2 (1+1)

Objectives

i. To heighten the sericulture knowledge and improve technology
ii. Is to prove a hypothesis or answer a specific question of sericulture by doing step by step research
iii. To address the region specific problem
iv. To solve pest and disease problem in mulberry crop production

Theory

Definition of research and sericulture research. Steps involved in basic research. Development of sericulture research in India and Karnataka. Modern trends, concepts in sericulture research and their impact on productivity: Mulberry improvement (Conventional practices and Modern Genetic Engineering concepts), Silkworm improvement, other trends in sericulture research (Mulberry based Integrated farming system, Integrated nutrient management and Integrated pest and disease management). Essence of research levels: Level-1, Level-2, Level-3, Level-4 and Level-5. Methods of research: (Scientific method, empherical method, experimental method, statistical method, survey method, case study method and historical method). Review of literature on sericulture research: Pot culture experiments, Animal experiments, Field experiments- varietal, cultural, fertilizer, pesticides, irrigation. Aims and Objectives of laboratory and field experiments: Aims and broad and specific objectives. Selection of site for experiment: Different criteria's to be considered for selection of site, plot size and shape. Sources of variation of experiments. Uniformity trials and interpretation of blocks. Factors considered in fixing treatments and in fitting the experiments: Criteria for choice and priority, Treatment fixing: Reviewing of previous literature, preliminary experiments, Decision of intervals. Different types of experiments-varietals, cultural, manurial, irrigation, weed control, silkworm rearing, Silk worm breeding, grainage, pests diseases and silk technology. Research project and Procedure to prepare research project proposal: Thrust area, background, Concept, introduction, methodology, expected outcome, Practical significance. Preparation of data for scientific papers and presentation of results. Experiments on mulberry and non- mulberry host plants. Short and long duration trials: Long term fertilizer and manurial experiment. Breeding of pest and disease resistant genotypes of mulberry and silkworm breeds. Maintenance of experimental records, Recording of observations, sampling techniques, tabulation, analysis and presentation of results. Scientific photography and preparation of transparencies for slide projector and overhead projector.

Practical

Types of laboratories and field experimentation; Selection site and land allotment. Experiments on grainage. Experiments on mulberry silkworm rearing and silk technology. Techniques for assessment of damage of pests, diseases and weeds among the host plans of silkworm. Assessment of soil fertility before experimentation and plot work. Techniques to record observations in mulberry and silkworm, growth and yield analysis of mulberry. Methods of measuring leaf area in mulberry. Calculations of measure of central tendency and dispersion. Analysis of variance techniques in computation of "F" and "T" tables. Analysis of data from a Completely Randomized Design (CRD). Analysis of data from Randomized Complete Block Design (RCBD). Analysis of data from Latin Square Design (LSD). Analysis of data from simple Factorial Experiment. Analysis of data from split-plot design. Practical Examination.

Silk Throwing, Dyeing and Weaving 3 (2+1)

Objectives

i. Students are able to understand the whole process of fabric making.

ii. Students are able to produce the twisted silk yarn and dyeing the silk yarn/printing on the silk fabric and plain weaving.

Theory

Introduction, Soaking of silk, winding, doubling, twisting, types of twisted yarns, types of twisting machines – up twister, two for one twister, steaming, warping- methods of warping – beam and sectional warping, ball warping. Weft yarn package – weft yarn by natwa winding, pirn winding, weft package/pirn. Wet processing – at yarn stage and at fabric stage. Degumming (boil off) of silk – soupling, Ecru silk. Bleaching of silk, methods, Dyeing of silk – dyeing of silk with acid dyes, metal complex dyes, reactive dyes, vinyl sulphone dyes, direct dyes. After treatment with dyei. Washing, acid treatment, hydro extractor, drying, skeining and packing. Silk printing for fabric. Classification of printing styles-silk printing styles. Printing tools and devices and quality control in printing. Silk finishing-mechanical: dry and wet, chemical finishing. Application of the finish. Finishes for the functional products. Weaving – handloom and powerloom weaving. Handloom weaving – types frame loom and pit loom, drawing – in and denting, heald shaft, heald count, reed, reed count, systems of counting, gaiting and piercing, yarn arrangement over the heald frames – straight, pointed and skip draft. Basic mechanisms of interlacing – primary, secondary and auxillary motions. Shedding – different types of shedding mechanisms-dobby, tappet (treadles) and jacquard. Types of shed. Picking mechanisms, beat up mechanism, warp let off and take up motions. Warp stop motion and filling stop motion, warp protector motion, transverse fabric control. Selvedges. Fabric structure- weave, thread densities of warp and weft, the coarseness and fineness of warp and weft yarn, the waviness of warp and weft, Basic fabric properties. Woven fabric design-Plain weave, ornamentation of plain cloth, warp rib weave, weft rib weave and Basket (matte weave) - 2 × 2, 3 × 3 or 4 × 4. Twill weave – 2/1 or ½, 2/2 3/3 4/4. Satin and sateen weaves. Concept of fabric quality, perspectives of fabric quality and fabric defects. Importance of crimps, Silk sarees of different weaving clusters, crepe fabrics, georgette, chiffon, soft silk fabrics, organza, tafetta, habutai and tabby. Power loom shuttle and shuttle less looms (gripper and jet-picking mechanism).

Practical

Silk throwing-winding, doubling, twisting-types of twisting. Steam setting of twisted yarn. Warping and yarn winding. Degumming of silk; Methods of degumming, water quality for wet processing. Bleaching and dyeing, classification of dyes, factors influencing dyeing, preparation of dye and methods of dyeing. Study of different types of looms and their characteristics. Printing and methods of printing –block and screen printing. Weaving-loom and its structure, different types of looms, arrangement of yarn for simple weaving and design weaving. Textile Designing, Motifs for weaving and textile printing, silk / fabric finishing, silk knitting. Study of different dyes, preparation of dyes, bleaching and dyeing of silk. Visit to cottage-weaving sectors.

Suggested Readings

1. Anonymous. 2003. *Seri-Business Manual* (Vol. III). Industrial Sector, CSB, Bangaluru.
2. Anonymous. 2013. *Wild Silks of India – A User's Compendium (Vol. IV: Profiles of non-Farm Activities).* CSB, Bengaluru.
3. Gohl E P G and Vilensky L D. 1999. *Textile Science, An Explanation of Fibre Properties*. CBS Publishers and Distributors, Delhi.
4. Singh Kanwar Varinder Pal . 2004. *Elementary Idea of Textile Dyeing, Printing and Finishing.* 186p. Kalyani Publishers.

Spun Silk Technology 1 (0+1)

Objectives

i. Usage of short or staple silk fibers to prepare a spun yarn

ii. Utility of spun yarn

Practical

Spun Silk – Characters. Manufacturing of Spun silk. Systems of spun silk processing, Raw material for spinning mill or cottage spinnning by hand spinning tools. Silk wastes, pierced cocoons and Eri cocoons as raw material for spinning industry. Flow chart of spinning, spinning operations, procurement and storing of silk waste. Degumming, opening, Dressing, Drawing, Roving, Spinning, Gasing. Re-reeling and packaging of Spun silk. Hand spinning of cocoon wastes, Katia, Matka, Geecha silk. Equipments used in cottage spinning units - Takli, Natwa, Medleri charka, amber charaka, Das, Trivedi and Chowdary spinning wheels. Motorized cum pedal operated spinning wheel. Study of different types of silk wastes, different types of spun Silks-Katia, Matka, Geecha, Noil, Machine spun silk, Machines used in spun silk industry. Study of different silk wastes. Raw silk waste, opened waste, combed / Dressed waste, sliver, Rovings. Processing of silk waste / Eri cocoons / pierced cocoons. Visit to Silk testing and grading units / spun silk industry.

Suggested Readings

1. Lipenkov Ya. 1983. *Wool Spinning (Vol. I)*. Moscow Mir publishers.
2. Anonymous. 2003. *Seri-Business Manual (Vol. III). Industrial sector*, CSB.
3. Kanwar Varinder Pal Singh. 2004. *Elementary Idea of Textile Dyeing, Printing and Finishing*. 186p. Kalyani Publishers, New Delhi.
4. Tammanna, N Sonuwalker. 1993. *Handbook of Silk Technology*. 119p. Wiley Eastern, New York.

Apparels in Sericulture Industry 1 (0+1)

Objectives

i. This course aims at updating the knowledge of students in the various process right from fibre to fabric production.

ii. This course focus on the following aspects viz. Silk Textile finishing, Silk fabric quality, Physical and chemical testing, Sourcing of raw materials, Textile designing, Sustainable practices.

Practical

Study of different types of yarns and fabrics and their classifications. Designs in fabrics, zaries blended fabrics. Caring of fabric, value addition in fabrics, Knitting, embroidery, embossing, dyeing, printing, self designing. Designing, Blending, Chiffon, Satin, Creping, Mercerisation. Induction of tentering, Special effects in fabric by different levels of twisting, combination of twisted yarns, blending of silk with other yarns. Designing of silk fabrics. Weaving- plain designs, zari designs. Loading/ weightening of silk/fabric. Silk in upholstery and interior decorations. Zari making from silk. Silk fabrics – traditional kacheevaram, dharmavaram, arni, illakal, molkalmur, pochampalli, venkatagiri, banarasi, rajasthani, paithani etc. apparels from vanya silks, Caring of silk fabrics.

Suggested Readings

1. Anonymous. 1975. *Textbook of Tropical Sericulture*. 594p. Japan Overseas Co-operation volunteers, Japan.
2. Anonymous. 2000. *Do's and Don'ts of Silk Twisting and Weaving Industry Part – II (Weaving)*. 35p. Central Silk Board, Bengaluru.
3. Aruga H. 1994. *Principles of Sericulture*. 376p. Oxford and IBH, New Delhi.
4. Bhattacharya M and Mahadevappa D. 2002. *Silk Weaving*. 376p. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
5. Ganga G and Sulochana Chetty J. 1991. *An Introduction to Sericulture*. 176p. Oxford and IBH, New Delhi.
6. Ganga G. 2003. *Comprehensive Sericulture. Volume 2, Silkworm Rearing and Silk Reeling*. 429p. Oxford and IBH, New Delhi.
7. Goswami B C, Martindale J G and Scardino F L. 2010. *Textile Yarns: Technology, Structure and Applications*. 565p. Wiley India Edition, New Delhi.
8. Jolly M S. 1987. *Appropriate Sericulture Techniques*. 215p. Central Sericultural Research and Training Institute, CSB, Mysore.
9. Mishra S P. 2006. *A Textbook of Fibre Science and Technology*. 326p. New Age International Publishers, New Delhi.
10. Reddy D N R, Shylaja T A and Narayanaswamy K C. 2000. *Reshmae Vasthra Vinyasa*. 78p. CVG Publicaions, Bengaluru.
11. Sengupta K. 1989. *A Guide for Bivoltine Sericulture*. 42p. Central Sericultural Research and Training Institute, Mysore.
12. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture*. 209p. Central Silk Board, Bengaluru.

Journals

- Bulletin of Indian Academy of Sericulture, CSTRI, Berhampore
- Indian Silk, CSB, Bengaluru
- Journal of Sericultural Science of Japan, Japan
- Seridoc, CSRTI (CSB), Mysore
- Sericologia, ISC, Bengaluru
- Korean Journal of Sericulture, Korea
- Indian Journal of Sericulture, CSRTI (CSB), Mysore
- And other Periodicals, Journals, Reports, Brochures, etc.

Online Sources:

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/
- www.tnau.ac.in/
- www.csrtimys.res.in/
- www.nift.ac.in/

Introduction to Agroforestry 2 (1+1)

Objectives

i. To understand the basic principles of frestry and agroforestry that combines the production of agricultural food, livestock and forest product.

ii. To provide information on different agroforestry systems and cultivation practices in relation to sericulture prevalent in the region.

Theory

Introduction - Definition of forest and forestry, branches of forestry, history and education of forestry in India, objectives of Silviculture, forest classification and types, crown classification, Tending operations: weeding. cleaning, thinning and pruning, Forest mensuration. Social forestry and its branches. Agroforestry-Definitions, Importance, history, Criteria of selection of tree in Agroforestry, different Agroforestry systems prevalent in the country, shifting cultivation, taungya, alley cropping, wind breaks and shelter belts, home gardens. Cultivation practices of two important tree species of the region (Mulberry and Hebbevu) in relation to Sericulture.

Practical

Identification of Important Agrofrestry tree species and seedlings. Collection of seeds of different tree. Diameter and height measurements, volume estimation. Nursery layout, seed sowing of important Agroforestry species. Field visit to different Agroforestry systems.

Suggested Readings

1. Bandyopadhyay K. 1997. *A Textbook of Agroforestry with Applications*. Vikas Publishing House Pvt Ltd, New Delhi.
2. Chundawat D S and Gautam S K. 2016. *Textbook of Agroforestry*, Oxford and IBH Publishing Company Pvt. Ltd., New Delhi.
3. Khanna L S. 2017. *Principles and Practices of Silviculture*, Khanna Bandhu, Dehradun.
4. Sagwal S S. 2020. *Introduction to Forestry*, Kalyani Publishers, Ludhiana.

Bio Formulation and Nanotechnology 2 (1+1)

Theory

Introduction to Bio Formulation and Nanotechnology-Overview of Bio Formulation and Nanotechnology; Historical development and current trends; Importance and applications in various fields. Basics of Nanotechnology-Introduction to Nanomaterials; Properties of Nanomaterials; Synthesis methods of Nanoparticles; Characterization techniques (TEM, SEM, AFM, etc.). Nanostructures in Biology-Biomolecules and their interactions with nanoparticles; Cellular uptake mechanisms; Biological barriers and overcoming strategies. Bio Formulation Techniques-; Formulation of Nanoparticles; Encapsulation.

Practical

Basic concepts of Nanoscience and Nanotechnology: Introduction, definition and meaning of nanotechnology, classification of nanomaterials, scientific revolutions –time and length scale in structures. Size effects on structure and morphology of nanoparticles. Synthesis of nano materials: Physical, chemical and biological methods. Role in Social, economic, ethical and ecological spheres. Green nanotechnology.

Application of nanotechnology in Agriculture: Effects of seed priming and foliar application of nanomaterial on growth and productivity of crops. Uptake and translocation of nanoparticles. Quantification of enhanced nano-nutrient content in edible parts. *In vitro* and field efficacy of nanoparticles (pesticides) against plant pathogens. Bioassay of nano-formulations of insecticide. Bio-safety of nano-formulations on natural enemies. Study the fate and behaviour of nano fertilizers in soils. Application of nanotechnology in recycling of Agriculture waste. Safety, toxicity and adoption of nanoparticles in the soil and aquatic life. Nanosensors in agriculture-nutrient, water, soil.

Suggested Readings

1. Morris Sylvin. 2006. *Nanotechnology.* 301p. Sarup & sons, New Delhi.
2. Don Norman. 2008. *A Student Handbook of Nano Biotechnology*. 630p.Dominant Publishers and Distributors, New Delhi.
3. Robert William. 2006. *Encyclopaedia of Nano Biotechnology*. 248p. Anmol Publications pvt. Ltd. New Delhi.
4. Parthasarathy B K. 2007. *Introduction to Nanotechnology*. 304p. Isha Books, Delhi.

Renewable Energy in Agriculture and Allied Sector 3 (2+1)

Objectives

i. To study the different renewable energy sources and its' conversion technologies
ii. To acquire a practical knowledge on design, installation, maintenance of potential renewable energy sources of the country
iii. To study the classification of energy sources-contribution of non-conventional energy sources in agriculture sector
iv. To familiarization with biomass utilization for size-reduction, production of bio alcohol, bio diesel and bio-oil production and its application
v. To Familiarization with design, types, maintenance of biogas plants and gasifier
vi. To study a solar energy, its collection, conversion methods and applications
vii. To study a wind energy and its application

Theory

Classification of energy sources, contribution of these sources in agricultural sector, Familiarization with biomass utilization for biofuel production and their application. Familiarization with production of biogas and producer gas and modifications of IC engines for usage. Production of bioalcohol, biodiesel and bio-oil production and their utilization as bioenergy resource. Introduction of solar energy, collection and their application, Familiarization with solar energy gadgets: solar cooker, solar water heater; application of solar energy: solar drying, solar pond, solar distillation, solar photovoltaic system: solar lighting system, solar lantern, solar fencing and solar pumping system and their application, introduction of wind energy and their application.

Practical

Availability and uses of non-conventional energy in agriculture sector. Bio fuel production from biomass and its application. Constructional details of different biogas plants (Deena bandu and KVIC), gas production, design aspects and and maintenance. Study of different types of gasifiers, running of gasifiers and and production of producer gas. Study and and constructional details of

different solar gadgets like solar dryer, grain dryers. Study of constructional details of solar cookers. Study of constructional details of solar water heating systems. Study of solar photovoltaic system and and observing various factors (light intensity, direction) influencing efficiency of the photo-voltaic systems. Study of solar water pumps, solar fencing. Visit to solar photovoltaic farm. Visit to biogas-based power generation farm.

Suggested Readings

1. Chakravarthy A and Amalendu Chakraverty. 1989. *Biotechnology and Other Alternative Technologies for Unitization of Biomass-Agricultural wastes.* (1st Edn.). Oxford and IBH Publishers, New Delhi.
2. Ojha T P and Michael A M. 2025. *Principles of Agricultural Engineering* (Vol. I). (16th Edn.). Jain brothers, New Delhi.
3. Rai G D. 2004. *Non-conventional Energy Sources*, Khanna Publishers, New Delhi.
4. Rajput R K. 2012. *Non-conventional Energy Sources.* S. Chand Publishers.
5. Rathore N S, Mathur A N and Kothari S. 2007. *Alternative Sources of Energy*. 259p. ICAR Publication.
6. Veeresh Kumargoud, Tulsidas T N, Eshwarappa H. 2007. *Biogas Technology*. Regional Biogas Development and Training Centre, UAS, GKVK, Bengaluru

Fundamentals of Agricultural Economics 2 (2+0)

Objectives

i. To acquaint the students with basics of agricultural economics

ii. Understanding Economic Principles: It provides a foundation in economic theories and principles that are applicable to agricultural activities, including sericulture

Theory

Economics: Meaning, scope and subject matter, definitions, activities, approaches to economic analysis; micro- and macro-economics, positive and normative analysis. Nature of economic Theory: Rrationality assumption, concept of equilibrium, economic laws as generalization of human behaviour. Basic concepts: Goods and services, desire, want, demand, utility, cost and price, wealth, capital, income and welfare. Agricultural economics: Meaning, definition, characteristics of agriculture, importance and its role in economic development. Technical change and types, Agricultural planning and development in the country. Land reforms: Meaning of land tenure, land tenancy, land reform measures – abolition of intermediaries, tenancy reforms, fixation of ceiling on land holdings, consolidation of holdings, development of cooperative farming. Agricultural labour and farm mechanization. Demand: Meaning, law of demand, demand schedule and demand curve, determinants, utility Theory: Law of diminishing marginal utility, equi-marginal utility principle. Consumer's equilibrium and derivation of demand curve, elasticity of demand: Concept and measurement of price elasticity, income elasticity and cross elasticity. Supply: Stock v/s supply, law of supply, supply schedule, supply curve, determinants of supply, elasticity of supply. Production: Process, creation of utility, factors of production, laws of returns and returns to scale. Market structure: Meaning and types of market, basic features of

perfectly competitive and imperfect markets. Distribution Theory: Meaning, factor market and pricing of factors of production. Concepts of rent, wage, interest and profit. National income: Meaning and importance, circular flow, concepts of national income accounting and approaches to measurement, difficulties in measurement. Population: Importance, Malthusian and Optimum population theories, natural and socio-economic determinants, current policies and programs on population control. Money: Barter system of exchange and its problems, evolution, meaning and functions of money, classification of money, money supply, general price index, inflation and deflation. Banking: Role in modern economy, Agricultural and public finance: Meaning, micro v/s macro finance, need for agricultural finance, public revenue and public expenditure. Tax: Meaning, direct and indirect taxes, agricultural taxation, VAT. Economic systems: Concepts of economy and its functions, important features of capitalistic, socialistic and mixed economies, elements of economic planning, NITI Ayoga.

Suggested Readings

1. Ahuja H L. 2016. Advanced *Economic Theory: Microeconomic Theory.* S. Chand and Co. Pvt. Ltd., New Delhi.
2. Dewett K K. 2006. *Modern Economic Theory*. S. Chand and Co. Pvt. Ltd., Delhi.
3. Lekhi R K and Joginder Singh. 2004. *Agricultural Economics*. Kalyani Publishers, Delhi.
4. Mitra J K. 1972. *Economics – An Introduction to its Basic Principles (Micro and Macro Economics)*. The World Press Pvt. Ltd., Calcutta.
5. Gaurav Datt and Biswajit Nag. 2024. *Datt & Sundharam's Indian Economy. (*73rd Edn.). S. Chand and Co. Pvt. Ltd., Delhi.
6. Samuelson P A and Nordhaus. 2000. *Economics*. Tata McGraw Hill Education, New York.
7. Subbareddy S, Raghu Ram P, Neelakanta Sastry T V and Bhavani Devi I. 2019. *Agricultural Economics*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Fundamentals of Plant Pathology 3 (2+1)

Objectives

i. To study the importance of plant disease epidemics and its economic impact on crops.
ii. To study biotic (living), mesobiotic (viruses/viroids), and abiotic (non-living and environmental) causes of diseases / disorders.
iii. To study the different types symptoms, cause and pathogens characteristics and and its reproduction
iv. To study the epidemiology of diseases.
v. To develop methods of management of plant diseases.

Theory

Introduction, scope and objectives of plant pathology: Definition, derivation and different disciplines of plant pathology; General terms (glossary) commonly used in plant pathology; Scope and objectives; Importance of plant pathology in agriculture.

Importance of plant diseases: Plant disease epidemics that cause economic imbalance over the years; Historical and present examples of losses caused by plant diseases viz. Irish famine, Bengal famine, Coffee rust, discovery of Bordeaux mixture, wheat rust etc.

History and development of plant pathology: Important milestones, famous discoveries/ inventions and contributions of National and International Phytopathologists; Development of Plant pathology in India.

Definition and concept of plant diseases: Plant disease; Conditions necessary for disease development; Disease triangle, disease tetrahedron/ pyramid concepts; classification of diseases based causal organism / agent, symptoms, plant organs they affect and type of host plant affected and mode of spread and severity.

Causes of plant diseases and symptoms: Plant diseases caused by abiotic and biotic agents; diseases caused by Fungi, bacteria, nematodes, viruses, Phytoplasmas and phanerogamic parasites.

Diseases due to biotic agents: Symptoms and Signs; Hypoplasia, Hyperplasia, Hypertrophy and Necrotic symptoms caused by Fungi, Bacteria, Viruses, Nematodes, Phytoplasmas etc.,

General characteristics of plant pathogens: Classification of Prokaryotes according to Bergey's manual of Systemic Bacteriology, Classification of fungi, and Classification of viruses, mollicutes and nematodes.

Growth and reproduction of plant pathogens and replication of plant viruses: Types of growth, methods of measurement and kinetics of growth observed in pathogens; Reproduction types and reproductive structures in plant pathogens; Multiplication of plant viruses and phytoplasmas. Reproduction in bacteria and nematodes.

Liberation / dispersal of plant pathogens and survival of plant pathogens: Active and passive discharge of spores / inoculum; mechanism of liberation; Distribution-dissemination, and direct and indirect methods of transmission; Introduction of plant diseases into India and in other countries; Survival of plant pathogens.

Types of parasitism and variability in plant pathogens: Biotrophs, necrotrophs, pathotrophs, facultative saprophytes; Variability in microorganisms and its necessity for survival; Mechanisms of variability in fungi: bacteria, viruses and nematodes. Mechanisms: Mutation, Recombination, Heterokaryosis, Heteroploidy, Parasexualism; Transmission, Transformation, Transduction and Conjugation.

Pathogenicity**:** Phenomenon of host infection by fungi, bacteria, viruses and nematodes, penetration, colonization, role of enzymes toxins and growth regulators in disease development and their classification. Introduction to principles of plant disease and management.

Practical

Study of Laboratory Equipment and Microscope, Study of Symptoms and Diagnosis of Plant Diseases, Study of Disease Symptoms Caused by Virus, Viriods and Mollicutes, Collection and Preservation of Disease Specimen, Morphological Characters of Fungi, Bacteria, Virus, Viriods, Molicutes and Nematodes, Macroscopic and Microscopic Examination of Plant Pathogenic Fungi and Nematodes, Microscopic Examination of Bacterial Cells Through Stainng Technique, Preparation of Culture Media and Sterilization, Isolation and Purification Techniques for Fungi and Bacteria, Virus Purification and Extraction of Nematodes, Methods of Incoulation and Proving Koch's Postulates, Study of Fungal Spore Liberation, Measurement of Size and Shape of Pathogens by Micrometry and Camera Lucida, Production of Pectolytic Enzymes (Degradation Of Pectin),

Cellulase Production Test (Degradation of Cellulose), Study of Life Cycle of Fungal Plant Pathogens, Field Visit to Acquaint Plant disease Symptoms.

Suggested Readings

1. Agrios G N. 2006. *Plant Pathology.* (4th Edn.). 996p. Academic Press, New York.
2. Mehrotra R S and Ashok Agarwal. 2003. *Plant Pathology*. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
3. Singh R S. 2002. *Introduction to Principles of Plant Pathology.* (4th Edn.). Oxford and IBH, Publishers Co. Pvt. Ltd., New Delhi.
4. Tripathi D P. 2014. *Introductory Plant Pathology*. 380p. Kalyani Publishers, New Delhi.

SEMESTER-VII

Elective subjects	Course	Credit Hours
Elective - I Host Plant Production Technology	Techniques in Host Plants Improvement	5 (2+3)
	Techniques in Host Plants Production	5 (2+3)
	Techniques in Host Plants Protection	5 (2+3)
	Value Addition to Host Plants By-products	5 (2+3)
		20 **(8+12)**
Elective - II Cocoon Crop Production Technology	Techniques in Silkworm Crop Improvement	5 (2+3)
	Techniques in Silkworm Cocoon Production	5 (2+3)
	Techniques in Silkworm Crop Protection	5 (2+3)
	Value Addition to Silkworm Rearing By-products	5 (2+3)
		20 **(8+12)**
Elective - III Silk Product Science Technology	Techniques in Raw Silk Production	5 (2+3)
	Techniques in Spun Silk Technology	5 (2+3)
	Techniques in Post Reeling Technology	5 (2+3)
	Value Addition of Silk Industry By-products	5 (2+3)
		20 (8+12)

*The student will take anyone elective as per choice

Techniques in Host Plants Improvement 5 (2+3)

Objectives

i. To basic knowledge about different plant improvement methods
ii. Breeding methods used in mulberry for increase leaf production

Theory

General introduction about plant breeding- Role of plant breeding, Challenges before plant breeder, Objectives of plant breeding. History of plant breeding and Mendalian genetics. Importance of Plant Genetic Resources Germplasm activities and their conservation methods. Importance of Self incompatibility and Male sterility in plants. Inheritance of Economic Traits - Classification

of Traits-Qualitative and Quantitative traits and Features of quantitative traits. Hybridization in plants- Objectives of hybridization, Types of hybridization and Procedure for hybridization. Back cross method of breeding - Requirement for back crosses transfer of dominant gene and transfer of recessive gene, merits of back cross methods. Heterosis and Inbreeding depression - Features, classification and effects of heterosis breeding, Procedure to develop inbred lines and their evaluation. Mutation Breeding - Definition and history of mutation, Types of mutations, Characteristics effects of mutations, Physical mutagens and their characteristics and mode of action of physical mutagens, Chromosomal aberrations. Polyploidy breeding - Classification of polyploids, Characteristics of polyploidy. Promising triploids in India. Stress resistance breeding for both biotic and abiotic factors. Method of breeding for vegetative propagated crops. Mulberry Varietal multiplication and distribution system. Primary and Secondary host plants of Eri silkworm. Distribution, Taxonomy and Floral biology of primary host plants of Eri silkworm Castor - *Ricinus communis* Tapioca: *Manihot utilissima* and Kesseru: *Heteropanax fragrans.* Primary and Secondary host plants of Tropical and temperate tasar silkworm: Distribution, Taxonomy and Floral biology of Primary host plants Tropical tasar silkworms: *Terminalia arjuna, Terminalia temontosa* and *Shorea robusta* Description of habitat, leaf, fruit and seed. Distribution, Taxonomy and Floral biology of Primary host plants temeperate tasar silkworms: Quercus species. Morphology /morphophytes of the muga silkworm food plants.

Practical

Study of floral structure of mulberry. Study of floral biology of mulberry. Practicing of staggered pruning in mulberry for inducing flowering. Asexual mode of reproduction in mulberry. Sporogenesis: Micro and Megasporogenesis in mulberry. Pollination and crossing techniques in mulberry. Collection of mulberry fruits, extraction of seeds and raising of seedlings. Study of different gene interaction methods - incomplete dominance, codominance, lethal gene action, epistasis, supplementary gene action, complementary gene action, duplicate gene action and additive gene action. Study of varietal characteristics of released mulberry varieties. Hybridization techniques in mulberry. Conservation of mulberry Germaplasm. Visit to Germplasm research station, CSGRC, Hosur.

Suggested Readings

1. Pundansingh. *Essentials of Plant Breeding.*
2. *FAO Manual on Sericulture*
3. Amitabha Sarkar. *Mulberry Breeding.*
4. Singh B D. *Plant Breeding.*
5. Allard R W. *Principles of Plant Breeding.*
6. *Tasar Culture: Principles and Practices*. CSB Publication

Journals

- Bulletin of Indian Academy of Sericulture, CSTRI, Berhampore
- Indian silk, CSB, Bengaluru
- Journal of Sericultural Science of Japan, Japan
- Seridoc, CSRTI (CSB), Mysore
- Sericologia, ISC, Bengaluru

- Korean Journal of Sericulture, Korea
- Indian Journal of Sericulture, CSRTI (CSB), Mysore
- And other Periodicals, Journals, Reports, Brochures, etc.

Techniques in Host Plants Production 5 (2+3)

Objectives

i. To understand the production technology of different host plants of silkworms

ii. To develop the technical skills in nursery techniques, propagation and cultivation techniques

Theory

Introduction, climatic requirements, sexual and asexual methods of propagation of different host plants of mulberry and Vanya silkworm. Popular varietal performance, improvement, varieties of mulberry and host plants of vanya silkworms recommended for different region of India. Nursery techniques, kissan nursery and its economics. Different pruning methods, irrigation schedules, integrated nutrient management system recommended for different host plants of mulberry (Both irrigated and rain fed mulberry) and Vanya sericulture. Weed management practices. Harvesting methods, leaf preservation techniques. Package of practices of tree mulberry plantation and chawki / young age mulberry plantation. Cultivation and propogation of host plants of eri silkworms: castor, tapioca and kesaru, cultivation and propogation of host plants of tropical tasar silkworms: Asan, Arjun and sal and temperate tasar / oak tasar silkworms: *Quercus serrata* and *Quercus incana*. Cultivation and propogation of host plants of muga silkworms - som and soalu. Economics of leaf production of mulberry and host plants of eri. muga and tasar silkworms.

Practical

Identification of host plants of mulberry silkworm, Eri silkworm, tasar silkworms and muga silkworms. Nursery bed preparation and raising of seedling through sexual propagation and saplings through asexual propagation in mulberry and and host plants of eri. muga and tasar silkworm.

Manures and fertilizer application. Planting methods. Irrigation, pruning methods, weed management. Harvesting and preservation of different host plants of silkworm. Cultivation of primary host plants of eri silkworms and tasar silkworms and cultivation of secondary host plants of muga silkworms. Herbarium preparation for the host plants and weeds.

Suggested Readings

1. Khan M A, Anil Dhar and Zeya S B. 2014. *Pests and Diseases of Mulberry and their Management*. M/s Bishen Singh Mahendra Pal Singh.
2. Sathe T V and Jadhav A. 2002. *Sericulture and Pest Management*. Daya Publishing House, Delhi.
3. Sakthivel N, Narendra Kumar J B, Dhahira Beevi N, Devamani Mani and Teotia R S. 2019. *Mulberry Pests: Current Status and Management Practices*. Tech. Bulletin. 56p. Central Sericultural Research and Training Institute, Central Silk Board, Masuru.
4. Singh R N and Saratchandra Beera. 2001. *Sericulture Entomology*.
5. Singh R N, Samson M Vand Datta R K. 2000. *Pest Management in Sericulture*. Indian Publisher and Distributions, Delhi.

6. Mohammad Ashraf Khan, Madan Mohan Bhat and Tribhuwan Singh. 2011. *Silkworm Crop Protection*. Daya Publishing House, Delhi.

7. Subrata Biswas and N P Singh. 2005. *Parasitic Diseases of Mulberry*. Kalyani Publishers.

Techniques in Host Plants Protection 5 (2+3)

Objectives

i. Studying the pest and diseases of host plants of silkworms. Developing the technical skill regarding IPM practices for pest management.

ii. Guiding the technical knowledge for effective management of pests and disease in host plants, by using innovative pest control method.

Theory

Concepts and principles of crop pest management, status of a pest. Biotic potential and environmental resistance. Insect and non-insect pests of Host plants of mulberry and non-mulberry silkworms (Host plants of tasar, eri and muga silkworms namely *Terminalia*s pp. Sal, Oak, Castor etc.) sequence of their appearance, duration, intensity, nature and symptoms of attack. Bioecology of pests, management practices, measures of control. Pesticides residue problems, safety periods to be observed. Economic importance, symptoms, causes, epidemiology, disease cycle/life cycle and integrated management of diseases of *Morus alba, Ricinus communis, Manihot utilisima, Michilius champaka, Zizypus* spp., *Machilus bombycina, Shorea robhusta, Ailanthus* spp., and other hosts of silkworms. Principles and methods of plant disease management: Avoidance of the pathogen: Choice of geographical area, selection of field and planting stock. Exclusion: Plant quarantine regulations and inspections, Post entry quarantine. Eradication: Cultural and physical methods of eradication and inoculums reduction. Biological methods: Crops rotation, use of trap crops, plant and plant products, use of biological control agents, their mass multiplication mechanisms of bio-control. Breeding for disease resistance: Types of resistance, Development of resistant varieties, induced resistance. Protection chemical methods: Nature, classification, mode of action and formulations of fungicides, bactericides antibiotics and nematicides; methods of applications of chemicals. Application of biotechnology in plant disease management.

Practical

Study of various pests of host plants, their diagnostic characters, symptoms of damage and management measures to be adopted. Visit to crop fields to record the incidence of pests noticed and control measures, management practices suggested in each case, in addition to recording nature and symptoms of damage and estimation of loses. Collection of pests and affected samples of host plants of silkworms. Study of symptoms, etiology and life cycle/disease cycle of the diseases of *Morus alba, Ricinus communis, Manihot utilisima, Michilius champaka, Zizypus*s pp., *Quarcus* spp., *Machilus bombycina, Shorea robhusta, Ailanthus* spp., and other hosts of silkworms. Study of fungicides, bactericides, nematicides and methods of applications. Isolation, mass multiplication of Biocontrol agents and their bioassay. Study of plant protection equipments. (Submission of 15 well preserved disease specimens and 15 semi-permanent slides depicting different plant pathogens).

Suggested Readings

1. Khan M A, Anil Dhar and Zeya S B. 2014. *Pests and Diseases of Mulberry and their Management*. M/s Bishen Singh Mahendra Pal Singh.
2. Sathe T V and Jadhav A. 2002. *Sericulture and Pest Management*. Daya Publishing House, Delhi.
3. Sakthivel N, Narendra Kumar J B, Dhahira Beevi N, Devamani Mani and Teotia R S. 2019. *Mulberry Pests: Current Status and Management Practices*. Tech. Bulletin. 56p. Central Sericultural Research and Training Institute, Central Silk Board, Masuru.
4. Singh R N and Saratchandra Beera. 2001. *Sericulture Entomology*.
5. Singh R N, Samson M Vand Datta R K. 2000. *Pest Management in Sericulture*. Indian Publisher and Distributions, Delhi.
6. Mohammad Ashraf Khan, Madan Mohan Bhat and Tribhuwan Singh. 2011. *Silkworm Crop Protection.* Daya Publishing House, Delhi.
7. Subrata Biswas and N P Singh. 2005. *Parasitic Diseases of Mulberry*. Kalyani Publishers.

Value Addition to Host Plants By-Products 5 (2+3)

Objectives

i. To make the students understand value addition to by-products of major host plants of silkworms (Mulberry, tasar, eri and muga), its utilization and entrepreneurship development
ii. To understand the best utilization of by-products generated during host plant production process and their value addition

Theory

Value addition to mulberry leaf - Importance, animal feed mulberry leaf anti-oxidation and Anti-aging, mulberry leaf extract in pharmaceuticals, cosmetics production, skin and hair caring products, hair dressing products, mulberry leaf soap. Mulberry tea: Health benefits of mulberry tea. Mulberry fruit: multipurpose uses of mulberry fruit, mulberry fruit jam, mulberry fruit syrup, mulberry fruit juice. Mulberry stem: Adhesive from waste mulberry stem, mulberry as fodder and fuel, mulberry wood art, mulberry root art, utilization of mulberry twigs for basket making.

Uses of arjun (*Terminalia arjuna*): Medicinal uses of arjun leaf, bark ashes and fruit. Uses of asan (*Terminalia tomentosa*) wood as furniture, decorative veneers and for musical instruments. Extraction of dye *and* tan leather from bark.

Uses of sal (*Shorea robusta*): Important sources of hardwood *timber in India, properties and uses of wood, dry leaves, sal tree resin. Sal seeds and fruit as a source of lamp oil and vegetable fat and cooking oil. Castor leaf for medicinal uses, castor oil produced from castor beans: important commercial value manufacturing of soaps, lubricants and coatings, castor bean cake for manure production. Cassava root and leaves for edible purpose. The nutritional value of cassava. Kesseru (Heteropanax fragrans*): rich source of manure, medicinal benefits.

Host plants of muga silkworm, *Litsea polyantha*: Medicinal uses of plant bark and leaves, source of fodder for the livestock, planted as ornamental plant. *Machilus bombycina*: Medicinal uses of plant bark and leaves, plant essential oil and its application.

Practical

Importance and scope of by-product utilization from major host plants of silkworms, Value addition during host plant cultivation: kisan nursery, composting, vermicomposting, livestock production. Medicinal uses of different parts of host plants and applications.

Suggested Readings

1. Dandin S B, Jayant, Jayaswal and Giridhar K. 2003. *Handbook of Sericulture Technologies*. 287p. CSB, Bengaluru.
2. Govindan R, Chinnaswamy K P, Krishnaprasad N K and Reddy D N R. 2000. *Non-Mulberry Sericulture, Silk Technology and Sericulture Economics and Extension (*Vol. III: Proceedings of NSTS – 1999). pp 1-88. UAS, Bengaluru.
3. Sinha Sanjay. 1990. *The Development of Indian Silk*. 128p. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.

Techniques in Silkworm Crop Improvement 5 (2+3)

Objectives

i. Studying the genetics background of mulberry and non-mulberry silkworm. Developing the technical skill regarding handling the parental race maintenance, hybridization, multiplication and addressing the stress tolerance research gap.

ii. Guiding the technical knowledge to make of available silkworm germplasm for hybridization. To Study the concept of conventional and non-conventional silkworm breeding methodology to develop robust silkworm hybrids.

Theory

Principles and objectives of breeding in mulberry and non-mulberry silkworm. Establishing / activities of silkworm breeding program. Maintenance of silkworm germplasm bank. Maintenance of breeds / stocks, 3-tier multiplication of parental stock with silk yield attributes. Genetic basis for silkworm breeding programs. Hybridization - objectives, types, hybridization procedure, problems in hybridization like inbreeding depression, lethal genes, etc. Heterosis studies in mulberry and non-mulberry silkworm, genetic basis for heterosis, manifestation of heterosis, commercial exploitation of heterosis, Parthenogenesis – methods of induction of parthenogenesis. Mutation Breeding – Mutagens - classification of mutagens, Procedure for mutation breeding. Ploidy breeding – heteroploid, autopolyploids, significance of polyploids. Breeding silkworms for biotic (disease) and abiotic (high temperature) stress tolerance, season and region specific mulberry and non-mulberry silkworm hybrids. Concepts of breeding auto-sexing silkworm breeds. Authorization of silkworm breeds and their hybrids. Breeding of non-mulberry silkworms.

Practical

Study of breed characteristics of *Bombyx mori*, Antheraea sp., and *Samia ricini*. Procedure and maintenance of silkworm germplasm bank. Procedure for hybridization in silkworms, Procedure for selection- pedigree and mass method. Assessment of variability (ANOVA). Genetic analysis of qualitative and quantitative traits. Estimation of heterosis. Diallel (partial

and complete) and three-way cross analysis. Analysis of double cross hybrids. Line × Tester analysis. Path analysis.

Suggested Readings

1. Gardner E J, Simmous M J and Snustad D P. 1991. *Principles of Genetics*. 649p. John Willey and Sons Inc., New York.
2. Sarkar D D. 1998. *The Silkworm Biology, Genetics and Breeding*. 338p. Vikas Publishing House Pvt. Ltd., New Delhi.
3. Sarkar Dilip De. 1998. *The Silkworm - Biology, Genetics and Breeding*. Vikas Publishing House Pvt. Ltd., New Delhi.
4. Basavaraj H K, Ashwath S K, Kumar N Suresh, Mal Reddy N and Kalpana G V. 2005. *Silkworm Breeding and Genetics*. Central Silk Board, Bengaluru.
5. Sreerama Reddy G. 1998. *Sikworm Breeding*. Oxford and IBH Publishing Co Pvt. Ltd., New Delhi and Calcatta.
6. Tazima Y. 1978. *The Silkworm: An Important Laboratory Tool*. 307p. Kodansha Ltd., Tokyo, Japan.

Techniques in Silkworm Cocoon Production 5 (2+3)

Objectives

i. To acquire the knowledge and skills, required for successful silkworm cocoon crop production.

ii. To impart the knowledge of silkworm rearing to students.

iii. To plan and execute silkworm rearing for both commercial and seed cocoon production

Theory

Garden management for quality host plants production (Mulberry and Non-mulberry); INM in mulberry and non-mulberry, harvesting index, harvesting and preservation of leaves; Planning for silkworm rearing suitable to different sized host plant garden holdings, rearing house, equipment and labour availability; Disinfection of rearing house and appliances, hygiene measures in rearing house; Procurement of quality DFLs, Improved method of incubation, black boxing, Calculation of hatching percentage, brushing; Different methods of Chawki and late-age silkworm rearing; Management of rearing environment; Silkworm feed, spacing, bed and moulting managements; Disease and Pest Management; Mounting of ripe worms and maintenance of environment in mountage shed; Harvesting, sorting, grading and marketing of cocoons; Feed utilization and conversion efficiency; Nutritional requirement of silkworms, *vis-a-vis* their availability in leaves / feed; Different nutrients and their role in silkworm growth, development and silk production; Nutrient supplements through mulberry leaf fortification; Application of artificial diets and juvenile hormone analogues in practical sericulture; Innovations and indigenous technology know how; Maintenance of rearing records; Economics of silkworm rearing; Project preparation and Benefit cost ratio of silkworm rearing.

Practical

Raising garden for quality host plants production; Disinfection of rearing houses; Large scale chawki rearing with available facilities; Large scale late-age silkworm rearing with available facilities; Practicing the management of rearing environment; Silkworms feed, spacing, bed and Moulting management; Management of diseases and natural enemies; Practicing mounting of ripe worms and maintenance of environment in mountage shed; Practicing harvesting, sorting, grading and marketing of cocoons; Practicing of application of artificial diets and juvenile hormone analogues during silkworm rearing; Practicing of maintenance of rearing records; Working out the economics of silkworm rearing; Preparing the Silkworm rearing project; Visit to Seri-agro-ecosystems (farmer's field); Visit to R and D institute;

Suggested Readings

1. Anonymous. 1975. *Textbook of Tropical Sericulture*. 594p. Japan Overseas Co-operation volunteers, Japan.
2. Aruga H. 1994. *Principles of Sericulture*. 376p. Oxford and IBH, New Delhi.
3. Dandin S B and Giridhar K. 2010. *Handbook of Sericulture Technologies*. 427p. Central Silk Board, Bangaluru.
4. Ganga G and Sulochana Chetty J. 1991. *An Introduction to Sericulture*. 302p. Oxford and IBH, New Delhi.
5. Ganga G. 2003. *Comprehensive Sericulture. Volume 2, Silkworm Rearing and Silk Reeling*. 429p. Oxford and IBH, New Delhi.
6. Govindaiah, Gupta V P, Sharma D D, Rajadurai S and Nishitha Naik V. 2005. *Textbook on Mulberry Crop Protection*. 247p. Central Silk Board, Bangalore.
7. Govindan R, Narayanaswamy T K and Devaiah M C. 1998. *Principles of Silkworm Pathology*. 420p. Seri Scientific Publishers, Bangalore.
8. Jolly M S. 1987. *Appropriate Sericulture Techniques*. 215p. Central Sericultural Research and Training Institute, CSB, Mysore.
9. Krishnaswami S, Narasimhanna M N, Suryanarayan, S K and Kumararaj S. 1979. *Silkworm Rearing*, pp 99-129. FAO Manual (Vol. II). FAO, Rome.
10. Narayanaswamy K C and Devaiah M C. 1998. *Silkworm Uzi Fly*. 232p. Zen Publishers, Bengaluru.
11. Nataraju B, Sathyaprasad K, Manjunath D and Aswani Kumar C. 2005. *Silkworm Crop Protection*. 324p. Central Silk Board, Bangalore.
12. Sengupta K. 1989. *A Guide for Bivoltine Sericulture*. 42p. Central Sericultural Research and Training Institute, Mysore.
13. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture*. 209p. Central Silk Board, Bengaluru.

Journals

1. Bulletin of Indian Academy of Sericulture, CSTRI, Berhampore
2. Indian Silk, CSB, Bengaluru

3. Journal of Sericultural Science of Japan, Japan
4. Seridoc, CSRTI (CSB), Mysore
5. Sericologia, ISC, Bengaluru
6. Korean Journal of Sericulture, Korea
7. Indian Journal of Sericulture, CSRTI (CSB), Mysore
8. And other Periodicals, Journals, Reports, Brochures, etc.

Online Sources:

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/
- www.tnau.ac.in/
- www.csrtimys.res.in/

Techniques in Silkworm Crop Protection **5 (2+3)**

Objectives

i. To acquire the knowledge and skills required for the management of silkworm pests and diseases.

ii. To familiarize students about the silkworm pests and diseases.

iii. To manage biotic and abiotic factors according to season.

iv. To assess the cocoon crop loss due to biotic and abiotic factors.

v. To mitigate the probable unforeseen risks during silkworm crop period.

Theory

Serology and its application in silkworm pathology; Isolation, ultra-purification and long-term storage of silkworm pathogens; Infectivity techniques in silkworm pathology; Cross infectivity of pathogens of crop pests to silkworms; Impact of insect crop pests on silkworm; Impact of biological pest control on sericulture; Pest management concepts; Assessment of toxicity, their nature, level and suggest remedies; Development of IPM and IDM schedules for management of pest and and diseases; Diagnosis of pest and disease incidence in silkworm rearing and acquainting with remedial measures; Survey of problematic rearing houses and find out the remedies for the cause.

Practical

Practicing the various serological techniques used in silkworm pathology; Isolation and purification of viruses and dissolution of viral inclusion bodies; Practicing the various infectivity techniques applicable in silkworm pathology; Studying the effects of cross infectivity in sericulture; Determination of LC_{50} and ET_{50}; Determination of silkworm breed and instar susceptibility; Practicing various histo-pathological techniques employed in the silkworm pathology; Studies on patho-physiological alterations due to silkworm pathogens; Development of IPM and IDM schedules for management of pest and diseases; Diagnosis of pest and disease

incidence in silkworm rearing and acquainting with remedial measures; Survey of problematic rearing houses and find out the remedies; Case studies.

Suggested Readings

1. Anonymous. 1975. *Textbook of Tropical Sericulture*. 594p. Japan Overseas Co-operation volunteers, Japan.
2. Aruga H. 1994. *Principles of Sericulture*. 376p. Oxford and IBH, New Delhi.
3. Dandin S B and Giridhar K. 2010. *Handbook of Sericulture Technologies*. 427p. Central Silk Board, Bangaluru.
4. Ganga G and Sulochana Chetty J. 1991. *An Introduction to Sericulture*. 302p. Oxford and IBH, New Delhi.
5. Ganga G. 2003. *Comprehensive Sericulture. Volume 2, Silkworm Rearing and Silk Reeling*. 429p. Oxford and IBH, New Delhi.
6. Govindaiah, Gupta V P, Sharma D D, Rajadurai S and Nishitha Naik V. 2005. *Textbook on Mulberry Crop Protection*. 247p. Central Silk Board, Bangalore.
7. Govindan R, Narayanaswamy T K and Devaiah M C. 1998. *Principles of Silkworm Pathology*. 420p. Seri Scientific Publishers, Bangalore.
8. Jolly M S. 1987. *Appropriate Sericulture Techniques*. 215p. Central Sericultural Research and Training Institute, CSB, Mysore.
9. Krishnaswami S, Narasimhanna M N, Suryanarayan, S K and Kumararaj S. 1979. *Silkworm Rearing,* pp 99-129. FAO Manual (Vol. II). FAO, Rome.
10. Narayanaswamy K C and Devaiah M C. 1998. *Silkworm Uzi Fly*. 232p. Zen Publishers, Bengaluru.
11. Nataraju B, Sathyaprasad K, Manjunath D and Aswani Kumar C. 2005. *Silkworm Crop Protection*. 324p. Central Silk Board, Bangalore.
12. Sengupta K. 1989. *A Guide for Bivoltine Sericulture*. 42p. Central Sericultural Research and Training Institute, Mysore.
13. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture*. 209p. Central Silk Board, Bengaluru.

Journals

1. Bulletin of Indian Academy of Sericulture, CSTRI, Berhampore
2. Indian Silk, CSB, Bengaluru
3. Journal of Sericultural Science of Japan, Japan
4. Seridoc, CSRTI (CSB), Mysore
5. Sericologia, ISC, Bengaluru
6. Korean Journal of Sericulture, Korea
7. Indian Journal of Sericulture, CSRTI (CSB), Mysore
8. And other Periodicals, Journals, Reports, Brochures, etc.

Online Sources:

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/
- www.tnau.ac.in/
- www.csrtimys.res.in/

Value Addition to Silkworm Rearing By-Products **5 (2+3)**

Objectives

i. To make students understand all seri-by-products and its utilization

ii. To understand the best utilization of by-products generated at each stage of Silkworm rearing and their value addition

Theory

Introduction: scope and importance of by-product utilization during silkworm rearing. Utilization of mulberry silkworm, *Bombyx mori* L, bed waste for effective recycling as nutri-rich manure- Compost, vermicompost, biodigester. Utilization of non-mulberry silkworms (Eri, Tasar and Muga) fecal matter for effective recycling as manure. Scope and importance of Biogas and production of biogas by using silkworms fecal matter. Importance of chlorophyll extraction from silkworms fecal matter and its applications. Scope and importance of mushroom production by using silkwroms rearing waste. Scope and importance of production of *Cordyceps mylitaris*, utilization of silkworm larvae for production of *Cordyceps mylitaris* and health benefits.

Practical

Importance and scope of bi-product utilization in silkworm rearing, Value addition during silkworm rearing: composting, vermin-composting, bio-digester, biogas production, livestock production, pisciculture, mushroom cultivation, silkworm litter as livestock feed; as an organic manure, poultry feed, silkworm excreta: chlorophyll extraction and its applications

Suggested Readings

1. Anonymous. 2002. *Silk Weaving*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.

2. Bernard P Corbman. 1983. *Textiles: Fiber to Fabric.* (6th Edn.). Mc. Graw – Hill

3. *International Editions*, *Home Economic Series*. 594p. Singapore.

4. Dandin S B and Gupta V P. 2002. *Advances in Indian Sericulture Research.* CSR&TI, Mysore.

5. Dandin S B, Jayant Jayaswal and Giridhar K (Eds.). 2003. *Handbook of Sericulture Technologies*. CSB, Bengaluru.

6. Govindan R, Chinnaswamy K P, Krishnaprasad N K and Reddy D N R. 2000. *Non-Mulberry Sericulture, Silk Technology and Sericulture Economics and Extension* (Vol. III: Proceedings of NSTS – 1999). UAS, Bengaluru.

7. Sanjay Sinha. 1990. *The Development of Indian Silk.* Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.

8. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture*. CSB, Bengaluru.

Techniques in Raw Silk Production **5 (2+3)**

Objectives

i. To understand the processing of cocoon for reeling a silk yarn

ii. To acquaint with the skills of cocoon reeling and raw silk production

Theory

World raw silk production and present silk production in India, Cocoon formation, Physical characteristics of mulberry cocoon- colour, shape, wrinkles etc., Cocoon markets-their functions, method of transaction, method of fixing the cocoon price, Transportation of cocoons-care and handling, Cocoon testing and grading, Cocoon sorting-manual and mechanical method. Different types of defective cocoons, Mulberry silk reeling process-steps involved in silk reeling, Cocoon stifling and methods, storage of stifled cocoons-sun drying, steam stifling, hot air drying, Cocoon cooking and its systems, open pan, two pan, three pan, pressurized cooking method/central cocoon boiling machine, mechanical cooking, brushing methods, Evolution of reeling machines. General principles in reeling, different reeling machines-charakha, improved charakha, cottage basin/domestic basin, multiend reeling machine, semi automatic and automatic reeling machine. Re-reeling and lacing, Silk examination, skeining, book and bale making, Storage and selling raw silk, silk exchange,

Practical

Physical and commercial properties of cocoons, sorting of cocoons, types of reelable and unreelable defective cocoons, cocoon stifling by steam method, hot air stifling by chamber method and storage of cocoons, cocoon cooking – open pan method, two pan and three pan method, hands on traininng in cocoon reeling for raw silk production in cottage basin and multiand end reeling machine, lacing, silk examination and skein submission. Crossbreed / Bivoltine silk reeling. Visit to silk exchange, filature and automatic reeling machine units.

Suggested Readings

1. Anonymous. 2003. *Seri Business Manual*. 112p. CSB.

2. Anonymous. 2013. *Vanya Silks*. 155p. CSB.

3. Krishnaswami S, Madhava Rao N R, Suryanarayan S K and Sundaramurthy T S. 1972. *Sericulture Manual 3 - Silk Reeling*. 112p. FAO, Rome.

4. Mahadevappa, V G Haliyal, D G Shankar and Ravindra Bhandiwad. 2000. *Mulberry Silk Reeling Technology*. 227p. Oxford & IBH Publishing Company.

5. Tammanna N Sonuwalker. 1993. *Handbook of Silk Technology.* 229p. Wiley Eastern.

6. Yong-woo Lee. 2005. *Silk Reeling and Testing Manual*. 130p. National Sericulture and Entomology Institute, Seoul, Republic of Korea.

7. Ananthanarayanan S K. 2008. *Silk Reeling*. 266p. Biotech books, Delhi.

Techniques in Spun Silk Technology 5 (2+3)

Objectives

i. Using eri cocoon and short staple silk fibers from mulberry and tasar to prepare spun like yarn

ii. Utility of spun like yarn.

Theory

Different raw materials for spun silk production, availability and its utility in fabric manufacturing. Eri cocoon cooking, preparation of cake, spinning with hand tools such as takli, natwa, pedal spinning machine, spinning wheel, simple charaka, amber charaka. Mechanical spinning in spun mills. Hand spinning of cocoon wastes – mulberry cocoon, tasar cocoon and muga cocoons by thigh spinning, matka spinning. Utility of silk wastes such as cookers waste, reelers waste, rereeling, winding, twisting, doubling and weaving wastes of mulberry and tasar. Noil silk - waste produced in spun silk mills. Properties of spun silk yarn and its comparison with raw silk. Processing of spun silk yarn for fabric production. Dyeing, preparation of warp yarn, weft yarn with different counts. Quality assessment of spun silk and grading. Recycling of old / used silk fabric in spun silk production.

Practicals

Spun Silk – Characters. Manufacturing of spun silk. Systems of spun silk processing, Raw material for spinning mill or cottage spinnning by hand spinning tools. Silk wastes, pierced cocoons and Eri cocoons as raw material for spinning industry. Flow chart of spinning, spinning operations, procurement and storing of silk waste. Degumming, opening, Dressing, Drawing, Roving, Spinning, Gasing. Re-reeling and packaging of Spun silk. Hand spinning of cocoon wastes, Katia, Matka, Geecha silk. Equipments used in cottage spinning units - Takli, Natwa, Medleri charka, amber charaka, Das, Trivedi and Chowdary spinning wheels. Motorized cum pedal operated spinning wheel. Study of different types of silk wastes, different types of spun silks-Katia, Matka, Geecha, Noil, Machine spun silk, Machines used in spun silk industry. Study of different silk wastes. Raw silk waste, opened waste, combed / Dressed waste, sliver, Rovings. Processing of silk waste / Eri cocoons / pierced cocoons. Visit to Silk testing and grading units / spun silk industry.

Suggested Readings

1. Ya Lipenkov. 1983. *Wool Spinning* (V*ol. I)*. Moscow Mir Publishers.

2. Anonymous. 2003. *Seri-Business Manual* (Vol. III). *Industrial Sector*, CSB.

3. Kanwar Varinder Pal Singh. 2004. *Elementary idea of Textile Dyeing, Printing and Finishing*. Kalyani Publishers, New Delhi.

4. Tammanna N Sonuwalker. 1993. *Handbook of Silk Technology*. 119p. Wiley Eastern.

Techniques in Post Reeling Technology 5 (2+3)

Objectives

i. To make students confident in producing issue fabric from raw silk

ii. To understand the processing of raw silk yarn for weaving a fabric

iii. To acquaint with the skills of raw silk processing for fabric production

Theory

Twisting of raw silk (Throwster's unit)-Soaking of raw silk, winding, doubling–making different plys of silk yarn, mixing up of the yarns and twisting. Different types of twist–S twist, Z twist and production of different types of yarns. Steaming and Re-reeling. Maintenance of working condition of throwsters unit. Working out tho economics of cost of production of twisted yarn. Wet processing of twisted silk yarn-Degumming–methodology, Dyeing of yarn–different types of dyes, methods of dyeing and its application for silk dyeing. Warp making–different methods of warping –ball warping, drum warping. Weft yarn prepartion. Working out the economics of silk warping. Visit to throwsters unit and warp making units. Wet processing–at yarn stage and at fabric stage. Degumming (boil off) of silk–soupling, Ecru silk. Bleaching of silk, methods, Dyeing of silk–dyeing of silk with acid dyes, metal complex dyes, reactive dyes, vinyl sulphone dyes, direct dyes. After treatment of dyeing. Washing, acid treatment, hydro extractor, drying, skeining and packing. Silk printing for fabric. Classification of printing styles-silk printing styles. Printing tools and devices and quality control in printing. Silk finishing-mechanical: dry and wet, chemical finishing. Application of the finish. Finishes for the functional products. Weaving – handloom and powerloom weaving. Handloom weaving types - frame loom and pit loom, drawing – in and denting, heald shaft, heald count, reed, reed count, systems of counting, gaiting and piercing, yarn arrangement over the heald frames – straight, pointed and skip draft. Basic mechanisms of interlacing – primary, secondary and auxillary motions. Shedding – different types of shedding mechanisms-dobby, tappet (treadles) and jacquard. Types of shed. Picking mechanisms, beat up mechanism, warp let off and take up motions. Warp stop motion and filling stop motion, warp protector motion, transverse fabric control. Selvedges. Fabric structure- weave, thread densities of warp and weft, the coarseness and fineness of warp and weft yarn, the waviness of warp and weft, Basic fabric properties. Woven fabric Design-Plain weave, ornamentation of plain cloth, warp rib weave, weft rib weave and Basket (matte weave) - 2 × 2, 3 × 3 or 4 × 4. Twill weave – 2/1 or ½, 2/2 3/3 4/4. Satin and sateen weaves. Concept of fabric quality, perspectives of fabric quality and fabric defects. Importance of crimps, Silk sarees of different weaving clusters, crepe fabrics, georgette, chiffon, soft silk fabrics, organza, tafetta, habutai and tabby. Power loom shuttle and shuttle less looms (gripper and jet-picking mechanism).

Practical

Silk throwing-winding, doubling, twisting-types of twisting. Steam setting of twisted yarn. Warping and yarn winding. Degumming of silk; Methods of degumming, water quality for wet processing. Bleaching and dyeing, classification of dyes, factors influencing dyeing, preparation of dye and methods of dyeing. Study of different types of looms and their characteristics. Printing and methods of printing –block and screen printing. Weaving-loom and its structure, different types of looms, arrangement of yarn for simple weaving and design weaving. Textile Designing, Motifs for weaving and textile printing, silk / fabric finishing, silk knitting. Study of different dyes, preparation of dyes, bleaching and dyeing of silk. Visit to cottage-weaving sectors.

Suggested Readings

1. Anonymous. 2003. *Seri-Business Manual* (Vol. III). *Industrial Sector*, CSB.
2. Kanwar Varinder Pal Singh. 2004. *Elementary Idea of Textile Dyeing, Printing and Finishing.* 186p. Kalyani Publishers, New Delhi.

Value Addition in Silk Industry By-Product 5 (2+3)

Objectives

i. To make the students understand all silk industry by-products and its utilization

ii. To understand the best utilization of by-products generated at each stage of post cocoon processing and their value addition

Theory

Introduction: scope and importance of by-product utilization in silk industry. Silk reeling byproducts: utilization, processing and applications of silk reeling water, pelade layer, silk waste and pupa. Silkworm pupa as best source of protien for poultry and fish feed and its importance as human food. Silkworm pupal oil extraction, pupal cake and its applications. Scope and Importance of biodigeter: use of silk reeling water for bidigester and its utilization as rich source of nutrients for mulberry and agricultural crops. Pharmaceutical importance of sericin and fibroin and its application, use of sericin and fiboin powder in cosmetics industry. Utilization of silk waste from reeling, re-reling, twisting, winding, doubling and weaving process as spun silk and its applications in furnishing material etc. Non woven products using silk waste. Scope and imporance of cocoon crafts using pierced/cut cocoons: preparation of different cocoon crafts, economics and marketing of cocoon craft products.

Practical

Importance and scope of by-product utilization in silk industry, Value addition during silk reeling: silk waste, reeling water, pupa, pelade layer. Re-reeling, winding, doubling and twisting waste composting, vermicomposting, bio-digester, bio gas production, livestock production, pisciculture, mushroom cultivation. Pupal oil extraction and its uses, pupal powder as animal feed and manure. Flimsy cocoons and waste cocoons for spun silk production and quilting purpose. Silkworm pupa in human consumption-commercialized products and locally prepared dishes. Preparation of handicrafts, toys, wall plates, garlands, greeting cards, etc., from pierced/ cut cocoons. Sericin for medicine, cosmetics, artificial membranes and plastic industry and other uses of silk.

Suggested Readings

1. Anonymous. 2002. *Silk Weaving*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.

2. Bernard P Corbman. 1983. *Textiles: Fiber to Fabric.* (6th Edn.). Mc. Graw – Hill

3. *International Editions*, *Home Economic Series*. 594p. Singapore.

4. Dandin S B and Gupta V P. 2002. *Advances in Indian Sericulture Research.* CSR&TI, Mysore.

5. Dandin S B, Jayant Jayaswal and Giridhar K (Eds.). 2003. *Handbook of Sericulture Technologies*. CSB, Bengaluru.

6. Govindan R, Chinnaswamy K P, Krishnaprasad N K and Reddy D N R. 2000. *Non-Mulberry Sericulture, Silk Technology and Sericulture Economics and Extension* (Vol. III: Proceedings of NSTS – 1999). UAS, Bengaluru.

7. Sanjay Sinha. 1990. *The Development of Indian Silk.* Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.

8. Ullal S R and Narasimhanna M N. 1981. *Handbook of Practical Sericulture.* CSB, Bengaluru.

Semester VIII

S. No.	Course Title	Credit Hours
1.	Student READY (RAWE/Industrial Attachment /Experiential Learning/Hands-on Training/Skill Development/Project Work/Internship etc.)	20 (0+20)
	TOTAL	20 (0+20)

** The student project will be R and D based, field study based or entrepreneurship based (incubation/ experiential learning)

Minimum Standards for Establishing a College of Sericulture

- **Degree Nomenclature:** B. Sc. (Hons.) Sericulture

1. **Minimum intake (per year): 60**
2. **Faculty:**

   A. Core faculty: 19

   Host Plant Production- Core (0+1+1), Host Plant Production- allied (0+6), Sericulture Crop Improvement (0+1+1), Cocoon Crop Production (0+1+2), Silk Product Science (0+1+3), Basic Sciences and Humanities (0+1+1)

   B. Allied faculty:

   Faculty for Mathematics, computer science, Sociology, Psychology, English, Food Science and Technology, Microbiology, Agrometerology and other supporting subjects, if any, shall be adjusted from other colleges, Guest faculty, adjunct faculty and part time faculty.

3. **Land requirement (ha): 15**
4. **Essential Instructional units:**
   - Mulberry Garden
   - Host plant field- 2 ha
   - Agronomy field- 2 ha
   - Horticultural crop field- 1 ha
   - Silkworm rearing house- 0.25 ha
   - Commercial silkworm rearing house- 0.25 ha
   - Chauki rearing house- 0.25 ha
   - Grainage Block- 0.5 ha
   - By product utilization & value additionblock- 0.5 ha
   - Laboratories and instructional facilities as per V Deans' Committee report.
   - ELP units to be established under skilldevelopment or Entrepreneurial mode- 0.5 ha

5. **Divisons/Departments/Sections:**
   - Department of Host Plant Production
   - Department of Sericulture Crop Improvement
   - Department of Cocoon Crop Production
   - Department of Silk Product Science
   - Basic Sciences and Humanities

6. Non-Teaching Staff:

Department/Section	Steno/PA/ Computer Operator	Assistant	Attendant/ Messenger	Clerk	Laboratory Assistant / Attendant	Field staff (can be outsourced)
Department of Host Plant Production	1	07	07	-	14	10
Department of Sericulture		02	02	-	04	04
Crop Improvement Department of Cocoon Crop Production	1	02	02	-	04	08
Department of Silk Product Science	1	02	02	-	04	04
Basic Science and Humanities	1	04	02	-	03	02
Total	**05**	**17**	**15**	**-**	**29**	**28**

7. Faculty Expertise

Department/Section	Faculty Expertise	
	Core	**Associated**
Department of Host Plant Production	• Host plant cultivation, production and management. • Host plant botany, cytology, and breeding • Host plant physiology • Host plant protection	• Agronomy • Plant Biotechnology • Soil Science and Agril. Chemistry genetics • Crop Physiology • Farm Machinery and Engineering • Forestry and Environmental Science • Horticulture • Agri. Entomology • Plant Pathology • Seed Science & Technology • Genetics and plant breeding
Department of Cocoon Production	• Silkworm Rearing • Vanya sericulture • Silkworm egg production • Silkworm protection	• Agricultural Microbiology Crop • Animal Science • Plant Biochemistry • Agri. Economics
Department of Sericulture Crop Improvement	• Silkworm cytology, genetics and breeding • Silkworm Morphology and Systematic • Silkworm Anatomy and Physiology • Silkworm Anatomy and Physiology	• Biotechnology • Applied Microbiology • Seri Biotechnology • Seri Biochemistry • Seri Physiology

Department/Section	Faculty Expertise	
	Core	**Associated**
Department of Silk Product Science	• Silk reeling and post reeling technology • By-products and value addition • Mechanical engineering • Spun silk production • Industrial Machinery	• Business management • Textile engineering • Silk weaving and wet processing
Basic Sciences, Humanities andSocial Sciences		• Agricultural Extension • Agricultural Economics • Seri. Business Management • Agricultural Statistics • Computer sciences • English • Physical Education

8. Manpower Requirements

Manpower	**Number**
Dean	01
A. Establishment	
Personal Secretary to Dean	01
Superintendent (Administration)	01
Superintendent (Accounts)	01
Superintendent (Academics)	01
Assistant Examination coordinator	01
Steno / Computer Operator	02
Attendants/Messengers	02
Clerical Staff / (LDC)	03
AE / AEE	02
Electrician	01
Store Keeper	01
Driver (Heavy Vehicle- 2) & (Light Motor vehicle - 4)	06
Security, Sanitation, garden maintenance and Landscaping	04
B. Library Shelf Assistants	01
Clerk	01
C. Student Welfare Assistant Director of Student Welfare	01

D. Hostel (Boys + Girls) Wardens	02
Clerk (LDC)	02
Cooks	02
Asst. cooks	04
Care taker	02
Attendants	10
Security, Sanitation and Landscaping	07
Total	**59**

9. **Central/Department/Section Laboratories (as per requirement of the teaching and research work of the college)**

Department/Section	**Laboratory**
Department of Host Plant Production	1. Host plant Fields
	a. Agronomy Fields
	b. Horticulture Fields
	c. Agril. Microbiology Lab
	d. Plant Pathology lab
	e. Agril. Engineering Lab
	f. Soil Science and Agril. Chemistry lab
	g. Agril. Entomology lab
	h. Plant Physiology
	1. Silkworm Pathology lab
Department of Cocoon Crop Production	
	2. Grainage lab
	Field labs
	3. Silkworm rearing house.
	4. Commercial silkworm rearing house
	5. Chawki rearing house
	6. Genetics & breeding lab
Department of Sericulture Crop Improvement	8. Biochemistry lab
	9. Host plant breeding lab
	10. Silkworm breeding lab Department of Silk Product Science
	11. Silk Reeling lab
	12. Raw Silk testing Lab

Department/Section	Laboratory
	13.Silk dyeing & Printing Lab
	14.Silk weaving Lab
	15.By-product value addition Lab
Basic Sciences, Humanities and Social Sciences	16. Audio-Visual Lab
18. Sports ground	17. Computer Lab

10. Floor Space Requirement

A. CENTRAL FACILITY

Sl. No.	Details	Number of rooms	Dimensions (ft)
1.	Dean office	1	20 × 24
2.	PA room	1	20 × 12
3.	Committee room with video conferencing facility	1	20 × 48
4.	Admin. Staff rooms	3	20 × 36 each
5.	Examination cell	1	20 × 12
6.	Evaluation room	1	20 × 36
7.	Faculty room	25	20 × 12 each
8.	Placement cell	1	20 × 48
9.	Smart Lecture rooms	4	Seating Capacity - 50
10.	Auditorium	1	Seating Capacity – 300
11.	Library/Book bank	1	30 × 72
12.	Examination hall	1	Seating Capacity - 60
13.	AE / AEE	1	20 × 12
14.	Multipurpose room	1	20 × 36
15.	Laboratories	20	30 × 48 each
16.	Hostel	2	UG & PG (Boys& Girls) accommodating 3 studentsin a room
17.	Generator shed	1	20 × 36
18.	Canteen	1	20 × 12 (Kitchen) & 20 × 36(Setting room)
19.	Toilets	-	4 sets each (Girls & Boys)
20.	Parking space	As per requirement	For college & hostels
		(APR)	
21.	Vehicles • Officer car	1	
	• Staff car/Jeep	2	

Sl. No.	Details	Number of rooms	Dimensions (ft)
	• Bus	1	
	• Mini bus	1	
	• Ambulance	1	

B. DEPARTMENT / SECTION

Sl. No.	Details	Number of rooms	Dimensions (ft)
1.	Office of the Head of the Department	5 (for 5 departments)	20 × 24 each
2.	Faculty room	25	As specified in Sl. No. 8
3.	Rooms for Research Scholars	4 (for 4 departments)	20 × 24 each
4.	Smart Lecture cum seminar room	2	Seating capacity – 50 each
5.	Laboratories (No. of laboratories & Field labs as per requirement and include UG teaching laboratory		
6.	Department of Host Plant Production	6	30 × 60 (one) 30 × 40 (Five)
7.	Department of Cocoon Crop Production	2	30 × 60 (one) 30 × 40 (one)
8 .	Department of Sericulture Crop Improvement	4	30 × 60 (Four)
9.	Department of Silk Product Science	5	30 × 60 (one) 30 × 40 (four)
10.	Basic Sciences, Humanities and Social Sciences	2	30 × 60 (Two)
11.	Field labs for Agronomy, Host plant cultivation,	As Per Horticulture, Rearing houses, Chawki rearing house, RequirementSports ground & Greenhouse / poly house / glass house	
12.	Smart class room	1	20 x30 ft sized

11. *Equipment Facilities: Central Teaching and Research Laboratories

A) Centralized Instrumentation Laboratories

Sl. No.	Name of Equipment	Number
1.	Laminar air flow chamber	1
2.	Shaker and Incubator	1
3.	Autoclave	1
4.	pH meter	1
5.	Mirco and macro balances	1 each

Sl. No.	Name of Equipment	Number
6.	Agarose Gel electrophoresis unit (Horizontal)	1
7.	PAGE- electrophoresis unit (Vertical)	1
8.	Gel Documentation Unit	1
9.	ELISA reader	1
10.	Microscopes (simple, compound and stereo)	1
11.	BOD incubator	1
12.	Cold room	1
13.	Liquid Nitrogen Plant	1
14.	Liquid Nitrogen Flask	2
15.	Ice maker	1
16.	High Speed Centrifuge	1
17.	High speed cooling centrifuge	1
18.	Double Distillation unit with RO	(As per requirement)
19.	Computers	4
20.	Table top Centrifuge	1
21.	Micropipettes (0.2-5ml)	1
22.	Hot air oven	2
23.	PCR unit	2
24.	Water bath	1
25.	Pestle & Mortar	10
26.	Micro oven	2
27.	Dissection microscope	5
28.	Compound microscope	5
29.	Megaphones	1
30.	Amplifier	1
31.	Handy cam	1
32.	Camera	1

Any other equipment as per requirement

B) Equipment in the Department Laboratories (additional specialized equipment may be requireddepending on the mandate of the institute).

Sl. No.	Name of the Equipment	Number of units Divisions	Total Number	Departmentsusing
1.	Tractor	1×1	1	HPP
2.	Tiller	1×1	1	HPP
3.	Secateurs	10×1	10	HPP

Sl. No.	Name of the Equipment	Number of units Divisions	Total Number	Departmentsusing
4.	Looping Shear	2×1	2	HPP
5.	Brush Cutter	1×1	1	HPP
6.	Sprayer	2×1	2	HPP
7.	Battery operated knapsack sprayer	2×1	2	HPP
8.	Sprayers	5×1	5	HPP
9.	Mulberry cutting preparation machine	1×1	1	HPP
10.	Mulberry stem crushing machine	1×1	1	HPP
11.	Screw auger	1×1	1	HPP
12.	Tube auger	1×1	1	HPP
13.	Other farm implements for cultivation	As per requirement		
14.	Laminar flow	1×2	2	HPP+CCP
15.	Autoclave	1×2	2	HPP+CCP
16.	Spectrophotometer	1×2	2	HPP+CCP
17.	Flame photometer	1×2	2	HPP+CCP
18.	Insect collection box	10×2	20	HPP+CCP
19.	Dissection microscopes	5×2	10	HPP+CCP
20.	Compound microscopes	5×3	15	HPP+CCP+SCI
21.	Acid treatment bath	2×1	2	CCP+SCI
22.	Chawki rearing stands	10×2	20	CCP+SCI
23.	Plastic trays	50×2	100	CCP+SCI
24.	Feeding stands	5×2	10	CCP+SCI
25.	Leaf chopping board	2×2	4	CCP+SCI
26.	Knives	2×2	4	CCP+SCI
27.	Leaf chamber	2×2	4	CCP+SCI
28.	Ant wells	50×2	100	CCP+SCI
29.	Room heater	8×2	16	CCP+SCI
30.	Atomizer	2×2	4	CCP+SCI
31.	Humidifier	4×2	8	CCP+SCI
32.	Leaf collecting basket	8×2	16	CCP+SCI
33.	Electrical balance	2×2	4	CCP+SCI
34.	Power sprayer	2×2	4	CCP+SCI
35.	Mask	2×2	4	CCP+SCI

Sl. No.	Name of the Equipment	Number of units Divisions	Total Number	Departmentsusing
36.	150×2	300	CCP+SCI	
37.	Cocoon harvester	10×2	20	CCP+SCI
38.	Cocoon cutting machine	2×2	4	CCP+SCI
39.	Plastic mountages	150×2	300	CCP+SCI
40.	Deflossing machine	1×2	2	CCP+SCI
41.	Plastic incubation frames	20×2	20	CCP+SCI
42.	Mountage deflossing machine	5×2	10	CCP+SCI
43.	Digital hygrometers	4×2	8	CCP+SCI
44.	Cellules	500×2	1000	CCP+SCI
45.	Small rearing cages with trays	25×2	50	CCP+SCI
46.	Cocoon deflossing machine	1×2	2	CCP+SCI
47.	Cocoon drying machine	1×1	1	SPS
48.	Cocoon cooking machine	1×1	1	SPS
49.	Cocoon reeling machine (either multi end reeling machine or Semi- automaticwith denier detecting system)	1×1	1	SPS
50.	Silk re-reeling machine	1×1	1	SPS
51.	Vacuum permeation device	1×1	1	SPS
52.	Cocoon assorting machine	1×1	1	SPS
53.	By-product treating machine	1×1	1	SPS
54.	Silk skein twisting machine	2×1	2	SPS
55.	Silk book making machine	2×1	2	SPS
56.	Seri plane winding machine	1×1	1	SPS
57.	Illumination equipment for inspection	1×1	1	SPS
58.	Denier scale	4×1	4	SPS
59.	Rewinding test machine (10 bobbins)	1×1	1	SPS
60.	Boiler	1×1	1	SPS
61.	Mechanical tools	1×1	1	SPS
62.	Water testing kit	1×1	1	SPS
63.	Spinning wheel	1×1	1	SPS

Sl. No.	Name of the Equipment	Number of units Divisions	Total Number	Departmentsusing
64.	Weaving unit (Hand loom and power loom)	1 each	2	SPS
65.	Serigraph	1×1	1	SPS
66.	Cohesion tester	1×1	1	SPS
67.	Tenacity and elongation testing machine	1×1	1	SPS

NB: HPP - Host Plant Production; CCP- Cocoon Crop Production; SCI- Sericulture Crop Improvement; SPS - Silk Product Science

Natural Farming

UG-Certificate (Natural Farming); UG-Diploma (Natural Farming); B.Sc. Ag. (Hons.) Natural Farming

INTRODUCTION

Agrological practices are gaining importance across the globe aiming to address the issues in agriculture especially for achieving the sustainability without affecting the ecosystems. In this endeavour, Government of India is focusing on various alternate options to make agriculture self-sustainable. Natural farming is one such avocation and it is gaining importance among the farmers. However, well trained human resource is essential to promote natural farming. Considering the above, ICAR constituted a committee to develop curricula for Undergraduate and Postgraduate Degree programs in Natural Farming. Subsequently, a Sub-committee was constituted for realignment and restructuring of syllabus for UG Degree on Natural Farming as per NEP-2020 and Sixth Deans" Committee framework.

Development and restructuring of undergraduate program in Natural Farming has been done as per NEP guidelines to build strong foundation of knowledge among students with increased practical exposure and skilling to build competence and confidence for the application of the gained knowledge.

This curriculum framework puts down the appropriate curricular goals, content, pedagogical approaches and also specifies the allocation of time for different curricular activities that is proportional to the intended learning outcomes.

The syllabus is based on Bhartiya Prakartik Krishi Paddhati (BPKP) in India to enhance production, sustainability, saving of water, improvement in soil health and farmland ecosystem and reducing the market inputs. These important aspects of natural farming are considered as cost- effective and suitable for livelihood of large number of farmers and sustainable rural development.

The restructured course curriculum aims at strengthening critical thinking, creativity, communication and collaboration among the students. An immersion- cum-foundation program of three weeks is included at the start of the course which is aimed at instilling life

and social skills, social awareness, ethics and values, knowing and being, team work, leadership, creativity, etc. More emphasis has been given on Skill Enhancement Courses (SEC), experiential learning, projects, industry attachments, flexibility in choice of courses via electives and also through online courses.

Provision has also been made for advanced skill enhancement through project work or experiential learning/ incubation, etc. Through such activities, more emphasis has been given on conceptual learning than rote learning as well as for inculcating ingenuity and critical thinking. Besides, as per NEP-2020, provision for multiple exit and entry options have also been included.

The details of the semester- wise course structure for the Undergraduate Courses in Natural Farming (UG-Certificate, UG-Diploma and B.Sc. Ag. (Hons.)) Natural Farming have been prepared after having multistage in-depth deliberations and discussions through virtual meetings and personal communications with the members of committee It is expected that the course curriculum will strengthen the knowledge and skill base of the students and meet the expectations of the NEP-2020 towards making India a knowledge superpower and realizing the dream of Atmanirbhar Bharat.

HIGHLIGHTS

- The whole course program of B.Sc. Ag (Hons.) Natural Farming is of 166+10* (*NC-MOOC) with total 176 credit hours. The minimum eligibility requirement for admission in undergraduate program on Natural Farming will be the same as in case of B.Sc. Agriculture (Hons.). After the admission of students in the university, the students will register for the Foundation Course of 2 weeks duration in the 1st semester. The course will include discussions on operational framework of academic process in university, sessions from alumni, business leaders, University academic and research managers and classes on personality development (instilling life and social skills, social awareness, ethics and values, team work, knowing and being, leadership, etc.) and communication skills. Steps will be taken to identify the strength and weakness of students (with remedial measures), diverse potentialities will be taken into account and cultural integration of students from different backgrounds will be encouraged. It will also create a platform for students to learn from each other's life experiences.
- The first year of the course is dedicated for knowledge and skill enhancement in Natural Farming including Indian heritage and applied aspects of natural farming. After satisfactory completion of 42 credits of courses in two semesters and subsequent satisfactory completion of 10 credits (10 weeks) of industry attachment institute training/ internship, the student will become eligible for the award of UG-Certificate in Natural Farming on exit. The students continuing the study further, would not have to attend the internship after 1st year.
- The skill program during the first year is termed as Skill Enhancement Courses (SEC). The students will have flexibility and choice in selection of skill development area from a basket of SEC modules to be offered by the parent institute. After one week common orientation on different skill enhancement modules, students will take up either one or more modules (maximum 4) as per the local needs and gain complete hands-on experience on these modules. In addition to the modules proposed in this report, the

SAUs can formulate other modules relevant to the respective regions or modify the titles of the proposed modules.

- An institution (University or College) is at liberty, and in fact it should work in partnership with capable organizations/ companies/ NGOs/ progressive entrepreneurs for running various SEC programs. In such cases, while the parent institution will control admission process, develop the content and delivery of the program and monitor the learning and skill development by students and the evaluation can be done jointly by the collaborating partners.
- The second year has been designed with the practical exposure on natural farming as well as some part of fundamental courses related to agricultural sciences with adequate theory and practical components, enabling the student to get acquainted with the basic principles and applications of natural farming. After satisfactory completion of the courses of 2nd year and subsequent completion of 10 credits (10 weeks) of industry/ institute training/ internship, the student will become eligible for the award of UG-Diploma in Natural Farming on exit. The students continuing the study further, would not have to attend the internship after 2nd year.
- The third year and fourth year courses have been designed to impart in depth details including specialized knowledge to the students in the major disciplines. In order to inculcate the moral and experiential habits in students to, research methodology and ethics were also added besides Student READY (Rural Entrepreneurship Awareness Development Yojana) include Rural Agricultural Work Experience program (RAWE)/experiential learning/internship hands-on-training and student projects.
- There will be adequate choice of electives/ specialized courses for the students in the final year. The Universities will have flexibility to include more courses as electives depending on specific needs. The objective is to enable the student to acquire deeper understanding in any particular field. As regards individual course contents, universities/colleges may modify the content to the extent of 30 percent whenever necessary as per the regional demands and needs. There will be choice of elective/ specialization in final year for students.
- Students will also be given freedom to opt 10 credits of non-credit courses from MOOC or any other portal in on line mode to groom up her/his passion and add on the knowledge components based on her/ his choice. There will also be flexibility to complete these non-credit elective courses of 20 credits throughout the span of the degree program.
- The online courses can be from any field such as Agriculture, Basic Sciences, Humanities, Psychology, Anthropology, Economics, Business Management, Languages including Foreign Languages, Communication Skills/ Music, etc. The objective is to allow the students to groom their passion or strengthen their knowledge and competency in any field beyond prescribed courses. These online courses will be non-gradial as separate certificates would be issued by institutes offering the courses. However, the university/ institute will keep a record of such courses registered and completed by each student and will indicate the title of the (successfully completed) courses in final transcript issued to the student.
- In eighth semester of the degree Program, students will be offered minimum 20 credits from Student READY Programs including RAWE/Project work/industrial attachment experiential learning, hands-on-training internship or any other option mentioned by the parent institute. The project work may be Natural Farming-based project/research based project or Industry based project depending on the interest of the students.

Entry and Exit Options

The entry and exit options for the B.Sc. Ag. (Hons.) Program in Natural Farming are shown in the figure 1.

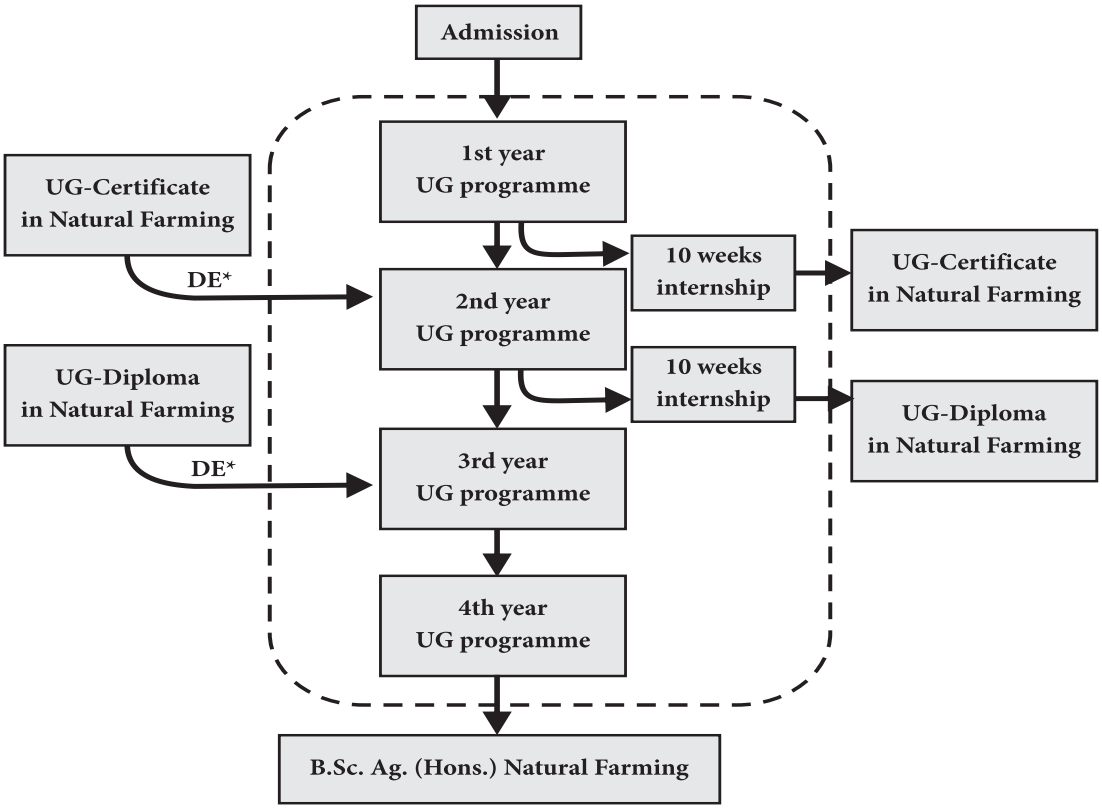


Fig 1. Entry and Exit Options in B.Sc.Ag. (Hons.) Natural Farming

DE* Direct Entry in the Respective Year

Exit options

- **UG-Certificate in Natural Farming** (exit after first year and completion of 10 weeks' internship)
- **UG-Diploma in Natural Farming** (exit after second year and completion of 10 weeks' internship)
- **B. Sc. Ag. (Hons.) Natural Farming** (on successful completion of four-year degree requirements)

Admission Eligibility for Entry into 1st year UG programme: The Universities may also consider allowing lateral entry for the candidates having Diploma in Natural Farming from Polytechnic colleges or other institutions approved by UGC/ICAR at the State and National level program) may be allowed admission into the 3rd year of the UG program, following the norms of lateral entry in respective universities/ institutions.

- The minimum eligibility requirement for admission in undergraduate program on Natural Farming will be the same as in case of B.Sc. (Hons.) Agriculture.

ACADEMIC PROGRAM

Semester Wise Course Distribution

S. No	Course Title	Credit Hours	Total Credits
First Year			
Semester I			
1.	Deeksharambh (Induction cum Foundation course)	2 (0+2)NG	**20 (10+10)**
2.	Indian Heritage of Natural Farming	3 (2+1)	
3.	Principles and Practices of Natural Farming	4 (3+1)	
4.	Bhumi Suposhan (Soil Nutrition)	3 (2+1)	
5.	Farming based Livelihood System	3 (2+1)	
6.	Communication Skills	2 (1+1)	
7.	Skill Enhancement Course (SEC-I)	2 (0+2)	
8.	Skill Enhancement Course (SEC-II)	2 (0+2)	
9.	NCC-I/NSS-I	1 (0+1)	
Semester II			
1.	Cow- based Natural Farming	3 (1+2)	**21 (9+12)**
2.	Soil Biology in Natural Farming	3 (2+1)	
3.	Integration of Horticulture Crops under Natural Farming	2 (1+1)	
4.	Insect Ecology, Nematodes and Pest Management	3 (2+1)	
5.	Entrepreneurship Development and Business Management	3 (2+1)	
6.	Personality Development	2 (1+1)	
7.	Skill Enhancement Course (SEC-III)	2 (0+2)	
8.	Skill Enhancement Course (SEC-IV)	2 (0+2)	
9.	NCC-II/NSS-II	1 (0+1)	
Post-Semester II (Only for exit option for award of UG-Certificate in Sericulture)			
1.	Internship (10 weeks)	10 (0+10)	
Second Year			
Semester III			
1.	Crop Management in Natural Farming	3 (2+1)	**22 (10+12)**
2.	Production of Bio-inputs	2 (1+1)	
3.	Farm Power and Machinery	3 (1+2)	
4.	Livestock and Poultry Production	3 (2+1)	
5.	Management of Plant Diseases	2 (1+1)	
6.	Biodiversity Conservation	2 (1+1)	
7.	Physical Education, First Aid Yoga Practice & Meditation	2 (0+2)	
8.	Skill Enhancement Course (SEC-V)	2 (0+2)	
9.	Environmental Studies and Disaster Management	3 (2+1)	

S. No	Course Title	Credit Hours	Total Credits
	Semester IV		
1.	Elements, Characteristics and Design of Natural Farming Systems	3 (2+1)	**22 (13+9)**
2.	Improvement of Traditional and Under-Utilized Crops	3 (2+1)	
3.	Agro-Ecosystem Analysis for Natural Farming	2 (1+1)	
4.	Beneficial Insects	3 (2+1)	
5.	Quantification and Valuation of Ecosystem Services	3 (2+1)	
6.	Agricultural Marketing and Trade	3 (2+1)	
7.	Agriculture Informatics and Artificial Intelligence	3 (2+1)	
8.	Skill Enhancement Course (SEC-VI)	2 (0+2)	
	Post-Semester IV* (Only For exit option for UG-Diploma in Sericulture)		
1.	Internship (10 weeks)	10 (0+10)	
	Third Year		
	Semester V		
1.	Post-Harvest Management –I	3 (2+1)	**20 (12+8)**
2.	Bio- resources and Agricultural Waste Management	3 (2+1)	
3.	Medicinal and Aromatic Plants	2 (1+1)	
4.	Seed Production Technology	3 (2+1)	
5.	Value Chain Management in Natural Farming	2 (1+1)	
6.	Renewable Energy Sources	2 (1+1)	
7.	Natural Farming and Human Health	2 (1+1)	
8.	Fundamentals of Entomology	3 (2+1)	
9.	Educational Tour (10-14 days)	2 (0+2) Non-gradial	
	Semester VI		
1.	Indian Traditional Knowledge	3 (2+1)	**20 (14+6)**
2.	Post-Harvest Management-II	3 (2+1)	
3.	Standards and Certification for Natural Farming	3 (2+1)	
4.	Aqua-based Natural Farming	3 (2+1)	
5.	Marketing of Natural Farming Produce	3 (2+1)	
6.	Agronomic Practices	2 (1+1)	
7.	Intellectual Property Rights	1 (1+0)	
8.	Principles of Agricultural Economics and Farm Management	2 (2+0)	
	Fourth Year		
	Semester VII		
1.	Community Mobilization for Natural Farming	2 (1+1)	**21 (13+8)**
2.	Water Management	2 (1+1)	
3.	Research Methodology and Ethics	2 (1+1)	
4.	Weather Forecasting	3 (2+1)	
5.	Basic and Applied Agricultural Statistics	3 (2+1)	
6.	Elective Course-I	3 (2+1)	
7.	Elective Course-II	3 (2+1)	
8.	Elective Course-III	3 (2+1)	

S. No	Course Title	Credit Hours	Total Credits
	Semester VIII		
1.	For students opting 4 Year B.Sc. Ag. (Hons.) Natural Farming Degree, Student READY (RAWE/Industrial Attachment/ Experiential Learning/Hands on Training/Project Work)/ Internship	20 credits	**20 (0+20)**

Table 2: Semester wise Credit Allocation (NF)

Sem-ester	Total Credits	Core Courses (Major+ Minor)	Multi-Disciplinary Course (MDC)	Value Added Course (VAC)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)	Internship/ Project/ Student READY	Non-Gradial	Online Courses/ MOOC
I	20	10	3[2]		1[3] + 2[4]	4	-	2[1]	
II	21	11	3[5]		1[3] + 2[7]	4	10[12]	-	
III	22	15	--	3[6]	2[8]	2	-		
IV	22	14	3[9]	3 [10]	----	2	10[13]	-	
V	20	20	-	-	-	-	-	2[11]	**10**
VI	20	20	-	-	-	-	-	-	
VII	21	21	-	-	-	-	-	-	
VIII	20	-	-	-	-	-	20	-	
Total	**166**	**111**	**9**	**6**	**8**	**12**	**20**	**4**	**10**

[1] *Deeksharambh* (Induction-cum-Foundation Course) of 2 credits (2 weeks duration).
[2] Farming based Livelihood systems.
[3] NCC/NSS
[4] Communication Skills.
[5] Entrepreneurship Development and Business Management.
[6] Environmental Studies and Disaster Management.
[7] Personality Development.
[8] Physical Education, First Aid. Yoga Practices and Meditation.
[9] Agriculture Marketing and Trade.
[10] Agriculture Informatics & Artificial Intelligence
[11] Study tour (10-14 days).
[12] Only for those opting for an exit with UG-Certificate.
[13] Only for those opting for an exit with UG-Diploma.

Section-Wise Course Breakup

Course Category	Course Title	Credit Hours
Induction cum Foundation course	*Deeksharambh*	2 Weeks (Non gradial)
Common Courses	Farming Based Livelihood Systems	3 (2+1)
	Communication Skill	2 (1+1)
	Entrepreneurship Development and Business Management	3 (2+1)
	Personality Development	2 (1+1)
	Environmental Studies and Disaster Management	3 (2+1)
	Agricultural Marketing and Trade	3 (2+1)
	Agricultural Informatics	3 (2+1)
	NCC/NSS/NSO-I	2 Courses each of 1 (0+1) credit
	Physical Education, First Aid and Yoga Practices	2 credit
	Total Credits	**23**

Course Category	Course Title	Credit Hours
Core courses (Major and Minor)	Indian Heritage of Natural Farming	3 (2+1)
	Principles and Practices of Natural Farming	4 (3+1)
	Bhumi Suposhan (Soil Nutrition)	3 (2+1)
	Cow- Based Natural Farming	3 (1+2)
	Soil Biology in Natural Farming	3 (2+1)
	Integration of Horticulture Crops Under Natural Farming	2 (1+1)
	Insect Ecology, Nematodes and Pest Management	3 (2+1)
	Crop Management in Natural Farming	3 (2+1)
	Production of Bio-Inputs	2 (1+1)
	Farm Power and Machinery	3 (1+2)
	Livestock and Poultry Production	3 (2+1)
	Management of Plant Diseases	2 (1+1)
	Biodiversity Conservation	2 (1+1)
	Elements, Characteristics and Design Of Natural Farming Systems	3 (2+1)
	Improvement Of Traditional and Under-Utilized Crops	3 (2+1)
	Agro-Ecosystem Analysis for Natural Farming	2 (1+1)
	Beneficial Insects	3 (2+1)
	Quantification and Valuation of Ecosystem Services	3 (2+1)
	Post-Harvest Management –I	3 (2+1)
	Bio- Resources and Agricultural Waste Management	3 (2+1)
	Medicinal and Aromatic Plants	2 (1+1)
	Seed Production Technology	3 (2+1)
	Value Chain Management in Natural Farming	2 (1+1)
	Renewable Energy Sources	2 (1+1)
	Natural Farming and Human Health	2 (1+1)
	Fundamentals of Entomology	3 (2+1)
	Indian Traditional Knowledge	3 (2+1)
	Post-Harvest Management-II	3 (2+1)
	Standards and Certification for Natural Farming	3 (2+1)
	Aqua-Based Natural Farming	3 (2+1)
	Marketing of Natural Farming Produce	3 (2+1)
	Agronomic Practices	2 (1+1)
	Intellectual Property Rights	1 (1+0)
	Principles of Agricultural Economics and Farm Management	2 (2+0)
	Community Mobilization for Natural Farming	2 (1+1)
	Water Management	2 (1+1)
	Research Methodology and Ethics	2 (1+1)
	Weather Forecasting	3 (2+1)
	Basic and Applied Agricultural Statistics	3 (2+1)
	Total Credits	**102 (63+39)**
Elective courses	9 Credits will be taken from list of choice based course list or department wise courses to be decided by host institution	9
	Total Credits	**9**
Skill Enhancement Courses	Skill Enhancement Course I	2 (0+2)
	Skill Enhancement Course II	2 (0+2)
	Skill Enhancement Course III	2 (0+2)
	Skill Enhancement Course IV	2 (0+2)
	Skill Enhancement Course V	2 (0+2)
	Skill Enhancement Course VI	2 (0+2)
	Total Credits	**12 (0+12)**
Student READY		20
	Total Credits	**20**

SUMMARY OF CREDIT DISTRIBUTIONS

Type of course(s)		Credit hours
Core courses	:	111
Skill Enhancement courses	:	12
Multidisciplinary/ Common courses	:	23
Student READY/Internship	:	20
*Online courses (non-gradial)	:	10
Grand Total	:	**166+10***

The credits of *Deeksharambh* (0+2) and Study tour (0+2) being non-gradial have not been included in the total 166 credit hours.

Detailed Syllabi

Semester I

Deeksharambh (Induction-cum-Foundation Course)- Non-gradial 2 (0+2)

The activities to be taken under *Deeksharambh* shall aim at creating a platform for students to

1. Helpings in for cultural Integration of students from different backgrounds
2. Know about the operational framework of academic process in University
3. Instilling life and social skills
4. Social awareness, ethics and values, team work, leadership, creativity, etc.
5. Identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario.

The details of activities will be decided by the parent universities. The structure shall include, but not restricted to:

i. Discussions on operational framework of academic process in university, as well as interactions with academic and research managers of the University
ii. Interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences
iii. Group activities to identify the strength and weakness of students (with expert advice for their improvement) as well as to create a platform for students to learn from each other's life experiences
iv. Activities to enhance cultural Integration of students from different backgrounds.
v. Field visits to related fields/ establishments
vi. Sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills

Indian Heritage of Natural Farming 3 (2+1)

Objectives

i. To impart knowledge on the heritage of natural farming in ancient India and various techniques of *Vedic Krishi.*

ii. To develop skills on *Vedic Krishi* practices for practicing natural farming.

Theory

The heritage of natural farming, Pioneers and scholars of natural farming and their contribution to the heritage of natural farming, Ancient methods of livestock management, health, nutrition, soil

fertility and plant protection, Description on ancient methods of rainfall prediction, Importance of seed and their collection, storage, removal of weed seeds and seed uniformity, Discussions on important rare documents like *Krishi-Parashar*, *Sitadhyaksha* chapter in *Kautilya Arthashastra* (Acharya Kautilya-321 BC), *Kashyapiya Krishi Sukti* (by sage Kashyap-c.800 CE), *Vrikshayurveda* (by Vaidya Surapala), *Upavanavinod* (Nalini, 2011), *Vishwavallabha* (by Chakrapani Mishra-1577 CE), *Brihat Samhita* (by Varahamihi- 600 AD), *Lokopakara* (1000-year-old manuscript), *Nuskha Dar Fanni-Falahat*-The Art of Agriculture(by Prince Dara Shikoh-1650 CE), *Krishi Gita-Agricultural Versus* (15th century by Vidwan C Govinda Warriar), etc. Measurement of wealth on natural resources, '*Gau-dhan*' (Cows), '*Ashwa-dhan*' (Horses), '*Gaj-dhan*' (Elephants) etc. as all different forms of wealth.

'*Vidya-dhan*'. The most important wealth '*dhanya*' or rice/crops, Mode of the transactions in the society through '*dhanya*'. Broad tradition of 'natural farming', propounded by advocates such as Dr Y.L Nene, (Asian Agri History Foundation), Narayana Reddy (Karnataka), Shripad Dabholkar (Maharashtra), G Nammalvar (Tamil Nadu), Partap C Aggarwal (Madhya Pradesh) and Bhaskar Hiroji Save (Gujarat). Rich heritage of plant protection in natural farming, Identification of disorders; Surapala's Vrikshayurveda describes various plant diseases based on Tridosha (Vata, Pitta, Kapha) Siddhanta of Ayurveda along with symptoms and remedial measures. Plant protection practices, Kunapajala, Herbal Kunapajala and other indigenous liquid concoctions.

Practical

Visit of natural farms to understand the concept, components and management practices. Identification of plant and animal-based products used in Vrikshayurveda for plant nutrition and crop protection. Preparation of Vrikshayurveda based on-farm inputs for nutrient, pest and disease management. Documentation of vrikshayuveda technology knowledge- base for resource conservation, soil health and plant protection.

Suggested Readings

1. Akbar R. 2000. *Nuskha Dar Fanni-Falahat (The Art of Agriculture) Prince Dara Shikoh (1650 CE): AAHF Classic Bulletin 3*. Asian Agri- History Foundation, Secunderabad, AP, India. 88p.
2. Ayachit S M. 2002. *Kashyapi Krishi Sukti (A Treatise on Agriculture by Kashyapa)*. Brig Sayeed Road, Secunderabad, Telangana: Asian Agri- History Foundation 4:205.
3. Beniwal S P S and Pandey S T. 2022. *Soil Nourishment and Conservation According to Soil Agriculture Heritage of India*, Bhumi Suposhan Commemorative Publication 43-56p
4. Beniwal S P S, Nene Y L and Pandey S T. 2020. *Relevance of Vrikshayurveda and Traditional Knowledge for Eco-friendly Sustainable Agriculture to Meet SDGs in India. Asian Agri-History* 1:3-22.
5. Bhat M and Ramakrishna. 1992. *Varahmihira's Brihat Samhita*. Motilal Banarasidas, Delhi India 561p.
6. Das P, Das S K, Arya HPS, Reddy Subba G and Mishra A. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission Mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 to 7*, Indian Council of Agricultural Research, New Delhi.
7. Gupta P K and Gupta A K (Eds.). 2019. *Smriti Jaagran Ke Harkaare, Jeevika Livelihoods Support organization,* Jabalpur, MP, India.

8. Kumar B Mohan. 2008. Krishi Gita *(Agricultural Verses) by Vidwan C Govinda Warriar (Ed.): AAHF Classic Bulletin 7.* Asian Agri-History Foundation, Secunderabad, AP, India. 134p.

9. Nalini S. 1996. Vrikshayurveda (*The Science of Plant Life) by Surapala. AAHF Classic Bulletin 1.* Asian Agri-History Foundation, Secunderabad, AP, India. 94p.

10. Nalini S. 1999. *Krishi-Parashara (Agriculture by Parashara) by Parashara,* Secunderabad, Telangana: AAHF Classic Bulletin. Asian Agri-History Foundation. 104p.

11. Nalini S. 2004. *Vishva Vallabha (Dear to the World: The Science of Plant Life) by Chakrapani Mishra (1577 CE): AAHF Classic Bulletin 5*. Asian Agri-History Foundation, Secunderabad, AP, India. 134p.

12. Nalini S. 2011. *Upavana Vinoda (Woodland Garden for Enjoyment) by Sarangdhara (13th century CE): AAHF Classic Bulletin 8*. Asian Agri-History Foundation, Secunderabad, AP, India. 64p.

13. Nene Y L. 2006. *Kunapajala – A Liquid Organic Manure of Antiquity*. Asian Agri History 4: 315-21.

14. Nene Y L. 2012 *A. Potential of Some Methods Described in Vrikshayurveda in Crop Yield Increase and Disease Management*. *Asian Agri-History* 1: 45- 54p.

15. Nene Y L. 2012. *B. Crop Disease Management Practices in Ancient, Medieval, and Pre- modern India*. *Asian Agri-History* **3**: 185-201p.

16. Saxena R C, Choudhary S L and Nene YL. 2009. *A Textbook on Ancient History of Indian Agriculture. AAHF Text Book*. Asian Agri-History Foundation, Brig Sayeed Road, Secunderabad, AP, and Rajasthan Chapter of Asian Agri-History Foundation, Udaipur, India. 139p.

17. Sreenivasa A V. 2004. *A. Herbal Kunapa*. Asian Agri-History 8:315–17.

18. Sreenivasa A V. 2004. *B. Manujala: A Liquid Manure.* Asian Agri-History 8: 319–21.

19. Sreenivasa A V. 2005. *INDSAFARI – An Organic Pesticide for Tea*. Asian Agri-History 9:317–19.

20. Watt G. 1889. *A Dictionary of the Economic Products of India*, *Central Secretariat Library*. https://indianculture.gov.in/rarebooks/dictionary-economic-Products-India-Vol. IV.

Principles and Practices of Natural Farming 4 (3+1)

Objectives

i. To make the students aware about the agro-ecology, concept and principles.

ii. To impart knowledge on various principles and practices in natural farming.

iii. To impart knowledge about different methods of natural farming.

Theory

Natural farming: Concept and importance. Modern agriculture and need for new strategies, origin of concept of natural farming, Agroecology: Concept and Principles, history of development in agro-ecology, Natural farming: principles, philosophy and components, Merits and demerits of natural farming, Principles of Fukuoka and other methods of natural farming, Practices of Natural Farming - case studies, Types of natural farming systems (Community based natural farming, Palekar's Natural Farming, Bio-dynamic, homa farming, natu- eco farming, rishi Krishi, panchagavvya Krishi, yogic farming etc., Scope of natural farming in modern time, Laws of nature, Indian philosophy /Bhartiya Chintan of Pancha Mahabhoot

and their role in human life and development, Important management practices for crops, fruits, vegetables and animals in natural farming, comparison of conventional, organic and natural farming production systems, Scientific aspects of ecological and natural farming for supporting food, nutritional and livelihood security - food sovereignty, livelihood of farmers and rural communities, biodiversity and conservation of biodiversity, Sustainable soil health and clean water, Ecological pest protection, Climate resilient food production, Indigenous farming systems prevalent in India and other countries. Government schemes supporting natural farming (PKVy, BPKP, National Mission on Natural Farming), Start-Ups in chemical free agriculture, Digital India.

Practical

Identification of indigenous crops and practices, Study of different farming systems and their characterization, Students' visit to natural farms to study the various components and practices of natural farming, Development of natural farm inventarity, Analysis of ancient Indian and modern natural farming, Bio- dynamics, homa farming, natu-eco farming, rishi Krishi, panchagavvya Krishi, Yogic farming and practical field application of these practices, Design of natural farm based on locally available resources, Preparation of on- farm inputs for nutrients, pest and disease management. Documentation of indigenous technology knowledge (ITK) for nutrient, insect, pest disease and weed management, Development of documentary on management of natural farm.

Suggested Readings

1. Behera U K. 2013. *A Text Book of Farming Systems*. Agrotech Publishing House, Udaipur, Rajasthan
2. Fukuoka M. 1978. *The One-Straw Revolution: An Introduction to Natural Farming.* Rodale Press, Emmaus, PA. 181p.
3. Hill S B and ott P. (Eds.). 1982. *Basic Techniques in Ecological Farming.* Berkhauser Verlag, Basel, Germany. 366p.
4. Khurana A and Kumar V. 2020. *State of Organic and Natural Farming: Challenges and Possibilities*. Centre for Science and Environment, New Delhi.
5. Malhotra R and Babaji S D. 2020. Sanskrit Non Translatables- *The importance of Sanskritizing English.* Amaryllis, New Delhi, India.
6. Nicole Faires. 2016. *The Ultimate Guide to Natural Farming and Sustainable Living: Permaculture for Beginners* (Ultimate Guides)
7. Prathapan Paramu. 2021. *Natural Farming Techniques: Farming Without Tilling.*
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9. Sharma S K, Choudhary R, Ravishankar N, Jat G, Sharma R K, Yadav S K and Jain R K. 2022. *Natural Farming: Concept, Importance, Scope and Status. Technical Bulleting.* Directorate of Research, Maharana Pratap University of Agriculture and Technology, Udaipur. 1-16p.
10. Shripad A Dabholkar and Prayog Pariwar. 2021. *Plenty For All: Natural Farming A To Z Prayog Pariwar Methodology.* Mehta Publishing House.

Bhumi Suposhan (Soil Nutrition) 3 (2+1)

Objectives

i. To impart knowledge on various properties of soils, soil evaluation procedures, factors of soil fertility and management of biological processes through natural farming practices

ii. To develop skills among students on soil management practices under natural farming

Theory

Soil as a natural medium for plant growth, Status of soil degradation; Weathering of rocks and minerals, Soil genesis and classification; Concept of essential, beneficial, functional and trace elements in soils; Role of essential nutrients in plants, their deficiency and toxicity symptoms and diagnosis, Nutrient movement in soils and mechanisms of nutrients uptake by plants, Cycling of nutrients in soils (C, N, P, S, secondary and micronutrients), Importance of physical, chemical, and biological properties of soil, Factors affecting soil fertility, Methods of soil fertility evaluation: physical, chemical and biological, origin, formation, extent of distribution and characteristics of acid soils, acid sulphate soils, alkali soils, saline soils and their management, Formation of soil organic matter and its management in agroecosystem, carbon sequestration, soil carbon and nitrogen management indices, Soil quality and health, soil quality indicators, characteristics of a healthy soil, Principles of supporting healthy rhizosphere interactions for improved soil fertility, Best management practices (BMPs) for promoting soil health and monitoring of soil-health: minimum tillage, mulching, organic residue incorporation, cover crops, green manuring, crop rotation, conducive environment for beneficial microbes, mixed cropping, intercropping, composts, FYM, biochar, bio- culture formulations, Sing Khad, (Horn manure), *Kunapajal*, Samadhi Khada, biogas manures (liquid and solid), etc., Principles and methods of production of various organic manures, Sources of contamination in soil and reclamation by bioremediation processes (Phytoremediation, phytoextraction, phytostabilization and microbial bioremediation), Ancient classification of soil based on soil fertility, irrigation, physical characteristics, and crop suitability; Ancient practices for soil enrichment under natural farming, Traditional festivals of the region with respect to soil health, Schemes promoting soil health in India.

Practical

Soil sampling methods, processing, and storage, Determination of soil texture (feel method, hydrometer method and international pipette method), Determination of soil bulk density, particle density, porosity, and water holding capacity, Determination of soil pH and EC, Determination of soil organic carbon, Determination of available nitrogen, Determination of available phosphorus, Determination of available potassium, Determination of available secondary plant nutrients (Ca, Mg, S,), Determination of available micronutrients (Zn, Fe, Cu, Mn, B, Mo), Plant sample digestion procedure, Analysis of important nutrient elements in plant, Studies on important ITKs for selection of crop-soil combination, Quantification of carbon-neutral farming practices.

Suggested Readings

1. Akshay Krishi Parivar. 2022. *Bhumi Suposhan-Commemorative Publication of the Nationwide Bhumi Suposhan and Samrakshan Abhiyan*. AK Publication No.11. 212p.

2. Biswas T D and Mukherjee S K. 1987. *Text Book of Soil Science*. Tata McGraw- Hill Publishing Company, New Delhi. ISBN 13, 0074516795, 9780074516799. 314p.

3. Choudhary S L, Sharma G S and Y L Nene. 2000. *Ancient and Medieval History of Indian Agriculture and its relevance to Sustainable Agriculture in the 21st Century.* Proceedings of the summer school held from 28th May to 17th June 1999, Rajasthan College of Agriculture, Udaipur, India. 363p.

4. Das D K. 2015. *Introductory Soil Science.* (4 Edn.). Kalyani Publishers, ISBN: 978-93-2725-754-0

5. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.

6. Gaur A C. 1999. *Microbial Technology for Composting Residues by Improved Methods.* ICAR, New Delhi. 78p.

7. Havlin J L, Tisdale S L, Nelson W L and Beaton J D. 2016. *Soil Fertility and Fertilizers.* (8th Edn.). Pearson Education India. ISBN 978-93-3257-034-4.

8. *Fundamental of Soil Science*. 2012. (2nd Edn.). Published by Indian Society of Soil Science (ISSS). ISBN: 978- 81-903-7974-7.

9. Rattan R K, Katyal J C, Dwivedi B S, Sarkar A K, Bhattacharyya T, Tarafdar J C and Kukal S S. 2015. *Soil Science: An Introduction.* Indian Society of Soil Science. New Delhi. ISBN: 978-81-903-7977-9

10. Weil R R and Brady N C. 2021. *The Nature and Properties of Soil.* (15th Edn.). ISBN 978-93-5606-271-9. Pearson Education.

11. Yawalkar K S, Agarwal J P and Bokde S. 2012. *Manures and Fertilizers*. Agri- Horticultural Publishing House. 288p.

Farming Based Livelihood Systems 3 (2+1)

Objective

To disseminate the knowledge and skill how farming systems can be a source of livelihood

Theory

Concept of farming system and integrated farming system- Definition, goal and advantages, Classification of farming systems, Components of farming systems- Crops and cropping systems, Livestock and poultry, Fishery and Secondary enterprises, Integration of components in farming system, Factors affecting integration of components in IFS, Selection of crops and cropping systems for various enterprises, Feasibility of different cropping systems for different agro- climatic zones, Horticultural crops and cropping systems feasible for different farming systems, Livestock and poultry as a component of integrated farming systems, Study of different livestock components feasible for IFS (Dairy, Piggery, goatry, poultry, duckry etc.), Aqua culture as a component of IFS, Duck/Poultry cum Fish, Dairy cum fish, Piggery cum fish etc. Problems, profitability and prospects, Sericulture as a component of IFS: Scope and potentiality of sericulture for small and marginal farmers of states, some suitable module of IFS for different agro-ecological situations,

Commercial livestock production- problems and prospects, Design for livestock shed and their maintenance, Importance of feed processing unit for livestock production, Silage and hay production, Marketing, Concept of sustainable farming system and their indicators.

Practical

Study of IFS models for different agroclimatic zones, Preparation of IFS model in groups, Recycling of organic waste in IFS, Study of production and profitability of IFS, Market survey for IFS products, Preparation of organic manures in IFS, Study of crops and cropping systems for diversification in IFS, Visit to farmer's field for feasibility study for scientific intervention in IFS, Study of Integrated Organic Farming Systems.

Suggested Readings

1. Panwar A S, Ravisankar N, Prusty A K, Shamim M, Singh R, Bhaskar S. 2019. *Integrated Farming System models for Agricultural Diversification, Enhanced Income and employment.* Indian Council of Agricultural Research, New Delhi.
2. Reddy S R. 2016. *Farming System and Sustainable Agriculture*, Kalyani Publishers, New Delhi.
3. Singh J P, Ravisankar N, Prusty A K, Sikka A K, Gangwar B. 2016. *Region Specific Integrated Farming System Models for Improved Production, Profitability and Nutrition.* ICAR-Indian Institute of Farming Systems Research, Modipuram.
4. Walia S S and Walia U S 2020. *Farming System and Sustainable Agriculture*. Scientific Publishers, Jodhpur, Rajasthan.

Communication Skills 2 (1+1)

Objective

To acquire competence in oral, written and non-verbal communication, develop strong personal and professional communication and demonstrate positive group communication.

Theory

Communication Process: The magic of effective communication; Building self-esteem and overcoming fears; Concept, nature and significance of communication process; Meaning, types and models of communication; Verbal and non-verbal communication; Linguistic and non-linguistic barriers to communication and reasons behind communication gap/ miscommunication.

Basic Communication Skills: Listening, Speaking, Reading and Writing Skills; Precis writing/ Abstracting/Summarizing; Style of technical communication Curriculum vitae/resume writing; Innovative methods to enhance vocabulary, analogy questions.

Structural and Functional Grammar: Sentence structure, modifiers, connecting words and verbals; phrases and clauses; Case: subjective case, possessive case; objective case; Correct usage of nouns, pronouns and antecedents, adjectives, adverbs and articles; Agreement of verb with the subject: tense, mood, voice; Writing effective sentences; Basic sentence faults.

Practical

Listening and note taking; Writing skills: precis writing, summarizing and abstracting; Reading and comprehension (written and oral) of general and technical articles; Micro-presentations and Impromptu Presentations: Feedback on presentations; Stage manners: grooming, body language, voice modulation, speed; Group discussions; Public speaking exercises; vocabulary building exercises; Interview Techniques; organization of events.

Suggested readings

1. Allport G W. 1937. *Personality: A Psychological Interpretation*. Holt, New York.
2. Brown Michele and Gyles Brandreth. 1994. *How to Interview and be Interviewed.* Sheldon Press, London.
3. Carnegie Dale. 1997. *The Quick and Easy Way to Effective Speaking*. Pocket Books, New York.
4. Francis Peter S J. 2012. *Soft Skills and Professional Communication*. Tata McGraw Hill, New Delhi.
5. Kumar S and Pushpa Lata. 2011. *Communication Skills.* Oxford University Press.
6. Neuliep James W. 2003. *Intercultural Communication A Contextual Approach.* Houghton Mifflin Co Boston.
7. Pease. Allan. 1998. *Body Language*. Sudha Publications, Delhi.
8. Raman M and Singh P. 2000. *Business Communication*. Oxford University Press.
9. Seely J. 2013. *Oxford Guide to Effective Writing and Speaking*. Oxford University Press.
10. Thomson A J and Martinet A V. 1977. *A Practical English Grammar*. Oxford University.

Skill Enhancement Course

Objectives

i. To enhance the employment potential and to set up small business enterprises skills of volunteers, a list of 12 to 15 vocational skills will be drawn up based on the local conditions and opportunities. Each volunteer will have the option to select two skill-areas out of this list of issues related environment.

ii. Environmental conservation, enrichment and sustainability, climatic change, natural resource management (rainwater harvesting, energy conservation, forestation, waste land development and soil conservations) and waste management. Disaster management. Introduction and classification of disaster, rehabilitation, and management after disaster; role of NSS volunteers in disaster management.

iii. Entrepreneurship development. Definition, meaning and quality of entrepreneur; steps in opening of an enterprise and role of financial and support service institution.

iv. Formulation of production-oriented project. Planning, implementation, management, and impact assessment of project. Documentation and data reporting. Collection and analysis of data, documentation, and dissemination of project reports

Skill Enhancement Courses 4 (0+4)

Two Courses each of (0+2) credits of skill enhancement courses will be offered from indicated list of skill enhancement courses.

National Cadet Corps (NCC-I) **1(0+1)**

- Aims, objectives, organization of NCC and NCC song. DG's cardinals of discipline.
- Drill- aim, general words of command, attention, stands at ease, stand easy and turning.
- Sizing, numbering, forming in three ranks, open and close order march, and dressing.
- Saluting at the halt, getting on parade, dismissing, and falling out.
- Marching, length of pace, and time of marching in quick/slow time and halt. Side pace, pace forward and to the rear. Turning on the march and wheeling. Saluting on the march.
- Marking time, forward march, and halt. Changing step, formation of squad and squad drill.
- Command and control, organization, badges of rank, honors, and awards
- Nation Building- cultural heritage, religions, traditions, and customs of India. National integration. Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizens. Leadership traits, types of leadership. Character/ personality development. Civil defense organization, types of emergencies, firefighting, protection. Maintenance of essential services, disaster management, aid during development projects.
- Basics of social service, weaker sections of society and their needs, NGO's and their contribution, contribution of youth towards social welfare and family planning.
- Structure and function of human body, diet and exercise, hygiene and sanitation. Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health. Adventure activities. Basic principles of ecology, environmental conservation, pollution and its control.

National Service Scheme (NSS-I) **1 (0+1)**

Evoking social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skilful in executing democratic leadership, developing skill in program, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

All the activities related to the National Service Scheme are distributed under four different courses viz., National Service Scheme I, National Service Scheme II, National Service Scheme III and National Service Scheme IV each having one credit load.

The entire four courses should be offered continuously for two years.

A student enrolled in NSS course should put in at least 60 hours of social work in different activities in a semester other than five regular one-day camp in a year and one special camp for duration of 7 days at any semester break period in the two years. Different activities will include orientation lectures and practical works. Activities directed by the Central and State Government have to be performed by all the volunteers of NSS as per direction.

Semester I: Introduction and Basic Components of NSS

- Orientation: history, objectives, principles, symbol, badge; regular programs under NSS
- Organizational structure of NSS, Code of conduct for NSS volunteers, points to be considered by NSS volunteers' awareness about health.

- NSS program activities. Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analyzing guiding financial patterns of scheme, youth program/ schemes of GOI, coordination with different agencies and maintenance of diary. Understanding youth. Definition, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change.
- Community mobilization. Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership. Social harmony and national integration
- Indian history and culture, role of youth in nation building, conflict resolution and peace-building. Volunteerism and *shramdaan*. Indian tradition of volunteerism, its need, importance, motivation, and constraints; shaman as part of volunteerism
- Citizenship, constitution, and human rights. Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to information. Family and society. Concept of family, community (PRIs and other community-based organizations) and society.

Semester II

Cow Based Natural Farming 3 (1+2)

Objectives

i. To acquaint the students about practicing natural farming involving cow and its relationship with farming activities

ii. To impart skill on farming practices and technologies in cow based natural farming

Theory

Sociology of natural farming, Indian Livestock scenario, Indigenous breeds of cattle, Differentiating features of indigenous, crossbred and exotic cattle, Traditional livestock farming practices, Draft animal power in natural farming, Feeding cattle at various phases, Forage production, Hay making, Preventive health care practices, Bio efficacy of cow urine on crop production, Effect of different natural inputs on yield, quality and soil properties, Effects of cow urine and its major constituents on pasture properties, Cow based rearing systems: land, feed and water requirement of traditional farming method, Advantages of cow based natural farming methods, Economics of cultivation and comparison with currently adopted practices, Role of cow based farming system in utilising the available cattle (*Desi* cow) as valuable resource, Cost of cultivation under cow based natural farming, Composition and constituents of desi cow milk vs cross breeds; role of tryptophan precursor of serotonin in relaxing human mind and better sleep, role of A2 Milk in controlling blood sugar level. Sustainable agriculture and fodder business, Natural farming business and entrepreneurship development, Supply chain management, Application of bio gas in agriculture, Traditional therapies for various ailments, ITKs in cow based natural farming.

Practical

Identification and characteristics of various cattle breeds, fodder varieties and feed ingredients; Visit to dairy farm to study the various components and their utilization, Visit to *gau-shala*, Visit to an institute involved in cow based natural farming, Design and development of cow based natural farm, Identification of herbal plants used for livestock treatment, Ethno veterinary medicines,; Feed and fodder conservation practices-Silage and Hay making, Concentrate making techniques including ration balancing for cow based farms, Calf management under natural Farm, Value addition of milk from dairy, Grassland management, Value addition of by-products from cow based natural farm, Bio- inputs preparation for natural farms, Traditional practices followed in cow-based natural farms, Record keeping and economics of cow based natural farming, Preparation of inputs for cow based natural farming, Demonstration of renewable energy sources in cow based natural farms.

Suggested Readings

1. Gaur A C. 2006. *Handbook of Oganic Farming and Biofertilizers*. Ambica Book Agency.
2. Dahama A K. 2003. *Organic Farming for Sustainable Agriculture*. Agrobios (India), Jodhpur.
3. Banerjee G C. 1989. *Text Book of Animal Husbandry*. oxford and IBH.
4. Chander M and Subrahmanyeswari B. 2017. *Organic Livestock Farming*. Indian Council of Agricultural Research Publication.
5. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.
6. ICAR. 2022. *Handbook of Animal Husbandry*. ICAR Publication.
7. Nivsarkar A E, Vij P K and Tantia M S. 2000. *Animal Genetic Resources of Indian Cattle and Buffalo*. by ICAR- KAB, New Delhi- 110012, 382p.
8. Sastry N S R and Thomas C K. 2019. *Livestock Production Management*. Kalyani Publishers, New Delhi.
9. Sastry NSR and Thomas C K. 1991. *Dairy Bovine Production*. Kalyani Publishers.
10. Taparia A L. 2007. *A Historical overview of Animal Husbandry in Ancient and Medieval India. In. Nene YL. (Eds.). Glimpses of the Agricultural Heritage of India*. Asian Agri-History Foundation. pp.151-156.
11. Thomas C K and Sastry NSR. 2013. *Livestock Production Management*. Kalyani Publishers.

Soil Biology in Natural Farming 3 (2+1)

Objectives

i. To impart knowledge on various aspects of soil biology, biological interactions and their roles in management of soil quality and productivity.

ii. To develop skills among students on isolation, purification, identification and use of soil beneficial microbes and fauna in natural farming system

Theory

Soil as a habitat for life, concept of soil biome and its components, Soil organic matter: Definition and its characterization, Biochemical processes of formation of soil organic matter, SOM as carbon source for soil biota, Decomposition processes, reaction order and its dynamics, Soil biodiversity and its methods of evaluation, Soil microbiota: its distribution and abundance, metabolism and physiology, classification of soil microorganisms and their importance in soil processes, Soil fauna (microfauna, mesofauna, macrofauna and megafauna): distribution, abundance, diversity and interactions; Factors affecting soil biodiversity, Significance of biota in soil development, Soil biological interactions: Functions and processes, Above- ground and below-ground biotic linkages, Rhizosphere, spermosphere, phyllosphere and their use in crop growth and development, Habitat adaptive fitness benefits to host crops in terms of tolerance to abiotic and biotic stresses, Biological nitrogen fixation: Symbiotic (*Rhizobium*-legume, Actinorhizal, *Azolla-Anabaena*), Associative (*Azotobacter*, *Azospirillum*, *Gluconacetobacter*, etc.), Free-living (BGA, *Klebsiella,* etc.), Microbiological methods of composting: various composting techniques, biofortification of various organic manures, *In- situ* decomposition techniques of crop residues using decomposers, Mechanisms of Biological Nitrogen Fixers (BNF), factor affecting BNF, Microbial mediated nutrient availability and exchange in soil, Nutrient mobilization, Arbuscular mycorrhizal symbiosis: its types, biochemical basis of interactions and benefits to host crops, Soil enzymes -characterization and mode of action, Agricultural management impacts on soil enzyme activities, Soil health, soil sickness, soil resistance concept, indicators and evaluation criteria, ITKs on soil health management through enriching soil microbiome.

Practical

Hands on microscopy and examination of microbes, Microbiological media and methods of sterilization, Isolation and purification of microbial cultures, Enumeration of microbial population in soil- bacteria, fungi, actinomycetes, Isolation of *Azospirillum*, *Azotobacter*, BGA, *Rhizobium,* Determination of microbial biomass C and N, Assay for soil enzyme activities, Assay for carbon substrate utilization, Determination of earthworm population and biomass, Estimation of soil carbon active pool (CO_2 evolution, SMBC), Estimation of different carbon fractions of soil, Estimation of soil carbon stock.

Suggested Readings

1. Bloem J, Hopkins D W and Benedetti A. 2006. *Microbiological Methods for Assessing Soil Quality*. CABI Publishing. Wallingford.
2. Chhonkar P K, Bhadraray S, Patra A K and Purkayastha T. 2007. *Experiments in Soil Biology and Biochemistry.* Westville Publishing House, New Delhi. 169p.
3. Elasas JDV, Jansson J K and Trevors. 2006. *Modern Soil Microbiology.* (2nd Edn.). CRC Press. Boca Raton.
4. Indian Society of Soil Science. 2015. *Introduction to Soil Science*. ISSS, New Delhi.
5. Kannaiyan S, Kumar K and Govindarajan K. 2004. *Biofertilizers Technology.* Scientific Publication.
6. Lal R and Shukla M K. 2004. *Principles of Soil Physics*. Marcel Dekker.

7. Mengel K and Kirkby E A. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.
8. Mortvedt J J, Shuman L M, Cox F R and Welch RM. 1991. Micronutrients in Agriculture. (2nd Ed.), SSSA, Madison.
9. Paul E A. 2007. *Soil Microbiology, Ecology and Biochemistry* (3rd Edn.). Academic Press, Amsterdam. 514p.
10. Richard Bardgett. 2005. *The Biology of Soil. A Community and Ecosystem Approach.* Oxford University Press. 231p.
10. Subba Rao, N S. 2005. *Soil Microbiology* (4th Edn.) of Soil Microorganisms and Plant Growth) Oxford and IBH Publishing Company Pvt. Limited.

Integration of Horticultural Crops under Natural Farming **2 (1+1)**

Objectives

i. To acquaint the students with package and practices for horticultural crops under natural farming.
ii. To impart the practical training on horticultural crop production.

Theory

Importance and scope of horticulture crops in natural farming, Soil management in relation to nutrient and water uptake and their effect on soil environment, Intercrops-types and its role in nutrient management, Biological efficiency of cropping systems in horticulture, Planting of fruit plants in combination with annual crops–principles and strategies, Types of planting system for fruit plants in natural farming, Competitive and complimentary effect of root and shoot systems, Type of mulches-sod mulch and organic mulches for soil moisture and nutrients management, Irrigation–defined systems of irrigation for natural farming in fruit crops, Soil microbes and their role for sustainable horticultural crop production system, Canopy management, Training and pruning, Methods of training and training of important fruit trees, High density planting (HDP) and meadow orchards and their management, Rejuvenation of old orchards - top working and frame working, Integrated pest and disease management (IPDM), Integrated nutrient management (INM), Crop regulation in relation in fruit crops, Management of resources constraints in existing systems, Climate aberrations and mitigation measures of horticultural crops, Management of fruit plants of important tropical, sub-tropical and temperate fruit crops under natural farming, Mulching of fruit crops and Whapasa management, ITK for management of fruit plants under natural farming system.

Practical

Selection of site for farm system design for establishment of natural farming of horticulture crops, different planting systems and its layout – Triangular system, contour lines, double row system, rectangular and square, Preparation of pit and procedures for filling, Soil depth and slope for fruit tree plantation, Irrigation methods and application of water to fruit crops, Growing of intercrops ginger, turmeric, colocasia, cowpea, cabbage and green manuring, Filler crops – definition and their use in young orchard, Training and pruning methods of important tropical, sub-tropical and temperate fruit crops, Weed management in orchards, Use of plant-based products and microbes for plant protection of tropical, sub- tropical and temperate fruit crops, Mulching of fruit crops and Whapasa management

Suggested Readings

1. Agriculture. ICAR. Document 2, Supplement 1. pp84-100.
2. Agriculture. ICAR. Document 2, Supplement 2. pp111-136.
3. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.
4. *Technical Knowledge, Document 1 to 7*, Indian Council of Agricultural Research, New Delhi.
5. Horticultural Crops / Pest and Disease Management / Soil and Water conservation/ Soil fertility Management. In Inventory of Indigenous Technical Knowledge in Agriculture Document 1; Document 2; Document 2 (Supplement 1 and 2); Document 3; Publ: ICAR New Delhi.
6. Horticultural Crops. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture*— Document 2 (Supplement 1).
7. Sharma K K and Singh N P. 2021. *Soil and Orchard Management*. Daya Publishing House.

Insect Ecology, Nematodes and Pest Management 3 (2+1)

Objectives

i. To teach students the insect ecology and effect of biotic and abiotic factors on pests
ii. To impart practical knowledge on various plant protection options under natural farming
iii. To impart knowledge on plant parasitic nematodes and management options under natural farming

Theory

Insect Ecology - Introduction, environment and its components, Effect of abiotic factors – temperature, moisture, humidity, rainfall, light, atmospheric pressure and air currents, Effect of biotic factors – food competition, natural and environmental resistance, Categories of pests, Storage pests. Solutions for insect-pest control in natural farming: surveillance, perimeter weeding, conventional land preparation, host plant resistance, interaction of plant resistance traits and biocontrol agents, crop rotation and planting practices (date of sowing), intercropping/mixed cropping, trap crops, border crops, sanitation, conserving natural enemies via habitat enrichment, Physical control strategies to reduce pest incidence, Mechanical control, Behavioral control (repellents and anti-feed ants plants, Biological control (Importation, Conservation, Augmentation; Parasitoids predators and Pathogens), Factors affecting success of biological control: Narrow host range/ Climatic adaptability/Synchrony with host life cycle/High reproductive potential/Efficient search ability/Short handling time/Survival at low host density, Botanicals (Plant extracts), Plant bioformulations: agniaster, brahmaster, neemaster, dasparni ark etc. Management of stored grain pests by non-chemical methods.

History and economic importance of nematodes: General characters of plant parasitic nematodes, their morphology, symptomatology and control of important plant parasitic nematodes of field and fruits by non-chemical methods, Use of various plant bioformulations like agniaster, brahmaster, neemaster, dasparni ark *etc*. for nematodes and pest management.

Practical

Sampling techniques for estimation of insect-pests and nematodes populations, Collection of insect-pests, nematodes, natural enemies and their identification, Diversity of insect- pests, nematodes, Calculation of diversity indices, Preparation of different bioformulations and their application methods.

Suggested Readings

1. DeBach P. 1973. *Biological Control of Insect Pests and Weeds*. Chapman and Hall, New York. 844p.
2. Dhaliwal G S, Singh Ram and Jindal Vikas. 2013. *A Textbook of Integrated Pest Management*. Kalyani Publishers, Ludhiana, 617p.
3. Panwar VPS. 2014. *Agricultural Insect Pests of Crops and Their Control*. Kalyani, Publishers, New Delhi.
4. Southwood TRE and Henderson P A. 2000. *Ecological Methods*. (*3rd Edn)* Blackwell Science, USA. 575p.
5. Walia R K and Bajaj H K. 2014. *Textbook of Introductory Plant Nematology* (2nd Edn.). Kalyani Publishers, New Delhi.

Entrepreneurship Development and Business Management 3 (2+1)

Objectives

i. To provide student an insight into the concept and scope of entrepreneurship.
ii. To expose the student to various aspects of establishment and management of a small business unit.
iii. To enable the student to develop financially viable agribusiness proposal.

Theory

Development of entrepreneurship, motivational factors, social factors, environmental factors, characteristics of entrepreneurs, entrepreneurial attributes/competencies. Concept, need for and importance of entrepreneurial development. Evolution of entrepreneurship, objectives of entrepreneurial activities, types of entrepreneurs, functions of entrepreneurs, importance of entrepreneurial development, and process of entrepreneurship development. Environment scanning and opportunity identification need for scanning–spotting of opportunity-scanning of environment– identification of product / service – starting a project; factors influencing sensing the opportunities. Infrastructure and support systems- good policies, schemes for entrepreneurship development; role of financial institutions, and other agencies in entrepreneurship development. Steps involved in functioning of an enterprise. Selection of the product / services, selection of form of ownership; registration, selection of site, capital sources, acquisition of manufacturing know how, packaging and distribution. Planning of an enterprise, project identification, selection, and formulation of project; project report preparation, Enterprise Management. Production management – product, levels of products, product mix, quality control, cost of production, production controls, Material management. Production management – raw material costing, inventory control. Personal management – manpower planning, labour turn over, wages / salaries. Financial management / accounting – funds, fixed capital and working capital, costing and pricing, long term planning and

short-term planning, book keeping, journal, ledger, subsidiary books, annual financial statement, taxation. Marketing management- market, types, marketing assistance, market strategies. Crisis management- raw material, production, leadership, market, finance, natural etc.

Practical

Visit to small scale industries/agro-industries, Interaction with successful entrepreneurs/ agric-entrepreneurs. Visit to financial institutions and support agencies. Preparation of project proposal for funding by different agencies.

Suggested Readings

1. Charantimath P M. 2009. *Entrepreneurship Development and Small Business Enterprises*. Pearson Publications, New Delhi.
2. Desai V. 2015. *Entrepreneurship: Development and Management*. Himalaya Publishing House.
3. Desai Vasant Desai. 1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publ. House
4. Gupta C B. 2001. *Management Theory and Practice*. Sultan Chand and Sons.
5. Grover Indu. 2008. *Handbook on Empowerment and Entrepreneurship*. Agrotech Public Academy.
6. Khanka S S. 1999. *Entrepreneurial Development*. S. Chand and Co.
7. Mehra P. 2016, *Business Communication for Managers*. Pearson India, New Delhi.
8. Pandey M. and Tewari D. 2010. *The Agribusiness Book*. IBDC Publishers, Lucknow.
9. Singh D. 1995. *Effective Managerial Leadership*. Deep and Deep Publishers.
10. Singhal R K 2013. *Entrepreneurship Development and Management,* Katson Books.
11. Tripathi P C and Reddy P N. 1991. *Principles of Management*. Tata McGraw Hill.

Personality Development 2 (1+1)

Objective

To make students realize their potential strengths, cultivate their inter-personal skills and improve employability.

Theory

Personality Definition, Nature of personality, theories of personality and its types. The humanistic approach - Maslow's self-actualization theory, shaping of personality, determinants of personality, Myers-Briggs Typology Indicator, Locus of control and performance, Type A and Type B Behaviours, personality and Organizational Behaviour.

Foundations of individual behavior and factors influencing individual behavior, Models of individual behavior, Perception and attributes and factors affecting perception, Attribution theory and case studies on Perception and Attribution. Learning: Meaning and definition, theories and principles of learning, Learning and organizational behavior, Learning and training, learning feedback. Attitude and values, Intelligence- types of Intelligence, theories of intelligence, measurements of intelligence, factors influencing intelligence, intelligence and Organizational behavior, emotional intelligence. Motivation- theories and principles, Teamwork and group dynamics.

Practical

MBTI personality analysis, Learning Styles and Strategies, Motivational needs, Firo-B, Interpersonal Communication, Teamwork and team building, Group Dynamics, Win-win game, Conflict Management, Leadership styles, Case studies on Personality and Organizational Behavior.

Suggested Reading

1. Andrews Sudhir. 1988. *How to Succeed at Interviews.* (21st Reprint). New Delhi.Tata McGraw-Hill.
2. Heller Robert. 2002. *Effective Leadership. Essential Manager Series*. DK Publishing.
3. Hindle Tim. 2003.*Reducing Stress. Essential Manager series*. DK Publishing.
4. Lucas Stephen. 2001. *Art of Public Speaking.* New Delhi. Tata - Mc-Graw Hill.
5. Mile D J. 2004. *Power of Positive Thinking*. Delhi. Rohan Book Company.
6. Pravesh Kumar. 2005. *All About Self- Motivation*. New Delhi. Goodwill Publishing House.
7. Smith B. 2004. *Body Language*. Delhi: Rohan Book Company.
8. Shaffer D R. 2009. *Social and Personality Development* (6th Edn). Belmont, CA: Wadswor.

Skill Enhancement Courses 4 (0+4)

Two courses each of (0+2) credits of skill enhancement courses will be offered from indicated list of skill enhancement courses.

National Cadet Corps (NCC-II) 1 (0+1)

- Arms Drill- Attention, stand at ease, stand easy. Getting on parade. Dismissing and falling out. Ground/take up arms, examine arms. Shoulder from the order and vice-versa, present from the order and vice-versa. Saluting at the shoulder at the halt and on the march. Short/long trail from the order and vice- versa. Guard mounting, guard of honor, Platoon/Coy Drill.
- Characteristics of rifle (.22/.303/SLR), ammunition, fire power, stripping, assembling, care, cleaning, and sight setting. Loading, cocking, and unloading. The lying position and holding.
- Trigger control and firing a shot. Range Procedure and safety precautions. Aiming and alteration of sight. Theory of groups and snap shooting. Firing at moving targets. Miniature range firing. Characteristics of Carbine and LMG.
- Introduction to map, scales, and conventional signs. Topographical forms and technical terms.
- The grid system. Relief, contours, and gradients. Cardinal points and finding north. Types of bearings and use of service protractor. Prismatic compass and its use. Setting a map, finding north and own position. Map to ground and ground to map. Knots and lashings, Camouflage and concealment, Explosives and IEDs.
- Field defenses obstacles, mines and mine lying. Bridging, waterman ship. Field water supplies, tracks and their construction. Judging distance. Description of ground and indication of landmarks. Recognition and description of target. Observation and concealment. Field signals. Section formations. Fire control orders. Fire and movement. Movement with/without arms. Section battle drill. Types of communication, media, latest trends and developments.

National Service Scheme (NSS-II) 1(0+1)

Evoking social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skilful in executing democratic leadership, developing skill in program, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

All the activities related to the National Service Scheme are distributed under four different courses viz., National Service Scheme I, National Service Scheme II, National Service Scheme III and National Service Scheme IV each having one credit load.

The entire four courses should be offered continuously for two years.

A student enrolled in NSS course should put in at least 60 hours of social work in different activities in a semester other than five regular one-day camp in a year and one special camp for duration of 7 days at any semester break period in the two years. Different activities will include orientation lectures and practical works. Activities directed by the Central and State Government have to be performed by all the volunteers of NSS as per direction.

- Importance and role of youth leadership
- Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership, Life competencies
- Definition and importance of life competencies, problem-solving and decision-making, interpersonal communication. Youth development programs
- Development of youth programs and policy at the national level, state level and voluntary sector; youth-focused and youth-led organizations
- Health, hygiene and sanitation. Definition needs and scope of health education; role of food, nutrition, safe drinking water, water borne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programs and reproductive health. Youth health, lifestyle, HIV AIDS and first aid. Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid. Youth and yoga. History, philosophy, concept, myths, and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method.

Post-Semester IV* (Only For exit option for UG-Certificate in Natural Farming)

S. No.	Course Title	Credit Hours
1.	Internship (10 weeks)	10 (0+10)

*Mandatory requirement for UG-Certificate.

Semester III

Crop Management in Natural Farming 3 (2+1)

Objectives

i. To acquaint students with the concepts of selection of crops and their cultivation practices under specific agroecological zones following natural farming principles

ii. To train the students about package of practices of different crops under natural farming

Theory

Selection of crop and variety – Criteria for selection of crops in natural farming, Traditional and indigenous variety - Advantages and disadvantages - Classification of crops - factors affecting selection of crops and variety, Importance of pulses of legumes in natural farming, Weather management- Concept of weather and climate, Factors affecting crop production: climatic factors, edaphic, biotic, physiographic etc., micro-climate management techniques, Windbreaks and shelter belts, Management of weather in natural farms, Seed, sowing and Irrigation– Importance and concept of seed selection, seed treatment, Seed rate- Factors affecting seed rate and seed germination, sowing- time, method and depth, indigenous methods and animal drawn techniques, time and method of irrigation, management of irrigation, ITKs in seed, sowing and water management, Crop Geometry: Definition of crop geometry and crop density, types of crop geometry, importance of crop geometry, thinning, gap filling, optimum plant population, factor affecting plant population, relation of crop geometry and growth, relation of crop geometry and yield, Weed management: Classification of weeds and their importance, methods of weed management, practices of weed management in natural farming, Nutrient management: Sources of nutrient application and their management in natural farming and modern agriculture, maintenance of soil health and plant health, under natural farming, Package of practices of crops under natural farming.

Practical

Selection of crops for natural farming according to agro-ecological zones, Know how on agro-met observatory and data interpretations, Calculation of seed rate for sowing, Plant geometry and population calculation, Traditional seed treatment methods, Preparation of traditional nutrient supply concoctions and their uses, Traditional knowledge techniques in crop management and on-farm waste management, Study of methods of crop residue management, Study of important methods of plant protection, Irrigation efficiency, Preparation of crop calendar for different sowing seasons under various micro-climates.

Preparation of contingency crop plan for natural farming, yield estimation in naturally grown crops, Field visit to natural farm, Documentation of sustainable natural farming practices.

Suggested Readings

1. Geol yu. 2018. *100 Herbs: For Making JADAM Natural Pesticide: The way to Ultra-Low-Cost agriculture*. Youngsang Cho.
2. E Somasundaram and M Mohamed Amanullah. 2017. *Agronomy Principles and Practices*. New India Publishing Agency, New Delhi.
3. Crops and Cropping Systems. 2004. *In: Inventory of Indigenous Technical Knowledge in Agriculture Document 2 (Supplement 1) pp 9-26.* Publ: ICAR, New Delhi.
4. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.
5. Gopal Chandra De. 2017. Fundamentals of Agronomy, Oxford and IBH Publication.
6. Tivari V N. 2010. *Natural Organic, Biological, Ecological and Biodyanamic Farming*. New Central Book Agency Pvt. Ltd.

6. Reddy S R. 2020. *Principles of Agronomy.* Kalyani Publications. New Delhi.

7. Reddy T Yellamanda and Shankara Reddy G H. 2016. *Principles of Agronomy.* Kalyani Publications, New Delhi.

8. Rathore P S and Sharma S K. 2003.*Scientific Pulse Production*. Yash Publishing House, Bikaner, pp. 1-269.

9. Nicole Faires. 2016. *The Ultimate Guide to Natural Farming and Sustainable Living: Permaculture for Beginners* (Ultimate Guides).

10. Swaminathan C and Nandhakumar M R. 2017. *Vrikshayurvedic Farming*: The Traditional Indian Agriculture.

Production of Bio-inputs 2 (1+1)

Objectives

i. To impart knowledge on types of bio-inputs, their functions, compositions, application doses and impacts on soil processes

ii. To develop skills among students in mass production of various bioinputs, their application methods and quality control

Theory

Definition and types of bioinputs, Importance of bioinputs, Mechanism of action of bioinputs, Quality standards of bioinputs, Methods of production and application doses of bioinputs, Factors affecting the product quality, Green manures, *Achhadana*, Cow-based bioproducts (*Beejamrutha, Jeevamrutha, GhanJeevamrutha* and other inputs (*agniaster, brahmaster, neemaster, sonthaster, Khatti lassi, dasparni ark, Kanupajala and saptdhanyaankur*) for pest, disease and nutrient management, compositions/ingredients of various bioinputs and their relative merits, Effects of bioinputs on soil biological components, their activities, soil enzymes and overall soil fertility, Impact of bioinputs on plant physiological activities and physiological stress indicators, Influence of bioinputs on plant- microbe and plant- faunal interactions, Initiatives taken by government(central/state), NGOs and other organizations in India for promotion of bioinputs under natural farming perspectives, Economic considerations, viability, marketing and export potential of different bioinputs, Quality aspects, grading, packaging, handling, and establishment of internal control system for bioinputs, Project formulation on bioinputs in natural farming.

Practical

Definition and types of bioinputs, compositional analysis (nutritional and microbiological), Assay on mode of action of bioinputs, Preparation of animal manure-based bioinputs and their uses, Preparation of *Beejamrutha, Jeevamrutha, Ghana Jeevamrutha*, soil microbes based improved bioinputs, mass production and its uses; Preparation of *Bramhaster* and their uses, Preparation of *Agniaster*, *Neemaster* and *Dashparni ark*, their mass production and uses, Preparation of plant-extract based bioinputs, Ginger-Garlic- Chilli extract and their use, Preparation of fermented butter milk and their uses, Preparation of herbal *kunapajala* and Neem -based concoctions and their specific uses, Study of physical, chemical and biological characteristics of important bioinputs, Determination of plant physiological stresses upon application of bioinputs.

Suggested Readings

1. Agri-History Report No. 1. Asian Agri-History Foundation. 36p.
2. Choudhary S L and Saxena R C. 2007. *Plant Protection in Medieval and Modern Indian Agriculture. Nene YL. ed. Glimpses of the Agricultural Heritage of India*. Asian Agri-History Foundation. 455-480p.
3. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7*. Indian Council of Agricultural Research, New Delhi.
4. Gaur A C. 1999. *Microbial Technology for Composting of Agricultural Residues by Improved Methods*. Indian Council of Agricultural Research, New Delhi, 78p.
5. Nene Y L. 2003. *Crop Disease Management Practices in Ancient, Medieval, and Pre- modern India*. Asian Agri-History. Vol. 7(3):185-201.
6. Nene Y L. 2007. *Plant Pathology in India Prior to Twentieth Century. In. Nene yL. ed. Glimpses of the Agricultural Heritage of India*. Asian Agri-History Foundation. p. 441-454.
7. Palaniappan S P and Anandurai K.1999. *Organic Farming – Theory and Practice.* Scientific Publishers, Jodhpur.
8. *Pest and Disease Management / Soil and Water conservation/ Soil fertility Management/ Garbage disposal and Management. In: Inventory of Indigenous Technical Knowledge in Agriculture* Document 1; Document 2; Document 2 (Supplement 1 and 2); Document 3; Publ: ICAR New Delhi.
9. Saharan B S, Parshad J, Kumar D and Sharma N. 2021. *Plant-Microbial Interactions in Natural/organic Cultivation of Horticultural Plants. Plant- Microbial Interactions and Smart Agricultural Biotechnology* (pp. 115-128). CRC Press.
10. Saharan B S and Nehra V. 2011. *Plant Growth Promoting Rhizobacteria: A Critical Review.* Life Sci Med Res, 21(1): 30.
11. Sharma Arun. 2009. *Biofertilizers for Sustainable Agriculture*. Agrobios (India).
12. Sreenivasa, Ayangarya Valmiki. 2006. *Organic Tea – A Vrikshayurveda Experience.*

Farm Power and Machinery 3 (1+2)

Objectives

i. To enable the students to understand the basic of farm power and machinery use in natural farming

ii. To gain the knowledge and skills necessary to effectively and efficiently manage farm machinery, optimize power utilization, and improve overall farm productivity.

Theory

Mechanization in agriculture: its potential and prospects, Sources of farm power, Draught animal power and its relevance to Indian Agriculture, Familiarization with different engine systems, Familiarization with different systems of I.C. engines, working principles of I C engines, Components of IC engine, Use of bio- diesel/bio-ethanol as alternative fuel for engines, Familiarization with tractor, Introduction to primary and secondary tillage equipment, Energy efficient improved tools and equipment's in natural farming: Introduction to rotavator, planter, vegetable transplanter, bed

former, disk harrow, mulch laying equipment, Ergonomically improved hand tools for intercultural operations: wheel hoe, long handle hoe, garden tools, labour saving/drudgery reducing tools, Plant protection equipment: knapsack sprayer, power sprayer, threshing and shelling machinery, Animal drawn farm equipment/tools: Animal drawn bund former, Seed drill, Planters, cultivator, ITK in farm machinery, ITKs on farm tools.

Practical

Study of different engine systems, Study of the different components of IC engines, Familiarization with tractor, Familiarization with tools and equipment for input production in field, Familiarization with tractor drawn primary and secondary tillage implements, Familiarization with animal drawn primary and secondary tillage implements, Familiarization with tractor drawn seed-cum- fertilizer drills their seed metering mechanism and calibration, Familiarization with animal drawn seed-cum-fertilizer drills their seed metering mechanism and calibration, Familiarization with planters, Familiarization with transplanters. Familiarization with different inter-cultivation equipment, Familiarization with different types of sprayers, Familiarization with different types of dusters, Familiarization with harvesting machinery, Familiarization with threshing machinery.

Suggested Readings

1. Akshay Krishi Parivar. 2022. *Bhumi Suposhan-Commemorative Publication of the Nationwide Bhumi Suposhan and Samrakshan Abhiyan*. AKP Publication No.11. 212p.
2. Dakshinkar N P and M Singh. 2022. *Draught Animal Power and its Relevance to Indian Agriculture. In:* Bhumi Suposhan, Akshay Krishi Parivar. pp 80-87.
3. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.
4. Peshwe D R, Ram Kumar Sing, K A Deshmukh and S Chopra. 2018. *Advances and Research in Agricultural Tools.* Publ: MME Publishing House Nagpur.
5. Pimental D. 1980. *Handbook of Energy Utilization in Agriculture*, CRC
6. Rathore N S, Joshi S and Choudhary N. 2022. *Digital Technologies for Agriculture.* NIPA Genx Electronic, Recourses and Solutions Pvt. Ltd.
7. Sahay J. 2006. *Elements of Agricultural Engineering* Standard Publishers Distributers, New Delhi.
8. Tillage and Interculture Management/Farm Implements. In: Inventory of Indigenous Technical Knowledge in Agriculture. Document 1; Document 2 (Supplement 1 & 2); Document 3. ICAR Publication, New Delhi.

Livestock and Poultry Production 3 (2+1)

Objectives

i. To impart knowledge and skill in rearing of livestock and poultry production

ii. To make them aware about basics of livestock and poultry production including managemental aspects under natural farming.

Theory

Historical account of livestock rearing in Vedic, medieval and modern era in India including free range, semi-intensive and intensive systems and major pastoral systems in India, Demographic distribution and characteristics of livestock (cattle, buffalo, sheep, goat, and poultry) and economy, Common farm management practices of livestock and poultry including housing, feeding, watering, sanitation, pest and disease management, Common vices of animals (cattle, buffalo, sheep, goat), their prevention and care. General principles of sewage disposal and purification, Solid and liquid manure management, Compost making. Ventilation requirements, Presumptive standards for permissible air pollution in buildings, Respiratory exchange in domestic animals, Importance and method of ventilation, Livestock and poultry rearing and carbon footprints, Breeding strategies and biotechnological tools for the improvement of dairy cattle, buffalo, sheep, goat, swine and poultry, Natural breeding for livestock and poultry, Methods of conservation – Livestock and poultry conservation program s in the state and the country, Fodder production and conservation - Importance of grasslands and fodder in livestock production and their management, Structures for storage of feeds and fodders, Scarcity fodders and preservation of green fodder, Recycling of animal shed washings and wastes in fodder production and use of recycle waste., Disposal, utilization and recycling of waste, etc. Sheep, goat, rabbit farming and swine farming: role and importance in natural farming, Classification of poultry with respect to production characters, age and standards, Production characters of other avian species, Description of indigenous fowls and their value in rural farming, Livestock production management - Housing systems, layout and design of different buildings for animals, Selection of site: General principles affecting the design and construction of building for housing for various livestock species. Scavenging system of management – Low input technology, backyard and semi- intensive units; their management and economic achievements.

Deep litter management – Control of litter-borne diseases and recycling of litter, Cage management – Different types; Advantages and disadvantages. Management of growers, layers, broilers and breeders, Stress management.

General management and feeding practices of calves, heifers, pregnant, lactating and dry animals, bulls and working animals. Systems of feeding, restricted feeding, phase feeding. Unconventional feed ingredients -Herbal Bio enhancers.

Protection and welfare of livestock, poultry and working animals. Draught ability of cattle and buffaloes; Routine animal farm operations and labour management, Animal farm accounts and records.

Indigenous technical knowledge related to livestock rearing and veterinary practices, Indigenous technical knowledge pertaining to health and management of livestock.

Classification of poultry with respect to production characters, age and standards; Description of indigenous fowls and their value in rural farming, Specific strains developed for rural poultry production their acceptability and importance in rural eco-system.

Brooding management – Types of brooders, preparation of shed, Importance of environmental factors; Housing – Types of poultry houses, space requirements. Feeding management– Classification of nutrients, Nutrient requirements and feed formulations, Feeding systems; Water management.

Sheep and goat farming: Introduction and scope in the country, Important breeds (exotic and indigenous) and their characteristics, Housing and feeding. Management of sheep and goat for optimal production.

Principles of disease and pest management, Ayurvedic, homeopathic, ethno-medicines, General principles of medication for livestock and poultry in natural farming.

Candling, sexing, grading, packing and disposal of hatchery waste. Trouble shooting hatchery failures, Poultry waste management, pollution and environmental issues, mixed and integrated poultry farming under natural landscape. Vertical and horizontal integration in poultry production, Management of ducks, turkeys, Japanese quails and guinea fowls.

Practical

Identification of indigenous breeds of livestock, small ruminants and poultry and other avians. Acquaintance with natural livestock farms (dairy and small ruminant), backyard poultry and other avians, Layout plans for different livestock houses and poultry, Fodder production and conservation: Visit to the fodder farm, Familiarization with various types of fodders in the states and India. Livestock waste utilization and recycling/ Familiarization with various fertilizers and manures. Human handling and restraining of cattle, buffalo, sheep and Goat: clipping, shearing, dipping, spraying and spotting sick animals, Determination of body weight using different measurements, Training of breeding males: detection of heat, Identification and care of pregnant animals, Care of neonatal and young stock, Diagnosis, prevention and treatment of important diseases and pests of livestock, small ruminants and poultry and other avians, Economic traits of broilers, egg-type chicken and breeders, Poultry farm and hatchery equipment, Brooding arrangement in broiler farms, ITKs related to livestock management, Vaccination, deworming and medication of birds, Keeping records and their maintenance, Feed ingredients and its quality assessment, Fundamentals in poultry post-mortem examination for sample collection and dispatch. Economics and preparation of project report for establishing livestock, fodder and poultry farms/festivals related to animals, Participation and documentation of the region-specific festivals related to animals.

Suggested Readings

1. Banerjee G C. 2019. *A Textbook of Animal Husbandry* (8th Edn.). Oxford and IBH Publishing. New Delhi.
2. Chander Mahesh and Subrahmanyeswari B. 2017. *Organic Livestock Farming.* Indian Council of Agricultural Research Publication, New Delhi.
3. Chatterjee B N and Das P K. 1989. *Forage Crop Production*. Oxford and IBH Publishing Co.
4. Dakshinkar N P and Singh M. 2022. *Draught Animal Power and its Relevance to Indian Agriculture. In: Akshay Krishi Parivar, Bhumi suposhan: commemorative publication of the nationwide bhumi suposhan and samrak shanjan abhiyan.* Akshay Krishi Parivar Publication Number 11. p. 80-87.
5. Ghotge N S. 2004. *Livestock and Livelihoods, the Indian Context*. Foundation Books, New Delhi.

6. ICAR. 2022. *Handbook of Animal Husbandry*. ICAR Publication, New Delhi.

7. Mission Unit, Division of Agricultural Extension, ICAR, New Delhi. 2003. *Veterinary and Animal Husbandry. Inventory of Indigenous Technical Knowledge in Agriculture (Document 1, Document 2 (Supplement 1 and 2) and Document 3)*. ICAR Publication, New Delhi.

8. Sreenivasaiah P V. 2006. *Scientific Poultry Production – A Unique Encyclopedia*, (3rd Edn.). International Book Distributing Company.

9. Uprit S. 2022. *Livestock Dung Based Model Sustainable Agriculture through Healthy and Enriched Soil*. In: Akshay Krishi Parivar, Bhumi Suposhan: Commemorative publication of the nationwide bhumi suposhan and samrak shanjan abhiyan. Akshay Krishi Parivar Publication Number 11. pp. 88-96.

10. Veterinary and Animal Husbandry. In: Inventory of Indigenous Technical Knowledge in Agriculture Document 1; Document 2 (Supplement 1 and 2); Document 3. ICAR Publication, New Delhi

Management of Plant Diseases 2 (1+1)

Objectives

i. To teach students the important plant diseases and plant pathogenic organisms.

ii. To impart practical knowledge on crop loss assessment and disease management methods under natural farming.

iii. To impart practical knowledge on the preparation of inputs for the management of plant diseases under natural farming.

Theory

Plant disease management under natural farming: Causes / factors affecting disease development, Disease triangle and tetrahedron and classification of plant diseases, Important plant pathogenic organisms, different groups: fungi, bacteria, fastidious vesicular bacteria, phytoplasmas, spiroplasmas, viruses, viroids, algae, protozoa, phanerogamic parasites and nematodes , Pathogenesis, Koch's postulates, Role of enzymes, toxins and growth regulators in disease development, Defense mechanism in plants, Epidemiology: Factors affecting disease development, survey, surveillance and vigilance, Crop loss assessment and models, Principles and pre-requisites of forecasting of diseases, Principles and methods of plant disease management, Symptoms, etiology, disease cycle and management of major diseases of field crops and horticulture crops, Methods of plant disease control: Host plant resistance, cultural, mechanical, physical, legislative, biological control, Ecological management of crop environment, Role of soil microbiome in disease management, Suppressive soils, concepts and potentialities for managing soil borne pathogens, Application of khatti lassi, jungle ki Kandi, sontha aster for the management of various types of diseases, Plant growth promoting rhizobacteria (PGPR) and their use in plant protection, Heritage perspective of plant protection (Drumraksha), Plant Protection through Botanicals, ITKs related to management of plant diseases.

Practical

Acquaintance with various laboratory equipment and microscopy, Collection and preservation of disease specimens, Preparation of media, isolation and Koch's postulates,

General study of different structures of fungi, Study of symptoms of various plant diseases, Study of representative fungal genera, Staining and identification of plant pathogenic bacteria, Transmission of plant viruses, Study of phanerogamic plant parasites, Preparation of extracts of natural plant products as fungicides, Field visit for the diagnosis of field problems, Collection and preservation of plant diseased specimens for Herbarium, Preparation of pressed and well mounted specimens, Preparation and methods of application of Khattilassi, Jungle ki Kandi, Sontha aster for disease management, Bio-surfactants and their use.

Suggested Readings

1. Alexopoulos C J, Mims CW and Blackwell M. 2007. *Introductory Mycology* (4th Edn.). Wiley India Pvt. Limited,880p.
2. Choudhary S L and Saxena R C. 2007. *Plant Protection in Medieval and Modern Indian Agriculture. Nene YL. Ed. Glimpses of the Agricultural Heritage of India.* Asian Agri-History Foundation. pp. 455-480.
3. George N Agrios. 2006. *Plant Pathology* (5th Edn.), Elsevier
4. Sinclair James B and Dhingra Onkar Dev. 1995. *Basic Plant Pathology Methods.* (2nd Edn.). CRC Press. 448p.
5. Nene Y L. 2007. *Plant Pathology in India Prior to Twentieth Century. Nene YL. Ed. Glimpses of the Agricultural Heritage of India*. Asian Agri-History Foundation. pp. 441-454.
6. Pest and Disease Management. Inventory of Indigenous Technical Knowledge in Agriculture Document 1; Document 2; Document 2 (Supplement 1 and 2); Document 3; Publication - ICAR, New Delhi.
7. Saharan B S and Nehra V. 2011. *Plant Growth Promoting Rhizobacteria: A Critical Review*. Life Sci Med Res.21(1): 30.
8. Saharan B S, Sahu R K and Sharma D. 2011. *A Review on Biosurfactants: Fermentation, Current Developments and Perspectives*. Genetic *Engineering and Biotechnology Journal*, 1-14.
9. Singh R S. 2017. *Introduction to Principles of Plant Pathology.* (4th Edn.). CBS Publishers and Distributors. 416p.

Biodiversity Conservation 2 (1+1)

Objectives

i. To impart knowledge on biodiversity in different agro-ecological zones

ii. To develop skills on assessment of biodiversity, procedures of biodiversity valuation and strategies of biodiversity conservation.

Theory

Definition, Genetic diversity, Species diversity, Ecosystem diversity: Structural and functional aspects. Agro ecological zones in India with a brief understanding of diversity in soil types, temperature, rainfall, watershed atlas of India, Seasons and season cycle in India, Festivals and seasons, Importance of local biodiversity, Bio-geographic classification of India, The value of biodiversity and conservation, India as a mega diversity nation, Hotspots of biodiversity: criteria for determining hot spots, Threats to biodiversity- habitat loss, pollution, species introduction, global climate change, overexploitation, poaching. Rare species, Extinction: mass

extinction, extinction processes, Human factors: social, economic, political and remedial actions, Endangered and endemic species of India, common plant species, common animal species, Conservation of biodiversity- strategies for conservation: i*n-situ* and *ex-situ* conservation, Conservation practices in India and world- organizations involved in resource conservation: IUCN, WWF, UNEP, UNESCO, Biodiversity International, IPGRI, FAO, BSI, ZSI. General account on activities of DBT, BSI, NBPGR, ZSI, FSI, NBFGR and NBAGR NFPTCR, Sacred groves, Biodiversity register, Conservation of biodiversity, Salient provisions of Biological Diversity Act, 2002, Role of Gramsabha in biodiversity conservation, Ancient Indian culture in biodiversity conservation, Role of biodiversity in SDGs, Ecological economics, Mission Life Style for Environment (Mission LiFE).

Practical

Field survey for studying plant species diversity in a village/region, Study of the morphology and reproductive structures of the types of micro-flora and micro- fauna, Staining of fungal filaments by Cotton Blue, Methylene Blue, Preparation of sterilization media, principles of isolation, pure culturing, Collection, identification and submission of non-wood forest products, Visit to forest to study genus/species distribution, Notes on pest and diseases of forest plants (any four), Study of ITKs on biodiversity conservation and documentation of tangible and non-tangible benefit of biodiversity conservation, Orientation about biodiversity register and its activities.

Suggested Readings

1. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.
2. Dubey R C and Maheswari D K. 2010. *A Text book of Microbiology.* S. Chand and Company, New Delhi.
3. Gadgil M and Seshagiri Rao P R. 1998. *Nurturing Biodiversity an Indian Agenda.* Ahmedabad: Centre for Environment Education.
4. Krishnamoorthy K V. 2004. *An Advanced Text Book on Biodiversity- Principles and Practice:* Oxford and IBH Publishing Company Pvt. Ltd., New Delhi.
5. Krishnamurthy K V. 2003. *Text Book on Biodiversity,* Science Publishers, New Hampshare.
6. Puri G S, Gupta R K, Meher-Homji V M, Puri S. 1989. *Forest Ecology. Vol. II: Plant Form, Diversity, Communities and Succession*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi
7. Sayan Bhattacharya. 2014. *Forest and Biodiversity Conservation in Ancient Indian Culture: A Review Based on Old Texts and Archaeological Evidences. International Letters of Social and Humanistic Sciences*. pp35-46.
8. Shahid N, Daniel E, Bunker, A H, Michel L and Charles Perrings. 2009. *Biodiversity, Ecosystem Functioning, and Human Wellbeing: An Ecological and Economic Perspective*. Oxford University Press, New York.
9. Sharma P D. 2003. *Ecology and Environmental Sciences*, Rastogi Publications, Meerut.
10. Trivedi P C. 2007. *Global Biodiversity Status and Conservation*. Pointer Publishers, Jaipur.

Physical Education, First Aid, Yoga Practices and Meditation 1 (0+2)

Objectives

i. To make the students aware about Physical Education, First Aid and Yoga Practices

ii. To disseminate the knowledge and skill how to perform physical training, perform first aid and increase stamina and general wellbeing through yoga

Practical

Physical education; Training and Coaching - Meaning and Concept; Methods of Training; aerobic and aerobic exercises; Calisthenics, weight training, circuit training, interval training, Fartlek training; Effects of Exercise on Muscular, Respiratory, Circulatory &Digestive systems; Balanced Diet and Nutrition: Effects of Diet on Performance; Physiological changes due to ageing and role of regular exercise on ageing process; Personality, its dimensions and types; Role of sports in personality development; Motivation and Achievements in Sports; Learning and Theories of learning; Adolescent Problems and its Management; Posture; Postural Deformities; Exercises for good posture.

Yoga; History of Yoga, Types of Yoga, Introduction to Yoga,

- Asanas (Definition and Importance) Padmasan, Gaumukhasan, Bhadrasan, Vajrajasan, Shashankasan, Pashchimotasan, Ushtrasan, Tadasan, Padhastasan, Ardhchandrasan, Bhujangasan, Utanpadasan, Sarvangasan, Parvatasan, Patangasan, Shishupalanasan – left leg-right leg, Pavanmuktasan, Halasan, Sarpasan, Ardhdhanurasan, Sawasan
- Suryanamskar Pranayama (Definition and Importance) Omkar, Suryabhedan, Chandrabhedan, AnulomVilom, Shitali, Shitkari, Bhastrika, Bhramari
- Meditation (Definition and Importance), Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandh
- Mudras (Definition and Importance) Gyanmudra, Dhyanmudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra
- Role of yoga in sports
- Teaching of Asanas – demonstration, practice, correction and practice.

History of sports and ancient games, Governance of sports in India; Important national sporting events; Awards in Sports; History, latest rules, measurements of playfield, specifications of equipment, skill, technique, style and coaching of major games (Cricket, football, table Tennis, Badminton, Volleyball, Basketball, Kabaddi and Kho-Kho) and Athletics.

Need and requirement of first aid. First Aid equipment and upkeep. First AID Techniques, First aid related with respiratory system. First aid related with Heart, Blood and Circulation. First aid related with Wounds and Injuries. First aid related with Bones, Joints Muscle related injuries. First aid related with Nervous system and Unconsciousness. First aid related with Gastrointestinal Tract. First aid related with Skin, Burns. First aid related with Poisoning. First aid related with Bites and Stings. First aid related with Sense organs, Handling and transport of injured traumatized persons. Sports injuries and their treatments.

Skill Enhancement Course **2 (0+2)**

One Course of (0+2) credits of skill enhancement courses will be offered from indicated list of skill enhancement courses.

Environmental Studies and Disaster Management **3 (2+1)**

Objectives

i. To acquaint students with the significance of environmental principles and remediation procedures

ii. To develop skills among students on environmental impact assessment

Theory

Multidisciplinary nature of environmental studies: Definition, scope and importance. Natural Resources: Renewable and non-renewable resources, Natural resources and associated problems, (a) Forest resources: Use and over- exploitation, deforestation, case studies, Timber extraction, mining, dams and their effects on forest and tribal people, (b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems, (c) Mining resources: Use and exploitation, environmental effects extraction and using mineral resources, case studies, (d) Food resources: World food problem, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies, (e) Energy resources: Growing energy needs, renewable and non-renewable energy resources, use of alternate energy sources, case studies, (f) Land resources: Land as resources, land degradation, man induced landslides, soil erosion and desertification, Role of an individual in conservation of natural resources, Equitable use of resources for sustainable lifestyles. Ecosystem: Concept of ecosystem, structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids, Introduction, types, characteristics features, structure and function of the following ecosystems: (a) Forest ecosystem, (b) Grassland ecosystem, (c) Desert ecosystem d. Aquatic ecosystem (ponds, streams, lakes, rivers, oceans, estuaries)

Biodiversity and its conservation: Introduction, definition genetic, species and ecosystem diversity and biogeographical classification of India. Value of biodiversity: consumptive use, productive use, social ethical, aesthetic and option values. Biodiversity at global, national and local level, India as a mega-diversity nation, Hot-sports of biodiversity, Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife, man-wildlife conflicts. Endangered and endemic spices of India. Conservation of biodiversity: In–situ and Ex-situ conservation of biodiversity.

Environmental pollution: Definition, cause, effects and control measures of: (a) Air Pollution, (b) Water Pollution, (c) Soil Pollution, (d) Marine Pollution, (e) Noise Pollution, (f) Thermal pollution e.g. nuclear hazards. Solid Waste Management: causes, effects, and control measures of urban and industrial wastes, Role of an individual in prevention of pollution.

Social issues and the environment: From Unsustainable to sustainable development, urban problem related to energy, water conservation, rain water harvesting, watershed management. Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust Dies, Wasteland reclamation, Consumerism

and waste products, Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and Control of Pollution) Act. Wildlife Protection Act. Forest Conservation Act. Issues involved in enforcement of environmental legislation, public awareness.

Human Population and the Environment: Population growth, variation among nations, population explosion, Family welfare Program, Environment and human health: Human Rights, Value Education, HIV/AIDS, Women and Child welfare, Role of information technology in environment and human health.

Disaster Management: Natural Disaster: Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves, climatic changes: global warming, sea level rise, ozone depletion. Man Made Disasters-Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, air pollution, water pollution, deforestation, industrial waste water pollution, road, rail, air and sea accidents.

Disaster Management: Effect to migrate natural disaster at national and global levels, International strategy for disaster reduction, Concept of disaster management, national disaster management framework, financial arrangement, role of NGOs, community-based organization and media, Central, state, district and local administration, Armed forces in disaster response, Disaster response, Police and other organizations.

Suggested Readings

1. Singh Y K. 2006. *Environmental Science*. New Age International (P) Ltd.
2. Palanisamy P N.2012. *Environmental Science,* (3rd Edn.). Pearson India.
3. Erach Bharucha. 2013. *Textbook for Environmental Studies*. University Grants Commission.

Semester IV

Elements, Characteristics and Design of Natural Farming Systems 3 (2+1)

Objectives

i. To make students aware about concept, function and design of natural farming as a system approach
ii. To train students on different advanced methodologies for analyzing and designing agro-ecological specific natural farming units.

Theory

Natural Farming Systems: Concept, importance, approaches, determinants and characteristics, Strength and weakness of natural farming systems, Ecosystems: Concept and components, System approach and concept for farming systems, natural farming systems and ecosystem analysis, The water cycle, nutrient Cycle and energy cycle, Types of ecosystems: Natural ecosystems and agri-ecosystems, concept and classification of ecosystem services, Concept and elements of natural systems, Classification of farming types (based on geographical condition, levels of technology and external input use, labour, demand of produce, etc.), Subsistence farming, Intensive subsistence and primitive subsistence, Traditional farming, intensive conventional farming, integrated

farming, conservation agriculture, eco-agriculture, ecologically intensive agriculture (Sustainable intensifications) biodynamic farming, permaculture, cow based farming, cosmic energy farming, prakritik shaswat yogic farming, natural farming, agnihoter farming (homa farming), astrology and astronomy in agriculture, vastu practices, Important agri-based, horti-based, animal based, agro forestry, aqua farming system models, The prairie model, Natural system models at the basis of mimicry (the rain forest model, the dry forest model, Concept of ecosystem based integration of crops, livestock, horticulture and fish farming as complimentary activities, Traditional integrated farming system models based on natural farming principles, Comparison of natural ecosystems, traditional farming system and modern agriculture, Production syndrome in natural farming, Hypotheses and concepts in designing the natural farming system models (Biodiversity and the mimicry hypothesis, productivity, resilience, equilibrium and stability, Levels of organization for nature mimicry in agro-ecosystems), Principles for cropping and farming system design based on natural ecosystem mimicry, Steps for development of agricultural systems based on mimicking natural ecosystems, Economic evaluation and comparative analysis of different farming systems and natural systems, optimization methodology: a potential approach for system, natural farming system and ecosystem analysis and design.

Practical

Identification and characterization of different natural and agro-ecosystems in the rainfed, hill and mountain, arid, coastal and irrigated regions, Study on characterization of natural eco-systems and intensive farming system, Study on characteristics of elements of water cycle in natural ecosystem and farming system, Study on characteristics of elements of nutrient cycle in natural ecosystem and farming system, Study on characteristics of elements of energy cycle in natural farming, Comparative biodiversity analysis in natural and conventional farming systems, Calculation of biodiversity index for different farming systems, Designing of cropping/farming and natural farming systems, Study and representation of resource flow and recycling in different farming systems, Budgeting: Farm records and farm book keeping in natural farming system, Cost and profit analysis of different components and whole system, Designing of natural farming systems models in different agro-ecosystems, Designing farming systems/natural farming systems using mathematical tools/optimization methodology.

Suggested Reading

1. Dwivedi A P. 2019. *Agroforestry: Principles and Practices*. Oxford IBH Publication.
2. Ahimsak Rishi-Krishi Deshpande Farming Technique. http:// rishikrishi.co.in/index. html
3. Behera U K. 2013. *A Text Book of Farming Systems*. Agrotech Publishing House, Udaipur.
4. Behera U K and France J. 2022. *Farming Systems Research: Concepts, Design and Methodology*. Advances in Agronomy 177: 1-49
5. Compendium of Success Stories of Natural Farming Publishing Agency: NITI Aayog. 2022. ISBN: 978-81- 953811-4-2.
6. Rudolf Steiner and Ikerd J E. 2019. *Agriculture and Spirituality. In: Zsolnai L and Flanagan, B. (Eds.). The Routledge International Handbook of Spirituality in Society and the Professions, Routledge*. Agriculture: Spiritual Foundations for the Renewal of Agriculture.

7. Manna M C, Rahman M M, Naidu R, Fazle Bari, A S M, Singh, A B, Thakur, J K, Ghosh, A, Patra, A K, Chaudhari, S K and Subbarao, A. 2021. *Organic Farming: A Prospect for Food, Environment and Livelihood Security in Indian Agriculture.* Advances in Agronomy, 170: 101-153.

8. Minamino Y. 1994. *Manifesto of Nature Farming. In the Front of organic* Agriculture. Fumin-Kyokai, Tokyo, 195p.

9. Pat Coleby. 2004. *Natural Farming: A Practical Guide*

10. Sharma S K, Choudhary R, Jat G, Chhipa B G, Jain D, Gupta L, Yadav S K, Jain R K, Verma A, Trivedi A and Jain P. 2022. *Compendium- Natural Farming: Perspectives and Prospects in Changing Agriculture Scenario, ICAR- Centre for Advanced Faculty Training on organic Farming, Directorate of Research,* MPUAT, Udaipur 313001 (Rajasthan). Pp 1-419. https://cbp.icar.gov.in/ebook22.aspx

11. Sharma S K, Choudhary R, Ravishankar N, Jat G, Sharma R K, Yadav S K. and Jain R K. 2022. *Natural Farming: Concept, Importance, Scope and Status.* Directorate of Research, MPUAT, Udaipur 313001 (Rajasthan).

12. Subash Paleker. The Principles of Spiritual Farming - Vol. II.

Improvement of Traditional and Underutilized Crops 3 (2+1)

Objectives

i. To gain the knowledge on different types of traditional and underutilized crops

ii. To train the students on the methods of improvement techniques.

Theory

Importance of traditional and underutilized crops, Genetic basis of crop Improvement: Laws of inheritance; qualitative and quantitative traits, multiple factor hypothesis, pureline theory, components of phenotypic variance, GXE interaction, heritability, breeder's equation, populations/ landraces/ farmers' varieties/ cultivars, Hardy Weinberg equilibrium and factors affecting it, Assortative and disassortative mating, Difference between self-pollinated, cross pollinated and clonal populations, Important physiological parameters for crop improvement- Photosynthesis, transpiration, water and mineral Details of the Course regulation, Breeding objectives under natural farming systems- Nutrient Use Efficiency, Tolerance to micronutrients, mineral deficiencies and toxicities, Weed competitiveness, Enhanced Interaction with Rhizospheric microorganisms, Multiple disease and insect resistance, Quality, Earliness/ crop duration to suit multiple cropping system and agro- ecologies, Wider adaptability and stability, Broad genetic base / population heterogeneity, High yield, Multipurpose crops- stay green, food, feed, fiber and fuel. Plant breeding techniques: Domestication, introduction, Selection, hybridization; Breeding self-pollinated crops- Pureline selection, mass selection, pedigree selection, mass selection, SSD, backcross breeding, Breeding cross pollinated crops- Population improvement, recurrent selection, composite and synthetic varieties, Improving clonally propagated crops- Clonal selection, Farmer participatory plant breeding. Molecular markers, Marker Assisted Selection (MAS), comparison of MAS vs. Phenotypic selection.

Practical

Study of floral biology of different crops, Hybridization techniques, DUS characterization important land races and traditional varieties of crops, Breeding methods for natural farming, Study of root characteristics of crops grown under natural and other production systems, Learning of techniques of participatory plant breeding, Techniques of conservation of plant genetic resources, PRA for mapping indigenous crops and their characteristics, Seed identification and collection for natural farming systems, Identification of important land races and traditional varieties of crops, Identification of important land races and traditional varieties of fruit crops.

Suggested Readings

1. Chahal G S and Ghosal S S. 2019. *Principles and Procedures of Plant Breeding.*
2. Chopra V L. 2004. *Plant Breeding*. Oxford and IBH Publishing Co Pvt Ltd, New Delhi.
3. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.
4. Geographical Indications of Plant Species. *In:* Inventory of Indigenous Technical Knowledge in Agriculture Document 5; Publ: ICAR, New Delhi.
5. Lammerts van Bueren E T. 2002. *Organic Plant Breeding and Propagation:* Concepts and strategies. Ph. D. Thesis, Wageningen University, Netherlands.
6. Lammerts van Bueren, E T Jones, S S, Tamm, L, Murphy, K M, Myers J R, Leifert C and Messmer M M. 2011. The need to breed crop varieties suitable for organic farming, using wheat, tomato and broccoli as examples: A review. NJAS - Wageningen, Journal of Life Sciences 580: 193-205.
7. Ranganathan Nithya. 2018. *Druma Vichitrikaranam - The Ancient Approach to Plant Mutagenesis*. Asian Agri-History, Vol. 22(3): 218-225.
8. Singh A K. 2007. *Plant Biodiversity and Agriculture in India: A Historical Perspective.In.* Nene Y L. (Ed.). Glimpses of the Agricultural Heritage of India. Asian Agri-History Foundation. pp. 493-505.

Agro-Eco System Analysis for Natural Farming 2 (1+1)

Objectives

i. To enhance the knowledge about the concepts, types and tools adopted in agro- ecosystem
ii. To study the techniques and strategies adopted in natural farming and as a tool in agro-ecosystem analysis

Theory

Definition of system, system hierarchy, Introduction, and concept of agro- ecosystem, Properties of agro-ecosystem, Types of agro ecosystem analysis, Tools and techniques used in agro-ecosystem analysis, agro-ecosystem analysis and sustainable agriculture, Steps involved in agro-ecosystem analysis, Methodology of agro-ecosystem analysis, Energy flow of agro-eco system analysis, Participatory rural appraisal related terms – RRA, PRA, PLA, PLAM, and philosophy of PRM, Participatory planning framework, Importance of participation, Principles of participatory extension, Participatory technology development process

Practical

Simulated exercise on space related methods, Time related methods, Flow related methods, Documentation of participatory technology development process, conducting agro-ecosystem analysis using PRA tools and techniques in village situation**,** Learn the techniques of action plan development.

Suggested Readings

1. Adhikary. 2006. *Participatory Planning and Project Management in Extension Science. Agrotech.* Publ. Academy.
2. Gordon R Conway. 1986. *Agro-ecosystem Analysis for Research and Development.*
3. Singh B K. 2008. *PRA/PLA and Participatory Training.* Adhyayan Publ. and Distr.

Beneficial Insects 3 (2+1)

Objectives

i. To teach students the role of beneficial insects viz., pollinators, decomposers, predators and parasitoids, soil builders, productive insects
ii. To impart knowledge on the beneficial insects used under natural farming

Theory

Ecological understanding of insects in natural farming, Study of their life cycle, population dynamics and interaction with other abiotic and biotic components in a natural farming ecosystem, Decomposers (insects) in natural farming system, Pollinators in natural farming systems: their kinds, types, diversity, conservation and profitable use for enhancing.

Productivity in terms of quality and quantity, Natural enemies of poriferous insect's generalist predators, specific predators, parasitoids (egg, larval, pupal and intermediary), Insects in ecological communities, Insects as food, soil builders and insects of aesthetic value, Promotion of required habitat for friendly insects, Pollinators: Honey -bee biology, commercial methods of rearing, equipment used, seasonal management, bee enemies and diseases, Bee pasturage, bee foraging and communication, Insect pests and diseases of honey bee, Role of pollinators in cross pollinated plants, Types of silkworms, voltinism and biology of silkworm, Mulberry cultivation, mulberry varieties and methods of harvesting and preservation of leaves, Rearing, mounting and harvesting of cocoons, Pests and diseases of silkworm, management, rearing appliances of mulberry silkworm and methods of disinfection, Species of lac insect, morphology, biology, host plant, lac production – seed lac, button lac, shellac, lac- products, Indigenous technical knowledge on management of insect pests, Knowledge and importance of beneficial insects in ancient India.

Practical

Rearing dung beetles for decomposing organic wastes as manure, Pollinators: Diversity, species richness and their use in enhancing productivity of crops, Natural enemies- diversity: species richness, their conservation in *in-situ* and wherever possible, artificial rearing for using pest management. Collection of beneficial insects, study of life cycle and habitats of beneficial insects, crop wise applications of beneficial insects for pest control.

Suggested Readings

1. Atwal A S. 2001. *The World of the Honey Bee*. Kalyani Publishers, New Delhi.
2. Bukhari R and Bhatt R A. 2022 *Fundamentals of Sericulture*. Narendra Publishing House, C-21, Varun Apartment, Sector 9, Rohini, Delhi
3. Choudhary S L, Sharma G S and Nene Y L (Eds). 2000. *Ancient and Medieval History of Indian Agriculture and its relevance to Sustainable Agriculture in the 21st Century. Proceedings of the Summer School held from 28th May to 17th June 1999, Rajasthan College of Agriculture,* Udaipur. 363p.
4. Danstan P Ambrose. 2018. *The Insects: Beneficial and Harmful Aspects*, Kalyani Publishers
5. David V Alford. 2019. *Beneficial Insects*. CRC Press. 400p.
6. Graham J M. 2015. *The Hive and Honey Bee.* Dadant and Sons Publication, USA.
7. Mishra R C. 2013. *Perspective in Indian Apiculture*. Agrobius Publication Jodhpur.
8. Pradip V J. 2008. *Text Book of Applied Zoology: Vermiculture, Apiculture, Sericulture, Lac culture and Agriculture Pests and their Controls*. Discovery Publishing Pvt. Ltd., New Delhi.
9. Prasad T V. 2019. *Handbook of Entomology.* (4th Edn.). New Vishal Publications.
10. Reddy A, Anusha C, Ramprasad, B, Kumar R and V Daravath. 2022. *Importance of Beneficial Insects in Agriculture. Research Trends in Multidisciplinary Research and Development* (pp.7-24*).* Wiser Publications, Germany.

Quantification and Valuation of Ecosystem Service 3 (2+1)

Objectives

i. To orient the students with basic concepts of ecosystems services

ii. To impart skills on quantification and valuation of ecosystem services

Theory

Ecosystem Services (ES)-Meaning, Concept and its importance, Classification of Ecosystem Services - Provisioning, Regulating, Supporting and Cultural services, Basics of natural capital, Quantification of ecosystem services-Direct and Indirect approaches, Valuation of Ecosystem Services and its need, Ecosystem valuation methods-Revealed preference methods: Market pricing, Production function , Hedonic pricing methods, Travel cost method and Random utility models, Stated preference methods-Contingent valuation method and choice modelling, Cost based approaches of Ecosystem Valuation- opportunity cost, Cost of alternatives or substitute goods, Replacement cost method, Methods for obtaining Non- economic Values-Focus groups, Citizens' Juries, Health-based valuation , Q- methodology and Delphi surveys, Payment for ecosystem services (PES), Governance and policy issues in ecosystem services, Challenges in valuation of ecosystem services.

Practical

Ecosystem Valuation methods- Direct and indirect methods of calculation, An overview-Millennium Ecosystem Services (MEA) Assessment, Case studies on payment for ecosystem services (PES), Case studies in Ecosystem Services in India and abroad, Study on Environmental Impact Analysis. Visits to the ecosystem areas (Agro ecosystem, Forest Ecosystem and Aquatic ecosystem).

Suggested Readings

1. Baskaran R, Cullen R and Takatsuka, Y. 2009. *Estimating the Value of Agricultural Ecosystem Services: A Case Study of New Zealand Pastoral Farming.* Australasian Journal of Environmental Management 16 (2): 103-112.
2. Costanza R, Cumberland J, Daily H, Goodland R and Norgard R. 1997. *An Introduction to Ecological Economics*. ISEE, Florida, 275p.
3. Costanza R, d'Arge R, De groot, R, Farber, S, Grasso M, Hannon B, Limburg, K, Naeem S, o'Neill, R V, Paruelo J, Raskin, R G, Sutton, P and van den Belt M. 1997. The Value of the World's Ecosystem Services and Natural Capital. Nature 387:253-260.
4. https://teebweb.org/our-work/nca/understanding-nca/
5. NAAS. 2020. *Payment for Ecosystem Services in Agriculture*. http://naas.org.in/ Policy%20 Papers/policy%2094.pd

Agricultural Marketing and Trade 3 (2+1)

Objectives

i. To understand the fundamentals of agricultural marketing and trade
ii. To analyze the factors influencing supply and demand in agricultural markets
iii. To explore different marketing channels and strategies in agriculture
iv. To examine the role of government policies and regulations in agricultural markets

Theory

Agricultural Marketing: Concepts and definitions of market, marketing, agricultural marketing, market structure, marketing mix and market segmentation, classification and characteristics of agricultural markets; demand, supply and producer's surplus of agri commodities: nature and determinants of demand and supply of farm products, producer's surplus–meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; pricing and promotion strategies: pricing considerations and approaches–cost based and competition based pricing; market promotion–advertising, personal selling, sales promotion and publicity–meaning, merits and demerits; marketing process and functions: Marketing process concentration, dispersion and equalization; exchange functions–buying and selling; physical functions–storage, transport and processing; facilitating functions–packaging, branding, grading, quality control and labelling (Agmark); Market functionaries and marketing channels: Types and importance of agencies involved in agricultural marketing; meaning and definition of marketing channel; number of channel levels; marketing channels for different farm products; Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs; Role of Govt. in agricultural marketing: Public sector institutions- CWC, SWC, FCI, CACP and DMI – their objectives and functions; cooperative marketing in India; Risk in marketing: Types of risk in marketing; speculation and hedging; an overview of futures trading; Agricultural prices and policy: Meaning and functions of price; administered prices; need for

innovations in agricultural price policy; Trade: Concept of International Trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; WTO; Agreement on Agriculture (AoA) and its implications on Indian agriculture; IPR. Role of government in agricultural marketing. Role of APMC and its relevance in the present day context.

Practical

Plotting and study of demand and supply curves and calculation of elasticities; Study of relationship between market arrivals and prices of some selected commodities; Computation of marketable and marketed surplus of important commodities; Study of price behaviour over time for some selected commodities; Construction of index numbers; Visit to a local market to study various marketing functions performed by different agencies, identification of marketing channels for selected commodity, collection of data regarding marketing costs, margins and price spread and presentation of report in the class; Visit to market institutions –NAFED, SWC, CWC, cooperative marketing society, etc. to study their organization and functioning. Application of principles of comparative advantage of international trade.

Suggested Readings

1. Acharya S S and Agarwal N L. 2006. *Agricultural Marketing in India*, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Chinna S S. 2005. *Agricultural Economics and Indian Agriculture*. Kalyani Publishers, New Delhi.
3. Dominic Salvatore. 2020. *Micro Economic Theory and Applications*. Oxford University Press.
4. Kohls Richard L and Uhl Josheph N. 2002. *Marketing of Agricultural Products*. Prentice-Hall of India Private Ltd., New Delhi.
5. Kotler and Armstrong. 2005. *Principles of Marketing*, Pearson Prentice-Hall.
6. Lekhi R K and Joginder Singh. 2006. *Agricultural Economics*. Kalyani Publishers, New Delhi.
7. Memoria C B, Joshi R L and Mulla N I. 2003. *Principles and Practice of Marketing in India.* Kitab Mahal, New Delhi.
8. Pandey Mukesh and Tewari Deepali. 2004. *Rural and Agricultural Marketing, International Book Distributing Co. Ltd,* New Delhi.
9. Sharma R. 2005. *Export Management, Laxmi Narain Agarwal,* Agra.

Agricultural Informatics and Artificial Intelligence 3 (2+1)

Objectives

i. To acquaint students with the basics of computer applications in agriculture, multimedia, database management, application of mobile app and decision- making processes, etc.
ii. To provide basic knowledge of computer with applications in Agriculture
iii. To make the students familiar with Agricultural-Informatics, its components and applications in agriculture

Theory

Introduction to Computers, Anatomy of Computers, Memory Concepts, Units of Memory, Operating System: Definition and types, Applications of MS-Office for creating, Editing and Formatting a document, Data presentation, Tabulation and graph creation, Statistical analysis, Mathematical expressions, Database, concepts and types, creating database, Uses of DBMS in Agriculture, Internet and World Wide Web (WWW): Concepts and components.

Computer programming: General concepts, Introduction to Visual Basic, Java, Fortran, C/ C++, etc. concepts and standard input/output operations.

e-Agriculture, Concepts, design and development, Application of innovative ways to use information and communication technologies (IT) in Agriculture, Computer Models in Agriculture: Statistical, weather analysis and crop simulation models, concepts, structure, inputs-outputs files, limitation, advantages and application of models for understanding plant processes, sensitivity, verification, calibration and validation, IT applications for computation of water and nutrient requirement of crops, Computer-controlled devices (automated systems) for Agri-input management, Smartphone mobile apps in agriculture for farm advice: Market price, postharvest management etc., Geospatial technology: Concepts, techniques, components and uses for generating valuable agri-information, Decision support systems: Concepts, components and applications in Agriculture, Agriculture Expert System, Soil Information Systems etc. for supporting farm decisions. Preparation of contingent crop-planning and crop calendars using IT tools, Digital India and schemes to promote digitalization of agriculture in India.

Practical

Study of computer components, accessories, practice of important DOS Commands, Introduction of different operating systems such as Windows, Unix/ Linux, creating files and folders, File Management. Use of MS-WORD and MS Power-point for creating, editing and presenting a scientific document, MS- EXCEL-Creating a spreadsheet, Use of statistical tools, Writing expressions, Creating graphs, Analysis of scientific data, Handling macros. MS-ACCESS: Creating Database, preparing queries and reports, Demonstration of Agri-information system, Introduction to World Wide Web (WWW) and its components, Introduction of programming languages such as Visual Basic, Java, Fortran, C, C++, Hands on practice on Crop Simulation Models (CSM), DSSAT/Crop-Info/Crop Syst/ Wofost, Preparation of inputs file for CSM and study of model outputs, computation of water and nutrient requirements of crop using CSM and IT tools, Use of smart phones and other devices in agro-advisory and dissemination of market information, Introduction of Geospatial Technology, Hands on practice on preparation of Decision Support System, Preparation of contingent crop planning, India Digital Ecosystem of Agriculture (IDEA).

Suggested Readings

1. Sethi Dhabal Prasad and Manoranjan. 2017. *Concepts and Techniques of Programming in C* Techsar Pvt. Ltd.
2. Rajaroman V. 2004. *Fundamentals of Computer*. Prentice Hall India Pvt. Limited.
3. Pearson.2005. *Introduction to Information Technology*. Pearson Education India.
4. Date C J. 2000. *Introduction to Database Management System.* Addison-Wesley.

SEC-VI

Skill Enhancement Course **2 (0+2)**

One Course of (0+2) credits of skill enhancement courses will be offered from indicated list of skill enhancement courses.

Post-Semester IV* (Only For exit option for UG-Diploma in Natural Farming)

S. No.	Course Title	Credit Hours
1.	Internship (10 weeks)	10 (0+10)

*Mandatory requirement for UG-Diploma.

Semester V

Post Harvest Management -I **3 (2+1)**

Objectives

i. To develop skills for primary and secondary processing, mechanical and biocontrol practices for storage of fruits and vegetables
ii. To create awareness about natural preservation methods and hygiene and handling of fruits and vegetables.

Theory

Post-harvest management: Importance of fruits and vegetables, Introduction to post- harvest physiology of fruits and vegetables; Post-harvest losses, Maturity indices, Harvesting methods and collection devices, Unit operations in packaging with emphasis on use of natural products like bee wax, gum Arabic, shellac, xantham gum etc., Environment friendly and safe ripening methods, Post-harvest diseases, Disorders and their management.

Storage techniques: Traditional and modern storage structures: on farm and off farm storage, refrigerated storage, evaporative cool chambers, refrigerated vehicles, Storage techniques for local cultivars seeds.

Value addition: Principles and methods of preservation, natural preservatives, indigenous and traditional preservation techniques, phytochemicals for preservation, FSSAI, BIS, and Codex standards for major processed products from fruits and vegetables Value addition in fruits and vegetables through drying, pickling, jam, jelly, marmalade, preserve (murabba), candy, juice, ready-to-serve, squash, nectar, crystallized products, etc.; minimal processing, Eco-friendly handling and packaging: Use of essentials oils and ecofriendly phytochemicals in postharvest handling; Edible films and coating, eco or bio- based polymeric films used for packaging.

Modified atmosphere packaging, Vacuum packaging, Smart packaging, Active packaging using natural or bio-colours, ITKs for handling and packaging; neem- based products for fruit and vegetable handling.

Practical

Demonstration and use of different harvesting tools, Practical demonstration on packhouse operations, Study of different preservation methods for fruits, and vegetables, Study of weight loss of produce in eco-friendly packaging, Determination of TSS and acidity in fresh and processed

products, Determination of ascorbic acid, Determination of sugars, Study of different types of dryers, Study of evaporative cooling system/low cost cooling system/Zero Energy Cool Chamber, Preparation of traditional value-added products from fruits and vegetables, Preparation of jam, Preparation of jelly, Preparation of fruit-based beverages, Preparation of pickles, Study of different packaging materials, Visit to industry/processing unit.

Suggested Readings

1. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.
2. De Freitas, S T and Pareek S. 2019. *Postharvest Physiological Disorders in Fruits and Disorders*. CRC Press, US.
3. Kader A A. 2002. *Postharvest Technology of Horticultural Crops.* University of Davis, USA.
4. Pareek S. 2016. *Fresh-Cut Fruits and Vegetables: Technology, Physiology, and Safety*. CRC Press, US.
5. Pareek S. 2016. *Postharvest Ripening Physiology of Crops.* CRC Press, US.
6. Pareek S. 2017. *Novel Postharvest Treatments of Fruits and Vegetables.* CRC Press, US.
7. Srivastava R P and Kumar S. 2002. *Fruit and Vegetable Preservation: Principles and Practices*. (3rd Edn.). International Book Distribution Co., Delhi.
8. Verma L R and Joshi V K. 2000. *Post-Harvest Technology of Fruits and Vegetables*.Vol. I, II. Indus Publishing Co., New Delhi
9. Wills R and Golding J. 2016. *Postharvest: An Introduction to the Physiology and Handling of Fruit and Vegetables.* (6th Edn.). CABI.
10. Yahia E M. 2019. *Postharvest Technology of Perishable Horticultural Commodities.* United Kingdom: Elsevier.

Bio-resources and Agricultural Waste Management 3 (2+1)

Objectives

i. To impart knowledge on various aspects of biowastes and agricultural wastes for managing as organic amendments in agricultural production system

ii. To develop skills on various methods of conversion of decomposable wastes into organic manures

Theory

Introduction to bio-resources and agricultural biomass waste, Classification and characterization of agri and livestock biomass waste, Principles of agricultural waste management: 4R's approach, Potential of recyclable crop residues and its management, In-situ management of agricultural waste, Role of soil and plants in waste management, Impact of agro-waste on soil and plant quality and the environment, Pre-treatment of agricultural wastes, Pre-treatment methods: biological treatment, biological-processes of waste management, Bio- conversion/bio-decomposition through native microflora biogas generation, operation and management of biogas plants, utilization of biogas

and spent slurry, landfill, Farm waste management machinery, Environmental benefit of waste management, ITK information on waste management. Mission Life Style for Environment (LiFE) and Govt. schemes to promote agriculture waste into wealth.

Practical

Visit to various agri-farms, Collection and preparation of agricultural waste samples, Characterization of agricultural waste, Determination of ash content of agricultural wastes and determination of un-burnt carbon in ash, Determination of pH, EC and CEC, Determination of BOD and COD, Nutrient status (N, P, K, and micronutrients) analysis of agricultural waste, Survey of different agri -waste from livestock, dairy, food processing, fruit and vegetable and agri-chemicals, Study of biogas production process and Study briquetting of agricultural residues and important commercial agri-waste management methods in public and private sector.

Suggested Readings

1. Peter Fonu and Charles Mbohwa. (Eds.). 2021. *Agricultural Waste Diversity and Sustainability Issues*. Academic Press. 187p.
2. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.
3. Deepthi Reddy, M Devender and Roja Mandapati. 2018. *Agricultural Waste Management* ICAR, New Delhi.
4. Shaktawat M S, Aery N C, Katewa M K, Singh Mohan and Swami B N. 2004. *Phosphate Rich organic Manure (PRoM).*
5. Waste Water Management/ Garbage disposal and Management. In: Inventory of Indigenous Technical Knowledge in Agriculture Document 1; Document 2; Document 2 (Supplement 1 and 2); Document 3; Publ: ICAR, New Delhi.
6. Zainul Akmar Zakaria. 2019. *Sustainable Technologies for the Management of Agricultural Wastes* (Applied Environmental Science and Engineering for a Sustainable Future.

Medicinal and Aromatic Plants 2 (1+1)

Objectives

i. To impart knowledge on diversity of medicinal and aromatic plants and their utilities
ii. To develop skilled manpower on cultivation practices of medicinal and aromatic plants under natural farming system

Theory

General aspects of Medicinal Plants: Definition, history, present and future needs, Introduction of plant parts (fruit, leaves, roots, stem, seeds and their modification), Cultivation and harvesting practices, Processing and storage practices, Marketing of medicinal products, Important Indian medicinal plants, Plant parts used as powder: Identification and utilization of Amla (*Embelica officinalis*), Behra (*Terminalia bellerica*), Harad (*Terminalia chebula*), Turmeric (*Curcuma*

longa), Garlic (*Allium sativum*), Bitter guard (*Momordica charantia*), Black plum (*Syzygium cumini*), Fenugreek (*Trigonella foenumgraecum*), Cinnamon (*Cinnamomum verum*), Sarpgandha (*Rauvolfia serpentina*), Black pepper (*Piper nigrum*), Ashwagandha (*Withania somnifera*), Psyllium husk (*Plantego ovata*). Plant parts used as juice/ decoction: Identification and utilization of Amla (*Embelica officinalis*), Ginger (*Gingiber officinalis*), Onion (*Alium cepa*), Bottle guard (*Lagenaria siceraria*), Basil (*Oscimum santum*), Arjun (*Terminalia arjuna*), Neem (*Azadirecta indica*), Gwarpatha (*Aloe vera*), Brahmi (*Bacopa monnieri*), Giloy (*Tinospora cordifolia*), Shankhpushpi (*Convolvulus prostrate*), Bael (*Aegle marmelos*). Plant parts used as Lotion and Ointments: Identification and utilization of Gwarpatha (*Aloe vera*), Fenugreek (*Trigonella foenumgraecum*), Pot marigold (*Calendula officinalis*), Neem (*Azadirecta indica*) Plant Parts Used as Oil: Clove (*Syzygium aromaticum*), Neem (*Azadirecta indica*), Coconut (*Coccus nucifera*), Nilgiri (*Eucalyptus* sp.). Plant parts used as Surgical Fibres, Sutures and Dressings: Identification and utilization of cotton (*Gossipium* sp.), Jute (*Corchorus capsularis*), Banana (*Musa sp*.). Plant parts used as Poultice: Identification and utilization of Turmeric (*Curcuma longa*), Nilgiri (*Eucalyptus sp*.), Ginger (*Gingiber officinalis*), Garlic (*Allium sativum*), Onion (*Alium cepa*), Dhatura (*Dhatura* sp.), Aak (*Calotropis* sp.), Arandi (*Ricinus communis*).

Practical

Identification of locally available common medicinal plants, Basic preparation of herbal products as kadha, powder (Ex. Neem leaf, moringa leaf, tulsi leaf, giloy, arandana), Juice (Ex. Amla, Aloe vera), Trifala, Chyavanprash, Amla candy, herbal tea, etc. Study and documentation of commercial production of at least five medicinal plants, (Using website/ you Tube). Submission of digital photo album of at least ten medicinal plants with brief description, Cultivation maintenance and reporting of at least five medicinal plants within college campus.

Suggested Readings

1. Atal and Kapoor. 1982. *Cultivation and Utilization of Medicinal Plants,* RRL Jammu Tavi.
2. *Brahmvarchas, Ayurved Ka Pran: Vanoshadhivigyan, Vedmata Gayatri Trust, Shaktikunj Haridwar*.2018.
3. Chaudhry R D.1996. *Herbal Drug Industry*, Eastern Publication. Eastern Publishers.
4. CSIR – Cultivation and Utilization of Medicinal Plants.
5. Dutt Ashwin.2009. *An Introduction to Medicinal Plants*. Adhyayan Publishers and distributers.
6. Panda H. 2017. *Hand Book of Ayurvedic Medicines*. National Institute of Industrial Research, Delhi.
7. Raphael Ikan. 1991. Natural Products: A Lab Guide (2nd Edn.). Academic Press.

Seed Production Technology 3 (2+1)

Objectives

i. To make the students aware about concept of seed and quality of seed
ii. Principles of seed production of important cereals, pulses, oilseeds, fodder crops vegetables
ii. To make aware about seed legislation, seed certification standards and seed processing.

Theory

Seed quality: Definition and concept of seed quality, Classification of seeds, Use of biodiversity for seed production, Formal and informal seed production systems. Principles of seed production of important cereals, pulses, oilseeds, fodder crops vegetables, Seed Physiology: Seed germination, viability, seed dormancy, types and requirements of seed germination, Seed health, quality seed collection from natural farming, Seed legislation, Seed testing, Varietal identification through Grow Out Test and electrophoresis, Biochemical tests and molecular tools, Minimum Seed Certification standards, field standards and seed standards, Seed drying and processing, Orthodox seed and recalcitrant seeds, General principles, stages and factors affecting seed longevity during storage and handling, Seed Village Concepts (seed self reliance), types and significance of indigenous seed conservation, community seed banks, Seed marketing, Role of WTo and oECD in seed marketing, Seed production, collection, storage and quality control in context with Natural farming, Technology of Seed Health during ancient time, Materials recommended (plant based, animal based) in ancient time for seed treatments, Sample case study of a few farmers initiative on conservation of seed in different states of India, PPVFR Act (2001) and Suo generis plant variety law approach, ITKs in seed storage and seed health as compiled by ICAR.

Practical

Seed production in major self-pollinated crops, Seed production in major cross pollinated crops, Seed production in selected vegetable crops, Seed sampling procedures, Seed testing: Physical purity, moisture test, varietal purity. RPL, germination, viability, Grow out test and electrophoresis, etc. Seedling vigour tests, Seed health tests, Genetic purity test: moisture tests, heterogeneity, Seed certification: Procedure, field inspection, taking of field counts, Preparation of field inspection and seed testing reports, Seed collection and rural improved storages, Visits to seed production farms, seed testing laboratories and seed processing plants.

Suggested Readings

1. Andersen M M, Landes X, Xiang W, Anyshchenko A, Falhof J and Osterberg J T. 2015. *Feasibility of new breeding techniques for organic farming.* Trends Plant Sci. 20:426–434.
3. Chahal G S and Ghosal S S. 2019. *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches*. Narosa Publishing House Pvt. Ltd, New Delhi.
4. Dawson J C, Murphy K M and Jones S S. 2008. *Decentralized selection and participatory approaches in plant breeding for low-input systems*. Euphytica. 160:143–54.
5. Fess T L, Kotcon J B and Benedito A V. 2011. *Crop Breeding for Low Input Agriculture: A Sustainable Response to Feed a Growing World Population*. Sustainability. 3:1742–72.
6. Mone S. 2016. *A Source Book on India's Organic Seeds. The Organic Farming Association of India*. 104p.
7. Nene Y L. 2007. *Seed Health in Ancient and Medieval History and its Relevance to Present Day Agriculture. In. Nene YL. ed. Glimpses of the Agricultural Heritage of India.* Asian Agri-History Foundation. pp. 533-553.
8. Phillips S L and Wolfe M S. 2005. *Evolutionary Plant Breeding for Low Input Systems.* J Agric Sci. 143:245.
9. Singh B D. 2018. *Plant Breeding-Principles and Methods*. Kalyani Publishers, Ludhiana.

Value Chain Management in Natural Farming 2 (1+1)

Objectives

i. Role and importance of value chains, value chain models

ii. Role of Farmer Producer organization in value chains of natural farming

Theory

Concept of agriculture value chain, characteristics of value chain management in natural farming, types of value chains, role and importance of value chains; dynamics of renewable and non-renewable resources, resource scarcity, pricing and valuation of natural resources; good agriculture practices, good manufacturing and good processing practices, Value chain models- Producer driven, buyer driven, facilitated models.

Role of farmer producer organizations in value chains of natural farming products; Market initiation and strategies, organization of value chains, roles and responsibilities of stakeholders of value chain, transportation, logistics and infrastructure, cold chain components, dispute resolutions and arbitration, physical asset collateralization, Quality certification like HACCP and FSSAI standards, Postharvest, quality, and value-added aspects for domestic and export market special economic zones, Theory of storage and Warehouses – Types, classification, advantages and disadvantages.

Practical

Case studies and success stories on natural farming or chemical free farming value chains in India and abroad, environmental resource accounting techniques, visit to special economic zones, identification of value chains for commodities, identification of niche markets for natural farming produces; post-harvest loss assessment.

Suggested Readings

1. Carlson G A, Miranowski J and Zilberman D. 1998. *Agricultural and Environmental Resource Economics*. oxford University Press.

2. Faires Nicole. 2022. *The Ultimate Guide to Natural Farming and Sustainable Living.* Skyhorse Publishing, ISBN- 9781634502818.

3. Gulati A, Ganguly K and Harshwardhan. 2022. *Agriculture Value Chains in India.*Springer open Access Book, India Studies in Business and Economics.

4. Prato T. 1998. *Natural Resource and Environmental Economics.* Iowa State University Press.

5. Singh R, Naik D and Feroze S M. 2014. *Agri-Business potentials in India: Experiences from Hill states.* EBH Publishers India136, M.L. Nehru Road, Pan Bazaar, Guwahati-781001.

6. Singh R, Yumnam A, Roy A and Choudhury A. 2018. *Agriculture Development: Technical and Policy options.* Biotech Books 4762-63/23 Ansari Road, Darya Ganj, New Delhi, 110002

7. Sterner T. 2003. *Policy Instruments for Environmental and Natural Resource Management. Resources for the Future*, Washington DC.

Renewable Energy Sources 2 (1+1)

Objectives

i. To gain the knowledge on different types of renewable energy sources

ii. To understand the importance of renewable energy technology and its applications

Theory

Introduction to energy, Forms of energy, Conservation of energy, Sources of energy and their classification, Energy consumption patterns in India, Concept of renewable energy sources, Potential of renewable energy sources, Classification of renewable energy sources, Ecological footprint, Carbon footprint. Role of renewable energy in natural farming and its impact on food system, Environment and economy, Solar Energy: Introduction of solar energy, solar thermal energy systems: solar cooker, solar distillation, solar water heater, solar dryer, solar photovoltaic systems and their different types and uses, soil solarization, Biomass Energy: Introduction of biomass, biogas–biogas generation process, types of biogas plants, application of biogas, usage of biogas spent slurry, Biomass Gasification- types of gasifiers, producer gas production and utilization, Introduction to ethanol, biodiesel and hydrogen production process. Wind Energy: Introduction, Traditional practices of wind energy, Wind mills and their applications, Role of renewable energy in carbon mitigation, Energy balance in natural farming, Programs and policies for promotion of renewable energy in India.

Practical

Visit to farms to study different source of energy and their consumption, Study of solar cooker, Study of solar dryer, Study of solar water heater, Study of solar distillation, Study of solar photovoltaic system, Study of biogas plant, Study of biomass gasifier, Study the production process of biodiesel, Study of improved biomass cookstove, Traditional practices of wind energy, Determination of energy balance in natural farming.

Suggested Readings

1. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.
2. Kothari D P, Singal K C and Ranjan R. 2008. *Renewable Energy Sources and Emerging Technologies.* PHI Learning Pvt. Ltd., New Delhi
3. Rai G D. 2013. *Non-Conventional Energy Sources,* Khanna Publishers, Delhi.
4. Rai G D. 2013. *Solar Energy Utilization.* Khanna Publishers, New Delhi.
5. Rathore N S and Panwar N L. 2021. *Biomass Production and Efficient Utilization for Energy Generation*. New India Publishing Agency, New Delhi.
6. Rathore N S and Panwar N L. 2021. *Fundamentals of Renewable Energy*. New India Publishing Agency, New Delhi.
7. Seveda M S, Narale P D and Kharpude S N. 2021. *Bioenergy Engineering*. CRC Press, Taylor and Francis Group, UK.

8. Seveda M S, Narale P and Kharpude S N. 2021. *Advances in Renewable Energy Engineering*. Narendra Publishing House, New Delhi.

9. Solanki C S. 2008. *Renewal Energy Technologies: A Practical Guide for Beginners*. PHI Learning.

Natural Farming and Human Health 2(1+1)

Objectives

i. To make the students aware about concept of healthy food, Nutritional garden, Homestead kitchen garden and Nutri smart village

ii. To understand the beneficial effects of medicinal crops on health

Theory

Changing lifestyles and food habits of the people over the years, Health and disease statistics of world and India, Food production and requirement vis-à-vis growth in human population in India and World, Need of healthy food, Concept of healthy food, safe food, organic food, green food, pesticide free food, fast food, slow food, Dietary guidelines, Traditional food vis-a-vis modern food and its potential health impact, Food Chain contamination and human health hazards, Deficiency in micro-nutrients by the human and livestock population, Malnutrition, Concept of one health, Traditional food of Indian population: Food and its nutrient content, Traditional diets in Indian and their adequacy- Nutritional value of traditional food, Concept of nutrition and health per acre, Interrelationship between natural farming and human health, Health and nutrition disconnect in the agriculture policy of India, Effect of natural farming on animal reproduction, Nutrients, taste, safety, immune system, antibiotic resistance, antioxidant value and protection of environment, Dietary requirement for Indian population: Current diet and nutrition scenario, Recommended Dietary Allowances (RDA): Food exchange list, food composition database, food composition and food groups, bio- fortification of crops, Criteria for classification of quality and safe food, Human health – Definition and philosophy, concept of health- biomedical, ecological, psychological and holistic, Criteria and qualities of organic and natural food, Comparison of natural and conventionally grown foods: Nutritional and non-nutritional components, bioactive components, their impact on human health, effect of processing on nutritional components, conservation of nutrients in processed foods, Food standards, food laws and labelling of natural foods, Concept of nutritional garden, homestead kitchen garden and nutri smart village. ITKs in human food and nutrition and health, Mission Life Style for Environment (LiFE).

Practical

Physical examination of food, determination of gluten, bulk density, hydration capacity and index, oil absorption capacity, Sensory evaluation and organoleptic evaluation of natural and conventional foods, Analysis of proximate composition in conventional foods and natural farming produce/foods based on available secondary data.

Determination of pesticide residues and heavy metal contamination in foods, Market survey and listing of natural farming foods available in the market, Preparation of nutri- thali, Composition of nutrient in different crop plants, Effect of processing on nutritive value of food, Determination of pesticides load in the food stuffs, Glycemic index of common food, Macro – nutrient and micro – nutrient and their sources, Calorie requirement among different class of population, Balance diet for different class of people, Drinking water standard - Limits of heavy metal content

Suggested Readings

1. Agarwal A and Udipi S. 2014. *Text Book of Human Nutrition.* Jaypee Medical Publication, Delhi.
2. AOAC International. 2016. *AOAC Official Methods of Analysis.* (20th Edn.). *Association of Official Analytical Chemists*. Washington DC.
3. Bamji S M, Rao P N and Reddy V. 2003. *Textbook of Human Nutrition.* Oxford and IBH Publishing Co Pvt Ltd.
4. Lamuela- Raventós. 2019. *Organic Food and the Impact on Human Health, Critical Reviews in Food Science and Nutrition,* 59:4, 704-714, DoI: 10.1080/10408398.2017.1394815
5. Sawhney S K and Singh R. 2000. In*troductory Practical Biochemistry*. Narosa Publishing House, New Delhi. Kalia M. 2002. Food Analysis and Quality Control. Kalyani Publishers, New Delhi.
6. Shiva V and Singh V. 2011. *Health per Acre-Organic Solutions to Hunger and Malnutrition.* Navdanya Research Foundation for Science, Technology and Ecology.
7. Shiva V, Shiva M and Singh V. 2013. *Poisons in our Food- Links between Pesticides and Diseases.* Natraj Publishers, Dehradun.

Fundamentals of Entomology 3 (2+1)

Objectives

i. To teach the students on external morphology and anatomy of different systems of insects

ii. To teach the students on classification and identification of insects upto family level

Theory

Entomology in ancient India, Historical classics of modern entomology, Classification of phylum Arthropoda up to classes, Relationship of class Insecta with other classes of Arthropoda, Major points related to dominance of Insecta in animal kingdom. Morphology: Structure and functions of insect cuticle and moulting, Body segmentation; Structure of head, thorax and abdomen. Structure and modifications of insect antennae, mouth parts, legs, wing venation, modifications and wing coupling apparatus, Structure and modifications of abdominal appendages, Anatomy of insect systems - Digestive, excretory, respiratory, circulatory, nervous, reproductive and glandular systems, sense organs and tropism and bio-communication in insects, Metamorphosis in insects, Taxonomy – Importance, history and development and binomial nomenclature, Definitions of Bio-types, Sub-species, Species, Genus, Family and Order, Classification of class Insecta up to Orders, basic groups of present days insects with special emphasis to orders and families of economic importance and their distinguishing characters.

Practical

External features of Grasshopper/Blister beetle, Methods of collection and preservation of insects including immature stages, Types of insect antennae, mouthparts, legs, wings, wing venation and wing coupling apparatus, Types of insect larvae and pupae, Dissection of digestive system in insects, Dissection of male and female reproductive systems in insects, Study on characters of orders orthoptera, Dictyoptera, odonata, Isoptera, Thysanoptera, Hemiptera, Lepidoptera, Coleoptera,

Diptera, Hymenoptera, Neuroptera, and their families of agricultural importance, Identification of major pests of crops.

Suggested Readings

1. Chapman R F. 1998. *The Insects Structure and Function.* (4th Edn.). Cambridge University Press, The Edinburgh Building Press, Cambridge CB2 @RU, UK.
2. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.
3. Dhaliwal G S, Singh R and Jindal V A .2013. *Text book of Integrated Pest Management.* Kalyani Publishers.
4. Gillott C. 2005. *Entomology.* (3rd Edn.). *Springer University of Saskatchenam- Saskatoon, Saskatchewam,* Canada Springer. P.o. Box 17, 3300 AA Dordrecht, The Netherlands.
5. Kapoor V C. 2019. *Theory and Practice of Animal Taxonomy and Biodiversity*. (8th Edn.). Oxford and IBH Publishing.
6. Richard J Elzinga. 2003. *Fundamentals of Entomology*. (6th Edn.). Printice Hall of India, New Delhi.
7. Southwood TRE and Henderson PA. 2000. *Ecological Methods*. Black Well Science.

Semester VI

Indian Traditional Knowledge 3 (2+1)

Objectives

i. To equip the students with importance of Indian Traditional Knowledge

ii. To develop skill for integration of traditional practices for the benefit of farming community

Theory

Introduction and importance of Indian Traditional Knowledge in agriculture and allied sciences: Definition, Difference between Traditional Knowledge System and Western Science System, Protection of Traditional Knowledge, IPR and other provisions, Indian Traditional Knowledge in Agriculture covering Veterinary and Animal Husbandry, Pest and Disease Management, Grain/ Seed storage, Horticultural Crops, Crops and Cropping systems, Farm implements, Weather forecasting, Soil and water conservation, Soil fertility management, Rain water management, Tillage practices, Fisheries, Post-Harvest Technology, Garbage disposal and management, Wind erosion, Waste water management.

Practical

Case studies on validation of ITKs, Need to revive traditional technologies relevant to the contemporary agricultural scenario, Geographical indications of plant species involved in various ITK's (Pest and disease management, Grain/ Seed Storage, Veterinary and Animal Husbandry and Weather forecasting).

Suggested Readings

1. *Cross-sectoral Validation of Indigenous Technical Knowledge in Agriculture Document 4. 2004.* Published by ICAR, New Delhi. 230p.
2. *Indigenous Technical Knowledge in Agriculture- Geographical Indications of Plant Species. Document 5. 2004.* Published by ICAR, New Delhi. 284p.
3. *Inventory of Indigenous Technical Knowledge in Agriculture. Document 1.* 2002.Published by ICAR, New Delhi. 411p.
4. *Inventory of Indigenous Technical Knowledge in Agriculture. Document 2. 2003*. Published by ICAR, New Delhi. 680p.
5. *Inventory of Indigenous Technical Knowledge in Agriculture. Document 1 (Supplement1). 2002.* Published by ICAR, New Delhi. 226p.
6. *Inventory of Indigenous Technical Knowledge in Agriculture. Document 1 (Supplement2). 2004.* Published by ICAR, New Delhi. 321p.
7. *Validation of Indigenous Technical Knowledge in Agriculture. Document 3. 2004.Published* by ICAR, New Delhi. 505p.

Post-Harvest Management -II 3 (2+1)

Objectives

i. To develop skills for primary and secondary processing, mechanical and biocontrol practices for storage pest management in cereals, pulses and oil seeds

ii. To create awareness about natural preservation methods and hygiene and handling of fish and meat

Theory

Physico-chemical and nutritive properties of cereals, pulses and oilseeds, causes of post-harvest losses, traditional and modern storage structures, on farm and off farm storage, bulk and bag storage (especially eco/bio-based bags), Primary processing of cereals, pulses and oilseeds: Cleaning, grading, curing/tempering/conditioning, pretreatments including parboiling, Secondary processing: Drying, size reduction (milling), Oil seed milling: Ghanis, hydraulic presses, expellers, extrusion processing and different types of extruded products (snack, breakfast cereals and weaning foods), bakery and confectionary products, Traditional value-added products (regional products like nuggets/wadi/badi, papad, vermicelli/sevai, etc.), Storage Pest Management: Use of ITKs like oil treatment, ash treatment, bio- control practices for storage pest control of cereals, pulses and oilseeds, Primary processing operations in poultry: Pre-slaughter operations and slaughtering operations for poultry: stunning, icing, grading, blanching, washing, evisceration, beheading, scaling, cutting off fins and belly flaps, steaking, filleting, skinning, deboning (meat-bone separator), mincing of skinned fillets, peeling, deveining, shucking, knobbing, Preservation methods for fish: Preservation of meat and fish by canning, chilling, freezing, marination (pickling), curing, cooking and smoking, dehydration, and biological preservatives (fermentation), etc. Value- added products from fish and meat, Hygienic handling and storage of fish: chilling or icing, refrigeration, pest infestations in stored fishery products, natural means to control pests infestation, Food-grade coatings as processing aids, Integrated pest management.

Practical

Study of physico-chemical properties of cereals, pulses and oils seeds, Determination of gluten content in wheat flour, Study of conditioning of wheat, Milling of wheat and rice by laboratory mill, Study of pre-treatment and milling of pulses, Study of oil expression equipment, Manufacture of value- added products, millets, guar gum and other minor crops, Study of primary processing of fish or meat, Study of preservation methods for fish/meat, Preparation of traditional value-added products from fish/meat, Preservation of meat/fish by freezing, Preservation of meat/fish by curing and pickling, Preservation of meat/fish by dehydration, Preparation of value-added poultry meat products, Quality evaluation and grading of eggs, Visit to processing facilities.

Suggested Readings

1. Alan H Varnam and Jane P Sutherland. 1995. *Meat and Meat Products: Technology, Chemistry and Microbiology.* Chapman and Hall, London.
2. Chakraverty Amalendu, Mujumdar Arun S, Vijaya Raghavan G S and Ramaswamy Hosahalli S. 2003. *Handbook of Post-Harvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices. Marcel Dekker,* Inc., NY, USA.
3. Sharma B D. 1999. *Meat and Meat Products Technology Including Poultry Products Technology.* Jaypee Brothers Medical Publishers Pvt. Ltd, New Delhi.
4. Chakraverty A K. 2008. *Post-Harvest Technology of Cereals, Pulses and Oilseeds.* (3rd Edn.). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
5. Cutting C L. 2002. *Processing and Preservation of Fish*. Agro Bios, New Delhi.
6. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.
7. Mishra R. 2022. *Handbook on Fish Processing and Preservation*. Taylor and Francis.
8. Kent N L and Evers A D. 1994. *Kent's Technology of Cereals: An Introduction for Students of Food Science and Agriculture.* (4th Edn.). Elsevier Science Ltd., Oxford, UK.
9. Sahay K M and Singh K K. 2001. *Unit Operations of Agricultural Processing.* (2nd Edn.). Vikas Publishing House Pvt. Ltd., Noida.
10. Samuel A Matz. 1991. *The Chemistry and Technology of Cereals as Food and Feed.* (2nd Edn.). Springer Science + Business Media, NY, USA.
11. William J Stadelman and Owen J Cotterill. 1995. *Egg Science and Technology.* (4th Edn.). Food Products Press, NY, USA.

Standards and Certification for Natural Farming 3 (2+1)

Objectives

i. To learn the natural farming standards and certification processes vis a vis other standards and certification in vogue.

ii. To impart the methods of certification in natural farming based set of standard practices.

iii. To understand the process of quality control of inputs and products in natural farming.

Theory

Scope and procedure of Natural Farming Certification System (NFCS), definitions, Crop production, habitat care, conversion, landscape, seeds and planting materials, diversity in crop production, inputs for soil and fertility management, Insect, pest and weed management, Contamination control, Transition / conversion Period and requirements for transition, Soil and water conservation, collection of non-cultivated material of plant origin forest produces, Livestock production, General requirements, Feed and fodder, Health care, Processing and handling, General requirement: Ingredients, Processing Methods, Packaging, Labelling, *Processed Products,* Storage and Transport, Marketing, Practices for use in soil preparation, Soil enrichment, practices for seed treatment, pest and disease management, procedure to evaluate natural farming input, Ethical Aspects — Animal welfare and socio-economic aspects, practices to be followed for livestock reared in natural farm, International and national regulations on quality assurance and certification for non- chemical farming systems, ICT enabled certification process.

Practical

Visit to natural farm, formulation of natural farm plan, characterization of farm sources (Investigation) and filling up of application forms for certification, exposure of students with the team certification agency, group discussion on natural farm conversion period and standards requirements, quality assurance and labelling requirement for certification of farm under natural farming standards. Visit of certification agency and learning about management of records and inspections.

Suggested Reading

1. APEDA.2018. *National Program for Organic Production- A Training Manual, Ministry of Commerce and Industry*. GoI, New Delhi.
2. Natural Farming Standards and Certification, Bureau of Indian Standards, Government of India (Under circulation).

Aqua-based Natural Farming 3 (2+1)

Objectives

i. To acquaint students about natural farming and technologies pertaining to aquaculture and their relationship with farming activities
ii. Basic understanding and knowledge on the overall view of the aquaculture sector, how to start aquaculture venture, opportunities and challenges

Theory

Physical, biological and components of aquatic ecosystem, Ecological structure and function of aquatic ecosystem, Organic matter recycling and nutrient cycles, Food web and food chain, Heterotrophic activities, Energy and matter flow in the ecosystem, Eutrophication and pollution. Definition and scope of aquaculture, Global and national scenario, Trends and constraints, Different aquaculture systems and utilization of natural food, pond, pen, enhanced

fisheries, Pre- stocking, stocking and post-stocking interventions for primary fish survival and growth, Aquaculture and climate change, Natural productivity and carrying capacity, Secondary and tertiary production, Carrying capacity of aquaculture system and associated factors, Natural food and feeding behavior of fishes and shellfishes: Concept of ecosystem based aquaculture, Integration of crop, live- stock, horticulture and fish farming as complimentary activities, Comparative nutritional value and decomposition of different types of organic wastes on organic productivity, Nutrient values of common animal waste and agro residues as potential manures and biofertilizers, Definition of reservoirs in India: nature and extent of reservoirs, pen and cage culture in reservoir, Health management in aquaculture, Traditional techniques for curing fish diseases and pond management, Probiotics and bioremediation, Renewable and eco-friendly bio- inputs in aquaculture, Management and conservation natural aquatic ecosystems.

Practical

Identification of important cultivable species, Estimation of carrying capacity, Practices on pre-stocking, Stocking and post stocking management, Growth studies in aquaculture system, Study on waste accumulation in aquaculture system (NH , Organic matter, CO_2), Analysis of certified manure/natural aquaculture inputs, Measurement of important soil and water quality parameters and their correction measures with certified standard materials/inputs, Preparation of artificial feeds using locally available permitted feed ingredients, Identification of different live food organisms and their rearing/culture with standard methods, Case studies on cage and pen culture.

Suggested Readings

1. Adhikari S and Chatterjee D K. 2008. *Management of Tropical Freshwater Ponds*. Daya Publishing House.
2. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture: Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7.* Indian Council of Agricultural Research, New Delhi.
3. Fisheries: In Inventory of Indigenous Technical Knowledge in Agriculture Document 1; Document 2 (Supplement1& 2); Document 3. ICAR Publication, New Delhi.
4. Khanna S S and Singh H R. 2014. *A textbook on Fish Biology and Fisheries*. Narendra Publishing House, New Delhi.
5. Martin O. 2016. *Aquaculture: Farming Aquatic Animals.* Latest Edition, Syrawood Publication, USA.
6. Pillay TVR and Kutty M N. 2011. *Aquaculture: Principles and Practices*. Blackwell Publishing, UK.
7. Veeranjaneyulu K, Krishnaveni G and Veerabhadra Rao N. 2016. *Recent Technologies in Fish and Fisheries.* RIGI Publication, Punjab.
8. Zaman A. *Integrated Farming System and Agricultural Sustainability*. New India Publishing Agency.

Marketing of Natural Farming Produce 3 (2+1)

Objectives

i. To study about the specific concepts of marketing channels, price spread market segmentation and market margin
2. To develop skill on calculating market margin and farmers share in consumer's rupee in natural farming

Theory

Concepts and definition of market, Agricultural marketing, Marketing of natural farming products, Market structure, Marketing mix and market segmentation, Demand, supply and producer's surplus of agricultural commodities marketable and marketed surplus, Pricing consideration and approaches cost based and competition based pricing, Market promotion and publicity, Marketing management-segmentation, Targeting and positioning, Marketing function-physical function, facilitating functions, Market functionaries and marketing channels, Marketing efficiency, Marketing costs, Market margin and price spread, Role of government in marketing of natural farming products, Public sector institutions – CWC, SWC, FCI,CACP, APEDA, Risks in marketing-types of risks involved speculation and hedging, Forward markets and Future markets.

Practical

Study of relationship between market arrival and prices, Demand and supply curves, Calculation of marketable and marketed surplus, Identification of market channels for selected commodities, Computation of market margin, Price spread, visit to marketing institutions to study their organization and functioning.

Suggested Readings

1. Acharya S S and Agarwal N L. 1994. *Agricultural Price Analysis and Policy* Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
2. Acharya S S and Agarwal N L. 2000. *Agricultural Marketing in India*. Oxford and IBH Publishing Co. New Delhi.
3. Kahlon A S and George M V. 1985. *Agricultural Marketing and Price Policy*. Allied Publication Pvt. Ltd. New Delhi.
4. Kohls Richard L and Uhl Joseph N. 1980. *Marketing of Agricultural Products.* Macmillan Publishing Co. Inc. New York.
5. Mamoria C B and Joshi R L. 1971. *Principles and Practices of Marketing in India*, Kitabmahal, Prayagraj.
6. Meena G L. Burak S S, Pant D C and Sharma R. 2017. *Fundamentals of Agribusiness Management*. (1st Edn.). Agrotech Publishing Academy, Udaipur, ISBN: 978-81-8321-418-6.

Agronomic Practices 2 (1+1)

Objectives

i. To acquaint students with management aspects of crops, weeds, water in natural farm fields
ii. To develop skills among students in practicing crop husbandry based natural farming

Theory

Classification of crops, Field crops – Origin, distribution, economic importance, soil and climatic requirements, varieties, cropping systems: definition, principles and its importance, physical resources, soil and water management in cropping systems, Importance of mixed cropping in natural farming, multiple cropping, alley cropping, sequential cropping and intercropping, cropping system indices - mechanism of yield advantage in intercropping systems, Complementary and competition relations, multi-storied cropping and yield stability in intercropping, Types of crops - Trap, cover, catch and restorative crops, ITK related to crops and cropping systems, Seeds- Traditional and recent varieties, classification of seeds, seed dormancy, nursery management, main field preparation, types of tillage, Seasons of India, Pre-monsoon sowing, Sowing techniques, Optimum time of sowing for different crops-ITK for seed treatment and seed selection, Methods of planting of crops,Time of planting of different crops and intercrops, Row spacing for different crops, Irrigation– Definition, irrigation types, water saving techniques and management, ITKs in irrigation and water management, Green manures and green leaf manures – Types of green manures, Ideal plant types for green manures, Nutrient content and biomass contribution, time and method of incorporation, decomposition pattern, Advantages and limitations, Weeds- Classification, habitat management of weeds, crop weed interaction, critical periods of weed competition, non-chemical weed management, weed mulch, trap crop, biological and herbal measures, Mulching – Types, cover crops – advantages and disadvantages, Soil moisture conservation approaches and water harvesting, ITKs on soil and water conservation. Alternate land use system – Definitions and types.

Practical

Identification of different growth stages in crops, manures and seeds, agriculture tools and implements, nursery and main field preparation, animal drawn, seed treatment and seed dormancy, methods of sowing, input requirement, water requirement and water use efficiency (WUE), weeds in wetland, irrigated up land, dryland system, low cost technology, indices for cropping systems, mulching practices, green manuring practices, alternate land use system, wind break and shelter belt, ITKs in crops and agronomic practices.

Suggested Readings

1. Chandsrasekaran B and Somasundram E. 2018. *A Text book of Agronomy.* New Age International Publication, New Delhi.

2. Choudhary S L, Sharma G S and Nene Y L (Eds). 2000. *Ancient and Medieval History of Indian Agriculture and its Relevance to Sustainable Agriculture in the 21st Century.* Proceedings of the Summer School held from 28th May to 17th June 1999, Rajasthan College of Agriculture, Udaipur, India 363p.

3. *Crops and Cropping Systems/ Soil and Water Management/ Rain water management. In: Inventory of Indigenous Technical Knowledge in Agriculture Document 1; Document 2; Document 2 (Supplement 1& 2); Document 3;* Publ: ICAR, New Delhi.

4. Das P, Das Reddy, G S, Das S K, Rani G, Mishra A, Gupta H P, Verma L R, Ray D P, Singh R P, Kavia Z D and Arya H P S. 2004. *Inventory of Indigenous Technical Knowledge in Agriculture:*

Mission mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge, Document 1 To 7. Indian Council of Agricultural Research, New Delhi.

5. Dwivedi A P. 2019. *Agroforestry Principles and Practices*. Oxford and IBH Publication.
6. Reddy S R. 2020. *Principles of Agronomy*. Kalyani Publishers, New Delhi.
7. Reddy T Yellamanda and Shankara Reddy G H. 2016. *Principles of Agronomy.* Kalyani Publishers, New Delhi.
8. Somasundaram E and Mohamed Amanullah M. 2017. *Agronomy: Principles and Practices*. New India Publishing Agency, New Delhi.

Intellectual Property Rights 1 (1+0)

Objectives

i. To acquaint the students about filing of patent, patent specification, patent claims, Patent opposition and revocation

ii. To create awareness in the students about infringement, compulsory licensing, patent search and patent database

Theory

Introduction, importance and meaning of intellectual property, changing scenario of agriculture in India, brief introduction to GATT, WTO,TRIPs and WIPO, Treaties for IPR protection: Madrid protocol, Berne Convention, Budapest treaty, etc.; Types of Intellectual Property and legislations covering IPR in India: Patents, Copyrights, Trademark, Industrial design, Geographical indications, Integrated circuits, Trade secrets, Patents Act, 1970 and patent system in India, patentability, process and product patent, filing of patent, patent specification, patent claims, Patent opposition and revocation, infringement, Compulsory licensing, Patent Cooperation Treaty, Patent search and patent database: Origin and history including a brief introduction to UPOV for protection of plant varieties, Protection of plant varieties under UPOV and PPV&FR Act of India, Plant Breeders rights, Registration of plant varieties under PPV&FR Act 2001, breeders, researchers and farmers rights, Traditional knowledge-Meaning and rights of TK holders. Convention on biological diversity, International treaty on plant genetic resources for food and agriculture (ITPGRFA), Indian Biological Diversity Act, 2002 and its salient features, access and benefit sharing. Understanding Intellectual Property Rights in ancient India.

Suggested Readings

1. Chawla H S. 2020. *Introduction to Intellectual Property Rights*. Oxford and IBH Publ. 312p.
2. Singh Prabhas Chandra. 2007. *Encyclopedia of Intellectual Property Rights. Anmol Publications Pvt. Ltd.*
3. Sridevan Prabha. 2015. *Intellectual Property in the Ancient Indian Texts. In: Diversity in Intellectual Property.pp.232-246.* Publ: Cambridge University Press.
4. Verma Deepak and Madhu Bala. 2020. *National Intellectual Property Rights Policy of India - A Review. In: Sensitizing and Imparting Awareness about Intellectual Property Rights among Students (pp.125-132).* Publisher: National Press Associates.

Principles of Agricultural Economics and Farm Management 2 (2+0)

Objectives

i. To impart knowledge on judicious use of resources for optimum production

ii. To impart knowledge about basic theories of demand, supply, production and exchange.

Theory

Economics: Meaning, scope and subject matter, definitions, activities, approaches to economic analysis: micro and macroeconomics, positive and normative analysis, Nature of economic theory: rationality assumption, concept of equilibrium, economic laws as generalization of human behavior, Basic concepts: Goods and services, desire, want, demand, utility, cost and price, wealth, capital, income and welfare, Agricultural economics: meaning, definition, characteristics of agriculture, importance and its role in economic development, Agricultural planning and development in the country, Demand: Meaning, law of demand, demand schedule and demand curve, determinants, utility theory; law of diminishing marginal utility, equi-marginal utility principle, Consumer's equilibrium and derivation of demand curve, concept of consumer surplus, Elasticity of demand: Concept and measurement of price elasticity, income elasticity and cross elasticity, Production: process, creation of utility, factors of production, input output relationship, Laws of returns: Law of variable proportions and law of returns to scale, Cost: Cost concepts, short run and long run cost curves, Supply: Stock v/s supply, law of supply, supply schedule, supply curve, determinants of supply, elasticity of supply, Distribution theory: meaning, factor market and pricing of factors of production, Concepts of rent, wage, interest and profit, National income: Meaning and importance, circular flow, concepts of national income accounting and approaches to measurement, difficulties in measurement, Population: Importance, Malthusian and Optimum population theories, natural and socio-economic determinants, current policies and program s on population control, Money: Barter system of exchange and its problems, evolution, meaning and functions of money, classification of money, money supply, general price index, inflation and deflation, Economic systems: Concepts of economy and its functions, important features of capitalistic, socialistic and mixed economies, elements of economic planning, Forms of business organizations, international trade and balance of payments, GST and its implication on Indian economy.

Suggested Readings:

1. Ahuja H L. 2011. *Principles of Microeconomics*. S. Chand and Company Ltd., New Delhi
2. Johl S S and Kapur T R. 2009. *Fundamentals of Farm Business Management.* Kalyani Publishers, New Delhi
3. Meena G L. 2022. *Fundamentals of Agricultural Economics*. Lucky Publishing House, Udaipur
4. Reddy S Subha, Raghu Ram P, Neelakanta T V and Devi I Bhvani. 2004. *Agricultural Economics*. Oxford and IBH publishing Co. Pvt. Ltd.
5. Sharma L, Acharya S K and Somani S S. 2015. *Principles of Agricultural Economics.* Agrotech Publishing House, Udaipur.

Semester VII

Community Mobilization for Natural Farming 2 (1+1)

Objectives

i. To gain the knowledge about the fundamental concepts and principles of community mobilization, program planning and about groups

ii. To develop an understanding of techniques and strategies for community mobilization in natural farming

Theory

Community mobilization – Meaning, historical background, types, strategies, steps, opportunities and challenges, Community mobilization process: community mobilization in rural areas and different models, community entry, profiling, social mapping, Yoga for community mobilization - Purpose, concepts, importance, types, benefits; SWOT Analysis- Meaning, advantages and case study, Social core value systems - Ethical principles, purpose, benefits, Development of understanding about rural society, Behavioral change and attitude, Program planning - Introduction, need and interest, concept, objectives and principles, process, Organizational structure - Define, key elements, types, span of control, Centralization and decentralization, formalization. Diffusion and Adoption Process- Define, meaning and stages.

Group: Definition, types, stages of group formation, modes of group development, process for group formation - stages of SHG, FPO/FPC and FBO development, group decision making techniques, FPO - benefits, activities, implementing agencies to form and promote FPOs, procedure to form FPC and organizational structure, Conflict -Meaning, types, process, conflict resolution and management strategies.

Motivation: Definition, elements, individual and group needs, motivation process, Maslow's Hierarchy theory of needs and Adam's Equity theory, motivation cycle, classification of motives, types of motivation, techniques of motivation, role/importance/factors of motivation. Capacity building and institutionalizing mechanism, Counselling – Need, functions and types, Mentoring: Definition, process, philosophy and mentor-mentee relationship, Training - meaning, advantages, types and process, training methodologies for creating awareness about natural farming, Monitoring and Evaluation - Define, objectives, types, concept, difference, importance; Impact analysis on social, economic and environmental effects of natural farming.

Case studies on community mobilization in natural farming, Traditional and social media for promoting natural farming, Government schemes and role of public and private institutions in promoting community mobilization in natural farming.

Practical

Preparation of Community Resource Mapping in selected rural villages, Community needs assessment techniques – Participatory Rural Appraisal, Yoga, SWOT analysis, Organization involved in community mobilization, Program planning and organizing events, Formation and functioning of SHG, Establishment, organizational structure and promotion of FPO and FBO, Group decision making techniques - Conduct of focused group discussion, Conflict management techniques, Motivation – preparation of Maslow's hierarchy theory of needs assessment, Counselling and mentoring- conduct sessions among beneficiaries of natural farming community, Organizing,

capacity building programs, Socio economic impact analysis on natural farming, Traditional and social media for promoting natural farming, Public and private institutions promoting community mobilization for natural farming.

Suggested Readings

1. Choudhary S L, Sharma G S and Nene Y L. 2000. *Ancient and Medieval History of Indian Agriculture and its relevance to Sustainable Agriculture in the 21st Century. Proceedings of the Summer School held from 28th May to 17th June 1999,* Rajasthan College of Agriculture, Udaipur. 363p.
2. Prasad R R. 2015. *Community Mobilization – Methods and Models*. Discovery Publishing House Pvt. Ltd.
3. Rasheed Sulaiman V, Onima V T, Nimisha Mittal and Athira E. 2019. *Taking Stock and Shaping the Future: Conversations on Extension*. AESA.
4. Sethuraman S P, Santakki B S, Sulaiman R, Saravanan V R and Mittal N. 2017. *Manual on Good Practices in Extension Research and Evaluation*. AESA.

Water Management 2 (1+1)

Objectives

i. To equip the students with the knowledge about the fundamental concepts and principles of water management
ii. To develop an understanding of techniques and strategies for conserving water resources and improving water use efficiency both in rainfed and irrigated ecosystems

Theory

History of water management in ancient and medieval India, Rainfed and irrigated farming; Water management: Definition, scope and importance, Water resources: Use and over- utilization of surface and ground water, floods, drought, Dams-Benefits and problems, Region specific traditional water harvesting and management systems, Rainfed farming, Rainwater conservation technologies - In-situ and ex-situ storage, water harvesting and recycling, Rain water harvesting, Farm ponds, Ground water recharge, Contour and graded bunding, *Chalkhal*, Water budgeting, Irrigation water requirement, Micro irrigation: Sprinkler, Drip irrigation systems, pitcher irrigation system, maintenance of micro irrigation system, fertigation, advantages and limitations of fertigation, Watershed management - Concept, objectives, factors affecting and watershed planning, Reservoirs, Ground water harvesting and conservation (Tanka, Talai, Nadi, Nada, Talab, Khadin), Indian Traditional Knowledge in rain water management, soil and water conservation.

Practical

Measurement of soil moisture by different soil moisture measuring instruments, Measurement of irrigation water requirement, Determination of bulk density by field method, Determination of field capacity by field method, Determination of permanent wilting point, Case study on water budgeting, Study of different types of farm ponds, Estimation of farm pond storage capacity, Testing of irrigation water quality, EC, pH and TDS, Study of different components of sprinkler irrigation system, Study of different components of drip irrigation, Field visit to micro irrigation system, Maintenance of different components of micro irrigation systems, Survey of watershed resources, Field visit to watershed, Field visit to water harvesting structure.

Suggested Readings

1. Choudhary M L and Kadam U S. 2006. *Micro Irrigation for Cash Crops*. Westville Publishing House.
2. Jat M L, Sharma S K, Balyan J K, Kothari A K and Jain L K. 2011. *Rainfed Farming*. Kalyani Publisher, Ludhiana. 324p.
3. Michael A M. 2012. *Irrigation: Theory and Practice*. Vikas Publishing House New Delhi.
4. Michael A M and Ojha T P. 2014. *Principles of Agricultural Engineering*. Vol. II. (5th Edn.). Jain Brothers Publication, New Delhi.
5. Mishra Anupam. 2021. *Aaj Bhi Khare Hai Talab*.
6. Murthy V V N. 2013. *Land and Water Management Engineering*. Kalyani Publishers, New Delhi.
7. Sadhale Nalini. 2007. Water Harvesting and Conservation in Ancient Agricultural Texts. *In:* Nene YL. ed. Glimpses of the Agricultural Heritage of India. Asian Agri- History Foundation. pp.414-424.
8. Singh Harpal and Kavia Z D. 2007. *Traditional Rainwater Harvesting Methods of Indian Thar Desert. In:* Nene YL. ed. Glimpses of the Agricultural Heritage of India. Asian Agri-History Foundation.pp.432-440.
9. Singh P K. 2000. *Watershed Management: Design and Practices*. E-Media Publications, Udaipur.

Research Methodology and Ethics 2 (1+1)

Objectives

i. To provide basic knowledge on research tools and techniques
ii. To develop skills on on-farm research and ethics in general with specific reference to natural farming

Theory

Research Ethics: Introduction, Ethical ethos- Researcher's obligations and participant's rights, Research Ethics: Researcher-Participant, General Ethics, Ethical Issues in India, Ethics Committees. Experimental techniques: Research design, sampling, data collection, On-station experimentation, On-Farm experimentation, tabulation, Statistical tools and analysis, techniques for interpretation of data, Geo-referenced characterization: Questionnaire design principles, Questionnaire design for consumers of organic products, Questionnaire design for farmers and producers of organic products, Questionnaire design for processors/traders/ exporters, Geo-spatial analysis and mapping of natural farms/ producers/traders/consumers.

Meta data analysis: Concepts, Niche area and crops for natural farming: Parameters for niche area and crop, Different scales of niche area, Tools and steps in niche area and crop identification, Parameterization and classification based on macro, regional and micro level.

Climate resilience of natural farming: Methodology for identification of climate resilient production systems, GHG's estimation using IPCC, GHG's measurement using instrumentation, Global warming potential, Energy and Carbon budgeting. Bio-chemical and molecular signature of natural produces, Commercial project formulation on natural farming: Internal rate of return, Pay Back period, B:C ratio, Net Present Value, Model project formulation for organic farming, Impact analysis tools and methods, Farming system model development: Practical synthesis of natural farming system model, Estimation of GHG emission from natural farm using IPCC tools, Identification of niche area and crops for a district or block, Identification of climate resilient production system using long term meteorological data, Commercial project formulation, Geo-spatial analysis using GIS platform, Comparative carbon and energy budgeting between organic and natural farms, Comparative food quality between natural and conventional produces by meta-analysis.

Suggested Readings

1. Kamat P V. 2006. Research Ethics. Retrieved from https://www3.nd.edu/~pkamat/pdf/ethics.pdf.
2. Parveen Huma and Showkat Nayeem. 2017. *Research Ethics*. https:// www. researchgate.net/publication

Weather Forecasting 3 (2+1)

Objectives

i. To provide the knowledge on different types of weather forecasting
ii. To acquaint the importance of weather forecasting and its applications
iii. To train the students on the ancient weather based agricultural practices

Theory

Ancient wisdom on weather forecasting: Rainfall prediction, analysis and forecast of winter monsoon based on ancient literature and simulated models, Rain forecasting in India Almanacs (Panchangs), Measurement of rainfall, Testing of traditional methods of weather forecast, Ancient astronomers, Indian Almanac (Nakshatras, Rashi, Months, Paksha, Seasons, Tithi, Var, Yog, Karn, Nadi,), Krishi Panchang, Effect of planets on weather, Ancients methods of weather forecast (Analytical methods, Observational methods). Principles of Astro- Meteorology, Rainfall predictions techniques (1) Parashara technique, (2) Varahamihira technique, (3) Predictions based on planets, (4) Bio-indicators, (5) Other ancient rainfall predictions, Sudden rainfall, Indications of famine, The method of ascertaining the type of cloud of the year, Folklore regarding weather forecasting (Ghagh and his wife Bhaddri), (6) ITKs with description and the practitioner for weather forecasting, Meaning and scope of agricultural meteorology, Earth atmosphere-Its composition, extent and structure, Atmospheric weather variables, Atmospheric pressure, its variation with height, Nature and properties of solar radiation, solar constant, depletion of solar radiation, shortwave, longwave and the normal radiation, net radiation, albedo, Atmospheric temperature, temperature inversion, lapse rate, daily and seasonal variations of temperature, vertical profile of temperature, Energy balance of earth, Atmospheric humidity, concept of saturation, vapor pressure, process of condensation, formation of dew, fog, mist, frost, cloud, Precipitation, process of precipitation, types of precipitation such as rain, snow, sleet and hail, cloud formation and

classification, Artificial rain making. Wind: causes and types of wind, cyclone, anticyclone, land breeze and sea breeze, General circulation; Indian Monsoon - mechanism and importance in Indian agriculture, Weather forecasting - types of weather forecast and their uses, ITK in weather forecasting, Weather hazards- High winds, drought, floods, tornado, frost, tropical cyclones, thunderstorms, dust storm, lightning and hailstorms and extreme weather conditions such as heat-wave and cold-wave, Agriculture and weather relations, Modifications of crop microclimate, climatic normal for crop and livestock production, Climate change, climatic variability, global warming, causes of climate change and its impact on regional and national agriculture, Types of climate models – GCM and RCM.

Practical

Visit of Agrometeorological Observatory, site selection, layout, exposure to instruments and data acquisition techniques, Study and use of different instruments for measuring air temperature, rainfall, Estimation of net short-wave radiation, net long wave radiation, total global and net radiation, Measurement of albedo and sunshine duration, wind speed and direction, Measurement of evaporation rate using USWB Class A Open Pan Evaporimeter, Determination of relative humidity and vapour pressure, Study and use of Duvdevani Dew Gauge for measurement of Dew, Computation of climatic normal using historical weather data, Study of ancient methods of weather forecast, Preparation of Krishi Panchang, Testing local folklore for weather forecasting.

Suggested Readings

1. Balkundi H V. 2007. *Measurement of Rainfall in Ancient India. In: Nene Y L (Ed.). Glimpses of the Agricultural Heritage of India*. Asian Agri-History Foundation. 365-372p.
2. Chandrasekaran B, K Annadurai and E Somasundaram. 2010. *A Textbook of Agronomy*. New Age International (P) Limited Publishers. 856p.
3. Choudhary S L, G S Sharma and Y L Nene (Eds). 2000. *Ancient and Medieval History of Indian Agriculture and its Relevance to Sustainable Agriculture in the 21st Century. Proceedings of the Summer School held from 28th May to 17th June 1999,* Rajasthan College of Agriculture, Udaipur, India 363p.
4. Inventory of Indigenous Technical Knowledge in Agriculture. Thematic area: Weather Forecasting. Document 1(2002); Document 2 (2003); Document 2- Supplement 1(2003); Document 2- Supplement 2(2004); Document 3 (2004); Document 4 (2004). ICAR Publication, New Delhi.
5. Kanani P R. 2007. *Testing of Traditional Methods for Weather Forecast in Gujarat. Nene Y L. (Ed.). Glimpses of the Agricultural Heritage of India*. Asian Agri-History Foundation. 373-388p.
6. Mishra S K, Dubey V K and Pandey R C. 2007. *Rain Forecasting in Indian Almanacs (Panchangs): A Case for Making Krishi – Panchang. Nene YL. ed. Glimpses of the Agricultural Heritage of India.* Asian Agri-History Foundation. 354-364p.
7. Murugan M, Miniraj N, Josephraj Kumar A, Pradeep K P and Yusuf L. 2007. *Analysis and Forecast of Winter Monsoon Based on Pre-Vedic Literature and Simulated Model. Nene YL. ed. Glimpses of the Agricultural Heritage of India.* Asian Agri- History Foundation. 344-353p.

8. Ram Niwas, Surinder Singh, Diwan Singh, M L Khichar and Raj Singh. 2006. *A Text Book on Agricultural Meteorology*. CSS HAU, Hisar.

9. Sharma B D. 2007. *Ancient Indian Wisdom on Agriculture and Weather Forecasting. Nene YL. (Ed.). Glimpses of the Agricultural Heritage of India*. Asian Agri-History Foundation. 323-325p.

10. Varshneya M C. 2007. *Ancient and Recent Methods of Rainfall Prediction. Nene YL. (Ed.). Glimpses of the Agricultural Heritage of India*. Asian Agri- History Foundation. 326-343p.

Basic and Applied Agricultural Statistics 3 (2+1)

Objectives

i. To provide an idea on Statistical concepts of both descriptive and inference Statistics

ii. To impart knowledge about tests of significance, ANOVA and sampling theory

Theory

Introduction to Statistics and its applications in agriculture, Types of Data, Scales of measurements of Data, Summarization of Data, Classification of Data, Frequency Distribution, Methods of Classification, Definition of Grouped and Ungrouped Data, Definition of Class Interval (formula for determining the no. of class interval), Width of CI, Class Limits (Boundaries), Mid Points, Types of Frequency Distribution, Diagrammatic Presentation of Data, Bar Diagrams – Simple, Multiple, Sub-divided and Percentage Bar Diagrams, Pie-diagram, Graphical Presentation of Data – Histogram, Frequency Polygon and Ogives.

Measures of Central Tendency, Requisites for an Ideal Measure of Central Tendency, Different Types of Measure, Arithmetic Mean– Definition, Properties, Merits, Demerits and Uses, A.M. (examples) for Grouped and Ungrouped Data, Step-deviation Method, Weighted Mean, Definition of Geometric Mean and Harmonic Mean, Relationship between A.M., G.M. and H.M. Median- Definition, Merits, Demerits and Uses, Graphical Location of Median, Mode- Definition, Merits, Demerits and Uses, Graphical Location of Mode, Relationship between Mean, Median and Mode, Measures of Dispersion, Characteristics for an Ideal Measure of Dispersion, Different Types of Measures of Dispersions, Definition of Range, Interquartile Range, Quartile Deviation and Mean Deviation, Standard Deviation- Definition, Properties, S.D. and Variance for Grouped and Ungrouped Data, Variance of Combined Series, Coefficients of Dispersions. Co-efficient of Variation, Measures of Skewness and Kurtosis: Definition of Symmetrical Distribution, Definition of Skewness, Measures of Skewness, Definition of Kurtosis, Measure of Kurtosis, Relationship between Mean, Median and Mode for Symmetrical and Skewed Distribution.

Probability Theory and Normal Distribution, Introduction to Probability, Basic Terminologies, Classical Probability- Definition and Limitations, Empirical Probability- Definition and Limitations, Axiomatic Probability, Addition and Multiplication Theorem (without proof), Conditional Probability, Independent Events, Simple Problems based on Probability, Definition of Random Variable, Discrete and Continuous Random Variable, Normal Distribution- Definition, Prob. Distribution, Mean and Variance, Assumptions of Normal Distribution, Normal Probability Curve.

Correlation and Regression, Definition of Correlation, Scatter Diagram, Karl Pearson's Coefficient of Correlation, Types of Correlation Coefficient, Properties of Correlation Coefficient, Definition of Linear Regression, Regression Equations, Regression Coefficients, Properties of Regression Coefficients.

Tests of Significance, Definition, Null and Alternative Hypothesis, Type I and Type II Error, Critical Region and Level of Significance, One Tailed and Two Tailed Tests, Test Statistic, One Sample, Two Sample and Paired t-test with Examples. F-test for Variance.

ANOVA and Experimental Designs, Definition of ANOVA, Assignable and Non assignable Factors, Analysis of One-way Classified Data, Basic Examples of Experimental Designs, Terminologies, Completely Randomized Design (CRD).

Sampling Theory, Introduction, Definition of Population, Sample, Parameter and Statistic, Sampling Vs Complete Enumeration, Sampling Methods, Simple Random Sampling with Replacement and without Replacement, Use of Random Number Table.

Practical

Diagrammatic and Graphical representation of data, Calculation of A.M., Median and Mode (Ungrouped and Grouped data), Calculation of S.D. and C.V. (Ungrouped and Grouped data), Correlation and Regression analysis, Application of t-test (one sample, two sample independent and dependent), Analysis of variance one way classification, CRD, Selection of random sample using simple random sampling.

Suggested Readings

1. Singh S P and Verma R P S. 2017. *Agricultural Statistics.* Publishing House.
2. Sahu P K. 2007. *Agriculture and Applied Statistics-I.* Kalyani Publishers.
3. Sahu P K and Das A K. 2009. *Agriculture and Applied Statistics-II*. Kalyani Publishers.
4. Agarwal B L.1998. *Basic Statistics*. New Age International Publishers.
5. Gupta S C and *Kapoor* V K. 2007. *Fundamentals of Applied Statistics*. Sultan Chand and Sons.
6. Elhance D N. 2018. *Fundamentals of Statistics*. Kitab Mahal Publishers.

Semester VIII

S. No.	Course Title	Credit Load
1.	For students opting for 4-year B. Sc. Ag. (Hons.) Natural Farming degree Based on the theme of Student READY Program, students may be allotted Experiential Learning/Hands on Training/Skill development/ RAWE/ Industrial attachment/IPT/ student project and Internship depending upon the resources and priorities.	20 Credits (Minimum 20 weeks)
	RAWE	8
	Experiential Learning	6
	IPT/Industrial Attachment	4
	Student Project/Internship	2

For B.Sc. Ag. (Hons.) Natural Farming

- Project work: Student Project will be either R&D based, field study based (RAWE) or entrepreneurship based (incubation/experiential learning). The project work will be of above mentioned credits (Minimum 20 weeks) during which they will be attached to projects to learn, field experience, laboratory and field research or incubation centres or experiential learning units for developing viable projects.
- Internship work: The students will be attached to industry/ research institute/ commercial farm/ NGO/ agribusiness entrepreneur for 10 weeks with 10 credits to complete internship work and to learn entrepreneurship skills.
- Each student will submit individual report for both project work and internship work which will be evaluated and given grades.

ELECTIVE COURSES

S. No.	Course Number	Title
1.	Ag Econ (E) 413	Agri-Business Management
2.	Agron (E) 413	Management of Natural Resources
3.	EE (E) 413	Agricultural Journalism
4.	Hort (EA) 323	Landscaping
5.	GPB (E) 413	Commercial Plant Breeding
6.	Hort (EB) 323	Food Safety and Standards
7.	PP (EA) 322	Bio-Formulation and Nano formulation
8.	PP (EB) 413	Biopesticides and Biofertilizers
9.	Ag Met (EA) 413	System Simulation and Agro-advisory
10.	Hort (EC) 413	Hi-tech Horticulture
11.	Hort (ED) 413	Protected Cultivation
12.	Ag Met (EB) 413	Climate Resilient Agriculture
13.	ABT(E) 413	Biotechnology of Crop Improvement
14.	Soil (E) 412	Geoinformatics and Remote Sensing, Precision Farming
15.	Hort (EE) 413	Micro-propagation Technologies
16.	SST-413	Commercial Seed Production

- More electives to be included by the universities / institutions, based on the facilities available, such as nano formulations, drones use in agriculture etc

Agri-Business Management 3 (2+1)

Objective

To impart knowledge on understanding the concepts processes, significance and role of management and organizational behavior

Theory

Transformation of agriculture into agribusiness, various stakeholders and components of agribusiness systems, Importance of agribusiness in the Indian economy and New Undergraduate Degree Program in Natural Farming

Agricultural Policy, Distinctive features of Agribusiness Management: Importance and needs of agro-based industries, Classification of industries and types of agro-based industries, Institutional arrangement, procedures to set up agro-based industries, Constraints in establishing agro-based industries, Agri-value chain: Understanding primary and support activities and their linkages, Business environment: PEST and SWOT analysis, Management functions: Roles and activities, Organization culture, Planning, meaning, definition, types of plans, Purpose or mission, goals or objectives, strategies, polices procedures, rules, programs and budget, Components of a business plan, Steps in planning and implementation, Organization staffing, directing and motivation, Ordering, leading, supervision, communications, control, Capital management and Financial management of Agribusiness, Financial statements and their importance, Marketing Management: Segmentation, targeting and positioning, Marketing mix and marketing strategies, Consumer behavior analysis, Product Life Cycle (PLC), Sales and Distribution management, Pricing policy, various pricing methods, Project management: Definition, project cycle, identification, formulation, appraisal, implementation, monitoring and evaluation, Project appraisal and evaluation techniques.

Practical

Study of agri–input markets: Seed, fertilizers pesticides, Study of output markets: grains, fruits, vegetables, flowers, Study of product market, retails trade commodity trading, and value added products, Study of financing institutions- Cooperative, Commercial Bank, RRBs, Agribusiness Finance Limited, NABARD, Preparations of projects and Feasibility reports for agribusiness entrepreneur, Appraisal/ evaluation techniques of identifying viable project- Non-discounting techniques, Case study of agro- based industries, Trend and growth rate of price of agricultural commodities, Net present worth technique for selection of viable project, Internal rate of return,

Suggested Readings

1. Bairwa S L. 2016. *Objective on Fundamentals of Agri-Business Management*. Kalyani Publishers.
2. Broadway A C and Arif A. 2002. *A Textbook of Agri-Business Management*. Kalyani Publishers.

Management of Natural Resources 3 (2+1)

Objectives

i. To enlighten students about available natural resources and their relationship with crop production
ii. To impart the knowledge of principles and practices of natural resource management

Theory

Introduction to Natural Resource Bases: Concept of resource, classification of natural resources, Factors influencing resource availability, distribution and uses, Interrelationships among different types of natural resources, Concern on productivity issues, Ecological, social and economic dimension of resource management, Land resources: Land as a resource, Dry land, land use classification, land degradation, man induced landslides, soil erosion and desertification, Landscape impact analysis, wetland ecology and management, Water resources: Use and over-

utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems, Water ecology and management, Energy resources: Growing energy needs, renewable and non- renewable energy sources, use of alternate energy sources, Resource Management Paradigms: Resource management the evolution and history of resource management paradigms, Resource conflicts: Resource extraction, access and control system, Approaches in Resource Management: Ecological approach; economic approach; ethnological approach; implications of the approaches: integrated resource management strategies, Introduction to soil and water conservation and causes of soil erosion, Definition and agents of soil erosion, Water erosion: Forms of water erosion, gully classification and control measures, Soil loss estimation by universal soil loss equation: Soil loss measurement techniques. Principles of erosion control: Introduction to contouring, strip cropping, Contour bund: Graded bund and bench terracing, Wind erosion: Mechanics of wind erosion, types of soil movement, Principles of wind erosion control and its control measures, Water harvesting techniques: Lining of ponds, tanks and canal systems.

Practical

Identifying natural resources and their utility, Practicing survey: Principles and educating to use pacing technique for measurement, Area calculations through chain survey: GPS demo for tracking and area measurement, Estimation of soil loss and calculation of erosion index, Leveling concepts and practical utility in agriculture, Preparation of contour maps, Concept of vegetative water ways and design of grassed water ways, Wind erosion and estimation process, Different irrigation pumps and their constructional differences, Farm pond construction and its design aspects, Visit to nearby farm pond, Visit to an erosion site, Exposure to strip cropping/contour bunding.

Suggested Readings

1. Rathore Vijay Singh and Rathor B S. 2013. *Management of Natural Resource for Sustainable Development*. Daya Publishing House.
2. Danill R Lynch. 2009. *Sustainable Natural Resource Management.* Cambridge University Press.

Agricultural Journalism 3 (2+1)

Objective

To acquaint the qualities and role of journalist /journalism in agricultural development and development of media

Theory

Journalism–Meaning, nature, importance and types of journalism, Agricultural Journalism–Meaning, definition, principle, objectives, types, and scope, Similarities and difference between agricultural journalism and other types of journalism, Role of agricultural journalist, Training of agricultural journalist, Qualities of journalist, Role of journalist /journalism in agricultural development and development of newspaper and magazines readers, Newspaper and magazines as communication media: Characteristics, kinds and functions of newspaper and magazines, Characteristics of newspaper and magazines readers, Form, content, style and language of newspaper and magazines, Standard part of newspaper and magazines, The agricultural story: Types of agriculture stories, subject matter of the agricultural story, structure of the agricultural story, Gathering farm information - Sources of farm information: abstracting from research and scientific

materials, interviews, coverage of events, other sources: electronic media, field study. Success stories-definition, nature, components, guidelines of writing a success story, Writing a news story difference between news and feature story, the principle of writing a news story, Inverted pyramid structure, Organizing the material, treatment of the story, writing the news lead and the body Readability measure-readability ease score, automated readability index, gunning fog index, How to improve readability of articles and stories, Use of photograph in agricultural journalism- Basic principles of photography – composition, exposure, lens, light Use of artwork (Graphs, charts maps, etc), Writing the captions, Editorial mechanism: Copy reading, headline and title writing Proof reading: definition, signs and symbols of proofreading, level of proofreading, duties of a proof-reader, Layout– Meaning, principles of layout and design.

Practical

Practice in writing an agricultural news story, Practice in writing an agricultural feature story, Covering agricultural events for the information collection, Practice in interviewing for the information collection, Abstracting stories from research and scientific materials and wire services, Selecting pictures and artwork for the agricultural story, Practice in editing, copy reading, Practice in headline and title writing, Practicing proof reading,, Practice in lay outing of newspaper, Testing copy with a readability formula, Visit a publishing office.

Suggested Readings

1. Singh A K. 2014. *Agricultural Extension and Farm Journalism.* Agrobios.
2. Parthasarathy Rangaswami. 1984. *Basic Journalism*. Macmillan India Limited.
3. Jana Balai Lal and Mitra Kanai Prasad.2005. *Farm Journalism*. Agrotech Pub. Academy.
4. Bhaskaran C. 2008.*Farm Journalism and Media Management*. Agrotech Publishing Academy
5. Carole Fleming, Emma Hemmingway and Gillian Moore. 2006. *Introduction to Journalism.* Sage Publications Ltd (UK)
6. Shrivastava K M. 2015. *News Reporting and Editing, Book.* Sterling Publishers Pvt. Ltd.
7. Kamath M V. 1980. *Professional Journalism. Book*. Vikas Publishing House.
8. Kamath M V. 2018. *The Journalist's Handbook. Book*. Sangam Books Ltd.

Landscaping 3 (2+1)

Objectives

i. To educate the students on designing different styles and types of gardens
ii. To enable the students to identify different ornamental plants and their utilization in landscaping design
iii. To enable students to design landscapes in softwares like AUTOCAD, ARCHCADE etc.

Theory

Importance and scope of landscaping, Principles of landscaping, garden styles and types terrace gardening, vertical gardening, garden components, adornments, lawn making, rockery water garden, walk-paths, bridges, other constructed features etc. gardens for special purposes, Trees: Selection, propagation, planting schemes, canopy management, shrubs and herbaceous perennials:

selection, propagation, planting schemes, architecture, Climber and creepers importance, selection, propagation, planting, Annuals: selection, propagation, planting scheme, Other garden plants: palms, ferns, grasses and cacti succulents, Pot plants: selection, arrangement, management, Bio-aesthetic planning: Definition, need, planning; landscaping of urban and rural areas, Peri-urban landscaping, Landscaping of schools, public places like bus station, railway station, townships, river banks, hospitals, play grounds, airports, industries, institutions, Bonsai principles and management, Lawn: establishment and maintenance. CAD application.

Practical

Identification of trees, shrubs, annuals, pot plants; Propagation of trees, shrubs and annuals, care and maintenance of plants, potting and repotting, identification of tools and implements used in landscape design, training and pruning of plants for special effects, lawn establishment and maintenance, layout of formal gardens, informal gardens, special type of gardens (sunken garden, terrace garden, rock garden) and designing of conservatory and lathe house. Use of computer software, visit to important gardens /parks /institutes.

Suggested Readings

1. Chandrasekhar S Y and Naik B Hemla. 2020. *Principles of Landscape Gardening*. ICAR Publication, New Delhi.
2. Singh Anil K and Sisodia Anjana. 2020. *Textbook of Floriculture and Landscaping*. New India Publishing Agency.

Commercial Plant Breeding 3 (2+1)

Objectives

i. To discuss about hybrid development and various crop improvement aspects of field crops viz., rice, wheat, maize, pearl millet, sorghum, pigeonpea, chickpea, green-gram, black gram, lentil, soybean, groundnut, rapeseed- mustard, cotton etc.
ii. To provide understanding on tissue culture and biotechnological approaches as alternative strategies for development of line and cultivars
iii. To impart knowledge on seed production, release and notification of varieties and PPV&FR Act, 2001

Theory

Types of crops and modes of plant reproduction, Line development and maintenance breeding in self- and cross- pollinated crops (A/B/R and two line system) for development of hybrids and seed production, Genetic test of commercial hybrids, Advances in hybrid seed production of maize, rice, sorghum, pearl millet, castor, sunflower, cotton pigeon pea, Brassica etc. Quality seed production of vegetable crops under open and protected environment, Alternative strategies for the development of the line cultivators: haploid inducer, tissue culture techniques and biotechnological tools, IPR issues in commercial plant breeding: DUS testing and registration of verities under PPV and FRA Act, Variety testing, release and notification systems in India, Principles and techniques of seed production, types of seeds, quality testing in self and cross pollinated crops.

Practical

Floral biology in self and cross pollinated species, selfing and crossing techniques, Techniques of seed production in self and cross pollinated crops using A/B/R and two line system, Learning techniques in hybrid seed production using male- sterility in field crops, Understanding the difficulties in hybrid seed production, Tools and techniques for optimizing hybrid seed production, Concept of rouging in seed production plot, Concept of line its multiplication and purification in hybrid seed production, Role of pollinators in hybrid seed production, Hybrid seed production techniques in sorghum, pearl millet, maize, rice, rapeseed-mustard, sunflower, castor, pigeon pea, cotton and vegetable crops, Sampling and analytical procedures for purity testing and detection of spurious seed, Seed drying and storage structure in quality seed management, Screening techniques during seed processing viz. grading and packaging, Visit to public and private seed production and processing plants.

Suggested Readings

1. Poehlman J M. 2013. *Breeding Field Crops*. Springer Science & Business Media.
2. Singh Phundan, Bisen Pratibha and Tiwari Reshu. 2021. *Commercial Plant Breeding at a Glance*. Daya Publishing House.
3. Singh B D. 2022. *Plant Breeding: Principles and Methods*. Kalyani Publishers.
4. Allard R W. 1999. *Principles of Plant Breeding*. (1st & 2nd Edn.). John Wiley & Sons.

Food Safety and Standards 3 (2+1)

Objectives

i. To develop the skills to convert raw materials into safe, attractive food products
ii. To manage the production of food products
iii. To use scientific knowledge to develop new products

Theory

Food safety –Definition, Importance, Scope and Factors affecting Food Safety, Hazards and Risks, Type of Hazards - Biological, Chemical Physical hazards, Management of hazards – Need, Control of Parameters, Temperature Control, Food Storage, Production Design, Hygiene and Sanitation in Food Service Establishments- Introduction. Sources of contamination and their control, Waste Disposal, Pest and Rodent Control, Personnel Hygiene, Food safety Measures, Food Safety Management Tool- Basic concepts, PRPs, GHPs, GMPs, SSOPs etc. HACCP.ISO series, TQM- Concept and need for quality, components of TQM, Kaizen, Risk Analysis, Accreditation and Auditing, Water Analysis, Surface Sanitation and Personal Hygiene, Food laws and Standards Indian Food Regulatory Regime, FSSAI. Global Scenario CAC, Other laws and standards related to food, Recent Concerns-New and Emerging Pathogens, Packaging, Product labelling and nutritional labelling, Genetically modified food/transgenic, Organic foods, Newer approaches to food safety, Recent Outbreaks, Indian and International Standards for food products.

Practical

Water quality analysis: physio–chemical and microbiological, Preparation of different types of media, Microbiological examination of different food samples, Assessment of surface sanitation by swab/rinse method, Assessment of personal hygiene. Biochemical tests for identification of bacteria, Scheme for the detection of food borne pathogens, Preparation of plants for implementation of FSMS- HACCP, ISO: 22000.

Suggested Readings

1. Sharma Avantina. 2017. *Text book of Food Science and Technology*. CBS Publishers & Distributors.

Bioformulation and Nano-formulation 3 (2+1)

Objectives

i. To enable students to acquire expertise and skill to develop bioformulation and Nano-formulation
ii. To know the importance of biopesticides and biofertilizers
iii. To make the students know about various techniques involved in biofertilizers and biopesticides production
iv. To get knowledge on essential oils, botanicals, predators, parasitoids, Pheromones, and parapheromone and their application in insect-pest management
v. To get concepts on agrochemical formulations with nanoparticles and acquaint them with nanotechnology

Theory

Introduction and history of biological control of pests and diseases, Microbial biopesticides: the global and Indian market scenario; biopesticides for organic agriculture, Different phytopathogenic biocontrol agents: Mode of action, Different entomopathogenic biocontrol agents: Mode of action, Microbial inoculants as biofertilizer candidates, Production, quality assessment and methods of application of biopesticides and biofertilizers, Regulatory system of biopesticides in India, Formulations of plant essential oils, botanicals, Pheromone, and parapheromone and their application in insect pest management, Use of predators and parasitoids for insect pest management, Nanotechnology: Its applications in pest and disease diagnosis and management, Nano biopesticides: Concept and importance, different techniques of producing nano biopesticides, Nano fertilizers: Concept and importance, Types of nano fertilizers, Different techniques of producing nano fertilizers, Green synthesis of nano fertilizers, green slow-release fertilizer composition based on urea-modified hydroxyapatite nanoparticles

Practical

Introduction and acquaintance with biopesticide laboratory, Preparation of culture media, Isolation and purification of bioagent from soil and infected insects, Microscopic study of different microbial bioagents, *In vitro* assay of microbial bioagents against plant pathogens.

In vitro compatibility study among different microbial bioagents, Mass multiplication of biopesticides, Population enumeration of biocontrol agents in different biopesticides, Preparation of plant extracts and their efficacy test against insect pests, Use of pheromone parapheromone for monitoring and management of insect pests, Bioassay of Entomopathogenic biocontrol agents on insect-pests, Preparation of microbial inoculants of biofertilizer microbes, Compatibility of biofertilizer microbes, Preparation of solid and liquid consortia of biofertilizer microbes.

Suggested Readings

1. Allhoff Fritz and Lin Patrick (Eds). 2009. *Nanotechnology and Society.* ISBN: 978-1-4020-6208-7 Springer Publications, UK.
2. Baker E F and James R C. 1982. *Biological Control of Plant Pathogens*. American Phytopathological Society.
3. Boland G J and David L.1998. *Plant Microbe Interactions and Biological Control*. Kuykendall Marel Dekker, INC.
4. Borkar S G. 2015. *Beneficial Microbes as Biofertilizers and its Production Technology.*
5. Ciancia A and Mukerji K J. 2007. *General Concepts of Integrated Pest and Disease Management.* Edited Published by Springer.
6. Cincholkar S B and Mukherji K G. 2007. *Biological Control of Plant Diseases*. Hawarth Food and Agricultural products.
7. Gnanamanickam S S. 2002. *Biological Control of Crop Disease*. Kuykendall Marel Dekker, INC.
8. Ramanujam B and Rabindra R J. 2006. *Current Status of Biological Control of Plant Disease using Antagonistic Organisms in India*. Precision Fototype Services Bengaluru.
9. Singh S P and Hussanini S S. 1998. *Biological Suppression of Plant Disease, Phytoparasitic Nematodes and Weeds. P*recision Fototype Services Bengaluru.

Biopesticides and Biofertilizer 3 (2+1)

Objectives

i. To provide knowledge on principles, methods, and mechanisms of bio-control agents and their use against plant diseases

ii. To provide knowledge on principles, methods, and mechanism of biofertilizers and their use in agriculture

Theory

History and concept of bio pesticides, Importance, scope and potential of biopesticides, Definitions, concepts and classification of biopesticides viz. Pathogen, botanical pesticides, and bio rationales. Botanicals and their uses. Mass production technology of bio-pesticides, Virulence, pathogenicity and symptoms of entomopathogenic pathogens and nematodes, Methods of application of biopesticides. Methods of quality control and Techniques of bio pesticides. Impediments and limitation in production and use of biopesticides.

Biofertilizers - Introduction, status and scope. Structure and characteristics features of bacterial biofertilizers – *Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium* and *Frankia*; Cynobacterial bio fertilizers- *Anabaena, Nostoc, Hapalosiphon* and fungal biofertilizers – AM mycorrhiza and ectomycorhiza. Nitrogen fixation –Free living and symbiotic nitrogen fixation. Mechanism of phosphate solubilisation and phosphate mobilization, K solubilisation. Production technology: Strain selection, sterilization, growth and fermentation, mass production of carrier based and liquid biofertizers, FCO specifications and quality control of biofertilizers. Application technology for seeds, seedlings, tubers, sets etc. Biofertilizers: Storage, shelf life, quality control and marketing. Factors influencing the efficiency of biofertilizers.

Practical

Isolation and purification of important biopesticides: *Trichoderma, Pseudomonas, Bacillus, Metarhyzium* etc. and its production, Identification of important botanicals, Visit to biopesticide laboratory in nearby area, Field visit to explore naturally infected cadavers, Identification of entomopathogenic entities in field condition, Quality control of biopesticides, Isolation and purification of *Azospirillum, Azotobactor, Rhizobium,* P-solubilizers and cyanobacteria, Mass multiplication and inoculums production of biofertilizers, Isolation of AM fungi- Wet sieving method and sucrose gradient method, Mass production of AM inoculants**.**

Suggested Readings

1. Baker E F and James R C. 1982. *Biological Control of Plant Pathogens*. American Phytopathological Society.
2. Boland G J and David L.1998. *Plant Microbe Interactions and Biological Control.* Kuykendall Marel Dekker, INC.
3. Borkar S G. 2015. *Beneficial Microbes as Biofertilizers and its Production Technology.*
4. Ciancia A and Mukerji K J. 2007. *General Concepts of Integrated Pest and Disease Management.* Edited Published by Springer.
5. Cincholkar S B and Mukherji K G. 2007. *Biological Control of Plant Diseases*. Hawarth Food and Agricultural Products.
6. P C Trivedi. 2015. *Fungal Biopesticides and VAM Applications.* Pointer Publishers, Jaipur, India
7. Gnanamanickam S S. 2002. *Biological Control of Crop Disease.* Kuykendall Marel Dekker, INC.
8. Singh Awani Kumar. 2018. *Handbook of Microbial Biofertilizers.* Agrotech Press, Jaipur, India
9. Singh A K. 2015. *Organic Farming*. New India Publishing Agency, New Delhi.
10. Gehlot Dushyent. 2005. *Organic Farming: Standards, Accreditation, Certification and Inspection.* Agrobios (India).
11. Ramanujam B and Rabindra R J. 2006. *Current Status of Biological Control of Plant Disease using Antagonistic Organisms in India*. Precision Fototype Services Bengaluru.
12. Singh S P and Hussanini S S. 1998. *Biological Suppression of Plant Disease, Phytoparasitic Nematodes and Weeds*. Precision Fototype Services Bengaluru.

System Simulation and Agro-advisory 3 (2+1)

Objectives

i. To impart the knowledge of statistical and simulation modelling in crop yield estimation
ii. To get acquainted with different weather forecasting techniques and their usability analysis
iii. To study about the preparation and dissemination of agro-advisory bulletin

Theory

System Approach for representing soil-plant-atmospheric continuum, system boundaries, Crop models, concepts and techniques, types of crop models, data requirements, relational diagrams, Evaluation of crop responses to weather elements; Elementary crop growth models: Calibration, validation, verification and sensitivity analysis, Potential and achievable crop production- concept and modelling, techniques for their estimation, Crop production in moisture and nutrients limited conditions; components of soil water and nutrients balance, Weather forecasting, types methods, tools and techniques, forecast verification; Value added weather forecast, ITK for weather forecast and its validity; Crop- Weather Calendars; Preparation of agro-advisory bulletin based on weather forecast, Use of crop simulation model for preparation of Agro-advisory and its effective dissemination.

Practical

Preparation of crop weather calendars, Preparation of agro-advisories based on weather forecast using various approaches and synoptic charts, Working with statistical and simulation models for crop growth, Potential and achievable production; yield forecasting, insect and disease forecasting models, Simulation with limitations of water and nutrient management options, Sensitivity analysis of varying weather and crop management practices, Use of statistical approaches in data analysis and preparation of historical, past and present meteorological data for medium range weather forecast, Feedback from farmers about the agro-advisory.

Suggested Readings

1. Rao, VUM Rao, Subba Rao AVM, Rao GGSN, Ramana Rao B V, P Vijaya Kumar and Venkateswarlu B. (Eds.). 2010. *Advances in Plant Atmospheric Interactions Central Research Institute for Dryland Agriculture* (CRIDA), Santoshnagar, Hyderabad.
2. Prasado Rao G S L H V. 2010. *Agricultural Meteorology*. PHI Learning Pvt. Ltd.
3. Mavi H S. 2018. *Introduction to Agrometeorology*. Oxford & IBH Publishing Company.
4. Bishnoi O P. 2007. *Principles of Agricultural Meteorology*. Oxford Book Company.
5. Varshneya M C and Pillai P B.2003. *Text Book of Agricultural Meteorology*. ICAR Publication, New Delhi.

Hi-tech Horticulture 3 (2+1)

Objective

Theory

Introduction and importance; Nursery management and mechanization; micro propagation of horticultural crops; Modern field preparation and planting methods, Protected cultivation:

advantages, controlled conditions, method and techniques, Micro irrigation systems and its components; EC, pH based fertilizer scheduling, canopy management, high density orcharding, Components of precision farming : Remote sensing, Geographical Information System (GIS), Differential Geo- Positioning System (DGPS), Variable Rate Applicator (VRA), application of precision farming in horticultural crops (fruits, vegetables and ornamental crops); mechanized harvesting of produce.

Practical

Types of polyhouses and shade net houses, Intercultural operations, tools and equipments identification and application, Micro propagation, Nursery- Portrays, micro-irrigation, EC, pH based fertilizer scheduling, canopy management, visit to hi-tech orchard/nursery.

Suggested Readings

1. Prasad S. 2020. *Hi-tech Horticulture*. Agrobios Pearson.
2. Paul V Nelson.2003. *Greenhouse Operation and Management*. Prentice Hall.

Protected Cultivation 3 (2+1)

Objectives

i. To educate the students on different protected structures
ii. To educate the students on agro-techniques and management of different horticultural crops under protected environmental conditions

Theory

Protected cultivation: Importance and scope, status of protected cultivation in India and World types of protected structure based on site and climate, Cladding material involved in greenhouse/poly house, Greenhouse design, environment control, artificial lights, Automation, Soil preparation and management, Substrate management, Types of benches and containers, Irrigation and fertigation management, Propagation and production of quality planting material of horticultural crops, Greenhouse cultivation of important horticultural crops-rose, carnation, chrysanthemum, gerbera, orchid, anthurium, lilium, tulip, tomato, bell pepper, cucumber, strawberry, pot plants etc. Cultivation of economically important medicinal and aromatic plants, Off- season production of flowers and vegetables, Insect pest and disease management.

Practical

Raising of seedlings and saplings under protected conditions, use of portrays in quality planting material production, Bed preparation and planting of crop for production, Inter cultural operations, Soil EC and pH measurement. Regulation of irrigation and fertilizers through drip, fogging and misting.

Suggested Readings

1. Paul V Nelson. 2011. *Green House Operation and Management*. (7th Edn.). Pearson.
2. Jha Madan K, Paikra Sujan Singh and Sahu Manju Rani. 2019. *Protected Cultivation of Horticultural Crops.* Educreation Publishing.

Climate Resilient Agriculture 3 (2+1)

Objectives

i. To impart the concept of climate resilient agriculture under the present context of climate change

ii. To study the integrated role of different sectors in building resilience to climate change in agriculture

Theory

Climate change and impacts of climate change on agriculture and food security; crop productivity under different climate change scenarios including extreme events such as drought, flood, pest and disease outbreak etc. Basics of adaption and mitigation in the agricultural sectors; analyzing and assessing climate vulnerability to identify vulnerable sectors and possible adaptation options in agriculture; assessing biophysical and socio- economic impacts on agricultural sector; risk assessment strategies, preparedness for weather and climate risks in agriculture; application of geospatial tools and techniques for sustainable agriculture.

Climate resilient agriculture (CRA) – Concept, scope and importance with special reference to India, climate resilient technologies for enhancing crop productivity and sustainability, Role of weather and climatic information, agro-advisories, ICTs and simulation models; climate resilient agronomic practices – Crop/cultivar selection, crop diversification/ crop mixtures; Water management practices – Rain water harvesting, micro-irrigation, deficit irrigation and drainage management, organic/natural farming, integrated farming systems (IFS); site specific nutrient management (SSNM), conservation agriculture technologies to build soil organic carbon, harnessing microbial biodiversity, biomass recycling; use of renewable sources of energy; climate resilient pest-disease management strategies.

Breeding strategies for development of climate change resilient crops and varieties, development of biotic and abiotic stress tolerant/resistant cultivars under changed climatic scenarios including extreme weather events.

Practical

Acquaintance with meteorological instruments including AWS, Statistical techniques to study trend of climatic parameters, Analysis of extreme weather events using non- parametric tests, Building climate change scenarios under different futuristic emission of GHGs, Designing strategies to mitigate the effect of climate change using climate resilient crops/cultivars, climate resilient technologies and manipulation of cropping patterns, Acquaintance with ICTs for effective dissemination of local weather information and agro- advisories, Analysing carbon sequestration potential of different agro-ecosystems; Designing climate smart village model considering the availability of resources. Awareness program on climate change and climate resilient agriculture among farming community.

Suggested Readings

1. Prasada Rao GSLHV. 2018. *Climate Resilient Animal Agriculture* (New India Publishing Agency).

2. Bhan Manish. 2018. *Climate Resilient Agriculture: Adaptation and Mitigation Strategies.* New India Publishing Agency.

3. FAO. 2013. *Climate-Smart Agriculture Source Book.*

Biotechnology of Crop Improvement 3 (2+1)

Objectives

i. To acquaint with biotechnological tools of crop improvement

ii. To know about direct and indirect methods of gene transfer

iii. To introduce about gene editing in plants

iv. To provide knowledge about marker assisted breeding and genomic selection

Theory

Impact of biotechnology on crop improvement and the perspective of society: Various biotechnological techniques available for crop improvement – Plant Tissue Culture, Genetic Engineering, Genome editing, Marker Assisted breeding and Genomic Selection, Biosafety regulations and their application in Agricultural Biotechnology, Soma clonal variation and its use in crop improvement: embryo culture, anther/pollen culture, somatic embryogenesis, artificial seeds, techniques of protoplast culture, regeneration and somatic cell hybridization, achievements and limitations, utility in the improvement of crop plants, Direct and Indirect methods of gene transfer in plants - Agrobacterium-mediated gene transfer in dicots and monocots, Direct DNA delivery methods (microinjection, particle gun method, electroporation), gene targeting, Gene silencing techniques, introduction to siRNA, siRNA technology, Micro RNA, construction of siRNA vectors, principle and application of gene silencing, creation of transgenic plants, debate over GM crops, introduction to methods of genetic manipulation in different model systems.

Introduction to genome editing: Various tools of genome editing, CRISPR-Cas9 with specific emphasis on Indian regulations, Cloning genomic targets into CRISPR/Cas9 plasmids, electroporation of Cas9 plasmids into cells, purification of DNA from Cas9 treated cells and evaluation of Cas9 gene editing, *in vitro* synthesis of single guide RNA (sgRNA), using Cas9/sgRNA complexes to test for activity on DNA substrates, evaluate Cas9 activity by T7E1 assays and DNA sequence analysis, Applications of CRISPR/cas9 technology in crop plants, Marker Assisted Breeding and Genomic Selection: Introduction to various DNA- based markers and their use in marker-assisted breeding, Foreground Selection, Recombinant Selection and background Selection, Marker-assisted backcross breeding, marker-assisted selection – success stories, Introduction to Genomic Selection.

Practical

Agrobacterium-mediated transformation in tobacco – Preparation of construct, transfer to binary vector, transform *Agrobacterium*, prepare explant, Inoculation and Co-cultivation, antibiotic based selection of putative transformants, validation using PCR; Genome editing-Preparation of CRISPR/Cas construct, direct transfer to plant, analysis of the targets, Planning of a MABB program–Selection of parents, crossing strategies, marker analysis.

Suggested Readings

1. Brown T A. 2006. *Genomes.* (3rd Edn.). New York: Garland Science Pub.
2. Gene Cloning and DNA Analysis. 2010. Retrieved from http:// biolab.szu.edu.cn/ other web/ lzc/genetic%20engineering/courseware/b1.pdf.
3. Green M R and Sambrook J. 2012. *Molecular Cloning: A Laboratory Manual. Cold Spring Harbor* NY: Cold Spring Harbor Laboratory Press.
4. Old R W, Primrose S B and Twyman R M. 2001. *Principles of Gene Manipulation and Genomics.* (7th Edn.). Oxford: Blackwell Scientific Publications.
5. Sander J D and Joung J K. 2014. *CRISPR-Cas Systems for Editing, Regulating and Targeting Genomes*. Nat Biotechnol. 32:347-355.

Geoinformatics and Remote Sensing, Precision Farming 3 (2+1)

Objective

To provide a comprehensive knowledge of remote sensing, precision farming and its benefits in improving crop production and soil health management.

Theory

Introduction and history of remote sensing; sources, principles of remote sensing, propagation of radiations in atmosphere; Interaction with matter, application of remote sensing techniques land use soil surveys, crop stress and yield forecasting, Advantages and disadvantages of remote sensing, Remote sensing institutes in India, Basic concepts about geoinformatics.

Artificial intelligence: History of artificial intelligence, Fundamentals of Big data and machine learning (ML), Use of artificial intelligence in autonomous systems: agricultural robots and drone monitoring systems, driverless tractors, automated sprinklers and self- harvesting machines etc.; Use of AI in crop analysis: monitoring soil quality, promoting organic crops, monitoring weeds, precision agriculture, using drones for crop analysis; Role of AI for sustainability and climate change, yield and demand forecasting, food tech/ wider value chain including impact of blockchain, AI use for in the emerging markets; Technology deployment like sensors, AI and agricultural technologies and How to scale AI for agricultural technologies applications, Responsible AI in agriculture, Data sharing; Expert System: Introduction to expert system, Characteristics and features of expert system, Applications of Expert System, Importance of Expert systems, Rule based system architecture; Software Agents.

Practical

Familiarization with different remote sensing equipments and data products, Interpretation of aerial photographs and satellite data for mapping of land resources, Global positioning system (GPS), Basics of Geographic Information System (GIS), Georeferencing of topo sheets.

Live examples and case study of AI use in Agriculture, Search and Control strategies: Blind search, Breadth - first search, Depth First search, Hill climbing method, Best First search, Branch and Bound search, Programming in Prolog Syntax and meaning of Prolog Programs, Using Data Structures, Controlling Back- tracking, Input and Output, Built-in Predicates, Using Prolog Grammar Rules, Higher level assignments/exercises for implementation using Prolog.

Suggested Readings

1. Satpathy Rabinarayan, Choudhary Tanupriya, Satpathy Suneeta, Nandan Sachi. *(Eds.)*. 2021. *Data Analytics in Bioinformatics: A Machine Learning Perspective. Editor (s): Wiley-Scrivener.*
2. Zheng Rong Yang. *Machine Learning Approaches to Bioinformatics*. orld Scientific Publishing Co Pte Ltd.
3. A El- Kader, M Sherine, M El-Basioni, M Basma. 2020. *Precision Agriculture Technologies for Food Security and Sustainability.* IGI Global.
4. Anji Reddy M. 2012. *Text Book of Remote Sensing and Geographical Information Systems.* BS Publications/BSP Books.

Micro-propagation Technologies 3 (2+1)

Objective

To educate the students in detail about the sterilization techniques for explants, preparation of stocks and working solution, culturing of explants, regeneration of whole plants from different explants and hardening procedures

Theory

Introduction, History, Advantages and limitations. Types of cultures (seed, embryo, organ, callus, cell), Stages of micro propagation, Axillary bud proliferation (Shoot tip and meristem culture, bud culture), Organogenesis (callusy and direct organ formation), Somatic embryogenesis, cell suspension cultures, production of secondary metabolites, Soma clonal variation, Cryopreservation.

Practical

Identification and use of equipment's in tissue culture Laboratory, Nutrition media composition, sterilization techniques for media, containers and small instruments, sterilization techniques for explants, Preparation of stocks and working solution, Preparation of working medium, Culturing of explants: Seeds, shoot tip and single node, Callus induction, Induction of somatic embryos regeneration of whole plants from different explants, Hardening procedures.

Suggested Readings

1. Singh Jitendra. 2014. *Basics of Horticulture*. Kalyani Publishers.
2. Kumar N. 2018. *Introduction to Horticulture*. Medtech a Division of Scientific International, Engaging Sciences- Developing Minds.
3. Chadda K L. 2001. *Handbook of Horticulture.* Directorate of Information and Publications of Agriculture, ICAR Publication, New Delhi.

Commercial Seed Production 3 (2+1)

Objective

To introduce the basic principles of planting material production at commercial scale and seed quality evaluation

Theory

General Principles of Seed Production**:** Raising the seed crop, Introduction, Procurement of a class of Improved seeds, Reporting to Monitoring or certification Agency, Principles and practices of selection of area and agronomic requirement of seed production of field crops, Importance of isolation distance and rouging, Principles of hybrid seed production in field crops, Principles and practices of selection of area and agronomic requirement of seed production of horticultural crops, Concept of apomixis, male sterility and self-incompatibility and its application in hybrid seed production of horticultural crops.

General Principles of Seed Processing: Introduction, Objectives of Seed Processing, Seed Drying, Principles of Drying, Water vapour equilibrium, Methods of drying seeds, Cleaning and grading, Air and screen machines, Dimensional separators, Density separators, Surface texture separators, Colour separators, Spiral separators, Electric separators, Vibrator separators, Separation based on Affinity to liquids, Seed treatment, Temperature treatment, Chemical treatment, Bagging and Labelling

General Principles of Seed Testing: Seed testing-introduction, Procedure of Seed testing, components of seed quality testing genetic, physical, physiological and seed health testing, Seed sampling, Types of seed sampling, Requirements of sampling, Concept of seed viability and vigour; dormancy, types and principles of seed dormancy, Physiological quality of seed, Principles of seed germination, types of germination, biochemical and genetic basis.

Seed Certification: History, concept and objectives of seed certification; seed certification agency/organization and staff requirement Indian Minimum Seed Certification Standards (I.M.S.C.S.) - General and specific crop standards including GM varieties, field and seed standards.

Seed Industry and Seed Marketing : Introduction, Evolution of the seed industry, Development of the vegetable and Flower seed industry, Seed marketing – Concept, definition and purpose, importance and promotion of quality seed, formal and informal seed supply systems, Seed marketing intelligence and product mix, sales promotion, distribution channels, marketing costs and margins; packaging and labeling, Seed Associations, Factors influencing seed marketing, Seed marketing programs, Seed industry organizations, Marketing of public versus private players, Demand and supply of seed; role of seed replacement rate (SRR), seed multiplication ratio (SMR), economics of seed production; determining seed needs, Seed pricing and price policy, seed processing and / packaging, demand forecasting and factors affecting demand for seeds, effect of price and farm income on seed demand.

Biotechnology in Seed Technology: History of plant tissue culture, Laboratory organization, Composition of nutrient medium, Micro-propagation, Axillary bud proliferation approach, Meristem and shoot tip culture, Bud culture, Advantages of Micro-propagation, Problems associated with micro-propagation, Synthetic seed production, Types of synthetic seeds, methods of development of synthetic seeds, Components of nutrient media for synthetic seed development**,** Storage of synthetic seeds, Advantages and limitations of synthetic seed production.

Practical

Planning of seed production, requirements for different classes of seeds in field crops – unit area and rate.

Operation and handling of mechanical drying equipment; effect of drying temperature and duration on seed germination and storability seed processing equipment; seed treating equipment.

Seed production in cross pollinated crops with special reference to land, isolation, Planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony; supplementary pollination, pollen storage, hand emasculation and pollination in tomato, Hybrid seed production in Maize, detasseling in maize, identification of rogues and pollen shedders, Pollen collection, storage, viability and stigma receptivity; gametocide application and visits to seed production plots etc., Visit to seed processing plant and commercial controlled and uncontrolled seed stores, Seed industries and local entrepreneurships visit to nearby areas, Different methods of examination of seeds to assess seed-borne microorganisms and to quantify infection percentage, detection of seed borne fungi, bacteria and viruses, identification of storage fungi, control of seed borne diseases, seed treatment methods., Maintenance of aseptic conditions and sterilization techniques, Preparation of nutrient stocks for synthetic media, Selection of explants for callus induction, Preparation of MS medium for micro-propagation and Callus induction, Selection of explants for callus induction, Preparation of MS medium for micro-propagation and Callus induction, Inoculation of explants for micro-propagation, Inoculation of explants for callus induction and subsequently regeneration of plantlets from matured seeds of field and horticultural crops, Synthetic seed preparation.

Suggested Readings

1. Agarwal R L. 1997. *Seed Technology.* (2nd Edn.). Oxford and IBH.
2. Chawla H S. 2008. *Introduction to Plant Biotechnology.* (2ndEdn.). Oxford &IBH publishing Co. Ltd. 113-B Shahpur Jat, New Delhi.
3. Justice O L and Bass L N. 1978. *Principles and Practices of Seed Storage*. Castle House Publ. Ltd.
4. McDonald M B Jr and Copeland L O. 1997. *Seed Production: Principles and Practices*. Chapman and Hall.
5. Singhal N C. 2003. *Hybrid Seed Production in Field Crops*. Kalyani.
6. Thompson J R. 1979. *An Introduction to Seed Technology*. Leonard Hill.
7. Tunwar N S and Singh S N. 1988. Indian Minimum Seed Certification Standards. CSCB, Ministry of Agriculture, New Delhi.

SKILL ENHANCEMENT COURSES

A student admitted into 1st year of B.Sc. Ag. (Hons.) Natural Farming degree program will take 2 skill enhancement courses each of 2 credits in each semester of first year. Likewise, the student continuing his/her study into 2nd year of B.Sc. Ag. (Hons.) Natural Farming will undergo one skill enhancement course each of 2 credits in each of the two semesters of 2nd year.

The student can select these courses from a basket of skill enhancement courses as indicated below or courses offered by a College. The courses may be offered as module of complementing

courses to help the student to achieve skill in a specific area of his interest. A college will select such skill enhancement courses in which it has strength as well as there is prospect of local employment and entrepreneurship development.

Indicative List of Skill Enhancement Courses

S. No.	Course Title	Credits
1.	Natural Farming for Crops, Vegetables and Orchard	2 (0+2)
2.	Production Technology of Bio-inputs	2 (0+2)
3.	Business Management in Natural Farming	2 (0+2)
4.	Seed Production and Certification under Natural Farming	2 (0+2)
5.	Agro-Eco Tourism in Natural Farming	2 (0+2)
6.	Animal Feed Management under Natural Farming	2 (0+2)
7.	Analytical Techniques and Instrumentation for Soil Health Card	2 (0+2)
8.	Landscape Designing and Gardening	2 (0+2)
9.	Self Sustainable Kitchen Gardening	2 (0+2)
10.	Commercial Bee-Keeping under Natural Farming	2 (0+2)
11.	Commercial Sericulture	2 (0+2)
12.	Beneficial Insect Farming	2 (0+2)
13.	Bio-fertlizer and Biopesticide (Microbials) Production	2 (0+2)
14.	Production Technology of Biocontrol Agents	2 (0+2)
15.	Mushroom Production Technology	2 (0+2)
16.	Post-harvest Processing Technology	2 (0+2)
17.	Plantation Crop Production and Processing	2 (0+2)
18.	Poultry Production Technology	2 (0+2)
19.	Piggery Production Technology	2 (0+2)
20.	Commercial Horticulture	2 (0+2)
21.	Floriculture and Landscaping	2 (0+2)
22.	Natural Food Processing	2 (0+2)
23.	Agriculture Waste Management	2 (0+2)
24.	Video Production	2 (0+2)
25.	E-marketing for Natural Farm Produce	2 (0+2)
26.	Production and Marketing of Aerated and Non-aerated Liquid Manures	2 (0+2)

ONLINE COURSES

The students will have to take a minimum of 10 credits of online courses (as per UGC guidelines for online courses) as a partial requirement for the B.Sc. Ag. (Hons.) Natural Farming.

The online courses can be from any field such as Basic Sciences, Humanities, Commerce, Business Management, Languages including foreign language, Communication skills, Music, etc. and can be taken from SWAYAM, Diksha, NPTEL, mooKIT, edX, Coursera, or any other portal. The objective is to allow the students to groom their passion or strengthen their knowledge and competency in any field beyond prescribed courses. The courses will be non-gradial as separate certificates would be issued by the Institute/ University offering the courses. However, the University/ institute will keep a record of such courses registered and completed by each student and will indicate the title of the (successfully completed) courses in final transcript issued to the student. The courses can be taken during whole span of degree parogram as per choice of students. The courses will be non-gradial (as separate certificates would be issued by the institutes offering the course). The MOOC courses taken by the student will be separately registered/ approved at the University level. The final transcript will indicate the title of courses taken by the student and the total weeks.

List of Suggestive Online Courses

Course Title	Duration	Credits
Digital Media	16 weeks	4
Basics of Photography	12 weeks	3
Design, Technology and Innovation	8 weeks	2
Visual Communication Design for Digital Media	4 weeks	1
Certificate course in Environmental Sustainability	8 weeks	2
Consumer Protection Legislation	8 weeks	2
Communication and Extension for Sustainable Development	15 weeks	3
Intellectual Property	12 weeks	3
Biopsychology	15 weeks	3
NGO'S and Sustainable Development	15 weeks	3
Counseling Psychology	12 weeks	3
Gender Sensitization: Society Culture and Change	16 weeks	4
Basics of Health Promotion and Education Intervention	8 weeks	2
Psychology of Stress, Health and Well-being	12 weeks	3
Diet Management in Health and Disease	12 weeks	3

Course Title	Duration	Credits
Dairy and Food process and products technology	12 weeks	3
Thermal Processing of Foods	12 weeks	3
Nano-technology, Science and Applications	8 weeks	2
Food Science and Processing	12 weeks	3
Diet Management in Health and Disease	8 weeks	2
Human Nutrition and Biochemistry	12 weeks	3
Personality Development and Communication Skills	8 weeks	2
Public Speaking	8 weeks	2
Personality Development	8 weeks	2
Emotional Intelligence	8 weeks	2
Yoga Practices1	12 weeks	3
Yoga Practices2	12 weeks	3
Ethics: Theories and Applications	12 weeks	3
Information Sources and Library Services	6 weeks	1
Qualitative Research Methods and Research Writing	12 weeks	3
Food Science & Processing	12 weeks	3
Food Safety & Quality Control	8 weeks	2
*Communication Skills and Computer Operations	16 weeks	4
*Human Resource Management	16 weeks	4
*Business Plan and Finance Management	16 weeks	4
$ Physical Education, First Aid and Yoga (to be added)	Compulsory Non-credit Course (CNC)	
$ Start-up (to be developed)		

SAUs will be free to include more Elective courses with approval from their competent bodies.

$ Compulsory Non-Credit (CNC) course for student.

* The list of Non-Credit courses will be uploaded on College/University website. The student will have choice to select courses of his/her choice up to 20 credits.

Minimum Standards for Establishing a College of Natural Farming

- **Degree Nomenclature:** B.Sc. (Ag) Hons. Natural Farming

1. **Minimum intake (per year): 60**
2. **Faculty:**

A. Core faculty: 25

Natural Farming/Agronomy (0+1+3)*, Agricultural Economics/ Agribusiness management (0+1+1), Agricultural Extension Education (0+1+1), Entomology (0+1+1), Genetics & Plant Breeding (0+1+2), Horticulture (0+1+2), Soil Science (0+1+1), Plant Pathology (0+1+1), Animal Science (0+0+1), Agricultural Engineering (0+0+1), Microbiology (0+0+1), Food Science &technology (0+0+1), Ecology/Agro-econolgy (0+0+1)

B. Allied Faculty:

Faculty for Statistics, Computer Science, Sociology, Rural Development Psychology, English, Agrometeorology, Biochemistry & Physiology and other supporting subjects, if any, shall be adjusted from other colleges, Guest faculty, adjunct faculty and part time faculty.

1. Land requirement (ha): 20

2. Essential Instructional Units:

S. No.	Details	Area
•	Farm house/threshing floor/processing Centre	1 ha
•	Natural Crop cafeteria	2 ha
•	Field classroom (2)	0.1 ha
•	ELP Units, Bio-inputs production unit, Livestock unit, ITK Unit.	
•	Natural Farm Unit with crops, vegetables, trees, animals & native enterprises	1ha
•	Nursery, Seed Production, Post harvest and Processesing, /any other for skill development or Enterpreneural mode	3 ha
•	Agronomy (Local Crops), Genetics and plant Breeding, Soil Science, Physiology, other department	1 ha
•	Horticulture (Orchard)	1 ha
•	Plant Protection practical	2 ha
•	UG Practical demonstration	2 ha
•	Laboratories and instructional facilities, Ancient Knowledge based products/ mechanisms Museum, IT enabled practical lab, ELP units to be established under skill development or Entrepreneurial mode	2 ha

1. **Divisons/Departments/Sections:**
   - Agronomy + (Agro-forestry)
   - Agricultural Economics + (Basic Economics, Maths & Computer Science and Statistics)
   - Agriculture Extension & Communication + (Sociology and Psychology, English)
   - Entomology
   - Genetics & Plant Breeding + (Seed Science & Technology)
   - Horticulture + (Food Science & Technology)
   - Soil Science and Agricultural Chemistry + (Microbiology, Agro-meteorology, Environmental Sciences)
   - Plant Pathology

2. Non- Teaching Staff:

Sl. No.	Divisions/Departments/Sections	Asstt.*	Lab Asstt.	Field Asstt.	Attendant/ Messenger	Total
1.	Agronomy + (Agro-forestry)	1	2	3	- **	**6**
2.	Agricultural Economics + (Basic Economics,Maths & Computer Science and Statistics)	1	3	-	-	**4**
3.	Agriculture Extension & Communication +(Sociology and Psychology, English)	1	1	-	-	**2**
4.	Entomology	1	1	1	-	**3**
5.	Genetics & Plant Breeding + (Seed Science & Technology)	1	2	2		**5**
6.	Horticulture + (Food Science & Technology)	1	2	2		**5**
7.	Soil Science and Agricultural Chemistry + (Microbiology, Agro-meteorology, Environmental Sciences)	1	3	1		**5**
8.	Plant Pathology	1	2	1		**4**
9.	Animal Sciences including Fisheries, Dairy Science & Poultry units)	1	1	1		**3**
10.	Agriculture Engineering + (Farm Management)	1	1	2		**4**
11.	Biochemistry and Crop Physiology	1	1	-		**2**
	Total	**11**	**19**	**13**		**43**

3. Dean's Office:

Sl. No.	Name of the Post	No. of Posts
1.	Dean	01
A. Establishment		
1.	P.A./P.S. to Dean	01
2.	Asstt. Administrative Officer	01
3.	Asstt. Academic Officer	01
4.	Assistant Accounts Officer	01
5.	Assistants (one for each AAO)	03
6.	Steno/Computer Operators	01
7.	Driver	01
8.	Farm Manager (Asstt. Prof.)	01*
9.	Store Keeper	01
* Will be with Engineering/Agronomy.		
Utility services like Wireman/Plumber/Janitors/ Attendants/Messengers, Landscaping and Mechanic, etc. tobe outsourced.		

B. Central Instrumentation Laboratory		
1.	Instrumentation Asstt. Engineer	01
2.	Instrumentation Technician/Lab Asstt.	01
C. Library Staff		
1.	Asstt. Librarian (Asstt. Prof. cadre)	01
2.	Library Asstt./Clerk	01
3.	Shelf Asstt.	01
D.	Students Welfare	
1.	Physical Education (Asstt. Prof.)	01
2.	Attendant	01
E.	Hostel Staff	
1.	Warden	01+01
2.	Care taker/Asstt.	01+01
F.	Estate Branch	
1.	Junior Engineer	01
2.	Security Asstt.	01

4. Dean Office and other associated units

A. Central Facilities

Sl. No.	Details	No. of Rooms	Dimensions (ft)
1.	Dean Office	1	20×24
2.	P.A. Room	1	10×12
3.	Committee Room with video conferencing facility	1	20×30
4.	Assistant Administrative Officer including staff	1	20×12
5.	Assistant Accounts Officer including staff	1	20×12
6.	Assistant Academic Officer including staff	1	20×12
7.	Exam Cell (300 capacity)	1	20×12
8.	Evaluation Room	1	20×36
9.	Faculty Room (Ladies)	1	10×12
10.	Faculty Room (Gents)	1	20×12
11.	Placement Cell	1	20×12
12.	Smart Lecture Halls	5	40×30 (60 capacity)
13.	Exam Hall Cum Auditorium	1	100×50
14.	Library/Book Bank	1	30×72
15.	Common Utility Room	1	20×36
16.	Central Laboratory	1	50×36

Sl. No.	Details	No. of Rooms	Dimensions (ft)
17.	Hostels including Mess, Gym/Indoor, Reading Room, Warden Room, Store etc.	1 (boys) 1 (girls)	150 150
18.	Canteen	1	20×12 (kitchen with store) 20×36 Seating
19.	Wash room (with toilet & urinary facilities)	10	20×12 (keeping ladies requirements)
20.	Parking space		As per requirement
21.	Farm stores, threshing yards including implements and tractor sheds		One core complex
22.	Vehicles i. Car ii. Jeep/Car staff iii. Bus iv. Pickup van v. Motor Bikes vi. Minibus (30 capacity) vii. Tractors	 1 2 1 1 2 1 2	
23.	Drinking water and irrigation facilities		As per requirements Vehicles shed 1 10×80

B. Divisions/Departments/Sections – Requirements

Sl. No.	Details No. of Rooms	No. of Rooms	Dimensions (in ft)
1.	Office of Head	12	24 × 12 with wash room facility
2.	Faculty Rooms 1+1	12	12 × 10 + 18 × 1224 × 10 depending on the strength of each deptt.
3.	Clerical/technical staff 12		12×10 to 24×10 depending on the strength of each deptt.
5.	Laboratories 12		30× 60 Larger department will have two

Sl. No.	Details No. of Rooms	No. of Rooms	Dimensions (in ft)
6.	Field/Lab Stores 5		1. Agronomy 2. Gen. & Pl. Breeding 3. Soil Sci. 4. Horticulture 5. Pests & Chemicals
7.	Green house/poly house/Nursery facilities (Hort. Deptt.) ½ acre		

4. Requirements of Lab/field equipment for each Division/Department/Section)

Agronomy + (Agroforestry)		
1.	Crop Cafeteria	• ½ acre land
		• small implements like spade, hoe, khurpi, darati etc.
2.	Museum for identification of seeds, fertilizer, weeds,	• Storage bottle
	commonly used agro-chemical and medicinal	• Herbarium posting material and aromatic plants etc.
3.	Field of sowing method, fertilizer application, irrigation and	• Small equipment/ implement soil productivity and yield estimation
4.	Irrigation water measurement, bulk density etc.	

Equipment		**Number**
i.	Hot air oven	02
ii.	Moisture box	30
iii.	Moisture meter	05
iv.	Tube Auger	10
v.	Bucket auger	10
vi.	Weighing Balance	01
vii.	Seed Germinator	02
viii.	Conductivity Meter	01
ix.	pH Meter	02
x.	Water Bath	01
xi.	Shaker	01
xii.	Chlorophyl Meter	01
xiii.	Drip and Sprinkler System	03
xiv.	Sprayer	03
xv.	Spring Balance 50 Kg	05
xvi.	Spring Balance 10 Kg	05
xvii.	Top Pan Balance 1 kg capacity	05
xviii.	Top Pan Balance 2 kg capacity	05
xix.	Meter Scale	10
xx.	Tape	05
xxi.	Brix meter	02

2. Agricultural Economics + (Basic Economics, Maths & Computer Science and Statistics)

Sl. No.	Items	Nos.
1.	Computers	15
2.	Camera	01
3.	Software	As per requirement

3. Agriculture Extension & Communication + (Sociology and Psychology, English) Audio-visual Lab

Sl. No.	Items	Nos.
1.	LCD projector	1
2.	Camera (SLR) with zoom, wide-angle, tele-photo lens	1
3.	Video camera with tripod, lighting accessories and editing facility	1
4.	Computers (workstation) with editing softwares	1
5.	Digital voice recorders	5
6.	Audio recording-mixing consoles	1
7.	Computation softwares for statistics	1

4. Entomology

Sl. No.	Items	Nos.
1.	Binocular Microscope	20
2.	Insect Box	60
3.	Insect Collection Nets	60
4.	Collection Bottles	60
5.	Insect Collection Big Boxes for Museum (1 for each order)	29
6.	Insecticides for showing students/Representative for each group	As per requirement
7.	Stereomicroscope	01
8.	Electronic Balance	01
9.	Soxhlet Extraction Apparatus	01
10.	Bee keeping equipment	01 Set
11.	Oven	01
12.	Patters Tower	01
13.	Sprayers	01 of each type
14.	Light traps	01 set
15.	Fumigation Chamber	01
16.	Sides/cover slips	as per requirement
17.	pH meter	01
18.	Computer with printer	01 set

5. Genetics & Plant Breeding + (Seed Science & Technology)

Genetics		
Sl. No.	**Items**	**Nos.**
1.	Microscope	10
2.	Binocular microscope	10
3.	Electronic Moisture Meter	02
4.	Electronic Balance	02
5.	Seed Germinator	02
6.	Automatic seed/grain counter	01

Biotechnology		
Sl. No.	**Items**	**Nos.**
10.	Hot Air Oven	01
11.	BOD Incubator	01
12.	Fluorescence microscope	01
11.	Centrifuge	01
12.	Growth Chamber	01
13.	Distillation Assembly	01

6. Horticulture + (Food Science & Technology)

a. Labs (Post Harvest)

Sl. No.	**Items**	**Nos.**
1.	Hand Refractometer	05
2.	Digital Refractometer	02
3.	Oven	01
4.	Refrigerator	01
5.	Electronic Weighing Balance	02
6.	Pan Balance (1 kg & 10 kg. capacity each)	02
7.	Deep Freezer	01
8.	pH Meter	01
9.	Fruit crusher	01
10.	Grinding and Mixing Machine	01
11.	Distillation Assembly	01

b. Lab (UG Lab)		
Sl. No.	**Items**	**Nos.**
1.	Seed Germinator	02
2.	Grafting and budding knife	60
3.	Secateur	60
4.	Saw	05
5.	Loppers	05
6.	Mist Chamber	01
7.	Poly house with drip irrigation system	02
8.	Microscope	02
c. Food Science & Technology		
Sl. No.	**Items**	**Nos.**
1.	Refrigerator	1
2.	Muffle furnace	1
3.	Weighing balance	2
4.	Water bath	2
5.	Hot air oven	2
6.	Fruit penetrometer	2
7.	Pulper	1
8.	Juice extractor	1
9.	Crown corking machine	1
10.	Spectrophotometer	1
11.	Microwave oven	1
12.	Baking oven	1
13.	Sieve shaker	1
14.	Poly pouch sealer	1
15.	Crusher	1
16.	Masala grinder	1
17.	Dehydrator	1
18.	Cold room	1
19.	Vacuum pump	1

7. Soil Science and Agricultural Chemistry + (Microbiology, Agro-meteorology, Environmental Sciences)

Sl. No.	Items	Nos.
1.	Electronic Top pan balance (0.1 g capacity)	02
2.	Electronic Top pan balance (1 mg capacity)	02
3.	Hot air oven	02
4.	pH Meter	05
5.	EC Meter	05
6.	Flame Photometer	01
7.	Visible spectrophotometer	01
8.	Hot Plate	02
9.	Distilled water unit	02
10.	Water Bath	01
11.	Rotary Shaker	02
12.	Binocular Microscope	20
13.	BOD Incubator	02
14.	Autoclave	02
15.	Laminar Air Flow	01
16.	Microwave oven	01
17.	Digestion block	02
18.	Hydrometer	05
19.	Infiltrometer	02
20.	Hydraulic conductivity meter	01
21.	Atterberg's limitsmeter	05
22.	Nitrogen Analyser	02

8. Agrometeorology

Sl. No.	Items	Nos.
1.	Thermometer Max	05
2.	Thermometer Min	05
3.	Digital Anemometer	02
4.	Cup Anemometer	02
5.	Pan Evaporimeter	01
6.	Soil thermometer 05 cm. 10 cm. 15 cm.	 05 05 05
7.	Rain gauge	01

Sl. No.	Items	Nos.
8.	Self-recording Rain gauge	01
9.	Sunshine Recorder	01
10.	Stevenson's Screen	01
11.	Thermograph	01
12.	Hygrograph	01
13.	Soil Heat Flux Plate	01
14.	GPS	10
15.	AWS (optional)	01
16.	Lysimeter (optional)	01
17.	Luxmeter	02
18.	Solar Pyranometer	01

9. Plant Pathology]

Sl. No.	Items	Nos.
1.	Microscope compound with photo display arrangement	03
2.	Sterobinocular	05
3.	Sample processing Board (Dry preservation of samples)	04
4.	Wet preservation Jars	50
5.	Autoclave	02
6.	Oven	01
7.	Deep Freeze	01
8.	Centrifuge (3000 rpm)	01
9.	Refrigerator	01
10.	Water bath	02
11.	Electronic balance	02
12.	Weighing machine	01
13.	Incubator	02
14.	Occular meter	05
15.	Stage Micrometer	05
16.	Camera Lucida	05

10. Animal Sciences including Fisheries

Sl. No.	Items	Nos.
1.	5000/6500 Feed and Forage Analyzer	01
2.	Hand and electric centrifuge	01

3.	Analytical balance	01
4.	Hot air oven	01
5.	Micro kjeldahl N digestion & distillation apparatus	01
6.	Soxhlet unit for fat estimation	01
7.	Hot plate, Fiber Tech.	01
8.	Vacuum pump	01
9.	Willy mill grinder	01
10.	Platform balance (100 kg cap)	01
11.	Gerber centrifuge unit (for milk fat testing)	01
12.	Milk analyzer (automatic)	01
13.	Crude fiber estimation unit	01
14.	Distilled water unit	

11. Dairy & Poultry

Sl. No.	Items	Nos.
1.	Incubator cum hatcher	01
2.	Brooder machine	01
3.	Feeder	01
4.	Waterer	01
5.	Egg candling machine	01
6.	Debeaker	01
7.	Vaccinator	01
8.	Milking machine	As per requirements
9.	Milking bucket	As per requirement
10.	Milking can	As per requirements
11.	Animal and bird identification tools	As per requirement
12.	Chaff cutter	01
13.	Lactometer	01
14.	Castrator	01
15.	Shearer	01
16.	Electric dehorner	01
17.	Artificial vagina	01
18.	Common medication device	01
19.	Cattle crate	01

12. Agriculture Engineering + (Farm Management)

Sl. No.	Items	Nos.
1.	Working models of MB plough, Disk plough and indigenous plough	2 sets each
2.	Working model of different harrows	Actual
3.	Seed drill	01
4.	Different types of threshing drums	As per requirement
5.	Working models of reaper and mowers	02
6.	Different types of sprayers and dusters	As per requirement
7.	Cut model of CI & SI engine	01
8.	Cut model of Tractor	01

13. Central Library and Information System

Sl. No.	Items	Nos.
1.	Internet Server	01
2.	Intranet Server	01
3.	Computers for Reading Hall	20
4.	Heavy Duty Photocopiers	02
5.	Computerized Issue and Catalogue Systems	02
6.	Wi-Fi facility in college/library/hostels	As per requirement
7.	CCTV monitoring system for library	01
8.	RFID and Access Control System (Optional)	01
9.	Broadband Internet Connectivity with minimum speed of	1Gbps

FORESTRY

Course Curricula for Undergraduate Program in Forestry: UG-Certificate (Forestry), UG- Diploma (Forestry); B.Sc. (Hons.) (Forestry)

INTRODUCTION

Forests are an integral part of the society and played a significant role in socio-economic development of the country due to its role in providing wood and wood products. The forest management in India has witnessed a paradigm shift in management from production oriented to a conservation-oriented system. The growing population, industrialization, urbanization and the increasing interest in housing and energy sector have accelerated the demand for forest-based products. The production, protection, management and the associated service roles played by forests demand professional manpower in order to manage the complex ecosystem sustainably. Considering this significance professional forestry education started in the country in 1985 and over three decades of forestry education has witnessed potential contribution by providing professional manpower to manage both natural and planted forests. However, with the changes in policy and legal issues coupled with the growing concerns and climate change, increasing demand for wood products have all necessitated transformation in forestry education towards meeting the changing demands for professionals.

Under such circumstances, the GoI through its National Education Policy-2020 has directed complete restructuring and revamping of curricula and syllabi as per the requirement of regional, national and global manpower demand. The NEP 2020 has directed to ensure higher education for all sections of society at levels. The policy also advocated imparting skill and choice-based education to cater to the demands of graduating scholars. The policy envisaged light but tight academic framework coupled with flexibility in education through multiple entry and exit activities. For this purpose, the policy directed to restructure and reframe completely the educational activities.

With this direction, the Indian Council of Agricultural Research (ICAR) has mandated restructuring of syllabus and curricula in the entire courses falling under agricultural disciplines. Against this back

drop, forestry syllabus has been restructured taking into consideration the directives from National Education Policy-2020 and the guidelines indicated by the Education Division of ICAR. Accordingly, the draft framework of forestry syllabus has been conceived and the framework has been discussed with almost all Forestry Colleges across India both through online and offline. Similarly, the syllabus has been presented to all levels of stakeholders like wood-based industries, farmers, NGOs, members of consortium of industrial agroforestry and agroforestry incubator. Besides, the framed syllabus has been presented to students and alumini of Forestry Colleges.

Based on these consultations and deliberations coupled with the directives from Deans' Committee, the syllabus has been redesigned and finally the framework of syllabus has been designed and presented in this syllabus framework. This syllabus has been conceived and designed in such a way that its satisfies the requirement of various nomenclatures of Forestry education like UG Certificate in Forestry, UG Diploma in Forestry and UG Degree with Hons. specialization program as per the provisions of NEP 2020. The syllabus has been framed in such a way that it will extend all entrepreneur skill and provides the students the required professional employment opportunities at all levels of entry and exit system.

In a holistic analysis and approach, the syllabus has been framed and presented to attract higher education in forestry sector towards managing and conserving the natural forests, extending technology based industrial plantations, create employment opportunities through skill-based courses and augment the ethics and value system in forestry education. I take this opportunity of thanking all stake holders for their suggestions and timely support in designing the Forestry Education curricula and syllabi as per the provisions of NEP 2020.

HIGHLIGHTS

- The forestry syllabus is restructured as per the direction of ICAR and also as per the needs and provision of NEP 2020 taking into consideration the current development in regional, national and global scenario.
- The 4-year undergraduate program in Forestry is designed with 167 core credits + 10 credits of MOOC course/ online courses preferred by the student as per his/ her choice.
- The course is designed judicially incorporating the fundamental and basic aspects of forestry coupled with management and technology orientation courses. Skill enhancement courses are also incorporated at various levels along with Entry and Exit options to facilitate the students as per his/her/ze professional requirement.
- The skill enhancement courses are incorporated in first two years (Semesters 1 to 4). Students have been given flexibility and choice in selection of skill enhancement courses from a basket of multiple skill enhancement modules offered in all the four semesters of first two years.
- Students will be given 4 credits of skill-based courses each in first and second semester, and 2 credits each in third and fourth semester respectively, so that he/she/ze will acquire enough knowledge and skill through hands-on training in related domain to get UG-Certificate at the end of first year and UG-Diploma at the end of second year, if he/she/ze opts to exit.

- After completing the courses of first year (Total 45 credits), if a student wishes to exit, he/she/ze will be eligible for award of UG-Certificate after completing an extra 10 weeks of internship (10 credits). The internship can be taken in form of Industry placement/ Industry exposure/ hands on training in related domain in the parent institute. The students continuing the study further, would not have to attend the internship after 1st year. Similarly, after completing the courses for first two years (total 86 credits) and 10 weeks' internship, the student becomes eligible for UG-Diploma on exit. The students continuing further for award of B.Sc. (Hons.) degrees need not take the internships after 1st and 2nd years.
- These students are expected to acquire competency and confidence to start their own enterprise, as well as will have adequate competency for getting jobs.
- More emphasis has been given in proper amalgamation of theory and practicals to provide them hardcore knowledge of the Forestry discipline. In third year, the student will be taught intensive core courses of forestry to get the needed skill and expertise on the subject.
- In 4th year, the VII semester is designed exclusively for elective courses to inculcate the art of professional skill enhancement of the graduating scholars. The elective courses are designed in such a way to develop skill on specific area of current forest development. Accordingly, four electives namely Plantation forestry, Multi-functional agroforestry, High yielding short rotation forestry and Forest product development and utilization have been designed and incorporated the new syllabus to cater to the needs of current regional, national and global development.
- In eighth semester of the degree program, the students will have to undergo Student READY Program to cover 20 credits. The Student READY Program may judicially incorporate internship attachment with wood-based industries/Forest department/Police/Special Task Force/Incubation centre/KVK/ Any research organization. Ideally, it is recommended to have Internship with Forest Department (Administrative Skill) for 5 weeks, Internship with wood-based industries (Technical Skill) for 2 weeks, Internship with Police/ Special Task Force (STF) for Jungle survival for 1 week and Internship with incubation centres/KVKs for 2 weeks.
- The new courses like Trees outside Forests, Forest Biomass Energy and Biofuels, Arboriculture, Forest Landscape Restoration, Forest Business Management and Industrial Agroforestry are designed as per the requirement of current national and international development in forestry sector, which will create enough skill and expertise on the graduating scholars.
- 10 credits of non-credit courses are at the discretion of students. Students have the choice of MOOCs to groom their passion to enhance their knowledge and competency beyond prescribed courses. Student also has flexibility to complete these online courses of 10 credits throughout the span of the degree program.

Entry and Exit Options

The entry and exit options for the B.Sc. (Hons.) programs in Forestry are shown in the Figure-1

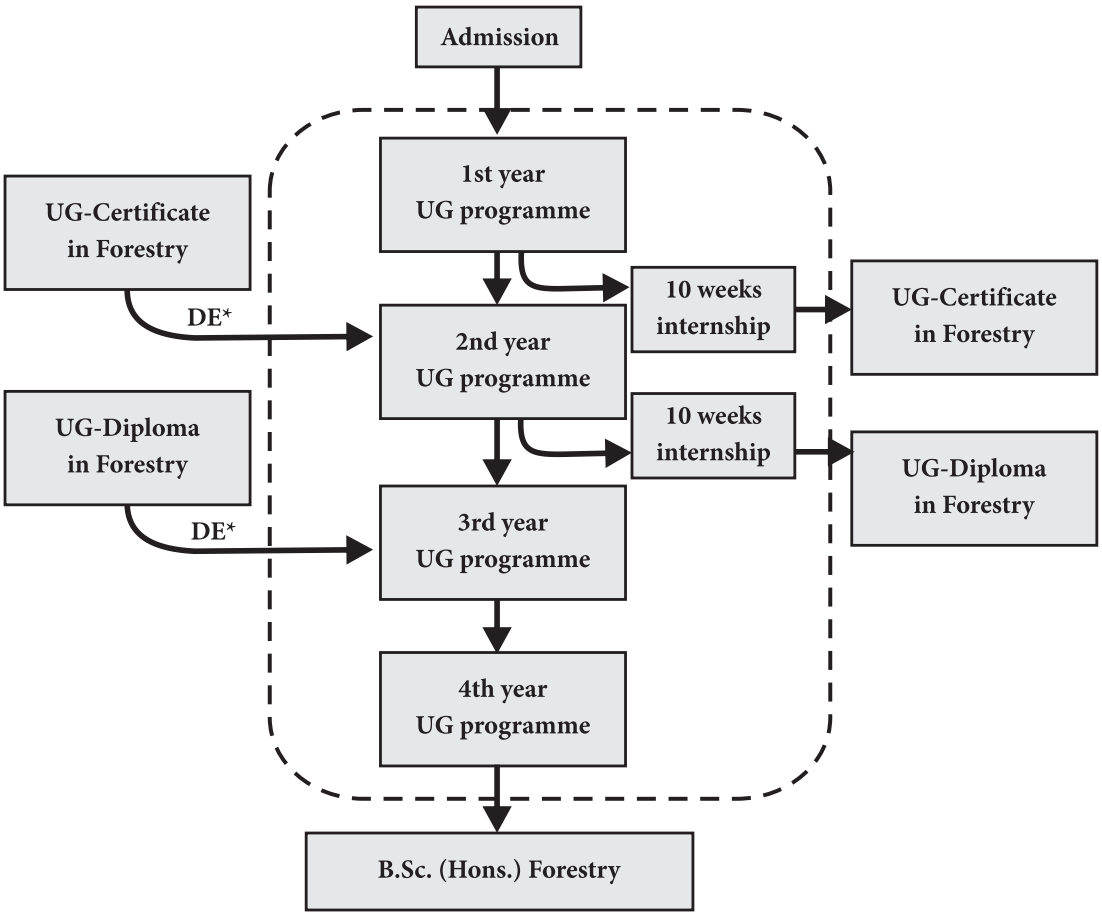


Fig.1 Entry and Exit options for the UG programs in Forestry

DE* Direct Entry in the Respective Year

Exit options

- **UG-Certificate in Forestry** (Exit after first year and completion of 10 weeks' internship)
- **UG-Diploma in Forestry** (Exit after second year and completion of 10 weeks' internship)
- **B.Sc. (Hons.) Forestry** (On successful completion of four-year degree requirements)

Admission Eligibility for Entry into 1st years UG Programme:10+2 Science with PCM/PCMB/ Agriculture (P-Physics, C–Chemistry, M-Mathematics, B-Biology) from a recognized Central/State Board/University or as per ICAR/SAU/HAEI norms.

ACADEMIC PROGRAM

Semester Wise Course Distribution

S. No.	Course Title	Credit Hours	Total Credit hours
	First Year		
	Semester- I		
1.	*Deeksharambh* (Induction-cum-Foundation Program)	2 (0+2) (Non gradial)	**22 (11+11) (+2 NG)**
2.	Introduction to Forest Resources	3 (2+1)	
3.	Forest Plant Biology	3 (2+1)	
4.	Silviculture – Principles and Practices	3 (2+1)	
5.	Agroforestry Systems and Management	3 (2+1)	
6.	Skill Enhancement Courses (SEC-I)*	4 (0+4)	
7.	Farming Based Livelihood Systems	3 (2+1)	
8.	Communication Skills	2 (1+1)	
9.	NCC-I/NSS-I	1 (0+1)	
	Semester- II		
1.	Tree Seed and Nursery Technology	3 (1+2)	**23 (10+13)**
2.	Fundamental of Forest Genetics	2 (1+1)	
3.	Wood Anatomy and Identification	2 (1+1)	
4.	Forest Measurements and Inventory	3 (2+1)	
5.	Personality Development	2 (1+1)	
6.	Environmental Studies and Disaster Management	3 (2+1)	
7.	Entrepreneurship Development and Business Management	3 (2+1)	
8.	Skill Enhancement Courses (SEC-II) **	1 (0+1)	
9.	NCC-II/NSS-II**	4 (0+4)	
	Post- II Semester Internship (Only for exit option for award of UG-Certificate)		
1.	Internship (10 weeks)	**10 (0+10)*****	**10 (0+10)*****
	Second Year		
	Semester III		
1.	Silviculture of Trees	2 (2+0)	**21 (10+11)**
2.	Wood Science and Technology	2 (1+1)	
3.	Forest Microbiology	2 (1+1)	
4.	Forest Soil and Nutrient Management	2 (1+1)	
5.	Forest Survey and Engineering	2 (1+1)	
6.	Wildlife Sciences	3 (2+1)	
7.	Forest Health and Protection	2 (1+1)	
8.	Arboriculture	2 (1+1)	
9.	Physical Education, First Aid, Yoga practices and Meditation	2 (0+2)	
10.	Skill Enhancement Courses (SEC-III)****	2 (0+2)	

Semester IV			
1.	Commercial Forest Products and Utilization	3 (2+1)	**20 (12+8)**
2.	Forest Ecology and Management	3 (2+1)	
3.	Tree Harvesting and Ergonomics	2 (1+1)	
4.	Forest Policy and Legislation	2 (2+0)	
5.	Statistical Methods	2 (1+1)	
6.	Agriculture Marketing and Trade	3 (2+1)	
7.	Agricultural Informatics and Artificial Intelligence	3 (2+1)	
8.	Skill Enhancement Courses (SEC-IV)*****	2 (0+2)	
Post- IV Semester Internship (Only for exit option for award of UG- Diploma)			
1.	Internship (10 weeks)	**10 (0+10)******	**10 (0+10)******
Third Year			
Semester V			
1.	Tree Physiology	2 (1+1)	**21 (13+8) + 2 NG**
2.	Plantation Forestry	3 (2+1)	
3.	Tree Improvement	3 (2+1)	
4.	Forest Resource Management	2 (1+1)	
5.	Non-Timber Forest Products	3 (2+1)	
6.	Forest Pest and Diseases	3 (2+1)	
7.	Wildlife and Protected Area Management	3 (2+1)	
8.	Industrial Agroforestry	2 (1+1)	
9.	Study tour (10-14 days)	2 (0+2) Non-Gradial	
Semester VI			
1.	Forest Biotechnology	3 (2+1)	**20 (13+7)**
2.	Forest Economics and Marketing	2 (1+1)	
3.	Watershed Planning and Management	2 (1+1)	
4.	Forest Tribology, Ethno-medicine and Extension	3 (2+1)	
5.	Remote Sensing and GIS	2 (1+1)	
6.	Forest Business Management	2 (1+1)	
7.	Forest Landscape Restoration (FLR)	2 (2+0)	
8.	Forest Biomass Energy and Biofuels	2 (1+1)	
9.	Trees Outside Forests	2 (2+0)	

Fourth Year			
Semester VII			
Elective Courses (Any of the following courses may be taken as electives)			
1	Plantation Forestry	20	**20**
2	Multifunctional Agroforestry	20	
3	High Yielding Short Rotation Forestry	20	
4	Forest Product Development and Utilization	20	
5	Forest Resource Management and Utilization	20	
Semester VIII			
1.	**Students READY Programme (RAWE/Industrial Attachment /Experiential Learning/Hands-on Training/ Skill Development/Project Work/Internship etc.) (RAWE/ Internship/ Student Project/ Hands-on training/Forest work Experience)**	**20**	**167 + 10******* (MOOC) + 4 (NG)**
	On-line courses (MOOC)	10	

*From the basket of available SEC-I modules
**From the basket of available SEC-II modules
*** Mandatory requirement for UG-Certificate. (On exit, the students will be eligible to be awarded UG-Certificate in Forestry)
****From the basket of available SEC-III modules (2 credits)
*****From the basket of available SEC-III modules (2 credits)
******Compulsory Internship for students exercising exit option (UG-Diploma) after IIndYear
*******On-line courses (MOOC); NG-Non Gradial

Department/ section wise course breakup

S. No.	Course Title	Credit hours	Total Credit Hours
A) CORE COURSES			
Silviculture and Agroforestry			
1	Silviculture – Principles and Practices	3 (2+1)	**17 (12+5)**
2	Silviculture of Trees	2 (2+0)	
3	Plantation Forestry	3 (2+1)	
4	Agroforestry Systems and Management	3 (2+1)	
5	Industrial Agroforestry	2 (1+1)	
6	Arboriculture	2 (1+1)	
7	Trees Outside Forests	2 (2+0)	
Forest Biology and Tree Improvement			
1	Forest Plant Biology	3 (2+1)	**16 (9+7)**
2	Tree Seed and Nursery Technology	3 (1+2)	
3	Fundamental of Forest Genetics	2 (1+1)	
4	Tree Improvement	3 (2+1)	
5	Forest Biotechnology	3 (2+1)	
6	Tree Physiology	2 (1+1)	

S. No.	Course Title	Credit hours	Total Credit Hours
Forest Products and Utilization			
1	Wood Anatomy and Identification	2 (1+1)	**15 (9+6)**
2	Wood Science and Technology	2 (1+1)	
3	Commercial Forest Products and Utilization	3 (2+1)	
4	Tree Harvesting and Ergonomics	2 (1+1)	
5	Non-Timber Forest Products	3 (2+1)	
6	Forest Biomass Energy and Biofuels	3 (2+1)	
Wildlife Sciences			
1	Wildlife Sciences	3 (2+1)	**6 (4+2)**
2	Wildlife and Protected Area Management	3 (2+1)	
Forest Resource Management			
1	Introduction to Forest Resources	3 (2+1)	**39 (24+15)**
2	Forest Measurements and Inventory	3 (2+1)	
3	Forest Ecology and Management	3 (2+1)	
4	Forest Health and Protection	2 (1+1)	
5	Forest Resource Management	2 (1+1)	
6	Forest Tribology, Ethno-medicine and Extension	3 (2+1)	
7	Forest Landscape Restoration (FLR)	2 (2+0)	
8	Forest Policy and Legislation	2 (2+0)	
9	Forest Soil and Nutrient Management	2 (1+1)	
10	Forest Economics and Marketing	2 (1+1)	
11	Forest Business Management	2 (1+1)	
12	Remote Sensing and GIS	2 (1+1)	
13	Forest Microbiology	2 (1+1)	
14	Forest Survey and Engineering	2 (1+1)	
15	Forest Pest and Diseases	3 (2+1)	
16	Watershed Planning and Management	2 (1+1)	
17	Statistical Methods	2 (1+1)	
ELECTIVE COURSES			
i) Plantation Forestry			
1	Commercial Tree Seedling Production	3 (1+2)	**Student can take 20 credits from any one elective**
2	Commercial Plantation Development and Management	3 (2+1)	
3	Forest Growth Modelling	2 (1+1)	
4	Marketing and certification of Wood Products	2 (1+1)	
5	Restoration of Degraded Lands	3 (2+1)	
6	Dendro-Biomass and Energy Plantation	3 (2+1)	
7	Plantation and Climate Change Mitigation	3 (2+0)	

S. No.	Course Title	Credit hours	Total Credit Hours
8	Plant Biochemistry	2 (1+1)	
9	Research Methodology	2 (1+1)	
10	Statistical Packages for Data Analysis	1 (0+1)	
11	Internship with forest plantations-based institutions/plantation companies	2 (0+2)	
ii) Multi-Functional Agroforestry			
1	Agroforestry system	3 (2+1)	
2	Interactions in Agroforestry Systems	2 (1+1)	
3	Agroforestry and Climate Change Mitigation	2 (2+0)	
4	Industrial agroforestry	3 (2+1)	
5	Ecotourism	3 (2+1)	
6	Dendro-biomass and energy plantation	3 (2+1)	
7	Introduction to Agronomy and Crop Production Technology	3 (2+1)	
8	Plant Biochemistry	2 (1+1)	
9	Research Methodology	2 (1+1)	
10	Statistical Packages for Data Analysis	1 (0+1)	
11	Agroforestry business incubation	2 (1+1)	
12	Internship with agroforestry-based institutions/industries	2 (0+2)	
iii) High Yielding Short Rotation (HYSR) forestry			
1	Applied Tree Improvement	3 (2+1)	
2	Biometrical Genetics in Tree Breeding	2 (1+1)	
3	Controlled breeding in tree crops	2 (0+2)	
4	Marker assisted breeding in forestry	3 (2+1)	
5	Tissue culture applications in forestry	3 (1+2)	
6	Reproduction biology of tree crops	3 (2+1)	
7	Forest genetic resources	2 (2+0)	
8	Tree seed orchards	3 (2+1)	
9	Clonal Forestry	2 (1+1)	
10	Plant Biochemistry	2 (1+1)	
11	Research Methodology	2 (1+1)	
12	Statistical Packages for Data Analysis	1 (0+1)	
13	Internship with tree breeding and biotechnology-based institutions/ industries	2 (0+2)	
iv) Wood and NWFPs Product Development and Utilization			
1	Wood identification	2 (0+2)	
2	Wood physics and chemistry	3 (2+1)	
3	Wood seasoning and preservation	3 (1+2)	
4	Forest products laboratory techniques	2 (0+2)	

S. No.	Course Title	Credit hours	Total Credit Hours
5	Composite wood technology	3 (2+1)	
6	Non-wood forest products and value addition technology	3 (2+1)	
7	Wood working and carpentry	2 (0+2)	
8	Ethnobotany, Medicinal and Aromatic plants	3 (2+1)	
9	Certification of Forest Products	2 (2+0)	
10	Plant Biochemistry	2 (1+1)	
11	Research Methodology	2 (1+1)	
12	Statistical Packages for Data Analysis	1 (0+1)	
13	Internship with forest products and technology-based institutions/ industries	2 (0+2)	
v) Forest Resources Management and Utilization			
1	RS and GIS Application for Forest Resource Management	3 (2+1)	
2	Ecosystem Services and Valuation of Forest Resources	3 (2+1)	
3	Entrepreneurship in value chain improvement of Forest Resources	3 (2+1)	
4	Joint Forest Planning and Management	2 (1+1)	
5	Climate Change Mitigation	3 (2+1)	
6	Ecotourism	3 (2+1)	
7	Restoration of Degraded Lands	3 (2+1)	
8	Urban Ecology and Environment	3 (2+1)	
9	Plant Biochemistry	2 (1+1)	
10	Research Methodology	2 (1+1)	
11	Statistical Packages for Data Analysis	1 (0+1)	
12	Internship with Forest Business Unit/RS-GIS Company or Organization	2 (0+2)	
B) MULTI-DISCIPLINARY COURSES			
1	Farming based livelihood systems	3 (2+1)	**9 (6+3)**
2	Entrepreneurship Development and Business Management	3 (2+1)	
3	Agriculture Marketing and Trade	3 (2+1)	
C) VALUE ADDED COURSES			
1	Environmental studies and Disaster Management	3 (2+1)	**6 (4+2)**
2	Agricultural Informatics and Artificial Intelligence	3 (2+1)	
D) ABILITY ENHANCEMENT COURSE			
1	National Cadet Corps (NCC)/National Services Scheme (NSS)	2 (0+2)	**8 (3+5)**
2	Communication Skills	2 (1+1)	
3	Personality Development	2 (1+1)	
4	Physical Education, First Aid, Yoga practices & Meditation	2 (1+1)	

S. No.	Course Title	Credit hours	Total Credit Hours
E) FORESTRY – SKILL ENHANCEMENT COURSES (SEC)			
1	Skill Enhancement Courses (SEC-I)	4 (0+4)	**12 (0+12)**
2	Skill Enhancement Courses (SEC-II)	4 (0+4)	
3	Skill Enhancement Courses (SEC-III)	2 (0+2)	
4	Skill Enhancement Courses (SEC-IV)	2 (0+2)	
F) Internship/ Project / Students READY Program			
1	Internship/ Project / Students READY Program	20 (0+20)	**20**
G) NON-GRADIAL			
1	Deeksharambh (Induction-cum-Foundation Program)	2	**2 (NG)**
2	Study Tour	2 (0+2)	**2 (NG)**
H) MOOC Curses			
1	Online Courses	10	**10**

*Massive open online courses

Table 1: Summary of credit hours for different categories of courses (Credit Hours)

Sem-ester	Core Courses (Major+ Minor)	Multi-Disciplinary Course (MDC)	Value Added Course (VAC)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)	Internship/ Project/ Student READY	Total Credits	Non-Gradial	Internship	Online Courses/ MOOC
I	12	3[2]		1[3] + 2[4]	4	-	22	2[1]		**10**
II	10	3[5]	3[6]	1[3] + 2[7]	4	-	23	-	10[12]	
III	17	----		2[8]	2	-	21			
IV	12	3[9]	3[10]	----	2	-	20	-	10[13]	
V	21	-	-	-	-	-	21	2[11]		
VI	20	-	-	-	-	-	20	-		
VII	20	-	-	-	-	-	20	-		
VIII	-	-	-	-	-	20	20	-		
Total	**112**	**9**	**6**	**8**	**12**	**20**	**167**	**4**		**10**

Note: The credit hours mentioned in the table includes both theory and practical.

1. *Deeksharambh* (Induction-cum-Foundation Course) of 2 credits (2 weeks duration).
2. Farming based Livelihood systems
3. NCC/NSS
4. Communication Skills
5. Entrepreneurship Development and Business Management
6. Environmental Studies and Disaster Management
7. Personality Development

8. Physical Education, First Aid, Yoga Practices and Meditation.
9. Agriculture Marketing and Trade
10. Agricultural Informatics and Artificial Intelligence
11. Study tour (10-14 days)
12. Only for those opting for an exit with UG-Certificate
13. Only for those opting for an exit with UG-Diploma

SUMMARY OF CREDIT DISTRIBUTIONS

Type of courses		**Credits**
Core courses (major and minor/s)	:	112
Skill Enhancement Courses (SEC)	:	12
Common courses (MDC+VAC+AEC)	:	23
Student READY (RAWE/Industrial Attachment /Experiential Learning/Hands-on Training/Skill Development/Project Work/ Internship etc.)	:	20
**MOOCS/ Online Courses	:	10 (Non-gradial)
Grand Total		**167+10****

Detailed Syllabi

Semester I

Deeksharambh (Induction-cum-Foundation Course) Non-Gradial 2 (0+2)

The activities to be taken under *Deeksharambh* shall aim at creating a platform for students to

1. Helpings in for cultural Integration of students from different backgrounds
2. Know about the operational framework of academic process in University
3. Instilling life and social skills
4. Social awareness, ethics and values, team work, leadership, creativity, etc.
5. Identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario.

The details of activities will be decided by the parent universities. The structure shall include, but not restricted to:

i. Discussions on operational framework of academic process in university, as well as interactions with academic and research managers of the University

ii. Interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences

iii. Group activities to identify the strength and weakness of students (with expert advice for their improvement) as well as to create a platform for students to learn from each other's life experiences

iv. Activities to enhance cultural Integration of students from different backgrounds.

v. Field visits to related fields/ establishments

vi. Sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills

Introduction to Forest Resources 3 (2+1)

Objective

To impart knowledge about the basic concepts of Forestry and familiarize the students about developments in the field of forestry.

Theory

Forests; definitions, role, benefits; direct and indirect. History of Forestry- Forestry- definitions, divisions and interrelationships. Classification of forests- Forest types. Agricultural lands and forests- Agroforestry systems; differences in nutrient cycling, diversity etc. Social forestry, joint forest management; programs and objectives. Important acts and policies related to Indian forests. Global warming; forestry options for mitigation and adaptation- carbon sequestration. Introduction to world forests- Geographical distribution of forests and their classification- Factors influencing world distribution of forests- productivity potential and increment of world forests. Forest resources and forestry practices in different regions of the world; Western Europe, North America, Central Africa, Australia, Central America, Russia, Japan, and China. General problems of forest development and

economy. Forest based industries in the developed and developing countries. Trade patterns of forest based raw materials. Recent trends in forestry development in the world. National and international organizations in forestry. Important events/dates related to forests and environment - Themes and philosophy.

Practical

Identification of important farm grown trees. Identification of tree seeds and seedlings. Visit to various forest types, viz., thorn forest, dry deciduous forests, moist deciduous forests, Shola grass land ecosystem, semi evergreen forests and wet evergreen forests to study the factors of locality and species composition. Visit to different forest plantations, Agroforestry plantations and other woodlots. Identification of wood and non- wood forest products. Visit to forest-based institutes and industries.

Suggested Readings

1. Beazley M. 1981. *The International Book of Forest*. London
2. Champion H G and Seth S K. 1968. *Forest types of India.* Manager of Publications.
3. Grebner D L, Bettinger P and Siry J P. 2012. *Introduction to Forestry and Natural Resources*. Academic Press.508p. (Google eBook).
4. Khanna L S. 1989. *Principles and Practice of Silviculture*. Khanna Bandhu, New Delhi.
5. Mather A S. 1990. *Global forest resources*. Belhaven, London
6. Mitchell Beazly. 1981. *The International Book of the Forest*. Mitchell Beazly Publishers, London.
7. Parthiban K T, Krishnakumar N, Palanikumaran B, Thirunirai Selvan R and Kanagaraj N. 2022. *FAQ'S on Forestry for IFS Aspirants*. Scientific Publishers, Jodhpur (ISBN No.: 9789392590061)
8. Parthiban K T, Krishnakumar N and Karthick M. 2018. *Introduction to Forestry*. 350p. Scientific Publisher, Jodhpur.
9. Persson R. 1992. *World forest resources*. Periodical experts, New Delhi.
10. Westoby J. 1991. *Introduction to World Forestry*. 240p. Wiley.

Forest Plant Biology 3 (2+1)

Objective

To inculcate the fundamentals of botany and taxonomy of gymnosperms and angiosperms

Theory

Plant classification and systematic. Botanical Nomenclature – ICBN (International code of Botanical Nomenclature) - Rules and Codes of ICBN, Binomial and Polynomials. Systems of classification - Natural, Artificial and Phylogenetic classification. Principles of systematics. Demerits and merits of plant classification as given by Engler and Prantl, Hutchinson, Bentham and Hooker, Angiosperm Phylogenic Group (APG) and Other modern classifications. Morphology as a tool for tree identification - Field characters - Branching pattern, Leaf, Fruit and Bark. Role of reproductive characters - Flower types, floral formulas and floral diagrams. Reproductive morphology of plants with reference to description and identification of reproductive parts - General form of woody trunk and deviations like buttresses, flutes, crooks, etc. Morphology and description of bark

of common Indian trees - Types of exfoliation patterns in bark. Methods of Floristic survey and need for botanical explorations. Herbarium techniques -Collection, processing and preservation of plant material. General study of herbarium, arboretum, Palmetum, Fruticetum, Bambusetum and Xylarium. Origin, geographical distribution, phylogenetic position, taxonomic description and economic importance of the flora of families of Gymnosperms viz., Pinaceae, Taxaceae, Coniferae. Origin, geographical distribution, phylogenetic position, taxonomic description and economic importance of the flora for the families of Angiosperms viz., Annonaceae, Magnoliaceae, Rhizophoraceae, Ebenaceae, Sapotaceae, Caesalpiniaceae, Santalaceae, Mimosaceae, Elaeagnaceae, Fabaceae, Meliaceae, Salicaceae, Lauraceae, Apocynaceae and Betulaceae. Origin, geographical distribution, phylogenetic position, taxonomic description and economic importance of the flora for the families of Angiosperms viz., Fagaceae, Moraceae, Tiliaceae, Euphorbiaceae, Dipterocarpaceae, Bixaceae, Cupressaceae, Guttiferae (Clusiaceae), Myrtaceae, Rubiaceae, Sterculiaceae, Bignoniaceae and Combretaceae.

Practical

Morphological description of plant parts with special reference to identification. Study on types of leaves, phyllotaxy and venation, Inflorescence, Bark with suitable examples. Methods of plant collections and herbarium preparation. Laboratory and field identification of important forestry species using vegetative and reproductive characteristics of Magnoliaceae, Ebenaceae, Fabaceae, Meliaceae, Salicaceae, Tiliaceae, Taxaceae, Pinaceae, Myrtaceae, Rubiaceae, Sterculiaceae, Bignoniaceae and Combretaceae. Visit to Botanical Garden and Arboretum for identification of trees.

Suggested Readings

1. Bhatnagar S P and Moitra Alok. 2000. *Gymnosperms*. New age International (P) Ltd.
2. Bor N L.1990. *Manual of Indian Forest Botany*. Periodical Expert Book Agency, New Delhi.
3. Jakarti R D. 2010. *Brandis*. Revised Indian Trees. Dehradun.
4. Dasgupta S. 1998. *Systematic Botany for Foresters*. Khana Bandhu Publ., New Delhi, India.
5. Datta S C. 1999. *Systematic Botany*. New Age International (P) Ltd. Publ. New Delhi, India.
6. Eric A. and Bourdo Jr. 2001. *The Illustrated Books of Trees. A Visual Guide to 250 species.* Salamander Books Pvt. Ltd. London.
7. Jain S K and Rao R R. 1977. *Handbook of Field and Herbarium Methods*. Today and Tomorrow's Printers and Publishers. New Delhi.
8. Krishnen Pradip. 2013. *Jungle Trees of Central India. Published* by Penguin Books India Pvt. Ltd. New Delhi.
9. Kumar Ashok. 2001. *Botany in Forestry and Environment*. Kumar Media (P) Ltd. Gandhinagar, Gujarat.
10. Mishra S R. 2010. *Textbook of Dendrology*. Discovery Publishing House Pvt. Ltd. New Delhi.
11. Naqshi R. 1993. *An Introduction to Botanical Nomenclature*. Scientific Publishers. Jodhpur.

12. Pandey S N and Mishra S P. 2008. *Taxonomy of Angiosperms*. Ane Books India, New Delhi.

13. Parker R N. 1933. *Forty Common Indian Trees and How to know them*. (Available online PDF)

14. Randhawa M S. 1957. *Flowering Trees in India*. Sree Saraswati Press Ltd. Kolkata.

15. Sahni K C. 2000. *The Book of Indian Trees*. Bombay Natural History Society. Mumbai.

16. Santapau, Father H. 1966. *Common Trees*. (Available online PDF)

17. Singh Gurucharan. 2000. *Plant Systematics*. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

18. Tewari N. 1992. *Tropical Forestry in India*. International Book Distributors, Dehradun.

Silviculture – Principles and Practices 3 (2+1)

Objectives

i. To develop basic understanding on forest and factors influencing forest growth and development

ii. To develop skill for the artificial and natural regeneration of forest

iii. Exposing students to develop skill on raising and maintaining plantation

iv. To impart knowledge on tending operations followed in forest with preliminary information on succession in forest

Theory

Definition and classification of Forest and Forestry - Branches of forestry and their relationships - Trees and their distinguishing features. Forest Reproduction - Flowering, fruiting and seeding behaviour. Site factors - Climatic, edaphic, physiographic, biotic and their interactions. Classification of Climatic Factors - Role of light, temperature, rainfall, snow, wind, humidity and evapotranspiration in relation to forest vegetation. Bioclimatic and Micro climate effects. Edaphic factors - Influence of biological agencies, parent rock, topography on the soil formation - Soil profile - Physical and chemical properties, mineral nutrient. Physiographic factors - influence of altitude, latitude, aspect and slope on vegetation. Biotic factors - Influence of plants, insects, wild animals, man and domestic animals on vegetation. Forest types of India - Basis and systems of classification - Major groups - Revised classification of forest types of India - Tropical, Montane sub-tropical, Montane temperate, Subalpine and Alpine - Sub groups - Types - Species composition and distribution. Forest types of Tamil Nadu. Regeneration of forests - Objectives, ecology of regeneration - Natural and Artificial regeneration. Natural regeneration - Seed production, seed dispersal, germination and establishment. Requirement for natural regeneration. Dieback in seedling with examples. Advance growth, coppice - Root sucker. Regeneration survey - Natural regeneration supplemented by artificial regeneration. Artificial regeneration - Object of artificial regeneration - Advantages. Factors governing the choice of regeneration techniques. Choice of species and factors that govern. Sowing v/s planting - Preparation of planting material - Field planting and techniques - Plant protection and sanitation measures - Forest nutrition and irrigation in trees.

Practical

Study about habits of plants and developmental stages of tree growth and its structure. Study about tree morphology - Stem, crown and root characters. Assessment of forest composition. Study about stand structure. Assessment of natural regeneration. Planting pattern and planting technique for afforestation and reforestation. Exercise on Seed and nursery practices. Planting pattern and planting technique for afforestation and reforestation. Field preparation, marking, alignment and stacking, pit making and planting. Plant protection and sanitation measures. Study of afforestation and reforestation success.

Suggested Readings

1. Champion H G and Seth S K. 1968. *A Revised Survey of the Forest Types of India.* Manager of Publication, Delhi.
2. David M Smith. 1989. *The Practice of Silviculture*. 526p. EBD Educational Pvt. Ltd., Dehradun.
3. Dwivedi A P. 2006. *A Text book of Silviculture*. 505p. International Book Distributors, Dehradun.
4. Haig I T, Huberman M A and U Aung Din. 1986. *Tropical Silviculture.*Vol. 1. 190p. Periodical Experts Book Dehradun Agency, New Delhi.
5. Khanna L S. 2000. *Principles and Practice of Silviculture*. 473p. Milton Book Company, Dehradun.
6. Luna R K. 1989. *Plantation forestry in India*. 176p. International Book Distributors, Dehradun.
7. Parthiban K T, Sudhagar R J, Kanna S Umesh, Vennila S, Sekar I and Baranidharan K. 2016. *Forestry: A Subjective Guide for IFS Aspirants*. Scientific Publishers - Competition Tutor, Jodhpur (ISBN No.: 9789386102096)

Agroforestry Systems and Management 3 (2+1)

Objectives

i. To develop basic understanding on agroforestry in different agro-climatic zones.
ii. To develop skill on various agroforestry systems and carbon sequestration in agroforestry systems.
iii. To Exposing students to develop skill on Industrial Agroforestry

Theory

Agroforestry systems in different agro climatic zones – Tropical agroforestry, temperate agroforestry, arid and semi-arid agroforestry and humid agroforestry - components, production and management techniques. Alley cropping- functional and structural attributes of alley cropping, soil management, choice of species - productivity of various Agroforestry systems. High-density short rotation plantation systems – choice of species, design, development and management - Silvicultural woodlots/energy plantations - choice of species, design, development and management. Different types of agroforestry systems – silvi-agriculture - shelterbelts and windbreaks - design, aerodynamics and management - silvopastoral systems - live fences; fodder trees and protein banks and Agri-silvopastoral systems – home gardens, hedge rows, Multistorey

system and their mangement; Special systems - Apisilviculture, silvisericulture, aquaforestry etc. Agroforestry for wasteland development. Canopy management - Lopping, pruning, pollarding, and hedging. Diagnosis and design methods and approaches. Biophysical and ecological functions of agroforestry: Nutrient cycling and role of agroforestry in soil and water conservation - micro-site enrichment by trees, N fixation, improvement in soil physico-chemical properties and soil organic matter status, litter and fine root dynamics, nutrient pumping; beneficial effects of species mixture - rhizosphere and phillosphere effects. Carbon Sequestration-Climate change mitigation and phytoremediation. Adverse effects of trees on soils - competition, allelopathy – Causes and mechanisms. Industrial Agroforestry – scope and potential in India – major wood based industries - People's participation, rural entrepreneurship through Agroforestry and industrial linkages – contract farming – types and systems – successful contract farming models – timber transit rules for farm grown trees - Financial and socio-economic analysis of Agroforestry systems. Evaluation of tangible and intangible benefits – Agroforestry research and development in India - National Agroforestry Policy 2014 – objectives and strategies.

Practical

Study characteristics of trees/shrubs/grasses for agroforestry – Designing and development of multifunctional agroforestry model - Survey agroforestry practices in local/ adjoining areas - Visit to prominent agroforestry systems, other plantation crop combinations, Homegardens, other integrated multitier agroforestry systems and study their structural and functional attributes- Establishment and management of fodder bank – Studies on Integrated Farming System - Establishment and assessment of Industrial agroforestry plantations - Volume and biomass estimation- Carbon sequestration assessment- Crown measurement, light interception, leaf area index measurements in agroforestry systems. Annual crops/grass growth measurements and yield estimation – Determination of cost and returns of various agroforestry systems.

Suggested Readings

1. Chundawat D S and Gautham S K. 2017. *Textbook of Agroforestry*. Oxford and IBH Publishing, (ISBN: 9788120408326)
2. Divya M P and Parthiban K T. 2005. *A Textbook on Social Forestry and Agroforestry*. Satish Serial Publishing, New Delhi (ISBN: 9384988952).
3. Nair P K Ramachandran. 1993. *An Introduction to Agroforestry*. Springer Dordrecht (ISBN: 978-0-7923-2134-7)
4. Parthiban K T and Keerthika A. 2021. *A Textbook of Agroforestry – Principles, Practices and Application*. Agro Bios (India), Jodhpur. (ISBN: 9788197377689)
5. Parthiban K T and Seenivasan R. 2017. *Plantation and Agroforestry: Pulpwood Value Chain Approach*. 517p. Published by Scientific Publisher, Jodhpur.
6. Parthiban K T, Ramah K, Sivakumar K, Rajeshwar Rao G. 2018. *Multifunctional Agroforestry – Ecosystem services*. 419p. Narendra Publishers. New Delhi.
7. Parthiban K T, Umarani R, Kanna S Umesh. Sekar I, Rajendran P and Durairasu P. 2014. . *Industrial Agroforestry Perspective and Prospectives*. 396p. Scientific Publisher. Jodhpur.

Skill Enhancement Course (Indicative SEC- I Courses) 4 (0+4)

- Commercial Seedling Production
- Forest Machine Learning Technology
- Commercial Forestry
- Landscape Management and Restoration
- Wildlife Photography
- Ecotourism
- Para-taxonomy
- Ornithology
- Herpetology
- Design and development of wood products

Farming Based Livelihood Systems 3 (2+1)

Objectives

i. To aware the students about farming-based livelihood systems in agriculture

ii. To disseminate the knowledge and skill how farming-based systems can be a source of livelihood

Theory

Status of agriculture in India and different states, Income of farmers and rural people in India, Livelihood-Definition, concept and livelihood pattern in urban and rural areas, Different indicators to study livelihood systems. Agricultural livelihood systems (ALS): Meaning, approach, approaches and framework, Definition of farming systems and farming based livelihood systems Prevalent Farming systems in India contributing to livelihood. Types of traditional and modern farming systems. Components of farming system/ farming-based livelihood systems- Crops and cropping systems, Livestock, (dairy, piggery, goatry, poultry, duckry etc.), Horticultural crops, Agro--forestry systems, Aqua culture Duck/Poultry cum Fish, Dairy cum Fish, Piggery cum Fish etc., small, medium and large enterprises including value chains and secondary enterprises as livelihood components for farmers, Factors affecting integration of various enterprises of farming for livelihood. Feasibility of different farming systems for different Agro-climatic zones, Commercial farming-based livelihood models by NABARD, ICAR and other organizations across the country, Case studies on different livelihood enterprises associated with the farming. Risk and success factors in farming-based livelihood systems, Schemes and programs by Central and State Government, Public and Private organizations involved in promotion of farming-based livelihood opportunities. Role of farming-based livelihood enterprises in 21st Century in view of circular economy, green economy, climate change, digitalization and changing life style.

Practical

Survey of farming systems and agriculture-based livelihood enterprises, Study of components of important farming-based livelihood models/ systems in different agro-climatic zones, Study of production and profitability of crop based, livestock based, processing based and integrated farming-

based livelihood models, Field visit of innovative farming system models. Visit of Agri-based enterprises and their functional aspects for integration of production, processing and distribution sectors and Study of agri-enterprises involved in industry and service sectors (Value Chain Models), Learning about concept of project formulation on farming-based livelihood systems along with cost and profit analysis, Case study of Start-Ups in agri-sectors.

Suggested Readings

1. Agarwal A and Narain S. 1989. *Towards Green Villages: A strategy for Environmentally, Sound and Participatory Rural Development, Center for Science and Environment*, New Delhi, India.
2. Ashley C and Carney D. 1999. *Sustainable Livelihoods: Lessons from Early Experience;* Department for International Development: London, UK; Volume 7. [Google Scholar]
3. Bhatt B P, Kumar Abhay, Thakur P K, Dey Ujjwal Kumar Amitava, Kumar Sanjeev, Jha B K, Kumar Lokendra, Pathak K N, Hassan A, Singh S K, Singh K K, Singh K M. Livelihood Improvement of Underprivileged Famring Community: Some Expericences form Vaishali, Samastipur, Darbhanga, Munger Districts of Bihar. ICAR Research Complex for Estern Region ICAR Parishar, P.O. Bihar Veterinary College of Agricultural Research, New Delhi.
4. Carloni A. 2001. *Global Farming Systems Study: Challenges and Priorities to 2030 – Regional Analysis: Sub-Saharan Africa, Consultation Document*. FAO, Rome, Italy.
5. Dixon J, Gulliver A and Gibbon D. 2001. *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World.* FAO and World Bank, Rome, Italy and Washington, DC, USA.
6. Evenson R E. 2000. *Agricultural Productivity and Production in Developing Countries'. In FAO. The State of Food and Agriculture.* FAO, Rome, Italy.
7. Reddy S R. 2016. *Farming System and Sustainable Agriculture* Kalyani Publishers, New Delhi.
8. Walia S S and Walia U S. 2020. *Farming System and Sustainable Agriculture*. Scientific Publishers, Jodhpur, Rajasthan.

Communication Skills 2 (1+1)

Objective

To acquire competence in oral, written and non-verbal communication, develop strong personal and professional communication and demonstrate positive group communication

Theory

Communication Process: The magic of effective communication; Building self-esteem and overcoming fears; Concept, nature and significance of communication process; Meaning, types and models of communication; Verbal and non-verbal communication; Linguistic and non-linguistic barriers to communication and reasons behind communication gap/ miscommunication.

Basic Communication Skills: Listening, Speaking, Reading and Writing Skills; Precis writing/ Abstracting/Summarizing; Style of technical communication Curriculum vitae/resume writing; Innovative methods to enhance vocabulary, analogy questions.

Structural and Functional Grammar: Sentence structure, modifiers, connecting words and verbals; phrases and clauses; Case: subjective case, possessive case; objective case; Correct usage of nouns, pronouns and antecedents, adjectives, adverbs and articles; Agreement of verb with the subject: tense, mood, voice; Writing effective sentences; Basic sentence faults.

Practical

Listening and note taking; Writing skills: precis writing, summarizing and abstracting; Reading and comprehension (written and oral) of general and technical articles; Micro-presentations and Impromptu Presentations: Feedback on presentations; Stage manners: grooming, body language, voice modulation, speed; Group discussions; Public speaking exercises; vocabulary building exercises; Interview Techniques; organization of events.

Suggested Readings

1. Barbara Pease & Allan Pease. 2006. *Definitive Book of Body Language*-RHUS.
2. Carnegie Dale. 2018. *The Quick and Easy Way to Effective Speaking*. Fingerprint Publishing.
3. Francis Peter S J. 2012. *Soft Skills and Professional Communication*. Tata McGraw Hill, New Delhi.
4. Kumar S and Pushpa Lata. 2011. *Communication Skills*. Oxford University Press.
5. Mark Goulston. 2015. Just Listen. Amacom, Reprint edn. HarperCollins.
6. Napoleon Hill. 2014. *Think and Grow Rich*-Fingerprint.
7. Neuliep James W. 2003. *Intercultural Communication: A Contextual Approach*. Houghton Mifflin Co Boston.
8. Raman M and Singh P. 2000. *Business Communication*. Oxford University Press.
9. Seely J. 2013. *Oxford Guide to Effective Writing and Speaking*. Oxford University Press.

National Cadet Corps (NCC-I) 1 (0+1)

- Aims, objectives, organization of NCC and NCC song. DG's cardinals of discipline.
- Drill- aim, general words of command, attention, stands at ease, stand easy and turning.
- Sizing, numbering, forming in three ranks, open and close order march, and dressing.
- Saluting at the halt, getting on parade, dismissing, and falling out.
- Marching, length of pace, and time of marching in quick/slow time and halt. Side pace, pace forward and to the rear. Turning on the march and wheeling. Saluting on the march.
- Marking time, forward march, and halt. Changing step, formation of squad and squad drill.
- Command and control, organization, badges of rank, honors, and awards
- Nation Building- cultural heritage, religions, traditions, and customs of India. National integration. Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizens. Leadership traits, types of leadership. Character/ personality development. Civil defence organization, types of emergencies, firefighting, protection. Maintenance of essential services, disaster management, aid during development projects.
- Basics of social service, weaker sections of society and their needs, NGO's and their contribution, contribution of youth towards social welfare and family planning.

- Structure and function of human body, diet and exercise, hygiene and sanitation. Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health. Adventure activities. Basic principles of ecology, environmental conservation, pollution and its control.

National Service Scheme (NSS-I)

Evoking social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skilfull in executing democratic leadership, developing skill in program, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

A student enrolled in NSS course should put in at least 60 hours of social work in different activities in a semester other than five regular one-day camp in a year and one special camp for duration of 7 days at any semester break period in the two years. Different activities will include orientation lectures and practical works. Activities directed by the Central and State Government have to be performed by all the volunteers of NSS as per direction.

Introduction and Basic Components of NSS

- Orientation: history, objectives, principles, symbol, badge; regular programs under NSS
- organizational structure of NSS, Code of conduct for NSS volunteers, points to be considered by NSS volunteers' awareness about health.
- NSS program activities. Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analyzing guiding financial patterns of scheme, youth program/ schemes of GOI, coordination with different agencies and maintenance of diary. Understanding youth. Definition, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change.
- Community mobilization. Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership. Social harmony and national integration.
- Indian history and culture, role of youth in nation building, conflict resolution and peace-building. Volunteerism and *shramdaan*. Indian tradition of volunteerism, its need, importance, motivation, and constraints; shaman as part of volunteerism.
- Citizenship, constitution, and human rights. Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to information. Family and society. Concept of family, community (PRIs and other community-based organizations) and society.

Semester II

Tree Seed and Nursery Technology 3 (1+2)

Objectives

i. To impart knowledge on production, collection, processing, quality control and storage of tree seeds and its application in production and conservation of forests.

ii. To impart knowledge on quality nursery stock and clonal technologies for production of quality planting stock in forest trees.

Theory

Introduction - Seed technology and its role in forestry - Seed quality. Seed biology - Seed structure, Fertilization and Seed development. Seed germination - Types and stages of seed germination - Factors affecting seed germination. Seed dormancy - Types - Causes - Merits and demerits. Production of quality seeds - Candidate tree, plus tree and elite tree. Seed production areas - Establishment and management of SPA. Seed orchards - Types of seed orchard - Establishment and management of seed orchards. Factors affecting tree seed production - Influence of provenance and seed source. Seed collection - Planning and organizing seed collection - Methods and factors affecting choice of seed collection. Seed extraction - Methods of extraction in different types of fruits. Seed treatment - Pre-sowing seed treatments - Priming - Pelleting - Dormancy breaking treatments - Pre-storage treatments. Seed storage - Orthodox and recalcitrant seeds - Natural longevity of tree seeds - Factors affecting longevity in storage - Storage conditions - Methods and containers. Seed testing. Classes of seeds - Seed quality control mechanism - Certification procedure- Classes of tree seeds - OECD procedure for tree seed certification - Plant quarantine - International organizations involved in seed quality control - Seed Legislation in India. Forest Nurseries - Types, selection of site, nursery layout and nursery area. Potting mediaseedbeds and containers (Poly bags and root trainers). Propagation - Types - Sexual and Asexual Propagation - Vegetative and Tissue Culture Techniques - Media and Potting Mixtures.

Practical

Tree Seed Technology: Identification and study on external and internal structure of tree seeds and physiological maturity tests. Visit to seed production area. Physical purity analysis, Determination of seed moisture, Seed germination test, Seed viability test, TTZ test, Hydrogen peroxide test, Seed vigour test, Conductivity test, Accelerated ageing test and Seed health testing. Tree Nursery Technology: Nursery technology for quality nursery stock production in small seeded species - Big seeded species - Recalcitrant seeds - Endangered tree species. Nursery techniques for large size seedlings for avenue planting and problem soils. Clonal forestry – Potting media – Plant growth substances – Propagation methods through cuttings, grafting, layering and budding.

Suggested Readings

1. Agrawal R L. 1986. *Seed Technology. Oxford* - IBH Publishing Co. New Delhi.
2. Bedell P E. 1998. *Seed Science and Technology: Indian Forestry Species*. Allied Publishers, New Delhi.
3. Bewely J D and Black M. 1985. *Seed- Physiology of development and germination*. Springer Nature Singapore.
4. Chin H F. and Roberts E H. 1980. *Recalcitrant Crop Seeds. Tropical Press Sdn*. Bhd. Kuala Lumpur - 22-03, Malaysia.
5. Hannah Jaenicke. 2007. *Good Tree Nursery Practices. International Centre for Research in Agro forestry*, Kenya.
6. Hartmann H T and Kester D E. 1968. *Plant propagation – principles and practice*. Prentice – Hall of India Private Limited, New Delhi.
7. ISTA. 1993. *International Rules for Seed Testing Rules. International Seed Testing Association*. Zurich, Switzerland.
8. Leadem C L. 1984. *Quick Tests for Tree Seed Viability. B.C. Ministry of Forests and Lands, Canada*. Province of British Columbia, Ministry of Forests.

9. Napier I and Robbins M. 1989. *Forest Seed and Nursery Practice in Nepal.* Nepal-UK Forestry Research Project, Kathmandu.
10. Ram Prakash. 2007. *Plantation and Nursery Techniques of Forest Trees*. International Book Distributers, Dehradun.
11. Ramamoorthy and Sivasubramanian. 2006. *Seed Legislation in India*. Agrobios, Jodhpur.
12. Renugadevi J, Srimathi P, Renganayaki P R and Manonmani V. 2020. *Seed Testing*. Agrobios, Jodhpur.
13. Sharma R R and Srivastava Manish. 2007. *Plant propagation and nursery management*. International Book Distributers, Dehradun.
14. Umarani R. 2006. *Tree Seed Technology*. Scientific Publishers, New Delhi.

Fundamentals of Forest Genetics 2 (1+1)

Objective

To understand the fundamental concepts of Genetics and Cytogenetics

Theory

Definition of genetics, heredity, inheritance, cytology, cytogenetics; Brief history of developments in genetics and cytogenetics. Physical basis of heredity. Structure and function of cell and cell organelles – Differences between Prokaryotes and Eukaryotes. Cell division – mitosis-meiosis and their significance - Gametogenesis and syngamy in Plants. Chromosome structure, chemical composition, nucleosome, centromere, telomere, euchromatin, heterochromatin, NOR, satellite chromosome, karyotype, ideogram. Types of chromosomes based on position of centromere, Chromosomal aberration: Variation in chromosome structure – deletion, duplication, inversion and translocation – genetic and cytological implications. Chromosomal aberration: Variation in chromosome number – euploid, aneuploid, types of aneuploids and their origin; Klinefelter syndrome and Turner syndrome; Polyploid - auto and allopolyploids, their characters; meaning of genome; evolution of wheat, triticale, cotton, tobacco, Brassica. Mendel's experiments and laws of inheritance. Rediscovery of Mendel's work. Terminologies: gene, allele, locus, homozygous, heterozygous, hemizygous, genotype, phenotype, monohybrid, dihybrid, trihybrid, polyhybrid. Allelic interactions – Dominance vs recessive, complete dominance, codominance, incomplete dominance, Non allelic interaction with modification in Mendelian ratio – (i) Dominant epistasis (12:3:1). (ii) Recessive epistasis (9:3:4). (iii) Duplicate and additive epistasis (9:6:1). (iv) Duplicate dominant epistasis (15:1). (v) Duplicate recessive epistasis (9:7). (vi) Dominant and recessive epistasis (13:3); Summary of epistatic ratios (i) to (vi). Lethal genes, Pleiotrophy, penetrance and expressivity, Multiple alleles, blood group in human, coat colour in rabbits, pseudo alleles, isoalleles. Polygenes – transgressive segregation, comparison of quantitatively and qualitatively inherited characters; modifiers; Linkage - coupling and repulsion; Crossing over – significance of crossing over; Factors controlling crossing over. Strength of linkage and recombination; Two point and three points test cross. Double cross over, interference and coincidence; genetic map, physical map.

Sex determination: Autosomes and sex chromosomes - chromosomal theory of sex determination different types –Sex determination in plants. Cytoplasmic inheritance and maternal effects – features of cytoplasmic inheritance, chloroplast, mitochondrial - plastid colour in *Mirabilis jalapa* - cytoplasmic male sterility. Watson and Crick model. Models of DNA replication; steps involved in DNA replication. RNA types - mRNA, tRNA, rRNA. Protein synthesis, Mutation – characteristics

of mutation – micro and macro mutation, Transition and transversion; major physical and chemical mutagens.

Practical

Study of microscopes – Preparation of fixatives and stains – Pretreatment of materials for mitosis and meiosis – study of mitosis and meiosis. Study of genetic ratios of – monohybrid, dihybrid – incomplete dominance. Gene interaction - multiple alleles and multiple factors. Study of linkage, Estimation of strength of linkage and recombination frequency in three points test cross data and F2 data – Drawing of genetic map – interference and coincidence. Studies on sex linked inheritance in Humans and Drosophila.

Suggested Readings

1. Benjamin Lewin. 2005. *Genes IX*. Oxford University Press, Oxford.
2. Daniel Sundararaj, G. Thulasidas and M. Stephen Dorairaj, 1997. *Introduction to Cytogenetics and Plant Breeding*. Popular Book Depot, Chennai.
3. Gupta P K. 1997. *Cytogenetics.* Rastogi Publications, Meerut.
4. Pundhansingh. 2014. *Elements of Genetics*. Kalyani Publishers.
5. Russel P J. 2000. *Fundamentals of genetics*. Addition Wesley Longman Publishers, USA.
6. Singh B D. 2004. *Fundamentals of Genetics*. Kalyani Publishers, Chennai.
7. Stansfield W D.1990. *Theory and problems of genetics*. Mc-Graw Hill Book Co., New York.
8. Strickberger M W. 1996. *Genetics*. Prentice-Hall of India Pvt. Ltd. New Delhi.
9. Verma P S and Agarwal V K. 2007. *Genetics.* S. Chand and Company Ltd. New Delhi.

Wood Anatomy and Identification 2 (1+1)

Objective

To develop basic understanding on wood identification, anatomical characterisation of both Gymnosperms and Angiosperms

Theory

Basics and introduction of wood anatomy-Classification of plant kingdom-Gymnosperms versus angiosperms - Kinds of woody plants. The plant body - a tree and its various parts. Meristems -Promeristem, primary meristem, secondary meristem. Simple tissues - Parenchyma, collenchyma, sclerenchyma and the vascular tissues. Parts of the primary body - Typical stems and roots of dicots and monocots. Basic process in tree growth - Vascular cambium – Expansion of cambium layer – Duration of cambial activity - Secondary growth in woody plants. Mechanism of wood formation - Special reference to typical dicot stem. Ray initials and fusiform initials -Anticlinal and periclinal division. Physiological significance of wood formation. The macroscopic features of wood - Sapwood, heartwood, pith, early wood, late wood, growth rings, dendrochronology, wood rays, Knots, Grain orientation etc - Sapwood versus heart wood - Anatomical differences. Transformation of sapwood to heartwood - Factors affecting transformation. Prosenchymatous elements, tracheids, vessels, fibers, parenchyma and rays, resin canals, gum canals, latex canals and infiltrants in wood. Three dimensional features of wood - Transverse, tangential and radial surfaces. Elements of wood cell walls. Structure and arrangement of cells - Simple pit and bordered pits. Extractives in wood.

Comparative anatomy of gymnosperms and angiosperms. Anatomical features of common Indian timbers - Classification into porous and non-porous woods, ring porous and diffuse porous woods. Effect of growth rate on wood properties. Juvenile wood and mature wood. Reaction wood. Bark structure - Composition and functions.

Practical

Study of primary growth in stems of typical dicots and monocots. Study of wood formation in typical dicot stem. Study of vascular bundles in monocots. Parts of the logs (Woody trunks), and the three distinctive surfaces of wood (i.e. cross, radial and tangential planes). Timber identification and its importance. Procedures for field identification of timbers and examination of wood samples. Study of physical features of wood. Study of gross features of wood. Study of anatomical features of wood, pores or vessels, different types. Study of soft tissue in timbers and their different types distributions. Study of wood rays, and their different types. Study of the non-porous woods, their physical and anatomical description. Study of infiltration and inclusions in wood. Anatomical keys and methods to use them. Dichotomous keys, punched card keys and computer aided identification. Field identification of important timbers of Tamil Nadu.

Suggested Readings

1. Brown H P. 1995. *Text Book of Wood Technology.* Vol. I & II. International Books and Periodical supplement service, New Delhi.
2. Haygreen J G and Bowyer J L. 1982. *Forest Products and Wood Science-An Introduction*. 495p. The Iowa State University Press, America.
3. Hoadley B. 2000. *Identifying Wood-Accurate Results with Simple Tools*. 223p. Taunton Press, Newtown, USA.
4. Panshin A J and De Zeeuw C. 1980. *Textbook of Wood Technology*. (4th Edn.). 722p. McGraw-Hill. New York, USA.
5. Rao R K and Juneja K B S. 1992. *Field Identification of Fifty Important Timbers of India.* 123p. Indian Council of Forestry Research and Education, New Forest, Dehradun.

Forest Measurements and Inventory 3 (2+1)

Objectives

i. To impart various methods of measurements on standing, felled trees, crops and determining the volume of trees

ii. To inculcate knowledge on volume table preparation for trees

Theory

Forest Mensuration-Definition and objectives-Scales of measurement-Units of measurements-Precision, bias and accuracy aimed and reasons. Diameter and girth measurements - Breast height measurements - instruments used. Measurement of height - Definitions - Methods of measurement of height - Ocular - non instrumental and instrumental methods. Sources of error in height measurement - Height measurement of leaning trees. Tree stem form - Metzger's theory - Form factor - Types of form factor - Form height, form quotient - Form class. Area measurement in trees and timber - Cross sectional and basal area. Volume measurement of standing trees – Volume of

felled logs - Branch wood. Volume table - Definition - Preparation of volume tables - Graphical, regression equation and alignment chart method. Forest inventory - Sampling techniques and methods - Measurement of crops - Sample plots. Increment - CAI and MAI - Increment Percent - Instruments and methods - Increment Borer. Stump analysis - Stem analysis - Increment Boring. Tree crops - Measurements - Objects - Crop diameter, crop height, crop age and crop volume. Yield table and stand table.

Practical

Determination of length - Measurements of diameter. Girth and basal area of trees using Callipers, Tape, Ruler, Penta Prism, Tree Calliper, etc. Measurement of height using non instrumental method - Shadow method and Single pole method. Measurement of tree height using instrumental methods - Haga altimeter - Clinometer - Blume leiss Hypsometer - Laser Hypsometer. Volume determination of standing and felled trees. Exercise on Stump analysis and Stem analysis. Annual ring counting in trees using ring borer. Preparation of volume tables - Local volume table. Yield Table - Preparation and Application. Point sampling - Theory - Wedge prism. Total enumeration and partial enumeration - Kinds of sampling and elementary statistical computations.

Suggested Readings

1. Chaturvedi A N and Khanna L S. 1982. *Forest Mensuration.* International Book Distributors, Dehradun.
2. Manikandan K and Prabhu S. 2014. *Indian Forestry. A Breakthrough Approach to Indian Forest Service.* Jain Brothers, New Delhi.
3. Eugene T. 1983. *Forest Mensuration*. McGraw Hill Company.
4. Panwar and Bharadwaj. *Handbook of Practical Forestry.* Updesh Purohit for Agrobios (India), Jodhpur.

Personality Development 2 (1+1)

Objective

To make students realize their potential strengths, cultivate their inter-personal skills and improve employability

Theory

Personality Definition, Nature of personality, theories of personality and its types. The humanistic approach - Maslow's self-actualization theory, shaping of personality, determinants of personality, Myers-Briggs Typology Indicator, Locus of control and performance, Type A and Type B Behaviors, personality and Organizational Behavior.

Foundations of individual behavior and factors influencing individual behavior, Models of individual behavior, Perception and attributes and factors affecting perception, Attribution theory and case studies on Perception and Attribution. Learning: Meaning and definition, theories and principles of learning, Learning and organizational behavior, Learning and training, learning feedback. Attitude and values, Intelligence- types of Intelligence, theories of intelligence, measurements of intelligence, factors influencing intelligence, intelligence and Organizational behavior, emotional intelligence. Motivation- theories and principles, Teamwork and group dynamics.

Practical

MBTI personality analysis, Learning Styles and Strategies, Motivational needs, Firo-B, Interpersonal Communication, Teamwork and team building, Group Dynamics, Win-win game, Conflict Management, Leadership styles, Case studies on Personality and Organizational Behavior.

Suggested Readings

1. Andrews Sudhir. 2008. *How to Succeed at Interviews.* Tata McGraw-Hill.
2. Heller Robert. 2008. *Effective Leadership*. Essential Manager series. DK Publishing.
3. Hindle Tim. 2003. *Reducing Stress. Essential Manager series*. DK Publishing.
4. Kumar Pravesh. 2005. *All About Self- Motivation*. Goodwill Publishing House, New Delhi.
5. Lucas Stephen. 2001. *Art of Public Speaking*. Tata - Mc-Graw Hill, New Delhi.
6. Mile D J. 2004. *Power of Positive Thinking*. Rohan Book Company, Delhi.
7. Smith B. 2004. *Body Language*. Rohan Book Company, Delhi.
8. Shaffer D R. 2009. *Social and Personality Development* (6th Edn.). Belmont, CA: Wadswor.

Environmental Studies and Disaster Management 3 (2+1)

Objective

To expose and acquire knowledge on the environment and to gain the state-of-the-art - skill and expertise on management of disasters.

Theory

Introduction to Environment - Environmental studies - Definition, scope and importance - Multidisciplinary nature of environmental studies - Segments of Environment - Spheres of Earth - Lithosphere - Hydrosphere - Atmosphere - Different layers of atmosphere. Natural Resources: Classification - Forest resources. Water resources. Mineral resources Food resources. Energy resources. Land resources. Soil resources. Ecosystems - Concept of an ecosystem - Structure and function of an ecosystem - Energy flow in the ecosystem. Types of ecosystems. Biodiversity and its conservation: Introduction, definition, types. Biogeographical classification of India. Importance and Value of biodiversity. Biodiversity hot spots. Threats and Conservation of biodiversity.

Environmental Pollution: Definition, cause, effects and control measures of: (a) Air pollution. (b) Water pollution. (c) Soil pollution. (d) Marine pollution. (e) Noise pollution. (f) Thermal pollution. (h) light pollution. Solid Waste Management: Classification of solid wastes and management methods, Composting, Incineration, Pyrolysis, Biogas production, Causes, effects and control measures of urban and industrial wastes. Social Issues and the Environment: Urban problems related to energy. Water conservation, rain water harvesting, watershed management. Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act. Wildlife Protection Act. Forest Conservation Act. Human Population and the Environment: Environment and human health: Human Rights, Value Education. Women and Child Welfare. Role of Information Technology in Environment and human health.

Disaster management - Disaster definition - Types - Natural Disasters - Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves. Man Made Disasters - Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, road accidents, rail accidents, air accidents, sea accidents. International and National strategy for disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, community-based organizations and media in disaster management. Central, state, district and local administration in disaster control; Armed forces in disaster response; Police and other organizations in disaster management.

Practical

Visit to a local area to document environmental assets river/forest/grassland/hill/mountain. Energy: Biogas production from organic wastes. Visit to wind mill / hydro power / solar power generation units. Biodiversity assessment in farming system. Floral and faunal diversity assessment in polluted and un polluted system. Visit to local polluted site - Urban/Rural/Industrial/Agricultural to study of common plants, insects and birds. Environmental sampling and preservation. Water quality analysis: pH, EC and TDS. Estimation of Acidity, Alkalinity. Estimation of water hardness. Estimation of DO and BOD in water samples. Estimation of COD in water samples. Enumeration of *E. coli* in water sample. Assessment of Suspended Particulate Matter (SPM). Study of simple ecosystem – Visit to pond/river/hills. Visit to areas affected by natural disaster.

Suggested Readings

1. De A K. 2010. *Environmental Chemistry.* 384p. New Age International Publishers, New Delhi. ISBN:13–978 81 224 2617 5.
2. Dhar Chakrabarti P G. 2011. *Disaster Management - India's Risk Management Policy Frameworks and Key Challenges.* 36p. Centre for Social Markets (India), Bangalore.
3. Erach Bharucha. 2021. *Text book for Environmental Studies*. University Grants Commission, New Delhi
4. Parthiban K T Vennila, S Prasanthrajan, M Umesh Kanna S. 2023. (In Press). Forest, Environment, Biodiversity and Sustainable development. Narendra Publishing House, New Delhi, India.
5. Prasanthrajan M and Mahendran P P. 2008. *A Text Book on Ecology and Environmental Science. ISBN 81-8321-104-6.* Agrotech Publishing Academy, Udaipur.
6. Prasanthrajan M. 2018. *Objective Environmental Studies and Disaster Management*. ISBN 9789387893825. 140p. Scientific Publishers, Jodhpur, India.
7. Sharma P D. 2009. *Ecology and Environment.* Rastogi Publications, Meerut, India
8. Tyler Miller and Scot Spoolman. 2009. *Living in the Environment (Concepts, Connections, and Solutions).* Brooks/cole, Cengage learning publication, Belmont, USA.

Entrepreneurship Development and Business Management 3 (2+1)

Objectives

i. To provide student an insight into the concept and scope of entrepreneurship

ii. To expose the student to various aspects of establishment and management of a small business unit

iii. To enable the student to develop financially viable agribusiness proposal

Theory

Development of entrepreneurship, motivational factors, social factors, environmental factors, characteristics of entrepreneurs, entrepreneurial attributes/competencies. Concept, need for and importance of entrepreneurial development. Evolution of entrepreneurship, objectives of entrepreneurial activities, types of entrepreneurs, functions of entrepreneurs, importance of entrepreneurial development, and process of entrepreneurship development. Environment scanning and opportunity identification need for scanning–spotting of opportunity-scanning of environment– identification of product / service – starting a project; factors influencing sensing the opportunities. Infrastructure and support systems- good policies, schemes for entrepreneurship development; role of financial institutions, and other agencies in entrepreneurship development. Steps involved in functioning of an enterprise. Selection of the product / services, selection of form of ownership; registration, selection of site, capital sources, acquisition of manufacturing know how, packaging and distribution. Planning of an enterprise, project identification, selection, and formulation of project; project report preparation, Enterprise Management. Production management – product, levels of products, product mix, quality control, cost of production, production controls, Material management. Production management – raw material costing, inventory control. Personal management – manpower planning, labour turn over, wages / salaries. Financial management / accounting – funds, fixed capital and working capital, costing and pricing, long term planning and short-term planning, book keeping, journal, ledger, subsidiary books, annual financial statement, taxation. Marketing management- market, types, marketing assistance, market strategies. Crisis management- raw material, production, leadership, market, finance, natural etc.

Practical

Visit to small scale industries. Agro-industries, Interaction with successful entrepreneurs, Agric-entrepreneurs. Visit to financial institutions and support agencies. Preparation of project proposal for funding by different agencies.

Suggested Readings

1. Charantimath P M. 2009. *Entrepreneurship Development and Small Business Enterprises*. Pearson Publications. New Delhi.
2. Desai V. 2015. *Entrepreneurship: Development and Management.* Himalaya Publishing House.
3. Desai Vasant. 1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publishing House.
4. Grover Indu. 2008. *Handbook on Empowerment and Entrepreneurship*. Agrotech Public Academy.
5. Gupta C B. 2001. *Management Theory and Practice*. Sultan Chand and Sons.
6. Khanka S S. 1999. *Entrepreneurial Development*. S. Chand and Co.
7. Mehra P. 2016. *Business Communication for Managers*. Pearson India, New Delhi.

8. Pandey M and Tewari D. 2010. *The Agribusiness Book*. IBDC Publishers, Lucknow.
9. Singh D. 1995. *Effective Managerial Leadership*. Deep and Deep Publishers.
10. Singhal R K. 2013. *Entrepreneurship Development and Management*, Katson Books.
11. Tripathi P C and Reddy P N. 1991. *Principles of Management*. Tata McGraw Hill.

Skill Enhancement Course (Indicative SEC Courses II) **4 (0+4)**

- Clonal Seedling Production
- Forest Based Industrial Training
- Urban Forestry Designing and Planning
- Wood Working and Carpentry
- Wood seasoning and Preservation Technology
- Zoo Management
- Wild and Commercial Beekeeping
- Mining Afforestation
- Advanced Wood Working
- Lac and Tassar Cultivation

National Cadet Corps (NCC-II) **1 (0+1)**

- Arms Drill- Attention, stand at ease, stand easy. Getting on parade. Dismissing and falling out. Ground/take up arms, examine arms. Shoulder from the order and vice-versa, present from the order and vice-versa. Saluting at the shoulder at the halt and on the march. Short/long trail from the order and vice- versa. Guard mounting, guard of honor, Platoon/Coy Drill.
- Characteristics of rifle (.22/.303/SLR), ammunition, fire power, stripping, assembling, care, cleaning, and sight setting. Loading, cocking, and unloading. The lying position and holding.
- Trigger control and firing a shot. Range Procedure and safety precautions. Aiming and alteration of sight. Theory of groups and snap shooting. Firing at moving targets. Miniature range firing. Characteristics of Carbine and LMG.
- Introduction to map, scales, and conventional signs. Topographical forms and technical terms.
- The grid system. Relief, contours, and gradients. Cardinal points and finding north. Types of bearings and use of service protractor. Prismatic compass and its use. Setting a map, finding north and own position. Map to ground and ground to map. Knots and lashings, Camouflage and concealment, Explosives and IEDs.
- Field defenses obstacles, mines and mine lying. Bridging, waterman ship. Field water supplies, tracks and their construction. Judging distance. Description of ground and indication of landmarks. Recognition and description of target. Observation and concealment. Field signals. Section formations. Fire control orders. Fire and movement. Movement with/without arms. Section battle drill. Types of communication, media, latest trends and developments.

National Service Scheme (NSS-II)

Evoking social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skilful in executing democratic leadership, developing

skill in program, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

A student enrolled in NSS course should put in at least 60 hours of social work in different activities in a semester other than five regular one-day camp in a year and one special camp for duration of 7 days at any semester break period in the two years. Different activities will include orientation lectures and practical works. Activities directed by the Central and State Government have to be performed by all the volunteers of NSS as per direction.

- Importance and role of youth leadership
- Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership, Life competencies
- Definition and importance of life competencies, problem-solving and decision-making, interpersonal communication. Youth development programs
- Development of youth programs and policy at the national level, state level and voluntary sector; youth-focused and youth-led organizations
- Health, hygiene and sanitation. Definition needs and scope of health education; role of food, nutrition, safe drinking water, water borne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programs and reproductive health. Youth health, lifestyle, HIV AIDS and first aid. Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid. Youth and yoga. History, philosophy, concept, myths, and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method

Post-II Semester

Internship (Only for exit option for award of UG-Certificate)-10 Weeks 10 (0+10)

General Objective

To provide students with an opportunity to put into practice the skills they have learned while in the institute, so that in case they exit with UG-certificate, they will be able to get proper engagement/ employment and consider having their own startups.

Specific Objectives

By the end of the internship, the students should be able to

i. Integrate theory and practice
ii. Assess interests and abilities in their field of study
iii. Develop work habits and attitudes necessary for job success
iv. Develop communication, interpersonal and other critical skills in the job interview process
v. Explore career alternatives prior to graduation.

Activity

The students will have internship/ training for 10 weeks' duration either in the parent institute (attaching the students to facilities such as farm machinery testing centre, incubation centres,

prototype production facilities, etc.) or in industry, farm machinery service centre or related organisations involved in agri-engineering activities. The College/ University will facilitate attaching the students to the organisations.

After completion of internship, the students will have to submit a report of their learnings and also present in form of a seminar before nominated faculty members and other students.

The assessment will be based on the report / assessment received from the industry/ organisation and the report and the presentation made at the University. Ideally the weightage will be 50% each for both internal and external. The SAUs may modify the weightage and breakups.

Semester III

Silviculture of Trees 2 (2+0)

Objective

To impart basic knowledge on silviculture and regeneration of broad leaved and conifer tree species

Theory

Origin, distribution, general description, phenology, silvicultural characters, regeneration methods, silvicultural systems, stand management practices, pest and diseases and economic importance of *Acacia nilotica, Acacia catechu, Azadirachta indica, Dalbergia sissoo, Shorea robusta, Tectona grandis, Terminalia* species, *Anogeissus latifolia, Pongamia pinnata, Bassia latifolia, Calophyllum inophyllum, Simarouba glauca* and *Albizia lebbeck*- Origin, distribution, general description, phenology, silvicultural characters, regeneration methods, silvicultural systems, stand management practices, pest and diseases and economic importance of *Bambusa* species, *Calamus* species, *Dendrocalamus strictus* and *Melocanna bambusoides.* Origin, distribution, general description, phenology, silvicultural characters, regeneration methods, silvicultural systems, stand management practices, pest and diseases and economic importance of Northern region trees: *Abies pindrow, Celtis australis, Diospyros* species, *Grewia* species, *Picea smithiana, Pinus wallichiana, Populus* spp., *Quercus* species, *Robinia pseudoacacia, Eucalyptus* spp. and *Salix* spp. Eastern trees region trees: *Neolamarckia cadamba, Chukrasia tabularis Cryptomaria japonica, Dipterocarpus* species, *Mesua ferrea, Morus laevigata, Pinus kesiya, Shorea assamica* and *Terminalia myriocarpa*. Origin, distribution, general description, phenology, silvicultural characters, regeneration methods, silvicultural systems, stand management practices, pest and diseases and economic importance of *Acacia* spps. (Wattles), *Anacardium occidentale, Casuarina* spp., *Dalbergia latifolia, Pterocarpus* spp., *Eucalyptus* spp., *Santalum album, Swietenia mahogany* and *Tamarindus indica*. Origin, distribution, general description, phenology, silvicultural characters, regeneration methods, silvicultural systems, stand management practices, pest and diseases and economic importance of the following conifer species: Tropical pines, *Abies pindrow, Picea smithiana, Cedrus deodara* and *Pinus roxburghii.*

Suggested Readings

1. Champion H G and Griffith A L. 1948. *Manual for General Silviculture for India. Indian Branch*. Oxford University Press.
2. Dwivedi A P. 1993. *A Text Book of Silviculture*. International Book Distributors. Dehradun.

3. Luna R K. 2005. *Plantation Trees.* International Book Distributors, Dehradun.
4. Troup K S. 1984. *The Silviculture of Indian Trees.* Vol. I, II & III. Controller of Publications, New Delhi.
5. Ralph D Nyland. 1996. *Silviculture Concepts and Applications*. McGraw-Hill, New York.

Wood Science and Technology 2 (1+1)

Objectives

i. To make students aware about the problems related to wood as basic material to manufacture various useful products
ii. To understand the wood treatment requirement

Theory

Wood – Natural defects in wood. Electrical, thermal and acoustic properties of wood. Mechanical properties of wood like tension, compression, bending, shearing, cleavage, hardness, impact resistance, nail and screw holding capacities. Wood water relationship - Hygroscopic nature of wood – Free and bound water – Shrinkage and swelling - Fibre saturation point - Equilibrium moisture content. Moisture content determination. Durability and treatability of wood – Natural defects and wood deterioration. Wood seasoning; merits, principles, seasoning of timber – Introduction and history of seasoning in India - purpose and scope -Factors influencing seasoning, Mechanism of drying and types; Selection and preparation of material for seasoning. Air seasoning, kiln seasoning and chemical seasoning. Refractory classes of timbers, kiln schedules; Special seasoning methods, Seasoning defects and their control. Wood biodeterioration. Classification of timbers based on durability and seasoning behavior. Wood preservation; Introduction– Development and progress of wood preservation in India - mechanism of wood preservation. Preparation of wood for preservative treatment principles, processes, need, types of wood preservatives (Water soluble, oil based, etc.). General idea about fire retardants and their usage, Durability of timbers. Methods of application of wood preservatives-Non pressure Methods-Brushing-Steeping-Hot and cold bath process –Diffusion Process-Momentary Dip Process-Sap displacement method - Boucherie method. Pressure Method-Full cell process - Empty Cell Process-Merits and demerits.

Practical

Mechanical tests on timber. Static bending, impact bending, compression parallel and perpendicular to the grain, hardness, shear, torsion, nail and screw pulling test, brittleness test and calculation of properties. Estimation of combustibility of wood using bomb calorimeter. Estimation of directional shrinkage and swelling of wood. Familiarization of non-destructive wood testing instruments. Visit to wood testing laboratories. Visit to timber depot/saw mill to study the stacking methods and various defects in wood. Determination of moisture content by different methods. Visit to Wood seasoning unit to study the various types of seasoning methods and Safety aspects. Exercise on fixing seasoning schedule for timbers under steam heated kiln and FRI solar heated kiln seasoning method. Visit to wood preservation unit to study the different methods of application of wood preservatives. Study on the environmental health and safety aspects of wood preservatives.

Non pressure and pressure methods of application of preservatives. Seasoning and preservative treatments for important tree species.

Suggested Readings

1. Bowyer J L. Shmulsky R and Haygreen J G. 2007. *Forest products and wood science: An introduction.* (5th Edn.) 496p. Blackwell Publishing, Ames, IA.
2. Brown H P. 1985. *Manual of Indian Wood Technology*. 121p. International Books and Periodicals Supply Service, New Delhi.
3. Divya M P, Parthiban K T, Packialakshmi M and Krishnamoorthi S. 2022. *Text Book on Wood Products and Utilization.* Scientific Publishers, Jodhpur (ISBN No.:9879392590795).
4. FRI. [Forest Research Institute]. 1976. *Indian Forest Utilization.* Vol. I & II. 941p. Forest Research Institute, Dehradun.
5. Panshin A J and De Zeeuw C. 1980. *Textbook of Wood Technology,* (4th Edn.) 722p. McGraw-Hill. New York, USA.
6. Madison W I. 1999. USDA *Wood handbook - Wood as An Engineered Material.* 508p. U.S. Department of Agriculture, Forest Service. Forest Products. Laboratory.

Forest Microbiology 2 (1+1)

Objective

To impart basic knowledge about the microbiological associations involved in promoting the growth of trees.

Theory

Forest soil Microbes. Rhizosphere concept- ecto and endo rhizosphere, rhizoplane and rhizosphere effect (R:S ratio); spermosphere - seed surface microflora and phyllosphere - lichens, algae and leaf nodulating microorganisms. Soil microbial biomass in different forests; qualitative and quantitative nature of microorganisms in various forest ecosystems - their role in improving soil nutrient availability and plant growth. Carbon cycle - forest litter / organic matter – types; composition of organic matter / litter. Biochemistry and microbiology of litter / organic matter decomposition under aerobic - tropical, subtropical and temperate forest ecosystem; and in anaerobic conditions – mangrove and swamp forests. Role of autotrophic microorganisms in sequestering carbon in forest soils. Biochemical cycling of nitrogen. Nitrogen fixation - free living, associative and symbiotic diazotrophs. Nitrogen fixing trees- leguminous trees with *Rhizobium* and non-leguminous / actinorhizal trees with *Frankia* and their nitrogen fixing capacity. Biochemistry and microbiology of nitrification and denitrification and their impact on nitrogen availability in aerobic and anaerobic forest ecosystem. Biochemical cycling of phosphorus. Microbial transformation of phosphorus – mycorrhizae – types; mycorrhizal status of tropical, sub tropical and temperate forest trees; nutritional and non-nutritional effects of mycorrhizae; mechanism of enhanced nutrient uptake and plant growth. Phosphate solubilisers - types – mechanism of phosphate solubilization. Microbial transformation of iron and sulphur. Microbial interactions in soil. Microbial inoculants - mass production, storage methods ISI / BIS standards and quality control; problems and constraints in production and application. Role of microbial inoculants in afforestation program. Generation

of biofuels – Development of biological conversion technologies – Biodiesel – Microorganisms and raw materials used for microbial Oil production – Treatment of the feedstocks prior to production of the Biodiesel – Current technologies of biodiesel production. Bioethanol – Properties – Feedstocks – Process technology – Pilot plant for ethanol production from lignocellulosic feedstock – Biomethanol – Principles, materials and feedstocks – Process technologies and techniques – Advantages and limitations.

Practical

Isolation and enumeration of rhizosphere and soil microorganisms. Quantification of heterotrophic microbial population and total microbial activity of different forest ecosystem. Isolation of cellulose and lignin degrading microorganisms from forest floor. Isolation of free living diazotrophs - Azotobacter and Beijerinckia from soil. Isolation of Azospirillum and Phosphobacteria. Study of root nodules of leguminous trees. Isolation of Rhizobium from root nodules of tree legumes. Study of root nodules of non-leguminous trees and isolation of Frankia from *Casuarina equisetifolia/Alnus nepalensis*. Examination of ecto- and endo-mycorrhizae from different forest soils. Bio composting of leaf litter. Mass culturing of bacterial and fungal inoculants- microbial inoculation techniques.

Suggested Readings

1. Alexander M. 1985. *Introduction to Soil Microbiology*. John Wiley and Sons, New York. New Delhi.
2. Paul E A. 2007. *Soil Microbiology, Ecology, and Biochemistry.* (2nd Edn.). Academic Press.
3. Pelczar M J, Chan C S and Krieg N R. 2003. *Microbiology.* Tata McGraw Hill Pub. Co. Ltd.
4. Prescott L M, Harley J P and Kelin D A. 2000. *Microbiology* (4th Edn.). McGraw Hill.
5. Shukla G and A Varma. 2010. *Soil Enzymology (Soil Biology),* Springer Verlag.
6. Singh R P. 2010. *Microbiology*. Kalyani Publishers. Ludhiana.
7. Smith S E and Read D J. 1997. *Mycorrhizal Symbiosis.* (2nd Edn.). Academic Press, San Diego.
8. Subba Rao N S and Dommergues Y R. 2000. *Microbial interactions in Agriculture and Forestry.* Vol. II. Oxyford and IBH Publications Co. Pvt. Ltd. New Delhi and Kolkata.
9. Rao Subba N S. 1997. *Biofertilizers in Agriculture and Forestry.* (3rd Edn.). Oxford and IBH Publishing Co. PVT Ltd., New Delhi, Bombay and Kolkata.
10. Tate R L. 1995. *Soil Microbiology*. John Wiley and Sons, Inc, New York.
11. Tauro P, Kapoor K K and Yadav K S. 1989. *An Introduction to Microbiology*. Wiley Pub.

Forest Soil and Nutrient Management 2 (1+1)

Objective

To impart knowledge about the forest soil fertility and productivity and to enhance the nutrient status in soil.

Theory

Forest soils vs cultivated soils - Soil fertility and productivity - Properties of soils under different forest ecosystem - Arnon's criteria of essentiality. Classification of nutrients based on Arnon's criteria - Sources of nutrients and forms of nutrients. Nutrient transformations – Mineralization and immobilization - Availability and uptake of nutrients by plants – Fixation and loss of nutrients – Nitrogen, Phosphorus and Potassium cycles in soil. Available forms of secondary nutrients – Ca, Mg and S. Availability of micronutrients. Deficiency and toxicity symptoms and their corrective measures for nutrients. Relationship between nutrient concentrations and plant growth. Deficiency, Hidden hunger, Critical limit, Sufficiency level, Excessive and Toxicity limits. Soil Reaction (pH) and Nutrient availability. Cation exchange – CEC – adsorption, desorption. AEC – calculation of BSP. Significance of CEC and exchangeable cations with respect to soil fertility. Factors affecting CEC in soils. Nutrient Interaction – Definition – Mechanisms, types of interactions between macro and micronutrients, chelates and plant nutrition. Diversity of organisms in the soil – Factors affecting their growth and activity in the soils viz., Organic matter, oxygen, temperature, pH etc. Soil Macro organisms - Earthworms, Ants and termites and plant roots, Soil micro animal's nematodes, protozoa etc. and their role in soil. Soil microorganisms- Prokaryotes (Bacteria and archaea), fungi, actinomycetes, Cyanobacteria (Blue-green algae) etc. in the soil ecosystem their distribution. Atmospheric N fixation by organisms and Nitrogen fixing tree species. Mycorrhiza - Types of Mycorrhiza and Beneficial effects on plant nutrition. Concepts of rhizosphere - Rhizodeposition and Phyllosphere. Organic matter decomposition - Factors affecting organic matter decomposition – Stages of organic matter decomposition - C: N ratio of organic matter, its importance and nutrient availability - Role of organic matter in the Forest soil improvement. Nutrient management - Nutrient Use efficiency – Importance. Methods of soil fertility evaluation – Diagnosis of deficiency symptoms, Biological test, Soil testing and Rapid plant tissue analysis and Fertilizers recommendation. Soil fertility management: Optimum, efficient and balanced use of nutrients. INM – SSNM – Fertigation - Crop rotation, Nutrient management through fortification of fertilizers. Permanent manurial experiments - LTFE experiments. Methods of fertilizer recommendations.

Practical

Available N, available P_2O_5, available K_2O, and micronutrients from the soils and interpretation of their results. Determination of CEC and derivation of ESP. Estimate the gypsum requirement of sodic soils and lime requirement of acid soils. Enumeration of soil micro-organisms -Estimation of N fixing micro-Organisms-Organic matter decomposition.

Suggested Readings

1. Brady N C. 1974. *The Nature and Properties of Soils*. Mac Millan Pub. Co., New York.
2. Burges A and Raw F. 1967. *Soil Biology*. Acad. Press, New York.
3. Mengel K and Kirkby A. 1978. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.
4. Pritchett and Fisher R F. 1987. *Properties and Management of Forest Soils*. John Wiley, New York.
5. Tisdale L S, Nelson L W and Beaton J D. 1985. *Soil Fertility and Fertilizers*. Macmillan Publishing Company, New York.
6. Young A. 1989. *Agroforestry for Soil Conservation*. CAB International, U.K.

Forest Survey and Engineering 2 (1+1)

Objectives

i. To educate the students on different types of surveying and latest technologies involved in surveying

ii. To impart basic knowledge on building materials, construction, roads and bridges, its types and its adoptability in forest areas.

Theory

Surveying – Scales - Measurement of distances - Chains – Cross staff - Chain surveying - Chaining on plain and sloping lands - Chaining around obstacles - Offset – Measurement of angles – Bearings and Meridians. Compass – Types: Prismatic and surveyor's compass. Compass surveying - Traversing – Closed and open - Methods of surveying - Radiation, intersection and traversing. Local attraction - Theodolite surveying – Methods: Repetition and reiteration. Measurement of horizontal angles and distances, vertical angles. Levelling - Utility and scope – Definitions - Methods - Levelling instruments - Dumpy level - Temporary and permanent adjustments. Bench marks – Types. Reduction of levels - Rise and fall method - height of collimation method. Topographical surveying - Methods of contouring - Characteristics and use of contours - Maps and Map Projections – Basics of Total Station – EDM - GPS - Study of minor survey instruments. Aerial Surveying – Concept - Stereo Photogrammetry – Aerial photogrammetry – Overlaps – Scale of photographs – Vertical and titled photographs distortion in aerial photographs – Stereostopic vision – Photo interpretation – Application. GPS Surveying –Basic Concept – Space, control and user segments – Satellite configuration – Signal structure – Orbit determination and representation – Hand held and geodetic receivers – Field work procedures – Data processing and application. Materials for construction – Bricks, Lime and Cement - Mortar – Concrete – Foundation and types -Bearing Capacity of soil – Brick masonry - Stone masonry - Roofs – Floors –Dampness – Anti termite treatment in buildings - Precautions – Safety measures. Estimating and costing - PWD schedule of rates – Preparation of estimate. Road – Introduction, definitions, types, road profile - Demarcation, alignment in plains and hills, curves and drainage. WBM and earthen road, road maintenance and road signs - Retaining wall – Types and construction features - Bridges – Principles of construction, selection of site and types - Culverts – Types.

Practical

Chain surveying –study of different types of chains - chaining on plain and sloping lands - chaining around obstacles - field work – plotting. Cross staff surveying and computation of areas. Compass surveying - radiation, intersection and traversing. Theodolite surveying - measuring horizontal angles and distances, vertical angles. Levelling – study of instruments - reduction of levels - rise and fall method - height of collimation method. Study of coordinate system – Aerial surveying - Total Station – GPS Surveying – Preparation of contour maps - Brick, Lime and cement manufacturing - Visit to Brick and Lime kilns - Design of foundation - Brick and stone masonry – section showing different components of brick and stone masonry. Types of roofs – trusses – king and queen post truss. Drawings of different types of windows and doors. Preparation of estimates for small structures and measurement book entries.

Suggested Readings

1. Arora K R. 2007. *Surveying.*Vol. I & II. Standard Book House, Delhi.
2. Basak N N. 1994. *Surveying and levelling*. Tata McGraw hill publications, New Delhi.
3. Deodhar S V and Singhal. 2001. *Civil Engineering Materials*. Khanna Publishers, New Delhi.
4. Duggal S K. 2008. *Building Materials*. New Age International Publishers. New Delhi
5. Masani N J. 2001. *Forest Engineering without Tears.* Nataraj Publication. Dehradun.
6. Ram Prakash. 1997. *Forest Surveying*. International Book Distributors, Dehradun.
7. Rangawala S C and Rangwala P S. 1985. *Surveying and Leveling*. Character Publishing House. Anand.
8. Rangwala S C. 1991. *Estimating and Costing*. Charotar Book Stall, Station Road, Anand.
9. Rangwala S C. 2000. *Building construction*. Charotar Publishing House, Anand.

Wildlife Sciences 3 (2+1)

Objective

To develop basic understanding on Reptiles, Aves and Amphibians and their ecology, behaviour and the habitat.

Theory

Wildlife – Definition - Types - Free living, Captive, domesticated and feral animals - History of Wildlife studies in India - Evolution of geological time scale - Significance - Classification of Indian Mammals - Phylum Cordata - Typical attributes of Cordates - Classification of Phylum Cordata - Description of Mammal, Reptiles, Aves and Amphibians Basic requirements of wildlife - food, water, shelter, space, limiting factors - Food chain, Food web, Ecological pyramids; Wildlife Ecology: Biotic factors, Biological basis of wildlife, Productivity; Effect of light and temperature on animals - Impact of Water and Temperature; Animal behavior - Systems of perception - Thermo receptors - Tactile receptors - Auditory receptors - Visual receptors - Chemo receptors - Biological rhythms - Circadian - Tidal - Lunar. Kinds of behavior - Innate - learning methods of communication - Mimicry - Aggressions - Social groups - Coronial - Fossorial - Seasonal - Aquatic adaptations. Niche- Territory - Home range - Cursing radius - Edge - Eco tone - Juxtaposition - Interspersion - Carrying capacity - Cover and its types - Habitat analysis and evaluation - Alternate Habitat AnalysisHabitat Improvement - Manipulation of forestry operations - Food and Water development - Cover construction - Shelter improvement.

Practical

Visit to various protected areas and observations on the morphological, behavioural, feeding and reproductive activities of different species of wild animals in India. Various study methods on the wild animals, such as focal animal sampling, Sherman trapping, mist netting, camera trapping, for identification, determination of age and sexing of animals including the small mammals. Faecal analysis of wild animals.

Suggested Readings

1. Berwick S H and Saharia V B. 1995. *Wildlife Research and Management*. Oxford University Press, New Delhi.
2. Dasmann R F. 1982. *Wildlife Biology*. Wiley Eastern Ltd. New Delhi.
3. Davis John W, Karstad Lars H and Trainer Daniel O. 1981. *Infectious Diseases of Wild Mammals.* (2nd Edn.). Iowa State University Press, USA. International Zoo Books, Published by New York Zoological Society, New York
4. Johnsingh A J T and Manjrekar N. 2014. *Mammals of South Asia.* Vol. I. 614p. University Press.
5. Johnsingh A J T and Manjrekar N. 2015. *Mammals of South Asia.* Vol. II. 739p. University Press.
6. Krebs C and Davis N. 1978. *Introduction to Behavioral Ecology*. Oxford University Press.
7. Menon V. 2014. *Indian Mammals: A Field Guide*. 528p. Hachette.
8. Mittermeier R A, Rylands A B and Wilson D E. 2013. *Handbook of the Mammals of the World* -Vol. III. 952p. Lynx Edicions.
9. Prater S H. 1971. *The Book of Indian Animals*. 324p. Oxford University press, Bombay.
10. Sukumar R.1993. *Asian Elephant Ecology and Management*. Oxford University Press, Cambridge.
11. Wilson D E and Mittermeier R A. 2009. *Handbook of the Mammals of the World.* Vol. I. 728p. Lynx Edicions.
12. Wilson D E and Mittermeier R A. 2011. *Handbook of the Mammals of the World.* Vol. II. 886p. Lynx Edicions.

Forest Health and Protection 2 (1+1)

Objective

To create professional knowledge on various disturbances, problems and other issues to forest and the associated heath and protection

Theory

Disturbances – Importance and Scope – Causes and kinds of forest disturbances – Problems due to the forest disturbances - Factors that determines the forest protection. Deforestation – Causes of deforestation – Extent and causes of forest and land degradation – Extent of global and national forest cover changes – Effects of deforestation – Strategies to reduce and control deforestation – Preventive and remedial measures. Shifting Cultivation – Causes – Extent of shifting cultivation areas – Methods of shifting cultivation areas – Impact of shifting cultivation - Preventive and remedial measures – Alternative land use practices to shifting cultivation. Forest fires – Characters, Components, Causes, Types – Status of forest fire in Global and Indian scenario – Injuries and Impact – Fire detection methods. Forest fires and its effect on forest ecosystems. Fire suppression – Firefighting equipment – Fire control policy and objectives. Fire fighting in other countries. Post fire suppression operations -Legal provisions – Economics of fire protection. Encroachment - Types, control of encroachment, illegal felling of trees – Legislation mechanism in encroachment. Damage caused by domestic and wild animals. Defective management – Errors in execution – Preventive measures. Invasive alien species in forests – Its effect on forest ecosystem - management techniques. Community forest protection – Role of forest dwellers and Village Forest committee (VFC). Awareness creation. Community participation in forest protection.

Practical

Visit to deforestation and shifting cultivation areas in nearby forest and study about its causes and prevention. Visit to forest areas with fire damages. Study of fire registers, records and fire monitoring stations. Fire line creation in forest. Study of fire reporting methods and instruments. Visit to fire station - Study and acquaint with machinery used for fire control. Application of recent techniques in fire forecasting, monitoring and mapping. Study of problems in forest encroachment. Field study of role of forest dwellers in forest protection. Visit to Community Forest protection area. Identification of weeds, parasites and epiphytes – Its impact in forest. Tree transplanting techniques and revival packages in wind and cyclone damaged trees. Symptoms of damages, causes their management methods.

Suggested Readings

1. Basher A E S. 1983. *Forest Fires and Their Control.* 159p. Gulab Primlani Amerind Publishing, New Delhi.
2. Elton C S. 2000. *The Ecology of Invasions by Animals and Plants*. University of Chicago Press.
3. Fuller M. 1991. *Forest Fires*. Wiley Nature Editions, New York.
4. Khanna L S. 1988. *Forest Protection*. 206p. Khanna Bandhu, Dehradun.
5. Parthiban K T, Suganthy M and Krishna Kumar N. 2019. *Forest Protection – Principles and Application.* Jain Brothers, New Delhi (ISBN No.: 9788183602952).

Arboriculture 2 (1+1)

Objective

To impart skill and expertise on urban tree management coupled with the knowledge on landscape management

Theory

Arboriculture – Tree identification and principles. Tree anatomy – Structure, function and mechanics. Tree physiology – Environmental factors affecting Photosynthesis, Respiration and Transpiration. Selection of trees – Tree propagation – Tree planting – Various tree planting techniques – Water and Plant Growth – Tree guards. Soil and Tree growth – Fertilizing Trees and Compacted Soils – Soil Nutrition. Tree disorder and Health – Frost protection – Wind damage minimizing – Mulching and watering – Diagnosing and management. Health disorders in trees – Pest and diseases in urban trees – Identification and diagnosing – Integrated pest and disease management. Tree pruning – Techniques, essential and safety – Basic pruning principles of woody plants – Canopy architecture: Crown cleaning, crown reduction, crown lifting. Felling a whole tree and felling in sections. Burlapping techniques. Arboricultural equipment – Pruning tools: Secateurs, Hand saws, Power tools – Felling tools: Chain saws, Hedge trimmers, Climbing equipment (Ladder, harness, rope, belt, sprus, etc.) – Tool maintenance. Tree surgery – Types of surgery: Cavity treatment, rods, cables, etc. – Propping – Treating bark wounds – Removing large branches. Climbing techniques – Preparing to climb, how to climb and anchoring point. Knots – Tree surgery safety. Workplace safety – Protective equipment: Personal protection, gloves, eyewear, hearing protection, skin protection, etc. Handling tools and machinery safety. Risk management, legal issues, and aesthetic

considerations. Landscaping – Principles and elements – Types of landscape designs – Formal: Persian and Mughal designs – Informal: British and Japanese. Landscape components – Plant and other components – Lawn, pergolas, hedges, edges, topiary, balloon, arbours, carpet beds, trees, flower beds, annuals and climbers. Practices of landscaping. Tools and implements for landscaping. Specialised gardens - Butterfly, water, bog or marsh, terrace, roof, sunken, indoor and rock. Planning and planting programs in institutional and industrial complexes, roads, bridges, parking area and other structures.

Practical

Tree Identification and principles – Tree Propagation – Tree planting techniques –Canopy architecture – Tree pruning techniques. Burlapping techniques. Arboricultural equipment – Pruning tools and Feeling tools – Tool maintenance. Tree surgery: Cavity treatment, rods, cables, etc. Climbing techniques – Tree climbing and equipment – Preparing to climb, how to climb and anchoring point. Common Insect pests and diseases to trees and woody plants. Landscaping – Types of landscape designs – Tools and implements for landscaping. Specialised gardens. Visit to different landscapes and gardens. Workplace safety and Protective equipment.

Suggested Readings

1. Harris R W. 1992. *Arboriculture: Integrated Management of Landscape Trees, Shrubs, and Vines* (2nd Edn.). Prentice-Hall International.
2. Konijnendijk C, Nilsson K, Randrup T and Schipperijn J. *(Eds.)*. 2005. *Urban Forests and Trees: A Reference Book*. Springer Berlin Heidelberg.
3. Shigo A L. 1991. *Modern Arboriculture: A Systems Approach to the Care of Trees and their Associates*. Shigo and Trees, Associates.
4. Watson G W and Himelick E B. 1997. *Principles and Practice of Planting Trees and Shrubs Savoy, IL:* pp. 107-113. International Society of Arboriculture.

Physical Education, First Aid, Yoga Practices and Meditation 2 (0+2)

Objectives

i. To make the students aware about Physical Education, First Aid and Yoga Practices
ii. To disseminate the knowledge and skill how to perform physical training, perform first aid and increase stamina and general wellbeing through yoga

Practical

Physical education; Training and Coaching - Meaning and Concept; Methods of Training; aerobic and aerobic exercises; Calisthenics, weight training, circuit training, interval training, Fartlek training; Effects of Exercise on Muscular, Respiratory, Circulatory and Digestive systems; Balanced Diet and Nutrition: Effects of Diet on Performance; Physiological changes due to ageing and role of regular exercise on ageing process; Personality, its dimensions and types; Role of sports in personality development; Motivation and Achievements in Sports; Learning and Theories of learning; Adolescent Problems and its Management; Posture; Postural Deformities; Exercises for good posture.

Yoga; History of Yoga, Types of Yoga, Introduction to Yoga,

- Asanas (Definition and Importance) Padmasan, Gaumukhasan, Bhadrasan, Vajrajasan, Shashankasan, Pashchimotasan, Ushtrasan, Tadasan, Padhastasan, Ardhchandrasan, Bhujangasan, Utanpadasan, Sarvangasan, Parvatasan, Patangasan, Shishupalanasan–left leg-right leg, Pavanmuktasan, Halasan, Sarpasan, Ardhdhanurasan, Sawasan
- Suryanamskar Pranayama (Definition and Importance) Omkar, Suryabhedan, Chandrabhedan, AnulomVilom, Shitali, Shitkari, Bhastrika, Bhramari
- Meditation (Definition and Importance), Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandh
- Mudras (Definition and Importance) Gyanmudra, Dhyanmudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra
- Role of yoga in sports
- Teaching of Asanas – demonstration, practice, correction and practice.

History of sports and ancient games, Governance of sports in India; Important national sporting events; Awards in Sports; History, latest rules, measurements of playfield, specifications of equipment, skill, technique, style and coaching of major games (Cricket, football, table Tennis, Badminton, Volleyball, Basketball, Kabaddi and Kho-Kho) and Athletics

Need and requirement of first aid. First Aid equipment and upkeep. First AID Techniques, First aid related with respiratory system. First aid related with Heart, Blood and Circulation. First aid related with Wounds and Injuries. First aid related with Bones, Joints Muscle related injuries. First aid related with Nervous system and Unconsciousness. First aid related with Gastrointestinal Tract. First aid related with Skin, Burns. First aid related with Poisoning. First aid related with Bites and Stings. First aid related with Sense organs, Handling and transport of injured traumatized persons. Sports injuries and their treatments.

Skill Enhancement Courses (SEC-III) **2 (0+2)**

- Timber Conversion
- Value addition of NTFPs
- Briquetting Technology
- Forest Fire Management
- Activated Carbon Technology
- Wood carving through CNC Technology
- Burlapping Technology
- Micro Forest
- Import and Export of forest Products
- e-Timber Market
- Community Forest
- Human Animal Ecosystem Interface
- AR/VR Module Creation in Forestry
- Forest Resource Assessment
- Multifunctional Agroforestry
- Biofuels Technology through forestry

Semester IV

Commercial Forest Products and Utilization 3 (2+1)

Objectives

i. To develop an understanding on the wood and wood panel related industries

ii. To understand the secondary timber species, composite wood products for structural usage, new generation wood composite and improved woods

Theory

Indian Timbers - Growth of wood-based industry in India and its relation to Indian economy – Production of roundwood and engineered wood in global and Indian scenario – National, International trade of important primary timber species – Volume of Import and Export details of wood and wood panels in India – Present status of wood and wood panel industries in India and Global scenario. Description of different forest-based industries – Paper and Pulp, Furniture, Bamboo, Sports Goods, Pencil, Match wood and Splint making and Composite wood industries. Primary conversion: Sawing techniques, kinds of saws – Wood Machining – Wood working tools used in wood working (Parting, Slicing, Shaping, Measuring and marking tools). Various stages in wood working – Wood Joinery – Finger Jointed Lumber – Veneer Production Process – Rotary cutting and Slicing – Types of veneer and their uses – Advantages of the use of veneered panels in wood products – Veneer jointing – Veneer grading – Storage and handling of veneers. Modern technologies for furniture making – Computer Numerical Control (CNC). Production, properties, properties and application of Plywood, Particle board, Sandwich board, Core board, Flake board, Fibre board (LDF, MDF, HDF). Production, properties, properties and application of Glue Laminated Timber (GLT), Structural Composite Lumber (LVL, PSL, LSL). Laminated wood – Multispecies laminates – Types of laminates – Matte finish laminates. Textured laminate, Gloss-finish laminates, Metallic laminate, PVC-finish laminate, Acrylic-finish laminates and Exterior laminates. Laminated wood from bamboo and bamboo laminates. Acoustic panels from laminated wood – Densified laminated panels. Wood adhesives – Types, characteristics and application. Eco friendly wood composites – Lignocellulosic composites – Adhesives for composites – Natural fibres – Wood plastic composites – Reinforced composite structures – Nano based wood composites – Bioactive wood polymer composites, Biotechnological production of wood composites – Wood polymer; Hybrid composite processing. Cross – Laminated Timber (CLT), Wood Plastic Composites (WPCs), Wood Inorganic Composites (WIC) approach. Chemical modification of wood, Thermal modification, acetylation and Furfurylation processes – Nanomaterials – Carbon nanotubes and cellulose nanofibres for wood modification, Impregnation / Polymerisation, microwave modification, Plasma and Laser for wood modification, Enzymatic modification. Scarification of wood – Wood Molasses, alcohol and yeast – Biochar and activated carbon technology

Practical

Visit to saw mill to study primary conversions of wood and Wood working industry for studying basic wood carpentry tools and application - Visit to pulp and paper industry, furniture industry, industrial plantations, pencil industry, matchwood industry, plywood industry, Briquette making industries and Gasification industries to study the production, manufacturing, grades and training process - Study the production, properties, and application of Particle board, Sandwich

board, Core board, Flake board, Fibre board, Glue Laminated Timber, Structural Composite Lumber, Laminated wood, PVC-finish laminate, Acrylic-finish laminates and Exterior laminates. Wood Plastic Composites (WPCs), Wood Inorganic Composites (WIC) approach. Chemical modification of wood - Carbon nanotubes and cellulose nanofibres for wood modification - Scarification of wood - Biochar and activated carbon technology.

Suggested Readings

1. Baldwin R F. 1981. *Plywood Manufacturing Practices.* (2nd Edn.). Miller and Freeman Publication, Inc. USA.
2. FRI [Forest Research Institute]. 1976. *Indian Forest Utilization.* Vol. I & II. 941p. Forest Research Institute and colleges, Dehradun.
3. Hoadley B. 2000. *Understanding Wood: A Craftsman's Guide to Wood Technology.* 223p. Taunton Press. Newtown, USA.

Forest Ecology and Management 3 (2+1)

Objectives

i. To develop basic understanding on ecology and its application in Forest ecology, biodiversity and conservation.
ii. To develop a working knowledge on forest ecosystem, productivity and conservation forest bio resources
iii. To be able to apply this knowledge base to unknown situations related to forest ecology

Theory

Definitions- interactions of biotic and abiotic components. Historical development of ecology as a science. Levels of biological organization. Major forest Ecosystem. Forest environment- major abiotic and biotic components and their interaction, trophic levels, food webs, ecological pyramids and energy flow. Population ecology - definition, population dynamics and carrying capacity. Speciation- sympatric and allopatrty. Population growth models-. Population distribution- Characters of forest communities. Community ecology species interactions. Ecological succession-Definition-terminology, basic concepts, theories of succession- climax vegetation types. Production ecology – primary and secondary production – Paterson's productivity index. Autecology of important tree species. Biodiversity – Definition, levels of study, distribution of diversity in life forms, hotspots of biodiversity, World mega biodiversity countries. Biodiversity of Western Ghats and Eastern Ghats. Measurement of diversity and diversity indices. Endemism – categories of endemism Rarity and Extinction of species - threat values of species - categories of existence. Principles of conservation biology, ex-situ and in-situ methods of conservation. Genetic and evolutionary principles in conservation. Sacred groves-concept-uses. Biosphere concept. Conservation – efforts in India and worldwide. - National Biodiversity Authority (NBA) - Salient features of NB Act - Convention on biological diversity (CBD) - Access and benefit sharing (ABS).

Practical

Study of ecological modifications in plants; Effects of fire on forest ecosystem; Study of population dynamics using model systems; Preparation of life tables; Study of spatial dispersion

among plants; Study of Forest composition; Niche analysis; Computation of diversity indices; Measurement of diversity of plants and insects in a nearby forest; Forest productivity estimation methods through harvest, Leaf area, LAI. Study of succession in field and water bodies; Visit to different ecosystems. Recording light transmission in forest relative to open fields. Estimation of growth and productivity of Plantation/site. Field data processing and Analysis-Calculation of IVI, Diversity indices Assessment of tree volume and carbon sequestration. Visit to *ex situ*, *in situ* conservation and Nilgiri biosphere reserve.

Suggested Readings

1. Frankel O H, Brown AHD, Burdon J J. 1995. *The Conservation of Plant Biodiversity*. 299p. Cambridge University Press. Cambridge.
2. Kimmins J P. 1976. *Forest Ecology*. MacMillan.
3. Michael P. 1984. *Ecological Methods for Field and Laboratory Investigations*. 404p. Tata McGraw-Hill Pub. Co. New Delh.
4. Misra K C. 1974. *Manual of Plant Ecology.* 491p. Oxford and IBH Pub Co. New Delhi etc.
5. Montagnini F and Jordan C F. 2005. *Tropical Forest Ecology: The Basis for Conservation and Management.* 295p. Springer.
6. Nautiyal S and Koul A K. 1999. *Forest Biodiversity and its Conservation Practices in India.* Oriental Enterprise.
7. Odum E P. 1983. *Basic Ecology*. 613p. Saunders College Publishing, Philadelphia.
8. Saggwal S S. 1995. *Forest Ecology of India*. 368p. Pioneer Publishers, India.
9. Sharma P D. 2013. *Ecology and Environment.* (11th Edn.). Rastogi Publications, Meerut.

Tree Harvesting and Ergonomics 2 (1+1)

Objective

To provide an understanding about the tools and implements used for logging mechanism, reduced impact during logging, transportation, grading and storage of felled logs

Theory

Definition, history, objective, and scope of harvesting, harvesting plan and execution. Location and demarcation of the area for logging and estimation of produce available for extraction – Phases of harvesting. Tools and Implements used in harvesting operation; traditional and improved tools, axes, saws, types of saws, accessory implements, mechanized felling machines and operations. Felling rules, felling season, felling methods, safety rules Work contracts related to felling and removing (Contract system, convener systems) etc. Conversion, cross cutting, hand and machine sawing, conversion of specialized logs, measurement and description of converted material. Recent trends in timber harvesting. Reduced impact logging (RIL), Concept - scope and objectives – impediments to adoption - difference between reduced impact logging and conventional logging - Criteria and Indicators - operations and ITTO guidelines - Steps beyond reduced impact logging towards Sustaining timber yield (STY) – Recent developments. Timber logistics; types and means of transport of timber, off and on road transportation; Minor transportation methods carts, dragging, skidding, overhead transport, ropeways, skylines. Major transportation methods, Transport by

road and railways. Transport by water; floating, rafting and concept of booms. Grading of timbers - storage and disposal of timber in the depots - Temporary and final storage. Timber Depots; types, layout and management. Protection from plants, animals and insect infestations – Diseases and their prevention. Systems of disposal of timber. Harvesting productivity – Economics of recovery – Cost of production – Constraints and Techniques used in harvest unit. Ergonomics: Definition, components and provision of energy. Requirement of energy and rest periods. Effect of heavy work, posture, weather and nutrition. Personal protective equipment, safety helmets, ear and eye protections. Accidents: causes, statistics, safety rules and first aids.

Practical

Equipment and tools used in harvesting operations, their uses and their maintenance. Instructions regarding maintenance of various records and registers in harvesting operations; Conversion of felled trees into logs, poles, firewood, pulpwood. Visit to local saw mills to study the equipment used and process of conversion. Field exercise on uses of axes (Traditional and improved), saws (Manual and power operated), felling of trees. Field exercise on estimation of felling and conversion waste. Visit to industrial plantation to study the mechanized means of felling and conversion of trees. Measurement of logs, poles and firewood in forests and maintenance of records in relevant registers. Visit to Timber depot to trace the logs delivered from different forest sites. Sorting of logs, poles and firewood in the depots according to species, quality, length and girth classes. Stacking and stock checking of different logs, poles and firewood in the depots so as to confirm that all the converted materials in the forests have reached their destination. Stacking of the lots for display and final disposal; recording of the lots for auction sale. Final disposal of the material. Visit during the auction sale in the government timber depots; Visit to Range Office to understand about transit permits for various types of forest produce. Cost of production of timber harvesting. Preparation of ergonomic check lists. Familiarize the e-auctioning procedure of State Forest Department.

Suggested Readings

1. Brown N C. 2002. *Principles and Methods of Harvesting of Timber*. Biotech Books, Delhi.
2. Forest Engineering Technology Program. 1996. *Introduction to Forest Harvesting Methods*. Vancouver, BC: BCIT.
3. FRI (Forest Research Institute). 1976. *Indian Forest Utilization*. Vol. I & II. 941p. Forest Research Institute and colleges, Dehradun.
4. GFC (Guyana Forestry Commission). 2002. *Code of Practice for Timber Harvest.* (2nd Edn.). 42p. Georgetown, Guayana.
5. Hakkila P. 1989. *Utilization of Residual Forest Biomass*. 567p. Springer-Verlag, Berlin.
6. Jones J T. 1993. *A Guide to Logging Aesthetics.* 36p. Northeast Regional Agricultural Engineering Service, Ithaca, New York.
7. Mehta T. 1981. *A Hand Book on Forest Utilization*. IBD, Dehradun.
8. Sharma P K. 1991. *Forest Resource and its Utilization in India.* Mittal Publication, New Delhi.
9. Staaf K A G and Wiksten N A. 1984. *Tree Harvesting Techniques*. DR W. Junk Publishers, Netherlands.
10. Wakermann A E. 2002. *Harvesting Timber Crops*. 433p. Biotech books, Delhi.

Forest Policy and Legislation 2 (2+0)

Objective

To impart knowledge on various policies and acts related to forests

Theory

Necessity of a Forest policy in a country. General basis of formulation, various considerations. National Forest Policies of 1894, 1952 and 1988 their comparative study, basis of their formulation and after effects. Constraints in the implementation of Forest Policy in India. Need based law for implementation of policy. National Forestry Action Program, formulation and constraint in implementation and State Forestry Action Programs. Code of Criminal Procedure, 1973 - Definitions. Position of forest offences - Constitution and powers of Criminal courts and important sections. Code of Civil Procedure 1908 - Summons and discovery. Indian Penal Code, 1860 - Abetment of forest offences - Offences directly connected with forests and its produce and Protection extended by law to Forest Officers. Forest Law: legal definition. Indian Evidence Act, 1872 as applied to forestry matters. Indian Forest Act. Detailed study of IFA 1927.Forest (Conservation) Act, 1980 and its amendments. The Biological Diversity Act, 2002, The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 and Environmental Protection Act, 1986. Brief description about other major forest laws of regional, national and international significance. National Green Tribunal.

Suggested Readings

1. Chaturvedi A N. 2011. *Forest Policy and Law.* Khanna Bandhu Publishers, Dehradun.
2. Negi S S. 1997. *Forest Policy and Law* IBD. Dehradun.
3. Dutta R and Yadav B. 2012. *Supreme Court on Forest Conservation.* Universal Law Publishing Co., New Delhi.
4. Ernakulam Shetty B J. 1985. *A Manual of Law for Forest Officers*. Sharda Press, Mangalore
5. Takwani C K T and Thakker M C. 2012. *Takwani Criminal Procedure*. Lexis Nexis Butterwarths Wadhwa, Nagpur.

Statistical Methods 2 (1+1)

Theory

Basic concepts – statistics – variable – types and sources of data – classification and tabulation of data. Diagrammatic and graphical representation of data – simple, multiple, component and percentage bar diagrams, pie diagram – frequency polygon, frequency curve and histogram. Construction of frequency distribution tables. Measures of central tendency: arithmetic mean, geometric mean, harmonic mean, median and mode – merits and demerits. Measures of dispersion: range, quartile deviation, mean deviation, standard deviation, and coefficient of variation – skewness and kurtosis – merits and demerits. Probability – basic concepts – additive and multiplicative laws (without proof). Probability distributions – Discrete distributions: Binomial and Poisson. Continuous distribution: Normal distribution – definitions and properties. Sampling theory – population – sample – parameter and statistic – sampling distribution – sampling vs complete

enumeration – Types of sampling – simple random sampling – selection of simple random sample using random number tables. Null and alternative hypothesis – types of errors – critical region and level of significance – degrees of freedom. Large sample test – single proportion and difference between two proportions – single mean and difference between two means. Small sample tests – F-test – t-test for testing the significance of single mean – independent t test and paired t test – chi square test for goodness of fit – chi square test for testing the association of attributes by m × n contingency table – 2 × 2 contingency table – Yates' correction for continuity. Correlation – Scatter diagram – Karl Pearson's correlation coefficient definition – computation – types of correlation and properties. Regression – simple linear regression – fitting of simple linear regression equation – properties of regression coefficient. Analysis of Variance (ANOVA) – assumptions – one way and two-way classifications. Basic principles of experimental designs – Completely Randomized Design (CRD) – Randomized Block Design (RBD) – Latin Square Design (LSD) – lay out, analysis, merits and demerits of the above-mentioned designs.

Practical

Formation of frequency distribution tables – Diagrammatic and graphical representation. Computation of different measures of central tendency and computation of various measures of dispersion for raw and grouped data – calculation of coefficient of variation (CV) – measures of skewness and kurtosis. Simple problems in Binomial distribution, Poisson and Normal distribution – Selection of simple random sampling. Large sample test for single proportion and difference between two proportions and Large sample test for single mean and difference between two means. t-test for single mean – t-test for testing the significance of two means for independent and paired samples – chi square test for goodness of fit and test for independence of two attributes in a contingency table – Yates correction for continuity – calculation of the correlation coefficient – fitting of simple linear regression equation – One way and two-way ANOVA – completely randomized design (CRD) – randomized block design (RBD) – Latin square design (LSD).

Agriculture Marketing and Trade 3 (2+1)

Objectives

i. To understand the fundamentals of agricultural marketing and trade
ii. To analyze the factors influencing supply and demand in agricultural markets
iii. To explore different marketing channels and strategies in agriculture
iv. To examine the role of government policies and regulations in agricultural markets

Theory

Agricultural Marketing: Concepts and definitions of market, marketing, agricultural marketing, market structure, marketing mix and market segmentation, classification and characteristics of agricultural markets; demand, supply and producer's surplus of agri commodities: nature and determinants of demand and supply of farm products, producer's surplus – meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; pricing and promotion strategies: pricing considerations and approaches – cost based and competition based pricing; market promotion – advertising, personal selling, sales promotion and publicity – their meaning and merits and demerits; marketing process and functions: Marketing process

concentration, dispersion and equalization; exchange functions – buying and selling; physical functions – storage, transport and processing; facilitating functions – packaging, branding, grading, quality control and labelling (Agmark);Market functionaries and marketing channels: Types and importance of agencies involved in agricultural marketing; meaning and definition of marketing channel; number of channel levels; marketing channels for different farm products; Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs; Role of Govt. in agricultural marketing: Public sector institutions- CWC, SWC, FCI, CACP and DMI – their objectives and functions; cooperative marketing in India; Risk in marketing: Types of risk in marketing; speculation and hedging; an overview of futures trading; Agricultural prices and policy: Meaning and functions of price; administered prices; need for agricultural price policy; Trade: Concept of International Trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; GATT and WTO; Agreement on Agriculture (AoA) and its implications on Indian agriculture; IPR. Role of government in agricultural marketing. Role of APMC and its relevance in the present-day context.

Practical

Plotting and study of demand and supply curves and calculation of elasticities; Study of relationship between market arrivals and prices of some selected commodities; Computation of marketable and marketed surplus of important commodities; Study of price behaviour over time for some selected commodities; Construction of index numbers; Visit to a local market to study various marketing functions performed by different agencies, identification of marketing channels for selected commodity, collection of data regarding marketing costs, margins and price spread and presentation of report in the class; Visit to market institutions – NAFED, SWC, CWC, cooperative marketing society, etc. to study their organization and functioning; Application of principles of comparative advantage of international trade.

Suggested Readings

1. Acharya S S and Agarwal N L. 2006. *Agricultural Marketing in India*. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.
2. Chinna S S. 2005. *Agricultural Economics and Indian Agriculture*. Kalyani Pub, New Delhi.
3. Dominic Salvatore.2003. *Micro Economic Theory.* (4th Edn.). OUP USA.
4. Kohls Richard L and Uhl Josheph N. 2002. *Marketing of Agricultural Products*. Prentice-Hall of India Private Ltd., New Delhi.
5. Kotler and Armstrong. 2005. *Principles of Marketing*. Pearson Prentice-Hall.
6. Lekhi R K and Singh Joginder. 2006. *Agricultural Economics*. Kalyani Publishers, Delhi.
7. Memoria C B, Joshi R L and Mulla N I. 2003. *Principles and Practice of Marketing in India*. Kitab Mahal, New Delhi.
8. Pandey Mukesh and Tewari Deepali. 2004. *Rural and Agricultural Marketing.* International Book Distributing Co. Ltd, New Delhi.
9. Sharma R. 2005. *Export Management*. Laxmi Narain Agarwal. Agra.

Agriculture Informatics and Artificial Intelligence 3 (2+1)

Objectives

i. To acquaint students with the basics of computer applications in agriculture, multimedia, database management, application of mobile app and decision- making processes, etc.

ii. To provide basic knowledge of computer with applications in Agriculture

iii. To make the students familiar with Agricultural-Informatics, its components and applications in agriculture

Theory

Introduction to Computers, Anatomy of Computers, Memory Concepts, Units of Memory, Operating System: Definition and types, Applications of MS-Office for creating, Editing and Formatting a document, Data presentation, Tabulation and graph creation, Statistical analysis, Mathematical expressions, Database, concepts and types, creating database, Uses of DBMS in Agriculture, Internet and World Wide Web (WWW): Concepts and components.

Computer programming: General concepts, Introduction to Visual Basic, Java, Fortran, C/ C++, etc. concepts and standard input/output operations.

e-Agriculture, Concepts, design and development, Application of innovative ways to use information and communication technologies (IT) in Agriculture, Computer Models in Agriculture: Statistical, weather analysis and crop simulation models, concepts, structure, inputs-outputs files, limitation, advantages and application of models for understanding plant processes, sensitivity, verification, calibration and validation, IT applications for computation of water and nutrient requirement of crops, Computer-controlled devices (automated systems) for Agri-input management, Smartphone mobile apps in agriculture for farm advice: Market price, postharvest management etc., Geospatial technology: Concepts, techniques, components and uses for generating valuable agri-information, Decision support systems: Concepts, components and applications in Agriculture, Agriculture Expert System, Soil Information Systems etc. for supporting farm decisions. Preparation of contingent crop-planning and crop calendars using IT tools, Digital India and schemes to promote digitalization of agriculture in India.

Introduction to artificial intelligence, background and applications, Turing test. Control strategies, Breadth-first search, Depth-first search, Heuristics search techniques: Best-first search, A* algorithm, IoT and Big Data; Use of AI in agriculture for autonomous crop management, and health, monitoring livestock health, intelligent pesticide application, yield mapping and predictive analysis, automatic weeding and harvesting, sorting of produce, and other food processing applications; Concepts of smart agriculture, use of AI in food and nutrition science etc.

Practical

Study of computer components, accessories, practice of important DOS commands. Introduction of different operating systems such as windows, Unix, Linux, creating files and folders, file management. Use of MS-Word and MS Power Point for creating, editing and presenting a scientific document, handling of tabular data, animation, video tools, art tool, graphics, template and designs. MS-EXCEL - Creating a spreadsheet, use of statistical tools, writing expressions, creating graphs, analysis of scientific data, handling macros. MS-ACCESS: Creating database, preparing

queries and reports. Introduction to World Wide Web (WWW) and its components, creation of scientific website, presentation, and management of health information through web. Use of smart phones and other devices in agriculture and human health warning systems. Hands on practice on preparation of decision support system for the above-mentioned aspects.

Suggested Readings

1. Rajaroman V. 2004. *Fundamentals of Computer.* New Delhi: Prentice Hall.
2. Pearson. 2005. *Introduction to Information Technology*. Pearson Education India.
3. Date C J. 1999. *Introduction to Database Management System*. Pearson; Publication.
4. Sethi D P and Manoranjan. 2017. *Concepts and Techniques of Programming in C.* TechSar Pvt. Ltd.

*Skill Enhancement Courses (SEC-IV) 2 (0+2)

- Wildlife Forensic Sciences
- Dendroenergy Generation
- Big Data Management
- Artificial Intelligence in Forestry Operation
- Specialty Seedling Production
- Woodlot Establishment and Management
- Tools for Consulting Forester's
- Application of Drone in Forestry
- Forest Certification
- Arboriculture
- Forest Project Designing and Analysis
- Wood Mechanics
- Mulberry and Non-mulberry based Silk Production
- Internet of Things (IoT) in Forestry
- Marketing and Economics of NTFPs
- Carbon financing projects

Post-IV Semester

Internship (only for exit option for award of UG Diploma) 10 weeks 10 (0+10)

General Objectives

To provide students with an opportunity to put into practice the skills they have learned while in the institute, so that in case they exit with UG-Diploma, they will be able to get proper engagement/ employment and consider having their own startups.

Specific Objectives

By the end of the internship, the students should be able to:

i. Integrate theory and practice
ii. Assess interests and abilities in their field of study
iii. Develop work habits and attitudes necessary for job success
iv. Develop communication, interpersonal and other critical skills in the job interview process
v. Explore career alternatives prior to graduation

Activity

The students will have internship/ training for 10 weeks' duration either in the institute or in industry or related organisations. The College/ University will facilitate attaching the students to the organisations.

After completion of internship, the students will have to submit a report of their learnings and also present in form of a seminar before nominated faculty members and other students.

The assessment will be based on the report / assessment received from the industry/ organisation and the report and the presentation made at the University. Ideally the weightage will be 50% each for both internal and external. The SAUs may modify the weightage and breakups.

Semester V

Tree Physiology 2 (1+1)

Objective

To impart basic knowledge on various functions and processes related to production, mineral nutrition, plant growth regulators and environmental stresses with reference to forestry.

Theory

Introduction to Tree Physiology and cell organelles - Plasma membrane, chloroplast, mitochondria, peroxisome and vacuole, Structure and role of water - Diffusion, osmosis, imbibition, plasmolysis, water potential and its components, Translocation of water, Ascent of sap, Stomata - Structure and function, Stomatal conductance and resistance, Water relations of forest trees, Transpiration from forest canopies – Evapo-transpiration models - Water use efficiency of forest stands. Criteria of essentiality - Classification of nutrients - Macro nutrients, micro nutrients, beneficial nutrients, Mechanism of nutrient uptake - Physiological functions, deficiencies and disorders of macro nutrients and micro nutrients, Nutrient dynamics and plant growth – Nutrient cycling of C,N,P,S. Photosystems, Light reaction - Photolysis of water and photo phosphorylation - Z scheme, Red drop and Emerson enhancement effect, Photosynthetic pathways - C3, C4 and CAM - difference between three pathways - Factors affecting photosynthesis - Photorespiration- pathway and its significance - Phloem transport, Munch hypothesis - Phloem loading and unloading – Glycolysis - TCA cycle- Oxidative phosphorylation. Plant Growth regulators – Classification and biosynthetic pathways, Sun plants and shade plants, shade tolerance, Carbon cycling, Carbon balance and dry matter production in forest trees. Classification of stress - Water stress - Mechanism

of drought tolerance and drought resistance - Physiological basis of drought avoidance and tolerance – Temperature stress - Temperature influence on forest development - Low and high temperature- Physiological adaptations for high temperature, Salinity stress - Effects on tree growth tolerance mechanisms.

Practical

Preparation of different types of solutions, Measurement of plant water potential by different methods, Estimation of chlorophyll, Estimation of stomatal index- Determination of leaf area of plants, Estimation of transpiration, Estimation of photosynthetic efficiency, Growth analysis – LAI, CGR, LAD etc., Identification of macro nutrients and micro nutrients deficiencies, Measurement of stress tolerance parameters in trees – soluble protein, membrane stability index, chlorophyll stability index, proline content, wax and cuticle thickness, Demonstration of practical applications of PGRs.

Suggested Readings

1. Jain V K. 2007. *Fundamentals of Plant Physiology*. S Chand and Co. Ltd., New Delhi.
2. Luttge U. 2008. *Physiological Ecology of Trophical Plants*. Springer– Verlag, Germany
3. Lamber H. Chapin III F S and Pons T L. 2008. *Plant Physiological Ecology.* (2nd Edn.) Springer. New York. USA.
4. Stephen G Pallardy. 2008. *Physiology of Woody Plants.* (3rd Edn.). Elsevier Incl. Academic press.
5. Taiz L and Zeiger E. 2010. *Plant Physiology* (5th Edn.). Sinauer Associates, Inc., Masachusetts, USA.

Plantation Forestry 3 (2+1)

Objective

To acquire knowledge on intensive silvicultural practices for different forest plantations for obtaining higher utilizable biomass

Theory

Plantation - Definition and scope - aims and objectives of Plantation forestry - Historical perspectives in plantation forestry - Indian and global scenario - Role of plantation forestry in meeting the wood demand- purpose of plantations, factors determining scale and rate of plantation. Plantation sites - Choice of species for plantation – Tree species suitable for different sites - Production technology for quality planting materials – Site selection and site preparation – Mechanization in plantation establishment - Planting program, planting season, planting pattern, spacing, planting method. Post planting activities in plantation - Tending operations – Irrigation and nutrient management in plantation – Plantation health management and sanitary measures – Stand dynamics- Stand density management in plantation – Biology of growth and development in plantation. Energy and Industrial plantations – definition and scope - project formulation - planning in plantation - choice of species and spacing - precision silvicultural techniques - Industrial plantation models - captive and agroforestry models. Plantation for specific purpose - timber - paper and pulp - match wood - ply wood - Plantation for NTFPs. High Density Short Rotation Forestry practices - Plantations as potential Carbon sinks- Carbon credits- Afforestation/ reforestation based CDM projects for climate change mitigation. Harvesting in plantation – harvesting types and

patterns based on domestic, industrial, and export requirements – Machineries used in harvesting operations – primary conversion at plantation site – Delimbing, bucking, debarking, stacking, *in-situ* chipping, and transportation. Coppice silviculture – principle, mechanisms and management. Economics of plantation – Scale of finance of plantations.

Practical

Study the tools and equipment in plantation establishment – Visits to small and large plantations and study their management - Exercise on plantation project planning, evaluation and appraisal. Choice of species for various types of plantations - Quality planting material for plantations - Layout of site and stacking - Planting and after care activities for different types of plantations - Irrigation and fertilizer application techniques for plantation – Fertilizer and irrigation schedule for various tree species – Tending operations - Study of Forest Development Corporation plantations – Plantation maintenance – Plantation records and plantation journal - Economic considerations in plantation: Preparation of scale of finance for various out growers and plantation schemes - Study of government vs. private plantations.

Suggested Readings

1. Balasubramanian A, Hari Prasath C N and Radhakrishnan S. 2020. *Textbook on Plantation Forestry.* 336p. Jain Publication, New Delhi.
2. Dwivedi A P. 1993. *A Text book of Silviculture*. International Book Distributors, Dehradun.
3. Luna R K. 1989. *Plantation Forestry in India*. International Book Distributors, Dehradun.
4. Ram Prakash R. 1998. *Plantation and Nursery Technique of Forest Trees*. International Book Distributors, Dehradun.
5. Evans J. 1982. *Plantation Forestry in the Tropics: Clarendon Press.* Oxford, Oxford Science Publications, Oxford University Press.

Tree Improvement 3 (2+1)

Objective

To develop a balanced and broad understanding of concepts and techniques related to tree breeding and tree improvement strategies

Theory

Tree Breeding – Tree Improvement – History and development. Essential of Tree improvement – Tree Breeding – Objectives – Advantages – Disadvantages – Limitations. Terminologies commonly used in tree improvement – Important tree breeding program in the Global and India – ICFRE and State Agricultural Universities. Introduction – Domestication. World collections – Centre of origin of cultivated species. Exotic forest species – Advantages – Problems. Reproductive systems – Devices of pollination control – Anthesis – Pollination – Self-pollination and cross pollination – Variation and its uses. Breeding methods – Introduction – Selection - Mass selection - Pure line selection – Plus tree selection – Comparison tree selection. Hybridization – Mutation – Biotechnology based tree breeding. Hybrid – Hybridization – Genetic consequences – Gene character – Relationship - Segregation – Recombination of genes. Hybrid vigour – Heterosis – Luxuriance. Tree hybrids developed in Global and India – Natural hybrids – Definition – Occurrence – Reasons determination

of natural hybrids. Hybrids in trees – Crossing in trees – Problems and perspectives – Crossing hybrids and hybrid breakdown – Hybrid nomenclature in trees – Future of hybrids in applied tree improvement. Mating design – Types – Advantages and disadvantages. Heritability - Genetic gain – Genetic advance – Combining ability – Types – GCA and SCA. Genetic tests – Provenance test – Seed source evaluation test – Progeny test – Clonal test. Experimental design – RBD – Analysis of Genetic test – Genotype and environment interaction. Release of tree varieties – Procedure and Protocol – Released tree varieties of regional and national importance. Varietal registration (PPVFRA) – Definition – Breeder's variety – Famer's variety – Traditional variety – Tribal varieties – Essentially derived varieties. Descriptors – development validation. DUS test – Definition, need and importance. Test guide lines –procedures – Conducting DUS test. Tree DUS testing – Development of descriptors for trees – DUS test centers. Recent developments in tree DUS testing.

Practical

Selection for different tree improvement programs – Hybridization – Inter and Intra specific - Evaluation. Controlled breeding – Phenotypic and genotypic coefficients of variation. Estimation of genetic advance – Heritability - Combining ability – GCA and SCA. Genetic tests – Provenance test – Seed source evaluation test – Progeny test – Clonal test. Experimental design – RBD – Analysis of Genetic test. Seed orchards – Genetical behavior in seed orchard. Forest genetic resource – Visit to progeny evaluation genotypes. Developing descriptors for varietal registration in trees.

Suggested Readings

1. Bruce Zobel and John Talbert. 1984. *Applied Forest Tree Improvement*. 504p. John Wiley and Sons, New York.
2. Parthiban K T, Krishna Kumar N and Devanand P S. 2020. *Tree Breeding and Improvement – Theory and Technology.* Scientific Publishers (India), Jodhpur, India (ISBN No.: 978-93-89412-83-3).
3. Surendran C, Sehgal R N and Paramathma M. 2003. *Forest Tree Breeding*. 204p. ICAR Publication, New Delhi.

Forest Resource Management 2 (1+1)

Objectives

i. To understand the principles and concepts of basic forest management, normal forest, sustainable forest management
ii. To acquire knowledge on methodology of working plan preparation

Theory

Forest Management - Definition and scope - Management of forests and its peculiarities - Forest management for environmental conservation - Forest management for soil and water conservation - Principles of forest management and their application. Objects of management: Purpose and policy, Objectives, Owner's attitude and social role of forestry. Sustained yield - Concept and meaning of sustained yield - Progressive yield - Sustained yield in relation to environmental management. Sustainable forest management-criteria and indicators - Increasing and progressive yields. Rotation-definitions-various types of rotations length of rotations - choice of type and kind

of rotation. Normal forest – Definitions - Basic factors of normality. Factors governing the yield and growth of forest stand. Growing Stock - General considerations - Distribution of age gradations or classes in regular forests, irregular forests and coppice systems. Growth estimation and reduction factors for density and Quality and price increment. Yield regulation - General principles of yield calculation - Silvicultural system in relation to yield regulation. Methods of yield regulation - Yield regulation in regular forests - By area, reduced area, Hufnagl's modification and By volume and increment methods. Yield regulation in irregular forests - Methods based on growing stock only, Von Mantel's formula and its modifications, Methods based on volume and increment, Austrian method, Method based on number of trees in various age classes and time taken to pass from one age class to next, Brandis method, Hufnagl's method and Smithies safeguard formula. Application of different methods of yield regulations in forest management in Indian forestry. Management (Working) Plan - Definition, object, scope, sphere, necessity for revisions - Division of forests into various units – Maps - Management (Working) Plan Code. Preparation of Management (Working) Plan - Preliminary Management Plan report - Field work - Stock mapping - Checking of maps - Compartment description - Collection of statistical data and other data.

Practical

Visit to different forest divisions to study the various stand management aspects including thinning, felling and sale of timber. Study forest organizational set up and forest range administration including booking of offences. Visit to forest plantation- Field Exercise for the estimation of actual growing stock volume. Yield regulation in regular forests and irregular forest. Field visit to JFM operational areas. Study the different field exercises for data collection for working plan. Writing preliminary working plan report and actual working plan report of a given area. New proposal for writing fire management plan.

Suggested Readings

1. Balakathiresan S. 1986. *Essentials of Forest Management*. Natraj Publishers, Dehradun.
2. Negi S S. 1988. *Forest Working Plan*. B.S.M. Pal Singh, Dehradun
3. Ramprakash. 1986. *Forest Management*. IBD Distributors, Dehradun

Non-Timber Forest Products 3 (2+1)

Objective

To impart knowledge on various Non-Timber Forest Products and their harvesting, processing, value addition, marketing and industries involved in NTFPs production

Theory

Non-Wood Forest Products – Definition, scope and present status, survey, economic importance, classification, distribution, marketing. Role of tribal co-operative societies in NWFPs. Recent trends in NWFP. Gums: Occurrence – Origin – Functions – Kinds – Properties – Tapping methods – Processing – Grading – Storage – Factors affecting gum formation - Commercial valuation – Industrial application. Resins and Oleoresins: Occurrence – Origin – Functions – Kinds – Properties – Tapping methods – Processing – Grading – Storage – Factors affecting resin and oleoresin formation - Commercial valuation – Industrial application. Grasses: types – Species – Uses.

Various grasses and their uses in village and cottage industries. Bamboos – Distribution, harvesting and uses, raw material scenario in bamboos. Canes - Distribution, harvesting, processing and uses. Fibres: species – Types – Soft, hard and surface fibres – Extraction and uses. Flosses: Species – Distribution – Collection – Extraction – Uses. Essential oils: Species – Types – Grass oils, wood oils, leaf oils, root oils, flower oils and minor essential oils. Tree Borne Oil seeds (TBOs): Collection – Extraction methods – Uses – Value addition. Tan: – Species – Nature and kinds – Occurrence – Function – Collection – Extraction – Uses – Supply and demand. Dyes: Definition – Species – types – Wood dyes – Bark dyes – Flower and fruit dyes – Leaf dyes – Extraction and uses. Cutch and katha: Species – Extraction methods – Uses. Rubber: Cultivation, and tapping – Processing - Uses of rubber. Lac: Species – Distribution – Improved method of cultivation – Collection and storage – Uses. Shellac: Cleaning and grading – Properties – Uses. Drugs, spices, wild edible plants part like fruits, flowers, roots, tubers, vegetables, leaves and edible products, poisons and bio-pesticides. Bidi leaves - Leaf fodder - Animal products – Honey and wax, collection, processing, storage, silk.

Practical

Identification of non-wood forest products; Visit to nearby forests to study important NTFP yielding plants. Study of fodder: grasses and tree leaves. Study of canes and bamboos and their sources. Study of essential oils and their sources. Visit to oil extraction unit Study of non-essential oils and their sources. Study of gums and resins and their collection. Study of tans and Visit to tannin industry; Study of dyes and Visit to dye extraction unit and their sources. Study of fibers, flosses and their collection from nearby forests. Visit to Herbal Gardens and herbaria to study medicinal plants. Study of plants yielding drugs, spices, wild edible plants, poisons and bio-pesticides and their collection from nearby forests. Visit to a tribal village involved in collection, processing and sale of NTFP's. Visit to nearby extraction units and NTFP museum. Visit to forest range office and study about the permits issued and collection methods of various NWFPs.

Suggested Readings

1. FRI (Forest Research Institute). 1976. *Indian Forest Utilization.* Vol. I & II. 941p. Forest Research Institute and College, Dehradun.
2. Krishnamurthi T. 1993. *Minor Forest Products of India*, Oxford and IBH Publishing Co Pvt. Ltd.
3. Krishnamurthi T. 2010. *Minor Forest Products of India (Non- Timber Forest Products),* (2nd Edn.). BS Publications.
4. Mehta T. 1981. *A Handbook of Forest Utilization*. Periodical Expert Book Agency.
5. Mishra T K, Banerjee S K and Pal D C. 2004. *An Omnibus of Non- Timber Forest Products of India, Prashant Gahlot* at Valley Offset Printers and Publishers, Dehradun.
6. Nair K K N. 2000. *Manual of Non-Wood Forest Produce Plants of Kerala*, Kerala Forest Department, Government of Kerala, Thiruvananthapuram.
7. Nautiyal S and Kaul A K. 2003. *Non –Timber Forest Products of India*, Jyothi- Publishers and Distributors, Dehradun.

Forest Pest and Diseases 3 (2+1)

Objective

To impart the knowledge on basic concepts and management of pest and diseases in forest trees

Theory

Insects - Insect Body regions - Position of Insect in Animal Kingdom - Reasons for insect dominance - Insect Systematics - major orders- Categories of pest - IPM definition - Economic Threshold Level- Economic Injury Level- Components of IPM - Pest Surveillance - Forecasting - Pest management - methods - Silvicultural - Mechanical - Physical - Host Plant Resistance - Biological (Parasitoid, Predators, Microbials) - forest (insects) biological chain - Legal - Chemical - Classification of Insecticides - Chlorinated Hydrocarbons- Organophosphates- Carbamates - Botanicals - Newer molecules (Photostable) -IBPM. Nursery Pests - Pests of Major trees and their management - Teak, Sandal, Sal, Ailanthus, Bamboo, Gmelina, Eucalyptus, Tamarind, Casuarina, Melia, Silk Cotton, Neem, Pungam - Termites - Termite pests of timbers - Dampwood termites - Drywood termites - Subterranean termites - Termites Castes and Management. Forest pathology - Definition - importance –History of forest pathology- Losses due to forest tree diseases- Etiology, symptoms, mode of spread and management practices for teak, sal, sandal, Gmelina, Dalbergia, Silver oak, Hardwickia, Eucalyptus, Casuarina, Bamboo, *Acacia, Ailanthus, Melia dubia*, Neem and Pungam, Chir pine and Blue pine. Disease assessment- IDM in forest trees- pathogens affecting timber, sap and pulpwood in storage - timber decay, white fibrous rot, white pocket rot, dry rot, brown rot - Stains - blue - sap stain - factors determining different wood decay - IDM practices for decay and wood preservation techniques.

Practical

Study of External structure of Insect; Type species - Grasshopper / Cockroach. Methods of Insect Collection, preservation, display and storage. Types of insect Head, antenna, mouthparts, Legs and Wings and Modifications. Major Orders Orthoptera, Thysanoptera, Diptera, Hymenoptera, Coleoptera, Hemiptera, Lepidoptera. Assessment of Insect and mite damage in nursery and plantations. Observing the characters and identification of Pests on Teak, Sandal, Bamboo, Eucalyptus, *Ailanthus*, *Melia*, Casuarina, Tamarind, and Pungam. Insecticide Formulations, Appliances and Applications. Study the symptoms and microscopic observation, Etiology of the diseases of Teak (*Tectona grandis*), Sal (*Shorea robusta*), Sandal, Gmelina, Dalbergia, Silver oak, Hardwickia, Eucalyptus sp., Casuarina sp., Casuarina, Bamboo sp, Ailanthus sp. and *Melia dubia*, Neem, Pungam, Chir pine, Blue pine. Disease assessment in forest trees. Study of fungi infecting timber, sap and pulp wood in storage, wood staining fungi. Study of wood decay and wood preservation technique.

Suggested Readings

1. FRI (Forest Research Institute). 1976. *Indian Forest Utilization.* Vol. I & II. 941p. Forest Research Institute and college. Dehradun.
2. Krishnamurthi T. 1993. *Minor Forest Products of India*. Oxford and IBH Publishing Co. Pvt. Ltd.
3. Krishnamurthi T. 2010. *Minor Forest Products of India. (Non- Timber Forest Products)*. (2nd Edn.). BS Publications.
4. Mehta T. 1981. *A Handbook of Forest Utilization*, Periodical Expert Book Agency.
5. Mishra T K, Banerjee S K and Pal D C. 2004. *An Omnibus of Non- Timber Forest Products of India, Prashant Gahlot* at Valley Offset Printers and Publishers, Dehradun.
6. Nair K K N. 2000. *Manual of Non-Wood Forest Produce Plants of Kerala,* Kerala Forest Department, Government of Kerala, Thiruvananthapuram.

7. Nautiyal S and Kaul A K. 2003. *Non –Timber Forest Products of India*, Jyothi- Publishers and Distributors, Dehradun.

Wildlife and Protected Area Management 3 (2+1)

Objectives

i. To impart basics, functional and technical knowledge to the students on the various aspects of management strategies of the wildlife in natural ecosystem and captive conditions

ii. To acquire knowledge on principles and concepts of habitat management help to understand a challenge/opportunity in a given protected area and also to understand the global protected area system

Theory

Foundation and basics of protected area management - History of the IUCN protected area categories - Purpose of the protected area management categories. Global and Indian status of protected area management. Biogeographic regions of India - Wild animal distribution pattern in India- IUCN Red data book. Habitat requirements of animals – Components of Habitat - Wildlife habitat assessment – Standard evaluation procedure (SEP) - Advancing the successional process and Setting back successional process - Management of protected areas (*In-situ* conservation) - National parks - Sanctuaries – Tiger Reserves – Community reserves – Conservation reserves - Zoning and buffering - Framework for preparing a wildlife management plan. Wildlife census - Purpose, techniques. Direct and indirect methods of population estimation. Sample and total counts, indices, encounter rates and densities, block counts, road side counts, dung counts, pug mark census, water hole census, line transect – Scat analysis – Population viability index (PVI) - Statistical analysis- Software's in wildlife management - Special projects for wildlife conservation – Biotelemetry - Transmitters, receivers, analysis of data, visual tagging and marking- Drone based animal monitoring systems - Role of Camera traps and MSTripES App- Role of Remote Sensing and GIS in Wildlife management. Captive wildlife – Zoos, Biological parks and safari parks - Captive breeding program- Conservation breeding program - Central Zoo Authority of India and its function - Wildlife (Protection) Act, 1972 and its amendments. Role of NGOs in wildlife management. Introduction and reintroduction of species - International conventions MAB, CITES, CMS and CBD. Wildlife corridors -. Human Animal Coexistence- Wildlife Damage - Appraisal, Mitigation measures and Management. Healthcare, Disease Management and Nutrition in Wildlife sanctuaries and National parks, Biosphere reserves and Zoos - Major protected areas of India - Wildlife education - Wildlife tourism.

Practical

Exercise on the census methods - Direct method - Total count, block count, water hole count, capture, mark and recapture method, point transect, and line transect method – Use of software for analysis. Indirect methods, dung count for elephants, pugmark method for larger cats and pellet count for other ungulates. Pitfall trap, mist net, Sherman trap, camera trap, and other traps to study the wildlife. Study on habitat analysis and evaluation. Studying habitat management and manipulation techniques. Wildlife damage and mitigation measures: Questionnaire survey. Wildlife photography. Wildlife tourism management.

Suggested Readings

1. Davil J W, Lars H, Daniel O. 1981. *Infectious Diseases of Wild Mammals. (2nd Edn.)*. Iowa State University Press, USA. International Zoo Books, Published by New York Zoological Society, New York
2. Krebs C and Davis N. 1978. *Introduction to Behavioral Ecology*. Oxford University Press, England.
3. Lever C. 1985. *Naturalised Mammals of the World.* John Wiley, London
4. Mills L S. 2013. *Conservation of Wildlife Populations Demography, Genetics and Management (2nd Edn)*. Wiley-Blackwell.
5. Nigel Dudley. 2013. *Guidelines for Applying Protected Area Management Categories*. IUCN, Gland, Switzerland.
6. Rajesh G. 1995. *Fundamentals of Wildlife Management*. Justice Home, Allahabad.
8. Wildlife Institute of India. 2004. *Compendium on the Notes on the Course Captive Management of Endangered Species.* Wildlife Institute of India. Dehradun
9. Wodroffe G. 1981. *Wildlife Conservation and Modern Zoo*. Saiga Publishing Co., England.

Industrial Agroforestry 2 (1+1)

Objective

To develop skill and expertise on Industrial Agroforestry and associated supply and value chain management

Theory

Forests and Agroforestry – Extent of Area - Current status – National and International scenario – Role of Forests in Industrial sector – Industrial raw material – Demand and supply – Indigenous and exotic industrial resources – Policy and legal issues in industrial wood plantations and agroforestry - Major wood-based industries in India – Timber, pulpwood, plywood, panel. match splints, sports and goods, agricultural implements, construction, body building, ship industry, etc. - raw material requirements and procurements – Industrial important NTFPs – Scope and importance - Promotion of industry-based farm and agroforestry – Strategies for promotional activities. Industrial Agroforestry plantations – Status in India – Preferred species – Plantation management and establishment – Precision silvicultural techniques for Timber, pulp and paper, Match, plywood, dendro power– Propagation and plantation techniques – Pest and disease management for major industrial agroforestry tree species. Harvest operation – Mechanization – Yield potential. Value addition – Utilization of plantation and industrial residues – Briquettes and pellets. Supply Chain - Definition – Concept – Supply chain network – Logistic activities – Marketing system – Marketing type and channel – Price patterns of various agroforestry industrial wood products – Contract farming - Definition – Concept and methods of contract farming – Contract tree farming systems in India – Experiences of wood based industries in contract farming – buy back– Corporates in Industrial Agroforestry – International corporate involved in Industrial Agroforestry –Success stories - Corporate social responsibilities – Tree Insurance Scheme (TIS) – Felling regulatory mechanism. Consortium of Industrial Agroforestry – TNAU Model for sustaining industrial agroforestry -

Agroforestry business innovations and entrepreneurship development - Agroforestry based business incubation opportunities. Impact of Industrial Agroforestry – Economic and Ecological impacts: Climatic, edaphic and biotic– Carbon sequestration – Carbon storage potential of Industrial Agroforestry and carbon trading mechanism of Industrial Agroforestry – Socio-economic impacts – Rural livelihood improvement and economic return – Environmental impact.

Practical

Study of various wood based industries – Preferred species (State specific) – Timber agroforestry -Pulp and paper based agroforestry– Plywood based agroforestry – Matchwood based agroforestry – Dendro energy agroforestry – NTFPs agroforestry - Plantation management – Harvest and mechanization – Value addition Technology – Contract tree farming – Economics – Bankable project preparation - Visit to wood and non-wood based industries – Exposure to Business opportunities –DPR preparation for industrial agroforestry based business model.

Suggested Readings

1. Balasubramanian A, Hari Prasath C N, Radhakrishnan S. 2020. *Textbook on Plantation Forestry*. 336p. Jain Publication, New Delhi.
2. Parthiban K T, Umarani R, Umesh Kanna S, Sekar I, Rajendran P and P Durairasu P. 2014. *Industrial Agroforestry: Perspective and Prospective.* 396p. Scientific Publishers, Jodhpur, India.
3. Parthiban K T and Seenivasan R. 2017. *Forestry Technologies- A complete Value Chain Approach.* 629p. Scientific Publishers, Jodhpur.
4. Parthiban K T and Keerthika A. 2020. *Textbook on Agroforestry – Principles, Practices and Applications.* 256p. Agrobios, Jodhpur.

Study Tour- Non-gradial 2 (0+2)

- To be conducted for 10-14 days during 5th semester.
- The students will visit industries/ institutions, preferably outside the state, so that, in addition to visiting the organisations/ industries (related to the profession), they will also be exposed to the geographical variability of different places/ states and the social and cultural differences existing in the country.
- After the visit, the students will be submitting a report/ make a presentation.

Semester VI

Forest Biotechnology 3 (2+1)

Objective

To educate on the principles, tools, possibilities and progress made in biotechnology

Theory

Basics of Plant Tissue Culture Plant tissue culture: Concepts, history and scope – Components of Media and their role; Sterilization techniques ,Culture Conditions and Factors affecting *in vitro* cultures; Regeneration methods - morphogenesis, organogenesis and embryogenesis; Techniques in plant tissue culture - Micropropagation, meristem tip culture, another culture, pollen culture,

ovule culture, embryo culture, callus culture and suspension culture; Somatic embryogenesis and synthetic seed production; Protoplast isolation, fusion and cybrids applications in crop improvement; Soma clonal variation, types, causes and applications; Secondary metabolite production and *in vitro* germplasm conservation ; National certification and Quality management of TC plants. Biotechnology-Definition, History and scope. Importance of biotechnology in Crop improvement. Genome organization. Structure of nucleic acids-Concept of gene and gene architecture. Central Dogma of molecular biology. Overview of DNA replication, transcription and translation. Regulation of gene expression. Basic techniques in molecular biology-Blotting techniques- Polymerase chain reaction-DNA sequencing methods. DNA manipulation enzymes: Polymerases, restriction endonucleases and ligases - Different types of vectors: plasmids, phagemids, cosmids, BAC,YAC,PAC, Expression, Shuttle, binary and co-integrate vectors - Construction of recombinant DNA molecules- Bacterial transformation - Direct and indirect gene transfer methods in plants: microinjection, electroporation, particle bombardment, *Agrobacterium* mediated method - Tissue specific promoters, selectable and scorable markers, reporter genes- Molecular analysis of transgenic plants – Transgenic plants: herbicide, pest and disease resistant, abiotic stress resistant, nutritional enhancement and traits for improved quality- Detection of GMOs – regulations and biosafety. DNA markers - hybridization based markers (RFLP) - PCR based markers: RAPD, SSR, SCAR, AFLP, STS and SNPs - DNA fingerprinting of crop varieties – Development of mapping populations- linkage and QTL analysis- principles, methods and applications of Marker Assisted Selection in crop improvement; Applications of Plant Genomics and genome databases. Micropropagation in forest trees – successful examples – bamboo, sandal wood, eucalyptus, Paulownia and Melia. Bioprospecting industrially useful compounds from forest trees. Application of genetic engineering in forestry sciences –Molecular markers and its applications in forestry, Lignocellulose degrading microorganisms, Cellulose gene in tree species.

Practical

Biotechnology Laboratory organization - safety regulations-Sterilization techniques for aseptic manipulation-Calculations in Biotechnology and preparation of plant nutrient stock solutions-Preparation of plant nutrient medium -Shoot Tip Culture, Meristem Tip Culture, Anther and embryo culture, Callus culture and suspension culture -Hardening and acclimation of *in vitro* regenerated plants. Isolation of bacterial plasmid DNA - Agarose Gel Electrophoresis - Gene cloning and Bacterial transformation-Genomic DNA extraction - Quantification of DNA and quality check- Plant genetic transformation- biolistic and *Agrobacterium* mediated transformation-DNA amplification using PCR -NTSys- Analysis of Diversity in Crop Plants- Visit to a Plant Biotechnology Lab /Commercial Plant Tissue Culture facility.

Suggested Readings

1. Brown T A. 2010. *Gene Cloning and DNA Analysis: An Introduction.* (6th Edn.). Wiley-Blackwell Companion site. UK.
2. Krebs J E, Goldstein E S, Kilpatrick S T. 2017. *Lewin's Genes XII*. 838p. Jones and Bartlett Publishers, Inc, USA.
3. Malacinski G M. 2015. *Freifelder's Essentials of Molecular Biology.* (4th Student Edn.). Jones and Bartlett Publishers, Inc.,USA.
4. D L Nelson and Cox M M. 2017. *Lehninger Principles of Biochemistry,* (7th Edn.). 1328p. W. H. Freeman and Company, New York, USA.

5. George E F, Hall M A and De Klerk G J. 2008. *Plant Propagation by Tissue Culture. Vol.I: The Background.* (3rd Edn.). 501p. Springer, ISBN 978-1-4020-5004-6.
6. Stewart, Neal Jr. C. 2008. *Plant Biotechnology and Genetics: Principles, Techniques and Applications*. John Wiley and Sons, Inc ISBN: 978-0-470-04381-3.
7. Singh B D. 2012. *Plant Biotechnology.* Kalyani publishers, Ludhiana.
8. Tomar R S, Parakhia M V, Patel S V and Golakia B A. 2010. *Molecular Markers and Plant Biotechnology*, New Publishers, New Delhi.

Forest Economics and Marketing 2 (1+1)

Objective

To give exposure to the students on market concepts, marketing of forestry commodities, intermediaries involved, risks in forestry marketing, marketing institutions involved, price dynamics and the role of Government in regulation of markets

Theory

Economics - Definition and concepts, divisions of economics, economic systems, approaches to the study of economics. Forest economics - Definition, characteristics of Forestry sector and its role in economic development. National Income – Definition and concepts: Gross National Product and Gross Domestic Product. Consumption - Utility and its measurement: Cardinal and Ordinal. Theory of consumer behavior – Law of diminishing marginal utility, law of equi-marginal utility, indifference curve and its properties, consumer equilibrium. Demand – Law of Demand - Elasticity of demand – Types of elasticity of demand - Importance of elasticity of demand. Engel's law of family expenditure. Consumer surplus. Theory of firm, concept of production, factors of production – Land and its characteristics, labour and division of labour and theories of population. Capital and its characteristics. Enterprises - Factor – Product relationship. Laws of returns – Law of diminishing marginal return – Law of supply – Distribution. Exchange: Marketing – Role of marketing – Marketing functions – Producer surplus – Marketable and Marketed surplus – Marketing channels of forest products – Price spread – Marketing Efficiency – Integration – Market intelligence. Market equilibrium, Price determination and forecasting under various market structures. Basic guidelines for preparation of project reports – Bank norms and Farm Financial Analysis – Crop Insurance – SWOT analysis – Crisis management. International Trade: Concept of International Trade - Free trade, Autarky and it needs - Absolute and Comparative advantage; present status and prospects of exports / imports - Role of institutions like APEDA, MPEDA, ITTO, UNCTAD and GATT – WTO. Free Trade Agreements – AoA and its implications on Indian agriculture.

Practical

Estimation of consumer's equilibrium – Cardinal and Ordinal Utility Approaches. Plotting and study of demand and supply curves and calculation of elasticities of demand and supply. Study on law of diminishing marginal return. Estimation of Optimal input and Output levels. Estimation of cost of cultivation and cost of production for forest products. Preparation of Bankable projects for forestry products and its value added products. Estimation of farm financial ratios. Computation of marketable and marketed surplus of important commodities, Identification of marketing channel

of Agriculture / Horticulture / Forest products – Calculation of Price Spread – Identification of Market Structure – Time series analysis of prices - TCSI. Index number construction and uses. Visit to wood depot/LAMPS/Co-operative marketing society/ Farmers' Markets. Visit to Commercial / Co-operative Bank. Visit to different markets and processing units of Forest products.

Suggested Readings

1. Acharya S.S and Agarwal N L. 2011. *Agricultural Marketing in India*. (5th Edn.). Oxford and IBH Publishers, New Delhi
2. Chadra P. 1984. *Projects: Preparation, Appraisal and Implementation*. McGraw Hill Inc., New Delhi.
3. Dewett K K. 2005. *Modern Economic. Theory*. S. Chand and Co., New Delhi.
4. Dewett K K and Verma. 2004. *Elementary Economic Theory.* S Chand and Co., New Delhi.
5. Jhingan M L. 2012. *Macro Economic Theory*. Vrinda Publishers, New Delhi.
6. Reddy S S, Raghu Ram P, Neelakanta Sastry T V and Bhavani D I. 2004. *Agricultural Economics.* Oxford and IBH Publishers, New Delhi.

Watershed Planning and Management 2 (1+1)

Objective

To teach the students on different aspects of hydrology and watershed management and to impart basic knowledge on various measures of soil and water conservation

Theory

Introduction – Hydrology and its importance in forestry. Hydrologic cycle. Precipitation – forms. Rainfall – types. Intensity, duration and frequency. Infiltration, percolation, evaporation, transpiration and evapotranspiration. Runoff - runoff process – factors affecting runoff - prediction and estimation of runoff. Hydrograph – unit hydrograph. Sedimentation and stream gauging. Soil erosion – Principles - types of erosion - geological and accelerated. Forms of erosion - water erosion - kinds and forms - causes and effects - degree of erosion. Wind erosion – types – saltation, suspension, surface creep. Control of wind erosion - shelter belts and wind breaks. Sand dune stabilization. Land capability classification - recommended land use. Soil and water conservation - historical review – its need. Biological measures – afforestation, contour farming, strip cropping, cropping systems as inter cropping, crop rotation and mixed cropping, mulching and tillage practices. Grassland management. Mechanical measures - Contour bunds, Graded bunds, Bench terracing and Stone wall - Design of structures for soil conservation. Erosion control measures for non-agricultural lands, Soil conservation on Wastelands - contour and staggered trenching. Gully control structures - Temporary and permanent –check dams – types. Spillways – drop and chute spillways, drop inlet. Water Harvesting – definition, methods and techniques - treatment of catchments. Water Harvesting for Trees and Shrubs. Ground water – Aquifer – water harvesting for ground water recharge. Storage structures – Ponds – types. Watershed Management – definitions. Characteristics of watershed - elements and components. Selection of Priority areas - Planning and implementation of watershed programs in forest watersheds. Watershed work plan. Monitoring and evaluation of watershed programs. Remote sensing and GIS in watershed management.

Practical

Computation of mean rainfall – Isohyet and Thiessen polygon methods. Determination of infiltration with double ring infiltrometer. Estimation of runoff. Erosion estimation – Problems on USLE. Design of shelterbelts and windbreaks. Design of contour bunds, stone wall and bench terraces. Design of check dams. Visit to erosion prone and watershed areas. Design of water harvesting systems – roof water harvesting and percolation ponds. Design of micro catchment water harvesting systems for trees. Visit to soil conservation sites and silt monitoring station. Exercises on Demarcation of watershed. Preparation of watershed plan - monitoring and evaluation of watershed programs.

Suggested Readings

1. Das Ghanshyam. 2009. *Hydrology and Soil Conservation Engineering*. PHI Publishers, New Delhi.
2. Datta S K. 1986. *Soil Conservation and Land Management*. International Book Distributors, Dehradun.
3. Hamilton I S. 1987. *Forest and Watershed Development and Conservation in Asia and the Pacific*. International Book Distributors, Dehradun.
4. Oswal M C. 1999. *Watershed Management (For Dry land Agriculture).* Associated Publishing Company, New Delhi.
5. Rama Rao. 1980. *Soil Conservation*. Standard Book Depot, Bangalore.
6. Richard Lee. 1980. *Forest Hydrology*, Columbia University Press, New York.
7. Suresh R. 2000. *Soil and Water Conservation Engineering*. Standard Publishers, New Delhi.

Forest Tribology, Ethno-medicine and Extension 3 (2+1)

Objective

To impart basic knowledge on local indigenous peoples their knowledge on ethno medicines and the extension skills and knowledge with reference to forestry

Theory

Definition and characteristics of a tribe. Tribes and aborigines- an anthropological perspective. Racial classification and distribution of tribes. Tribes in India and Kerala. Tribal economy. Tribals and Constitution of India Administration of tribal areas in independent India- appraisal of tribal development - problems of tribal identity and integration in the mainstream. Relation between tribes and forests- forest as their immediate environment. Forests as the means of livelihood. Girijan habitat - changes consequent to government control of forests. Forest management and tribal welfare- management conflicts and way forward. Role of forest department in tribal welfare. Role of Non wood Forest products in the economy of tribal's and Tribal cooperative societies. Social forestry and tribal welfare. Ethno- medicines of tribals in Southern India. Traditional Botanical Knowledge. Ethno- medicines of the plants from the following families. Guttiferae (Clusiaceae), Malvaceae, Fabaceae, Mimosaceae, Caesalpiniaceae, Combretaceae, Umbelliferae (Apiaceae), Rubiaceae, Asteraceae, Ebenaceae, Apocynaceae,

Asclepiadaceae, Euphorbiaceae, Lauraceae, Palmaceae, Poaceae, Liliaceae, Coniferae, Santalaceae and Thymeliaceae. Introduction- human behaviour and psychology. Extension education: meaning, definition, nature, scope, objectives, principles, approaches and history. Types of education, Formal, informal non-formal education. Rural Development: meaning, definition, objectives and genesis. Transfer of technology programs like RD, OFT, FLD, KVKs – AKIS (Agricultural Information System), ATMA – ICT enable extension services. Communication: meaning, definition, elements and selected models. Audio-visual aids: importance, classification and selection. Diffusion and adoption process. Programming planning process – meaning, scope, principles and steps. Evaluation: meaning, importance and methods. Scope and importance of Participatory Rural Appraisal (PRA). Rural social groups, primary and secondary groups, formal, informal group, temporary, permanent groups, references group, classification of group.

Practical

Visits to study structure, functions, linkages and extension programmers of KVKs or ICFRE institutes/voluntary organizations/Mahila Mandal/Village Panchayat/Van Panchayat/ State Forest Department (Social forestry wing). Group discussion at farm homesteads. Preparing individual and village level production plans. Preparation of charts, posters and flash cards. Participation in conducting exhibitions and method demonstrations/campaigns at the village level. Familiarization of the use of audio-visual aids. PRA exercises. Field visit to Different tribal regions to gain ethnobotanical knowledge and the interrelation between plant and people - Survey and identification of plants used by the tribals for medicine, food and other social purposes - Collection and preparation of herbarium specimens of the above plants.

Suggested Readings

1. FAO. 1984. *Forestry Extension, Making it Works, An International Journal of Forestry and Forest Industries, Unasylva - No. 143*, Published by FAO.
2. Furer-Haimendorf C V. 1985. *Tribes of India - The Struggle for Survival*. OUP. New Delhi
3. Hasnain N. 2007. *Tribal India.* New Royal Book Company, Lucknow, Uttar Pradesh.
4. Jalihal K A and Veerabhadraiah V. 2007. *Fundamentals of Extension Education and Management in Extension.* Concept Publishing Company, New Delhi.
5. Jha L K, Sen P K and Sharma A P H. 2008. *A Manual of Forestry Extension Education*. 386p. Published by VEDAMS, New Delhi .
6. Maheshwari J K. 2000. *Ethnobotany and Medicinal Plants of Indian Subcontinent*. 672p. Scientific Publishers, Jodhpur, India.
7. Sharma R N and Bakshi S. 1984. *Tribes and Tribal Evelopment*. Uppal Publ. House, New Delhi.
8. Sim D and Hilmi H A.1987. *Forestry Extension Methods*, FAO, United Nations.(Forestry Paper-80). 153p.
9. Thakur D. 1986. *Socio-Economic Development of Tribes in India.* Deep and Deep Publications, New Delhi.
10. Vidyarthi L P and Rai B K. 1985. *The Tribal Culture of India*. Concept Publ. Co., New Delhi.

Remote Sensing and GIS 2 (1+1)

Objective

To inculcate students regarding the concept of Remote sensing and GIS tools in forestry sector

Theory

Definition, scope, history and development of remote sensing; Electromagnetic radiation (EMR) and electromagnetic spectrum; EMR interaction with atmosphere and earth surface; Types of remote sensing; Principles and applications of optical, thermal and microwave remote sensing; Aerial photographs – types, scale, and resolution; Photo interpretation, Satellite remote sensing - platforms and sensors; Satellite systems. Indian Remote Sensing Program. Different concepts of RS. Visual and digital image processing; Application of satellite based remote sensing techniques in forestry - vegetation mapping using satellite imagery; Forest cover monitoring and Forest fire damage assessment; Microwave remote sensing. Studies of different vegetation indices like NDVI. Wild life assessment. Introduction to GIS - Components of GIS, Hardwares and software's; Differences between GIS and conventional cartography; Spatial and non-spatial data, Integration of attribute data with spatial data. Spatial data - Raster and Vector data. Thematic over lays in GIS- topology building and calculation of area and length etc. Application of GIS in forestry – using imageries and integration with GIS data. Maps-its projection, Topo sheet and Map reading; Global Positioning System (GPS) applications in resource inventory, Global Navigation Satellite System, Galileo, IRNSS.

Practical

Preparation of base maps, thematic maps; Visual interpretation of satellite imagery; Forest cover mapping and land use mapping; Digital image processing; Introduction to various GIS and RS software; Exercises in viewing, editing, overlay. Visit to the RS and GIS labs at State level. Using of QGIS Software to prepare different maps.

Suggested Readings

1. Curran P J. 1985. *Principles of Remote Sensing*. Long man Group Ltd., England.
2. Janssen L F. 2000. *Principles of Remote Sensing*. ITC. Edl. Text Book Series II. The Netherlands.
3. Rolf A.de. 2000. *Principles of Geographical Information Systems*. ITC. Edl. Text Book Series I. The Netherlands.
4. Sabins F F. 1978. *Remote Sensing-Principles and Interpretation*. W.H. Freeman and Co. San Francisco.
5. Sharma M K. 1986. *Remote Sensing and Forest Surveys*. International Book Distributors, Dehradun.
6. Sharma S and Dey S K. 2021. *Entrepreneurship Development and Business Ethics*. V.K. Global Pvt. Ltd., New Delhi.

Forest Business Management 2 (1+1)

Objective

To understand the concept of forest business management and steps to start and manage the forest based business

Theory

Management – Definition – Importance of Management – Evolution of Management thoughts - Management functions – Nature of management functions – Management Roles – Functions at various levels of Management – Management skills. Forest Business Management– Definition, Scope, Importance and Characteristics of Forest Business Management -. Special features of Forest Business – Classification of Enterprises-Micro, Small, Medium and Large. Forms of Business Organisations – Sole Proprietorship – Partnership –Private and Public Limited - Business environment – Micro and Macro environment - Startup and Business incubators. Planning – Concept – Nature – Types of Planning – Importance of Planning - Plans-Types of plans –Steps in planning - Organising – Concept of Organising - Departmentation – Basis of Departmentation – Span of control Co-ordination -– Types and Techniques. Staffing – Concept – Human Resource Planning – Process. Recruitment and Selection - Training – Concepts – Methods – Evaluation. Directing – Concept – Principles – Techniques – Supervision. Controlling – Concept – Types. Operations Management – Meaning and Scope, Supply Chain Management – Drivers and flows– Meaning and Principles, Marketing Management – Market Segmentation and Marketing Mix Financial Management – Meaning, Objectives and Scope.

Practical

Assessment of entrepreneurial traits-Identification of new business opportunities-Exercise on SWOC Analysis of Agribusiness Sector in India -Market survey for understanding customer needs-Starting new business - Visit to firms / discussion with entrepreneurs-Documenting Procedure for Establishing Agribusiness Firms-Government programs and institutions for entrepreneurship development-Financing new agribusiness ventures - Visit to banks / discussion-Exercise on Demand Forecasting for Agricultural Inputs/Products - Preparation of Advertisement and Sales Promotion Measures for Agribusiness - Exercise on Inventory Management – ABC Analysis and EOQ Model-Exercise on discounted measures of Capital Budgeting-Calculation of Break Even Point and its Business Implication-Understanding balance sheet and income statement-Financial Performance Analysis - Ratio Analysis.

Suggested Readings

1. Shahapurmath Girish B and Inamati S S. 2020. *Forest Business Management*. Satish Serial Publishing House, New Delhi.
2. Koontz H and Weihrich H. 2007. *Principles of Management*, Tata McGraw Hill, New Delhi.
3. Charles W L Hill and Steven L McShane. 2007. *Principles of Management*. Tata McGraw Hill, New Delhi.
4. Massie J L. 1995. *Essentials of Management.* Prentice Hall of India Pvt. Ltd., New Delhi. Prasad L M. 2005. *Principles and Practices of Management*. S Chand and Sons Educational Publishers, New Delhi.
5. Rao V S B and Narayana P S. 2004. *Principles and Practices of Management*. Konark Publishing Pvt. Ltd. New Delhi.

Forest Landscape Restoration (FLR) 2 (2+0)

Objective

To develop students' in-depth understanding of forest landscape restoration through both traditional and modern technology

Theory

Definition, Scope and Objectives of FLR – Role of FLR in national, regional and global commitments – Land Capability Classification and Forest Cover Classification. Need for forest restoration programs. Principles and Guiding Elements. Diverse Knowledge Systems in Forest Landscape Restoration – Social-Ecological Systems and Forest Landscape Restoration - Integrated Landscape Approaches to Forest Restoration. Landscape Ecology - Scope of landscape ecology - Spatial statistics in landscape ecology - Landscape disturbance - Organisms and landscape pattern - Ecosystems processes on landscapes - Land use planning and conservation - Landscape Ecology's contribution to Forest Landscape Restoration. Different Techniques for Forest Restoration – Broad-Scale Traditional Restoration of Landscape techniques – Reforestation with Timber and other woods, Invasive Species Management, Restoring Historic Groundwater Levels and restoration with carbon efficiency trees. Integration of Traditional and Western Knowledge in Forest Landscape Restoration. Restoration to conserve and increase biodiversity - Achieve Climate Goals - Achieve the Sustainable Development Goal - Spiritual and Social Renewal. Linking forest conservation and food security through agroecology: Insights for Forest Landscape Restoration. Integration for Forest Landscape Restoration Implementation. Stakeholders and Forest Landscape Restoration - Tenure, Property Rights and Forest Landscape Restoration - Polycentric Governance and FLR: Governance process versus governance outcome, Formal and informal governance and Re-scaling, mapping and contextualizing.

Suggested Readings

1. Erbaugh J T and Oldekop J A. 2018. *Forest Landscape Restoration for Livelihoods and Well-being.* Current Opinion in Environmental Sustainability. Elsevier B.V., The Netherlands.
2. Lamb D, Stanturf J, and Madsen P. 2012. *What is Forest Landscape Restoration? Forest Landscape Restoration: Integrating Natural and Social Sciences. Springer imprint. New Delhi.*
3. Maginnis S, Rietbergen-McCracken J and Sarre A. (*Eds*). 2012. *The Forest Landscape Restoration Handbook.* Eartscan, London.
4. Mansourian S, Vallauri D, Dudley N, Mansourian S and Vallauri D. 2005. *Forest Landscape Restoration in Context. Forest Restoration in Landscapes: Beyond Planting Rrees.* Springer, USA.
5. Schultz C A, Jedd T and Beam R D. 2012. *The Collaborative Forest Landscape Restoration Program: A History and Overview of the First Projects*. Journal of Forestry, 110(7), 381-391.
6. Stanturf J A and Mansourian S. 2020. *Forest Landscape Restoration: State of Play*. Royal Society Open Science, 7(12): 2012-18.
7. Chaturvedi R, Duraisami M, Jayahari K M, Kanchana C B, Singh R, Segarin S and Rajagopal P. 2018. *Restoration Opportunities Atlas of India.* Washington, DC: World Resources Institute. Retrieved November 10, 2019.

8. Singh R, Shelar K, Chaturvedi R, Duraisami M and Gautam R S. 2020. *Restoring Landscapes in India for Climate and Communities.*

9. ITTO. 2020. *Guidelines for Forest Landscape Restoration in the Tropics.* ITTO Policy Development Series No. 24.

Forest Biomass Energy and Biofuels 2 (1+1)

Objectives

i. To expose the graduating scholars on the existing challenges in energy sector

ii. To create skill and expertise on the need for forest-based bioenergy and biofuel towards creating self-reliance in raw material besides combating the climate change risks and uncertainties

Theory

Energy status in India – demand for electricity –energy generation from various sources- Coal demand and supply-demand for liquid fuels –Petrol and diesel - Need for alternate energy resources – forest biomass and biofuel as an alternate- Government initiatives and policies - National Policy on Biofuels (2018) - National Policy on Biofuels (2018) Amendment, 2022. Indian scenario – biomass availability - types of biomasses – Agricultural residues - Short Gestation non-edible oil rich crops - Algal feedstock - Non- Edible Oilseeds (TBOs) - Used Cooking Oil (UCO) - Animal tallow – Acid oils - Current challenges and constraints. Forest-based biomass and biofuels.

Introduction - scope and potential of dendro energy in India – Dendro biomass: composition, sources, benefits - biomass properties of dendro energy species. Potential dendro energy species – cultivation technology - plantation models – High density energy plantation (HDEP). Harvesting of biomass – hrvesting methods – plantation residues - value addition technology - biomass briquettes, pellets and biocoal. TBOs for biofuels - Introduction and scope - International Scenario - Indian Scenario – Current availability and potential of TBOs-Properties of TBOs - Major TBOs in India – *Jatropha curcas*, *Pongamia pinnata - Azadirachta indica - Calophyllum inophyllum - Madhuca latifolia, Simorouba glauca* - Other TBOs – Plantation technologies for major TBOs– Value chain on TBOs – marketing potential of TBOs.

Forest biomass - Biomass based power production methods – Pyrolysis - Gasification – Combustion - TBO based biofuels - oil extraction methods - transesterification for biodiesel production -SAF Production process through TBO - Hydroprocessing of Esters and Fatty Acids (HEFA) process – quality characteristics of biodiesel and SAF.

Practical

Dendro energy resources – study of different tree species – short, medium and long duration- QPM Production technology for energy species- Wood and biomass quality characterization – physical and chemical properties - Wood and biomass quality characterization – thermo chemical properties - Study of energy plantation models – block, agroforestry, farmforestry, linear, multi functional, etc - Primary conversion technology for biomass – biomass – converted woods – chips – various sizes and grades – visit to an industry - Study of dendro energy generation technology – pyrolysis, gasification – visit to a gasification unit - Visit to thermal power plants/ biomass combustion plant – study of energy generaion through combustion and co-firing process - Study of biofuel crops - TBOs – *Jatropha curcas*, *Pongamia pinnata - Azadirachta indica - Calophyllum inophyllum*

- *Madhuca latifolia, Simorouba glauca* - Nursery production technology for TBOs - Plantation production technology for TBOs - block, agroforestry, farmforestry, linear, multi functional, etc - Study of seed collection, storage and processing of TBOs- Oil quality characterization of various TBOs – laboratory analysis - Visit to oil processing centre – study of oil production and by-products - Study of biodiesel production tecnology – transesterification and by-products - Study of SAF – properties.

Suggested Readings

1. Adams P, Bridgwater T, Langton L A, Ross A and Watson I. 2018. *Biomass Conversion Technologies: Greenhouse Gas Balances of Bioenergy Systems.* 134p. (ISBN: 9780081010365).
2. Bajpai P. 2020. *Biomass to Energy Conversion Technologies -The Road to Commercialization.* 204p. Elsevier. (ISBN: 978-0-12-818400-4).
3. Hakem K R, Jawaid M and Rashid U. 2014. *Biomass and Bioenergy - Processing and Properties.* Springer. 343p. (ISBN : 978-3-319-07641-6).
4. Pande M and Bhaskarwar A N. 2012. *Biomass Conversion to Energy - The Interface of Biotechnology, Chemistry and Materials Science*. 468p. Springer. (ISBN: 978-3-642-28418-2).
5. Parthiban K T and Seenivasan R. 2017. *Forestry Technologies- A Complete Value Chain Approach.* 629p. Scientific Publisher. Jodhpur. (ISBN: 978-93-86102-60-7).
6. Parthiban K T, Kumar N Krishna, Palanikumaran B and Kanna S Umesh. 2020. *Dendro Biomass Resources for Solid and Liquid Fuel Generation - Opportunities and Challenges*. 30p. Madras Agricultural Journal.
7. Paramathma M, Parthiban K T and Neelakantan K S. 2004. *Strategies for Improvement and Utilization of Tree Borne Oil Seeds. 218p.* Forest College and Research Institute, TNAU, Mettupalayam.
8. Radhakrishna P. 2003. *Tree Borne Oil Seeds as a Source of Energy for Decentralised Planning. Renewable Energy Science Series XII. Government of India. Ministry of Non-conventional Energy Sources*, Regional office, Chennai.
9. Venkata R P and Srinivas S N .1996. *Biomass Energy Systems*. 345p. Tata Energy Research Institute. (ISBN: 81-85419-25-6).

Trees Outside Forests **2 (2+0)**

Objectives

i. To expose students to the growing importance of trees outside forests

ii. To make student understand the need of augmenting tree cover towards meeting the domestic and industrial wood requirement

iii. To expose students to the existing technologies, models, policies and other government schemes

Theory

Trees Outside Forests (TOF) – introduction –classification-based on Land use – Trees with Settlements- Trees with Agricultural Lands–Trees along Manmade or Natural Features–based on Geometrical Formation - Isolated and scattered trees - Zonal Trees - Methodology of Assessment by FSI - Stratified random sampling design - Multistage stratified sampling design – Status of TOF

in India - State wise TOF status and opportunities – demand and supply pattern of wood and non-wood requirements - Government policies to promote TOF – National Forest Policy (1988), National Agroforestry Policy (2014). TOF- Regeneration, restoration and rehabilitation opportunities and methods– Quality Planting Material (QPM)- Principles and criteria - design and development - General Quality Standards for Nurseries and Plants Produced - Hi-tech Nursery - Design and Development – Components and characteristics - Choice of species – utility based – general plantation techniques for prioritized species –Market and industrial linkages – timber and NTFPs –economically important tree species – various models for TOF –Agroforestry – Farm forestry - Linear plantations- windbreaks-shelterbelts -boundary plantations- riverbank plantations - trees on pasture lands- green cities- urban green space – micro forests– Impacts of TOF – contribution to Forest cover - Restoration of degraded lands – ecosystem services – Provisional – Regulating – Cultural – Supporting.

Timber products – Global status- National status- Saw logs and veneer logs- Pulpwood - Ply and panel- Industrial round wood - Non-timber products- Global status and National status- Gums-Resins- Latex – Dammar – Tannins - Fibres- Floss - Market size -Demand and supply - Processing technology- Value addition- Government regulations- Trade channels-Organizations involved -TOF based TBE opportunities – Production – processing – marketing – value addition-based business enterprises – creation of startups – MSMEs – Business incubation. TOF certification - schemes – scope and opportunities – International certification agencies - certification Institution and organization - FSC certification - PEFC certification - Sustainable Forestry initiative (SFI) – Indian Forest and Wood Certification Council (IFWCC) - NCCF - Quality Planting Material – Government Initiatives- Carbon sequestration potential- UNFCC - Kyoto protocol- COP - carbon credit – International and national status - TOF based carbon trading opportunities -Types of carbon markets – Methodology - Benefits to farmers – Circular economy from TOF based products-Significance of TOF in achieving SDGs and NDCs.

TOF related Schemes and Programs - National Bamboo Mission –Submission on Agroforestry-Green highways missions - Mission for integrated development of horticulture -Nagar Van Yojana (NVY) -National Mission for a Green India (GIM) - USAID funded project on TOFI – objectives, activities and partner institution - participating states – innovative platform – tree out growers schemes-NITI Aayog: Greening and Restoration of Wastelands with Agroforestry (G.R.O.W)-National Mission on Oilseeds and Oil Palm (NMOOP): Mini Mission - III (TBOs).

Suggested Readings

1. Parthiban K T and Keerthika A. 2020. *A Textbook of Agroforestry: Principles, Practices and Applications*. 256p. AgroBios (India), Jodhpur. (ISBN: 978-81-973776-8-9).
2. Parthiban K T and Seenivasan R. 2017. *Forestry Technologies- A Complete Value Chain Approach*. 629p. Scientific Publisher, Jodhpur. (ISBN: 978-93-86102-60-7).
3. Parthiban K T, Jude Sudhagar R, Cinthia Fernandaz C and Suresh K.K. 2018. *Agroforestry Strategies for Climate Change (Mitigation and Adaptation)*. 395p. Jaya Publishing House, New Delhi.
4. Atyi E and Simmula M. 2002. *Forest Certification: Pending Challenges for Tropical Timber. Background Paper Prepared for the ITTO International Workshop on Comparability and Equivalence of Forest Certification Schemes*. Kuala Lumpur.

5. *Indian Forest and Wood Certification Scheme – Guidelines. Program for Recognition and Accreditation of Sustainable Management Practices for Agroforestry and Natural Forestry Resources. Ministry of Environment, Forest and Climate Change Government of India.* 76p.

6. NITI Aayog. *Technical Report on Greening and Restoration of Wastelands with Agroforestry*. (G.R.O.W). 2024. 96p. (ISBN No. 978-81-956821-3-3)

7. Pandey D. 2008. *Trees Outside the Forest (TOF) Resources in India. The International Forestry review*, 10(2): 125–33. *JSTOR*, http://www.jstor.org/ stable/43740329.

8. Hegde N G. 1991. *Agroforestry in India: Scope and Strategies. Agroforestry in Asia and Pacific. RAPA Publication:1991/5 Regional Office for Asia and the Pacific*. pp 47-63. FAO. Bangkok.

9. ICFRE (Indian Council of Forestry Research and Education). 2023. *Forestry Statistics India* 200p. Directorate of Statistics, New Forest, Dehradun.

10. Rudolph S and Aydos E. 2021. *Carbon Markets Around the Globe. Sustainability and Political Feasibility*. Elgar online. (ISBN: 978-18-391090-8-9).

11. Duraisami M, Singh R and Chalia S. 2022. Roadmap for Scaling Trees outside Forests in India: Learning from select States on Policy Incentives, Enabling Conditions, and Barriers. Working Paper. Mumbai: World Resources India. Available online at https://www.wri.org/research/roadmap-scaling-trees-outside-forests-india.

12. Parthiban K T, Subbalakshmi V, Jawahar Vishnu M V and Dabbas M. 2024. *A Textbook on Trees Outside Forests.* Scientific Publisher, Jodhpur.

Semester VII (Elective Courses)

The student will choose one Elective group among the four major disciplines with a total of 20 credits

S. No.	Course category	Credit Hours
1.	Plantation Forestry	20
2.	Multi-Functional Agroforestry	20
3.	High Yielding Short Rotation Forestry	20
4.	Forest Product Development and Utilization	20
5.	Forest Resource Management and Utilization	20
	Total	**20**

Semester VIII

S. No.	Course Title	Credit Hours
1.	Students READY Programme (RAWE/Internship/Student Project/Hands-on training/Forest Work Experience)	20 (0+20)
	Total	**20 (0+20)**

Training attachment in wood-based industry/ forest departments/ Police/ Special Task Force (STF)/ incubation centres/ KVKs or research Institutes/ NGO/ agribusiness entrepreneur, etc. (May be conducted in split manner in more than one industry/ institution/ organization). Ideally it is recommended to have Internship with Forest Department (Administrative Skill) for 5 weeks, Internship with wood-based industries (Technical Skill) for 2 weeks, Internship with Police/ Special

Task Force (STF) for Jungle survival for 1 week and Internship with incubation centres/KVKs for 2 weeks. Either project (R and D based, field study based) or entrepreneurship based (Incubation/ Experiential learning)/ Hands-on training.

ELECTIVE COURSES

Courses under each major discipline

A) Plantation Forestry

1. Commercial tree seedling production (1+2)
2. Commercial plantation development and management (2+1)
3. Forest growth modelling (1+1)
4. Marketing and certification of wood products (1+1)
5. Restoration of degraded lands (2+1)
6. Dendro-biomass and energy plantation (2+1)
7. Plantation and climate change mitigation (2+0)
8. Plant Biochemistry (1+1)
9. Research Methodology (1+1)
10. Statistical Packages for Data Analysis (0+1)
11. Internship with forest plantations-based institutions/plantation companies (0+2).

Commercial Tree Seedling Production 3 (1+2)

Objective

To impart knowledge on seed collection, tree seedling production through the natural as well as artificial regeneration techniques

Theory

Introduction and scope for nursery technology. Nursery establishment-site selection – planning, and layout of nursery area. Types of nursery, types of nursery beds, preparation of beds, fumigation. Pre- sowing treatments. Methods of seed sowing and mulching, seed size and position of sowing, seedling growth and development, pricking, watering methods, weeding, hoeing, rotation, organic matter supplements and cover crops, mycorrhizae, fertilization, shading, pruning, root culturing techniques, lifting windows, grading, packaging. Storing and transportation. Containerised nursery technique – advantages, disadvantages – root deformations- container designs and types/root trainers and rooting media. Conditions/practices affecting survival and early growth, acclimating containerised stock, field handling of containerised stock, planting techniques for containerized stock. Planting bare-root seedlings: advantages, disadvantages, conditions/practices affecting early survival and early growth. Methods for field handling and planting bare-root stock. Containerised nursery Technique-Type and size of containers. Merits and demerits of containerized nursery. Root trainer techniques Preparation of ingredient mixture. Nursery practices that influence seedling uniformity, diameter/height and size of root system. Stump preparation. Study of important nursery pests and diseases and their control measures. Nursery practices for some important tree species.

Target seedling concept. Temporary and permanent nursery development- preparation of proposal, layout, economic Considerations-Implementation-Emerging trends in forest tree propagation and nursery technology, VMG: Vegetative multiplication garden.

Practical

Raising of stocks, practicing grafting, budding and layering techniques in tree species-anatomical studies of graft and bud joints – studies on cell differentiation and union-studies on treatment effect and pre curing of scion, growth regulator effect on asexual methods – raising nurseries, practicing seed propagation, taking observations, visit of commercial nurseries. Preparation of production and planning schedule for bare root and containerized nurseries. Nursery site and bed preparation. Pre-sowing treatments. Sowing methods of small, medium, and large sized seeds. Mother bed and transplant bed preparation- Pricking and transplanting of in transplant beds. Intermediate nursery management operations. Preparation of ingredient mixture. Filling of containers Study of vegetative techniques-cutting, grafting etc. Visit to tissue culture laboratory and other nurseries Temporary and permanent nursery development preparation of proposal, layout, economic considerations.

Suggested Readings

1. Bewely J D and Black M. 1985. *Seed Physiology of Development and Germination*.
2. Bose T K, Mitra S K and Sadhu M K. 1986 *Propagation of tropical and sub-tropical*. Crops. Naya Prakash, Calcutta.
3. Duryea M L and Landis T D. (Eds.). 1984. *Forest Nursery Manual: Production of Bare root Seedlings*. 386p. Dr. W. Junk Publishers, The Hague/Boston/Lancaster for Forest Research Laboratory. Oregon State University, Corvallis.
4. Evans J. 1982. *Plantation Forestry in the Tropics.* The English Language Book Society and Claredon Press.
5. Liegel L H and Venator R. 1987. *A Technical Guide for Forest Nursery Management in the Carribean and Latin America*. Gen. Tech. Rep. SO-67, New Orleans, LA: U.S. Department of Agriculture.
6. May J T, Belcher Jr. E W, Cordell C E, Filer, Jr. T. H, David South, and Lantz. C W. 1985. *Southern Pine Nursery Handbook, USDA Forest Service, Southern Region, Cooperative Forestry Mehta, A.R and Bhatt, P.N. 1990. Hand book of plant tissue and all cultures.* Academic book centre, Ahmedabad
7. Napier and Robbins M. 1989. *Forest Seed and Nursery Practice in Nepal. Nepal UK Forestry Research Prakash, R. 1990. Propagation Practices of Important Indian Trees. International Book Distributors, Dehradun*. 472p. Project, Kathmandu Oxford.

Commercial Plantation Development and Management 3 (1+2)

Objective

To acquaint students with various aspects of production, integrated nutrient and irrigation management and ecological factors in raising forest plantations

Theory

Role of plantation forestry in meeting the wood demand - Plantation forestry in India and abroad. Production technology for quality planting stock - preliminary site preparation for establishing plantation - Enrichment of site - Planting program - time of planting - planting pattern - spacing - planting methods. Precision silviculture - concept - advantages of precision silviculture. Tree management - canopy, root and stem engineering. Fertigation system - drip irrigation management for short and long rotation tree species. Fertilizer management for plantation productivity. Assessment and yield prediction in plantation. Nutrient and irrigation management in plantation, INM, mulching, weed management - Mechanization of plantation operation - Protection and after care of plantation - Pruning and thinning of plantation for quality wood production - Rotation in plantation - Failure of plantations. Management of coppice stand. Industrial Plantation – Importance - Demand and supply scenario in India - Wood based industries - NTFP Plantations - Choice of species and plantation technology - Silvicultural packages for Eucalyptus, Casuarina, Acacias, Silver Oak, Ailanthus, Bamboo, *Melia dubia*, Gmelina, Teak, Sandal and Red sanders. Post-harvest silvicultural techniques. Tools and Implements used in logging operation. Reduced impact logging (RIL), Concept - scope and objectives – impediments to adoption - difference between reduced impact logging and conventional logging. Economics of commercial plantation.

Practical

Plantation planning - Preparation of plantation calendar- Arrangement and preparation of improved planting stock - Planting geometry and calculation of planting stock - Site preparation and planting - Studies on wood-based industries - Plantation geometry - Canopy architecture and management, root pruning and root management, stem management and inter-callery augmentation. Plantation techniques for difficult sites - saline, alkaline soils, rocky area and waterlogged areas and other inhospitable sites. Modern plantation techniques for Eucalyptus, Casuarina, Teak, Acacias and Bamboo plantations - Production technology for energy plantations and NTFP Plantations - Economics of commercial plantation.

Suggested Readings

1. Dwivedi A P.1992. *Principles and Practices of Indian Silviculture*. 420p. Surya Publications.
2. Julius E. 1992. *Plantation Forestry in the Tropics*. Oxford University Press.
3. Khanna L S. 2015. *Theory and Practice of Indian Silviculture Systems*. Bio-Green Publisher.
4. Lamprecht. 1986. *Silviculture in the Tropics. Verlag Paul Parey*. Hamburg und Berlin.

Forest Growth Modelling 2 (1+1)

Objective

To impart knowledge on forest growth model for predicting the future of the forest by incorporating the silvicultural treatments

Theory

Model development and validation - Important uses - Indices of competition - Two-sided competition (Distance-independent vs. Distance-dependent) - One-sided competition (Distance-

independent vs. Distance-dependent) – Limitations - Low predictive power (Distance-independent vs. distance-dependent) - Influence of sampling design. Whole-stand models - Yield tables and equations - Compatible growth and yield equations - Systems of equations - State-space models - Transition matrix models. Size-class models - Stand table projection - Matrix models – Diameter (Class models and Cohort models) - Single-tree distance-dependent models - Tree-list distance-independent models. Stand-level mortality – Individual tree-level mortality - Mechanistic models of mortality -Development and application of mortality equations. Genetic improvements (Stand-level and Tree-level) - Early stand treatments (Stand-level and Tree -level) –Thinning (Stand-level and Tree-level) – Fertilization (Stand-level and Tree-level)- Combined thinning and fertilization (Stand-level and Tree-level) – Harvesting (Stand-level and Tree-level).Types of hybrid models - Statistical growth equations with physiologically derived covariate -Statistical growth equations with physiologically derived external modifier - Allometric models -Comparison to statistical models.

Practical

Collection of biometric data for growth model preparation – Sampling design analysis. Whole-stand models - Yield tables and equations. Mortality model and mechanism of model. Modelling silvicultural treatments are Genetic improvements - Early stand treatments –Thinning – Fertilization - Combined thinning and fertilization – Harvesting models. Benefits and uses of working out the growth models.

Marketing and Certification of Wood Products 2 (1+1)

Objective

To impart knowledge on marketing of the wood products and certification of the forest plantations and wood

Theory

Market, definition, types of markets for timber produce, Economic features of specialized markets in terms of degree and type of competition in buying and selling, price spread, costs of marketing functions involved like harvesting, hauling, sawing, transportation, treatment of wood, carpentry, and other processing activities involved in timber, composite wood, pulp wood, match wood. Demand forecasts. Price determination in timber produce. Domestic and International demand and trade in timber products. Market integration and market inefficiencies in timber and measures to check inefficiencies. Role of cooperative societies and NGO's in marketing of timber and non-timber forest produce. Economic policy and regulations of international timber trade. WTO - background, structure, functions and decision-making process. Essentials of World Trade Organization, GATT, Dunkel proposals, Intellectual Property Rights and Patenting. International Timber Trade Organization (ITTO). Forest Certification- Definition of forest certification- Origin of certification- process and methods – Advantages and Disadvantages. Principal stages in the process of certification. Producer's motivation for supplying certified forest products. Key aspects of certification. Principles of sustainable forest management. Organizations involved in certification. Legislations and

policies of importance. Certification schemes in operation. Forest Stewardship Council (FSC), Program for Endorsement of Forest Certification Schemes (PEFC) etc. CIFOR certification tool kit. Indian scenario in certification. International trade in tropical logs and sawn wood. Pros and cons of certification. Potential for certifying forests and forest products of India. Tracing illegal logging. Identification of species and region of origin. Case studies in forest certification.

Practical

Questionnaire preparation for primary data collection; Visit to various wood based (Timber, composite wood, pulp wood, match wood) and non-wood-based industries to study its role in marketing; identification of marketing channel and estimation of price spread for major timber and non-timber forest products; Estimation of marketing efficiency; Analysis of price and quantity data of timber a produce for examining trend, seasonal, cyclical and secular variations. Valuation of timber (Existence value, use and option values, intrinsic value etc).

Suggested Readings

1. Bass S, Thornber K, Markopoulos M, Roberts S and Grieg-gran M. 2001. *Certification's Impact on Forests, Stakeholders and Supply Changes*. 153p. International Institute for Environment and Development. London.
2. Conroy M E. 2007. *Branded! How the "Certification Revolution" is Transforming Global Corporations*. 354p. New Society Publishers, Gabriola Island, BC.
3. Gupta H S, Yadav M, Sharma D K and Singh A M. 2013. *Ensuring Sustainability in Forestry: Certification of forests*. 284p. TERI, New Delhi.
4. Kula E. 1996. *The Economics of Forestry: Modern Theory and Practice*. 182p. Timber press, Portland, Oregon.
5. Muraleedharan P K, Subramanian K K and Pillai P P. 1998. *Basic Readings in Forest Economics*. 177p. Kerala Forest Research Institute and Ford Foundation, Thrissur, Kerala.
6. Tewari D N. 1995. *Marketing and Trade of Forest Produce*. 140p. International Book Distributors (Book Sellers and Publishers), Dehradun, India.

Restoration of Degraded Lands 3 (2+1)

Objective

To impart practical understanding about rejuvenation of forest with tree vegetation and to develop skills on tacking different problem soils with suitable vegetation

Theory

Degraded lands: Concept, classification, status, extent and causes of degraded lands/ wastelands, different types of degraded lands – physical, chemical and biological land degradation. Soil erosion- types, causes and mechanism, measures to control erosion, ravine and sand dune formation and their control measures. Salt affected soils- classes of salt affected soils, causes, extent and their effects on plant growth and afforestation / reclamation practices. Acid soils- definition, characteristics, causes and afforestation. Water logged areas- explanation, impact on pant growth and Biodrainage techniques. Afforestation and reclamation of denuded hill slopes, land slips and

landslides, avalanche and cold desert, mined out, dry, rocky and murramy areas. Desertification-definition, impact and causes, prevention and counter measures (shelter belts and wind breaks). Soil pollution- types, effects and control measures through forestry techniques. National and state level programs on degraded lands/wasteland development. Role of Government agencies and NGO's in degraded lands/wasteland development program

Practical

Tree species suitable for different degraded lands. Identification and study of various degraded lands. Visit to nearby degraded lands (Eroded site, ravine and sand dune, coastal area, waterlogged area, denuded hill slopes, land slips and landslides, avalanche and cold desert, mined out, dry, rocky and murramy areas) and afforestation program.

Suggested Readings

1. Hegde N G 1987. *Handbook of Wasteland Development*. 102p. BAIF, Pune.
2. ICAR. 1977. *Desertification and its Control*. 358p. ICAR, New Delhi.
3. Imeson A. 2012. *Desertification, Land Degradation and Sustainability*. John Wiley and Sons.
4. Kumar Anil and Pandey R N 1989. *Wastelands Management in India*. Ashish Publishing House, New Delhi.
5. Luna R K. 1989. *Plantation Forestry in India*. International Book Distributors, Dehradun. Forestry; Ministry of Agriculture and Irrigation, Govt. of India, New Delhi. 457p.
6. National Commission on Agriculture 1976. Report of the National Commission on Agriculture, Part IX.

Dendro- biomass and Energy Plantation 3 (2+1)

Objective

To develop skill and expertise among the students regarding the Forest Energy Resources

Theory

Forests and Dendro-energy – Definition and Scope Role of Forests – Forest Energy Potential – Status of Forest Biomass – Applications of forest biomass energy resources – Advantages and Disadvantages of Forest Biomass energy resources. Introduction – Biomass Production – Photosynthetic and energy production– Biomass Composition – (Cellulose, Hemicellulose, Lignin, Starch, Proteins, Mineral Elements, Other components (Organic and inorganic) – Biomass Energy Content – Properties of Forest Biomass – Physical – Thermodynamic and other properties. Energy Trees – Short rotation species – Eucalyptus, Casuarina, Subabul, Prosopis and Bamboos – Medium rotation species – All Acacias – Long rotation species – Energy characteristics of the species – Tree borne oilseeds as a source of biofuel – Dendro energy production technology – Site selection – Choice of species – Plantation establishment– Maintenance of plantation– Protection – Harvesting of biomass – Harvesting Methods – Plantation residues – Types – Utilization and value addition through briquetting –– Yield potential of different dendro energy species. Dendro energy models – Farm Forestry – Agroforestry – Captive Plantations – High Density Short Rotation Model (HDSR) – High Density Energy Plantation (HDEP) – Clonal Plantations – Monoclonal and Polyclonal Model – Sporadic model – Linear model – Paired row model– Establishment and management – Economics

– Handling of Biomass – Drying biomass material –Drying techniques – Biomass storage and Transportation – Sustainable Production of woody biomass for energy generation. Introduction– Species selection – Energy species amenable for farm forestry – Types of farm forestry models. CDM approach– CDM benefits through Energy Plantations – Carbon sequestration potential of energy trees. Contract energy farming – Scope and methods – Dendro biomass power plants in India – Scope and potential.

Practical

Study on natural and artificial methods for tree biomass production. Identifying suitable tree species (Short rotation, medium rotation and long rotation species) for energy generation. Estimation of calorific value for Short rotation, medium rotation and long rotation species. Study on energy characteristics of the species. Dendro energy production technology – Site selection – Plantation establishment – Plantation management – Harvesting operation. Biomass estimation in trees by using both destructive and non-destructive methods. Plantation residues for dendro-energy production. Dendro energy models. High Density Short Rotation Model (HDSR) and High Density Energy Plantation (HDEP).

Suggested Readings

1. Divya MP, Parthiban K T, Vanangamudi K, Srinivasan K and Govinda Rao M. 2008. A *Text Book on Social Forestry and Agroforestry.* Sathish Serial Publishing House, Delhi.
2. Luna RK. 1989. *Plantation Forestry in India.* pp 320-338.International Book Distributors. New Delhi.
3. Khanna L S. 1999. *Principles and Practice of Silviculture*. Khanna Bandhu, New Delhi.
4. Parthiban K T, Umarani R, Umesh Kanna S, Sekar I, Rajedran P and Durairasu P. 2014 .*Industrial Agroforestry Perspectives and Prospectives*. 396p. Scientific Publishers, Jodhpur.
5. Parthiban K T, Subbulakshmi V, Umesh Kanna S, Sekar I, Rajendran P, Durairasu P and Suresh G. 2013. *Dendro Power Generation - Principles and Applications*. 275p. FCRI, Publications.
6. Parthiban K T, Paramathma M and Neelakantan K S. 2006. *Clonal forestry.* FC&RI publication (ISBN no.81-902081-2-8).

Plantation and Climate Change Mitigation 2 (2+0)

Objective

To understand the scenario of climate change and international treaties on climate change, adaptive silviculture for climate change mitigation, silviculture for conservation of ecosystems

Theory

Global climate change - factors involved greenhouse gases, potential threats, global carbon cycle and C-budget, carbon sequestration. Forests and climate change. Forest responses and vulnerabilities to climate change mitigation. Status of forests in global climate change. Harnessing Forests for Climate Change Mitigation, International climate negotiation, UNFCCC, IPCC, CoP, LULUCF, REDD++ and CDM. National action plan for climate change - Green India mission-Indian Network for Climate Change Assessment (INCCA) - State Action Plan on Climate Change. Silviculture and sustainability- criteria and indicators for sustainable plantation forestry in India.

CIFOR guidelines. Silvicultural and stand management strategies for carbon sink maximization and source minimization. Adaptive silviculture for climate change. Analog forestry for site productivity and carbon value. Disturbance- natural and anthropogenic, short- and long- term impacts and their implications. Fire loss estimation in forests. Deforestation and degradation trends at global, national and regional levels. Mega development projects, Road widening projects and conservation of native and threatened species, management and rehabilitation plans. Invasive – major invasive species in forests – area affected and methodology for mapping. Eradication methods- management. Restoration of invasive affected areas – types - methods approaches, strategies and opportunities. Silvicultural treatments for habitat restoration, catchment area treatments, enrichment planting. Silviculture Climate resilience - definition - resilient forestry - concept - practices and models - resilient forestry practices for different land use systems - Role of canopy in regulating functional inputs to stand: canopy and forest continuum, Continuous Cover Forestry. Silviculture of old growth stands and sacred grooves- their ecological significance and biodiversity values. Silviculture activities for conserving forest resources. Expanding forest and tree cover area - TOF sector in India. Carbon sequestration potential of Trees Outside forests (TOFs), home gardens and urban forests.

Suggested Readings

1. Adam Markham (Ed.). 2010. *Potential Impacts of Climate Change on Tropical Forest Ecosystems.* Amazon publishers.
2. Anderson P and Palik B. 2011. *Silviculture for Climate Change.* U.S. Department of Agriculture, Forest Service. Climate Change Resource Center.
3. Bravo F, LeMay V, Jandl R and Gadow von K. (Eds). 2008. *Managing Forest Ecosystems: The Challenge of Climate Change*. 324p. Springer publication, New Delhi.
4. Claussen Eileen, Cochran Vicki, Davis Arroyo and Debra P Pew. 2001. *Climate Change: Science, Strategies, and Solutions.* 393p. Brill Academic Publisher, The Netherlands.
5. Streck Charlotte, O'Sullivan Robert, Richard Tarasofsky G and Janson-Smith Toby. 2011. *Climate Change and Forests: Emerging Policy and Market Opportunities*. Brookings Institution Press.

Plant Biochemistry 2 (1+1)

Objective

To understand the basic scenario of biochemical action that happens in the plant system

Theory

Introduction to biomolecules. Chemistry of carbohydrates: Monosaccharides, classification, Configurations and conformations (Anomerism, epimersim, mutarotation, inversion); Disaccharides and polysaccharides (structural and storage); Glycosaminoglycans and glycoproteins. Chemistry of lipids: Lipid classification- Fatty acids, triacylglycerols, glycerophospholipids and sphingolipids. Amino acids of proteins – General properties, peptide bonds, classification and characteristics, acid-base properties; Optical activity. Primary, secondary, tertiary and quaternary structure of proteins; fibrous and globular proteins; protein stability and denaturation. Chemistry of nucleic acids: Bases, sugars, Nucleosides and nucleotides. Chemical structure and properties of

DNA and RNA. Chemical catalysts vs. biological catalysts; substrate specificity-stereo, geometric specificities; Enzymes – nomenclature, classification, enzyme kinetics- rates of reactions; Lock and Key hypothesis and induced fit models; Enzyme assay, transition state theory, Michaelis Menten equation, Lineweaver-Burk plot, enzyme inhibition-reversible (Competitive, uncompetitive and mixed) and irreversible, allosteric enzymes, Effect of pH and temperature on enzyme activity; Isozymes, coenzymes. Photosynthesis – light reactions, dark reaction, Hill's reaction, photorespiration, C4 pathway, C3, C4 and CAM plants, CO2 fixation, regulation of photosynthesis. Metabolism of carbohydrates -glycolysis, TCA cycle, electron transport chain. Lipid metabolism – beta oxidation and fatty acid biosynthesis. Secondary metabolites- Classification and functions of phenolics, terpenoids and alkaloids.

Practical

Qualitative analysis of carbohydrates. Estimation of sugar by Dubois method. Determination of reducing sugars by DNS method. Determination of total carbohydrate by anthrone method. Protein estimation by Bradford method. Absorbance curve of two dyes. Qualitative analysis of amino acids. Titration of amino acids. Purification of acid phosphatase from mustard seedlings. Qualitative analysis of oils and fats. Estimation of saponification value of oils. Estimation of iodine number of oils/fats. Chromatography of photosynthetic pigments. Lipid analysis by thin layer chromatography. Total protein estimation by Lowry's method. Kinetics of alkaline phosphatase.

Suggested Readings

1. Berg J M, Tymoczko J L and Stryer L. 2007. *Biochemistry* (7th Edn.). Wiley Eastern Ltd. ISBN:0-7167-8724-5.
2. Buchanan, Bob B. Gruissem, Wilhelm and L. Jones, Russell. 2000. *Biochemistry and Molecular Biology of Plant*s. Rockville, Md. : American Society of Plant Physiologists. USA
3. Jeremy M, Berg, Lubert Stryer, Tymoczko, John and Gregory Gatto. 2011. Biochemistry. W. H. Freeman and Company, New York.
4. Nelson David L and Michael M Cox. 2000. *Principles of Biochemistry.* Lehninger.
5. Plummer David T. 1987. *An Introduction to Practical Biochemistry.* McGraw-Hill, New York.
6. Rao, Beedu Sashidhar, Deshpande, Vijay. *Experimental Biochemistry: A Student Companion.*
7. Sadasivam, S and Manickam, A. 2009. *Biochemical Methods.* (3rd Edn.). New Age International, New Delhi.
8. Thayumanavan, B., Krishnaveni S and Parvathi K. 2004. *Biochemistry for Agricultural Sciences.* Galgotia Publications Pvt Ltd., New Delhi.
9. Voet Donald and Voet Judith G. 2010. *Biochemistry.* John Wiley & Sons. USA.
10. Wilson K and Walker J M. 2000. *Principles and Techniques of Practical Biochemistry.* Cambridge University Press, UK.

Research Methodology 2 (1+1)

Objective

To inculcate the art of research and expose the students through various methodologies of data collection, processing, tabulation and interpretation

Theory

Role of research methodology - Induction and deduction, Sources of information - Review of literature, Identification of problem - Formulation of objectives and hypothesis - Scope of survey-based research - Types of surveys- identification of research problem - Analysis of research problem, customer identification, categorization- Data collection, analysis and compilation of survey report - Types of data, concepts of population - Analysis of data, graphical and diagrammatic presentation - Measures of central tendencies-mean, median, mode- problems- Reliability and validity of measuring tools.- Reporting: Significance of report writing, steps in report writing- Processing Information in Research Methodology - Importance of Experiments in research - Interview studies in Research methodology -Solutions of research methodology.

Practical

Research problem identification, objective and Hypothesis Formulation - Research design, Collection of data, Analysis of Data for the identified Problem- Hypothesis testing, interpretation and report writing for the identified problem- Application of Scales for measurement – Nominal and ordinal- Application of Scales for measurement –Interval and Ratio- Application of Scales for measurement – Likert and other scales-Identification of Primary and Secondary Data -Correlation - Simple and partial correlation - Correlation - Multiple correlation analysis - Regression – Simple and Multiple regression analysis- Dummy variable analysis - Construction of Index Numbers - Factor analysis - Cluster analysis.

Statistical Packages for Data Analysis 1 (0+1)

Objective

To learn the art of data collection, processing, analysis and interpretation will be developed to translate simple data into scientific data

Practical

SYSTAT package – data entry and creation of a data file – importing an excel file, SPSS file, database file, BMDP file and SAS file in Systat for analysis- Data manipulation – transformation – ranking, sorting, appending, merging and transposing of data in SYSTAT- SAS package – data entry and creation of data files in SAS – opening a file – importing an excel file, Systat file, database file and SPSS file in SAS for analysis- Data manipulation – transformation – ranking, sorting, appending, merging and transposing of data in SAS- Data analysis using SYSTAT and SAS packages- Descriptive statistics- Cross tabulation – one way, two way and multi-way tables- Chi square test- Student's t test – comparing a single mean- Comparison of two means – independent t test- Comparison of two means – paired t test- One way ANOVA- Two way ANOVA- Correlation analysis- Spearman's rank correlation and Kendall's tau- Jaccard and tetra correlation coefficients- Complete regression analysis.

Suggested Readings

1. Nigam A K and Gupta V K. 1979. *Hand Book on Analysis of Agricultural Experiments*. IASRI Publication, New Delhi.
2. Panse V G and Sukhatme P V. 1967. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi, India.

3. Petersen Roger G. 1994. *Agricultural Field Experiments: Design and Analysis*. Marcel Dekker, New York.
4. Jayaraman K and Rugmini P. 1990. *Statistical Techniques in Forestry - Research and forestry.* Kerala Forest Research Institute, Peechi, Thrissur.

B) Multi-functional Agroforestry

1. Agroforestry System (2+1)
2. Interactions in Agroforestry Systems (1+1)
3. Agroforestry and Climate Change Mitigation (2+0)
4. Industrial Agroforestry (2+1)
5. Ecotourism 2+1)
6. Dendro-Biomass and Energy Plantation (2+1)
7. Introduction to Agronomy and Crop Production Technology (2+1)
8. Plant Biochemistry (1+1)
9. Research Methodology (1+1)
10. Statistical Packages for Data Analysis (0+1)
11. Agroforestry Business Incubation (1+1)
12. Internship with Agroforestry-Based Institutions/Industries (0+2)

Agroforestry Systems 3 (2+1)

Objectives

i. To impart knowledge on suitable agroforestry practices for different land uses
ii. To study their role in ecosystem services
iii. To teach recent trends in agroforestry research and development

Theory

Agroforestry - objectives, importance, potential and limitations for implementation. Agroforestry systems - simultaneous and sequential agroforestry systems, Basis for classification of agroforestry systems and principles - Structural, functional, ecological and socio-economic basis of classification - Indigenous vs exotic tree species in agroforestry, intraspecific variations- Tree crown architecture and tree root architecture – silvicultural options to minimize negative interactions- Ideotype concept for selection of multipurpose trees and nitrogen fixing trees. Land use – Land capability classification- Survey and analysis of land use system Description of agroforestry systems viz. agri-silviculture, silvipasture, agro-silvipasture, horti-silvipasture -Description of other systems – silvi-mediculture, silvi-pisciculture, silvi-apiculture, urban agroforestry systems and aqua forestry- Wind break and shelter belt agroforestry systems – Agroforestry practices for wetlands – Agroforestry practices for garden land - Agroforestry practices for semi-arid and arid lands – Agroforestry practices for coastal and hilly areas - Bio saline agroforestry. Ecosystem services – Provisional services – food, fuel, fodder, fibre, timber and non-timber resources, Regulating services - Agroforestry for soil enrichment-biodiversity conservation - improved air and water quality - Cultural services – Religious, aesthetic, recreation - Supporting services – education, soil and environmental conservation, carbon sequestration, climate change mitigation. Nutrient cycling and nutrient pumping in agroforestry systems -Soil productivity and management in agroforestry - Plant management in Agroforestry – manipulation of trees, population densities and mixture of trees

and herbaceous crops – ecosystem structure and function- interactions relevant to agroforestry. Formulation of Agroforestry projects - preparation of bankable projects, economic analysis of various agroforestry systems - Budget and other constraints - Financial and socio-economic analysis of agroforestry projects - Role of time in decision making- social and private discount rate - Role of risk and uncertainty in decision making- Participatory Rural Appraisal (PRA) -Rapid Rural Appraisal (RRA) tools for Agroforestry problem diagnosis.

Practical

Studies on global agroforestry systems - Designing agroforestry practices for wet lands - garden lands - dry lands -coastal and hilly areas - multitier systems - light intensity and shade effect under agroforestry systems-quantifying tree-crop interaction by LER method allelopathic studies- case studies on role of agroforestry in carbon sequestration, biodiversity conservation and air and water quality-Agroforestry D &D exercise - Preparation of bankable projects - financial and economic appraisal - Profitability analysis of various agroforestry systems.

Suggested Readings

1. Divya M P, Parthiban K T, Srinivasan K, Vanangamudi K and Rao M Govinda. 2008. A *Textbook on Social Forestry and Agroforestry*. 315p. Satish Publishers, Delhi.
2. Janaki R R, Alavalapati and Mercer, D Evan (Eds). 2005.*Valuing Agroforestry Systems, Methods and Applications. Advances in Agroforestry, Vol. 2.* 314p. Kluwer Academic Publishers, Dordrecht, Netherlands.
3. Jose S. 2009. *Agroforestry for Ecosystem Services and Environmental Benefits*. 266p. Springer Science, The Netherlands.
4. Nair P K R.1993. *An Introduction to Agroforestry*. 499p. Kluwer Academic Publishers, Netherlands.
5. Kumar B M and Nair P K R. 2011. *Carbon Sequestration Potential of Agroforestry Systems: Opportunities and challenges. Advances in Agroforestry. Vol.VIII*. 307p. Springer Science, The Netherlands.
6. Ong C K and Huxley P K. 1996. *Tree Crop Interactions -A Physiological Approach*. ICRAF.
7. Parthiban K T, Ramah K, Sivakumar K and Rao G R. 2019. *Multifunctional Agroforestry. Vol*. I-II. Jaya Publishing House, New Delhi.
8. Parthiban K T and Keerthika A. 2021. *A Text Book of Agroforestry – Principles, Practices and Applications*. Agrobios, Jodhpur.
9. Puri Sunil and Panwar Pankaj. 2007. *Agroforestry Systems and Practices*. 461p. New India Publishing Agency, New Delhi.
10. Raj Antony Joesph and Lal S B. 2014. *Agroforestry- Theory and Practices*. Scientific Publishers, New Delhi.

Interactions in Agroforestry Systems 2 (1+1)

Objective

To make students understand the concepts of tree- crop interactions, their quantification and techniques to neutralize the negative interactions

Theory

Agroforestry –general principles of plant productivity – photosynthesis – respiration – plant productivity – manipulation of photosynthesis in Agroforestry – multipurpose tree species - fodder trees – fuel wood trees – fruit trees – industrial wood species – other woody perennials – herbaceous species. Tree-crop interface – factors influencing tree – crop interaction- types of tree –crop interactions based on effect, association and output, position – positive interactions – competition, complementarity in resource sharing – above ground and below ground interaction. Negative interaction – competition, allelopathy – characteristics of tree species and crops – Allelochemicals - source of allelochemicals - process and leaching of allelochemicals - Tree management – manipulation of densities and arrangement of trees – Tree crown and root manipulation - Animal-tree-crop interaction. Method for quantifying interactions, principles of resource capture and utilization of light and water, nutrition and space. Tree-soil-crop interactions- nitrogen fixing trees interactions in agroforestry systems – Use of radioisotopes in tree-crop interaction studies - Root distribution of trees and crops. Management options to neutralize negative interactions – tree husbandry practices for alleviating competition – thinning, pruning, pollarding, lopping, hedging etc. – management of light interception.

Practical

Different methods for quantifying interactions- Studies on allelopathy - Laboratory bioassay with tree /crop parts and rhizosphere soil - different plant mixtures and estimating tree-soil-crop interactions - Working out indices for evaluating agroforestry systems - Measurement and interpretation of light interception in agroforestry system - Interpretation of yield responses to shelter, soil water and drainage measurement - transpiration measurement, quantifying root distribution.

Suggested Readings

1. Avery M A, Cannel M G R and Ong C K. 2005. *Biophysical Research for Asian Agroforestry.* Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Dagar J C and Tewari J C. 2016. *Agroforestry Research Developments*. Nova Science Publishers.
3. Parthiban K T and Keerthika A. 2021. *A Text book of Agroforestry – Principles, Practices and Applications*, Agrobios, Jodhpur.
4. Raj Antony Joesph and Lal S B. 2014. *Agroforestry- Theory and Practices*. Scientific Publishers (India), New Delhi.

Agroforestry and Climate Change Mitigation 2 (2+0)

Objective

To develop understanding of students about ecosystem services, environmental benefits and quantification of ecosystem services along with their valuation.

Theory

Global CO_2 emission and patterns of climate variability - Multifunctionality of Agroforestry - Major ecosystem services, environmental benefits and international conventions, charters on climate change (UNFCCC, UNCCD, Agroforestry and Kyoto protocol – genesis, goals, signatories and latest developments - climate change negotiations (CoP), Reduced Emissions from Deforestation

and Degradation (REDD) and biodiversity conservation (CBD) – an overview. Agroforestry for carbon conservation, sequestration, substitution – role and potential of various agroforestry systems - Estimates of carbon sequestration potential – measurement – Aspects and criticisms, Factors affecting above and belowground carbon sequestration potential. Agroforestry for soil enrichment – mechanisms – litter and fine root dynamics, rhizo-deposition and other rhizosphere effects, symbiotic and free-living N_2 fixation, mycorrhizal associations - Soil and water conservation benefits through agroforestry. Agroforestry for biodiversity conservation - Synergy with climate change mitigation - Landscape connectivity for wildlife, supporting the pollinators of plant species - Agroforestry for improved air and water quality - Non-point source pollution in Indian agro-ecosystems - Riparian buffers for alleviating agricultural non-point source pollution – Pollution reduction measures in forestry. Private profitability vs. social profitability - exclusion or inclusion of social benefits and costs and non-market values, or externalities - Theory of externalities, effect of environmental costs and benefits on the profitability of agroforestry practices - Valuing environmental services - Profitability of timber, pulp wood, ply wood and match wood-based agroforestry systems - Costs and benefits in agroforestry- valuation of inputs and outputs- environmental outputs.

Suggested Readings

1. Alavalapati J R R, Shrestha R K, Stainback G A and Matta J R. 2004. *Agroforestry development: Anenvironmental Economic Perspective*. Agroforestry Systems. 61: 299– 310.
2. Huxley P. 1999. *Tropical Agroforestry*. Blackwell.
3. IPCC. 2007. *Climate Change 2007*. Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
4. Jain S K and Singh P. 2000. *Economic Analysis of Industrial Agroforestry: Poplar (Populus deltoides) In Uttar Pradesh (India)*. Agroforestry Systems. 49: 255–273.
5. Jeffers J N R. 1978. *An Introduction to System Analysis with Ecological* Application. Edward Arnold.
6. Jose S. 2009. *Agroforestry for Ecosystem Services and Environmental Benefits: An Overview*. Agroforestry Systems. 76: 1-10.
7. Lyngbaek A E, Muschler R G and Sinclair F L. 2001. *Productivity and Profitability for Multistrata.* Springer.
8. Nair PKR. 1993. *An Introduction to Agroforestry*. Kluwer, Netherlands.
9. *Organic Versus Conventional Coffee Farms in Costa Rica. Agroforest. Syst. 53: 205–213.*
10. Schroth G and Sinclair F. 2003. *Tree Crops and Soil Fertility: Concepts and Research Methods.* CABI, Wallingford, UK.
11. Young A. 1997. *Agroforestry for Soil Management.* (2nd Edn.). CABI, Wallingofrd, UK.

Industrial Agroforestry 3 (2+1)

Objective

To develop skill and expertise on Industrial Agroforestry and associated supply and value chain management

Theory

Forests and Agroforestry – Extent of Area - Current status – National and International scenario – Role of Forests in Industrial sector – Industrial raw material – Demand and supply – Indigenous and exotic industrial resources – Policy and legal issues in industrial wood plantations and agroforestry - Major wood-based industries in India – Timber, pulpwood, plywood, panel. match splints, sports and goods, agricultural implements, construction, body building, ship industry, etc. - raw material requirements and procurements – Industrial important NTFPs – Scope and importance - Promotion of industry-based farm and agroforestry – Strategies for promotional activities. Industrial Agroforestry plantations – Status in India – Preferred species – Plantation management and establishment – Precision silvicultural techniques for Timber, pulp and paper, Match, plywood, dendro power– Propagation and plantation techniques – Pest and disease management for major industrial agroforestry tree species. Harvest operation – Mechanization – Yield potential. Value addition – Utilization of plantation and industrial residues – Briquettes and pellets. Supply Chain - Definition – Concept – Supply chain network – Logistic activities – Marketing system – Marketing type and channel – Price patterns of various agroforestry industrial wood products – Contract farming - Definition – Concept and methods of contract farming – Contract tree farming systems in India – Experiences of wood based industries in contract farming – buy back– Corporates in Industrial Agroforestry – International corporate involved in Industrial Agroforestry –Success stories - Corporate social responsibilities – Tree Insurance Scheme (TIS) – Felling regulatory mechanism. Consortium of Industrial Agroforestry – TNAU Model for sustaining industrial agroforestry - Agroforestry business innovations and entrepreneurship development - Agroforestry based business incubation opportunities. Impact of Industrial Agroforestry – Economic and Ecological impacts: Climatic, edaphic and biotic– Carbon sequestration – Carbon storage potential of Industrial Agroforestry and carbon trading mechanism of Industrial Agroforestry – Socio-economic impacts – Rural livelihood improvement and economic return – Environmental impact.

Practical

Study of various wood based industries – Preferred species (State specific) – Timber agroforestry -Pulp and paper based agroforestry– Plywood based agroforestry – Matchwood based agroforestry – Dendro energy agroforestry – NTFPs agroforestry - Plantation management – Harvest and mechanization – Value addition Technology – Contract tree farming – Economics – Bankable project preparation - Visit to wood and non-wood based industries – Exposure to Business opportunities –DPR preparation for industrial agroforestry based business model.

Suggested Readings

1. Balasubramanian, A, Hari Prasath CN, Radhakrishnan S. 2020. Textbook on Plantation Forestry. 336p. Jain Publication, New Delhi.
2. Parthiban KT, Umarani R, Umesh Kanna S, Sekar, I, Rajendran, P and Durairasu P. 2014. *Industrial Agroforestry: Perspective and Prospective*. 396p. Scientific Publishers, Jodhpur, India.
3. Parthiban KT and Seenivasan R. 2017. Forestry Technologies- A Complete Value Chain Approach. 629p. Scientific Publishers. Jodhpur.
4. Parthiban KT and Keerthika A. 2020. Textbook on Agroforestry – Principles, practices and Applications. 256p. Agrobios, Jodhpur.

Ecotourism 3 (2+1)

Objective

To develop knowledge, understanding, and appreciation of environmentally responsible travel to relatively undisturbed natural areas that promote biodiversity conservation, has low negative visitor impact, and provide socio-economic benefits to the local stakeholder communities

Theory

Ecotourism – Definition - History of tourism and evolution of ecotourism. Various forms of tourism - Dimensions of tourism and essential conditions for tourism to occur. Differences between tourism components. Mass tourism versus ecotourism. Organised tours and Free Independent Traveller – World Tourism Organization. Concept of ecotourism and flaws in real world. Problems with definition of ecotourism and criticisms. Dimensions of ecotourism and the criteria to qualify for ecotourism. Declaration – Different forms of ecotourism. Ecotourism indicators and conceptual differences between developing and developed countries. International organizations and NGOs promoting ecotourism. Ecotourism-its potential in developing countries- Poverty and biodiversity, Ecotourism as a rural development strategy in tropical countries Ecotourism as a land use- possibilities of integration – Ecotourism policies at national and local level. Environmental Impacts of ecotourism and its mitigation - Case studies from different parts of the world- Concept of "scale". The checks and controls and institutional mechanisms for controlling the environmental impacts, Mitigation of pollution. Social Impacts of ecotourism and precautionary principles to avoid ill effects Stories from different parts of the world narrating ecotourism development and its influence on society and their culture – The societal advantages and the negative impacts of ecotourism development – Ways forward to address the negative social impacts Indigenous people and ecotourism. Ecotourism economics and business – Investment of international agencies like World Bank in ecotourism projects Ecotourism economics at macro and micro economic level in developing countries Ecotourism as a green business and role of green consumerism – Business plans- unique selling points for marketing – Potential of internet in marketing ecotourism – Payments for Environmental services and role of ecotourism Multiplier effects, opportunity costs and leakage in ecotourism industry Sharing ecotourism revenues among stakeholders – Training in ecotourism to deliver quality service. Ecotourism as a vehicle for the conservation of common property resources – potentials and pitfalls, Dangers involved in management of common property resources Relations between the government and the private sector. Ecotourism and Protected Areas Changing paradigms in the Protected Area Management Support at international level for ecotourism Integrated Conservation Development Projects (ICDPS) and role of ecotourism Community based ecotourism programs. Planning and management of ecotourism – Ecotourism plans and management of visitors and other resources including human and natural resources – Quality control, codes of conduct etc. Use of GIS and ICT for effectively managing and planning ecotourism – Criteria and indicators for sustainable management and monitoring – Charter for Sustainable Tourism – Sustainability issues in ecotourism management and ecotourism certification. Ecotourism design – Role of socio-economic factors in decision making – Designing ecotourism products using local technologies – Carrying capacity considerations. – Use of GIS in ecotourism. Ecotourism markets and influences of climate change Existing ecotourism markets and ecotourism market segmentation – Paradigm shifts possible due to climate change and its potential influence of carbon economy on existing ecotourism markets.

Practical

Preparation of a thematic compendium after extensive and original independent investigation about the chosen Protected Area. Be familiar with Government policy and legislation, the current policies regarding the component land uses of the study site. Stakeholder analysis and social Impacts Assessment. Identify different stakeholders at different levels. Based on this perform a stakeholder analysis and then conduct social surveys to gather the information required for assessing the impacts of current management and to explore the intervention needed in the chosen protected area. Ecological surveys including Environmental Impact Assessment. Assess the ecological impacts of current human use using standard techniques in order to identify the intervention needed in the chosen protected area.

Suggested Readings

1. Bhatt S and Liyakhat S. 2014. *Ecotourism Development in India:* Communities, Capital and Conservation. Cambridge University Press.
2. Lindberg K, Wood M E and Engeldrum D. 1998. *Ecotourism- A Guide for Planners and Managers (Environment and Development)*. Foundation Books
3. Page S J and Dowling R K. 2002. Ecotourism. Pearson Education Limited, Essex. Scientific Research Publishing.
4. Weaver D. 2002. *Ecotourism. Milton, Queensland, Australia*. John Wiley and Sons Australia.

Dendro-Biomass and Energy Plantation 3 (2+1)

Objective

To develop skill and expertise among the students regarding the Forest Energy Resources

Theory

Forests and Dendro-energy – Definition and Scope Role of Forests – Forest Energy Potential – Status of Forest Biomass – Applications of forest biomass energy resources – Advantages and Disadvantages of Forest Biomass energy resources. Introduction – Biomass Production – Photosynthetic and energy production– Biomass Composition – (Cellulose, Hemicellulose, Lignin, Starch, Proteins, Mineral Elements, Other components (Organic and inorganic) – Biomass Energy Content – Properties of Forest Biomass – Physical – Thermodynamic and other properties. Energy Trees – Short rotation species – Eucalyptus, Casuarina, Subabul, Prosopis and Bamboos – Medium rotation species – All Acacias – Long rotation species – Energy characteristics of the species – Tree borne oilseeds as a source of biofuel – Dendro energy production technology – Site selection – Choice of species – Plantation establishment– Maintenance of plantation– Protection – Harvesting of biomass – Harvesting Methods – Plantation residues – Types – Utilization and value addition through briquetting –– Yield potential of different dendro energy species. Dendro energy models – Farm Forestry – Agroforestry – Captive Plantations – High Density Short Rotation Model (HDSR) – High Density Energy Plantation (HDEP) – Clonal Plantations – Monoclonal and Polyclonal Model – Sporadic model – Linear model – Paired row model– Establishment and management – Economics – Handling of Biomass – Drying biomass material –Drying techniques – Biomass storage and Transportation – Sustainable Production of woody biomass for energy

generation. Introduction– Species selection – Energy species amenable for agroforestry – Types of agroforestry models– Silvi agriculture – Silvi pastoral based energy farming– Alley cropping– CDM approach– CDM benefits through Energy Plantations – Carbon sequestration potential of energy trees. – Contract energy farming – Scope and methods – Dendro biomass power plants in India – Scope and potential.

Practical

Study on natural and artificial methods for tree biomass production. Identifying suitable tree species (Short rotation, medium rotation and long rotation species) for energy generation. Estimation of calorific value for Short rotation, medium rotation and long rotation species. Study on energy characteristics of the species. Dendro energy production technology – Site selection – Plantation establishment – Plantation management – Harvesting operation. Biomass estimation in trees by using both destructive and non-destructive methods. Plantation residues for dendro-energy production. Dendro energy models. High Density Short Rotation Model (HDSR) and High-Density Energy Plantation (HDEP).

Suggested Readings

1. Luna R K. 1989. *Plantation Forestry in India*. pp 320-338. International Book Distributors, New Delhi.
2. Divya M P, Parthiban K T, Vanangamudi K, Srinivasan K and Rao M Govinda. 2008. A Text *Book on Social Forestry and Agroforestry*. 315p. Sathish Serial Publishing House, Delhi. ISBN: 81-89304-48-8.
3. Khanna L S. 1999. *Principles and Practice of Silviculture*. 473p. Khanna Bandhu, New Delhi. ISBN: 81-58-933-01-4.
4. Parthiban K T, Umarani R, Umesh Kanna S, Sekar I, Rajendran P and Durairasu P. 2014. *Industrial Agroforestry: Perspective and Prospective*. 396p. Scientific Publishers, Jodhpur, India.
5. Parthiban K T, Subbulakshmi V, Umesh Kanna S, Sekar I, Rajendran P, Durairasu P and Suresh G. 2013. *Dendro Power Generation - Principles and Applications*. 275p. FC&RI Publications.
6. Parthiban K T, Paramathma M and Neelakantan K S. 2006. *Clonal forestry.* 209p. FC&RI Publication (ISBN no.81-902081-2-8).

Introduction to Agronomy and Crop Production Technology (2+1)

Objective

To impart the basic and fundamental knowledge of Agronomy

Theory

Agronomy and its scope: Definition, Meaning and scope of Agronomy; Art, science and business of crop production, relation of Agronomy with other disciplines of Agricultural Science, Fields crops and classification, importance, ecology and ecosystem, Seeds and sowing: Definitions of crops, variety and seed. Factors affecting crop stands establishment: good quality seed, proper tillage, time of sowing seed rate, depth and method of sowing: broadcasting, drilling, dibbling,

transplanting etc. Tillage and tilth: Definition, objectives, types, advantages and disadvantages of tillage including conservation tillage. Crop density and geometry: plant geometry and planting geometry, its effect on growth, yield Crop nutrition: Definition of essential nutrients, criteria of essentiality, functional elements, classification of essential nutrients, role of macro and micro nutrients. Nutrient absorption, active and passive absorption of nutrients, forms of plant nutrients absorbed by plants, Combined /un-combined forms Manures and fertilizers, nutrient use efficiency: Sources of nutrients: Inorganic (fertilizers), organic (manures) and bio-fertilizers; their classification and characteristics, method of preparation and role of organic manures in crop production Integrated Nutrient Management: Meaning, different approaches and advantages of INM Green manure- role in crop production: Definition, objectives types of green manuring, desirable characteristics, advantages and limitations of green manuring , Water management: Water resources of the world, India and the state; Soil Moisture Constants –gravitational water, capillary water, hygroscopic water, Soil moisture constants, Concept of water availability to plants, soilplant-water relationship, crop water requirement, water use efficiency, Methods of irrigation : Scheduling of irrigation, different approaches of scheduling irrigation Weeds: Definition, Importance and basics of classification of weeds and their control Cropping systems: Factors affecting cropping systems, major cropping patterns and systems in the country. Sustainable crop production: Definition, importance and practices, natural resources and conservation pollution and pollutants, Allelopathy: Meaning and importance in crop production, Growth and development of crops: Definition, Meaning and factors affecting growth and development.

Practical

A visit to Instructional Crop farm and study on field crops, Identification of crops, seeds, fertilizers, pesticides, Crops and cropping systems in different Agro-climatic zones of the state, Study of some preparatory tillage implements, Study of inter tillage implements, Practice of ploughing / puddling, Study and practice of inter cultivation in field crops, Numerical exercises on calculation of seed, plant population and fertilizer requirement, Study of yield contributing characters and yield estimation of crops, Identification of weeds in different crops, Seed germination and viability test of seed, Practice on time and method of application of manures and fertilizers, Measurement of soil moisture by gravimetric and volumetric method and bulk density,

Suggested Readings

1. Donn William L. 1965. *Meteorology.* McGraw-Hill Book Co. New York.
2. Rao V S. 1992. *Principles of Weed Science*. Oxford and IBH Publishing Co. Ltd. New Delhi.
3. Reddy Yellamanda T and Shankar Reddy G H. 1995. *Principles of Agronomy*. Kalyani Publishers. Ludhiana.
4. Reddy S R. 2008. *Principle of Crop Production*. Kalyani Publisher, Ludhiana.
5. Yawalkar K S and Agarwal J P. 1977. *Manures and Fertilizers*. Agricultural Horticultural Publishing House, Nagpur.

Plant Biochemistry 2 (1+1)

Objective

To understand the basic scenario of biochemical action that happens in the plant system

Theory

Introduction to biomolecules. Chemistry of carbohydrates: Monosaccharides, classification, Configurations and conformations (Anomerism, epimersim, mutarotation, inversion); Disaccharides and polysaccharides (structural and storage); Glycosaminoglycans and glycoproteins. Chemistry of lipids: Lipid classification- Fatty acids, triacylglycerols, glycerophospholipids and sphingolipids. Amino acids of proteins – General properties, peptide bonds, classification and characteristics, acid-base properties; Optical activity. Primary, secondary, tertiary and quaternary structure of proteins; fibrous and globular proteins; protein stability and denaturation. Chemistry of nucleic acids: Bases, sugars, Nucleosides and nucleotides. Chemical structure and properties of DNA and RNA. Chemical catalysts vs. biological catalysts; substrate specificity-stereo, geometric specificities; Enzymes – nomenclature, classification, enzyme kinetics- rates of reactions; Lock and Key hypothesis and induced fit models; Enzyme assay, transition state theory, Michaelis Menten equation, Lineweaver-Burk plot, enzyme inhibition-reversible (Competitive, uncompetitive and mixed) and irreversible, allosteric enzymes, Effect of pH and temperature on enzyme activity; Isozymes, coenzymes. Photosynthesis – light reactions, dark reaction, Hill's reaction, photorespiration, C4 pathway, C3, C4 and CAM plants, CO_2 fixation, regulation of photosynthesis. Metabolism of carbohydrates -glycolysis, TCA cycle, electron transport chain. Lipid metabolism – beta oxidation and fatty acid biosynthesis. Secondary metabolites- Classification and functions of phenolics, terpenoids and alkaloids.

Practical

Qualitative analysis of carbohydrates. Estimation of sugar by Dubois method. Determination of reducing sugars by DNS method. Determination of total carbohydrate by anthrone method. Protein estimation by Bradford method. Absorbance curve of two dyes. Qualitative analysis of amino acids. Titration of amino acids. Purification of acid phosphatase from mustard seedlings. Qualitative analysis of oils and fats. Estimation of saponification value of oils. Estimation of iodine number of oils/fats. Chromatography of photosynthetic pigments. Lipid analysis by thin layer chromatography. Total protein estimation by Lowry's method. Kinetics of alkaline phosphatase.

Suggested Readings

1. Berg J M, Tymoczko J L and Stryer L. 2007. *Biochemistry.* (7th Edn.). Wiley Eastern Ltd. ISBN:0-7167-8724-5.
2. Berg Jeremy M, Stryer Lubert, Tymoczko John and Gatto Gregory. 2015. *Biochemistry*. Macmillan Learning.
3. Bob B. Buchanan, Wilhelm Gruissem, Russell L Jones. 2015. *Biochemistry and Molecular Biology of Plants.* John Wiley & Sons.
4. David L Nelson and Michael M. Cox. 2013. *Lehninger. Principles of Biochemistry.* Macmillan Learning.

5. Plummer David T. 1978. *An Introduction to Practical Biochemistry*. McGraw-Hill.
6. Rao Beedu Sashidhar and Deshpande Vijay. 2006. *Experimental Biochemistry: A Student Companion. Anshan.*
7. Sadasivam S and Manickam A. 2009. *Biochemical Methods, (3rd Edn.)*. New Age International.
8. Thayumanavan B, Krishnaveni S and Parvathi K. 2004. *Biochemistry for Agricultural Sciences*. Galgotia Publications Pvt Ltd., New Delhi. ISBN :81-7515-459-4.
9. Voet Donald and Voet Judith. 2010. Biochemistry. Wiley.
10. Wilson K and Walker J M 2000. *Principles and Techniques of Practical Biochemistry.*

Research Methodology 2 (1+1)

Objective

To inculcate the art of research and expose the students through various methodologies of data collection, processing, tabulation and interpretation

Theory

Role of research methodology - Induction and deduction, Sources of information - Review of literature, Identification of problem - Formulation of objectives and hypothesis - Scope of survey-based research - Types of surveys- identification of research problem - Analysis of research problem, customer identification, categorization- Data collection, analysis and compilation of survey report - Types of data, concepts of population - Analysis of data, graphical and diagrammatic presentation - Measures of central tendencies-mean, median, mode- problems- Reliability and validity of measuring tools.- Reporting: Significance of report writing, steps in report writing- Processing Information in Research Methodology - Importance of Experiments in research - Interview studies in Research methodology -Solutions of research methodology.

Practical

Research problem identification, objective and Hypothesis Formulation - Research design, Collection of data, Analysis of Data for the identified Problem- Hypothesis testing, interpretation and report writing for the identified problem- Application of Scales for measurement – Nominal and ordinal- Application of Scales for measurement –Interval and Ratio- Application of Scales for measurement – Likert and other scales-Identification of Primary and Secondary Data -Correlation - Simple and partial correlation - Correlation - Multiple correlation analysis - Regression – Simple and Multiple regression analysis- Dummy variable analysis - Construction of Index Numbers - Factor analysis - Cluster analysis

Statistical Packages for Data Analysis 1 (0+1)

Objective

The art of data collection, processing, analysis and interpretation will be developed to the translate simple data in to scientific data

Practical

SYSTAT package – data entry and creation of a data file – importing an excel file, SPSS file, database file, BMDP file and SAS file in Systat for analysis- Data manipulation – transformation – ranking, sorting, appending, merging and transposing of data in SYSTAT- SAS package – data entry and creation of data files in SAS – opening a file – importing an excel file, Systat file, database file and SPSS file in SAS for analysis- Data manipulation – transformation – ranking, sorting, appending, merging and transposing of data in SAS- Data analysis using SYSTAT and SAS packages- Descriptive statistics- Cross tabulation – one way, two way and multi-way tables- Chi square test- Student's t test – comparing a single mean- Comparison of two means – independent t test- Comparison of two means – paired t test- One way ANOVA- Two way ANOVA- Correlation analysis- Spearman's rank correlation and Kendall's tau- Jaccard and tetra correlation coefficients- Complete regression analysis.

Suggested Readings

1. Jayaraman K and Rugmini P. 1990. *Statistical Techniques in Forestry - Research and Forestry.* Kerala Forest Research Institute, Peechi, Thrissur.
2. Nigam A K and Gupta V K. 1979. *Hand book on Analysis of Agricultural Experiments*. IASRI Publication, New Delhi.
3. Panse V G and Sukhatme P V. 1967. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi, India.
4. Petersen Roger G. 1994. *Agricultural Field Experiments: Design and Analysis*. Marcel Dekker, New York.

C) High Yielding Short Rotation (HYSR) Forestry

1. Applied Tree Improvement (2+1)
2. Reproduction Biology of Tree Crops (2+1)
3. Biometrical Genetics in Tree Breeding (1+1)
4. Marker Assisted Breeding in Forestry (2+1)
5. Tissue Culture Application in Forestry (1+2)
6. Controlled Breeding in Tree Crops (0+2)
7. Tree Seed Orchards (2+1)
8. Forest Genetic Resources (2+0)
9. Clonal Forestry (1+1)
10. Plant Biochemistry (1+1)
11. Research Methodology (1+1)
12. Statistical Packages for Data Analysis (0+1)
13. Internship with Tree Breeding and Biotechnology-Based Institutions/Industries (0+2)

Applied Tree Improvement 3 (2+1)

Objectives

i. To impart applications of principles of tree breeding and improvement to the students
ii. To breed new varieties with increased productivity to cater needs of user agencies

Theory

General concept of tree breeding, tree improvement and forest genetics – History of tree improvement – Reproduction in forest trees - Mode of Reproduction – Significance – Pollination – Types of pollination – Pollination mechanism - Pollination in cross pollinated and self-pollinated tree species. Pollen dispersion distances, pollinators and their energetics. Pollen handling - Forced flowering for seed orchard manipulation. Variation in trees, importance and its causes. Natural variation as a basis for tree improvement. Geographic variations – Ecotypes, clines, races and land races – Selective breeding methods. Plus tree selection for wood quality, disease resistance and agroforestry objectives. Selection strategies and choice of breeding methods and progress in selective breeding for forest trees. Indirect selection for biotic and abiotic stresses. Wood and tree improvement – wood properties and their genetic relationships. Progeny selection and clonal selection – Concepts – scope – limitations. Progeny and clonal testing. Estimating genetic parameters and genetic gain breeding values. Average performance of half sibs and full-sibs. GxE interaction in trees. Seed orchards – type, functions and importance. Exotic forestry and tree breeding - gains and risks - donor and receptor countries - genetic improvement of exotics. Heterosis breeding: inbreeding and hybrid vigour. Manifestation and fixation of heterosis. Species and racial hybridization. Natural and artificial hybrids - Indian examples – Teak, sal, shisham, eucalypts, acacias, pines and poplars. Polyploidy, aneuploidy and haploidy in soft and hard wood species. Induction of polyploidy. Mutation Breeding and its application in tree improvement. Biotechnology in tree improvement. Genetically Modified tree species – Varietal registration- procedures-conducting DUS test. Tree DUS testing- development of descriptors for trees. Economics of tree improvement.

Practical

Identification of ecotypes, races, and land-races in natural forest. Selection of superior phenotypes. Marking of candidate trees, plus trees and elite trees. Progeny and clone testing. Mating and field designs. Estimating genetic parameters and genetic gain - Visit to species, provenance and progeny trials. Visit to seed orchards. Comparison of parents and their putative hybrids. Macro and micro propagation. Tree Improvement Programs in Timber species and non-Timber species.

Suggested Readings

1. FAO. 1985. *Forest Tree Improvement*, FAO, Publication.
2. Faulkner R. 1975. *Seed Orchard Forestry*. Commission Bull. No. 34.
3. Khosla PK. 1981. *Advances in Forest Genetics*. Ambika Publ., New Delhi.
4. Mandal A K and Gibson G L. (Eds). 1997. *Forest Genetics and Tree Breeding*. CBS.
5. Parthiban K T, Krishnakumar N and Devanand P S. 2020. T*ree Breeding and Improvement – Theories and Techniques*. Scientific Publishers. Jodhpur.
6. Sandeep Kumar and Matthias Fladung. 2005. *Molecular Genetics and Breeding of Forest Trees*. 436p. International book distribution Co. India.
7. Surendran C, Sehgal R N and Paramathma M. 2003. *Text Book of Forest Tree Breeding.* ICAR Publication, New Delhi.
8. White J W. 1976. *Introduction to Forest Genetics*. Academic Press.
9. Zobel B J and Talber J. 1984. *Applied Forest Tree Improvement*. John Wiley and Sons.

Biometrical Genetics in Tree Breeding 2 (1+1)

Objective

To impart knowledge in the field of biometry as applied to breeding population, provinces and making experiment in forest genetics and tree breeding

Theory

History and principles of quantitative genetics in forest trees and importance of qualitative and quantitative traits in tree breeding; Basic statistical Tools-Mean, mean, mode, standard deviation; Experimental design, principles and components of experimental design; Phenotypic variance, genotypic variance and its partitioning, models of gene action. Nature of Gene Action - Dominance and Epistatic-Qualitative and quantitative traits in tree breeding; Biometrical Techniques used for assessing the variability in germplasm collection various types of variability – Significance; Heterosis, types of heterosis, Factors affecting heterosis, Genetic basis of heterosis; Heritability, Types of heritability – methods of estimation of heritability, genetic gain and genetic advance. Association analysis - Correlation coefficient analysis – Types of correlation – Application in tree improvement; Path analysis Merits, Demerits, Application in Plant Breeding; Combining ability, types of combining ability –Inbreeding depression and its effects in tree breeding; Mating design in trees and its classification. D^2 statistics – Merits and Demerits; Molecular Diversity Analysis –marker approach – Computation of Data; Adaptation, Types of adaptation, causes of adaptation; Stability analysis of important fast-growing trees; Comparison of stability, combining ability and Heritability analysis.

Practical

Estimation of first and second degree of statistics -mean, median, range, mode, standard deviation and coefficient of variation in tree species-Problems on multiple factor inheritance - Estimation of genotypic and phenotypic variance in Eucalyptus tree species - Analysis of additive and dominance component of variances in red sanders - Estimation of heterosis in Kadamba trees - Estimation of heritability and genetic gain in Casuarina - Analysis of phenotypic and genotypic correlation in Eucalyptus - Estimation of path analysis in sandal trees - Estimation of GCA and SCA in teak tree species - Studies of different mating design in tree species - Estimation of selection methods in tree species of *Melia dubia* - Line × tester analysis in Eucalyptus tree species - Diallel analysis in *Melia dubia* - Stability analysis in teak tree species - D^2 analysis in Kadamba tree species - Studies of different DNA markers in improving tree species

Suggested Reading

1. Nadarajan N and M Gunasekaran. 2005. *Quantitative Genetics and Biometrical Techniques in Plant Breeding.* Kalyani Publishers, Ludhiana.

Controlled Breeding in Tree Crops 2 (0+2)

Objective

To provide insight into development of hybrids for tree crops and its exploitation for yield improvement through conventional and modern plant breeding approaches

Practical

Pollination and Reproduction in tree crops - Alternation of generation and life cycle -Mode of pollination - Mechanisms enforcing self and cross pollination in tree crops. Methods of survey, exploration and collection of genetic resources of tree crops - Methods of conservation and maintenance of different tree crops. Study of germplasm characterization and evaluation of different tree crops. Study of cataloguing and data storage of genetic resources of tree crops. Study of Cryopreservation techniques of different tree crops – need and utilization. Breeder's kit and its components for tree crops. Pollen morphology - Exine structure of different tree crops. Techniques for pollen collection and storage for different tree crops. Study of pollen viability and sterility for different tree crops. Emasculation and pollination techniques for self-pollinated tree crops. Emasculation and pollination techniques for cross pollinated tree crops. Basic techniques for selfing in tree crops. Basic techniques for crossing in tree crops. Lay out of different yield trials - Observing the experimental plots in tree crops. Assessment of variability parameters (mean, range, PCV, GCV, heritability, genetic advance) in tree crops. Studies on hybrids – Estimation of heterosis in different tree crops. Studies on segregating generations and maintenance of records of different tree crops. Studies on different wild species in tree crops and wide hybridization. Mutagenesis study - physical and chemical mutagens. Polyploidy breeding - Agents for the induction of various ploidy levels. Identification of polyploids in different tree crops. Screening methods – laboratory – field – for specific traits. Screening techniques for biotic stresses in tree crops. Screening techniques for abiotic stresses in tree crops. Floral Biology, Anthesis, Pollination, Selfing and Crossing techniques in Teak. Rosewood, Sandalwood, Eucalypts, *Melia dubia,* Acacia and *Mahogany.*

Suggested Readings

1. Mandal A K and Gibson G L (Eds.). 1998. *Forest Genetics and Tree Breeding*. CBS Publishers and Distributors.
2. Schmidt L H. 1997. *Tree Improvement Glossary Illustrated Glossary of Terms used in Forest Tree Improvement*. Danida Forest Seed Centre (Technical Note No. 46).
3. Singh B D. 2016. *Plant Breeding: Principles and Methods*. Kalyani Publishers.
4. Zobel B and Talbert J. 1984. *Applied Forest Tree Improvement*. John Wiley and Sons.

Marker Assisted Breeding in Forestry 3 (2+1)

Objective

To provide insight into development of markers in the tree improvement program for identifying the important traits

Theory

Domestication: The Evolution of Crop Plants – Breeding methods- transgenic technology- Molecular markers- Achievement and future prospective in Marker Assisted breeding. Hybridization based markers- Restriction Fragment Length polymorphism (RFLP) techniques and application; PCR based markers –Randomly Amplified Polymorphic DNA marker (RAPD) and its types; Amplified Fragment Length polymorphism (AFLP) principle and their application - Microsatellites marker/ Simple Sequence Repeat maker (SSR) development and application - Development of SCAR and STS marker principle and application. Introduction – SNP marker

discovery – methods and tools - whole genome SNP analysis for major gene discovery – Allele mining; Applications of DNA markers in diversity analysis – characterization of plant genetic resources – role of markers in Plant Variety protection. Mapping populations- Linkage Mapping of Molecular Markers and Oligogenes- Mapping of Quantitative Trait Loci - Association Mapping. Marker-Assisted characterization of germplasm and genetic purity- Marker-Assisted Backcrossing- Multitrait Introgression- Innovative Breeding methods for effective use of MAS-Genomic Selection- Phylogenetic Relationships and Genetic Diversity- High-Throughput SNP Genotyping- Bioinformatics Tools and Databases for Genomics Research-Phenomics.

Practical

Analysis of morphological diversity through statistical package like NTSYS - Extraction, quantification and separation of protein markers using SDS-PAGE. Isolation of plant genomic DNA, quantification and quality assessment by agarose gel - PCR using RAPD primers and separation of RAPD fragment using agarose gel electrophoresis. Amplified Fragment Length Polymorphism marker data generation - PCR amplification of genomic DNA using SSR primers -Separation of SSR markers using urea PAGE denaturing gel and silver staining - Finger printing of germplasm lines and seed varietal purity test using SSR markers -Development of SCAR marker from RAPD marker. Phenotyping the mapping population RILs or F_2 using the morphological traits - Genotyping the mapping population RILs or F_2 using the SSR markers - Construction of linkage map using map maker software and QTL analysis. SNP markers data generation and analysis using Real time PCR. Whole genome SNP array data analysis using the Microarray platform. SNP data analysis using pLink software. Marker assisted breeding – MABB studies.

Suggested Readings

1. Ahmar S, Ballesta P, Ali M and Mora-Poblete F. 2021. *Achievements and Challenges of Genomics-Assisted Breeding in Forest Trees: From Marker-Assisted Selection to Genome Editing*. International Journal of Molecular Sciences. 22(19):10583.
2. Grattapaglia D. 2008. *Perspectives on Genome Mapping and Marker-Assisted Breeding of Eucalypts. Southern Forests.* A Journal of Forest Science. 70(2): 69-75.
3. Nilausen C, Gélinas N and Bull G. 2016. *Perceived Acceptability of Implementing Marker-Assisted Selection in the Forests of British Columbia*. Forests. 7(11): 286.
4. O'malley D M and McKeand S E. 1994. *Marker Assisted Selection for Breeding Value in Forest Trees.* Springer Science and Business Media LLC.

Tissue Culture Applications in Forestry 3 (1+2)

Objective

To provide basic knowledge on the plant tissue culture, techniques, mass propagation, hardening and certification

Theory

Introduction-Concepts and principles. History of Plant tissue culture. Sterilization Techniques-Nutritional requirements for plant tissue culture - Factors affecting plant tissue Culture-Commercial PTC Lab Organization-Micropropagation – applications and limitations. Low cost alternatives in micro propagation. Morphogenesis – direct and indirect, organogenesis

and somatic embryogenesis. Callus initiation - establishment and maintenance. Synthetic seeds and applications. Meristem culture and virus elimination - virus indexing methods. Shoot tip culture and *in vitro* clonal Multiplication-Applications. Embryo culture and embryo rescue-applications. *In vitro* fertilization techniques. Ovule, ovary and endosperm culture. Anther and microspore culture - production of Haploids-Protoplast isolation, culture and protoplast fusion - applications - Somaclonal variation - applications. *In vitro* germplasm conservation. Commercial scale micropropagation –Micropropagation of - Neem, Teak, Bamboo, Paulownia, Eucalyptus, Red sanders, Mahogany, Sandal wood, Melia, Casuarina and Gmelina. Micropropagation of rare and endangered plants. Methods for Hardening-Acclimatization-Physiological changes during hardening. Packaging and transport of tissue cultured plants – Domestic and export. National certification system – Guidelines for Accreditation of Test laboratory for virus diagnosis and genetic fidelity testing of tissue culture raised plants and Tissue Culture Production Facility. Classification of secondary plant metabolites. Extraction and quantification methods for secondary metabolites. Plant Cell cultures for secondary metabolite production–steps. Large scale production through bioreactors.

Practical

Laboratory organization - safety regulations and Sterilization techniques for aseptic manipulation. Nutrient stock and growth regulator stock preparation -Culture media preparation. Micropropagation of Neem, Teak, Bamboo, Paulownia, Eucalyptus, Red sanders, Mahogany, Sandal wood, Melia, Casuarina, Gmelina. Inoculation of explants for callus culture - Clonal propagation through meristem culture - Anther and Microspore culture - Embryo culture - Sub-culturing technique for regeneration. *In vitro* and *ex vitro* rooting of tissue culture plantlets - Induction of somatic embryos and synthetic seeds - Establishment of suspensions and viability assay - Determination of cell growth in suspensions - Extraction of secondary metabolites. Phytochemical assay of secondary metabolites - Quantification by HPLC and GC-MS - Testing anti-microbial activity. Induction of hairy roots-medium preparation, strain selection, co-cultivation and maintenance of hairy roots. NCSTCP-Procedures and Quality analysis by Genetic Fidelity test - Virus indexing in TC plants - A demonstration on hardening and field transfer of TC plants - Visit to commercial tissue culture laboratory - Project preparation for establishment of tissue culture lab.

Suggested Readings

1. Bonga J M and Durzan D J (*Eds*). 1982. *Tissue Culture in Forestry*. Springer Science and Business Media.
2. Bonga J M and Durzan D J (*Eds.*). 2012. *Cell and Tissue Culture in Forestry. Vol.2. Specific Principles and Methods: Growth and Developments.Vol. 24.* Springer Science and Business Media.
3. Hasnain S and Cheliak W. 1986. *Tissue Culture in Forestry: Economic and Genetic Potential*. The Forestry Chronicle, 62(4): 219-225.
4. Savangikar V A. 2004. *Role of Low-Cost Options in Tissue Culture. In Low-Cost Options for Tissue Culture Technology in Developing Countries. Proceedings of a Technical Meeting organized* by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture (pp. 11-15).
5. Tanase C, Volf I, Vintu S, Gradinaru R, and Popa V I. 2013. *Potential Applications of Wastes from Energy and Forestry Industry in Plant Tissue Culture.* Cell. Chem. Technol, 47(7-8): 553-563.

6. Thorpe T A. 1983. *Biotechnological Applications of Tissue Culture to Forest Tree Improvement*. Biotechnology Advances. 1(2): 263-278.

Reproduction Biology of Tree Crops 3 (2+1)

Objective

To impart the knowledge of reproduction in forest tree species and to make them understand the mechanism of breeding and sex expression

Theory

Reproductive Biology – Introduction – Concepts – Importance – Mode of reproduction – types – Tropical trees – Temperate trees – Tree characteristics - growth and development (both vegetative and reproductive) - Floral morphology and types of flowers- floral initiation and breeding systems. Floral Measurement and prediction of Flowering-Juvenility and vernalization - Floral diversity and pollination. Mode of pollination – Cross pollinated and self-pollinated tree species. Mechanisms and significance - Pollination syndromes and their evolution; Plant – Pollinator systems, Diversity of pollination syndromes in selected plant families. Sex expression, monoecy, dioecy and its evolution. Environmental effects on sex expression. Floral attractants and rewards; Biology of floral and extra floral nectaries; Examples of plant insect interactions involving pollination. Floral characteristics of the main pollination syndromes- Mating system dynamics in Forest trees – Factors affecting different mechanisms – Mechanisms promoting high levels of Out-Crossing – self incompatibility – Factors leading to unusually low levels of out crossing – Factors that prevent or limit self-fertilization. Environmental effects on sex expression - Plant-pollination interactions, Pollinator energetic and nectar production, Pollen travel within and between trees – pollination efficiency, reproductive efficiency, Distance of pollen travel, pollen transport and pollen viability. Fertilization in hard wood trees – Double fertilization – Seed formation in angiosperms - fertilization in soft wood trees – Cone formation in softwood trees. Seed dispersal – Benefits of seed dispersal – types of dispersal – consequences of seed dispersal – Gene flow- Barrier to gene flow – Gene flow between species (Genetic pollution) – Models of gene flow – Gene flow mitigation.

Practical

Sex expression in forest trees – Out crossing mechanisms in forest trees – Measurement of pollen flow in wind – pollinated and insect-pollinated species – Pollen viability – Hanging drop techniques and fertility – Seed dispersal mechanisms – wind – water.

Suggested Readings

1. Dattee Christian Dumas and Andre Gallais.1992. *Reproductive Biology and Plant Breeding*. Springer.
2. Khosla P K. 1981. *Advances in Forest Genetics*. Ambika Publ., New Delhi.
3. Mandal A K and Gibson G L. (Eds) 1997. *Forest Genetics and Tree Breeding*.
4. Ramawat Kishan Gopal, Mérillon Jean-Michel, and Shivanna K R. 2014. *Reproductive Biology of Plants*. CRC Press.
5. Shivanna K R and Rangaswamy N S.1992. *Pollen Biology: A Laboratory Manual*. Springer-Verlag. New York.

6. Zobel B J and Talbert J. 1984. *Applied Forest Tree Improvement.* John Wiley and Sons.

7. Zobel B J, Wyk G V and Stahl P. 1987. *Growing Exotic Forests*. John Wiley and Sons.

Forest Genetic Resources 2 (2+0)

Objective

To impart knowledge on forest genetic diversity, biodiversity assessment, global conservation initiatives and conventions related to conservation of forest genetic diversity

Theory

Genetic diversity and differentiation: definition, characteristics and importance for tree breeding. Genetic erosion. Techniques to assess genetic diversity. Analysis of karyotypic variation. Molecular approaches for assessing genetic diversity; isozymes, biochemical makers and molecular markers: principles, importance and relevance. Biological diversity: concept and levels. Inventory and monitoring biodiversity: sampling strategies for genetic diversity assessments sufficiency of sampling procedures, neutral allele model and optimal allocation of sampling efforts. Effects of sampling on genetic diversity. Factors influencing levels of genetic diversity in woody plant species. Population size and genetic variability – Genetic variation in natural population: data, models and hypotheses – Inbreeding depression -Changes genetic diversity over time – Effects of logging and other forms of harvesting - Forest Fragmentation and environmental population - Gene flow in forest trees – Methods of estimating gene flow – Conservation methods - Threats to *in situ* and *ex situ* Genetic Conservation. Conservation of genetic diversity and invasive species. Global and local initiations for biodiversity conservation. Law and policies. Criteria and indicators for the conservation of genetic diversity. Methods for maintenance of conservation: gene banks, arboreta, botanical gardens, breeding populations as repositories of gene conservation. Rare, threatened biodiversity, endangered and endemise plants (IUCN). Global and local initiations for Biodiversity conservation. Concept of island biogeography. Managing corridors and natural habitat fragments. Monitoring and recovery plans for endangered plants. Plant community reserves. Managing wild flora, tourism impacts and urbanization of rare plants. Implications of rarity. Dunkal draft – need for trade agreement – TRIPS, TRIMS – IPR - WTO – TRIPS and Patenting Issues – The Protection of Plant Varieties and Farmers' Rights Act 2001 - National Biodiversity Act 2002 – Biopiracy – CITES – Cartagena Protocol on Biosafety - Biosafety protocol.

Suggested Readings

1. Bebarta, Kailash Chandra. 2002. *Planning for Forest Resources and Bio-Diversity Management Principles, Organization and Methodology*. Concept Publishing company, New Delhi, India. ISBN 81-7022-879-4.

2. Groom M J, Meffe G K and Carroll C R. 2006. *Principles of Conservation Biology*. Sinauer Associates Inc. USA.

3. Heywood V H and Watson R T. 1995. *Global Biodiversity Assessment*. 1140p. Cambridge University Press.

4. Mandal A K and Gibson G L. (Eds.). 1997. *Forest Genetics and Tree Breeding*. CBS Publishers.

5. Kotwal P C and Banerjee Sujoy. 2004. *Biodiversity Conservation-in Managed Forests and Protected Areas*. Agrobios (India). 81-7754-119-6.

6. Parthiban K T, Krishnakumar N and Devanand P S. 2020. *Tree Breeding - Theories and Techniques*. 391p. Scientific Publishers.

Tree Seed Orchard 3 (2+1)

Objective

To develop understanding among students about tree seed orchards

Theory

Importance of genetically improved seed in plantation forestry. Status of seed production among major plantation species. Short term supply of superior seed. Selection and delineation of seed stands, seed production areas, seed zones, seed ecological zones. Seed orchard: need, evolving seed orchards, containerized seed, hybrid and research seed orchards; first, second and advanced generation seed orchards. Seed orchard genetics: random mating, gamete exchange and parental balance. Estimation of genetic parameters from seed orchard data. Ortet age and its effect on seed production. Importance of progeny testing. Establishment of seed orchards, selection and preparation of orchard site, isolation, orchard size, and designs. Seed orchard management: rouging, silvicultural practices to increase seed yield. Pest and disease management. Seed collection and record keeping, seed orchard registration and documentation. Importance of seed orchards in gene conservation.

Practical

Seed orchard - Visits and study of seed orchard designs - Estimation of overlap in flowering among genotypes - Study of inter and intra-clonal variation in floral, seed characters - Effect of girdling on flowering. Plant growth regulator application for flower induction - Pollen viability/ fertility - Assessment of pollen dispersal. Supplemental mass-pollination - Effects of foliar application of fertilizers on seed set - Estimation of genetic parameters for a few traits - Estimation of parental balance.

Suggested Readings

1. Faulkner R. 1975. *Seed Orchard Forestry*. Commission Bull. No. 34.
2. Fins L, Friedman S T and Brotschol J V. 1992. *Handbook of Quantitative Forest Genetics*.
3. Khosla P K. 1981. *Advances in Forest Genetics*.
4. Mandal A K and Gibson G L. (Eds). 1997. *Forest Genetics and Tree Breeding*. Ambika Publ., New Delhi. CBS.
5. Nanson A. 2004. *Genetics of Forest Tree Breeding*. Agronomic Press.
6. Surendran C, Sehgal R N and Parmathama M. (Eds). 2003. *A Text Book of Forest Tree Breeding*. ICAR Publication, New Delhi.
7. Wright J W. 1976. *Introduction to Forest Genetics*. Academic Press.
8. Zobel B J and Talbert J. 1984. *Applied Forest Tree Improvement*. John Wiley and Sons.

Clonal Forestry 2 (1+1)

Objective

To learn the state-of-the-art clonal technology and its application in operational plantation development program

Theory

Clonal Forestry – definition – History of clonal forestry- Basic concepts in clonal forestry – Strategies for clonal forestry for higher productive potential – advantages of clonal forestry constraints – Selection of Plus Trees – Propagation methods- auto and hetero propagation methods – rooting of cutting, grafting, layering, budding- micro-clonal propagation methods. Potting media – components of potting media - physical and chemical characteristics of potting media – peat, vermiculite, perlite, styrofoam, soil, sand - Plant growth substances – Auxins – cytokinins – gibberellins – ethylene – preparation of powder and liquid formulations –Applications in clonal multiplication. Juvenility and maturation, rejuvenation and maintenance, regulation of phase changes, markers of phase changes. Breeding strategies using vegetative propagation- selection and breeding for extreme genotypes. Physiological research for higher productivity of clonal forest. Field design, testing and evaluation of clones. Genetic gains from breeding with clonal option. Clonal conservation approaches- management of populations for genetic diversity and gain - Designs of clonal evaluation – Amplified clonal test. Hi-tech Nursery – Components and Characters. Mini clonal technology – Clonal mother garden – Care and Management of mother garden – Multiplication technology for commercially important species - Clonal plantation establishment- management strategies – Problem and constraints in clonal forestry – Development of QPM through clonal plants - Role of industries in clonal production.

Practical

Clonal forestry – Hi-tech nursery – Components and characters – Biological components – Clonal genetic resources – Commercially important species – Mother Garden establishment – Care and management – Irrigation – Fertilization. Physical components - Propagation Chambers – Mist chamber – Green house – Cost of establishment – Technology component – Mini clonal technology – Design and Development – Potting media – Hardware's – Growth regulators – Root trainer technology. Visit to industries and other nurseries involved in clonal production – Economics of clonal production.

Suggested Readings

1. Ahuja and Libby. 1986. *Clonal Forestry.* Martinus Nijhoff Publishers, Dordrecht, Netherlands.
2. Hartman H T, Kester DE, Davies F T and Geneve R L. 1997. *Plant Propagation –Principles and Practices.* 770p. Prentice- Hall of India Pvt. Ltd., New Delhi.
3. Parthiban K T. 2024. *Hi-tech Nursery – Components and Characters. Technical Bulletin.* TNAU Publication, Coimbatore.
4. Parthiban K T, Paramathma M and Neelakantan K S. 2004. *Clonal Forestry*. 209p. TNAU Publications, Coimbatore.

Plant Biochemistry 2 (1+1)

Objective

To understand the basic scenario of biochemical action that happens in the plant system

Theory

Introduction to biomolecules. Chemistry of carbohydrates: Monosaccharides, classification, Configurations and conformations (Anomerism, epimersim, mutarotation, inversion); Disaccharides and polysaccharides (structural and storage); Glycosaminoglycans and glycoproteins. Chemistry of lipids: Lipid classification- Fatty acids, triacylglycerols, glycerophospholipids and sphingolipids. Amino acids of proteins – General properties, peptide bonds, classification and characteristics, acid-base properties; Optical activity. Primary, secondary, tertiary and quaternary structure of proteins; fibrous and globular proteins; protein stability and denaturation. Chemistry of nucleic acids: Bases, sugars, Nucleosides and nucleotides. Chemical structure and properties of DNA and RNA. Chemical catalysts vs. biological catalysts; substrate specificity-stereo, geometric specificities; Enzymes – nomenclature, classification, enzyme kinetics- rates of reactions; Lock and Key hypothesis and induced fit models; Enzyme assay, transition state theory, Michaelis Menten equation, Lineweaver-Burk plot, enzyme inhibition-reversible (Competitive, uncompetitive and mixed) and irreversible, allosteric enzymes, Effect of pH and temperature on enzyme activity; Isozymes, coenzymes. Photosynthesis – light reactions, dark reaction, Hill's reaction, photorespiration, C4 pathway, C3, C4 and CAM plants, CO_2 fixation, regulation of photosynthesis. Metabolism of carbohydrates -glycolysis, TCA cycle, electron transport chain. Lipid metabolism – beta oxidation and fatty acid biosynthesis. Secondary metabolites- Classification and functions of phenolics, terpenoids and alkaloids.

Practical

Qualitative analysis of carbohydrates. Estimation of sugar by Dubois method. Determination of reducing sugars by DNS method. Determination of total carbohydrate by anthrone method. Protein estimation by Bradford method. Absorbance curve of two dyes. Qualitative analysis of amino acids. Titration of amino acids. Purification of acid phosphatase from mustard seedlings. Qualitative analysis of oils and fats. Estimation of saponification value of oils. Estimation of iodine number of oils/fats. Chromatography of photosynthetic pigments. Lipid analysis by thin layer chromatography. Total protein estimation by Lowry's method. Kinetics of alkaline phosphatase.

Suggested Readings

1. Berg J M, Tymoczko J L and Stryer L. 2007. *Biochemistry.* (7th Edn.). Wiley Eastern Ltd. ISBN:0-7167-8724-5.
2. Berg Jeremy M, Stryer Lubert, Tymoczko John and Gatto Gregory. 2015. *Biochemistry*. Macmillan Learning.
3. Buchanan Bob B, Wilhelm Gruissem and Russell L Jones. 2000. *Biochemistry and Molecular Biology of Plants.* Rockville, Md. : American Society of Plant Physiologists, USA.
4. David L Nelson and Michael M. Cox. 2000. *Lehninger Principles of Biochemistry*. W. H. Freeman and Company, London.

5. Plummer David T. 1987. *An Introduction to Practical Biochemistry*. McGraw-Hill, New York.
6. Rao Beedu Sashidhar and Deshpande Vijay. 2006. *Experimental Biochemistry: A Student Companion*. Anshan, UK
7. Sadasivam S and Manickam A. 2009. *Biochemical Methods*. (3rd Edn.). New Age International, New Delhi.
8. Thayumanavan B, Krishnaveni S and Parvathi K. 2004. *Biochemistry for Agricultural Sciences* Galgotia Publications Pvt Ltd., New Delhi. ISBN :81-7515-459-4.
9. Voet Donald and Voet Judith. 2010. *Biochemistry*. John Wiley & Sons, USA.
10. Wilson K and Walker J M. 2000. *Principles and Techniques of Practical Biochemistry*. Cambridge University Press, UK.

Research Methodology 2 (1+1)

Objective

To inculcate the art of research and expose the students through various methodologies of data collection, processing, tabulation and interpretation

Theory

Role of research methodology - Induction and deduction, Sources of information - Review of literature, Identification of problem - Formulation of objectives and hypothesis - Scope of survey-based research - Types of surveys- identification of research problem - Analysis of research problem, customer identification, categorization- Data collection, analysis and compilation of survey report - Types of data, concepts of population - Analysis of data, graphical and diagrammatic presentation - Measures of central tendencies-mean, median, mode- problems- Reliability and validity of measuring tools.- Reporting: Significance of report writing, steps in report writing- Processing Information in Research Methodology - Importance of Experiments in research - Interview studies in Research methodology -Solutions of research methodology.

Practical

Research problem identification, objective and Hypothesis Formulation - Research design, Collection of data, Analysis of Data for the identified Problem- Hypothesis testing, interpretation and report writing for the identified problem- Application of Scales for measurement – Nominal and ordinal- Application of Scales for measurement –Interval and Ratio- Application of Scales for measurement – Likert and other scales-Identification of Primary and Secondary Data -Correlation - Simple and partial correlation - Correlation - Multiple correlation analysis - Regression – Simple and Multiple regression analysis- Dummy variable analysis - Construction of Index Numbers - Factor analysis - Cluster analysis.

Statistical Packages for Data Analysis 1 (0+1)

Objective

To develop the art of data collection, processing, analysis and interpretation to translate simple data into scientific data

Practical

SYSTAT package – data entry and creation of a data file – importing an excel file, SPSS file, database file, BMDP file and SAS file in SYSTAT for analysis- Data manipulation – transformation – ranking, sorting, appending, merging and transposing of data in SYSTAT- SAS package – data entry and creation of data files in SAS – opening a file – importing an excel file, SYSTAT file, database file and SPSS file in SAS for analysis- Data manipulation – transformation – ranking, sorting, appending, merging and transposing of data in SAS- Data analysis using SYSTAT and SAS packages- Descriptive statistics- Cross tabulation – one way, two way and multi-way tables- Chi square test- Student's t test – comparing a single mean- Comparison of two means – independent t test- Comparison of two means – paired t test- One way ANOVA- Two way ANOVA- Correlation analysis- Spearman's rank correlation and Kendall's tau- Jaccard and tetra correlation coefficients- Complete regression analysis.

Suggested Readings

1. Nigam A K and Gupta V K. 1979. *Hand book on Analysis of Agricultural Experiments.* IASRI Publication, New Delhi.
2. Panse V G and Sukhatme P V.1967. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi, India.
3. Petersen Roger G. 1994. *Agricultural Field Experiments: Design and Analysis*. Marcel Dekker, New York.
4. Jayaraman K and Rugmini P. 1990. *Statistical Techniques in Forestry - Research and Forestry*. Kerala Forest Research Institute, Peechi, Thrissur.

D) Wood Product Development and Utilization

1. Wood Identification (0+2)
2. Wood Physics and Chemistry (2+1)
3. Forest Products Laboratory Techniques (0+2)
4. Wood Seasoning and Preservation (1+2)
5. Wood Working and Carpentry (0+2)
6. Composite Wood Technology (2+1)
7. Non-Wood Forest Products and Value Addition Technology (2+1)
8. Ethnobotany, Medicinal and Aromatic plants (2+1)
9. Certification of Forest Products (2+0)
10. Plant Biochemistry (1+1)
11. Research Methodology (1+1)
12. Statistical Packages for Data Analysis (0+1)
13. Internship with tree breeding and biotechnology-based institutions/industries (0+2)

Wood Identification 2 (0+2)

Objectives

i. To equips students with knowledge of macro and micro-structure of softwoods and hardwoods and their relation with properties of wood

ii. To exposes students to use of anatomical features of wood in timber identification and classification

Practical

Planes of wood and physical characteristics of important woods. Identification of different types of cells and tissues. Anatomical studies of soft and hard woods. Hand lens features and identification of wood - soft wood and hardwood, sapwood and heartwood specimens. Maceration, staining, slide preparation and measurement of dimensions of woody tissues. Anatomical studies of reaction wood. Ultrastructures and their interpretation. Measurement of fibril angle and tissue proportions. Microscopic features of Bamboo, Palmyrah, Cane and Coconut. Classification of timber using dichotomous keys. Modern timber identification techniques. Microscopic features, slide inspection of twenty-five species characteristics. Morphological observations on import timber species of common occurrence for architectural patterns of habit, and buttress.

Suggested Readings

1. Meier E. 2015. *Wood Identifying and Using Hundreds of Woods Worldwide*. Wood Database.
2. Porter T. 2004. *Wood Identification and Use. Guild of Master Craftsman*, UK.
3. Purkayastha S K. 1982. *Indian woods: Their Identification, Properties and Uses*. Controller of Publication, New Delhi
4. Ratura and Juneja KDS.1971. *A Handbook for Field Identification of Fifty Important Timbers of India*. Manager of Publications.

Wood Physics and Chemistry 3 (2+1)

Objectives

i. To impart knowledge about the physical and chemical properties of wood, cell wall constituents and wood extractions

ii. To study the industrial utilization of wood extractives

Theory

Density and specific gravity. Variation in density of early and late wood constituents. Effect of growth rings on density. Pith to peripheral density variations. Different modes of presentation in relation to moisture content-wood water relationship and moisture estimation in wood. Physical properties of wood as influenced by moisture content. Specific gravity of wood substance. Anisotropy in Wood. Dimensional changes on heating green wood. Effect of dry and wet heat and heating in presence or absence of air on strength and dimensional stability. Thermal expansion, specific heat, thermal insulation value, ignition of wood and fuel value. Thermal conductivity and diffusivity. Change of temperature in wood under heating. Effect of moisture on thermal properties. Thermal properties of wood composites. DC and AC characteristics of wood-electrical conductivity, effect of moisture content and temperature. Activation energy associated with electrical conduction. Voltage breakdown strength. Dielectric properties of wood under alternating current and electro. Dielectric strength - dielectric constant and loss. Power factor - magnetic field conditions, effect of specific gravity, moisture content, temperature and extractives. Principles of induction and dielectric heating. Piezo-electric properties of wood and its applications. Sound transmission and acoustics in buildings.

Speed of sound- wave resistance - coefficient of sound absorption - Response of defects to stress waves in timber-acousto-ultrasonics based non-destructive evaluation techniques. Wood chemistry-introduction-present status-scope of wood chemical Industry-Chemical composition of cell wall. Carbohydrate polymers - holo cellulose, cellulose, hemi-cellulose and other minor polysaccharides. Lignin and extractives. Chemistry of bark, extractives, hemi celluloses, cellulose, lignin and inorganics. Distribution of chemical components in the cell wall. Components of cell. Volatile oils and extractives. Chemical relativities of cellulose, hemicellulose and lignin. Cellulose derivatives and their applications. Lignin based products. Hydrolysis and fermentation of ligno cellulosic materials. Pyrolysis and gasification of wood. Bioactive components from wood. Eco-friendly dyes from bark and wood. Isolation of extractives from wood and bark. Separation of secondary metabolites. Industrial utilization of wood and bark extractives such as natural rubber, resin and turpentine from pines, tannins, pharmacologically active metabolites and future directions for their utilization.

Practical

Properties of wood, electrical, acoustic. Sonic and ultra-sonic properties. Determination of strength properties, specific gravity, F.S.P. from shrinkage and sorption. Determination of thermal conductivity, dielectric constant, permeability of wood to air. Extraction of cellulose, hemicellulose, lignin, extractives and ash content of wood. Determination of calorific value of different wood species and ligno cellulosic wastes. Making charcoal and briquettes. Wood chemical isolation through chromatography. Isolation of pure chemical constituents using thin layer and column chromatography. Estimation of turpentine and resin. Isolation of polysaccharides and characterization of mono sugars. Estimation of oil from sandal wood. Extraction of dyes from different wood species. Visit to natural dye industry and study its properties.

Suggested Readings

1. Franz F P, Kollmann Kuwnzi E and Stamm A J. 1975. *Principle of Wood Science and Technology. Wood Based Material.* Vol. II. Springer-Verlag, Berlin, Heidelberg.
2. Meyland B A and Butterfield B G (Eds). 1972. *Three-Dimensional Structure of Wood: A Scanning Electron Microscope Study*. Syracuse University Press.
3. Roger R M (Ed). 2013. *Handbook of Wood Chemistry and Wood Composition.* (2nd Edn.) CRC Press.
4. Rowell R M. 1984. *The Chemistry of Solid Wood (Advances in Chemistry Series).* American Chemical Society.

Wood Seasoning and Preservation 3 (1+2)

Objective

To understand the importance of wood seasoning and preservation for utilizing secondary timber for multipurpose use.

Theory

Wood water relationship, absorption behavior and wood drying, Refractory and non-refractory behavior of wood, Wood seasoning, types- air, kiln and special seasoning methods like steaming, chemical, high temperature drying, vacuum drying and water conditioning. Defects of timber -

natural, seasoning defects, defects due to external agencies, machining defects. Effect of defects on utilization. Detection and diagnosis of discoloration and decay in wood: decaying agencies - fungi, insects and borer. Durability of timbers. Mechanism of wood preservation – kinds of wood preservatives - Advantages and safety concern of wood preservatives, fire retardants. Graveyard test and anti-fungal activity of wood. Biopreservation. Methods of application of wood preservatives – Non pressure methods – Brushing – Steeping – Hot and cold bath process – Diffusion process – Momentary dip process – Sap displacement method – Boucherie method – Pressure method – Full cell process – Empty cell process.

Practical

Determination of moisture content and swelling coefficients of different woods. Visit to timber depot/saw mill to study the stacking methods and various defects in wood. Visit to Wood seasoning unit to study the various types of seasoning methods and Safety aspects. Exercise on fixing seasoning schedule for timbers under steam heated kiln and FRI solar heated kiln seasoning method. Comparative studies on air and kiln dried woods. Analysis of decayed wood for physical and chemical parameters. Visit to wood testing laboratories. Laboratory methods for testing efficacy of wood preservative against fungi and termite. Study on the environmental health and safety aspects of wood preservatives. Exercise on non-pressure methods of application of preservatives for plantation timber - End coating - Sap Displacement Method and Boucherie process. Exercise on Full cell process techniques. Study of seasoning and preservative treatments for fast growing tree species. Study of seasoning and preservative treatments for lesser known tree species. Conducting Grave yard test to evaluate natural durability of plantation and imported timber.

Suggested Readings

1. FAO. 2007. *Wood Preservation Manual*. International Book Distributor
2. Hunt G M. 1967. *Wood Preservation.* (3rd Edn.) McGraw-Hill Book Company.
3. Purushotham A, Pande J N and Jadhav. 1959. *Wood Preservation in India*. Manager of Publications.

Forest Products Laboratory Techniques 2 (0+2)

Objectives

i. To acquaint the students to commonly used techniques in laboratory
ii. To expose the students to the practical aspects of laboratory techniques employed in forest products

Practical

Introduction to laboratory techniques - Applicability of laboratory techniques in Forest Products Lab - Practicing of machine vision techniques - Morphometric and anatomical changes during wood Seasoning and Preservation - Wood and non-wood product sampling, drying and storage. Estimation of extraneous components of wood. Analysis of volatile compounds. Estimation of chemical composition of wood samples (Hardwoods, softwood and other lingo cellulosic material) and ash. Separation of components by column, paper, and thin layer chromatography. HPLC techniques. Determination of strength properties of paper and wood composites.

Suggested Readings

1. Furr A K. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
2. Meyland B A and Butterfield B G. 1972. *Three-Dimensional Structure of Wood: A Scanning Electron Microscope Study*. Syracuse University Press.

Composite Wood Technology 3 (2+1)

Objective

To impart knowledge regarding the processing technology for wood composites and modified woods

Theory

Introduction to wood modification, its need and scope, chemical modification of wood (Acetylation, reaction with isocyanates, acetates, ethers, epoxides, etc.). Wood impregnation and compregnation, heat stabilization, compressed wood, wood densification. Wood plastic composites-polymer used-manufacturing process. Scope and importance-veneer production process-rotary cutting and slicing-types of veneer and their uses-advantages of veneered panels in wood products-veneer jointing – finger joints -veneer grading-storage and handling of veneer. Production, properties, performance and application of Glue Laminated Timber (GLT), Structural Composite Lumber (LVL, PSL, LSL). Production, properties, performance and application of plywood, Particle board, Sandwich board, Core board, Flake board, Fibre board (LDF, MDF, HDF) and Nano Composites. Wood adhesives - types, characteristics and their applications. Scope and merits of laminated wood-choice of species and dimensional stability consideration, multispecies laminates-types of Laminates-Matte-finish laminate, textured laminate, gloss-finish laminate, metallic laminate, PVC-finish laminate, acrylic-finish laminate and exterior laminate. Laminated wood from bamboo and bamboo laminates. Acoustic panels from laminated wood densified laminate panels. Bamboo composite wood-based Industries. Bamboo Mat based Products-Bamboo Mat Board (BMB), Bamboo Mat Veneer Composites [(BMVC) and Bamboo Mat Corrugated Sheet (BMCS), Bamboo mat tray. Bamboo strip-based products - Bamboo flooring tiles and high density transport flooring.

Practical

Preparation of veneer and testing the quality. Visit to plywood industry, particle board and hard board industry. Plywood preparation and Accelerated ageing test on plywood. Preparation of particle board and hard board and conducting accelerated ageing test, glue shear strength and internal bond strength test. Assessment of wood quality in plantation grown timber for the production of plywood and particle board. Visit to Wood Plastic Composite manufacturing unit, wood plasticization unit and studying the plasticity of wood. Determination of linear and volumetric shrinkage of composite wood. Study of different grades of composite wood, nano composite preparation and commercial utilization. Assessment of different grades of plywood. Evaluation of penetrability of preservatives in composite wood. Study on wood modification technology. Study on Bamboo Mat Based Products-BMB, BMVC and BMCS. Study on Bamboo Strip Based Products - Bamboo flooring tiles and high density transport flooring. Visit to Laminated bamboo furniture industry.

Suggested Readings

1. Antole A Klyosov. 2007. *Wood Plastic Composites. (*1st Edn.). Wiley-Interscience,
2. Ansell Martin P. 2015. *Wood Composites*. Wood head publishing.
3. Jin Kuk Kim. 2011. *Recent Advances in the Processing of Wood-Plastic Composites*. Springer Publications.
4. Papadopoulos Antonios N. 2020. *Advances in Wood Composites*.
5. Roger M and Rowell. 2005. *Handbook of Wood Chemistry and Wood Composites*. Published by Taylor and Francis.

Non-Wood Forest Products and Value Addition Technology 3 (2+1)

Objective

To make students understand and learn about the different non wood Forest Products and their scientific extraction, processing and disposal

Theory

Non-Wood Forest Products - Present status, demand and supply, classification, distribution and marketing. Role of tribal co-operative societies in NWFPs. Recent trends in NWFP. Quality assessment of important products and their methods for storage. Important non-wood forest products industries. Gums – Occurrence, origin, functions, kinds, properties, tapping methods, factors affecting gum formation, scientific management, collection, processing and storage -value addition - industrial application- uses. Resins –occurrence, origin, kinds, properties, tapping methods, processing and storage, uses, industrial application and value addition. Lac -different species, distribution, improved method of cultivation, scientific management, collection, processing and storage, value addition and uses. Shellac - cleaning and grading, properties, value addition and their uses. Tannins - Definition, species - nature and kinds, occurrence, function, collection, extraction, processing, value addition and uses. Dyes - definition, species, types, extraction, processing value addition and uses. Cutch and Katha - species, extraction methods, processing value addition and uses. Essential oils - species, types, extraction process, value addition and commercial applications -Tree Borne Oil seeds (TBOs) tree species, collection, extraction methods and uses. Drugs species – extraction process – industrial applications. Animal products – honey and wax -collection, processing, storage. Silk – silk farming – silk types, mulberry –types, distribution, improved method of cultivation, collection and storage, value addition and uses. Mineral products - other miscellaneous products.

Practical

Visit to nearby forests to study important NTFP yielding plants. Visit to non-wood forest products-based industries. Visit to agave extraction unit and study the fiber extraction process. Visit to Sericulture unit to study Silk production technology. Visit to Essential oil extraction unit and study the different extraction methods. Study of tans and visit to tannin industry. Study of dyes and visit to dye extraction unit and their sources. Visit to biodiesel production and study the trans-estrification process. Visit to Herbal Gardens and herbaria to study medicinal plants. Quality assessment of important NWFP and their methods for storage. Study of plants yielding drugs,

spices, wild edible plants, poisons and bio-pesticides and their collection from nearby forests. Visit to a tribal village involved in collection, processing and sale of NTFPs. Utilization of various NWFP and their scientific management for processing, value addition and disposal.

Suggested Readings

1. Linskens H F and Jackson J F (*Eds.*). 1991. *Essential Oils and Waxes.* Springer-Verlag Berlin Heidelberg.
2. Mathe A. 2015. *Medicinal and Aromatic Plants of the World-Scientific, Production, Commercial and Utilization Aspects*. Springer, Netherlands.
3. Panda H. 2005. *Hand Book on Specialty Gums, Adhesive, Oils, Rosin and Derivatives, Resins, Oleoresins, Katha, Chemicals with others Natural Products*. Asia Pacific business press. Inc.
4. Panshin A J, Harrer E S and Bethel J S. *Forest Products, their Sources, Production and Utilization.*
5. Shackleton S, Shackleton C and Shanley P. (Eds.) 2011. *Non-Timber Forest Products in the Global Context.* Springer-Verlag Berlin Heidelberg.

Wood Working and Carpentry 2 (0+2)

Objective

To make students to understand and learn about the wood working and carpentry skills

Practical

Identify timber/ wood and apply measuring, marking and testing instrument and holding and supporting hand tools following safety precautions. Work on various saws and portable power saw machines for Ripping, cross cutting, Oblique sawing and curve cutting. Analyze the surface finish with exact sizing by planning operation - Identify and apply various shaving tools or portable power planning machine. Identify and apply various paring tools and analyze and choose the positioning and employ holding device for chiselling. Identify and classify various types of joints, analyze and prepare correct joint at correct position, related with strength and appearance. Make small wooden job as per drawing with schedule sizes of timber or alternatives of timber. Analyze and identify various carving tools and convert a wooden block/ piece into a decorative article. Demonstrate preservation of wooden item through surface finishing with various processes such as painting, polishing, varnishing etc. Demonstrate ripping, cross cutting, pedestal grinding, Tenon and mortise machine. Demonstrate different operations on Sanding machine. Prepare various roof truss, door and windows frame and shutters. Check, identify, analyze and repair the wooden job.

Suggested Readings

1. Bates D. 2013. *Carpentry and Joinery Book 1.* Routledge.
2. Brett, P. (2012). Carpentry and Joinery Book Two: Practical Activities. Oxford University Press-Children.
3. Goring, L. (2018). Manual of First and Second Fixing Carpentry. Routledge.
4. Wheeler C G. 2018. *Wood-Working for Beginners*. BoD–Books on Demand.

Ethnobotany, Medicinal and Aromatic Plants 3 (2+1)

Theory

Definition and scope of ethno-botany. Terms employed in relation to ethnobotany and its relationship with man and domestic animals. Ethnic – people and their contribution in therapeutic and ethnobotanical knowledge especially with respect to medicinal and allied aspects. Important plants and their folk uses for medicines, food, dyes, tans, *etc* Methods and tools in Ethnobotanical studies. Ethnobotany of tribals in Southern India. Traditional Botanical Knowledge- concepts.

Definition - role of medicinal and aromatic plants in Indian economy - Important essential oil yielding plants in India - Detailed study of lemon grass, citronella, palmarosa, vetiver, japanese mint, eucalyptus, Champaka, Sandal, Cinnamum spp., *Bursera delpechiana* - botany, climate and soil requirements, planting cultural and manorial practices - harvesting, curing and extraction of essential oils. Medicinal plants in India and Karnataka - history, origin, area and distribution, production, botany and varieties - cultivation, extraction of active principles and their uses - uses of different medicinal plants like atropa, cinchona, rauvolfia, opium, sandal, acorus, cannabis, digitalis, *Strychnos nux-vomica, Aconitum,* Neem*, Dioscorea, Costus, Solanum* etc. Cultivation practices of medicinal plants like *Adhathoda zylanica*, *Sida cordifolia, Sterospermum colais*, *Plumbago zylanica*, *Tinospora cordifolia*, *Kaemferia glanga*, *Indigofera tinctoria, Morinda citricifolia and Phyllanthus neeruri.* Conservation packages for the medicinal plants collected in wild.

Practical

Ethnobotanical studies of the important plants from the following families: Guttiferae (Clusiaceae), Malvaceae, Fabaceae, Mimosaceae, Caesalpinaceae, Combretaceae, Umbelliferae (Apiaceae), Rubiaceae, Asteraceae, Ebenaceae, Apocynaceae, Asclepiadaceae, Euphorbiaceae, Lauraceae, Palmaceae, Poaceae, Liliaceae, Coniferae, Santalaceae, Thymeliaceae.

Field visit to different tribal regions to gain ethno-botanical knowledge and the inter-relation between plant and people- Survey and identification of plants used by the tribals for medicine, food and other social purposes- Collection and preparation of herbarium specimens of the above plants- Identification of medicinal and aromatic plants – propagation techniques – Harvesting and oil extraction of aromatic plants – Field visit, collection and preparation of herbarium – Visiting commercial units of medicinal plants.

Suggested Readings

1. Atul C K and Kapur B K. 1982. *Cultivation and Utilization of Medicinal Plants.* RRL., CSIR, Jammu-Tawi.
2. Chopra R N, Nayar S L and Chopra I C. 1956. *Glossary of Indian Medicinal Plants*. CSIR, New Delhi.
3. Cunningham A. 2014. *Applied Ethnobotany: People, Wild Plant Use and Conservation.* Taylor and Francis.
4. EIRI Board. 2007. *Handbook of Medicinal and Aromatic Plants: Cultivation, Utilisation and Extraction.*
5. Cotton C M. 1997. *Ethnobotany. Principles and Applications*. John Wiley and Sons Ltd., England.
6. Gunther E. 1975. *The Essential Oils. Robert*. K Krieger Pub. Co., New York.
7. Jain S K. 2010. *Manual of Ethnobotany.* (2nd Edn.). Scientific Publishers, India
8. Maheshwari J K. 2000. *Ethnobotany and Medicinal Plants of Indian Subcontinent.* 672p. Scientific Publishers, Jodhpur, India.

Certification of Forest Products 2 (2 +0)

Theory

Definition of forest certification. Responsible sourcing of wood. Principal stages in the process of certification. Producer's motivation for supplying certified forest products. Key aspects of certification. Principles of sustainable forest management. Origin of certification. Organizations responsible. Legislations and policies of importance. Certification schemes in operation. Forest Stewardship Council (FSC), Program for Endorsement of Forest Certification Schemes (PEFC) etc. CIFOR certification tool kit. Indian scenario in certification. International trade in tropical logs and sawn wood. Pros and cons of certification. Potential for certifying forests and forest products of India. Tracing illegal logging. Identification of species and region of origin. Timber tracing through genetic methods and (analysis of stable isotope ratios).

Suggested Readings

1. Bass, S. 1996. *Introducing Forest Certification. A Report Prepared by the Forest Certification Advisory Group (FCAG) for DGVII of the European Commission. European Forest Institute, Discussion Paper 1.* Details available at: http://www.giz.de/Themen/de/dokumente/en-d28-inenpenennt-certification-verification-forest-manage.pdf.
2. Bass S, Thornber K, Markopoulos M, Roberts S and Grieg-gran M. 2001. *Certification's Impact on Forests, Stakeholders and Supply Changes.* 153p. International Institute for Environment and Development. London.
3. Conroy M E. 2007. *Branded! How the "Certification Revolution" is Transforming Global Corporations.* 354p. New Society publishers, Gabriola Island, BC.
4. Gupta H S, Yadav M, Sharma D K and Singh A M. 2013. *Ensuring Sustainability in Forestry: Certification of Forests.* 284p. TERI, New Delhi.

Plant Biochemistry 2 (1+1)

Objective

To understand the basic scenario of biochemical action that happens in the plant system

Theory

Introduction to biomolecules. Chemistry of carbohydrates: Monosaccharides, classification, Configurations and conformations (Anomerism, epimersim, mutarotation, inversion); Disaccharides and polysaccharides (structural and storage); Glycosaminoglycans and glycoproteins. Chemistry of lipids: Lipid classification- Fatty acids, triacylglycerols, glycerophospholipids and sphingolipids. Amino acids of proteins – General properties, peptide bonds, classification and characteristics, acid-base properties; Optical activity. Primary, secondary, tertiary and quaternary structure of proteins; fibrous and globular proteins; protein stability and denaturation. Chemistry of nucleic acids: Bases, sugars, Nucleosides and nucleotides. Chemical structure and properties of DNA and RNA. Chemical catalysts vs. biological catalysts; substrate specificity-stereo, geometric specificities; Enzymes – nomenclature, classification, enzyme kinetics- rates of reactions; Lock and Key hypothesis and induced fit models; Enzyme assay, transition state theory, Michaelis Menten equation, Lineweaver-Burk plot, enzyme inhibition-reversible (Competitive, uncompetitive

and mixed) and irreversible, allosteric enzymes, Effect of pH and temperature on enzyme activity; Isozymes, coenzymes. Photosynthesis – light reactions, dark reaction, Hill's reaction, photorespiration, C4 pathway, C3, C4 and CAM plants, CO_2 fixation, regulation of photosynthesis. Metabolism of carbohydrates -glycolysis, TCA cycle, electron transport chain. Lipid metabolism – beta oxidation and fatty acid biosynthesis. Secondary metabolites- Classification and functions of phenolics, terpenoids and alkaloids.

Practical

Qualitative analysis of carbohydrates. Estimation of sugar by Dubois method. Determination of reducing sugars by DNS method. Determination of total carbohydrate by anthrone method. Protein estimation by Bradford method. Absorbance curve of two dyes. Qualitative analysis of amino acids. Titration of amino acids. Purification of acid phosphatase from mustard seedlings. Qualitative analysis of oils and fats. Estimation of saponification value of oils. Estimation of iodine number of oils/fats. Chromatography of photosynthetic pigments. Lipid analysis by thin layer chromatography. Total protein estimation by Lowry's method. Kinetics of alkaline phosphatase.

Suggested Readings

1. Berg J M, Tymoczko J L and Stryer L. 2007. *Biochemistry.* (7th Edn.). Wiley Eastern Ltd. ISBN:0-7167-8724-5.
2. Berg Jeremy M, Stryer Lubert, Tymoczko John, Gatto Gregory. 2015. *Biochemistry.* Macmillan Learning.
3. Buchanan Bob B, Gruissem Wilhelm and Jones Russell L. 2000. *Biochemistry and Molecular Biology of Plants.*
4. David L Nelson and Michael M. Cox. 2017. *Lehninger. Principles of Biochemistry.* (7th Edn.). WH Freeman.
5. Plummer David T. 1978. *An Introduction to Practical Biochemistry*. McGraw-Hill.
6. Rao Beedu Sashidhar and Deshpande Vijay. 2006. *Experimental Biochemistry: A Student Companion.* Anshan.
7. Sadasivam S and Manickam A. 2009. *Biochemical Methods, (3rd Edn.*) New Age International.
8. Thayumanavan B, Krishnaveni S and Parvathi K. 2004. *Biochemistry for Agricultural Sciences.* Galgotia Publications Pvt Ltd., New Delhi. ISBN :81-7515-459-4.
9. Voet Donald and Voet Judith. 2010. *Biochemistry*. John Wiley & Sons.
10. Wilson K and Walker J M. 2000. *Principles and Techniques of Practical Biochemistry*

Research Methodology 2 (1+1)

Objective

To inculcate the art of research and expose the students through various methodologies of data collection, processing, tabulation and interpretation

Theory

Role of research methodology - Induction and deduction, Sources of information - Review of literature, Identification of problem - Formulation of objectives and hypothesis - Scope of survey-based research - Types of surveys- identification of research problem - Analysis of research problem, customer identification, categorization- Data collection, analysis and compilation of survey report

- Types of data, concepts of population - Analysis of data, graphical and diagrammatic presentation - Measures of central tendencies-mean, median, mode- problems- Reliability and validity of measuring tools.- Reporting: Significance of report writing, steps in report writing- Processing Information in Research Methodology - Importance of Experiments in research - Interview studies in Research methodology -Solutions of research methodology.

Practical

Research problem identification, objective and Hypothesis Formulation - Research design, Collection of data, Analysis of Data for the identified Problem- Hypothesis testing, interpretation and report writing for the identified problem- Application of Scales for measurement – Nominal and ordinal- Application of Scales for measurement –Interval and Ratio- Application of Scales for measurement – Likert and other scales-Identification of Primary and Secondary Data -Correlation - Simple and partial correlation - Correlation - Multiple correlation analysis - Regression – Simple and Multiple regression analysis- Dummy variable analysis - Construction of Index Numbers - Factor analysis - Cluster analysis.

Statistical Packages for Data Analysis 1 (0+1)

Objective

The art of data collection, processing, analysis and interpretation will be developed to the translate simple data in to scientific data

Practical

SYSTAT package – data entry and creation of a data file – importing an excel file, SPSS file, database file, BMDP file and SAS file in SYSTAT for analysis- Data manipulation – transformation – ranking, sorting, appending, merging and transposing of data in SYSTAT- SAS package – data entry and creation of data files in SAS – opening a file – importing an excel file, SYSTAT file, database file and SPSS file in SAS for analysis- Data manipulation – transformation – ranking, sorting, appending, merging and transposing of data in SAS- Data analysis using SYSTAT and SAS packages- Descriptive statistics- Cross tabulation – one way, two way and multi-way tables- Chi square test- Student's t test – comparing a single mean- Comparison of two means – independent t test- Comparison of two means – paired t test- One way ANOVA- Two way ANOVA- Correlation analysis- Spearman's rank correlation and Kendall's tau- Jaccard and tetra correlation coefficients- Complete regression analysis.

Suggested Readings

1. Jayaraman K and Rugmini P. 1990. *Statistical Techniques in Forestry - Research and Forestry. Kerala Forest Research Institute,* Peechi, Thrissur.
2. Nigam A K and Gupta V K. 1979. *Hand Book on Analysis of Agricultural Experiments*. IASRI Publication, New Delhi.
3. Panse V G and Sukhatme P V. 1967. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi.
4. Petersen Roger G. 1994. *Agricultural Field Experiments: Design and Analysis*. Marcel Dekker, New York.

Forest Resource Management and Utilization

1) RS and GIS Application for Forest Resource Management (2+1)
2) Ecosystem Services and Valuation of Forest Resources (2+1)
3) Entrepreneurship in Value Chain Improvement of Forest Resources (2+1)
4) Joint Forest Planning and Management (1+1)
5) Climate Change Mitigation (2+1)
6) Ecotourism (2+1)
7) Restoration of Degraded Lands (2+1)
8) Urban Ecology and Environment (2+1)
9) Plant Biochemistry (1+1)
10) Research Methodology (1+1)
11) Statistical Packages for Data Analysis (0+1)
12) Internship with Forest Business Unit/RS-GIS Company or Organization (0+2)

RS and GIS Application for Forest Resource Management (2+1)

Theory

Remote sensing types, Digital data formats, Image processing techniques, Electromagnetic spectrum and its interaction with atmosphere and surface, Creation of False Color Composites (FCC). Geometric and Radiometric Errors of images, Geometric and Radiometric corrections: contrast enhancement, Linear contrast stretch, Histogram equalization, Filtering, Image fusion technique, Vegetation Indices, Supervised and Unsupervised Classification. GIS and its components, Raster and vector data models, Visual image interpretation, database management system(DBMS), Essential map elements, Coordinate System and Projection, Attribute data and thematic mapping. Geographical Positioning System (GPS), GPS accuracy, Segments of GPS.

Practical

Introduction to GIS Software, Satellite data handling, Geo-referencing. Creation of False Color Composite. Image processing techniques: Contrast enhancement, Linear contrast stretch, Histogram equalization, Filtering, Image fusion technique, Vegetation Indices. Projection of digital data. On screen digitization with QGIS. Spatial and attribute data in maps in DBMS. Handling GPS receiver.

Suggested Readings

1. Campbell J B. 2002. *Introduction to Remote Sensing.* (3rd Edn.). Taylor and Francis, London.
2. Environment System Research Institute. 1999. GIS for Everyone. Redlands, CA: ESRI.
3. Jackson M J. 1992. *Integrated Geographical Information Systems*. International Journal of Remote Sensing, 13(6-7): 1343-1351
4. Joseph G. 2005. *Fundamentals of Remote Sensing.* (2nd Edn.). Universities Press.
5. Lillesand T M and Kiefer W R. 1994. *Remote Sensing and Image Interpretation.* (4th Edn.). John Wiley and Sons, Inc., USA.
6. Obi Reddy G P and Sarkar D. 2012. *RS and GIS in Digital Terrain Analysis and Soil Landscape Modelling.* NBSS and LUP, Nagpur.

Ecosystem Services and Valuation of Forest Resources 3 (2+1)

Theory

Ecosystem Services (ES) basics, importance, history of ES and natural capital, Classification of ES-provisioning, regulating, supporting and cultural services and their status and changes, drivers of change of ecosystem services, international conventions and charters on ES-Inter-Governmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES) and Millennium Ecosystem Services (MEA) assessment - an overview. Linkages among biodiversity, ecosystem services and human wellbeing. Quantification of ecosystem services-direct and indirect approaches. Ecological Economics: Valuation of ES, need for valuation. Use values and Non-Use values direct value, indirect value, optional value, bequest value, existence value. Valuation Methods-Market price-based approach such as stumpage value method, productivity and cost-based approaches such as replacement cost method and surrogate market and stated preference approaches such as stumpage value method, Hedonic Pricing Method, Contingent Valuation Method, Travel Cost Method, etc., Case studies in India and abroad. Challenges in valuation of ES. Governance and policy issues in ecosystem services, Payment for ecosystem services (PES), mechanisms of benefit sharing, eco-certification, Certification process in agro-forestry based carbon projects and carbon finance. Geographic Indications, Forest Stewardship Council, Landscape labelling. National and International initiatives in PES and recent policy and programs.

Practical

Valuation methods - direct and indirect methods, Valuation of standing timber, Case studies of PES in India and Abroad, Case studies on certification and geographical indications.

Suggested Readings

1. Alavalapati JRR and D Evan Mercer. 2004 *Valuing Agro-forestry Systems: Methods and Applications*. Kluwer Academic Publishers.
2. Huxley P. 1999. *Tropical Agro-forestry*. Blackwell.
3. Jain S K and Singh P. 2000. *Economic Analysis of Industrial Agro-forestry: Poplar (Populus deltoides) in Uttar Pradesh (India).* Agro-forestry Systems.
4. Jeffers JNR. 1978. *An Introduction to System Analysis with Ecological Application*. Edward Arnold.
5. Jose S. 2009. *Agro-forestry for Ecosystem Services and Environmental Benefits: An Overview.* Agro-forestry Systems.
6. Nair PKR. 1993. *An Introduction to Agro-forestry*. Kluwer, Netherlands.
7. Paulo ELD and Nunes. 2014. *Handbook on the Economics of Ecosystem and Biodiversity*. E-book.
8. Sander J, Nicolas D and Hans K. 2014. *Ecosystem Services: Global Issues and Local Practices.* (1st Edn.). Elsevier Publications, Netherlands.
9. Schroth G and Sinclair F. 2003. Tree Crops and Soil Fertility: Concepts and Research Methods, CABI, Wallingford, UK.
10. Young A. 1997. *Agro-forestry for Soil Management.* (2nd Edn.). CABI, Wallingford, UK.

Entrepreneurship in value chain improvement of Forest Resources 3 (2+1)

Theory

Forest resources as Agri-business option for rural development, SWOT analysis of forest resource entreprise, Demand and supply forecasts in forest resources, Price determination and price discovery in forest resources, Collection, processing and value addition of forest resources, Value chain analysis (VCA) of forest resources, market dynamics and trade mechanism in forest resources, Cost benefit considerations in forest resources production, Economics and marketing of forest resources, Cooperative societies, industries, NGOs and Government organizations in strengthening forest based livelihood.

Practical

Field based value chain study of any important forest resource. Case study on entrepreneurship of any cooperative, NGO, society, industry.

Suggested Readings

1. Charles W, Hill L and Steven L McShane. 2007. *Principles of Management*. Tata McGraw Hill, New Delhi.
2. Girish B and S S Inamati. *Forest Business Management* by Shahapurmath. Satish Serial Publishing House
3. Koontz H and Weihrich H. 2007. *Principles of Management*. Tata McGraw Hill, New Delhi.
4. Massie J L. 1995. *Essentials of Management*. Prentice Hall of India Pvt. Ltd., New Delhi.
5. Prasad L M. 2005. *Principles and Practices of Management*. Sultan Chand and Sons Educational Publishers, New Delhi.
6. Rao V S B and Narayana P S. 2004. *Principles and Practices of Management*. Konark Publishing Pvt. Ltd. New Delhi.

Joint Forest Planning and Management 2 (1+1)

Theory

Concept of JFM. Definition. Meaning what is your idea of JFM, CFM? Learn Definition of JFM in state and national JFM guidelines (latest versions): what is common to all? -what is different? -if different, why? -what is specific to your own state?

Concept-why from the conventional management of forests did JFM evolve? -what was the status of: protection, harvest and provision of benefits in: 1. conventional forest management 2. Social forestry.

JFM Key Principles What is management of resources? -what are the resources available to be managed in the forests? -why the resources are to be managed? -what is the difference of carrying capacity of forests with canopy? -visualize canopy wise availability of resources. (Between 0.1 and 0.4, more than 0.7) 1.2 what is joint management of resources.

Legal position-what are the criteria to identify target areas? Area coverage? Community? -what will be the time span to be earmarked for JFM? -Why? - Figure out stages of JFM program period. -what is the functional role of FD and local people? - What is the legal frame that endorses the above identified factors? 1 hour

Scope and limitations-what will be the measures to fill gaps? -what will be possible limitations? Community Forestry: Introduction to the concept of forestry as a common property resource– Definition, Scope and necessity of community forestry. Forests and man: Forestry in support to agriculture, animal husbandry and horticulture – development of cottage industry in rural Environment-NFP 1988 and the importance of people in forest conservation. Community forest management, Community forest development, social economical and environmental aspects, Community forest development through NGOs, civil societies, citizen groups. Social Forestry for fodder production, fuel wood, production, leaf manure, timber production.

NTFPs Joint Forest management: concept, legislation, rules, importance Joint Forest management: concept, legislation, rules, importance. Joint Forest management: concept, legislation, rules, importance. Case studies of JFM implementation- problems and prospects, Micro plan Preparation. JFMS, FDCS. VFCS, CBOS. NGOS and co-operative societies Social Forestry for fodder production, fuel wood, leaf manure, timber production, NTFPS. Integrated rural development approach with proper marketing facility, employment generation in raising, tending and harvesting of tree crops. Joint Forest management: concept, legislation, rules, importance. Case studies of JFM implementation- problems and prospects, Micro plan Preparation. JFMs, FDCs, VFCs, CBOs, NGOs and co-operative societies.

Practical

Joint Forest management: concept, legislation, rules, importance Joint Forest management: concept, legislation, rules, importance. Joint Forest management: concept, legislation, rules, importance. Case studies of JFM implementation- problems and prospects, Micro plan Preparation. JFMS, FDCS. VFCS, CBOS. NGOS and co-operative societies Social Forestry for fodder production, fuel wood, leaf manure, timber production, NTFPS. Integrated rural development approach with proper marketing facility, employment generation in raising, tending and harvesting of tree crops. Joint Forest management: concept, legislation, rules, importance. Case studies of JFM implementation-problems and prospects, Microplan Preparation. JFMs, FDCs, VFCs, CBOs, NGOs and co-operative societies. Community forest development, social economical and environmental aspects, Community forest development through NGOs, civil societies, citizen groups. Social Forestry for fodder production, fuel wood, production, leaf manure, timber production, PRA exercises. Visit to village to study the community forestry components- Community reserve, organizational set up and administrative procedures in a social forestry (SF) Range, Microplan Preparation-Field visit to a JFM operational area and conduct PRA surveys. Afforestation techniques and social forestry.

Suggested Readings

1. Balakathiresan S. 1986. *Essentials of Forest Management*, Nataraj Publishers, Dehradun.
2. Bullock R C L and Hanna K S. 2012. *Community Forestry Local Values, Conflict and Forest Governance*. Cambridge University Press.
3. FAO 1984. *Forestry extension, making it Work, An International Journal of Forestry and Forest Industries, Unasylva - No. 143,* Published by FAO.
4. Jha L K, Sen P K and Sarma A P H. 2008. *A Manual of Forestry Extension Education.* 386p. VEDAMS.
5. Jalihal K A and Veerabhadraiah V. 2007. *Fundamentals of Extension Education and Management in Extension.* Concept Publishing Company.
6. Gunter J. (Ed.). 1973. *The Community Forestry Guidebook* (http://www.forrex.org/ sites/default/ files/ forrex_series/FS15.pdf).

7. Ojha H R, Timsina N P, Kumar C, Banjade M R and Belcher B. 2007. *Communities, Forests and Governance: Policy and Institutional Innovations from Nepal.* Adroit Publishers, New Delhi, India.
8. Roy S B and Chatterjee M. 1994. *Joint Forest Management*. Inter India Publications Tiwari K M. 1983. *Social forestry for rural development*. International Book Distributors. Vyas G. P.D. 2006. *Community Forestry*. Agrobios, India.
9. Sim H and Hilmi A. 1987. *Forestry Extension Methods*. 153p. FAO Forestry Paper-80..

Climate Change Mitigation 3 (2+1)

Objective

To understand the scenario of climate change and international treaties on climate change, for climate change mitigation and conservation of ecosystems

Theory

Global climate change - factors involved greenhouse gases, potential threats, global carbon cycle and C-budget, carbon sequestration. Forests and climate change. Forest responses and vulnerabilities to climate change mitigation. Status of forests in global climate change. Harnessing Forests for Climate Change Mitigation, International climate negotiation, UNFCCC, IPCC, CoP, LULUCF, REDD++ and CDM. National action plan for climate change - Green India mission- Indian Network for Climate Change Assessment (INCCA) - State Action Plan on Climate Change. Silviculture and sustainability- criteria and indicators for sustainable plantation forestry in India. CIFOR guidelines. Analog forestry for site productivity and carbon value. Disturbance- natural and anthropogenic, short- and long- term impacts and their implications. Fire loss estimation in forests. Deforestation and degradation trends at global, national and regional levels. Mega development projects, Road widening projects and conservation of native and threatened species, management and rehabilitation plans. Invasive – major invasive species in forests – area affected and methodology for mapping. Eradication methods- management. Restoration of invasive affected areas – types - methods approaches, strategies and opportunities. Role of canopy in regulating functional inputs to stand: canopy and forest continuum, Continuous Cover Expanding forest and tree cover area – TOF sector in India. Carbon sequestration potential of Trees Outside forests (TOFs), home gardens and urban forests.

Suggested Readings

1. Anderson P and Palik B. 2011. *Silviculture for Climate Change. U.S. Department of Agriculture, Forest Service.* Climate Change Resource Center.
2. Bravo F, LeMay V, Jandl R and Gadow von K. *(Eds)*. 2008. *Managing Forest Ecosystems: The Challenge of Climate Change.* 324p. Springer publication.
3. Claussen, Eileen, Cochran, Vicki, Arroyo, Davis, Debra P and Pew. 2001. *Climate Change: Science, Strategies, and Solutions.* 393p. Brill Academic Pub.
4. Markham, Adam (Ed.). 2010. *Potential Impacts of Climate Change on Tropical Forest Ecosystems*. Amazon publishers.
5. Streck Charlotte, O'Sullivan Robert, Tarasofsky Richard G, Janson-Smith Toby. 2011. *Climate Change and Forests: Emerging Policy and Market Opportunities*. Brookings Institution Press.

Ecotourism 3 (2+1)

Objective

To develop knowledge, understanding, and appreciation of environmentally responsible travel to relatively undisturbed natural areas that promotes biodiversity conservation, has low negative visitor impact, and provides for socio-economic benefits to the local stakeholder communities

Theory

Ecotourism – Definition - History of tourism and evolution of ecotourism. Various forms of tourism - Dimensions of tourism and essential conditions for tourism to occur. Differences between tourism components. Mass tourism versus ecotourism. Organised tours and Free Independent Traveller – World Tourism Organization. Concept of ecotourism and flaws in real world. Problems with definition of ecotourism and criticisms. Dimensions of ecotourism and the criteria to qualify for ecotourism. Declaration – Different forms of ecotourism. Ecotourism indicators and conceptual differences between developing and developed countries. International organizations and NGOs promoting ecotourism. Ecotourism-its potential in developing countries- Poverty and biodiversity, Ecotourism as a rural development strategy in tropical countries Ecotourism as a land use- possibilities of integration – Ecotourism policies at national and local level. Environmental Impacts of ecotourism and its mitigation - Case studies from different parts of the world- Concept of "scale". The checks and controls and institutional mechanisms for controlling the environmental impacts, Mitigation of pollution. Social Impacts of ecotourism and precautionary principles to avoid ill effects Stories from different parts of the world narrating ecotourism development and its influence on society and their culture – The societal advantages and the negative impacts of ecotourism development – Ways forward to address the negative social impacts Indigenous people and ecotourism. Ecotourism economics and business – Investment of international agencies like World Bank in ecotourism projects Ecotourism economics at macro and micro economic level in developing countries Ecotourism as a green business and role of green consumerism – Business plans- unique selling points for marketing – Potential of internet in marketing ecotourism – Payments for Environmental services and role of ecotourism Multiplier effects, opportunity costs and leakage in ecotourism industry Sharing ecotourism revenues among stakeholders – Training in ecotourism to deliver quality service. Ecotourism as a vehicle for the conservation of common property resources – potentials and pitfalls, Dangers involved in management of common property resources Relations between the government and the private sector. Ecotourism and Protected Areas Changing paradigms in the Protected Area Management Support at international level for ecotourism Integrated Conservation Development Projects (ICDPS) and role of ecotourism Community based ecotourism programs. Planning and management of ecotourism – Ecotourism plans and management of visitors and other resources including human and natural resources – Quality control, codes of conduct etc. Use of GIS and ICT for effectively managing and planning ecotourism – Criteria and indicators for sustainable management and monitoring – Charter for Sustainable Tourism – Sustainability issues in ecotourism management and ecotourism certification. Ecotourism design – Role of socio-economic factors in decision making – Designing ecotourism products using local technologies – Carrying capacity considerations. – Use of GIS in ecotourism. Ecotourism markets and influences of climate change Existing ecotourism markets and ecotourism market segmentation – Paradigm shifts possible due to climate change and its potential influence of carbon economy on existing ecotourism markets.

Practical

Preparation of a thematic compendium after extensive and original independent investigation about the chosen Protected Area. Be familiar with Government policy and legislation, the current policies regarding the component land uses of the study site. Stakeholder analysis and social Impacts Assessment. Identify different stakeholders at different levels. Based on this perform a stakeholder analysis and then conduct social surveys to gather the information required for assessing the impacts of current management and to explore the intervention needed in the chosen protected area. Ecological surveys including Environmental Impact Assessment. Assess the ecological impacts of current human use using standard techniques in order to identify the intervention needed in the chosen protected area.

Suggested Readings

1. Bhatt S and Liyakhat S. 2014. *Ecotourism Development in India.* Communities, Capital and Conservation
2. Lindberg K, Wood M E and Engeldrum D. 1998. *Ecotourism- A Guide for Planners and Managers (Environment and Development)*. Foundation Books.
3. Page S J and Dowling R K. 2002. *Ecotourism.* Pearson Education Limited, Essex. The Ecotourism Society, Vermont.
4. Weaver D. 2002. *Ecotourism. Milton, Queensland, Australia*. John Wiley and Sons Australia.

Restoration of Degraded Lands 3 (2+1)

Objective

To impart practical understanding about rejuvenation of forest with tree vegetation and to develop skills on tacking different problem soils with suitable vegetation

Theory

Degraded lands: Concept, classification, status, extent and causes of degraded lands/ wastelands, different types of degraded lands – physical, chemical and biological land degradation. Soil erosion- types, causes and mechanism, measures to control erosion, ravine and sand dune formation and their control measures. Salt affected soils- classes of salt affected soils, causes, extent and their effects on plant growth and afforestation /reclamation practices. Acid soils- definition, characteristics, causes and afforestation. Water logged areas explanation, impact on pant growth and Bio-drainage techniques. Afforestation and reclamation of denuded hill slopes, land slips and landslides, avalanche and cold desert, mined out, dry, rocky and murramy areas. Desertification- definition, impact and causes, prevention and counter measures (shelter belts and wind breaks). Soil pollution- types, effects and control measures through forestry techniques. National and state level programs on degraded lands/wasteland development. Role of Government agencies and NGO's in degraded lands/wasteland development program.

Practical

Tree species suitable for different degraded lands. Identification and study of various degraded lands. Visit to nearby degraded lands (Eroded site, ravine and sand dune, coastal area, waterlogged area, denuded hill slopes, land slips and landslides, avalanche and cold desert, mined out, dry, rocky and murramy areas) and afforestation program.

Suggested Readings

1. Hegde N.G. 1987. *Handbook of Wasteland Development*. 102p. BAIF, Pune.
2. ICAR. 1977. *Desertification and its Control*. ICAR, New Delhi.
3. Imeson A. 2012. *Desertification, Land Degradation and Sustainability*. John Wiley and Sons.
4. Kumar Anil and Pandey R N. 1989. *Wastelands Management in India.* Ashish Publishing House, New Delhi.
5. Luna R K. 1989. *Plantation Forestry in India*. 457p. International Book Distributors, Dehradun.
6. National Commission on Agriculture 1976. Report of the National Commission on Agriculture, Part IX.

Urban Ecology and Environment 3 (2+1)

Objectives

i. To understand urban ecology, biodiversity conservation and management for sustainable development
ii. To evaluate environmental and social impacts to deal with global challenges of climate change in cites

Theory

Concepts of urban ecology: Theories of urban ecology and linkages with sustainable urbanism, Concepts of Eco cities, smart cities, compact cities etc., Challenges and opportunities of urban, rural and peri-urban growth. Green Spaces, bio-diversity conservation and conflicts: Urban greens: challenges and choices for management, Human nature interactions and urban forest management, introduction to functional diversity and traits, Bio-diversity conservation conflicts, Spatial dimensions of urban ecology. Urban Environment: Introduction to urban morphology, Industrial ecology and symbiosis, Management of air quality and noise, Urban solid waste management, Urban water ecological challenges. Impact Analysis and Ecological Footprint Analysis: Environmental Impact Analysis 10 2, Social Impact Analysis and Strategic Environmental Assessment, Urban metabolism and Ecological Footprint Analysis. Ecological risk assessment framework (Definition, Problem formulation, Risk analysis, Risk characterization, Risk management), Climate change, mitigation and adaptation, Climate modifications and managing climate change challenges in cities, Adaptation and mitigation measures to make cities resilient, Ecosystem services and nature-based solution to address urban resilience.

Practical

Vegetation analysis and characterization of green spaces in nearby urban areas. Identifying challenges in soil waste management in nearby urban areas. Urban Risk assessment and mitigation in urban areas.

Suggested Readings

1. Adler F R and Tanner C J. 2013. *Urban Ecosystems*. Cambridge University Press.
2. Cities and Bio-diversity Outlook. 2013. *Action and Policy: A Global Assessment of the Links between Urbanization, Biodiversity, and Ecosystem Services*. by Secretariat of the Convention on Biological Diversity.

3. Dale R. 2004. *Evaluating Development Program and Project*. (2nd Edn.) Sage Publication.
4. Keitaro Ito. 2021. *Urban Biodiversity and Ecological Design for Sustainable Cities. Springer.*
5. *Mostafavi, M. and Doherty, G. 2010. Ecological Urbanism*. Published by Baden: Harvard University Graduate School of Design.
6. Morrison-Saunders A and Arts J. (Eds) 2004. *Assessing Impact: Handbook of EIA and SEA Follow-up*. Earthscan James and James, London.
7. Parris K M. 2016. *Ecology of Urban Environments. Chichester, West Sussex; Hoboken, Nj.* John Wiley and Sons Ltd.
8. Singhal S and Kapur A. 2002. *Industrial Estate Planning and Management in India – An Integrated Approach towards Industrial Ecology.* Journal of Environmental Management, Elsevier Science Ltd., 66, 2002.
9. Sivaramakrishnan K. and Rademacher, A. 2013. *Ecologies of Urbanism in India Metropolitan Civility and Sustainability.* Hong Kong China: Hong Kong University Press, Baltimore.
10. United Nations Human Settlements Program (UN-HABITAT). 2011. *Global Report on Human Settlements - Cities and Climate Change*. Policy Directions
11. World Bank. 2009. *Strategic Environmental Assessment in East and Southeast Asia, A Progressive and Comparison Country Systems and Cases.* Washington D.C.
12. WWF India. 2011. *Impact of urbanization on bio-diversity: Case Studies From India.*

Plant Biochemistry 2 (1+1)

Objective

To understand the basic scenario of biochemical action that happens in the plant system

Theory

Introduction to biomolecules. Chemistry of carbohydrates: Monosaccharides, classification, Configurations and conformations (Anomerism, epimersim, mutarotation, inversion); Disaccharides and polysaccharides (structural and storage); Glycosaminoglycans and glycoproteins. Chemistry of lipids: Lipid classification- Fatty acids, triacylglycerols, glycerophospholipids and sphingolipids. Amino acids of proteins – General properties, peptide bonds, classification and characteristics, acid-base properties; Optical activity. Primary, secondary, tertiary and quaternary structure of proteins; fibrous and globular proteins; protein stability and denaturation. Chemistry of nucleic acids: Bases, sugars, Nucleosides and nucleotides. Chemical structure and properties of DNA and RNA. Chemical catalysts vs. biological catalysts; substrate specificity-stereo, geometric specificities; Enzymes – nomenclature, classification, enzyme kinetics- rates of reactions; Lock and Key hypothesis and induced fit models; Enzyme assay, transition state theory, Michaelis Menten equation, Lineweaver-Burk plot, enzyme inhibition-reversible (Competitive, uncompetitive and mixed) and irreversible, allosteric enzymes, Effect of pH and temperature on enzyme activity; Isozymes, coenzymes. Photosynthesis – light reactions, dark reaction, Hill's reaction, photorespiration, C4 pathway, C3, C4 and CAM plants, CO_2 fixation, regulation of photosynthesis. Metabolism of carbohydrates -glycolysis, TCA cycle, electron transport chain. Lipid metabolism – beta oxidation and fatty acid biosynthesis. Secondary metabolites-Classification and functions of phenolics, terpenoids and alkaloids.

Practical

Qualitative analysis of carbohydrates. Estimation of sugar by Dubois method. Determination of reducing sugars by DNS method. Determination of total carbohydrate by anthrone method. Protein

estimation by Bradford method. Absorbance curve of two dyes. Qualitative analysis of amino acids. Titration of amino acids. Purification of acid phosphatase from mustard seedlings. Qualitative analysis of oils and fats. Estimation of saponification value of oils. Estimation of iodine number of oils/fats. Chromatography of photosynthetic pigments. Lipid analysis by thin layer chromatography. Total protein estimation by Lowry's method. Kinetics of alkaline phosphatase.

Suggested Readings

1. Berg Jeremy M, Stryer Lubert, Tymoczko John and Gatto Gregory. 2015. *Biochemistry*. Macmillan Learning.
2. Berg J M, Tymoczko J L and Stryer L. 2007. *Biochemistry.* (7th Edn.) Wiley Eastern Ltd. ISBN:0-7167-8724-5.
3. Buchanan Bob B, Gruissem Wilhelm and Jones Russell L. 2015. *Biochemistry and Molecular Biology of Plants*. John Wiley & Sons.
4. David L. Nelson and Michael M. Cox. 2013. *Lehninger. Principles of Biochemistry.* Macmillan Learning
5. Plummer David T. 1978. *An Introduction to Practical Biochemistry*. McGraw-Hill.
6. Rao Beedu Sashidhar and Deshpande Vijay. 2006. *Experimental Biochemistry: A Student Companion.* Anshan.
7. Sadasivam S and Manickam A. 2009. *Biochemical Methods.* (3rd Edn.). New Age International.
8. Thayumanavan B, Krishnaveni S and Parvathi K. 2004. *Biochemistry for Agricultural Sciences*, Galgotia Publications Pvt Ltd., New Delhi. ISBN :81-7515-459-4.
9. Voet Donald and Voet Judith. 2010. *Biochemistry*. John Wiley & Sons.
10. Wilson K and Walker J M. 2000. *Principles and techniques of Practical Biochemistry*. Cambridge University Press.

Research Methodology 2 (1+1)

Objective

To inculcate the art of research and expose the students through various methodologies of data collection, processing, tabulation and interpretation

Theory

Role of research methodology - Induction and deduction, Sources of information - Review of literature, Identification of problem - Formulation of objectives and hypothesis - Scope of survey-based research - Types of surveys- identification of research problem - Analysis of research problem, customer identification, categorization- Data collection, analysis and compilation of survey report - Types of data, concepts of population - Analysis of data, graphical and diagrammatic presentation - Measures of central tendencies-mean, median, mode- problems- Reliability and validity of measuring tools.- Reporting: Significance of report writing, steps in report writing- Processing Information in Research Methodology - Importance of Experiments in research - Interview studies in Research methodology -Solutions of research methodology.

Practical

Research problem identification, objective and Hypothesis Formulation - Research design, Collection of data, Analysis of Data for the identified Problem- Hypothesis testing, interpretation

and report writing for the identified problem- Application of Scales for measurement – Nominal and ordinal- Application of Scales for measurement –Interval and Ratio- Application of Scales for measurement – Likert and other scales-Identification of Primary and Secondary Data -Correlation - Simple and partial correlation - Correlation - Multiple correlation analysis - Regression – Simple and Multiple regression analysis- Dummy variable analysis - Construction of Index Numbers - Factor analysis - Cluster analysis.

Statistical Packages for Data Analysis 1 (0+1)

Objective

The art of data collection, processing, analysis and interpretation will be developed to the translate simple data into scientific data

Practical

SYSTAT package– data entry and creation of a data file– importing an excel file, SPSS file, database file, BMDP file and SAS file in SYSTAT for analysis- Data manipulation – transformation – ranking, sorting, appending, merging and transposing of data in SYSTAT- SAS package – data entry and creation of data files in SAS– opening a file – importing an excel file, SYSTAT file, database file and SPSS file in SAS for analysis- Data manipulation – transformation – ranking, sorting, appending, merging and transposing of data in SAS- Data analysis using SYSTAT and SAS packages- Descriptive statistics- Cross tabulation–one way, two way and multi-way tables- Chi square test- Student's t test – comparing a single mean- Comparison of two means– independent t test- Comparison of two means – paired t test- One way ANOVA- Two way ANOVA- Correlation analysis- Spearman's rank correlation and Kendall's tau- Jaccard and tetra correlation coefficients- Complete regression analysis.

Suggested Readings

1. Jayaraman K and Rugmini P. 1990. *Statistical Techniques in Forestry - Research and Forestry*. Kerala Forest Research Institute, Peechi, Thrissur.
2. Nigam A K and Gupta V K. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publication, New Delhi.
3. Panse V G and Sukhatme P V. 1967. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi.
4. Petersen Roger G. 1994. *Agricultural Field Experiments: Design and Analysis*. Marcel Dekker, New York.

SKILL ENHANCEMENT COURSE

Skill Enhancement Course (Indicative SEC Courses I)

- Commercial Seedling Production
- Forest Machine Learning Technology
- Commercial Forestry
- Landscape Management and Restoration
- Wildlife Photography
- Ecotourism
- Para-taxonomy

- Ornithology
- Herpetology
- Design and Development of Wood Products

Skill Enhancement Course (Indicative SEC Courses II)

- Clonal Seedling Production
- Commercial tree seed production
- Forest Based Industrial Training
- Urban Forestry Designing and Planning
- Wood Working and Carpentry
- Wood Seasoning and Preservation Technology
- Zoo Management
- Wild and Commercial Beekeeping
- Mining Afforestation
- Advanced Wood Working
- Lac and Tassar Cultivation

Skill Enhancement Course (Indicative SEC Courses III)

- Timber Conversion
- Value addition of NTFPs
- Briquetting Technology
- Forest Fire Management
- Activated Carbon Technology
- Wood carving through CNC Technology
- Burlapping Technology
- Micro Forest
- Import and Export of forest Products
- e-Timber Market
- Community Forest
- Human Animal Ecosystem Interface
- AR/VR Module Creation in Forestry
- Forest Resource Assessment
- Multifunctional Agroforestry
- Biofuels Technology through forestry

Skill Enhancement Course (Indicative SEC Courses IV)

- Wildlife Forensic Sciences
- Dendroenergy Generation
- Big Data Management
- Artificial Intelligence in Forestry Operation
- Specialty Seedling Production
- Woodlot Establishment and Management
- Tools for Consulting Forester's
- Application of Drone in Forestry
- Forest Certification
- Arboriculture
- Forest Project Designing and Analysis
- Wood Mechanics

- Mulberry and Non-mulberry based Silk Production
- Internet of Things (IoT) in Forestry
- Marketing and Economics of NTFPs
- Carbon financing projects

ONLINE COURSES

The students will have to take a minimum of 10 credits of online courses (as per UGC guidelines for online courses) as a partial requirement as for the B. Sc. (Hons.)

The online courses can be from any field in forestry can be taken from NPTEL, mooKIT, edX, Coursera, SWAYAM or any other portal.

The objective is to allow the students to groom their passion or strengthen their knowledge and competency in any field beyond prescribed courses.

The courses will be non-gradial as separate certificates would be issued by institutes offering the courses. These can be taken any time during the 3rd and 4th years of the UG program. However, the University/ institute will keep a record of such courses registered and completed by each student and will indicate the title of the (satisfactorily completed) courses in final transcript issued to the student.

List of Suggestive Courses on SWAYAM/MOOC

Course Title	Duration	Credits
Forests and their Management	12 weeks	3
Wildlife Ecology	12 weeks	3
Introduction to Biology: Ecology	4 weeks	1
Introduction to Biology: Ecology, Evolution, and Biodiversity	15 weeks	4
Introduction to Biology: Biodiversity	5 weeks	1
Ecology: Ecosystem Dynamics and Conservation	5 weeks	1
Fire Ecology	8 weeks	2
Ecology and Society	12 weeks	3
Environmental Studies	12 weeks	3
Environmental Studies: A Global Perspective	6 weeks	2
Toolbox for Environmental Management	5 weeks	1
Environmental Protection and Sustainability	8 weeks	2
Ecosystem and Natural Resources	12 weeks	3
NGO'S and Sustainable Development	15 weeks	4
Nanotechnology Applications in Respective Fields	8 weeks	2
Personality Development and Communication Skills	8 weeks	2
Personality Development	8 weeks	2
Yoga Practices 1	12 weeks	3
Yoga Practices 2	12 weeks	3
Ethics: Theories and Applications	12 weeks	3

Minimum Standards for Establishing a College of Forestry

- **Degree Nomenclature:** B. Sc. (Hons.) Forestry

1. Minimum intake (per year): 60

2. Faculty:

A. Core faculty: 22

Silviculture and Agroforestry(0+1+4), Forest Biology and Tree Improvement (0+1+3), Natural Resource Management (0+1+2), Forest Product Utilization (0+1+3), Wild Life Sciences (0+1+2), Basic and Social Sciences (0+1+2)

B. Allied faculty: Faculty for Mathematics, computer science, Sociology, Psychology, English, Food Science and Technology, Microbiology, Agrometerology and other supporting subjects, if any, shall be adjusted from other colleges, Guest faculty, adjunct faculty and part time faculty.

3. Land requirement (ha): 20

4. Essential Instructional units:

	Details	Area
•	Forest genetic resources	2 ha
•	Arboretum Garden	1 ha
•	Tree Improvement units	2 ha
•	Silvicultural model	2 ha
•	Agroforestry model	1ha
•	Natural forestry	5 ha (additional)
•	Biodiversity experiment	2ha (additional)
•	Land for wild life	5 ha (additional)
•	Non timber forest	1 ha
•	Area for Nursery	0.5 ha
•	Watershed	4 ha (additional)
•	Workshops in academic block.	
•	College of forestry must be established either in forest area or adjacent to forests.	
•	Laboratories and instructional facilities as per V Deans' Committee report.	
•	ELP units to be established under skill development or Entrepreneurial mode	0.5 ha

5. Divisons/Departments/Sections:

- Silviculture and Agroforestry
- Forest Biology and Tree Improvement
- Natural Resource Management
- Forest Product Utilization
- Wild Life Sciences
- Basic and Social Sciences

6. Non-Teaching Staff:

Department	Steno/PA/ Computer Operator	Attendant/ Messenger	Laboratory Assistant / Attendant	Field Staff
Silviculture and Agroforestry	1	1	1	3
Forest Biology and Tree Improvement	1	1	1	3
Natural Resource Management	1	1	1	3
Forest Products and Utilisation	1	1	1	3
Wildlife Sciences	1	1	1	3
Basic and Social Sciences	1	1	1	3
Total	**6**	**6**	**6**	**18**

Note: Security services to be outsourced.

7. Manpower Requirements

A. Dean s Office

Manpower	Number
Dean	1
A. Establishment	
PA to Dean	1
Assistant Registrar	1
Accounts Officer	1
Superintendent	1
Computer operator	2
Steno/Assistant	2
Operator (Audio visual)	1
Attendants /Messengers	4
Clerk (LDC)	4
Electrician	1
Storekeeper	1
Driver (office vehicle/student buses/tractors)	4
Security, Sanitation and Landscapingand transportation	To be outsourced
B. Central Research and Teaching Laboratories	
Laboratory Technicians	2
Laboratory Assistant	2
Laboratory Attendant	1
C. Library Staff	

Assistant Librarian	1
Library Assistant	1
Clerk	1
Shelf Assistant	2
D. Students Welfare	To be provided by the Institute/ University as the Central Facility
E. Hostel Staff for two Hostels	
Warden	1 (UG and PG; Men & Women)
Assistant Wardens	2 (UG and PG; Men & Women)
Care Taker/Matron	4 (UG and PG; Men & Women, Men &Women)
Attendants	8
Security, Sanitation and Landscaping	To be outsourced

8. Floor Space Requirement

A. Central Facilities

S. No.	Details	Number of Rooms	Dimensions (ft)
1.	Dean office	1	20 × 24
2.	PA room	1	10 × 12
3.	Committee room with video conferencing facility	1	20 × 48
4.	Administrative officer room	1	20 × 12
5.	Admin. staff rooms	2	20 × 12 each
6.	Examination cell	1	20 × 12
7.	Placement cell	1	30 × 18
8.	Smart Lecture rooms	6	Seating capacity -70
9.	Library	1	60 × 140
10.	Examination hall	1	Seating capacity -150
11.	Laboratories	10	30 × 48 each
12.	Hostels	4	UG and PG Boys & UG and PG Girls
13.	Toxic chemical waste storage/disposal Unit	1	20 × 24
14.	Canteen	1	20 × 12 (kitchen) and 20 × 36 (Seating)
15.	Toilets	2 sets for each floor	For college

16.	Parking space	as per requirement (APR)	and hostels
17.	Vehicles –		
	Dean's car	One	
	For Field trips as part of research-		
	Jeep/SUV with four wheel drive	Two	
	For Students Field trip - 30 seat capacity bus	Two	
	Pick up van	One	
18.	Common room for boys and girls	Two	

B. Departments

S. No.	Detail	Number of rooms	Dimensions (ft)
1.	Office of Head of the Department	10 (one for each Department)	20 × 12 each
2.	Administrative Staff	10(one for each Department)	12 × 10 each
3.	Faculty Room	10 (one for each Department)	30 × 30 each and to be partitioned
4.	Rooms for Research Scholars	10 (one for each Department)	20 × 24 each
5.	Smart Lecture cum seminar room	10 (one for each Department)	Seating capacity – 40 each
6.	Laboratories	20 - Two laboratories (one each for UG and PG)in each department	20 × 60 (one) 20× 36 (one each for 6 departments)

9. Central/Division/Section Laboratories (as per requirements of the teaching and research work ofthe college)

10. Common laboratory/facility

Botanical Garden Natural History MuseumXylarium

Tree Nursery

GIS and Remote sensing LabComputer Lab

Auditorium (optional)

Students Activity Centre (optional)

11. Department wise list of Minimum Equipment/ Instruments in Laboratories

S. No.	Name of the Equipment	Number	UG	Department
1.	Soil analysis kit	1	UG	Silviculture (SAF)
2.	Portable soil moisture kit	1	UG	(SAF)

S. No.	Name of the Equipment	Number	UG	Department
3.	Telescopic tree ladder	1	UG	(SAF)
4.	Seed moister meter	1	UG	(SAF)
5.	Seed/ grain divider	1	UG	(SAF)
6.	Seed precision divider	1	UG	(SAF)
7.	Seed divider	1	UG	(SAF)
8.	Seed grader	1	UG	(SAF)
9.	Seed hand-test sieves	1	UG	(SAF)
10.	Seed sieve shaker	1	UG	(SAF)
11.	Laboratory aspirator	1	UG	(SAF)
12.	Seed blower	1	UG	(SAF)
13.	Illuminated purity work board	1	UG	(SAF)
14.	Hot air seed drier	1	UG	(SAF)
15.	Growth Rooms	3	UG	Forest Biology and Tree Improvement (FBT)
16.	Hot Plates, Magnetic stirrers, Vortex etc.	6	UG	(FBT, WLS)
17.	Laminar Flow	4	UG	(FBT, WLS)
18.	Multiflow Dispenser	2	UG	(FBT, WLS)
19.	Precision Ovens	6	UG	(FBT, WLS)
20.	Plant Imager	2	UG	(FBT)
21.	Shakers (Table Top)	3	UG	(FBT, WLS)
22.	Spectrophotometer	2	UG	(FBT)
23.	Thermocycler	6	UG	(FBT, WLS)
24.	Thermomixer	3	UG	(FBT)
25	Tissue Lyser	3	UG	(FBT)
26.	Vacuum Concentrator	2	UG	(FBT)
27.	Computer for Bioinformatics Section	6	UG	(FBT, WLS)
28.	PAR & LAI Ceptometer /Canopy analyzer	1	UG	(FBT)
29.	Leaf area meter	1	UG	(FBT)
30.	Steady state porometer	1	UG	(FBT)
31.	Leaf wetness sensor	1	UG	(FBT)
32.	Scholanders pressure bomb (Plant water console)	1	UG	(FBT)
33.	Osmometer	1	UG	(FBT)
34.	Compound microscope (Students)	30	UG	(FBT)
35.	Stereo microscopes	5	UG	(FBT)
36	Compound microscopes (Research) binocular / trinocular)	3	UG	(FBT, WLS)

S. No.	Name of the Equipment	Number	UG	Department
37	Wildlife census equipments (compass, GPS, range finder, bat detectors, mist nets,Sherman traps, tapes etc)	100	UG	Wildlife Sciences(WLS)
38.	Wildlife handling equipments	As perre-quirement (APR)	UG	(WLS)
39.	Wildlife Field research equipment (binoculars, telescopes, ultrasonic bat detectors (APR) audio equipments, remote cameras and triggering devises, museum collection equipments, specimen storage cabinets etc.)	As perre-quirement	UG	(WLS)
40.	SLR digital camera and accessories	5	UG	(WLS)
41.	Spectrophotometer	1	UG	(NRM)
42.	Flame photometer	1	UG	(NRM)
43.	Conductivity meter	1	UG	(NRM)
44.	Water bath	1	UG	(NRM)
45.	incubator	1	UG	(NRM)
46.	Laminar Air flow	1	UG	(NRM)
47.	Bomb calorimeter	1	UG	(NRM)
48.	Incubator	1	UG	(NRM)
49.	Automatic weather station	4	UG	(SAF, WLS)
50.	Pyranometer	1	UG	(FBT)
51.	Salinity meter	1	UG	(NRM)
52.	Tensiometers	2	UG	(NRM)
53.	Tree telescope	2	UG	(NRM)
54.	Canopy analyzer	1	UG	(NRM)
55.	Laser Digital caliper	3	UG	(NRM)
56.	Moisture meter	1	UG	(NRM)
57.	Viscometer	1	UG	(NRM)
58.	Digital balance	3	UG	(NRM)
59.	prismatic compass	5	UG	(NRM)
60.	Swedish Bark gauge	3	UG	(NRM)
61.	Altimeter	5	UG	(NRM)
62.	Clinometer	5	UG	(NRM)
63.	Hypsometer	APR	UG	(NRM)
64.	Pressler's Increment borers	4	UG	(NRM)
65.	Abney level	10	UG	(NRM)
66.	dumpy level	3	UG	(NRM)
67.	Alidade	3	UG	(NRM)
68.	Christen's hypsometer	APR	UG	(NRM)
69.	Smythie's hypsometer	APR	UG	(NRM)

S. No.	Name of the Equipment	Number	UG	Department
70.	Improvised calipers	APR	UG	(NRM)
71.	Brandis hypsometer	5	UG	(NRM)
72.	Haga altimeter	5	UG	(NRM)
73.	Blume-Leiss hypsometer	4	UG	(NRM)
74.	Spiegel relaskop	5	UG	(NRM)
75.	Global positioning systems	5	UG	(NRM)
76.	Wheeler's pentaprism	4	UG	(NRM)
77.	Chain (20 or 30 m)	4	UG	(NRM)
78.	Offset	APR	UG	(NRM)
79.	Cross Staff	APR	UG	(NRM)
80.	Plump Bob	APR	UG	(NRM)
81.	Ranging rods	APR	UG	(NRM)
82.	Tape (30 m)	5	UG	(NRM)
83.	Plane table	5	UG	(NRM)
84.	Trough compass	5	UG	(NRM)
85.	U fork	5	UG	(NRM)
86.	Spirit level	5	UG	(NRM)
87.	Digital level	2	UG	(NRM)
88.	Laser level	2	UG	(NRM)
89.	Level staff	5	UG	(NRM)
90.	Microscope- simple microscope, compound microscope and stereo microscope	5 each	UG	Forest Protection (FPU, WLS)
91.	Autoclave- vertical and horizontal	1 each	UG	(FPU)
92.	Pressure cooker (20 L)	2	UG	(FPU)
93.	Hot air oven	1	UG	(FPU)
94.	B O D Incubator	1	UG	(FPU)
95.	Temperature and humidity control chamber	1	UG	(FPU)
96.	pH meter	2	UG	(FPU, FRM)
97.	Water bath- rectangular thermostatic	1	UG	(FPU)
98.	Common balance	2	UG	(FPU)
99.	Bunsen burner	2	UG	(FPU)
100.	Herbarium press	15	UG	(FPU)
101.	Workstation for GIS	10	UG	Basic Sciences (BSS)
102.	Scanner cum plotter/Printer	2	UG	(BSS)
103.	Global positioning systems	10	UG	(BSS)
104.	GIS software - ERDAS/Arc GIS/I GIS Ver.1.1 GIS	2	UG	(BSS)
105.	3D Printer	1	UG	(BSS)
106.	Universal testing machine micro-processor based	1	PG	Forest Products and

S. No.	Name of the Equipment	Number	UG	Department
	with PC system and printer			Utilization (FPU)
107.	Near Infra-Red (NIR) / Fourier Transform Infrared	1	PG	(FPU)
	(FT-IR) Spectrophotometers			
108.	Wiley mill for powdering wood samples (for cellulose and lignin analysis)	1	PG	(FPU)
109.	Nuclear Magnetic Resonance Spectroscopy (NMR)	1	PG	(FPU)
110.	Atomic Absorption Spectrophotometer (AAS)	1	PG	(SAF)
111.	Yoder apparatus	1	PG	(SAF)
112.	Tree radar system	1	PG	(SAF)
113.	CHNS analyzer	1	PG	(SAF)
114.	Mini tractor will tiller/disc facility	1	PG	(SAF)
115.	Radio transmitters and radio telemetry equipment	5	PG	(WLS)
116.	Wildlife marking equipment such as split-rings, bands, tags, ball chain necklace, beta lights, cyalume, punch marking and tattooing equipment, fluorescent powder and hand-held ultra-violet lights	As per requirement (APR)	PG	(WLS)
117.	Sequencer - ABI 3730xl	1	PG	(FBT)
118.	Illumina Sequencing Platform	1	PG	(FBT)
119.	Cold room -20 C	1	PG	(FBT)
120.	Cold room 4 C	1	PG	(FBT)
121.	SNP Genotyping Platform	1	PG	(FBT)
122.	HPTLC	1	PG	(FBT)
123.	High Performance Computing Grid	1	PG	(FBT)
124.	Inductively Coupled Plasma (ICP-OES	1	PG	(FBT)
125.	High Speed Centrifuge	4	PG	(FBT)
126.	Water Purification Unit	APR	PG	(FBT)
127.	-20 C Freezer	3	PG	(FBT)
128.	-80 C Freezer	3	PG	(FBT)
129.	Autoclaves	5	PG	(FBT)
130.	Automated Capillary Electrophoresis System	3	PG	(FBT)
131.	Autopipetting System	3	PG	(FBT)
132.	Biolistic Particle Gun	3	PG	(FBT)
133.	Biophotometer	2	PG	(FBT)
134.	Biosafety Cabinet	3	PG	(FBT)
135.	Centrifuge	6	PG	(FBT)
136.	Cryo-cans	6	PG	(FBT)
137.	Dry Baths	6	PG	(FBT)

S. No.	Name of the Equipment	Number	UG	Department
138.	Electrophoresis Systems and Power Packs	3	PG	(FBT)
139.	Electroporator	4	PG	(FBT)
140.	Environmental Chamber	2	PG	(FBT)
141.	Fermenter	3	PG	(FBT)
142.	Fluorescent Microscope	3	PG	(FBT)
143.	Gel Documentation System	4	PG	(FBT)
144.	Gel Dryers	2	PG	(FBT)
145.	Hybridization Ovens	2	PG	(FBT)
146.	Ice Making Machines	2	PG	(FBT)
147.	Incubator Shakers	4	PG	(FBT)
148.	Incubator	5	PG	(FBT)
149.	Lypholyser	1	PG	(FBT)
150.	Microcentrifuge	6	PG	(FBT)
151.	Microplate Washer	2	PG	(FBT)
152.	Microplate Readers	2	PG	(FBT)
153.	Microwave Digestion Oven	2	PG	(FBT)
154.	Nanodrop for DNA Quantification	2	PG	(FBT)
155.	Plate Centrifuges	3	PG	(FBT)
156.	Real Time PCR	4	PG	(FBT)
157.	Refrigerator 4 C	5	PG	(FBT)
158.	Semi Dry Blotter	2	PG	(FBT)
159.	Ultracentrifuge	2	PG	(FBT)
160.	Ultrasound Sonicator	3	PG	(FBT)
161.	UV Transilluminator	3	PG	(FBT)
162.	UV Stratalinker	2	PG	(FBT)
163.	Water Bath - Shaking	3	PG	(FBT)
164.	Major Softwares-CLC Genomics and other relevant softwares	APR	PG	(FBT)
165.	Portable Ethylene Analyzer	1	PG	(FBT)
166.	Programmable LED Experimentation System	1	PG	(FBT)
167.	Leaf Spectrometer	1	PG	(FBT)
168.	Root Image Analysis System	1	PG	(FBT)
169.	In Situ Root Imager	1	PG	(FBT)
170.	UV to Near Infrared Range Spectro-radiometer	1	PG	(FBT)
171.	HemiView - Forest Canopy Image Analysis System	1	PG	(FBT)
172.	IRGA Photosynthesis System	1	PG	(FBT)
173.	Chlorophyll Fluorimeter	1	PG	(FBT)
174.	Sap flow meter	1	PG	(FBT)
175.	Infra red thermometer	1	PG	(FBT)

S. No.	Name of the Equipment	Number	UG	Department
176.	Eddy covariance CO2/H2O flux measurement system	1	PG	(FBT)
177.	Soil CO2 flux system	1	PG	(FBT)
178.	UV-Bio Radiometer with Recorder	1	PG	(FBT)
179.	Florescence microscope	1	PG	(FBT)
180.	Dissection microscopes	20	PG	(FBT)
181.	Microtome	1	PG	(FBT)
182.	Vacuum oven with vacuum pump	1	PG	(NRM)
183.	Microwave oven	2	PG	(NRM)
184.	Melting point apparatus	1	PG	(NRM)
185.	Bark separator	2	PG	(NRM)
186.	Topo Abney	5	PG	(NRM)
187.	CHN Analyzer	1	PG	(NRM)
188.	Ravi multimeter	5	PG	(NRM)
189.	Vertex digital hypsometer (Haglof)	3	PG	(NRM)
190.	Micrometer- stage and ocular	4 each	PG	(FPU)
191.	Colony counter	1	PG	(FPU)
192.	Inoculation chamber (Laminar airflow chamber)	2	PG	(FPU)
193.	Ultra violet lamps	APR	PG	(FPU)
194.	centrifuge	2	PG	(FPU)
195.	Electronic monopan balance	2	PG	(FPU)
196.	Spectrophotometer or colorimeter	1	PG	(FPU)
197	Haemocytometer/ Petroff-Hausser counting chamber	1	PG	(FPU)
198.	Filters-Seitz filter	1	PG	(FPU)
199.	Orbital incubator / hot palte stirrer	1	PG	(FPU)
200.	Rotary flask shaker	1	PG	(FPU)
201.	Inoculation needle	APR	PG	(FPU)
202.	ICP (OES)	1	PG	(BSS)
203.	Microwave digester	1	PG	(BSS)
204.	Infrared thermometer	1	PG	(BSS)
205.	Air weather monitoring system	1	PG	(BSS)
206.	Manual and automatic agro-meteorology	1	PG	(BSS)
207.	Solar radiation assessment system	1	PG	(BSS)
208.	Soxhlet apparatus	1	PG	(NRM)

BIOTECHNOLOGY

Course Curricula for Undergraduate Programme in Biotechnology: UG-Certificate in Biotechnology; UG-Diploma in Biotechnology; B. Tech. (Biotechnology)

INTRODUCTION

Biotechnology encompasses a range of tools and techniques aimed at comprehending the molecular biology of plants and animals to facilitate precise enhancements. Recent advancements in these methodologies have enabled remarkable progress in manipulating macromolecules such as DNA, RNA, and proteins, ultimately benefiting both plants and animals. It is crucial to equip undergraduates with skills in biotechnology to address the increasing global demand. Recognizing this need, the VI Deans" Committee has undertaken the task of restructuring the Biotechnology course curriculum. The core tenets of the National Education Policy–2020 (NEP–2020) have been integrated into the curriculum. Alongside fundamental coursework, students now have access to Skill Enhancement Courses (SECs), which are meticulously crafted to instill proficiency in various facets of Biotechnology. Furthermore, a *Deeksharambh* (Foundation Course) along with the Multi-Disciplinary Courses (MDCs), Value Added Courses (VAC), Ability Enhancement Courses (AECs) and internships have been included. During their final year (first semester of fourth year), students will have the flexibility to select elective courses. These elective courses are structured around four primary themes: Plant Biotechnology, Animal Biotechnology, Microbial and Environmental Biotechnology, and Bioinformatics.

This report reflects the outcomes of extensive consultations and discussions with Deans' and educators from diverse Universities across the country. It is my earnest belief that students will immensely benefit from the amalgamation of theoretical knowledge and practical skills embedded within this restructured program.

Highlights

- The B.Tech. (Biotechnology) program is designed over 4 years, covering 167 credit hours of coursework. Additionally, students to register in 4 credit hours of non-gradial courses and 10 credit hours of MOOCs/Online Courses.
- The coursework consists of 112 credit hours, comprising 80 credits in major courses (including 20 credit hours of elective courses) and 32 credits in minor courses, 9 credit hours of MDC, 6 credit hours of VAC, 8 credit hours of AEC, 12 credit hours of SEC, and 20 credit hours of student READY activities. Two credit hours each of non-gradial courses and 10 credit hours of (massive open online courses) MOOCs/Online Courses.
- Upon completing the first year and undertaking a 10-credit (10-week) industry/institute training or internship, students qualify for the first-level exit with a UG-Certificate in Biotechnology. However, students advancing to the second year of the program will not participate in this industry or institute training/internship.
- Upon completing the first and second years and undertaking a 10-credit (10-week) industry/institute training or internship, students are eligible for the second level exit with a UG-Diploma in Biotechnology. However, students progressing to the third year of the program will not participate in this industry or institute training/internship.
- During the fifth and sixth semesters in the third year, the students will be offered with specialized and advanced courses in Biotechnology and related disciplines. In the fifth semester, students participate in an Educational Tour spanning two weeks (10-14 days), designated as a non-gradial course.
- A selection of courses categorized under four elective themes is proposed to provide a total of 20 credits in the seventh semester. Institutes may choose to adjust this selection to include additional specialized and advanced courses in areas such as Plant Biotechnology, Animal Biotechnology, Microbial and Environmental Biotechnology, and Bioinformatics.
- In the eighth semester, the student READY including in-plant training (RAWE/industry attachment/experiential learning/hands on training/project work/internship) will be taken up by the students.
- Students will enroll MOOCs/Online Courses totaling 10 credit hours during the four years (preferably during the third and fourth years) through approved portals with prior notification to the Head of the Institution.

Entry and Exit Options

The entry and exit options for the UG program in B. Tech. (Biotechnology) are shown in the Figure 1 below:

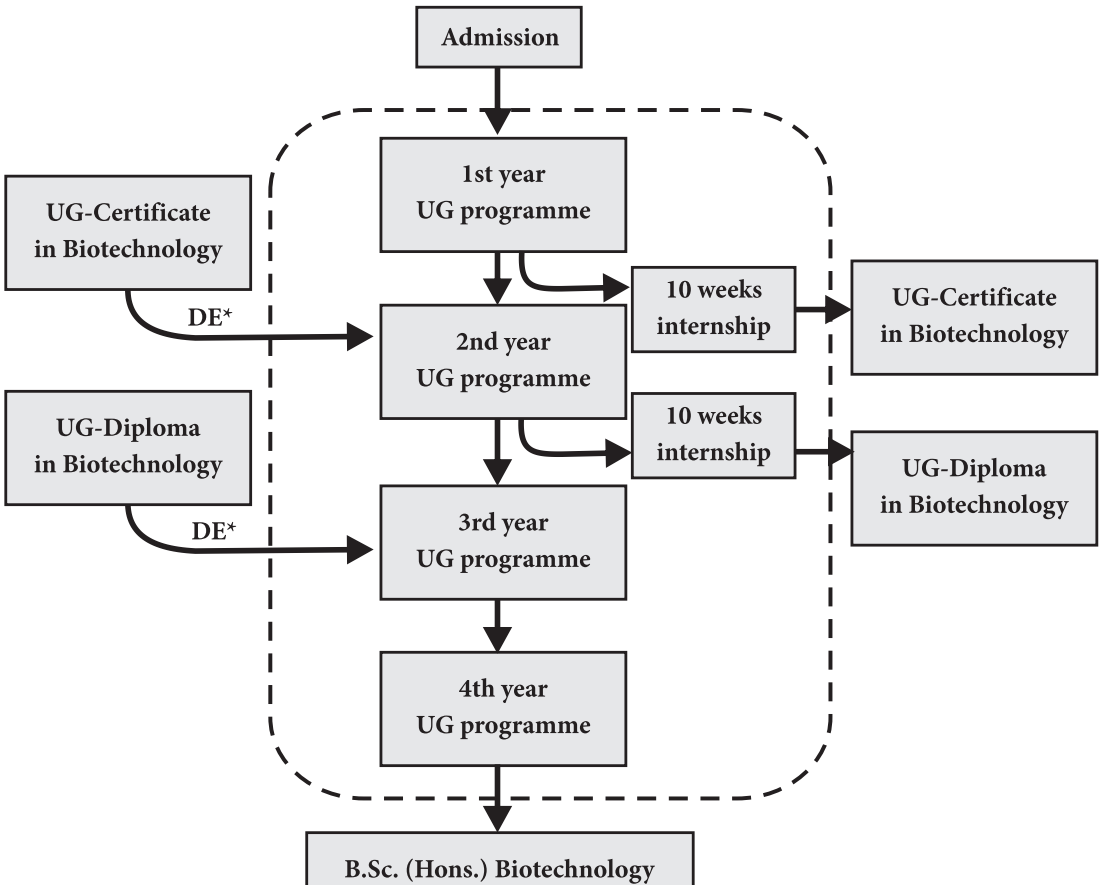


Fig. 1. Entry and exit options for the UG program in Biotechnology.
DE* Direct Entry in the respective year

Exit options

- **UG-Certificate in Biotechnology:** Exit after the first year and completion of a 10-week internship.
- **UG-Diploma in Biotechnology**: Exit after the second year and completion of a 10-week internship.
- **B. Tech. (Biotechnology):** On successful completion of four-year degree requirements.

Admission eligibility in 1st year UG programme : 10+2 or intermediate with Physics, Chemistry, Mathematics Biology from a recognized Central/State/Board/University as per the criteria decided by the ICAR/ SAU/HAEI.

ACADEMIC PROGRAMME
Semester-Wise Course Distribution

S. No.	Course Title	Credit Hours	Total Credit hours
	First Year		
	Semester I		
1.	*Deeksharambh* (Induction-Cum-Foundation Course)	2 (0+2) NG Non-gradial	
2.	Molecular Biology	3 (3+0)	21 (14+7) +2 Non-gradial
3.	Introductory Cell Biology	3 (3+0)	
4.	Fundamentals of Genetics	3 (3+0)	
5.	Basic Mathematics/Basic Botany/Basic Zoology	2 (2+0)	
6.	Farming Based Livelihood Systems	3 (2+1)	
7.	National Cadet Corps I/ National Service Scheme I	1 (0+1)	
8.	Communication Skills	2 (1+1)	
9.	SEC 1: Practices in Plant Tissue Culture/ Practices in Animal Cell Culture	2 (0+2)	
10.	SEC 2: Laboratory Management and Instrumentation	2 (0+2)	
	Semester II		
1.	Introduction to Biotechnology	3 (3+0)	**21 (11+10)**
2.	Introduction to Plant Breeding	3 (2+1)	
3.	Elementary Microbiology	2 (1+1)	
4.	Entrepreneurship Development and Business Management	3 (2+1)	
5.	Environmental Studies and Disaster Management	3 (2+1)	
6.	National Cadet Corps II/ National Service Scheme II	1 (0+1)	
7.	Personality Development	2 (1+1)	
8.	SEC 3: Basic Techniques of Molecular Biology and Biotechnology	2 (0+2)	
9.	SEC 4: Bioinformatics and Biocomputation	2 (0+2)	
	Post-Semester II (Only for exit option for award of UG-Certificate in Biotechnology)		
1	Internship (10 weeks)	10 (0+10)	
	Second Year		
	Semester III		
1.	Livestock Production and Management	3 (2+1)	**20 (12+8)**
2.	Recombinant DNA Technology	2 (2+0)	
3.	Classical and Molecular Cytogenetics	3 (2+1)	
4.	Plant Physiology/Anatomy and Physiology of Livestock	3 (2+1)	
5.	Fundamentals of Crop Protection/ Livestock Product Technology	3 (2+1)	
6.	Biomathematics	2 (2+0)	
7.	Physical Education, First Aid, Yoga Practices and Meditation	2 (0+2)	
8.	SEC 5: Methods in Recombinant DNA Technology	2 (0+2)	

Semester IV			
1.	Introductory Bioinformatics	4 (3+1)	**21 (15+6)**
2.	Molecular Marker Technology	2 (2+0)	
3.	Biodiversity and Its Conservation	2 (2+0)	
4.	Basic Biochemistry	4 (3+1)	
5.	Human Ethics	1 (1+0)	
6.	Agriculture Marketing and Trade	3 (2+1)	
7.	Agricultural Informatics and Artificial Intelligence	3 (2+1)	
8.	SEC 6: Practices in Molecular Marker Technology	2 (0+2)	
Post-Semester IV* (Only For exit option for UG-Diploma in Biotechnology)			
1	Internship (10 weeks)	10 (0+10)	
Third Year			
Semester V			
1.	Microbial Genetics	4 (3+1)	**23 (18+5) +2 (Non-gradial)**
2.	Molecular Genetics	3 (3+0)	
3.	Nanobiotechnology	4 (3+1)	
4.	Animal Biotechnology	3 (2+1)	
5.	Genomics and Proteomics	3 (3+0)	
6.	Enzymology and Enzyme Technologies	3 (2+1)	
7.	Immunology	3 (2+1)	
8.	Study Tour (10-14 days)	2 (0+2) NG	
Semester VI			
1.	Molecular Diagnostics	3 (2+1)	**21 (16+5)**
2.	Industrial Biotechnology	3 (3+0)	
3.	Epigenetics and Gene Regulation	2 (2+0)	
4.	IPR, Biosafety and Bioethics	2 (2+0)	
5.	Computational Biology	3 (2+1)	
6.	Introduction to Animal Breeding	3 (2+1)	
7.	Biostatistics	2 (1+1)	
8.	Food Science and Processing	3 (2+1)	
Fourth Year			
Semester VII			
Elective I. Plant Biotechnology			
1.	Applications of Genomics and Proteomics	4 (3+1)	**20 (14+6)**
2.	Principles of Molecular Breeding	4 (3+1)	
3.	Principles and Procedures of Plant Tissue Culture	3 (2+1)	
4.	Molecular Breeding in Field and Horticultural Crops	3 (2+1)	
5.	Seed Biology, Biotechnology, Production and Management	3 (2+1)	
6.	Plant Genetic Transformation	3 (2+1)	

Elective II. Animal Biotechnology			
1.	Principles and Procedures of Animal Cell Culture	4 (3+1)	**20 (15+5)**
2.	Animal Genomics	4 (3+1)	
3.	Transgenic Animal Production	3 (3+0)	
4.	Molecular Virology and Vaccine Production	3 (2+1)	
5.	Embryo Transfer Technologies	3 (2+1)	
6.	Animal Reproductive Biotechnology	3 (2+1)	
Elective III. Microbial and Environmental Biotechnology			
1.	Fundamentals of Molecular Pharming and Biopharmaceuticals	4 (3+1)	**20 (16+4)**
2.	Microbial Biotechnology	4 (3+1)	
3.	Bioprospecting of Genes and Molecules	3 (3+0)	
4.	Molecular Ecology and Evolution	3 (3+0)	
5.	Food Biotechnology	3 (2+1)	
6.	Green Biotechnology	3 (2+1)	
Elective IV. Bioinformatics			
1.	Programming in Bioinformatics	4 (2+2)	**20 (13+7)**
2.	Bioinformatics Tools and Biological Databases	3 (2+1)	
3.	Structural Bioinformatics	3 (2+1)	
4.	Pharmacogenomics	3 (2+1)	
5.	Metabolomics and Systems Biology	4 (3+1)	
6.	Computational Methods for Data Analysis	3 (2+1)	
Semester VIII			
1.	Student READY (RAWE/industry attachment/experiential learning/hands on training/project work/internship) in the area of Plant Biotechnology, Animal Biotechnology, Microbial and Environmental Biotechnology and Bioinformatics	20 (0+20)	**20 (0+20)**

Department-Wise Course Breakup

S. No	Department-wise Courses	Credit Hours
Agriculture Courses		
1.	Farming Based Livelihood Systems	3 (2+1)
2.	Introduction to Plant Breeding	3 (2+1)
3.	Fundamentals of Crop Protection	3 (2+1)
4.	Agriculture Marketing and Trade	3 (2+1)
Animal Science Courses		
1.	Livestock Production and Management	3 (2+1)
2.	Anatomy and Physiology of Livestock	3 (2+1)
3.	Livestock Product Technology	3 (2+1)
4.	Introduction to Animal Breeding	3 (2+1)

S. No	Department-wise Courses	Credit Hours
Basic Science Courses		
1.	Plant Physiology	3 (2+1)
2.	Biomathematics	2 (2+0)
3.	Basic Biochemistry	4 (3+1)
4.	Enzymology and Enzyme Technologies	3 (2+1)
5.	Immunology	3 (2+1)
6.	Biostatistics	2 (1+1)
Biotechnology Core Courses		
1.	Molecular Biology	3 (3+0)
2.	Introductory Cell Biology	3 (3+0)
3.	Fundamentals of Genetics	3 (3+0)
4.	Practices in Plant Tissue Culture	2 (0+2)
5.	Practices in Animal cell Culture	2 (0+2)
6.	Laboratory Management and Instrumentation	2 (0+2)
7.	Introduction to Biotechnology	3 (3+0)
8.	Elementary Microbiology	2 (1+1)
9.	Basic Techniques of Molecular Biology and Biotechnology	2 (0+2)
10.	Bioinformatics and Biocomputation	2 (0+2)
11.	Recombinant DNA Technology	2 (2+0)
12.	Classical and Molecular Cytogenetics	3 (2+1)
13.	Methods in Recombinant DNA Technology	2 (0+2)
14.	Introductory Bioinformatics	4 (3+1)
15.	Molecular Marker Technology	2 (2+0)
16.	Biodiversity and Its Conservation	2 (2+0)
17.	Practices in Molecular Marker Technology	2 (0+2)
18.	Microbial Genetics	4 (3+1)
19.	Molecular Genetics	3 (3+0)
20.	Nanobiotechnology	4 (3+1)
21.	Animal Biotechnology	3 (2+1)
22.	Genomics and Proteomics	3 (3+0)
23.	Molecular Diagnostics	3 (2+1)
24.	Industrial Biotechnology	3 (3+0)
25.	Epigenetics and Gene Regulation	2 (2+0)
26.	IPR, Biosafety and Bioethics	2 (2+0)
27.	Applications of Genomics and Proteomics	4 (3+1)
28.	Principles of Molecular Breeding	4 (3+1)
29.	Principles and Procedures of Plant Tissue Culture	3 (2+1)
30.	Molecular Breeding in Field and Horticultural Crops	3 (2+1)
31.	Seed Biology, Biotechnology, Production and Management	3 (2+1)

S. No	Department-wise Courses	Credit Hours
32.	Plant Genetic Transformation	3 (2+1)
33.	Principles and Procedures of Animal Cell Culture	4 (3+1)
34.	Animal Genomics	4 (3+1)
35.	Transgenic Animal Production	3 (3+0)
36.	Molecular Virology and Vaccine Production	3 (2+1)
37.	Embryo Transfer Technologies	3 (2+1)
38.	Animal Reproductive Biotechnology	3 (2+1)
39.	Fundamentals of Molecular Pharming and Biopharmaceuticals	4 (3+1)
40.	Microbial Biotechnology	4 (3+1)
41.	Bioprospecting of Genes and Molecules	3 (3+0)
42.	Molecular Ecology and Evolution	3 (3+0)
43.	Food Biotechnology	3 (2+1)
44.	Green Biotechnology	3 (2+1)
45.	Programming in Bioinformatics	4 (2+2)
46.	Bioinformatics Tools and Biological Databases	3 (2+1)
47.	Structural Bioinformatics	3 (2+1)
48.	Pharmacogenomics	3 (2+1)
49.	Metabolomics and Systems Biology	4 (3+1)
50.	Computational Methods for Data Analysis	3 (2+1)
Deficiency/Remedial Courses		
1.	Basic Mathematics	2 (2+0)
2.	Basic Botany	2 (2+0)
3.	Basic Zoology	2 (2+0)
General Courses		
1.	National Cadet Corps I/ National Service Scheme I	1 (0+1)
2.	Communication Skill	2 (1+1)
3.	Entrepreneurship Development and Business Management	3 (2+1)
4.	Environmental Studies and Disaster Management	3 (2+1)
5.	National Cadet Corps II/ National Service Scheme II	1 (0+1)
6.	Personality Development	2 (1+1)
7.	Physical Education, First, Aid, Yoga Practice & Meditation	2 (0+2)
8.	Human Ethics	1 (1+0)
9.	Agriculture Informatics & Artificial Intelligence	3 (2+1)
10.	Computational Biology	3 (2+1)
11.	Food Science and Processing	3 (2+1)
Student READY		**20 (0+20)**
Non-gradial Courses		
1.	*Deeksharambh* (Induction-Cum-Foundation Course)	2 (0+2)

S. No	Department-wise Courses	Credit Hours
2.	Educational Tour	2 (0+2)
MOOCs/Online Courses		**10 (0+10)**

*Massive Open Online Courses

Summary of Credit Hours for Different Categories of Courses

S. No.	Major Courses	Credit Hours	Total Credit Hours
1	Molecular Biology	3 (3+0)	**60 (51+9)**
2	Introductory Cell Biology	3 (3+0)	
3	Fundamentals of Genetics	3 (3+0)	
4	Introduction to Biotechnology	3 (3+0)	
5	Introduction to Plant Breeding	3 (2+1)	
6	Elementary Microbiology	2 (1+1)	
7	Livestock Production and Management	3 (2+1)	
8	Recombinant DNA Technology	2 (2+0)	
9	Classical and Molecular Cytogenetics	3 (2+1)	
10	Introductory Bioinformatics	4 (3+1)	
11	Molecular Marker Technology	2 (2+0)	
12	Biodiversity and Its Conservation	2 (2+0)	
13	Microbial Genetics	4 (3+1)	
14	Molecular Genetics	3 (3+0)	
15	Nanobiotechnology	4 (3+1)	
16	Animal Biotechnology	3 (2+1)	
17	Genomics and Proteomics	3 (3+0)	
18	Molecular Diagnostics	3 (2+1)	
19	Industrial Biotechnology	3 (3+0)	
20	Epigenetics and Gene Regulation	2 (2+0)	
21	IPR, Biosafety and Bioethics	2 (2+0)	
Minor Courses			
1	Basic Mathematics/Basic Botany/Basic Zoology	2 (2+0)	**32 (23+9)**
2	Plant Physiology/Anatomy and Physiology of Livestock	3 (2+1)	
3	Fundamentals of Crop Protection/Livestock Product Technology	3 (2+1)	
4	Biomathematics	2 (2+0)	
5	Basic Biochemistry	4 (3+1)	
6	Human Ethics	1 (1+0)	
7	Enzymology and Enzyme Technologies	3 (2+1)	
8	Immunology	3 (2+1)	

9	Computational Biology	3 (2+1)	
10	Introduction to Animal Breeding	3 (2+1)	
11	Biostatistics	2 (1+1)	
12	Food Science and Processing	3 (2+1)	
Multi-Disciplinary Courses			
1	Farming Based Livelihood Systems	3 (2+1)	**9 (6+3)**
2	Entrepreneurship Development and Business Management	3 (2+1)	
3	Agriculture Marketing and Trade	3 (2+1)	
Value Added Courses			
1	Environmental Studies and Disaster Management	3 (2+1)	**6 (4+2)**
2	Agriculture Informatics & Artificial Intelligence	3 (2+1)	
Ability Enhancement Courses			
1	National Cadet Corps I/ National Service Scheme I (NCC-I/NSS-I)	1 (0+1)	**8 (2+6)**
2	Communication Skill	2 (1+1)	
3	National Cadet Corps II/ National Service Scheme II (NCC-II/NSS-II)	1 (0+1)	
4	Personality Development	2 (1+1)	
5	Physical Education, First Aid, Yoga Practices and Meditation	2 (0+2)	
Skill Enhancement Courses (SEC)			
1	SEC 1: Practices in Plant Tissue Culture/ Practices in Animal Cell Culture	2 (0+2)	**12 (0+12)**
2	SEC 2: Laboratory Management and Instrumentation	2 (0+2)	
3	SEC 3: Basic Techniques of Molecular Biology and Biotechnology	2 (0+2)	
4	SEC 4: Bioinformatics and Biocomputation	2 (0+2)	
5	SEC 5: Practices in Recombinant DNA Technology	2 (0+2)	
6	SEC 6: Practices in Molecular Marker Technology	2 (0+2)	
Elective Courses in Plant Biotechnology			
1	Applications of Genomics and Proteomics	4 (3+1)	**20 (14+6)**
2	Principles of Molecular Breeding	4 (3+1)	
3	Principles and Procedures of Plant Tissue Culture	3 (2+1)	
4	Molecular Breeding in Field and Horticultural Crops	3 (2+1)	
5	Seed Biology, Biotechnology, Production and Management	3 (2+1)	
6	Plant Genetic Transformation	3 (2+1)	
Elective Courses in Animal Biotechnology			
1	Principles and Procedures of Animal Cell Culture	4 (3+1)	**20 (15+5)**
2	Animal Genomics	4 (3+1)	
3	Transgenic Animal Production	3 (3+0)	
4	Molecular Virology and Vaccine Production	3 (2+1)	

5	Embryo Transfer Technologies	3 (2+1)	
6	Animal Reproductive Biotechnology	3 (2+1)	
Elective Courses in Microbial and Environmental Biotechnology			
1	Fundamentals of Molecular Pharming and Biopharmaceuticals	4 (3+1)	**20 (16+4)**
2	Microbial Biotechnology	4 (3+1)	
3	Bioprospecting of Molecules and Genes	3 (3+0)	
4	Molecular Ecology and Evolution	3 (3+0)	
5	Food Biotechnology	3 (2+1)	
6	Green Biotechnology	3 (2+1)	
Elective Courses in Bioinformatics			
1	Programming in Bioinformatics	4 (2+2)	**20 (13+7)**
2	Bioinformatics Tools and Biological Databases	3 (2+1)	
3	Structural Bioinformatics	3 (2+1)	
4	Pharmacogenomics	3 (2+1)	
5	Metabolomics and Systems Biology	4 (3+1)	
6	Computational Methods for Data Analysis	3 (2+1)	
Student READY			**20**
Non-gradial Courses			
1	Deeksharambh (Induction-Cum-Foundation Course)	2 (0+2)	**4 (0+4)**
2	Educational Tour	2 (0+2)	
MOOCs/Online Courses			**10**

Abstract of Credit Hour Allocation over the Semesters (Credit Hours)

Semester	Core Courses (Major+ Minor)	Multi-Disciplinary Courses (MDC)	Value Added Courses (VAC)	Ability Enhancement Courses (AEC)	Skill Enhancement Courses (SEC)	Internship/ Project/ Student READY	Total Credit Hours	Non-gradial	MOOCs/ Online Courses
I	11	$3^{(1)}$		$1^{(2)} + 2^{(3)}$	$4^{(4,5)}$	-	21	$2^{(6)}$	10
II	8	$3^{(7)}$	$3^{(8)}$	$1^{(9)} + 2^{(10)}$	$4^{(11,12)}$	-	21	-	
Post-II	-	-	-	-	-	$10^{(13)}$	-	-	
III	16	-	-	$2^{(14)}$	$2^{(15)}$	-	20	-	
IV	13	$3^{(16)}$	$3^{(17)}$	-	$2^{(18)}$	-	21	-	
Post-IV	-	-	-	-	-	$10^{(19)}$	-	-	
V	23	-	-	-	-	-	23	$2^{(20)}$	
VI	21	-	-	-	-	-	21	-	
VII	20	-	-	-	-	-	20	-	
VIII	-	-	-	-	-	20	20	-	
Total	**112**	**9**	**6**	**8**	**12**	**20**	**167**	**4**	**10**

Note: The credit hours indicated represent the combined total of theory and practical components.

(1) Farming Based Livelihood Systems
(2) National Cadet Corps I/ National Service Scheme I
(3) Communication Skills
(4) Practices in Plant Tissue Culture/ Practices in Animal Cell Culture
(5) Laboratory Management and Instrumentation
(6) *Deeksharambh* (Induction-Cum-Foundation Course)
(7) Entrepreneurship Development and Business Management
(8) Environmental Studies and Disaster Management
(9) National Cadet Corps II/ National Service Scheme II
(10) Personality Development
(11) Basic Techniques of Molecular Biology and Biotechnology
(12) Bioinformatics and Biocomputation
(13) Internship for those exiting with UG-Certificate in Biotechnology
(14) Physical Education, First Aid, Yoga Practices and Meditation
(15) Practices in Recombinant DNA Technology
(16) Agriculture Marketing and Trade
(17) Agricultural Informatics and Artificial Intelligence
(18) Practices in Molecular Marker Technology
(19) Internship for those exiting with UG-Diploma in Biotechnology
(20) Study Tour (10-14 days)

Summary of Credit Distributions

Categories of Courses		Credit Hours
Core Courses (Major and Minor)	:	92
Common Courses (MDC+VAC+AEC)	:	23
Skill Enhancement Courses (SEC)	:	12
Elective Courses	:	20
Student READY (RAWE/Industrial Attachment /Experiential Learning/Hands-on Training/Skill Development/Project Work/Internship etc.)	:	20
MOOCs/Online Courses (Non-gradial)	:	10**
Grand Total	**:**	**167+10****

*Massive Open Online Courses

Detailed Syllabi
Semester I

Deeksharambh (Induction-cum-Foundation Course)- Non-gradial 2 (0+2)

The activities to be taken under *Deeksharambh* shall aim at creating a platform for students to

1. Help for cultural Integration of students from different backgrounds
2. Know about the operational framework of academic process in university
3. Instilling life and social skills
4. Social Awareness, Ethics and Values, Team Work, Leadership, Creativity, etc.
5. Identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario.
6. The details of activities will be decided by the parent universities. The structure shall include, but not restricted to:
    i. Discussions on operational framework of academic process in university, as well as interactions with academic and research managers of the University
    ii. Interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences
    iii. Group activities to identify the strength and weakness of students (with expert advice for their improvement) as well as to create a platform for students to learn from each other's life experiences
    iv. Activities to enhance cultural Integration of students from different backgrounds.
    v. Field visits to related fields/ establishments
    vi. Sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills.

Molecular Biology 3 (3+0)

Objectives

i. To study the principles and techniques of molecular biology
ii. To study the central dogma of life
iii. To study the tools in molecular biology

Theory

History of molecular biology. Central dogma of life. Structure of DNA and RNA. Gene structure and function. DNA replication and transcription. Genetic code and translation. Structure of prokaryotic and eukaryotic nuclear and organelle genomes. Gene regulation in prokaryotes. Lac operon concept and tryp operon concept.

Introduction to microbial genetics; conjugation, transformation and transduction. Tools in molecular biology. Role of enzymes in molecular biology. Principles of Polymerase Chain Reaction and electrophoresis.

Suggested Readings

1. Cooper G M and Hausman R E. 2018. *The Cell: A Molecular Approach*. (8th Edn.), Sinauer Associates Inc.
2. Kharade S. 2024. *Molecular Biology: Central Dogma*. LAP LAMBERT Academic Publishing, Saarbrücken, Germany.

3. Lewin B. 2017. *Gene XII*, Oxford University Press.
4. Nelson D L and Cox M M. 2017. *Lehninger principles of biochemistry*. (7th Edn), W. H. Freeman.
5. Satyanarayana U and Chakrapani U. 2021. *Essentials of Biochemistry*. Elsevier.

Introductory Cell Biology 3 (3+0)

Objectives

i. To study the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles
ii. To understand how these cellular components are used to generate and utilize energy in cells
3. To understand the cellular components underlying mitotic cell division
4. To apply their knowledge of cell biology to selected examples of changes or losses in cell function. These can include responses to environmental or physiological changes, or alterations of cell function brought about by mutation.

Theory

Origin and evolution of cell. Introduction to microscopy. Sub-cellular structure of prokaryotic and eukaryotic cells. Membrane structure and function: plasma membrane, cell wall and extracellular matrix. Structural organization and function of intracellular organelles and organelle biogenesis. Nucleus, mitochondria, endoplasmic reticulum, golgi apparatus, lysosomes, peroxisomes, plastids and vacuoles.

Structure and function of the cytoskeleton and its role in motility. Cell membrane transport. Introduction to cell signalling. Cell growth, cell cycle and its control. Cell death and cell renewal.

Suggested Readings

1. Alberts B, Bray D, Hopkin K, Johnson A D, Lewis J, Raff M, Roberts K and Walter P. 2019. *Essential Cell Biology*. (5th Edn.) W.W. Norton & Company, New York, NY, USA.
2. Cooper G M and Hausman R E. 2018. *The Cell: A Molecular Approach*. Sinauer Associates Inc.
3. Dalton L and Young R. 2024. *Fundamentals of Cell Biology*. Oregon State University, Corvallis, OR, USA.
4. Verma P S and Agarwal V K. 2016. *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*. S Chand and Sons.

Fundamentals of Genetics 3 (3+0)

Objectives

i. To study the history of genetics
ii. To study inheritance and variation
iii. To study chromosomes and cell division
iv. To study the genetic basis of traits

Theory

History of Genetics. Mendel's principles and rediscovery. Cell division. Chromosome structure and function. Chromosome theory of inheritance. Sex-linked, sex-limited and sex-influenced inheritance. Sex determination and sex differentiation.

Multiple allelism. Linkage and crossing-over. Gene-gene interaction. Genetic analysis in prokaryotes and eukaryotes. Extra chromosomal inheritance. Mutations. Hardy-Weinberg law. Quantitative inheritance. Introduction to human genetics. Genetic basis of evolution.

Suggested Readings

1. Brah G S. 2014. *Animal Genetics: Concepts and Implications*. (2nd Edn.). 424p. Kalyani Publishers, Ludhiana.
2. Gardener E J, Simmons M J and Snustad D P. 1991. *Principles of Genetics*. John Wiley and Sons, Inc, New York, USA.
3. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India.

Basic Mathematics 2 (2+0)

Objectives

i. To study the basic principles and functions in mathematics like limits and continuity
ii. To study differentiation and integration
iii. To study matrices and determinants

Theory

Functions; Limit: Introduction, left-handed and right-handed limits, general rules for the calculation of limits Standard limits. Continuity: Definition of continuity, continuity of algebraic functions. Continuity of trigonometric and exponential functions.

Differentiation: Differentiation by the first principle, sum, difference, product and quotient formulae, differentiation using the chain rule, differentiation of functions in parametric and implicit form, logarithmic differentiation, geometrical interpretation of derivative. Successive differentiation, geometrical interpretation of derivative, maxima and minima, tangent and normal.

Integration: Integration by substitution, integration by partial fractions, integration by parts, integration by trigonometric substitution.

Matrices and Determinants: Definition of matrix, addition, subtraction and multiplication, inverse of matrix. Solution of linear equations; by Crammer's rule and inverse of matrix.

Suggested Readings

1. Bhatia K N and Tyagi M P. 2020. *Elementary Biology*. Truemen Publication.
2. Chopra G and Dhami P S. 2021. *A Text Book of Biology*. Pradeep Publications.
3. David M H, Craig H H, Sally D H, David W H and David E S. 2020. *Life: the science of biology*. (12th Edn.), Sunderland Publication.
4. NCERT. 2022. *Biology of Class XI*. NCERT, India.
5. Trivieri L A. 2024. *Basic Mathematics*. Collins College Outlines. HarperCollins, New York, USA.

Basic Botany 2 (2+0)

Objectives

i. To study the basic taxonomy and classification of plants
ii. To study the features of plant kingdom and morphology
iii. To study the internal structure of plants

Theory

Plant kingdom and features of each group. Morphology, modifications and functions of root, stem, leaf, flower and inflorescence. Pollination and fertilization. Fruit types. Structure of dicot and monocot seed, and seed germination. Cell structure. DNA, chromosome and genes. Cell and tissue types. Internal structure of root, stem and leaf. Plant taxonomy, systems of classification. Characteristics and economic importance of Poaceae, Brassicaceae, Fabaceae, Malvaceae, Rutaceae, Rosaceae, Asteraceae and Solanaceae families.

Suggested Readings

1. Bendre A M and Kumar A. 1999. *Textbook of Practical Botany*. Vol. 2, (7th Edn.), Rastogi Publications.
2. Bendre A M and Pande P C. 2009. *Introduction to Botany*. Rastogi publications.
3. Bhatia K N and Tyagi M P. 2020. *Elementary Biology*. A truemen publication.
4. David M H, Craig H H, Sally D. Hacker, David W Hall and David E Sadava. 2020. *Life: The Science of Biology*. (12th Edn.), Sunderland Publications (eBook).
5. Dutta A C. 1995. *A Class Book of Botany*. (16th Edn.), Oxford University Press.
6. Michaels T, Hoover E and Hill H. 2021. *The Science of Plants*. University of Minnesota Libraries Publishing, Minneapolis, MN, USA.
7. NCERT. 2021. *Biology of Class XI*. NCERT, India.
8. Pande P C and Jain D K. 2022. *A textbook of Botany Angiosperm*. S. Chand publications.

Basic Zoology 2 (2+0)

Objectives

i. To study cells and biomolecules
ii. To study animal kingdom and nomenclature
iii. To study the organization of mammalian systems

Theory

Introduction to Zoology. Structure and functions of cell and cell organelles. Difference between prokaryotic and eukaryotic cell. Structure and function of biomolecules. Types of simple and compound tissues.

Binomial nomenclature. Classification and general survey of the animal kingdom. Functional organization of various systems of a mammal; digestive, circulatory, respiratory, excretory, nervous and reproductive. Laws of inheritance. Multipleallelism - blood groups. Genetic disorders in human and their inheritance.

Suggested Readings

1. Bhatia K N and Tyagi M P. 2020. *Elementary Biology*. A Truemen Publication.
2. Chopra G and Dhami P S. 2021. *A Text Book of Biology*, Pradeep Publications.
3. David M H, Craig H H, Sally D Hacker, David W Hall and David E Sadava. 2020. *Life: The Science of Biology*. (12th Edn.), Sunderland Publications (eBook).
4. Hickman C P Jr., Roberts L S, Keen S L, Larson A, I'Anson H and Eisenhour D J. 2019. *Integrated Principles of Zoology*. (18th Edn.), McGraw-Hill Education, New York, NY, USA.
5. Miller S A and Harley J B. 2018. *Zoology*. (11th Edn.), McGraw-Hill Education, New York, NY, USA.
6. NCERT. 2022. *Biology of Class XI*, NCERT, India.
7. Springer J T and Holley D. 2012. *An Introduction to Zoology: Investigating the Animal World*. Jones & Bartlett Learning, Burlington, MA, USA.

Farming Based Livelihood Systems 3 (2+1)

Objectives

i. To make the students aware about farming based livelihood systems in agriculture

ii. To disseminate the knowledge and skill how farming based systems can be a source of livelihood

Theory

Status of agriculture in India and different states. Income of farmers and rural people in India. Livelihood-definition, concept and livelihood pattern in urban and rural areas. Different indicators to study livelihood systems. Agricultural livelihood systems (ALS); meaning, approach, approaches and framework. Definition of farming systems and farming based livelihood systems prevalent farming systems in India contributing to livelihood. Types of traditional and modern farming systems. Components of farming system/ farming-based livelihood systems- crops and cropping systems, livestock, (dairy, piggery, goatry, poultry, duckry etc.). Horticultural crops, agroforestry systems, aquaculture, duck/poultry cum fish, dairy cum fish, piggery cum fish etc. Small, medium and large enterprises including value chains and secondary enterprises as livelihood components for farmers. Factors affecting integration of various enterprises of farming for livelihood. Feasibility of different farming systems for different agro-climatic zones. Commercial farming-based livelihood models by NABARD, ICAR and other organizations across the country. Case studies on different livelihood enterprises associated with the farming. Risk and success factors in farming-based livelihood systems. Schemes and program by central and state government, public and private organizations involved in promotion of farming-based livelihood opportunities. Role of farming-based livelihood enterprises in 21st century in view of circular economy, green economy, climate change, digitalization and changing life style.

Practical

Survey of farming systems and agriculture-based livelihood enterprises. Study of components of important farming-based livelihood models/ systems in different agro-climatic zones. Study of production and profitability of crop based, livestock based, processing based and integrated farming-based livelihood models. Field visit of innovative farming system models. Visit of agri-based enterprises and their functional aspects for integration of production, processing and distribution sectors and study of agri-enterprises involved in industry and service sectors (value chain models).

Learning about concept of project formulation on farming-based livelihood systems along with cost and profit analysis. Case study of start-ups in agri-sectors.

Suggested Readings

1. Agarwal A and Narain S. 1989. *Towards Green Villages: A strategy for Environmentally, Sound and Participatory Rural Development*. Center for Science and Environment, New Delhi, India.
2. Ashley C and Carney D. 1999. *Sustainable Livelihoods: Lessons from Early Experience; Department for International Development*: London, UK, Volume 7.
3. Bhatt B P, Kumar Abhay, Thakur P K, U K Amitava Dey, Kumar Sanjeev, Jha B K, Kumar Lokendra, Pathak K N, Hassan A, Singh S K, Singh K K and Singh K M. 2014. *Livelihood Improvement of Underprivileged Farming Community: Some Experiences from Vaishali, Samastipur, Darbhanga and Munger Districts of Bihar*. ICAR Research Complex for Eastern Region ICAR Parisar, P.O. Bihar Veterinary College, Patna - 800 014, Bihar.
4. Carloni A. 2001. *Global Farming Systems Study: Challenges and Priorities to 2030 – Regional Analysis: Sub-Saharan Africa*. Consultation Document, FAO, Rome, Italy.
5. Dixon J, Gulliver A and Gibbon D. 2001. *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World*. FAO & World Bank, Rome, Italy & Washington, DC, USA.
6. Evenson R E. 2000. *Agricultural Productivity and Production in Developing Countries*. FAO, Rome, Italy.
7. Panwar A S, Ravisankar N, Prusty A K, Shamim M, Singh R, Bhaskar S, Malik S K, Tomar R K, Arunachalam A and Alagusundaram K. 2019. *Integrated Farming System Models for Agricultural Diversification, Enhanced Income and Employment*. ICAR, New Delhi, India.
8. Reddy S R. 2016. *Farming System and Sustainable Agriculture*, Kalyani Publishers, New Delhi, India.
9. Singh J P, Ravisankar N, Prusty A K, Sikka A K and Gangwar B. 2016. *Region Specific Synthesized Integrated Farming System Models for Improved Production, Profitability and Nutrition* (Series 1). IIFSR Bulletin No. 2016-1, AICRP on Integrated Farming Systems, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut.
10. Walia S S and Walia U S. 2020. *Farming System and Sustainable Agriculture*. Scientific Publishers, Jodhpur, Rajasthan.
11. Chavan K. 2024. *Farming Based Livelihood Systems*. Pustakmarket Publication.
12. Mounika Leena C H, Chaithanya L K, Saurav S K and Sajjan R. 2024. *Agriculture Based Livelihood Systems in Drylands: Challenges and Strategies*. International Journal of Agriculture Environment and Biotechnology, 17(3):645-652.

National Cadet Corps (NCC-I) 1 (0+1)

Objectives

i. To develop qualities of character, courage, comradeship, discipline, leadership, secular outlook, spirit of adventure and sportsmanship and the ideals of selfless service among the youth to make them useful citizen

ii. To create a human resource of organized trained and motivated youth to provide leadership in all walks of life including the Armed Forces and be always available for the service of the nation

Practical

Aims, objectives, organization of National Cadet Corps (NCC) and NCC song. DG's cardinals of discipline. Drill- aim, general words of command, attention, stands at ease, stand easy and turning. Sizing, numbering, forming in three ranks, open and close order march, and dressing. Saluting at the halt, getting on parade, dismissing, and falling out. Marching, length of pace, and time of marching in quick/slow time and halt. Side pace, pace forward and to the rear. Turning on the march and wheeling. Saluting on the march. Marking time, forward march, and halt. Changing step, formation of squad and squad drill. Command and control, organization, badges of rank, honours, and awards.

Nation Building- cultural heritage, religions, traditions, and customs of India. National integration. Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizens. Leadership traits, types of leadership. Character/personality development. Civil defense organization, types of emergencies, firefighting, protection. Maintenance of essential services, disaster management, aid during development projects. Basics of social service, weaker sections of society and their needs, NGO's and their contribution, contribution of youth towards social welfare and family planning. Structure and function of human body, diet and exercise, hygiene and sanitation. Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health. Adventure activities. Basic principles of ecology, environmental conservation, pollution and its control.

National Service Scheme-I (NSS-I) 1 (0+1)

Objective

Evoking social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skillful in executing democratic leadership, developing skill in program, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

Practical

Orientation: history, objectives, principles, symbol, badge; regular programs under National Service Scheme (NSS). Organizational structure of NSS, Code of conduct for NSS volunteers, points to be considered by NSS volunteers' awareness about health. NSS program activities. Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analyzing guiding financial patterns of scheme, youth program/ schemes of GoI, coordination with different agencies and maintenance of diary. Understanding youth. Definition, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change. Community mobilization. Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership. Social harmony and national integration. Indian history and culture, role of youth in nation building, conflict resolution and peace- building. Volunteerism and *shramdaan.* Indian tradition of volunteerism, its need, importance, motivation, and constraints; shaman as part of volunteerism. Citizenship, constitution, and human rights. Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to information. Family and society. Concept of family, community (PRIs and other community-based organizations) and society.

Communication Skills 2 (1+1)

Objective

To acquire competence in oral, written and non-verbal communication, develop strong personal and professional communication and demonstrate positive group communication

Theory

Communication process: the magic of effective communication. Building self-esteem and overcoming fears. Concept, nature and significance of communication process. Meaning, types and models of communication. Verbal and non-verbal communication. Linguistic and non-linguistic barriers to communication and reasons behind communication gap/ miscommunication.

Basic communication skills. Listening, speaking, reading and writing skills. Precise writing/ abstracting/summarizing. Style of technical communication. Curriculum vitae/resume writing. Innovative methods to enhance vocabulary, analogy questions.

Structural and functional grammar. Sentence structure, modifiers, connecting words and verbal. Phrases and clauses. Case: subjective case, possessive case, objective case. Correct usage of nouns, pronouns and antecedents, adjectives, adverbs and articles. Agreement of verb with the subject: tense, mood, voice. Writing effective sentences. Basic sentence faults.

Practical

Listening and note taking. Writing skills; precise writing, summarizing and abstracting. Reading and comprehension (written and oral) of general and technical articles. Micro-presentations and impromptu presentations. Feedback on presentations. Stage manners; grooming, body language, voice modulation, speed. Group discussions. Public speaking exercises; vocabulary building exercises. Interview techniques. Organization of events.

Suggested Readings

1. Allport G W. 1937. *Personality: A Psychological Interpretation*. Holt, New York.
2. Brown M and Gyles B. 1994. *How to Interview and be Interviewed.* Sheldon Press, London.
3. Carnegie D. 1997. *The Quick and Easy Way to Effective Speaking.* Pocket Books, New York.
4. Floyd K. 2024. *Interpersonal Communication*. McGraw-Hill Education, New York, USA.
5. Francis Peter S J. 2012. *Soft Skills and Professional Communication*. Tata McGraw Hill, New Delhi, India.
6. Kumar S and Pushpa Lata. 2011. *Communication Skills.* Oxford University Press.
7. Neuliep J W. 2003. *Intercultural Communication A Contextual Approach*. Houghton Mifflin Co Boston.
8. Pease A. 1998. *Body Language*. Sudha Publications, Delhi.
9. Raman M and Singh P. 2000. *Business Communication*. Oxford University Press.
10. Seely J. 2013. *Oxford Guide to Effective Writing and Speaking*. Oxford University Press.
11. Thomson A J and Martinet A V. 1977. *A Practical English Grammar*. Oxford University.

Practices in Plant Tissue Culture 2 (0+2)

Objectives

i. To Impart hands-on training on the calculation of per cent solutions, molarity, molality, normality; and preparation of buffers

ii. To study basic equipments used in plant molecular biology and cell culture laboratories; washing, packing and sterilization of glass and plastic wares for cell culture

iii. Preparation of media and reagents for cell culture, primary culture technique, culture and sub-culturing of continuous cell lines, viability assay by trypan blue dye exclusion method, micropropagation, haploid production embryo rescue, cryopreservation of primary cultures and cell lines

iv. Preparation of phytohormones and sterilization

v. To Study tissue culture laboratory management

Practical

Laboratory safety and aseptic techniques, sterilization methods for equipment and media, media preparation, preparation of solid and liquid media, pH adjustment and sterilization of media. Culture initiation and explant selection. Selection of explants: meristem, node, leaf, embryo etc. Surface sterilization of plant material. Techniques for explant preparation and inoculation on to culture media. Callus induction and subculture. Subculture techniques: transfer of cultures to fresh media, monitoring and maintenance of cultures, organogenesis and embryogenesis. Micropropagation. Genetic transformation. Cryopreservation and conservation. Project Work: students design and conduct a small-scale tissue culture project. They will choose a plant species, select appropriate explants, culture them in vitro, and document the progress and results.

Suggested Readings

1. Bhojwani S S and Razdan M K. 1996. *Plant Tissue Culture: Theory and Practice*. Elsevier.
2. Khurana S M P and Kumar N. 2022. *Plant Biotechnology: A Textbook*. Scientific Publishers, Jodhpur.
3. Loyola-Vargas V M and Ochoa-Alejo N. 2021. *Plant Cell Culture Protocols*. (4th Edn.), Springer, New York, USA.
4. Reddy J. 2024. *Plant Tissue Culture*. Routledge, New York, USA.
5. Reinert J and Bajaj Y P S. 1989. *Applied and Fundamental Aspects of Plant Cell, Tissue, and Organ Culture*. Springer-Verlag.

Practices in Animal Cell Culture 2 (0+2)

Objectives

i. Washing of glasswares, packing and sterilization of glass and plasticware for cell culture

ii. Preparation of media and reagents for cell culture.

iii. Primary culture technique. Culture and sub-culturing of continuous cell lines. Viability assay by trypan blue dye exclusion method. Cryopreservation of primary cultures and cell lines.

iv. Tissue culture laboratory management.

Practical

Laboratory safety and aseptic techniques. Cell culture media and supplements. Composition of cell culture media: DMEM, RPMI, MEM, etc. Serum and serum-free media formulations. Preparation and sterilization of media supplements. Cell culture initiation and maintenance. Cell line authentication and characterization, Thawing and subculturing of cells. Monitoring cell growth and viability. Cell passaging and cryopreservation. Cell line development and authentication. Methods for establishing new cell lines. Authentication techniques: STR profiling, isoenzyme analysis, quality control measures in cell culture. Cell-based assays. Principles of cell-based assays: viability, proliferation, apoptosis, techniques for measuring cell responses: MTT assay, flow cytometry, ELISA. Application of cell-based assays in drug screening and toxicity testing. Transfection (lipofection, electroporation) and gene expression, 3D-cell culture and tissue engineering, cell culture project. Students design and conduct a small-scale cell culture project. They will choose a specific cell line or assay, culture cells accordingly, perform experiments, analyze data, and present their findings.

Suggested Readings

1. Al-Rubeai M. 2015. *Animal Cell Culture*. Springer International Publishing, ISBN: 978-3-319-10319-8, 978-3-319-10320-4.
2. Bhatia S, Naved T and Sardana S. 2019. *Introduction to Animal Tissue Culture Science*. IOP Publishing Ltd.
3. Butler M. 2004. *Animal Cell Culture and Technology*. Taylor and Francis, ISBN: 9781859960493, 1859960499.
4. Capes-Davis A. 2021. *Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications*. (8th Edn.), Wiley-Blackwell, Hoboken, NJ, USA.
5. Choudhary R K, Manu M and Malik Y S. 2025. *Animal Cell Culture*. NIPA, New Delhi, India.
6. Davis J M. 2011. *Animal Cell Culture: Essential Methods*. John Wiley and Sons, ISBN: 0470666587, 9780470666586.
7. Mani S, Singh M and Kumar A. 2023. *Animal Cell Culture: Principles and Practice*. Springer, Cham, Switzerland.
8. Michael B. 2003. *Animal Cell Culture and Technology*. THE BASICS (Garland Science).

Laboratory Management and Instrumentation 2 (0+2)

Objectives

i. To study the establishment and management of different molecular biology laboratories
ii. To impart hands-on training on good laboratory practices, calculation of per cent solutions, molarity, molality, normality; and preparation of buffers
iii. To study basic equipments used in animal molecular biology and cell culture laboratories, record keeping, teamwork, and SOP of different instruments of the labs
iv. Safe disposal of laboratory chemiclas and reagents as per the biosafety guidelines.

Practical

Importance of laboratory safety and regulatory compliance. Quality management systems: ISO 9001, GLP, GMP, laboratory safety and regulatory compliance. Risk assessment and hazard identification. Inventory management and equipment maintenance. Principles of laboratory inventory management. Equipment calibration and preventive maintenance. Documentation and record-keeping for regulatory compliance. Quality assurance and control. Introduction to

quality assurance (QA) and quality control (QC). Quality control checks for laboratory reagents and instruments, Troubleshooting common laboratory errors and deviations. Spectroscopy and spectrophotometry, applications in quantitative analysis and molecular biology. Chromatography techniques, microscopy and imaging. Molecular biology techniques. Instrumentation project: students design and conduct a small-scale project using one of the laboratory instruments covered in the course. They will collect data, analyze results, and present their findings.

Suggested Readings

1. Brown J K. 2011. *Biotechnology: A Laboratory Skills Course*. ISBN-13: 978-0983239604.
2. Fulekar M H and Pandey B. 2013. *Bioinstrumentation*. ISBN: 9789382332398.
3. Gakhar S K. Miglani M and Ashwani K. 2013. *Molecular Biology: A Laboratory Manual*. ISBN: 9789382332305.
4. Green M R and Sambrook J. 2012. *Molecular Cloning: A Laboratory Manual*. (4th Edn.), Cold Spring Harbor.
5. Khurana S M P and Kumar N. 2022. *Plant Biotechnology: A Textbook*. Scientific Publishers, Jodhpur.
6. Kreuzer H and Massey A. 2008. *Molecular Biology and Biotechnology: a guide for students*. (3rd Edn.), ASM Press.
7. Kumar S and Kaur S. 2024. *Basic Laboratory Skills*. NIPA, New Delhi, India.
8. Rapley R and Whitehouse D. 2015. *Molecular Biology and Biotechnology*. Royal Society of Chemistry.

Semester II

Introduction to Biotechnology 3 (3+0)

Objectives

i. To understand the basic concepts of molecular biology and methods used in the manipulation of nucleic acids to isolate and characterize genes

ii. To understand how molecular tools are used to modify an organism. To study the history, concepts and scope of biotechnology

iii. To study the applications of biotechnology

Theory

Introduction to genetic material, history of genetic material, physical and chemical basis of genetic material. Structure of DNA and RNA, scope and importance of Biotechnology. Plant, microbial, animal, medical, environmental, industrial. Marine, agricultural and food biotechnology. Nanobiotechnology.

Introduction to recombinant DNA technology. Vectors, DNA manipulating and modifying enzymes, gene cloning. Introduction to genomics and proteomics. Molecular markers, DNA sequencing. Genetic transformation and transgenic organisms. Bioinformatics. Biosafety guidelines.

Suggested Readings

1. Chawla H S. 2024. *Introduction to Plant Biotechnology*. (4th Edn.), CBS Publishers and Distributors Pvt. Ltd.
2. Khurana S M P and Kumar N. 2022. *Plant Biotechnology*. Scientific Publishers, Jodhpur.

3. Kumar A, Kapoor N, Kumar R, Sirohi A, Singh A and Upadhyay S. 2024. *Applications of Advanced Biotechnological Tools*. NIPA, New Delhi, India.
4. Singh B D. 2020. *Biotechnology Expanding Horizons*. Kalyani publishers.
5. Singh B Gautam S K, Chauhan M S and Singla S K. 2015. *Textbook of Animal Biotechnology*. The Energy and Resources Institute, TERI.
6. Singh B. D. 2022. *Plant Biotechnology*. (4th Edn.), MedTech Science Press.
7. Thieman W and Palladino M. 2018. *Introduction to Biotechnology (What's New in Biology)*. (4th Edn.), Pearson ISBN 0134650190, 9780134650197.

Introduction to Plant Breeding 3 (2+1)

Objectives

i. Development and goals of plant breeding
ii. Modes of reproduction
iii. Methods of plant breeding

Theory

History, aims and objectives of plant breeding. Role of related sciences in plant breeding. Modes of reproduction - sexual, asexual, apomixes and significance in plant breeding. Modes of pollination, genetic consequences, differences between self- and cross-pollinated crops. Germplasm resources and their utilization.

Methods of breeding: introduction and acclimatization. Selection: mass selection, Johannesen's pureline theory, genetic basis, pure-line selection. Hybridization: aims and objectives, types of hybridization. Methods of handling segregating generations. Pedigree method, bulk method, back cross method. Heterosis, inbreeding depression, various theories of heterosis, exploitation of hybrid vigour. Hardy Weinberg law, selection in cross-pollinated crops. Population improvement program. Synthetics and composites. Methods of breeding vegetatively propagated crops.

Incompatibility and male sterility and their utilization in crop improvement. Mutation breeding. Ploidy breeding. Wide hybridization and its significance in crop improvement. Procedure for release of new varieties.

Practical

Classification of plants. Botanical description and floral biology of field crops: rice, sorghum, maize, wheat, bajra, sugarcane, brassicas, groundnut, sunflower, sesamum, red gram, bengal gram, green gram, soybean, black gram, cotton. Study of megasporogenesis and microsporogenesis. Fertilization and life cycle of an angiosperm plant. Hybridization techniques and precautions to be taken. Selfing, emasculation and crossing techniques. Study of male sterility and incompatibility.

Suggested Readings

1. Allard R W. 1960. *Principles of Plant Breeding.* John Wiley and Sons.
2. Chahal G S and Gosal S S. 2002. *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches.* Narosa Publishers.
3. Ram H H. 2023. *Principles of Plant Breeding*. NIPA, New Delhi, India.

4. Singh B D. 2009. *Plant Breeding: Principles and Methods*. Kalyani Publishers.
5. Singh P. 2014. *Essentials of Plant Breeding*. Kalyani Publishers.
6. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India..

Elementary Microbiology 2 (1+1)

Objectives

i. History of microbiology and major groups of eukaryotes and prokaryotes
ii. Preservation methods and repositories
iii. Bacterial growth and metabolism
iv. Applications of microbes

Theory

History of microbiology and its applied areas. Microorganisms and their role in health and environment. Control and prevention measures against microorganisms/diseases. Introduction to eukaryotic and prokaryotic cells. Major groups of eukaryotes; fungi, algae and protozoa. Major groups of prokaryotes; bacteria, archaebacteria, rickettsia and chlamydia. Preservation of microorganisms, microbial repositories at national and international level.

Bacterial growth. Metabolism in bacteria, ATP generation, chemoautotrophy, photoautotrophy, respiration, fermentation. Viruses and Bacteriophages, structure and properties, lytic and lysogenic cycles, viroids, prions.

Beneficial microorganisms in agriculture, biofertilizers, microbial pesticides. Microbes in composting and biodegradation. Microbiology of water and food.

Practical

Microscope and other instruments in a microbiological laboratory. Media preparation, sterilization and aseptic methods for isolation, identification, preservation and storage. Identification of bacteria by staining methods. Enumeration of bacteria by pour plate and spread plate methods. Micrometery.

Suggested Reading

1. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India.
2. Woolverton C J, Sherwood L M, and Willey J M. 2016. *Presscotts Microbiology*. McGraw-Hill Education.

Entrepreneurship Development and Business Management 3 (2+1)

Objectives

i. To provide student an insight into the concept and scope of entrepreneurship
ii. To expose the student to various aspects of establishment and management of a small business unit
iii. To enable the student to develop financially viable agribusiness proposal

Theory

Development of entrepreneurship, motivational factors, social factors, environmental factors, characteristics of entrepreneurs, entrepreneurial attributes/competencies. Concept, need for and importance of entrepreneurial development. Evolution of entrepreneurship, objectives of entrepreneurial activities, types of entrepreneurs, functions of entrepreneurs, importance of entrepreneurial development, and process of entrepreneurship development. Environment scanning and opportunity identification need for scanning–spotting of opportunity-scanning of environment– identification of product / service – starting a project; factors influencing sensing the opportunities. Infrastructure and support systems- good policies, schemes for entrepreneurship development; role of financial institutions, and other agencies in entrepreneurship development. Steps involved in functioning of an enterprise. Selection of the product / services, selection of form of ownership; registration, selection of site, capital sources, acquisition of manufacturing know how, packaging and distribution. Planning of an enterprise, project identification, selection, and formulation of project; project report preparation, Enterprise Management. Production management – product, levels of products, product mix, quality control, cost of production, production controls, Material management. Production management – raw material costing, inventory control. Personal management – manpower planning, labour turn over, wages / salaries. Financial management / accounting – funds, fixed capital and working capital, costing and pricing, long term planning and short-term planning, book keeping, journal, ledger, subsidiary books, annual financial statement, taxation. Marketing management- market, types, marketing assistance, market strategies. Crisis management- raw material, production, leadership, market, finance, natural etc.

Practical

Visit to small scale industries/agro-industries, Interaction with successful entrepreneurs/ agric-entrepreneurs. Visit to financial institutions and support agencies. Preparation of project proposal for funding by different agencies.

Suggested Readings

1. Charantimath P M. 2009. *Entrepreneurship Development and Small Business Enterprises*. Pearson Publications, New Delhi, India.
2. Desai V. 1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publication House.
3. Desai V. 2015. *Entrepreneurship: Development and Management*. Himalaya Publishing House.
4. Grover I. 2008. *Handbook on Empowerment and Entrepreneurship*. Agrotech Public Academy.
5. Gupta C B. 2001. *Management Theory and Practice*. Sultan Chand & Sons.
6. Kala S. 2024. *Entrepreneurship Development, Innovation and Business Management*. AGPH Books.
7. Khanka S S. 1999. *Entrepreneurial Development*. S. Chand & Co.
8. Mehra P. 2016. *Business Communication for Managers*. Pearson India, New Delhi, India.
9. Pandey M and Tewari D. 2010. *The Agribusiness Book*. IBDC Publishers, Lucknow.
10. Singh D. 1995. *Effective Managerial Leadership*. Deep & Deep Publications.
11. Singhal R K. 2013. *Entrepreneurship Development & Management*. Katson Books.
12. Tripathi P C and Reddy P N. 1991. *Principles of Management*. Tata McGraw Hill.

Environmental Studies and Disaster Management 3 (2+1)

Objective

To expose and acquire knowledge on the environment and to gain the state-of-the-art - skill and expertise on management of disasters

Theory

Introduction to environment; environmental studies. Definition, scope and importance, multidisciplinary nature of environmental studies. Segments of environment, spheres of earth; lithosphere, hydrosphere, atmosphere. Different layers of atmosphere. Natural resources; classification. Forest resources. Water resources. Mineral resources. Food resources. Energy resources. Land resources. Soil resources. Ecosystems. Concept of an ecosystem; structure and function of an ecosystem. Energy flow in the ecosystem. Types of ecosystems. Biodiversity and its conservation: Introduction, definition, types. Biogeographical classification of India. Importance and value of biodiversity. Biodiversity hot spots. Threats and conservation of biodiversity.

Environmental pollution. Definition, cause, effects and control measures of air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, light pollution. Solid waste management; classification of solid wastes and management methods, composting, incineration, pyrolysis, biogas production, causes, effects and control measures of urban and industrial wastes. Social issues and the environment. Urban problems related to energy. Water conservation, rain water harvesting, watershed management. Environmental ethics; issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Environment protection act. Air (prevention and control of pollution) act. Water (prevention and control of pollution) act. Wildlife Protection Act. Forest Conservation act. Human population and the environment; environment and human health. Human rights, value education. Women and child welfare. Role of information technology in environment and human health.

Disaster management; disaster definition, types, natural disasters, floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, heat and cold waves. Man-made disasters, nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, road accidents, rail accidents, air accidents, sea accidents. International and national strategy for disaster reduction. Concept of disaster management, national disaster management framework, financial arrangements, role of NGOs, community-based organizations and media in disaster management. Central, state, district and local administration in disaster control. Armed forces in disaster response. Police and other organizations in disaster management.

Practical

Visit to a local area to document environmental assets river/forest/grassland/hill/mountain. Energy; biogas production from organic wastes. Visit to wind mill / hydro power / solar power generation units. Biodiversity assessment in farming system. Floral and faunal diversity assessment in polluted and un polluted system. Visit to local polluted site urban/rural/industrial/agricultural to study of common plants, insects and birds. Environmental sampling and preservation. Water quality analysis; pH, EC and TDS. Estimation of Acidity, alkalinity. Estimation of water hardness. Estimation of DO and BOD in water samples. Estimation of COD in water samples. Enumeration of *E. coli* in water sample. Assessment of suspended particulate matter (SPM). Study of simple ecosystem, visit to pond/river/hills. Visit to areas affected by natural disaster.

Suggested Readings

1. Barucha E. 2004. *Textbook for Environmental studies*. University Grants Commission, New Delhi.
2. De A K. 2010. *Environmental chemistry*. 384p. New Age International Publishers, New Delhi, India. ISBN:13–978 81 224 2617 5.
3. Dhar Chakrabarti P G. 2011. *Disaster management - India's risk management policy frameworks and key challenges*. 36p. Centre for Social Markets (India), Bangalore.
4. Dubey A K, Malviya S J and Kushwaha P. 2022. *Environmental Studies and Disaster Management*. Astral International Pvt. Ltd., New Delhi, India.
5. Parthiban K T, Vennila S, Prasanthrajan M, Umesh Kanna S. 2023. *Forest, Environment, Biodiversity and Sustainable development*. Narendra Publishing House, New Delhi, India.
6. Prasanthrajan M, and Mahendran P P. 2008. *A text book on Ecology and Environmental Science*. ISBN 81-8321-104-6. Agrotech Publishing Academy, Udaipur.
7. Prasanthrajan M. 2018. *Objective Environmental Studies and Disaster Management*. ISBN 9789387893825, Scientific publishers, Jodhpur.
8. Shameem S A, Yatoo S A, Kangroo I N and Ganai N A. 2024. *Environmental Studies and Disaster Management*. AGPH Books.
9. Sharma P D. 2009. *Ecology and Environment.* Rastogi Publications, Meerut.
10. Tyler M and Scot S. 2009. *Living in the Environment (Concepts, Connections, and Solutions)*. Cengage Learning Publication, Belmont, USA.
11. Vitnor S S, Bharade V M and Chavan E D. 2024. *Environmental Studies and Disaster Management*. AkiNik Publications, New Delhi, India.

National Cadet Corps (NCC- II) 1 (0+1)

Objectives

i. To develop qualities of character, courage, comradeship, discipline, leadership, secular outlook, spirit of adventure and sportsmanship and the ideals of selfless service among the youth to make them useful citizen

ii. To create a human resource of organized trained and motivated youth to provide leadership in all walks of life including the Armed Forces and be always available for the service of the nation

Practical

Arms Drill- Attention, stand at ease, stand easy. Getting on parade. Dismissing and falling out. Ground/take up arms, examine arms. Shoulder from the order and vice-versa, present from the order and vice-versa. Saluting at the shoulder at the halt and on the march. Short/long trail from the order and vice- versa. Guard mounting, guard of honour, Platoon/Coy Drill. Characteristics of rifle (.22/.303/SLR), ammunition, fire power, stripping, assembling, care, cleaning, and sight setting. Loading, cocking, and unloading. The lying position and holding. Trigger control and firing a shot. Range Procedure and safety precautions. Aiming and alteration of sight. Theory of groups and snap shooting. Firing at moving targets. Miniature range firing. Characteristics of Carbine and LMG. Introduction to map, scales, and conventional signs. Topographical forms and technical terms. The grid system. Relief, contours, and gradients. Cardinal points and finding north. Types of bearings and use of service protractor. Prismatic compass and its use. Setting a map, finding north and own position. Map to ground and ground to map. Knots and lashings, Camouflage and concealment,

Explosives and IEDs. Field defenses obstacles, mines and mine lying. Bridging, waterman ship. Field water supplies, tracks and their construction. Judging distance. Description of ground and indication of landmarks. Recognition and description of target. Observation and concealment. Field signals. Section formations. Fire control orders. Fire and movement. Movement with/without arms. Section battle drill. Types of communication, media, latest trends and developments.

National Service Scheme (NSS-II) 1 (0+1)

Objective

To evoke social consciousness among students through various activities, viz., working together, constructive, and creative social work, to be skillful in executing democratic leadership, developing skill in program, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

Practical

Importance and role of youth leadership. Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership, Life competencies. Definition and importance of life competencies, problem-solving and decision-making, interpersonal communication. Youth development programs. Development of youth programs and policy at the national level, state level and voluntary sector; youth-focused and youth-led organizations. Health, hygiene and sanitation. Definition needs and scope of health education; role of food, nutrition, safe drinking water, water borne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programs and reproductive health. Youth health, lifestyle, HIV AIDS and first aid. Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid. Youth and yoga. History, philosophy, concept, myths, and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method.

Personality Development 2 (1+1)

Objective

To make students realize their potential strengths, cultivate their inter-personal skills and improve employability

Theory

Personality Definition, nature of personality, theories of personality and its types. The humanistic approach, Maslow's self-actualization theory, shaping of personality, determinants of personality, Myers-Briggs typology indicator. Locus of control and performance. Type A and Type B behaviours, personality and organizational behaviour.

Foundations of individual behaviour and factors influencing individual behaviour. Models of individual behaviour. Perception and attributes and factors affecting perception. Attribution theory and case studies on perception and attribution. Learning; meaning and definition, theories and principles of learning. Learning and organizational behaviour. Learning and training, learning feedback. Attitude and values. Intelligence; types of intelligence, theories of intelligence, measurements of intelligence, factors influencing intelligence, intelligence and organizational behaviour, emotional intelligence. Motivation; theories and principles. Teamwork and group dynamics.

Practical

MBTI personality analysis. Learning styles and strategies. Motivational needs. Firo-B, Interpersonal Communication. Teamwork and team building. Group Dynamics. Win-win game. Conflict Management. Leadership styles. Case studies on Personality and Organizational Behaviour.

Suggested Readings

1. Abdaal A. 2023. *Feel-Good Productivity: How to Do More of What Matters to You*. Penguin Life, London, UK.
2. Andrews S. 2008. *How to Succeed at Interviews*. 21st (reprint). Tata McGraw-Hill, New Delhi, India.
3. Heller R. 2002. *Effective Leadership*. Essential Manager series, DK Publishing.
4. Hindle T. 2009. *Reducing Stress*. Essential Manager series, DK Publishing.
5. George Matthew Adams. 2020. You can. Finger Print Publishing.
6. Mile D J. 2004. *Power of Positive Thinking*. Rohan Book Company, New Delhi, India.
7. Pravesh Kumar. 2005. *All about Self- Motivation*. Goodwill Publishing House, New Delhi, India.
8. Shaffer D R. 2009. *Social and Personality Development*. (6th Edn.), Wadswor. Belmont. CA.
9. Smith B. 2004. *Body Language*. Rohan Book Company, New Delhi, India.

Basic Techniques of Molecular Biology and Biotechnology 2 (0+2)

Objectives

i. To provide hands-on training on isolation and purification of DNA. Measurement of nucleic acid concentration using spectrophotometer and gel electrophoresis. Designing of PCR primers, DNA amplification using PCR, elution of PCR products, SDS PAGE, staining and de-staining of proteins, Western blot.

ii. To study bacteriological media, preparation of media for bacterial culture, preparation of competent cells and transformation, isolation of plasmids from bacteria, and preservation of bacterial clones.

iii. To study basic computing. Introduction to UNIX, LINUX. Nucleotide information resource: EMBL, GenBank, DDBJ, unigene, protein information resource: SwissProt, TrEMBL, Uniprot; structure databases: PDB, MMDB. Search engines: Entrez, ARSA, SRS. Similarity searching: BLAST and interpreting results. Multiple sequence alignment: ClustalW; structure visualization of DNA and proteins using Rasmol.

Practical

Overview of molecular biology: DNA, RNA, proteins. Laboratory safety and basic techniques. Nucleic acid extraction. Principles of DNA and RNA extraction from various sources. Extraction methods: Phenol-chloroform, silica-based columns, quality assessment and quantification of nucleic acids. Polymerase Chain Reaction (PCR), Optimization of PCR conditions and troubleshooting, gel electrophoresis, analysis of PCR products, restriction digests, and DNA/RNA samples. Molecular cloning, DNA sequencing. Principles of DNA sequencing: Sanger sequencing, DNA sequencing reaction setup and analysis, interpretation of sequencing data and sequence alignment. Protein analysis techniques. Gene expression analysis. Practical project: students design and conduct a small-scale molecular biology project and will choose a specific technique or experiment, perform the necessary procedures, analyze data, and present their findings.

Suggested Readings

1. Brown T A. 2010. *Gene Cloning and DNA Analysis: An Introduction*. (6th Edn.), Wiley-Blackwell, Hoboken, NJ, USA.
2. Green M R and Sambrook J. 2012. *Molecular cloning: A Laboratory Manual*. (4th Edn.), Cold Spring Harbor.
3. Kreuzer H and Massey A. 2008. *Molecular Biology and Biotechnology: a guide for students*. (3rd Edn.), ASM Press.
4. Rapley R and Whitehouse D. 2015. *Molecular Biology and Biotechnology*. Royal Society of Chemistry.
5. Sambrook J and Russell D W. 2001. *Molecular Cloning: A Laboratory Manual*. (3rd Edn.), Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, USA.

Bioinformatics and Biocomputation 2 (0+2)

Objectives

i. To expose the students to the construction and use of computers, special algorithms, new complexity theories, computing science and related mathematics
ii. To understand the scientific and economic impact of bioinformatics
iii. To have a better understanding of organisms, their metabolism and their evolution
iv. To study their applications in health care and drug design, new (bio)materials and their engineering, food (engineering) and food production

Practical

Information search and data retrieval, genome analysis and gene mapping, alignment of pairs of sequences, alignment of multiple sequences and phylogenetic analysis, tools for similarity search and sequence alignment, profiles and hidden Markov models, gene identification and prediction, gene expression analyses, protein classification and structure analysis and visualization, protein structure prediction, computational methods for pathway and systems biology, technologies and strategies for drug discovery, biomarkers in drug development, computer-aided drug design.

Suggested Readings

1. Altman R B, Dunker A K, Hunter L, Ritchie M D, Murray T A and Klein T E. 2017. *Pacific Symposium on Biocomputing.* World Scientific Publishing Co. Pvt. Ltd., 5 Toh Tuck Link, Singapore. https://doi.org/10.1142/10388
2. Laplante P A. 2004. *Biocomputing*. Ova Biomedical.
3. Maulik U. 2024. *Multiobjective Optimization Algorithms for Bioinformatics*. Springer, Germany.

Post-Semester II (Only for exit option for award of UG-Certificate in Biotechnology)

S. No.	Course Title	Credit Hours
1.	Internship (10 weeks)	10 (0+10)

*Mandatory requirement for UG-Certificate.

Semester III

Livestock Production and Management 3 (2+1)

Objectives

i. History of livestock in India, animal husbandry and breeds of livestock
ii. Management of livestock in terms of the housing system, health, and diseases
iii. Economic importance of livestock

Theory

Livestock history in India: Vedic, medieval and modern era. Demographic distribution of livestock and role in economy. Introductory animal husbandry. Breeds of livestock, cattle, buffalo, sheep, goat and pig. Important traits of livestock. General management and feeding practices of animals. Handling and restraining of animals. Housing systems. Importance of grasslands and fodders in livestock production. Common farm management practices including disinfection, isolation, quarantine and disposal of carcass. Common vices of animals and their prevention. Diseases and parasite control and hygiene care.

History and economic importance of poultry. Poultry breeds. Reproductive system of male and female birds. Formation and structure of eggs. Important economic traits of poultry. Egg production, egg weight, egg quality. Fertility and hatchability, plumage characteristics and comb types. Care and management of chicks, grower and layers/broiler. Brooding management. Hatchery practices. Poultry diseases, control and hygiene care.

Practical

Visit to livestock farms/demonstration centres. Breeds of cattle, buffalo, sheep, goat and pigs. Familiarization with body parts of animals. Handling and restraining of cattle, buffalo, sheep, goat and swine. Male and female reproductive system and artificial Insemination. Feeding of livestock. Methods of identification: marking, tattooing, branding, tagging. Milking methods. Record Keeping. Visit to the poultry farm, poultry breeds, body parts of chicken, duck, quail and turkey. Housing, equipment, nesting and brooding requirements. Male and female reproductive system. Methods of identification and sexing. Hatchery layout and equipment. Identification of diseases and control of parasites. Vaccination and maintenance of farm records.

Suggested Readings

1. Bais B. 2023. *The Essentials of Livestock Production Management*. NBS Publishers and Distributors, Bikaner.
2. Banday M T. 2024. *Livestock Production and Management in a Nutshell*. Elite Publishing House.
3. Banerjee G C. 2020. *A Textbook of Animal Husbandry.* Oxford and IBH Publication.
4. Rayfield J S, Smith K L, Falk J, Wolf K, Pettey A, Benson D P, Fife J and Gomez N A. 2025. *Animal Science: Principles of Production, Management, and Selection*. Goodheart-Willcox Publisher, Tinley Park, IL, USA.
5. Sastry N S R and Thomas C K. 2020. *Dairy Bovine Production*. Kalyani Publishers.
6. Thomas C K and Sastry N S R. 2020. *Livestock Production Management*. Kalyani Publishers.

Recombinant DNA Technology 2 (2+0)

Objectives

i. The students will be trained on the principles of genetic engineering
ii. To study the components like vectors, enzymes, and host cells
iii. To study methods used for confirming cloning and expression

Theory

Recombinant DNA technology. Restriction endonucleases: types and uses. DNA manipulating enzymes, DNA ligases. Vectors: properties of an ideal vector, structure of vector, cloning vectors and expression vectors; plasmids, cosmids, phagemids, BACs, PACs, YACs, transposon vectors, shuttle vectors, co-integrating vectors. Competent cells. Gene isolation and cloning; Genetic transformation of *E. coli*, gel electrophoresis, preparation of probes, Southern blotting; Northern blotting; Western blotting, PCR and PCR based methods in recombinant DNA technology.

Suggested Readings

1. Singh B D. 2021. *Biotechnology Expanding Horizons*. Kalyani Publishers.
2. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India.

Classical and Molecular Cytogenetics 3 (2+1)

Objectives

i. Basics of chromatin
ii. Chromosome, banding and chromosome variations
iii. Genome analysis through chromosome variations

Theory

Introduction and history. Structure of chromatin. Chromosome structure and chromosome landmarks. Specialized chromosomes. Differential staining of the chromosomes - Q-banding, G banding, C banding, R banding. In situ hybridization-FISH, GISH.

Changes in chromosome number: aneuploidy - monosomy, trisomy and tetrasomy, haploidy and polyploidy- autopolyploidy and allopolyploidy. Methods of doubled haploid production. Structural aberrations of chromosomes: deletions, duplications, inversions and translocations. Locating genes on chromosomes. Genome analysis.

Practical

Lymphocyte culture from blood for karyotyping. Fibroblast cultures from eggs for karyotyping. Preparation of metaphase chromosome spread. Staining techniques of chromosome spreads. Karyotyping and ideogram preparation, chromosome banding techniques: Q-banding, G banding, C banding, R banding

Suggested Readings

1. Becker K and Hardin. 2004. *The World of Cell*. (5th Edn.), Pearson Edu.
2. Carroll M. 1989. *Organelles*. The Guilford Press.
3. Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall.

4. Fan Y S. 2002. *Molecular Cytogenetics: Protocols and Applications*. Humana Press.
5. Gupta P K. 2007. *Cytogenetics*. Rastogi publications.
6. Mahabal R. 2010. *Fundamentals of Cytogenetics and Genetics*. PHI Learning Pvt. Ltd.
7. Popescu P, Hayes H and Dutrillaux B. 2000. *Techniques in Animal Cytogenetics*. Springer Science and Business Media.
8. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India.

Plant Physiology 3 (2+1)

Objectives

i. To introduce concepts of plant physiology and their importance in agriculture
ii. To study the plant growth and metabolism
iii. To study plant's response to stresses

Theory

Plant physiology, its scope in agriculture. Osmosis, imbibition, water absorption, water translocation and transpiration. Stomatal mechanisms. Physiological role and deficiency symptoms of major and minor elements. Absorption and translocation of minerals.

Concepts of photosynthesis, photorespiration, respiration and translocation of photoassimilates. Dynamics of growth. Stress physiology. Nitrogen and sulphur metabolism. Plant growth regulators. Their biosynthesis and physiological roles, seed germination and seed dormancy, senescence, vernalization.

Practical

Demonstration of processes of diffusion, osmosis, imbibition and plasmolysis. Ascent of sap, transpiration. Deficiency symptoms of nutrients in crop plants. Plant growth analysis. Quantitative and qualitative estimation of plant pigments. Experiments on photosynthesis and respiration. Effects of plant growth regulators on plant growth and seed germination. Experiments on seed dormancy. Relative water content and plant water potential. Proline estimation.

Suggested Readings

1. Bhatia K N and Prashar A N. 1990. *Plant Physiology*. Trueman Book Company.
2. Kaya E. 2024. *Plant Physiology: From Historical Roots to Future Frontiers*. Bentham Science Publishers, Sharjah, UAE.
3. Khurana S M P and Kumar N. 2022. *Plant Biotechnology: A Textbook*. Scientific Publishers, Jodhpur.
4. Salisbury F B and Ross C W. 1992. *Plant Physiology*. Wordsworth Publishing Company.
5. Srivastava H N. 2000. *Plant Physiology*. Pradeep Publications.
6. Taiz L and Zeiger E. 2002. *Plant Physiology*. Sinauer Associates.
7. Taiz L, Møller I M, Murphy A and Peer W A. 2024. *Fundamentals of Plant Physiology*. Sinauer Associates, Sunderland, MA, USA.

Anatomy and Physiology of Livestock 3 (2+1)

Objectives

i. To introduce the basic concepts in the anatomy and physiology of livestock
ii. To study the structure and function of various tissues and organs
iii. To study the physiological aspects of tissues and organs

Theory

Definition of terms used in veterinary anatomy, topography, contour, landmarks and functional anatomy of various organs in cow, buffalo, sheep and goat structural and functional classification of muscles.

Structure of animal cells and tissues: study of microscopic structure of organs from digestive, urinary, respiratory, reproductive, nervous, cardiovascular and endocrine systems. Gametogenesis, fertilization, cleavage, gastrulation and the development of fetal membranes in livestock, structure and types of mammalian placenta. Development of the organs of digestive, urogenital, cardiovascular, nervous and endocrine glands.

Introduction to blood physiology. Genetic and endocrine control of the reproductive system; maternal recognition of pregnancy. Introduction to physiology of mammary glands: structure and development, hormonal control of mammary growth, lactogenesis and lactation cycle.

Practical

Hands-on training on the structure and function of the major body systems in livestock, including mammals such as cattle, sheep, goats, and pigs. Practical applications in livestock management and health.

Suggested Readings

1. Dyce K M, Sack M O and Wensing C J S. 2016. *Textbook of Veterinary Anatomy*. (5th Edn.), W. B. Saunders Co.
2. Fails A D and Magee C. 2018. *Anatomy and Physiology of Farm Animals*. (8th Edn.), Wiley-Blackwell, Hoboken, NJ, USA.
3. Ghosh R K. 2013. *Essentials of Veterinary Histology and Embryology*. (3rd Edn.), Current Book International.
4. Ghosh R K. 2020. *Primary Veterinary Anatomy (Systemic and Regional)*. (8th Edn.), Current Book International.
5. Hafez E S E and Hafez B. 2013. *Reproduction in Farm Animals*. (7th Edn.), Wiley–Blackwell.
6. McGeady T A. 2017. *Veterinary Embryology*. (2nd Edn.), Wiley Blackwell, Singapore.
7. Swenson M J. 2004. *Dukes' Physiology of Domestic Animals*. (9th Edn.), Comstock Publishing.

Fundamentals of Crop Protection 3 (2+1)

Objectives

i. To study insects, their classification, structure and incidences
ii. To study pathogens, their classification, pathogenesis and disease development
iii. To study the best practices of insect and disease management

Theory

Insects – their general body structure. Importance of insects in agriculture. Life cycle of insects. Insects diversity. Feeding stages of insects and kinds (modifications) of mouthparts. Concepts in population build-up of insects – GEP, DB, EIL, ETH and pest status.

Causes of insect-pests outbreak. General symptoms of insect attack. Principles and methods of insect-pests management. Integrated Pest Management concept.

Importance and scope of plant pathology. Concept of disease in plants. Nature and classification of plant diseases. Importance and general characters of fungi, bacteria, fastidious bacteria, nematodes, phytoplasmas, spiroplasmas, viruses, viroids, algae, protozoa and phanerogamic parasites.

Pathogenesis due to obligate and facultative parasites. Variability in plant pathogens. Conditions necessary for the development of disease epidemics. Survival and dispersal of plant pathogens. Management of key diseases and nematodes of major crops.

Practical

Familiarization with generalized insect's body structure and appendages. Life stages. Acquaintance with insect diversity. Identification of important insect pests of cereals, cotton, oilseeds, pulses, sugarcane, fruit and vegetables crops and stored-grains, and their symptoms of damage. Acquaintance with useful insects: predators, parasitoids, pollinators, honey bees and silkworms. Acquaintance with various pesticidal formulations. Principles and working of common plant protection appliances. Calculation for preparing spray material.

Acquaintance with plant pathology laboratory equipment. Preparation of culture media for fungi and bacteria. Demonstration of Koch's postulates. Study of different groups of fungicides and antibiotics and methods of their evaluation. Diagnosis and identification of important diseases of cereals, cotton, oilseeds, pulses, sugarcane, fruit and vegetable crops and their characteristic symptoms.

Suggested Readings

1. Agrios G N. 2010. *Plant Pathology*. Acad. Press.
2. Ahmad L, Shah G M S, and Biswas A. 2024. *Fundamentals and Applications of Crop and Climate Science*. Springer, Cham, Switzerland.
3. Atwal A S and Dhaliwal G S. 2002. *Agricultural Pests of South-Asia and Their Management*. Kalyani Publishers.
4. Das T P and Sahoo S. 2024. *Agronomic Principles: Fundamentals of Crop Production*. In: Agricultural Extension Worldwide Innovations. Elite Publishing House.
5. Dhaliwal G S and Arora R. 1996. *Principles of Insect Pest Management*. National Agriculture Technology Information Centre.
6. Dhaliwal G S, Singh R and Chhillar B S. 2006. *Essentials of Agricultural Entomology*, Kalyani Publishers.
7. Kumar S. 2021. *Fundamentals of Plant Pathology*. SBN9789390591206, NIPA.
8. Mehrotra R S and Aggarwal A. 2007. *Plant Pathology*. (7th Edn.), Tata Mc Graw Hill Publ. Co. Ltd.
9. Sehgal P K. 2017. *Fundamentals of Agricultural Entomology Unknown Binding*. Kalyani Publishers.
10. Singh H. 1984. *Household and Kitchen Garden Pests – Principles and Practices*. Kalyani Publishers.
11. Singh R S. 2008. *Plant Diseases*, (8th Edn.), Oxford and IBH. Pub. Co.
12. Singh R S. 2013. *Introduction to Principles of Plant Pathology*. Oxford and IBH Pub. Co.
13. Stakman E C and Harrar J G. 1957. *Principles of Plant Pathology*, Ronald Press, USA.
14. Tarr S A J. 1964. *The Principles of Plant Pathology*, McMillan, London.

Livestock Product Technology 3 (2+1)

Objectives

i. To study the composition and value of milk
ii. To study milk processing and milk standards
iii. To study properties and values of the meet

Theory

Composition and nutritive value of milk and factors affecting composition of milk; current status of dairy industry in India. Physiochemical properties of milk. Milk Processing: milk collection, chilling, transportation, standardization, homogenization, pasteurization and packaging. Toxins and pesticide residues in milk and milk products. Organic milk food products. Bureau of Indian standards for milk and milk products; FSSAI standards for milk and milk products. Sanitation in milk plant.

Retrospect and prospects of the meat industry in India. Structure and composition of muscle (including poultry). Conversion of muscle into meat; nutritive value of meat. Meat adulteration, preservation of meat, physicochemical and microbiological quality of meat and meat products. Laws governing national, and international trade in meat and meat products, organic meat food products, and food products of genetically modified animals.

Practical

Sampling of milk, estimation of fat, solids-not-fat (SNF) and total solids. Determination of specific gravity of milk. Platform tests, cream separation. Microbiological quality of milk, meat and meat products. Visit modern milk and meat processing units.

Suggested Readings

1. Rayfield J S, Smith K L, Falk J, Wolf K, Pettey A, Benson D P, Fife J and Gomez N A. 2025. *Animal Science: Principles of Production, Management, and Selection*. Goodheart-Willcox Publisher, Tinley Park, IL, USA.
2. Sharma B D. 1999. *Meat and Meat Products Technology: Including Poultry Products Technology*. Jaypee Bros Medical Publishers.
3. Singh V P. 2021. *Livestock Products Technology*. NIPA, New Delhi, India.
4. Sukumar D. 2001. *Outlines of Dairy Technology*. Oxford University Press.

Biomathematics 2 (2+0)

Objectives

i. To study the basic theories of mathematics
ii. To study factor reduction and eigenvalues
iii. To study the applications of biomathematics

Theory

Rolle's theorem, Lagrange's theorem, Taylor's and Maclaurin's series. Partial differentiation, Euler's theorem on homogeneous function, change of variable. Jacobian, maxima and minima of two or more than two variables eigen values and eigen vectors of a matrix. Reduction formulae, definite integrals and its applications.

Solution of ordinary differential equation of first degree and first order and their application for determination of the volume of blood and drug distribution. Epidemic models, simultaneous

differential equation of first order and their applications to predator models. Linear differential equations of higher order and their applications to the simple biological problem. Numerical methods for solving algebraic and transcendental equations.

Suggested Readings

1. de Vries G, Hillen T, Lewis M, Müller J and Schönfisch B. 2006. *A Course in Mathematical Biology: Quantitative Modeling with Mathematical and Computational Methods*. Society for Industrial and Applied Mathematics, Philadelphia, PA, USA.
2. Gonzalez O. 2024. *Topics in Applied Mathematics and Modeling: Concise Theory with Case Studies*.
3. American Mathematical Society, Providence, RI, USA.
4. Grewal B S. 2013. *Higher Engineering Mathematics*. Khanna Publishers.
5. Keener J P. 2021. *Biology in Time and Space: A Partial Differential Equation Modeling Approach*.
6. American Mathematical Society, Providence, RI, USA.
7. Rastogi S K. 2008. *Biomathematics*. Krishna Prakashan Media Pvt. Ltd.
8. Srivastava A C and Srivastava P K. 2011. *Engineering Mathematics*. Vol. I, PHI Learning Pvt. Ltd.
9. Srivastava A C and Srivastava P K. 2011. *Engineering Mathematics*. Vol.III, PHI Learning Pvt. Ltd.

Physical Education, First Aid, Yoga Practices and Meditation 2 (0+2)

Objectives

i. To make the students aware about Physical Education, First Aid and Yoga Practices

ii. To disseminate the knowledge and skill how to perform physical training, perform first aid and increase stamina and general wellbeing through yoga.

Practical

Physical education: Training and coaching, meaning and concept. Methods of training; aerobic and aerobic exercises. Calisthenics, weight training, circuit training, interval training, Fartlek training. Effects of exercise on muscular, respiratory, circulatory and digestive systems. Balanced diet and nutrition; effects of diet on performance. Physiological changes due to ageing and role of regular exercise on ageing process. Personality, its dimensions and types. Role of sports in personality development. Motivation and achievements in sports. Learning and theories of learning. Adolescent problems and its management. Posture, postural deformities. Exercises for good posture.

Yoga: history of yoga, types of yoga, introduction to yoga. Asanas, definition and importance, Padmasan, Gaumukhasan, Bhadrasan, Vajraasan, Shashankasan, Pashchimotasan, Ushtrasan, Tadasan, Padhastasan, Ardhchandrasan, Bhujangasan, Utanpadasan, Sarvangasan, Parvatasan, Patangasan, Shishupalanasan – left leg-right leg, Pavanmuktasan, Halasan, Sarpasan, Ardhdhanurasan, Sawasan. Suryanamaskar, Pranayama (Definition and Importance), Omkar, Suryabhedan, Chandrabhedan, AnulomVilom, Shitali, Shitkari, Bhastrika, Bhramari. Meditation, definition and importance, Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandh. Mudras, definition and importance, Gyanmudra, Dhyanmudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra. Role of yoga in sports. Teaching of asanas, demonstration, practice, correction and practice.

History of sports and ancient games. Governance of sports in India. Important national sporting events. Awards in sports. History, latest rules, measurements of playfield, specifications of equipment, skill, technique, style and coaching of major games (Cricket, Football, Table Tennis, Badminton, Volleyball, Basketball, Kabaddi and Kho-Kho) and Athletics.

Need and requirement of first aid. First aid equipment and upkeep. First aid techniques. First aid related with respiratory system. First aid related with heart, blood and circulation. First aid related with wounds and injuries. First aid related with bones, joints, muscle related injuries. First aid related with nervous system and unconsciousness. First aid related with gastrointestinal tract. First aid related with skin, burns. First aid related with poisoning. First aid related with bites and stings. First aid related with sense organs. Handling and transport of injured traumatized persons. Sports injuries and their treatments.

Methods in Recombinant DNA Technology 2 (0+2)

Objectives

i. Hands on training on good laboratory practices Media and stock preparation
ii. To enable skill development by providing hands-on training on methods in recombinant DNA technology

Practical

Preparation of growth, media, stock solutions and buffers. Plasmid DNA isolation. Quality and quantity assessment of DNA. Restriction digestion of DNA. Agarose gel electrophoresis. Preparation of competent cells and genetic transformation of *E. coli*. Screening of recombinant DNA clones in *E. coli*. Confirmation of recombinant clones.

Suggested Readings

1. Carson S and Robertson D. 2005. *Manipulation and Expression of Recombinant DNA*. Elsevier.
2. Glick B R and Patten C L. 2022. *Molecular Biotechnology: Principles and Applications of recombinant DNA*. John Wiley and Sons.
3. Green M R and Sambrook J. 2012. *Molecular Cloning: A Laboratory Manual*. (4th Edn.). Cold Spring Harbor.
4. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India.

Semester IV

Introductory Bioinformatics 4 (3+1)

Objectives

i. To train the students on applications of computers on analyzing the biomolecules (DNA, RNA and protein)
ii. To study various types of databases
iii. To study various operations and algorithms in bioinformatics

Theory

Introduction to bioinformatics. Development and scope of bioinformatics. Applications of computers in bioinformatics. Operating systems, hardware, software, internet, www resources, FTP, application of bioinformatics in agriculture.

Primary databases: Nucleotide sequence databases (GenBank, EMBL), protein sequence databases; Secondary databases: SwissProt/TrEMBL, conserved domain database, Pfam; Structure databases: Protein Data Bank (PDB), MMDB, SCOP, CATH; File formats: GenBank, EMBL, FASTA, PDB, Flat file, ASN.1, XML.

Introduction to sequence alignment and its applications. Pairwise and multiple sequence alignment, the concept of local and global alignment; Algorithms. Dot Matrix method, dynamic programming methods (Needleman–Wunsch and Smith–Waterman). Tools of MSA: ClustalW, TCoffee. Phylogeny. Introduction to BLAST and FASTA; MSA and phylogeny. Assembly and annotation.

Practical

Hands-on training on databases, database construction and management, algorithms and analysis of DNA, RNA and proteins.

Suggested Readings

1. Baxevanis A D, Ouellette B F F. 2011. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. John Wiley and Sons.
2. Compeau P and Pevzner P. 2024. *Bioinformatics Algorithms: An Active Learning Approach*. Active Learning Publishers, La Jolla, CA, USA.
3. Dandekar T and Kunz M. 2023. *Bioinformatics: An Introductory Textbook*. Springer, Berlin, Germany.
4. Mount D W. 2001. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor.
5. Xiong J. 2012. *Essential Bioinformatics*. Cambridge University Press.

Molecular Marker Technology 2 (2+0)

Objectives

i. To study the importance and types of molecular markers
ii. To study the mapping populations; development and analysis
iii. To study the applications of molecular markers in mapping and breeding

Theory

Types of molecular markers - RFLP; PCR-based markers like RAPD, SCAR, SSR, STS, CAPS, AFLP, SNP and their variants. Uses of molecular markers. Application as a genetic tool for genotyping and gene mapping. Mapping populations: F_2, DH, RILs, NILs. Bulked segregant analysis, linkage maps, physical maps.

Application of molecular markers. Assessing genetic diversity, variety protection. Introduction to genomic selection, marker-assisted breeding for accelerated introgression of trait/transgene and quantitative traits. Human and animal health. Association with genetic-based diseases. Paternity determinations. Parentage using SNP data. Forensic studies. DNA Fingerprinting.

Suggested Readings

1. Bhat R S, Brijesh Patil M P, Tilak I S and Shirasawa K. 2023. Molecular markers for mutant characterization. *(In) Mutation Breeding for Sustainable Food Production and Climate Resilience.* pp 205-232. Suprasanna P and Jain M S (Eds.). Springer, Singapore.

2. Gupta P K. 2015. *Molecular Biology and Genetic Engineering*. Rastogi Publication.
3. Manikanda Boopathi N. 2013. *Genetic Mapping and Marker-Assisted Selection*. Springer.
4. Manikanda Boopathi N. 2020. *Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits*. Springer.
5. Schook L B. 2020. *Gene-Mapping Techniques and Applications*. CRC Press.
6. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India.
7. Verma P S. 2018. *Cell Biology Genetics Molecular Biology Evolution and Ecology*. Chaukhamba Auriyantaliya Publishers.
8. Watson J D, Levine M, Baker T A, Gann A, Bell S P and Losick R. 2014. *Molecular Biology of the Gene*. Pearson.

Biodiversity and Its Conservation 2 (2+0)

Objectives

i. To study the concepts of biodiversity
ii. To study the methods of protecting biodiversity
iii. To study regulations on biodiversity conservation

Theory

Concepts of biodiversity, bioresource and wildlife management, conservation strategies: in situ and ex-situ conservation. Wildlife conservation projects in India. Protection of biodiversity for its suitable utilization. Threats to biodiversity. WCU Red data book; Biodiversity hotspots in India. National bureaus of genetic resources. Biodiversity Mapping. Biogeographical regions.

Sustainable development. Diversification of cropping system. Diversity of indigenous livestock. Threats to biodiversity; WCU Red data book. Vulnerability and extinction of flora and fauna. Endangered species in various ecosystems. Germplasm banks. Environmental impact assessment. Bioremediation and biosafety. Introduction to regulatory agencies and legislation.

Suggested Readings

1. Boss P K. 2024. *Biodiversity & Its Conservation*. PK DiGiTaL Company Private Limited, India.
2. Das M K and Choudhury B P. 2008. *A Textbook on Plant Nomenclature and Biodiversity Conservation*. Kalyani Publishers.
3. Gaston K J and Spicer J I. 2004. *Biodiversity An Introduction*. Blackwell Publishers.
4. Hopsetti B B and Venketashwarlaru M. 2001. *Trends in Wild Life Conservation and Management*. Vol. 2, Daya Publishing House.
5. Shanmugam T. 2024. *Biodiversity and Conservation*. LAP LAMBERT Academic Publishing, Mauritius.
6. Singh M P and Singh B S. 2002. *Plant Biodiversity and Taxonomy*. Daya Publishing House.

Basic Biochemistry 4 (3+1)

Objectives

i. To study the structure and functions of biomolecules of living organisms
ii. To study metabolism and bioenergetics
iii. To study secondary metabolites and their applications

Theory

Introduction and importance. Biomolecules: carbohydrates, lipids, proteins and nucleic acids – structure, functions and properties. Acids, bases and buffers of living systems. The pK of biomolecules. Vitamins and hormones.

Bioenergetics. Metabolism – basic concept: glycolysis, citric acid cycle, glycogenesis, glycogenolysis, oxidative phosphorylation, fatty acid oxidation; Ketone bodies' metabolism.

Secondary metabolites: alkaloids, phenolics and their applications in food and pharmaceutical industries.

Practical

Qualitative tests for carbohydrates, amino acids, proteins and lipids. Extraction and characterization of lipids by TLC. Determination of acid, iodine and saponification values of oil. Extraction, quantitative estimation and separation of sugars by paper chromatography.

Suggested Readings

1. Ahern K and Rajagopal I. 2012. *Biochemistry Free & Easy*. Oregon State University, Corvallis, OR, USA.
2. Ali A, Ayaz A and Ahmad B S. 2025. *Fundamentals of Biochemistry*. NIPA, New Delhi, India.
3. Lieberman M A and Peet A. 2022. *Marks' Basic Medical Biochemistry: A Clinical Approach*. (6th Edn.), Wolters Kluwer, Philadelphia, PA, USA.
4. Nelson D L and Cox M M. 2017. *Lehninger principles of biochemistry.* (7th Edn.), W. H. Freeman.
5. O'Daly A. 2024. *The Basics of Biochemistry*. Rosen Publishing, New York, NY, USA.
6. Sachdeva A and Lal H. 2024. *Biochemistry for Medical Laboratory Technology Students*. (3rd Edn.) CBS Publishers and Distributors Pvt. Ltd., New Delhi, India.
7. Satyanarayana U and Chakrapani U. 2021. *Essentials of Biochemistry*. Elsevier.

Human Ethics 1 (1+0)

Objectives

i. To study the meaning and concepts of human behaviour
ii. To study human ethical values
iii. To study spirituality and attitude
iv. To study the methods of stress management

Theory

Universal human aspirations. Happiness and prosperity. Human values and ethics. Concept, definition, significance and sources. Fundamental values. Right conduct, peace, truth, love and non-violence. Ethics: professional, environmental, ICT. Sensitization towards others particularly senior citizens, developmentally challenged and gender.

Spirituality, positive attitude and scientific temper. Teamwork and volunteering. Rights and responsibilities. Road safety. Human relations and family harmony. Modern challenges and value conflict. Sensitization against drug abuse and other social evils. Developing personal code of conduct (SWOT Analysis). Management of anger and stress.

Suggested Readings

1. Gaur R R, Sangal R and Bagaria G P. 2011. *A Foundation Course in Human Values and Professional Ethics*, Excel Books.
2. Gaur R R, Sangal R and Bagaria G P. 2011. *A Foundation Course in Human Values and Professional*
3. Mathur S S. 2010. *Education for Values, Environment and Human Rights*. RSA International.
4. Russ-Eft D F and Alizadeh A. 2024. *Ethics and Human Resource Development: Societal and Organizational Contexts*. Springer International Publishing, Cham, Switzerland.
5. Shadbolt N and Hampson R. 2024. *As If Human: Ethics and Artificial Intelligence*. Yale University Press, New Haven, CT, USA.
6. Sharma R A. 2011. *Human Values and Education -Axiology, Inculcation and Research*. R. Lall Book
7. Sharma R P and Sharma M. 2011. *Value Education and Professional Ethics*. Kanishka Publishers.
8. Srivastava S. 2011. *Environmental Science*. S K Kataria and Sons.
9. Srivastava S. 2011. *Human Values and Professional Ethics*. S K Kataria and Sons.
10. Tripathi A N. 2009. *Human Values*. New Age International (P) Ltd Publishers.

Agriculture Marketing and Trade 3 (2+1)

Objectives

i. To understand the fundamentals of agricultural marketing and trade
ii. To analyze the factors influencing supply and demand in agricultural markets
iii. To explore different marketing channels and strategies in agriculture
iv. To examine the role of government policies and regulations in agricultural markets

Theory

Agricultural Marketing: Concepts and definitions of market, marketing, agricultural marketing, market structure, marketing mix and market segmentation, classification and characteristics of agricultural markets; demand, supply and producer's surplus of agri commodities: nature and determinants of demand and supply of farm products, producer's surplus – meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; pricing and promotion strategies: pricing considerations and approaches – cost based and competition based pricing; market promotion – advertising, personal selling, sales promotion and publicity – meaning, merits and demerits; marketing process and functions: Marketing process concentration, dispersion and equalization; exchange functions – buying and selling; physical functions – storage, transport and processing; facilitating functions – packaging, branding, grading, quality control and labelling (Agmark); Market functionaries and marketing channels: Types and importance of agencies involved in agricultural marketing; meaning and definition of marketing channel; number of channel levels; marketing channels for different farm products; integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs. Role of Government in agricultural marketing: Public sector institutions- CWC, SWC, FCI, CACP and DMI – their objectives and functions; cooperative marketing in India. Risk in marketing: Types of risk in marketing; speculation and hedging; an overview of futures

trading. Agricultural prices and policy. Meaning and functions of price; administered prices; need for innovations in agricultural price policy. Trade: concept of international trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; WTO; Agreement on Agriculture (AoA) and its implications on Indian agriculture; IPR. Role of government in agricultural marketing. Role of APMC and its relevance in the present-day context.

Practical

Plotting and study of demand and supply curves and calculation of elasticities. Study of relationship between market arrivals and prices of some selected commodities. Computation of marketable and marketed surplus of important commodities; Study of price behaviour over time for some selected commodities. Construction of index numbers; Visit to a local market to study various marketing functions performed by different agencies, identification of marketing channels for selected commodity, collection of data regarding marketing costs, margins and price spread and presentation of report in the class. Visit to market institutions – NAFED, SWC, CWC, cooperative marketing society, etc. to study their organization and functioning. Application of principles of comparative advantage of international trade.

Suggested Readings

1. Acharya S S and Agarwal N L. 2006. *Agricultural Marketing in India*. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi, India.
2. Chinna S S. 2005. *Agricultural Economics and Indian Agriculture*. Kalyani Publications, New Delhi, India.
3. Food and Agriculture Organization of the United Nations (FAO). 2024. *The State of Agricultural Commodity Markets 2024: Trade and Nutrition—Policy Coherence for Healthy Diets*. FAO, Rome, Italy.
4. Kohls R L and Uhl J N. 2002. *Marketing of Agricultural Products*. Prentice-Hall of India Private Ltd., New Delhi, India.
5. Kotler and Armstrong. 2005. *Principles of Marketing*, Pearson Prentice-Hall.
6. Lekhi R K and Singh J. 2006. *Agricultural Economics*. Kalyani Publishers, New Delhi, India.
7. Memoria C B, Joshi R L and Mulla N I. 2003. *Principles and Practice of Marketing in India*. Kitab Mahal, New Delhi, India.
8. Pandey M and Tewari D. 2004. *Rural and Agricultural Marketing*. International Book Distributing Co. Ltd, New Delhi, India.
9. Rout R K. 2024. *A Text Book of Agricultural Marketing, Trade and Prices*. Kalyani Publishers, New Delhi, India.
10. Salvator D. 2008. *Microeconomics: Theory and Applications*. New York: Oxford University Press.
11. Sharma R. 2005. *Export Management*. Laxmi Narain Agarwal, Agra.

Agricultural Informatics and Artificial Intelligence 3 (2+1)

Objectives

i. To acquaint students with the basics of computer applications in agriculture, multimedia, database management, application of mobile app and decision- making processes, etc.

ii. To provide basic knowledge of computer with applications in agriculture

iii. To make the students familiar with Agricultural-Informatics, its components and applications in agriculture

Theory

Introduction to computers, anatomy of computers, memory concepts, units of memory, operating system. Definition and types, applications of MS-Office for creating, editing and formatting a document, data presentation, tabulation and graph creation, statistical analysis, mathematical expressions, database, concepts and types, creating database. Uses of DBMS in agriculture, internet and World Wide Web (WWW); concepts and components.

Computer programming. General concepts, introduction to visual basic, Java, Fortran, C/ C++, etc. concepts and standard input/output operations.

e-Agriculture, Concepts, design and development, application of innovative ways to use information and communication technologies (IT) in agriculture, computer models in agriculture. Statistical, weather analysis and crop simulation models, concepts, structure, inputs-outputs files, limitation, advantages and application of models for understanding plant processes, sensitivity, verification, calibration and validation, IT applications for computation of water and nutrient requirement of crops. Computer-controlled devices (automated systems) for agri-input management, smartphone mobile apps in agriculture for farm advice. Market price, postharvest management etc. Geospatial technology; concepts, techniques, components and uses for generating valuable agri-information. Decision support systems; concepts, components and applications in agriculture. Agriculture expert system, soil information systems etc. for supporting farm decisions. Preparation of contingent crop-planning and crop calendars using IT tools, Digital India and schemes to promote digitalization of agriculture in India.

Introduction to artificial intelligence, background and applications, Turing test. Control strategies, Breadth-first search, Depth-first search, Heuristics search techniques: Best-first search, A* algorithm, IoT and Big Data; Use of AI in agriculture for autonomous crop management, and health, monitoring livestock health, intelligent pesticide application, yield mapping and predictive analysis, automatic weeding and harvesting, sorting of produce, and other food processing applications; Concepts of smart agriculture, use of AI in food and nutrition science etc.

Practical

Study of computer components, accessories, practice of important DoS Commands, Introduction of different operating systems such as Windows, Unix/ Linux, creating files and folders, File management. Use of MS-WORD and MS Power-point for creating, editing and presenting a scientific document, MS- EXCEL - Creating a spreadsheet. Use of statistical tools. Writing expressions, Creating graphs, Analysis of scientific data, Handling macros. MS-ACCESS, creating database, preparing queries and reports, demonstration of agri- information system, Introduction to World Wide Web (WWW) and its components, Introduction of programming languages such as Visual Basic, Java, Fortran, C, C++, Hands on practice on Crop Simulation Models (CSM), DSSAT/Crop-Info/Crop Syst/Wofost, Preparation of inputs file for CSM and study of model outputs, computation of water and nutrient requirements of crop using CSM and IT tools, Use of smart phones and other devices in agro-advisory and dissemination of market information, Introduction of Geospatial Technology, Hands on practice on preparation

of Decision Support System, Preparation of contingent crop planning, India Digital Ecosystem of Agriculture (IDEA).

Suggested Reading

1. Date C J. 2007. *An Introduction to Database Systems*. Addison-Wesley.
2. Dhabal P S and Manoranjan P. 2017. *Concepts and Techniques of Programming in C*. I. K. International Publishing House Pvt. Limited.
3. Fatima F and Parveen S. 2024. *A Textbook on Agri-Informatics*. Kalyani Publishers, New Delhi, India.
4. ITL Education Solutions Ltd. 2006. *Introduction to Information Technology*. PEARSON Education.
5. Mahapatra S K. Mishra P and Pradhan J. 2022. *Introductory Agri Informatics*. Jain Brothers.
6. Raj P, Gayathri N and Kathrine G J W. 2024. *Artificial Intelligence for Precision Agriculture*. CRC Press, Boca Raton, FL, USA.
7. Rajaroman V and Adabala N. 2015. *Fundamentals of Computer*. PHI Learning Private Ltd, New Delhi, India.

Practices in Molecular Marker Technology 2 (0+2)

Objectives

i. This course aims at imparting skills through hands-on training in the area of molecular markers and their applications

ii. To study the development of markers and marker systems, genotyping with various types of markers, mapping, diversity analysis, marker-assisted selection, DNA fingerprinting, diversity and cluster analysis, phylogenetic analysis

Practical

Overview of molecular markers: types, applications, significance. Principles of genetic variation and inheritance, DNA Extraction and quantification, PCR-Based molecular markers, RFLP (Restriction Fragment Length Polymorphism) analysis, AFLP (Amplified Fragment Length Polymorphism) analysis, SSR (Simple Sequence Repeat) analysis, SNP (Single Nucleotide Polymorphism) analysis. Principles of SNP detection, PCR-based SNP genotyping assays, SNP array and sequencing-based approaches. DNA sequencing and sequence analysis, interpretation of sequencing data and sequence alignment, Marker-Assisted Selection (MAS), genomic selection and marker discovery. Practical Project: students design and conduct a small-scale molecular marker project. They will choose a specific technique or experiment, perform the necessary procedures, analyze data, and present their findings.

Suggested Readings

1. Gupta P K. 2015. *Molecular Biology and Genetic Engineering*. Rastogi Publication.
2. Kumar N. 2023. *Molecular Marker Techniques: A Potential Approach of Crop Improvement*. Springer Nature Singapore, Singapore.
3. Kumar S, Kumar A, and Kumar S. 2024. *Plant Molecular Breeding in Genomics Era: Concepts and Tools*. Springer, Cham, Switzerland.

4. Manikanda Boopathi N. 2013. *Genetic Mapping and Marker-Assisted selection*. Springer.
5. Manikanda Boopathi N. 2020. *Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits*. Springer.
6. Schook L B. 2020. *Gene-Mapping Techniques and Applications*. CRC Press.
7. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India.
8. Verma P S. 2018. *Cell Biology Genetics Molecular Biology Evolution and Ecology*. Chaukhamba Auriyantaliya Publishers.
9. Watson J D, Levine M, Baker T A, Gann A, Bell S P and Losick R. 2014. *Molecular Biology of the Gene*. Pearson.

Post-Semester IV* (Only For exit option for UG-Diploma in Biotechnology)

S. No.	Course Title	Credit Hours
1.	Internship (10 weeks)	10 (0+10)

*Mandatory requirement for UG-Diploma.

Semester V

Microbial Genetics 4 (3+1)

Objectives

i. To provide an understanding of using microorganisms for genetic analyses
ii. To study genetic variability and recombination among microbes
iii. To study plasmids, their types and use in recombinant DNA technology

Theory

Microorganisms as tools for genetic studies. Genetic variability in microorganisms. Genetic analysis of representative groups of bacteria, fungi and viruses. Random and tetrad spore analysis. Recombination and chromosomal mapping. Complementation-intergenic and intragenic.

Bacterial plasmids. Structure, life cycle, mode of infection and their role in genetic engineering. Transfer of genetic material in bacteria. Conjugation, transformation and transduction. Genetics of bacteriophage: T4, lambda and M13, life cycle, mode of infection. Mutation: types, mutagens, DNA damage and repair. Transposable elements; Lac operon, yeast genetics.

Concept and application of recombinant DNA technology. Use of genetic tools to improve the microbial strains for industry, agriculture and health.

Practical

Conjugation and transformation in bacteria. Spontaneous and auxotrophic mutation. Chemical and UV mutagenesis in fungi and bacteria. Complementation in fungi. Identification of mutants using replica plating technique. Isolation of genomic DNA from *E. coli*. Isolation and curing of plasmid. Identification of plasmid by electrophoresis / antibiotic plates.

Suggested Readings

1. Michael R G and Joseph S. 2012. *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor Laboratory Press.

2. Okoń S, Zimowska B and Rai M. 2024. *Microbial Genetics*. CRC Press, Boca Raton, FL, USA.
3. Reece R J. 2013. *Analysis of Genes and Genomes*. Wiley.

Molecular Genetics 3 (3+0)

Objectives

i. To introduce DNA structure and function
ii. To study DNA functions like replication and gene expression
iii. To provide an understanding of gene regulation in prokaryotes and eukaryotes

Theory

Structures, properties and modification of DNA. Molecular mechanisms of DNA replication, repair. Types of mutation. Linkage and recombination. Molecular mechanisms of crossing over. Centromere and telomere sequences, and DNA packaging. Repetitive DNA sequences and transposable elements. Markers and QTL.Synthesis and processing of RNA and proteins. Regulation of gene expression.

Genetic code, properties of genetic code, structure of a gene, promoters and their isolation. Synthesis and processing of RNA.

Regulation of gene expression. Transcription factors – their classification and role in gene expression. Epigenetic control of gene expression. Analysis of gene expression. Small RNAs, RNA interference and its applications.

Suggested Reading

1. Allison L A. 2011. *Fundamental Molecular Biology*. Wiley Global Education.
2. Bhat T A, Shakoori A R and Al-Khayri J M. 2024. *Molecular Genetics, Structures, Mechanisms, and Functions*, Volume 2: Applications and Exploring the Nucleus. Apple Academic Press, Palm Bay, FL, USA.
3. Brown T A. 1998. *Genetics: A Molecular Approach*. (3rd Edn.), Stanley Thornes.
4. Chen J-T, Khan M, Parveen A and Patra J K. 2025. *Molecular and Biotechnological Tools for Plant Disease Management*. Springer Singapore, Singapore.
5. Gardener E J, Simmons M J and Snustad D P. 1991. *Principles of Genetics*. John Wiley and Sons, Inc, New York, USA.
6. Hartl D L. 2021. *Essential Genetics and Genomics*. (7th Edn.), Jones and Bartlett Learning.
7. Lewin B. 2009. *Genes*. Jones and Bartlett Learning.
8. Lewin B. 2017. *Gene XII*. Oxford University Press.
9. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India.
10. Tropp B E. 2012. *Molecular Biology: Genes to Proteins*. (4th Edn.), Jones and Bartlett Learning.
11. Tropp B E. 2014. *Principles of Molecular Biology*. Jones and Bartlett Learning.

Nanobiotechnology 4 (3+1)

Objectives

i. To provide an understanding of the concepts and terminologies related to nanobiotechnology
ii. To study nanosystems, their synthesis and application

Theory

Introduction to nanotechnology. Concepts and Terminology. Nano-Bio Interface. Biological-based nanosystems, molecular motors, biosensors and other devices.

Self-assembly of molecules for nanotechnology applications. Biomimetics, biotemplating and de novo designed nanostructures and materials. DNA-nanotechnology. Nanomanipulations, material design, synthesis and their applications.

Practical

Introduction to nanomaterials and their properties. Nanoscale characterization techniques. Scanning electron microscopy (SEM) and transmission electron microscopy (TEM). Atomic force microscopy (AFM) for nanoscale imaging and manipulation. Spectroscopic techniques (UV-Vis, fluorescence, Raman) for nanoparticle analysis. Nanoparticle synthesis and functionalization, chemical synthesis methods for nanoparticles (top-down and bottom-up approaches), surface functionalization techniques for controlling nanoparticle properties. Biomolecular interactions at the nanoscale, nanotoxicology and safety assessment. Project and presentations.

Suggested Readings

1. Bhowmick T K, Gayen K and Maity S K. 2024. *Nanobiotechnology: Applications of Nanomaterials in Biotechnology, Medicine, and Healthcare*. CRC Press, Boca Raton, FL, USA.
2. Gabor L, Hornyak J, Moore J, Tibbals H F and Joydeep D. 2009. *Fundamentals of Nanotechnology*. CRC Press.
3. Kumar U. 2008. *Nanotechnology: A Fundamental Approach*. Agrobios.
4. Saxena J, Singh A and Jyoti A. 2023. *Nanobiotechnology: Principles and Applications*. Bentham Books, Sharjah, UAE.
5. Singh N A, Khangarot R K, Nagda G. 2025. *Nanotechnology: Journey from Laboratory to Society*. NIPA, New Delhi, India.
6. Visakh P M and Bayraktar O. 2024. *Recent Progress in Nanobiotechnology: Modern Techniques in Biomedical Applications*. Springer Nature Singapore, Singapore.

Animal Biotechnology 3 (2+1)

Objectives

i. To study historical developments in animal biotechnology
ii. To study the biotechnological tools for improving animal health and products
iii. To study the use of molecular markers for animal genome analysis

Theory

History and development of animal biotechnology. Basic techniques in animal cell culture. Introduction to embryo biotechnology, oocyte collection and maturation. Sperm preparation. in vitro fertilization. Cryopreservation of oocyte, sperm and embryos. Embryo transfer technology.

Breeds of livestock and their characteristics. Marker-assisted breeding of livestock. Introduction to animal genomics: RFLP, RAPD, SSRs, QTL, SNP, STR, mitochondrial DNA

polymorphism. Rumen and its environment. Rumen microbes - manipulation of rumen microbes for better utilization of feed. Introduction to nutrigenomics. Milk biome. Manipulation of lactation by biotechnological tools. Application of biotechnology in meat and meat products.

Genome and protein-based diagnostics of important animal diseases: FMD, brucellosis, PPR, mastitis, bluetongue, newcastle disease. Introduction to vaccinology, live attenuated vaccines, killed vaccines, cell culture-based vaccines, recombinant vaccines.

Practical

Basic cell culture techniques, oocyte aspiration from ovaries, sperm preparation, in vitro fertilization. PCR-based detection of animal pathogens. PCR-RFLP. Immunohistochemical localization of protein marker in tissues/cells – meat species identification by PCR.

Suggested Readings

1. Sasidhara R. 2024. *Animal Biotechnology*. MJP Publishers, Chennai.
2. Singh B, Gautam S K, Chauhan M S and Singla S K. 2015. *Textbook of Animal Biotechnology*. The Energy and Resources Institute, TERI.
3. Srivastava A K and Singh R K. 2018. *Animal Biotechnology*. CBS Publishers and Distributors, ISBN 9788120416482, 8120416481.
4. Yata V K, Mohanty A K and Lichtfouse E. 2024. *Sustainable Agriculture Reviews: Animal Biotechnology for Livestock Production 4*. Springer Nature Switzerland, Cham, Switzerland.

Genomics and Proteomics 3 (3+0)

Objectives

i. To provide an understanding of genomics; structural and functional
ii. To study comparative genomics and its applications
iii. To study proteomics and related tools

Theory

Introduction to genomics. Functional genomics and proteomics. Structural genomics: classical ways of genome analysis. BAC and YAC libraries. Next generation sequencing. Genome analysis and gene annotation. Genome projects: *E. coli*, Arabidopsis, Bovine, Human. Comparative Genomics: orthologous and paralogous sequences. Synteny, gene order, phylogenetic footprinting.

Functional genomics: Differential gene expression techniques: ESTs, cDNA-AFLP, microarray, Differential display, SAGE, RNAseq, Real-time PCR

Introduction to proteomics. Analysis of proteome. Native PAGE, SDS PAGE, 2D PAGE. Edmann Degradation. Chromatographic techniques: HPLC, GC, Mass Spectrometry: MALDI-TOF, LC-MS, SWATH-MS. Post Translational modifications.

Suggested Readings

1. Andreas H and Samuel C. 2018. *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
2. Saraswathy N, Ramalingam P. 2011. *Concepts and Techniques in Genomics and Proteomics*. Elsevier Science.

3. Thangadurai D and Sangeetha J. 2021. Genomics and Proteomics: Principles, Technologies, and Applications. Apple Academic Press, Palm Bay, FL, USA.
4. Ukkund S J, Yashaswini B M, and Shabeeba V. 2024. *Genomics & Proteomics*. LAP Lambert Academic Publishing, Saarbrücken, Germany.

Enzymology and Enzyme Technologies 3 (2+1)

Objectives

i. To study the basic structure, function and types of enzymes.
ii. To study enzyme kinetics, regulation of enzyme activity and applications of enzymes.

Theory

Classification and nomenclature of enzymes. General characteristics of enzymes, active site, cofactors, prosthetic groups. Metalloenzymes; Isolation, purification, characterization and assays of enzyme and international units. Criteria for purity.

Enzyme kinetics, effect of pH, temperature, determination of Km and Vmax. Regulation of enzyme activity. Enzyme inhibition. competitive, non-competitive and uncompetitive. Isoenzymes, schizomers and isoschizomers. Ribozymes. Immobilization of enzymes. Applications of enzymes; biotechnology, industry, environment, agriculture, food and medicine.

Practical

Isolation, purification and assay of enzymes. Determination of optimum pH and optimum temperature of enzymes. Thermostability of enzymes. Activators and inhibitors of enzyme catalysis. Immobilization of enzymes. Isoenzymes analysis.

Suggested Readings

1. Holdgate G A, Turberville A and Lanne A. 2024. *Laboratory Guide to Enzymology*. Wiley, Hoboken, NJ, USA.
2. Latoo S A. 2024. *Enzymes and DNA Recombinant Technology*. Nova Science Publishers, Hauppauge, NY, USA.
3. Nelson D L and Cox M M. 2017. *Lehninger Principles of Biochemistry*. (7th Edn.), W. H. Freeman.
4. Punekar N S. 2025. *ENZYMES: Catalysis, Kinetics and Mechanisms*. (2nd Edn.), Springer Nature Singapore, Singapore.
5. Satyanarayana U and Chakrapani U. 2021. *Essentials of Biochemistry*. Elsevier.

Immunology 3 (2+1)

Objectives

i. To study the meaning and importance of immunology
ii. To study the classes of antigens and antibodies
iii. To study the immunological techniques and DNA vaccines

Theory

History and scope of immunology. Components of the immune system: organs, tissues and cells. Immunoglobulin structure and functions. Molecular organization of immunoglobulins

and classes of antibodies. Antibody diversity; antigens, haptens, antigens antibody interactions. Immuno-regulation and tolerance.

Allergies and hypersensitive response. Immunodeficiency. Concept of Vaccines and Vaccinology. Conventional Vaccines. Recombinant subunit vaccines. DNA vaccines and vectored vaccines. Immunological techniques. Immunological application in animal science, monoclonal antibodies and their uses.

Practical

Preparation of buffers and reagents. Precipitation and agglutination test; HA, HI test; immunoblotting, immune electrophoresis and fluorescent antibody test; enzyme immunoassays including ELISA variants, Western blotting. Raising of antisera in laboratory animals. Collection and preservation of antisera – separation, filtration and aliquoting.

Suggested Readings

1. Judy O, Jenni P, Sharon S and Patricia J. 2018. *Kuby Immunology*. Macmillan Learning.
2. Abbas A K, Lichtman A H and Pillai S. 2024. *Basic Immunology: Functions and Disorders of the Immune System*. (7th Edn.), Elsevier, Philadelphia, PA, USA.
3. Cherayil B J. 2024. *The Logic of Immunity: Deciphering an Enigma*. Johns Hopkins University Press, Baltimore, MD, USA.
4. Matsumoto M. 2024. *Basic Immunology and Its Clinical Application*. Springer, Singapore.

Study Tour- Non-gradial 2 (0+2)

The study tour will be of 10-14 days duration within the 5th semester.

The students will visit industries/ institutions, preferably outside the state, so that, in addition to visiting the organisations/ industries (related to the profession), they will also be exposed to the geographical, social, socio-economic and cultural diversity of different places/ states. After the visit, the students will submit a report/ make a presentation.

Semester VI

Molecular Diagnostics 3 (2+1)

Objectives

i. To understand the importance of molecular diagnostics
ii. To acquaint with various methods of diagnostic methods
iii. To compare the advantages of molecular diagnostic methods with those of conventional methods

Theory

Principle and applications of molecular diagnostic tests. Nucleic acid-based diagnostics for detection of pathogenic organisms. Application of restriction endonuclease analysis for identification of pathogens. Polymerase chain reaction (PCR) and its variants. Reverse transcriptase polymerase chain reaction (RT-PCR); isothermal amplification (LAMP); LCR, nucleic acid sequence-based amplification (NASBA); Real-Time PCR; DNA Probes; Southern blotting; Northern blotting.

Protein-based assays: SDS-PAGE, Western Blot, Dot-blot, ELISA and lateral flow device.

Advantages of molecular diagnostics over conventional diagnostics, serodiagnostic, DNA array technology, Protein array, tissue array. Biosensors and nanotechnology. Development and validation of diagnostic tests.

Practical

Preparations of buffers and reagents. Collection of clinical and environmental samples for molecular detection of pathogens (bacteria/virus). Extraction of nucleic acids (DNA and RNA) from the clinical specimens. Restriction endonuclease digestion and analysis using agarose gel electrophoresis. Polymerase chain reaction for detection of pathogens in blood and animal tissues. RT-PCR for detection of RNA viruses. PCR based detection of meat adulteration in processed and unprocessed meats. PCR based detection of pathogens in milk, eggs and meat. Lateral flow assay, ELISA.

Suggested Readings

1. Buckingham L. 2019. *Molecular Diagnostics: Fundamentals, Methods, and Clinical Applications*. (3rd Edn.). F.A. Davis Company, Philadelphia, PA, USA.
2. Lela B. 2019. *Molecular Diagnostics: Fundamentals, Methods and Clinical Applications*. FA Davis Company.
3. Rifai N. 2024. *Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics*. (9th Edn.). Elsevier, Philadelphia, PA, USA.
4. Singh B D. 2021. *Biotechnology Expanding Horizons*. Kalyani Publishers.

Industrial Biotechnology 3 (3+0)

Objectives

i. To understand various industrial bioprocesses
ii. To acquaint with the production of primary metabolites and secondary metabolites
iii. To study the industrial production of bioproducts

Theory

Introduction to industrial bioprocess. Fermentation- bacterial, fungal and yeast. Traditional and modern biotechnology- a brief survey of organisms, processes, and products. Basic concepts of upstream and downstream processing in bioprocess.

Production of primary metabolites. Primary metabolites- production of commercially important primary metabolites like organic acids, and alcohols.

Production of secondary metabolites. Secondary metabolites- production processes for various classes of secondary metabolites: antibiotics, vitamins and steroids.

Production of bioproducts. Production of biopesticides, biofertilizers, biopreservatives, biopolymers biodiesel. bheese, beer, and bushroom culture, bioremediation.

Suggested Readings

1. Balasubramanian D, Bryce C F A, Dharmalingam K, Green J and Kunthala J. 2004. *Concepts in Biotechnology*. Universities Press Pvt.Ltd.

2. Benvenuto M A. 2024. *Industrial Biotechnology*. (2nd Edn.). De Gruyter, Berlin, Germany.
3. Dubey R C. 2006. *A Textbook of Biotechnology*. S. Chand and Sons.
4. Kumar H D. 1998. *A Textbook on Biotechnology*. (2nd Edn.). Affiliated East West Press Pvt.
5. Ratledge C and Bjorn K. 2001. *Basic Biotechnology*. (2nd Edn.). Cambridge University Press.
6. Suganthi R. 2024. *Industrial Biotechnology Laboratory Manual*. LAP Lambert Academic Publishing, Saarbrücken, Germany.
7. Verma P. 2024. *Industrial Microbiology and Biotechnology: An Insight Into Current Trends*. Springer, Singapore.

Epigenetics and Gene Regulation 2 (2+0)

Objectives

i. To have an understanding the epigenetics; its manifestation and consequences
ii. To study the forms of DNA and histone modifications and their role in gene regulation
iii. To study the influence of epigenetics on the small RNAs

Theory

DNA methylation and histone modifications. DNA methylases, methyl binding proteins and histone modifiers. Epigenetic changes in response to external stimuli leading to changes in gene regulation. Role of DNA methylation in plant development: mutant case studies.

Introduction to small RNAs. History, biogenesis. In silico predictions, target gene identification, methylation of heterochromatin by het associated siRNAs. Gene regulation by small RNA and other classes of siRNAs. Role in epigenetics. Jacob Monod model, RNA editing, genome imprinting.

Suggested Readings

1. Sambrook J F and Russell D W. 2001. *Molecular Cloning: A Laboratory Manual*. (3rd Edn.) (Vol. I, II, III). Cold Spring Harbor Laboratory Press.
2. Mohanpuria P, Kumar V, Mahajan M, Mohammad H and Yadav S K. 2010. *Gene Silencing: Theory, Techniques and Applications: Genetics-Research and Issues*. Nova Science Publishers.
3. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India.

IPR, Biosafety and Bioethics 2 (2+0)

Objectives

i. To study the importance and forms of IPR.
ii. To study the role of IPR in connection with biodiversity and research outcomes.
iii. To study the biosafety guidelines for handling the GMOs.

Theory

Introduction to Intellectual Property, concepts and types. International treaties for the protection of IPR. Indian Legislations for the protection of various types of intellectual property. Patent search, filing process. Material transfer agreements.

Biodiversity definition, importance and geographical causes for diversity. Species and population biodiversity, maintenance of ecological biodiversity hot spots in India. Convention on biological diversity. Cartagena protocol of bio-safety, and risk management for GMO's. Bio-safety guidelines, rules and regulations and regulatory framework for GMOs in India.

Suggested Readings

1. Deepa G and Shomini P. 2013. *IPR, Biosafety and Bioethics*. Pearson Education.
2. Goel D and Parashar S. 2013. *IPR, Biosafety and Bioethics*. Pearson India, New Delhi, India.
3. Singh B D. 2021. *Biotechnology Expanding Horizons*. Kalyani Publishers.
4. Srivastav A K, Sharma P, Das P and Parashar V B. 2024. *Intellectual Property Rights, Biosafety, and Bioethics: Ethical Frontiers*. Namya Press, New Delhi, India.

Computational Biology 3 (2+1)

Objectives

i. To study the basics of web-based servers and software in genome analysis.
ii. To study the procedure and steps in DNA/RNA/protein sequence submission
iii. To study the methods of analysing the sequences for similarity and phylogenetics

Theory

Introduction to computational biology. Web-based servers and software for genome analysis. Ensembl, UCSC genome browser, MUMMER, BLASTZ. Sequence submission: sequence submission, whole genome sequence submission; NGS: basics and types. Introduction to bioprogramming; Perl, Python and R development of web server; basic concepts.

Protein interaction databases: BIND, DIP, GRID, STRING, PRIDE. Principles of Protein structure prediction. Fold Recognition (threading). Homology modeling. SCOP, CATH, PDB, PROSITE, PFAM. Methods for comparison of 3D structures of proteins.

Phylogenetic analysis. Evolutionary models, tree construction methods, statistical evaluation of tree methods; PHYLIP, dendroscope, MEGA; DNA barcoding database-BOLD.

Practical

Application of Genome browsers in genomic research. Exploring protein-protein interaction databases. Working with protein structural classification databases. SNP and SSR identification tools; PHYLIP.

Suggested Readings

1. Creighton T E. 1993. *Proteins: Structures and Molecular Properties*. (2nd Edn.). W. H. Freeman.
2. Dov S. 2003. *Microarray Bioinformatics*. (1st Edn.). Cambridge University Press.
3. Gusfield D. 2024. *Proven Impossible: Elementary Proofs of Profound Impossibility from Arrow, Bell, Chaitin, Gödel, Turing, and More*. Cambridge University Press, Cambridge, UK.
4. Malcolm Campbell A and Laurie J H. 2007. *Discovering Genomics, Proteomics and Bioinformatics*. (2nd Edn.). Benjamin Cummings.

5. Maulik U. 2024. *Multiobjective Optimization Algorithms for Bioinformatics*. Springer, Germany.
6. Mount D. 2001. *Bioinformatics: Sequence and Genome Analysis*. (2nd Edn.). Cold Spring Harbor Laboratory Press.
7. Setubal J and Meidanis J. 2004. *Introduction to Computational Molecular Biology*. PWS Publishing Company.

Introduction to Animal Breeding 3 (2+1)

Objectives

i. To study the development and goals of animal breeding
ii. To study population genetics
iii. To study the methods of animal breeding

Theory

Population and population genetics; Hardy- Weinberg law; Hardy Weinberg equilibrium. Approaching to equilibrium for sex-linked trait; linkage equilibrium. Effect of linkage on HW-equilibrium. Stochastic and deterministic forces acting on population; mutation; migration; selection.

Dissection of phenotype into its components. Transmitting ability, substitution effect of allele. Breeding value. Definition, concept. Heritability: definition, concept, estimation of heritability from regression of offspring to parents. Resemblance among relatives. Repeatability. Definition, concept and estimation. Correlated traits. Phenotypic and genetic correlation, environmental correlation, selection index. Basic concept and types. Basis of selection. Selection differential and genetic gain.

Breeding strategies in large ruminants (cattle, buffalo), small ruminants (sheep, goat) and swine. Poultry breeding. Lab animal breeding. Breed improvement program conducted in India. Molecular breeding: complementation of traditional breeding strategies with molecular genetics.

Practical

Chi-squared test for determining goodness of fit for HW-equilibrium. Estimation of effect of allelic substitution. Estimation of heritability, regression of offspring on parents. Estimation of repeatability. Phenotypic correlation, genetic correlation, environmental correlation. Chi-squared test for determining goodness of fit for HW-equilibrium. Linkage analysis from pedigree data. Selection index.

Suggested Readings

1. Bourdon R M. 2000. *Understanding Animal Breeding*. (2nd Edn.). Prentice Hall, Upper Saddle River, NJ, USA.
2. Brah G S. 2014. *Animal Genetics: Concepts and Implications*. (2nd Edn.). Kalyani Publishers.
3. Mackay T F C and Falconer D S. 2009. *Introduction to Quantitative Genetics*. (4th Edn.). Pearson.
4. Oldenbroek K and Calus M. 2024. *Textbook Animal Breeding and Genetics*. (2nd Edn.). Wageningen University & Research, Wageningen, Netherlands.

Biostatistics 2 (1+1)

Objectives

i. To study the variables and descriptive statistics
ii. To study various distributions
iii. To study experimental data analysis and interpretation

Theory

Random variables: expected value and its variance; probability distribution of random variables. Conditional probability. Baye's theorem and its applications. Introduction to uniform, binomial, poisson, normal, exponential and gamma probability distributions.

Random mating populations, Hardy-Weinberg Law. Introduction to poisson process and Markov chains. Transition probability matrix, n-step transition probabilities, steady state. Random walk models. Sensitivity and specificity. Positive and negative predictive values.

Chi-square test: testing heterogeneity, use in the genetic experiment, detection of linkage, linkage ratios and its estimation. Analysis of variance. One-way and two-way classification with interaction. Analysis of covariance. Incomplete block designs. Estimation and significance of genotypic and phenotypic variation.

Practical

Expected value and variance of discrete and continuous distributions. Uniform, binomial, poisson, normal, nxponential and namma probability distributions. Hardy-Weinberg Law. Construction of transition probability matrix in Markov Chains. Calculation of sensitivity and specificity. Positive and negative predictive values. Detection and linkage using chi-square test; one-way and two-way analysis of variance. Analysis of covariance. Incomplete block designs. Estimation of heritability.

Suggested Readings

1. Galwey N W. 2024. *The False Discovery Rate: Its Meaning, Interpretation and Application in Data Science.* Wiley, Hoboken, NJ, USA.
2. Gupta S C, Kapoor V K. 2007. *Fundamentals of Applied Statistics*. (4th Edn.). S Chand and Sons.
3. Kaps M and Lamberson W R. 2017. *Biostatistics for Animal Science*. (3rd Edn.). CABI.
4. Patra B, Bhushan B, Purohit H and Gaur P. 2025. *Basic Biostatistics*. NIPA, New Delhi, India.
5. Piantadosi S. 2024. *Clinical Trials: A Methodologic Perspective*. (4th Edn.). Wiley, Hoboken, NJ, USA.
6. Triola M M, Triola M F and Roy J. 2017. *Biostatistics for the Biological and Health Sciences*. (2nd Edn.). Pearson.

Food Science and Processing 3 (2+1)

Objectives

i. To study food and nutrition for good health
ii. To study food spoilage, processing and preservation
iii. To study the methods of assessing physical and chemical qualities

Theory

Definition: Food and nutrition. Food production and consumption trends in India. Major deficiencies of calories, proteins, vitamins and micronutrients. Food groups and concept of balanced diet. RDA, biotoxins, anti-nutritional factors and metabolites.

Causes of food spoilage. Principles of processing and preservation of food by heat, low temperature, drying and dehydration, chemicals and fermentation. Preservation through ultraviolet and ionizing radiations.

Post-harvest handling and technology of fruits, vegetables, cereals, oilseeds, milk, meat and poultry. Food safety, adulteration and food laws. Status of food industry in India

Practical

Physical and chemical quality assessment of cereals, fruits, vegetables, egg, meat and poultry. Value-added products from cereals, millets, fruits, vegetables, milk, egg and meat. Visit to local processing units.

Suggested Readings

1. Goyal M R, Mishra S K and Birwal P. 2024. *Food Processing and Preservation Technology: Advances, Methods, and Applications*. Apple Academic Press, Palm Bay, FL, USA.
2. Potter N N and Hotchkiss J H. 1995. *Food Science*. Chapman and Hall Publishers.
3. Prakash A and Kuila A. 2024. *Nonthermal Food Processing, Safety, and Preservation*. Wiley, Hoboken, NJ, USA.
4. Swaminathan M. 1990. *Food Science: Chemistry and Experimental Foods*. BAPPCO.
5. Swaminathan M. 2005. *Handbook of Foods and Nutrition*. Ganesh and Co. Pvt. Ltd.
6. Vaclavik V A and Christian E W. 2003. *Essentials of Food Science*. (2nd Edn.). Kluwer Academic/ Plenum Publishers, New York.

Semester VII

Elective Courses

Applications of Genomics and Proteomics 4 (3+1)

Objectives

i. To introduce the concepts of omics; genomics, transcriptomics and proteomics
ii. To study the methods in genomics and their applications
iii. To study the techniques in proteomics

Theory

Genome of Arabidopsis, rice, tomato, pigeon pea, wheat. Mutants and RNAi in functional genomics. Site-directed mutagenesis. Transposon tagging. Transient gene expression: VIGS and FACS based, targeted genome editing technologies, introductory genome editing principle and concepts.

Protein 3D structure modelling (homology modelling and crystallography). Proteome analysis. Protein-protein interaction. FRET, yeast two-hybrid and co-immunoprecipitation, Bimolecular

Fluorescence Complementation (BiFC). Applications of genomics and proteomics in agriculture, human health and industry. Metabolomics and ionomics for elucidating metabolic pathways.

Practical

SDS-PAGE; 2D Electrophoresis. Protein characterization through HPLC. Specialized crop-based genomic resources: TAIR, Gramene, Graingenes, Maizedb, Phytozome, C e re a l d b, Citrusdb and miRbase.

Suggested Readings

1. Aggarwal R K, Kaler S and Bhatnagar N. 2024. *Cell Biology*. Thakur Publication Private Limited, Jaipur.
2. Connor D O and Hames B D. 2007. *Proteomics: Methods Express*. Royal College of General Practitioners.
3. Pennington S R, Dunn M J. 2001. *Proteomics from Protein Sequence to Function*. BIOS Scientific Publishers Ltd.
4. Sangeetha J and Thangadurai D. 2015. *Genomics and Proteomics: Principles Technologies and Applications*. Taylor and Francis
5. Tropp B E. 2012. *Molecular Biology Genes to Proteins*. (4th Edn.). Jones and Bartlett Learning.
6. Verma P S and Agarwal V K. 2014. *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*. S. Chand and Company Pvt. Ltd.

Principles of Molecular Breeding 4 (3+1)

Objectives

i. To introduce the concept of molecular breeding with reference to conventional breeding
ii To study the mapping populations, genotyping, phenotyping and mapping
iii. To study the validation of genomic resources and their employment in breeding

Theory

Introduction to molecular breeding, advantages, requirements and methodologies. Limitations of conventional breeding. Development of specific mapping populations, association panels, MAGIC and NAM populations.

Phenotyping and genotyping of the populations, construction of the linkage maps, and linkage-disequilibrium maps. Analysing marker-trait associations, validation of QTL and markers, fine-mapping, and candidate gene discovery.

Marker-assisted selection (MAS) and marker-assisted backcross breeding. Foreground selection, background selection and recombination selection. MAS for major and minor genes, marker-assisted pyramiding, and marker-assisted recurrent selection.

Practical

Methodologies in phenotyping, genotyping, handling marker data, linkage analysis, candidate gene discovery, and fine-mapping. Software for linkage mapping and association mapping. Working

on some genotyping and phenotyping datasets for linkage mapping using software such as Mapmaker, MapDisto and QTL mapping software such as WinQTL Cartographer.

Suggested Readings

1. Acquaah G. 2020. *Principles of Plant Genetics and Breeding*. (3rd Edn.). Wiley-Blackwell, Hoboken, NJ, USA.
2. Bharadwaj D N. 2019. *Molecular Plant Breeding: Meeting the Challenge of Food Security*. Apple Academic Press.
3. Chawla R. 2024. *Basics to Advances in Molecular Breeding for Crop Improvement*. Iterative International Publishers, Chikmagalur, Karnataka, India.
4. Singh B D and Shekhawat N S. 2017. *Molecular Plant Breeding*. Scientific Publishers.
5. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India.
6. Xu Y. 2010. *Molecular Plant Breeding*. CABI, Science.

Principles and Procedures of Plant Tissue Culture 3 (2+1)

Objectives

i. To understand the concept of totipotency and its applications in plant tissue culture
ii. To study the composition of plant tissue culture media and the role of different components
iii. To study the principles, procedures and uses of various types of cultures

Theory

History of plant tissue culture. Concept of totipotency. Concept of aseptic culture practices and sterilization techniques. Components of *in vitro* culture media and role of different macro and micronutrients, vitamins, plant growth regulators and growth supplements. Various plant cell, tissue and organ culture techniques and uses. Somatic cell cultures. Morphogenesis: organogenesis and somatic embryogenesis. Micropropagation; *In vitro* grafting. Meristem culture. Anther, pollen. embryo, ovule and ovary culture. Protoplast culture and somatic hybridization. Somaclonal variation.

Practical

Good laboratory practices. Media preparation and sterilization. Surface sterilization of explants. Establishment of callus/cell suspension cultures. Micropropagation. Embryo culture. Anther culture. Induction of plant regeneration. Hardening and transfer to soil.

Suggested Reading

1. Bhojwani S S and Razdan M K. 1996. *Plant Tissue Culture: Theory and Practice*. Elsevier.
2. Chawla H S. 2009. *Introduction to Plant Biotechnology*. Oxford & IBH Publishing Co Pvt. Ltd.
3. Dixon R A and Gonzales R A. 2003. *Plant Cell Culture: A Practical Approach*. Oxford University Press.
4. Khurana S M P and Kumar N. 2022. *Plant Biotechnology: A Textbook*. Scientific Publishers, Jodhpur.
5. Razdan M K. 2008. *Introduction to Plant Tissue Culture*. Oxford & IBH Publishing Co Pvt. Ltd.

Molecular Breeding in Field and Horticultural Crops 3 (2+1)

Objectives

i. To study the principles and applications of molecular breeding in field and horticultural crops
ii. To understand breeding objectives in field and horticultural crops
iii. To study the success stories of molecular breeding in field and horticultural crops

Theory

MAS for specific traits with examples from field crops with success stories. Development, testing and release of improved genotypes developed using MAS. Specific case studies. Reproductive biology of major field and horticultural crops. Target traits in major field and horticultural crops. Breeding methods of self- and cross-pollinated field and horticultural crops. Pseudo test cross-mapping strategy in fruit crops. Molecular mapping in vegetable crops. Marker-assisted breeding in field and horticultural. Mutation breeding and characterization of mutants.

Practical

Use of gene-based and closely linked markers for foreground selection for target traits in target field crops. Hands-on training on MAS with a specific crop. Modifications in DNA extraction methods for field and horticultural crops. Agarose gel electrophoresis, and DNA quantification. Mapmaker; Diversity analysis using UPGMA. Identifying repeat sequences using MISA. Standard gene cloning and expression methods.

Suggested Readings

1. Bal J S. 2013. *Fruit Growing*. Kalyani Publishers.
2. Bharadwaj D N. 2019. *Molecular Plant Breeding: Meeting the Challenge of Food Security*. Apple Academic Press
3. Chada K L. 2012. *Handbook of Horticulture*. ICAR.
4. Kumar N. 2006. *Breeding of Horticultural crops: Principles and Practices*. New India Publishing Agency.
5. Kumar N. 2018. *Breeding of Horticultural Crops: Principles and Practices*. (3rd Edn.). NIPA.
6. Kumar S, Kumar A, and Kumar S (Eds.). 2024. *Plant Molecular Breeding in Genomics Era*: *Concepts and Tools*. Springer Nature Switzerland, Cham, Switzerland.
7. Nagat T, Lorz H and Widholm J M. 2008. *Biotechnology in Agriculture and Forestry*. Springer.
8. Schnell R J and Priyadarshan P M. 2012. *Genomics of Tree Crops*. Springer.
9. Singh B D and Shekhawat N S. 2017. *Molecular Plant Breeding*. Scientific Publishers.
10. Singh J. 2014. *Basic Horticulture*. Kalyani Publishers.
11. Singh R. 2012. *Fruits*. National Book Trust.
12. Spangenberg G. 2001. *Molecular Breeding of Forage Crops*. Kluwer Academic Publishers.
13. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India.
14. Trivedi P C. 2000. *Plant Biotechnology: Recent Advances*. Panima Publishers.
15. Xu Y. 2010. *Molecular Plant Breeding*. CABI, Science.

Seed Biology, Biotechnology, Production and Management 3 (2+1)

Objectives

i. To provide an overview of the aspects of seed biology
ii. To study the principles and methods of quality seed production
iii. To study the techniques and management for seed processing

Theory

Seed structure, seed development and maturation. Seed germination. Seed senescence- causes, quality characters.

Molecular seed biology: gene expression during seed development, molecular markers and seed quality, omics technologies in seed research and male sterility systems. Biofortification and seed enhancement, seed coatings and treatments, biopesticides and biofertilizers. Advances in seed biotechnology, sustainable seed production practices and future challenges and opportunities in seed science.

Principles of quality seed production. Factors affecting quality seed production. Causes of varietal deterioration and maintenance of genetic purity during seed production.

Post-harvest handling of seeds - threshing methods - drying methods - advantages and disadvantages. Seed processing principles and sequencing. Seed enhancement technologies (coating, priming, pelleting and hardening)

Practical

Seed production in rice varieties and hybrids. Seed production in sorghum varieties and hybrids. Seed production in pearl millet varieties and hybrids. Seed production in maize. Hybrid seed production in maize. Seed production in pulses (black gram and green gram and red gram). Seed production in groundnut and gingelly. Seed production in sunflower varieties and hybrids. Seed production in cotton. Seed production in solanaceous vegetables. seed production techniques of bhendi and onion. Seed production in cucurbits (snake gourd, bitter gourd, ash gourd, ridge gourd and pumpkin).

Suggested Readings

1. Basra A. 2006. *Handbook of Seed Science and Technology (Seed Biology, Production, and Technology)*. CRC Press.
2. Dadlani M and Yadava D K (Eds.). 2023. *Seed Science and Technology: Biology, Production, Quality*. Springer Nature Singapore, Singapore.
3. Khedar O P, Singh R V, Sinsinwar Y K and Ved Prakash V. 2013. *Seed Production Technology in Field Crops*. Pointer, ISBN 10: 817132746XISBN 13: 9788171327461.
4. Tiwari A K (Ed.). 2020. *Advances in Seed Production and Management*. Springer Nature Singapore, Singapore.

Plant Genetic Transformation 3 (2+1)

Objectives

i. To study the historical developments of plant transformation
ii. To study the methods of plant transformation

iii. To get acquainted with the methods used for analysing the transgenics

Theory

History of plant genetic transformation. Development of gene constructs. Methods of genetic transformation: *Agrobacterium*-mediated, biolistics, electroporation, liposome, polyethylene glycol, in planta methods.

Selection and characterization of transgenic plants using selectable and reportable markers. PCR; qRT-PCR; Southern and Northern hybridization, ELISA and Western blotting. Application of genetic transformation for improvement of important traits. Biosafety aspects of transgenic plants and regulatory framework.

Practical

Preparation of stock solutions. Construction of binary vector. Preparation of competent cells of *Agrobacterium tumefaciens* and transformation. Restriction analysis of plasmids, confirmation of transformed bacterial colonies. *Agrobacterium tumefaciens* mediated and biolistic plant transformation.

Suggested Readings

1. Gardener E J, Simmons M J and Snustad D P. 1991. *Principles of Genetics*. John Wiley and Sons, Inc, New York, USA.
2. Grierson D. 2012. *Plant Genetic Engineering*. Springer Netherlands.
3. Khurana S M P and Kumar N. 2022. *Plant Biotechnology: A Textbook*. Scientific Publishers, Jodhpur.
4. Primose S B and Twyman R M. 2006. *Principles of Gene Manipulation and Genomics*. (7th Edn.). Black Well Publishing.
5. Sambrook J F and Russell D W. 2001. *Molecular Cloning: A Laboratory Manual*. (3rd Edn.). (Vol. I, II, III). Cold Spring Harbor Laboratory Press.
6. Stewart N C. 2008. *Plant Biotechnology and Genetics: Principles, Techniques and Applications*. John Wiley and Sons Inc.

Principles and Procedures of Animal Cell Culture 4 (3+1)

Objectives

i. To study the principles and importance of animal cell culture
ii. To study the basic requirements for animal cell culture
iii. To study the techniques in cryopreservation and applications of animal cell culture

Theory

History, importance and development of animal cell culture techniques. Basic requirements for animal cell culture. Sterilization procedures for cell culture work. Different types of cell culture media, growth supplements, serum-free media and other cell culture reagents.

Different cell culture techniques including primary and secondary cultures; continuous cell lines, suspension culture, organ culture etc. Commonly used animal cell lines: CHO, HeLa, BHK-21, VERO, Sf 9, C636, their origin and characteristic, growth kinetics of cells in culture, differentiation of cells. Characterization and maintenance of cell lines. Applications of animal cell cultures.

Cryopreservation and revival of cells. Hybridoma technology. Scaling up methods, bioreactors. Overview of insect cell culture. Stem cell culture and its application, overview of induced pluripotent stem cells (iPSCs). Common cell culture contaminants and their management.

Practical

Basic equipments used in animal cell culture laboratories. Washing, packing and sterilization of glass and plastic wares for cell culture. Preparation of media and reagents for cell culture. Primary culture technique of chicken embryo fibroblast/any other animal tissue. Culture and sub-culturing of continuous cell lines. Viability assay by trypan blue dye exclusion method. Isolation and cultivation of lymphocytes. Cryopreservation of primary cultures and cell lines. Cytopathic effect of viruses on cultured mammalian cells.

Suggested Readings

1. Capes-Davis A. 2021. Freshney's Culture of Animal Cells: *A Manual of Basic Technique and Specialized Applications*. (8th Edn.). Wiley-Blackwell, Hoboken, NJ, USA.
2. Mani S, Singh M, and Kumar A. 2023. *Animal Cell Culture: Principles and Practice*. Springer, Cham, Switzerland.

Animal Genomics 4 (3+1)

Objectives

i. To study the genome sequencing and organisation of the animal genome and chromosomal aberrations
ii. To study the application of genomics in the development of molecular markers
iii. To study the application of genomics and molecular markers in animals

Theory

Genome organization in eukaryotes. Satellite DNA: VNTRs and families, LINE and SINE. Sex determination: chromosomal basis of sex determination, molecular markers for sex determination, environmental sex determination. Chromosomal aberrations: euploidy, chromosomal non-disjunction and aneuploidy, polyploidy, induced polyploidy, syndromes, structural aberrations. Robertsonian translocations, position effect, chromosomal mosaics, Philadelphia chromosome, chromosomal aberrations and evolution.

Molecular markers: markers, genetic markers: RAPD, STR, DNA fingerprinting, SSCP, RFLP, SNP, EST; SNP Analysis. Karyotyping. Somatic cell hybridization, SNP-array. Radiation hybrid maps. FISH technique. Major histocompatibility complex. Concept and its relevance in disease resistance and immune response. Quantitative trait Loci. Marker Assisted Selection: concept, linkage equilibrium, application in animal sciences. Genomic selection: concept, linkage disequilibrium. Methodologies of genomic selection. Mitochondrial DNA analysis and its application in livestock; applying DNA markers for breed characterization, molecular signatures.

Practical

Extraction of genomic DNA from peripheral blood. Analysis of DNA by agarose or polyacrylamide gel electrophoresis. Checking the quality and quantity of genomic DNA. Restriction

digestion and analysis. Sanger sequencing data analysis. Extraction of mitochondrial DNA. Extraction of RNA from PBMC. Quality checking of total RNA. cDNA synthesis.

Suggested Readings

1. Brown T A. 2006. *Genomes*. (5th Edn.). Wiley-Blackwell.
2. Dale J W, Schantz M V and Plant N. 2012. *From Genes to Genomes: Concepts and Applications of DNA Technology*. John Wiley and Sons.
3. Green and Sambrook J F and Russel D W. 2014. *Molecular Cloning: A Laboratory Manual*. (4th Edn.). (Vol I, II, III). Cold Spring Harbor Laboratory Press.
4. Mondal S and Singh R L (Eds.). 2020. *Advances in Animal Genomics*. Academic Press, Cambridge, MA, USA.
5. Oldenbroek K and Calus M. 2024. *Textbook Animal Breeding and Genetics*. (2nd Edn.). Wageningen University & Research, Wageningen, Netherlands.
6. Reece R J. 2004. *Analysis of Genes and Genomes*. Wiley.
7. Sue C, Heather B M, Scott D W and Melissa C S. 2019. *Molecular Biology Techniques: A Classroom Laboratory Manual*. Academic Press.

Transgenic Animal Production 3 (3+0)

Objectives

i. To study the historical developments of developing transgenic animals
ii. To study the methods of animal transformation
iii. To get acquainted with the methods used for analysing the transgenics
iv. To study the applications of transgenic animals

Theory

History of transgenesis. Isolation of gene, preparation of gene construct. Methods of transgenic animal production. Calcium chloride mediated transfection, lipofection, electroporation, microinjection, nano delivery.

Production of gene knockouts: cre-lox, zinc finger nucleases; CRISPR; TALENs. Production of chimeric animals, gene silencing by lentivirus system.

Stem cell technology, isolation and characterization of stem cell lines from different sources: embryo, mesenchymal, induced pluripotent stem cell. Introduction to animal cloning. Application of stem cells in transgenesis and animal cloning.

Fundamental assays of transgenic products: confirmation of integration of transgene. Validation of transgenic products like isolation of transgenic protein from milk and characterization. Application of transgenics in production of disease resistance models and carcinogenesis. Regulatory issues associated with transgenic animal production.

Suggested Readings

1. Armstrong B. 2023. *Textbook of Transgenic Animals and Cloning*. American Academic Publisher.
2. Pinkert C A. 2014. *Transgenic Animal Technology*. Elsevier.

Molecular Virology and Vaccine Production 3 (2+1)

Objectives

i. To study the viruses to develop vaccines
ii. To study the antigens and methods of producing the vaccines
iii. To study the properties of ideal vaccines

Theory

Properties of viruses. Classification of viruses. Virus replication. Cell transformations, cultivation of viruses, assay techniques for detection/quantification. Important animal viruses. Virus-host interactions. Viral infections. Immune responses to viruses. Interferon and other cytokines. Bio-safety and bio-security principles.

Properties of an ideal vaccine. Classification of vaccines. Methods of inactivation and attenuation of viruses. New generation vaccines: subunit, synthetic, rDNA, marker and edible. Adjuvants and vaccine delivery systems. Novel immunomodulators and vaccine delivery using nanotechnology. Vaccine preparation. Stabilizers, preservatives and vehicles. Quality control and testing of vaccines. Sero-surveillance and sero-monitoring.

Practical

Outline of a virology lab and guidelines to work in a virology lab. Processing of clinical specimens for isolation of viruses. Cultivation of viruses in cell cultures and embryonated eggs. Harvesting of virus. Study of cytopathic effects. Titration of virus and estimation of TCID50. Haemagglutination and haemagglutination inhibition test. Detection of virus by SNT, AGID and ELISA.

Suggested Readings

1. Maclachlan N J and Dubovi E J. 2016. *Fenner's Veterinary Virology*. (5th Edn.), Elsevier.
2. Rybicki E P. 2024. *Cann's Principles of Molecular Virology*. (7th Edn.) Academic Press, Cambridge.
3. Buckland B C. 2024. *Vaccine Process Technology—A Decade of Progress*. *Biotechnology and Bioengineering*. Wiley Online Library.

Embryo Transfer Technologies 3 (2+1)

Objectives

i. To study the veterinary reproductive technologies used to obtain offspring from animals as an alternative to natural mating
ii. To study the techniques in embryo transfer
iii. To study gene transfer and biopharming in conjunction with embryo transfer

Theory

History, advantages, limitations and scope of embryo transfer technology. Estrus cycle and its detection in animals. Methodology of superovulation. Ovum pick up (OPU). Preparation of sperm for in vitro fertilization (IVF). Embryo grading and culture. Micromanipulation and immuno-modulation for enhancement of fecundity.

Different methods of gene transfer and their limitations; embryo splitting; embryo sexing by different methods; production of transgenic livestock by nuclear transfer and its application. Animal Biopharming, animal gene bank; regulatory issues (social, ethical, religious and environmental). Cloning of domestic animals. Conservation of endangered species. Characterization of embryonic stem cells and applications.

Practical

Demonstration of estrus detection methods. Estrus synchronization. Superovulation. Oocyte collection from slaughterhouse ovaries. Grading of oocytes from slaughterhouse ovaries. Collection and preparation of semen samples. In vitro fertilization. Collection of embryos using non-surgical procedures. Grading and culture of embryos. Embryo sexing by different methods. Embryo splitting. Embryo freezing.

Suggested Readings

1. Gordon I. 2004. *Reproductive Technologies in Farm Animals*. CABI.
2. Hafez E S E. 2000. *Reproduction in Farm Animals*. Lippincott, Williams and Wilkins.
3. Nagy Z P, Varghese A C and Agarwal A. 2019. *In Vitro Fertilization: A Textbook of Current and Emerging Methods and Devices*. (2nd Edn.). Springer, Cham, Switzerland.
4. Roberts L and Franasiak J. 2023. *Embryo Transfer Technique*. In: Gardner D K, Weissman A, Howles C M and Shoham Z (Eds.). 2023. *Textbook of Assisted Reproductive Techniques*. (6th Edn.). CRC Press, Boca Raton, FL, USA.

Animal Reproductive Biotechnology 3 (2+1)

Objectives

i. To study the basics of animal reproductive technologies used to analyse, understand and enhance the fertility of animals
ii. To study male and female reproduction and methods of checking the quality of gametes
iii. To study the direct and indirect methods of checking pregnancy

Theory

Follicle development, oogenesis, endocrinology of female reproduction, spermatogenesis, endocrinology of male reproduction, structure of spermatozoa and oocyte, semen: composition and contribution to semen by different accessory glands, capacitation of spermatozoa, acrosome reaction, estrus cycle, estrus detection.

Oocyte maturation analysis, methods of semen collection, semen analysis (morphological, microscopic, biochemical or molecular, computer assisted sperm analysis), semen extenders, cryopreservation of semen, oocytes and embryos (history and methods: slow, rapid/ vitrification), polyspermy. fertilization, embryo development, gastrulation, pregnancy diagnosis: different methods (direct and indirect).

Basic terms related to infertility, morphological abnormality in semen, male infertility: terms and causes (genetic and infectious), female infertility: terms and causes (genetic and infectious), artificial gametes, sex sorting of semen.

Practical

Semen collection by artificial vagina, semen analysis (color, volume etc., live dead staining, mass motility, progressive motility, concentration of semen, HOST, abnormality in semen, TUNEL assay, Free Radical Assay). Preparation of semen extender, calculation for semen doses preparation, semen doses preparation, oocyte maturation assessment.

Suggested Readings

1. Dugwekar Y G. 2006. *Reproductive Biotechnology of Farm Animals*. Agrotech Publishing Academy.
2. Farstad W K. 2023. *Textbook of Farm Animal Reproductive Biotechnology*. Hamilton Books, Lanham, MD, USA.
3. Hafez E S E and Hafez B. 2000. *Reproduction in Farm Animals*. (7th Edn.). Blackwell Publishing.
4. Niemann H and Wrenzycki C. 2018. *Animal Biotechnology 1: Reproductive Biotechnologies*. Springer, Cham, Switzerland.
5. Niemann H and Wrenzycki C. 2018. *Animal Biotechnology 2: Emerging Breeding Technologies*. Springer, Cham, Switzerland
6. Yadav P S, Singh B, Singh I and Sethi R K. 2010. *Reproductive Biotechnology in Buffalo*. SSPH, ISBN: 8189304801.

Fundamentals of Molecular Pharming and Biopharmaceuticals 4 (3+1)

Objectives

i. To provide a basic understanding and principles of molecular pharming
ii. To study various hosts and techniques for molecular pharming
iii. To study the biopharmaceuticals that are successfully pharmed

Theory

Concept of molecular pharming and production of biopharmaceuticals. Mammalian cell culture manufacturing and microbial fermentation. Fermentation and cell culture processing. Protein purification and processing. Industrial fermentation: batch and continuous cultures, production of biopharmaceuticals, immobilization techniques.

Biopharmaceutical analytical techniques. Biopharma drug discovery and development; production of specific vaccines and therapeutic proteins, click chemistry/ bioorthogonal chemistry for application in plant science.

Practical

Isolation and purification of proteins from microbes and plants. Production of recombinant proteins in prokaryotes. Analysis of proteins by one and two-dimensional gel electrophoresis. Affinity chromatography. Immunoblotting. Cell culture and immobilization techniques. Visit to biopharmaceutical industry.

Suggested Readings

1. Brown T A. 2010. *Gene Cloning and DNA Analysis*: *An Introduction*. (6th Edn.). Wiley-Blackwell Publishing.
2. Crommelin D J A, Sindelar R D and Meibohm B. 2024. *Pharmaceutical Biotechnology: Fundamentals and Applications*. Springer International Publishing, Cham, Switzerland.

3. Kermode A R and Jiang L. 2018. *Molecular Pharming: Applications, Challenges and Emerging Areas*. Wiley, Hoboken, NJ, USA.
4. Kirkosyan A and Kaufman P B. 2009. *Recent Advances in Plant Biotechnology*. Springer.
5. Primrose S B and Twyman R M. 2013. *Principles of Gene Manipulation and Genomics*. John Wiley and Sons.

Microbial Biotechnology 4 (3+1)

Objectives

i. To study the scope and methods of using industrially useful microorganisms
ii. To study the applications of microbes in industry and agriculture
iii. To study the methods used for improving the microorganisms

Theory

Microbial biotechnology, scope and techniques. Industrially important microorganisms. Gene transfer mechanisms in microbes. Transformation, transduction, conjugation and recombination. Genetic variability in microorganisms. Biotechnological tools to improve the microbial strains with respect to industry and agriculture.

Biotransformation and biodegradation of pollutants, biodegradation of lignocelluloses and agricultural residues. Biotechnological treatment of wastewater, sewage and sludge. Industrial production of alcohols, ethanol, acids (citric acid, acetic acid), solvents (glycerols, acetone, butanol), antibiotics (penicillin, streptomycin, tetracycline), amino acids (lysine, glutamic acid), single-cell proteins. Recombinant and synthetic vaccines.

Practical

Isolation and preservation of industrially important microorganisms. Microbial fermentation, production of proteins and enzymes using bacteria, yeast and fungus. Microbial biomass production, utilization of plant biomass by recombinant microorganisms. Production of secondary metabolites from microbes.

Suggested Readings

1. Glaze A N and Nikaido H. 2007. *Microbial Biotechnology: Fundamentals of Applied Microbiology*. (2nd Edn.). Cambridge University Press.
2. Mohapatra P K. 2006. *Text Book of Environmental Biotechnology*. International Publishing House Pvt. Ltd.
3. Tomar R S, Patel S V, Parakhia M V and Golakiya B A. 2024. *Handbook of Genetics and Biotechnology*. NIPA, New Delhi, India.

Bioprospecting of Genes and Molecules 3 (3+0)

Objectives

i. To study the concepts of bioprospecting
ii. To study the methods and techniques used for producing bioactive molecules
iii. To study the IPR in relation to novel genes and molecules

Theory

Concepts and practices of bioprospecting. Traditional and modern bioprospecting. Gene prospecting. Isolation, synthesis and purification of new bioactive molecules; clinical and field trials; intellectual property rights and the legal framework. Patenting of new genes and/or novel biomolecules and their applications.

Principles of the convention on biological diversity, biodiversity conservation and biotechnology. Development and management of biological, ecological, taxonomic, and related systematic information on living species and systems.

Bioprospecting of microorganisms and their components. Bioprospecting of biodiversity for new medicines. Identification and collection of material by random and traditional (medicinal) approaches. Screening for particular bio-activities. Elucidation of novel molecular form, process technology. Development of techniques for large scale industrial production of the bioactive product and developing market linkage.

Suggested Readings

1. Carlberg C. 2024. *Gene Regulation and Epigenetics: How Science Works*. Springer, Cham, Switzerland.
2. Mattick J and Amaral P. 2022. *RNA, the Epicenter of Genetic Information: A New Understanding of Molecular Biology*. CRC Press, Boca Raton, FL, USA.
3. Mohapatra P K. 2006. *Text Book of Environmental Biotechnology*. International Publishing House Pvt. Ltd.
4. Sharma P D. 2012. *Ecology and Environment*. (11th Edn.). Rastogi Publications.
5. Upadhyay S K and Singh S P. 2021. *Bioprospecting of Microorganism-Based Industrial Molecules*. John Wiley and Sons.
6. Upadhyay S K and Singh S P. 2021. *Bioprospecting of Plant Biodiversity for Industrial Molecules*. John Wiley and Sons. ISBN: 978-1-119-71721-8.

Molecular Ecology and Evolution 3 (3+0)

Objectives

i. To study the meaning and concepts of molecular evolution
ii. To study the concepts of speciation and domestication in conjunction with evolution
iii. To study the application of molecular tools for understanding molecular evolution

Theory

Molecular Evolution. Concept, molecular divergence and molecular clocks. Speciation and domestication. Evolution of earth and earlier life forms. Primitive organisms, their metabolic strategies and molecular coding. New approaches to taxonomical classification including ribotyping. Ribosomal RNA sequencing. Molecular tools in phylogeny, classification and identification.

Protein and nucleotide sequence analysis. Origin of new genes and proteins. Gene duplication and divergence. Genome evolution, components of genomes, whole genome duplications, chromosome rearrangements and repetitive sequence evolution.

Application of molecular genetics and genomics to ecology and evolution. Assessment of genetic diversity, phylogeny, inbreeding, quantitative traits using molecular tools. Mutations. Regulations of gene expression.

Suggested Readings

1. Beebee T and Rowe G. 2008. *An Introduction to Molecular Ecology*. (2nd Edn.). Oxford University Press.
2. Brown T A. 2007. *Genome 3*. Garlan Science Publishing.
3. Carvalho G R. 2002. *Advances in Molecular Ecology*. IOS Press Netherland.
4. Davinack D. 2024. *Molecular Ecology & Evolution: An Introduction*. Wheaton College, Norton, MA, USA.

Food Biotechnology 3 (2+1)

Objectives

i. To study the meaning and concepts of food biotechnology
ii. To study the techniques in food processing and preservation
iii. To study the application of microorganisms and genetic engineering in food biotechnology

Theory

Food Biotechnology. Introduction, history and importance. Applications of biotechnology in food processing; recent developments, risk factors and safety regulations. Food spoilage and preservation process. Food and beverage fermentation: alcoholic and non-alcoholic beverages, food additives and supplements.

Industrial use of microorganisms. Commercially exploited microbes: *Saccharomyces*, *Lactobacillus, Penicillium, Acetobactor, Bifidobacterium, Lactococcus* and *Streptococcus*; dairy fermentation and fermented products. Prebiotics and probiotics. Genetic engineering for food quality and shelf life improvement. Bioactive peptides. Labelling of GM foods.

Practical

Isolation, culture and maintenance of biotechnologically important micro-organisms. Use of laboratory and industrial scale shakers. Batch and continuous cultures. Use of fermentors. Detection of pathogens in food and feed. Detection of GM food. Visit to the food processing industry.

Suggested Readings

1. Ahmad F, Mohammad Z H, Ibrahim S A and Zaidi S. 2024. *Microbial Biotechnology in the Food Industry*: *Advances, Challenges, and Potential Solutions*. Springer, Cham, Switzerland.
2. Anandharamakrishnan C and Moses J A (Eds.). 2024. *Emerging Technologies for the Food Industry*, Volume 1: Fundamentals of Food Processing Technology. Apple Academic Press, Palm Bay, FL, USA.
3. Hui Y H and Khachatourians G G. 1995. *Food Biotechnology: Microorganisms*. Wiley-VCH.
4. Shetty K, Paliyath G, Pometto A and Levin R E. 2006. *Food Biotechnology*. (2nd Edn.). CRC Press.

5. Tiwari B K and Bhavya M L. 2024. *Chemistry of Thermal and Non-Thermal Food Processing Technologies*. Elsevier, Amsterdam, Netherlands.
6. Yaradoddi J S, Meti B S and Mudgulkar S B. 2024. *Frontiers in Food Biotechnology*. Springer, Singapore.

Green Biotechnology 3 (2+1)

Objectives

i. To study the meaning and concepts of green biotechnology
ii. To study the methods and products for better plant growth
iii. To study carbon sequestration and other biosafety approaches for a better environment

Theory

Green biotechnology: definition, concept and implication. Bio-fertilizers and bio-pesticides. Plant growth promoting rhizobacteria. Production of biofuels, biodiesel and bioethanol. Biomass enhancement through biotechnological interventions. Generation of alternate fuels in plants. Identification and manipulation of micro-organisms for biodegradation of plastics and polymers. GMOs for bioremediation and phytoremediation, their roles. Strategies for detection and control of soil, air and water pollutants, circular economy-based resource utilization for biofuel generation.

Carbon sequestration; methanogenic microbes for methane reduction. Microbes for phytic acid degradation. Genetic engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency. Marker-free transgenic development strategies. Development of disease-resistant and pest-resistant crops through biotechnological tools. Biotechnology and sustainable development: sustainable agriculture practices and biotechnology, biotechnological solutions for food security, biotechnology in the context of climate change mitigation and policy and regulatory aspects of green biotechnology.

Practical

Identification and efficiency assays of micro-organisms for biodegradation and bioremediation. Isolation of *Bacillus thuringiensis* and plant growth promoting rhizobacteria. Production of biofertilizers, biopesticides and biofuel. Assays for removal of oil spillage.

Suggested Readings

1. Kirkosyan A and Kaufman P B. 2009. *Recent Advances in Plant Biotechnology*. Springer.
2. Kumar A. 2004. *Environmental Biotechnology*. Daya Publishing House.
3. Murray D C. 2011. *Green Biotechnology*. Dominant Publishers and Distributors.
4. Nirmala C B, Rajalakshmi G and Karthik C. 2024. *Plant Biotechnology*. MJP Publishers, Chennai, India.
5. Tomar A S. 2019. *Green Biotechnology*. Daya Publishing House, New Delhi, India.

Programming in Bioinformatics 4 (2+2)

Objectives

i. To study the importance and essentials of programming in bioinformatics
ii. To study the operating system, algorithms, languages and functions for bioinformatics with hands-on practical
iii. To study programming language

Theory

Introduction: operating systems, programming concepts, algorithms, flow chart, programming languages, compiler and interpreter. Computer number format: decimal, binary, octal and hexadecimal.

C-Language: history, constant, variables and identifiers, character set, logical and relational operators, data input and output concepts. Decision making: if statement, if-else statement, for loop, while loop and do-while loop. Arrays and functions, file handling. Program related to arithmetic operations, arrays and file handling in C.

Practical

PERL-Language: introduction, variables, arrays, string, hash, subroutines, file handling, conditional blocks, loops string operators and manipulators, pattern matching and regular expressions in PERL; sequence handling in PERL demonstrating string, array and hash. Shell Programming: concepts and types of UNIX shell, Linux variables, if statements, control and iteration, arithmetic operations, concepts of awk, grep and sed; Sequence manipulations using shell scripting.

Suggested Readings

1. Balagurusamy E. 2008. *Programming in ANSI C*. Tata McGraw-Hill Education.
2. Botwright R. 2024. *Bioinformatics: Algorithms, Coding, Data Science and Biostatistics*. Pastor Publishing Ltd, London, UK.
3. Christiansen T, Foy B D, Wall L and Orwant J. 2012. *Programming Perl*. (4th Edn.). O'Reilly Media.
4. Compeau P and Pevzner P. 2024. *Bioinformatics Algorithms: An Active Learning Approach*. Active Learning Publishers, La Jolla, CA, USA.
5. Jha A N, Swargam S and Kumari I. 2023. *Systems Biology, Bioinformatics and Livestock Science*. Bentham Science Publishers, Singapore.
6. Kanetkar Y. 2013. *Let Us C*. BPB Publications.
7. Tisdall J. 2003. *Mastering Perl for Bioinformatics*. O'Reilly Media.

Bioinformatics Tools and Biological Databases 3 (2+1)

Objectives

i. To study various tools of bioinformatics for sequence analysis
ii. To study biological data, databases and their applications
iii. To study algorithms and methods for bioinformatic analysis, and visualization of results

Theory

Introduction: biological data types, collection, classification schema of biological databases. Biological databases retrieval systems. Sequence and molecular file formats.

Biological databases: nucleotide database, protein database, structural database, genome databases, metabolic pathway database, literature database, chemical database, gene expression database, crop database with special reference to BTISNET databases.

Bioinformatics tools: concept of alignment, scoring matrices, alignment algorithms, heuristic methods, multiple sequence alignment, phylogenetic analysis, molecular visualization tools.

Practical

NCBI; Expasy: SwissProt; EBI; Search engines: ENTREZ and SRS; Perform local alignment using all BLAST variants. Multiple sequence alignment using ClustalW. T Coffee. phylogenetic analysis by PHYLIP. MEGA.

Suggested Readings

1. Baxevanis A D and Ouellette B F F. 2001. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. John Wiley and Sons.
2. Janardhan S, Suresh Babu C V and Siva R. 2024. *Bioinformatics: Methods, Tools and Applications*. New Century Publications, New Delhi, India.
3. Jha A N, Swargam S, and Kumari I. 2023. *Systems Biology, Bioinformatics and Livestock Science*. Bentham Science Publishers, Singapore.
4. Mount D W. 2001. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor.
5. Sharma V, Sheikh I, Kushwaha V, Gupta S, Kaushal A, Ramniwas S, Bansal P, Sharma A, Sharma V, Sharma J, Panwar A, and Sharma A K. 2025. *Bioinformatics: Drug Discovery*. De Gruyter, Berlin, Germany.
6. Xiong J. 2006. *Essential Bioinformatics*. Cambridge University Press.

Structural Bioinformatics 3 (2+1)

Objectives

i. To acquaint the students with the creation of new methods of analysing and manipulating biological macromolecular data in order to solve problems in biology and generate new knowledge

ii. To study the analysis and prediction of the three-dimensional structure of biological macromolecules such as proteins, RNA, and DNA

Theory

Introduction to structural databases of macromolecules, natural and synthetic small molecules. Structure of amino acids. Protein structure classification, Ramachandran plot. Experimental structure determination methods. Motifs, domain, profiles, fingerprint and protein family databases. Structural features of RNA, RNA secondary structure predictions. RNA folding. Small RNA prediction.

Structure prediction; basics of protein folding, protein folding problem, molecular chaperons. Secondary structure prediction methods and algorithms: homology, ab initio and folding-

based tertiary structure prediction. Structure validation tools, energy minimization techniques. Introduction to molecular dynamics and simulation, Monte-Carlo methods, Markov chain and HMM. Structure visualization and comparison methods.

Practical

Protein structural classification databases, 3D-Structural databases searching and retrieval, Ramachandran Plot, structural visualization tools, tools for protein secondary and tertiary structure prediction; RASMOL, Cn3D, CHIMERA, SWISSPDB viewer, CPH, MODELLER, SWISS Model, EasyModeler, Procheck. GROMAC, SANJIVNI, BHAGI RATH.

Suggested Readings

1. Allan H. 2008. *Modeling for Beginners*. Wiley.
2. Creighton T E. 1993. *Proteins: Structures and Molecular Properties*. W. H. Freeman.
3. Dijkstra M, Bawono P, Houtkamp I, Gavaldá-Garciá J, Okounev M, Bouwmeester R, Stringer B, Heringa J, Abeln S, Feenstra K A and van Gils J H M. 2023. *Structural Property Prediction*. arXiv preprint arXiv:2307.02172.
4. Gavaldá-Garciá J, Stringer B, Ivanova O, Abeln S, Feenstra K A and Mouhib H. 2023. *Data Resources for Structural Bioinformatics*. arXiv preprint arXiv:2307.02171.
5. Gu J and Bourne P E. 2009. *Structural Bioinformatics*. (2nd Edn.), Wiley-Blackwell, Hoboken, NJ, USA.
6. Jha A N, Swargam S and Kumari I. 2023. *Systems Biology, Bioinformatics and Livestock Science*. Bentham Science Publishers, Singapore.
7. Malcolm C A and Laurie J H. 2007. *Discovering Genomics, Proteomics and Bioinformatics*. Benjamin Cummings.
8. Mount D W. 2001. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor.
9. Setubal J and Meidanis J. 1997. *Introduction to Computational Molecular Biology*. PWS Publishing Company.

Pharmacogenomics 3 (2+1)

Objectives

i. The students are exposed to develop strategies for individualizing therapy for patients, to optimize outcomes through knowledge of human genome variability and its influence on drug response

ii. To study the research on genes and medications which has advanced the understanding of the genetic basis of individual drug responses

Theory

Basic concepts of pharmacogenomics, clinical application and challenges in pharmacogenomics. Human Genome Project, genetic diseases, personalized medicine and pharmacogenomics necessity in drug designing. Prediction of structural changes among sequence variants and genetic analysis. Microsatellites for studying genetic variations. Drug databanks. Gene therapy.

Drug Design: study of important drug targets and their variations. Pharmacophore designing, prediction of ADME properties. Computational tool for toxicity prediction. SAR and QSAR

techniques in drug designing. Drug receptor interactions. Structural-based drug design. Lipinski's rule in drug design.

Practical

Receptor-Ligand interactions, pharmacophore development. OSDD. DrugBank. PubChem. Molecular representation using SMILES. Chemsketch: 2D and 3D structure. Structure analyses using Chimera/VMD. Detection of the active site of proteins using various software; bioavailability using Mol inspiration. Docking using HEX and AUTODOCK.

Suggested Readings

1. Allan H. 2008. *Modeling for Beginners*. Wiley- Blackwell Publishing.
2. Gupta S P. 1996. *Quantum Biology*. New Age International Pvt. Ltd.
3. Holtje H D, Wolfgang S, Didier R and Hans D. 2003. *Molecular Modeling: Basic Principles and Applications*. Wiley-VCH.
4. Lam J T, Gutierrez M A and Shah S. 2021. *Pharmacogenomics: A Primer for Clinicians*. McGraw-Hill Education, New York, USA.
5. Lisa B. 2014. *Combinatorial Library Methods and Protocols*. Humana Press.
6. Primorac D, Höppner W and Bach-Rojecky L. 2024. *Pharmacogenomics in Clinical Practice*. Springer, Cham, Switzerland.

Metabolomics and Systems Biology 4 (3+1)

Objectives

i. To comprehensively identify and quantify all endogenous and exogenous small molecule metabolites in a biological system in a high-throughput manner.
ii. To study the model and discover emergent properties, properties of cells, tissues and organisms functioning as a system.

Theory

Introduction to metabolomics, metabolomic databases, metabolite architecture, metabolic footprinting, enzyme discovery, *E. coli* metabolomics, fungal exo-metabolome, and diagnostic biomarkers in metabolomics.

Introduction to systems biology, transcriptome analysis, simple synthetic networks, noise in gene expression, structure of biological networks, pathway architecture, applications of systems biology in the discovery of disease signatures, drug targeting and design, and metabolomics in systems biology.

Practical

Metabolic pathway databases KEGG, BRENDA, Biosilico, Protein-protein interaction databases, Swiss 2D PAGE, E-PCR. Creating networks using Cytoscape, DAVID, MAS3; in silico functional annotation using GO, AGRIGO, PANTHER, BLAST2GO.

Suggested Readings

1. Berg J M, Tymoczko J L and Stryer L. 2002. *Biochemistry*. (5th Edn.). W. H. Freeman and Company.
2. Fersht A. 1999. *Structure and Mechanism of Protein Science*. W. H. Freeman and Company.
3. Jha A N, Swargam S and Kumari I. 2023. *Systems Biology, Bioinformatics and Livestock Science*. Bentham Science Publishers, Singapore.
4. Klipp E, Herwig R, Kowald A, Wierling C and Lehrach H. 2006. *Systems Biology in Practice, Concepts, Implementation and Application*. Wiley VCH.
5. Nielsen J and Jewett M C. 2007. *Metabolomics, A Powerful Tool in Systems Biology*. Springer-Verlag Berlin Heidelberg, ISBN 978-3-540-74718-5.
6. Tomita M and Nishioka T. 2005. *Metabolomics, The Frontier of Systems Biology*. Springer-Vertag, ISBN 4-431-25121-9.
7. Vaidynathan S, Harrigan G G and Royston G. 2005. *Metabolome Analysis: Strategies for System Biology*, Springer.
8. Voet D and Voet J D. 2004. *Biochemistry*. (3rd Edn.). Wiley, NewYork.

Computational Methods for Data Analysis 3 (2+1)

Objectives

i. To apply statistical analysis and technologies to data to find trends and solve problems
ii. To introduce students to some of the key computational techniques used in modelling and simulation of real-world phenomena
iii. To study the applications of computational methods in biology using sequence data

Theory

Introduction to UNIX/LINUX operating system. Knowledge discovery and data mining techniques. Machine learning and pattern recognition, hidden Markov models. Artificial neural networks, support vector machines.

Principal component analysis, ANOVA. AMOVA and different clustering methods. Gene prediction algorithms and phylogeny algorithms. Basics of R statistical package.

Practical

Gene prediction: FGENESH. R statistical package installation and configuration, GUI for R: R-commander, R Studio, RKWard. Analysis of gene expression using R; GNU PSPP, Scilab, QtiPlot.

Suggested Readings

1. Dinov I D. 2023. *Data Science and Predictive Analytics: Biomedical and Health Applications Using R*. (2nd Edn.). Springer, Cham, Switzerland.
2. Gareth J, Daniela W, Trevor H and Robert T. 2013. *An Introduction to Statistical Learning: with Applications in R*. Springer.
3. Karaca Y and Cattani C. 2019. *Computational Methods for Data Analysis*. De Gruyter, Berlin, Germany.
4. Mathur K S. 2010. *Statistical Bioinformatics with R*. Elsevier.

Semester VIII			
1.	Student READY (RAWE/industry attachment/experiential learning/hands on training/project work/internship) in the area of Plant Biotechnology, Animal Biotechnology, Microbial and Environmental Biotechnology and Bioinformatics	20 (0+20)	**20 (0+20)**

MOOCs/ONLINE COURSES (10 credits)

The students will register for online courses of 10 credit hours (as per UGC guidelines for online courses) as a partial requirement for the comprising one or more courses at the approved portals during the third and fourth years with prior approval from the Head of the institution.

Suggested Readings

1. Sharma R C and Mishra S. 2023. *Online Learning and MOOCs in Higher Education: A Digital Transformation*. Springer, Singapore.
2. Agarwal P K. 2022. *Digital Education in India: A Roadmap to MOOCs and Online Learning*. Wiley India, New Delhi.
3. Mangal S K and Mangal U. 2021. *Essentials of Educational Technology and e-Learning*. PHI Learning Pvt. Ltd., New Delhi.

Minimum Standards for Establishing a College of Biotechnology

- **Degree** Nomenclature: B. Tech. (Biotechnology)

1. **Minimum intake (per year):** 60

2. **Faculty:**

   A. Core faculty: 21

   Plant Biotechnology (0+2+4), Animal Biotechnology (0+2+4), Microbial and Environmental Biotechnology (0+2+4), Bioinformatics (0+1+2)

   B. Allied faculty: Faculty for Mathematics, computer science, Sociology, Psychology, English, Food Science and Technology, Microbiology, Agro- meteorology and other supporting subjects, if any, shall be adjusted from other colleges, Guest faculty, adjunct faculty and part time faculty.

3. **Land Requirement(ha):** 5

4. **Essential Instructional units:**
   - Practical molecular biology laboratory.
   - Green house (10m × 20m each) – 2 Numbers.
   - High speed internet/servers/DNA/RNA and protein sequence.
   - Tissue culture: transformation facility/media preparation/incubation/washing/ hardening– facilities.
   - Laboratories and instructional facilities as per V Deans' Committee report.
   - ELP (Experiential Learning Programme) units to be established under skill development or Entrepreneurial mode- 0.5 ha.

5. **Divisions/Departments/Sections:**
   - Division of Plant Biotechnology (PB)
   - Division of Animal Biotechnology (AB)
   - Division of Microbial and Environmental Biotechnology (MEB)
   - Division of Bioinformatics

6. **Non-Teaching Staff:**

Division/Section	Steno/PA/ Computer Operator	Assistant	Attendant/ Messenger		Clerk Laboratory Assistant/ Attendant	Field Staff
Plant Biotechnology	2	1	2	1	6	3
Animal Biotechnology	2	1	2	1	6	3
Microbial and Environmental Biotechnology	2	1	2	1	6	3
Bioinformatics	5	1	2	1	1	-
Total	**11**	**4**	**8**	**4**	**19**	**9**

7. Faculty Expertise:

Division/Section	Faculty Expertise	
	Core	**Associated**
Plant Biotechnology	Plant Molecular Biology,	Plant Breeding,
	Tissue culture and Genetic Transformation,	Plant Protection,
	Genetics,	Plant Physiology,
	Microbiology,	Agronomy,
	Plant Biochemistry	Horticulture,
		Forestry
Animal Biotechnology	Cell Culture and Genetic Transformation,	Animal Breeding,
	Molecular Biology,	Animal Physiology,
	Animal Genetics,	Live Stock Production and
	Animal Biochemistry,	Management
	Animal Microbiology,	
	Immunology	
Microbial and	Microbiology,	Plant Physiology,
Environmental	Microbial Genetics,	Water and Soil Sciences,
Biotechnology	Microbial Engineering, Biochemistry	Analytical Chemistry,
		Agrometeorology,
		Food Science and Technology
Bioinformatics Section	Bioinformatics,	Plant and Animal Biotechnology,
	Information Technology	Statistics/ Biostatistics

8. Central/Division/Section Laboratories (as per requirements of the teaching and research workof the college)

Division/Section	Laboratory
Central Research and	-DNA sequencing, SNP Genotyping and Proteomics Laboratory Teaching Laboratories
	- High Performance Computing Facility
	- Cold Rooms: -20°C, 4°C
	- Liquid Nitrogen Plant
	- Computer Lab
Plant Biotechnology	- Plant Genomics Laboratory
	- Functional Genomics Laboratory
	- Genetic Transformation Laboratory
	- Molecular Breeding Laboratory
	- Proteomics and Metabolomics
Animal Biotechnology	- Animal Genomics Laboratory
	- Functional Genomics Laboratory

Division/Section	Laboratory
	- Arthropod Molecular Biology Laboratory
	- Animal Cell Culture Laboratory
	- Immunology Laboratory
Microbial and Environmental Biotechnology	- Environmental and Microbial biotechnology Laboratory - Microbial Genetics and Genomics Laboratory
	- Bioremediation Laboratory Bioinformatics - Sequence Analysis Laboratory - Computational Biology Laboratory

9. Manpower Requirements of Dean s Office

Manpower	Number
Dean	1
A. Establishment PA to Dean	1
Administrative Officer	1
Superintendent	1
Steno/Computer operator	4
Assistant	2
Operator (Audio Visual)	1
Attendants/Messengers	4
Clerk (LDC)	4
Electrician	1
Store Keeper	1
Driver	6
Security, Sanitation and Landscaping	To be outsourced
B. Central Research and Teaching Laboratories (Four Laboratories) Assistant Professor (Genomics)	1
Assistant Professor (Computer Engineering)	1
Computer Assistant	1
Laboratory Technicians	2
Laboratory Assistant	1
Laboratory Attendant	3
C. Library Staff Assistant Librarian	1
Library Assistant	1
Clerk	1
Shelf Assistant	2
D. Students Welfare To be provided by the Institute as the Central Facility	

E. Hostel Staff for two Hostels	
Wardens	1+1
Assistant Wardens	1+1
Clerk (LDC)	2
Attendants	8
Security, Sanitation and Landscaping	To be outsourced

10. Floor Space Requirement

A) Central Facilities

Sl. No.	Details	Number of Rooms	Dimensions (ft)
1.	Dean office	1	20 × 24
2.	PA room	1	20 × 12
3.	Committee room with video conferencing facility	1	20 × 48
4.	Administrative officer room	1	20 × 12
5.	Admin. staff rooms	3	20 × 36 each
6.	Examination cell	1	20 × 12
7.	Evaluation room	1	20 × 36
8.	Faculty room	1	20 × 12 each
9.	Placement cell	1	20 × 48
10.	Smart Lecture rooms	5	Seating capacity - 70
11.	Auditorium (optional)	1	Seating capacity - 300
12.	Library/Book bank	1	30 × 72
13.	Examination hall (optional)	1	Seating capacity - 300
14.	Multipurpose room	1	20 × 36
15.	Laboratories	4	30 × 48 each
16.	Hostels	2	One each for Boys & Girls
17.	Generator shed	1	20 × 36
18.	Liquid Nitrogen plant	1	20 × 24
19.	Toxic chemical waste storage/disposal Unit	1	20 × 24
20.	Canteen	1	20 × 12 (Kitchen) and
21.	Toilets	-	20 × 36 (Seating) 2 sets for each floor
22.	Parking space		As per requirement (APR) For college and hostels
23.	Vehicles:		
24.	Office car	1	
25.	Staff car/Jeep	3	
26.	Bus	1	
27.	Pick-up van	1	

B) Division/Section

Sl. No.	Detail	Number of rooms	Dimensions (ft)
1.	Office of Head of the Division	3 (one for each Division)	20 × 24 each
2.	Administrative Staff	4 (one for each Division)	20 × 36 each
3.	Faculty room	21 (as per faculty strength)	20 × 24 (3 rooms) 20 × 12 (18 rooms)
4.	Rooms for Research Scholars	4 (one for each Division)	20 × 24 each
5.	Committee room cum library	4 (one for each Division)	20 × 36 each
6.	Smart Lecture cum seminar room 4 (one for each Division)	Seating capacity	50 each
7.	Laboratories (no. of laboratories as per requirement and include UG and PG teaching laboratories) Plant Biotechnology	5	20 × 60 (one); 20 × 36 (four)
	Animal Biotechnology	5	20 × 60 (one); 20 × 36 (four)
	Microbial and Environmental Bio-technology	4	20 × 60 (one); 20 × 36 (three)
	Bioinformatics Section	2	20 × 48 each
8.	Screen houses, glass houses, transgenic greenhouse	APR	

11. Equipment Required

(A) Central Teaching and Research Laboratories

Sl. No.	Name of the Equipment	Number
1.	Cold room -20°C	1
2.	Cold room 4°C	1
3.	SNP Genotyping Platform	1
4.	HPTLC	1
5.	High Performance Computing Grid	1
6.	Liquid Nitrogen Plant	1
7.	Inductively Coupled Plasma (ICP-OES) Central laboratory	1
8.	High Speed Centrifuge	4
9.	Water Purification Unit	As per requirement

(B) Equipment in the Divisional Laboratories (additional specialized equipment may be requireddepending on the mandate of the institute) #

Sl. No	Name of the Equipment	Number of units	Total number	Divisions
	Divisions			
1	-20°C Freezer	2×3	6	PB, AB, MEB
2	-80°C Freezer	1×3	3	PB, AB, MEB
3	Autoclaves	2×3	6	PB, AB, MEB
4	Automated Capillary Electrophoresis System	1×3	3	PB, AB, MEB
5	Auto pipetting System	1×2	2	PB, AB
6	Biolistic Particle Gun	1×1	1	PB, AB
7	Bio photometer	1×3	3	PB, AB, MEB
8	Biosafety Cabinet	4×3	12	PB, AB, MEB
9	Centrifuge	8×3	24	PB, AB, MEB
10	Cryo-cans	5×3	15	PB, AB, MEB
11	Dry Baths	APR	-	PB, AB, MEB
12	Electrophoresis Systems and Power Packs	10×3	30	PB, AB, MEB
13	Electroporator	1×3	3	PB, AB, MEB
14	Environmental Chamber	1×3	3	PB, MEB
15	Fermenter	2×1	2	MEB
16	Fluorescent Microscope	1×2	2	PB, AB
17	Gel Documentation System	2×3	6	PB, AB, MEB
18	Gel Dryers	1×3	3	PB, AB, MEB
19	Growth Rooms	2×1	2	PB
20	Hot Plates, Magnetic stirrers, Vortex etc.	APR	-	PB, AB, MEB
21	Hybridization Ovens	1×2	2	PB, AB
22	Ice Making Machines	1×3	3	PB, AB, MEB
23	Incubator Shakers	4×3	12	PB, AB, MEB
24	Incubator	APR	-	PB, AB, MEB
25	Laminar Flow	3×3	9	PB, AB, MEB
26	Lyophilizer	1×3	3	PB, AB, MEB
27	Microcentrifuge	10×3	30	PB, AB, MEB
28	Microplate Washer	1×2	2	PB, AB
29	Microscope	1×3	3	PB, AB, MEB
30	Microscopes (for teaching)	10×2	20	PB, AB
31	Microplate Readers	1×2	2	PB, AB

Sl. No	Name of the Equipment	Number of units	Total number	Divisions
32	Microwave Digestion Oven	1×1	1	MEB
33	Multiflow Dispenser	2×3	6	PB, AB, MEB
34	Nanodrop for DNA Quantification	1×3	3	PB, AB, MEB
35	Precision Ovens	APR	-	PB, AB, MEB
36	Plant Imager	1×2	2	PB, MEB
37	Plate Centrifuges	2×3	6	PB, AB, MEB
38	Real Time PCR	2×3	6	PB, AB, MEB
39	Refrigerator 4°C	4×3	12	PB, AB, MEB
40	Semi Dry Blotter	1×3	3	PB, AB, MEB
41	Shakers (Table Top)	3×3	9	PB, AB, MEB
42	Spectrophotometer	1×3	3	PB, AB, MEB
43	Thermocycler	10×3	30	PB, AB, MEB
44	Thermomixer	4×3	12	PB, AB, MEB
45	Tissue lyser	2×3	6	PB, AB, MEB
46	Ultracentrifuge	1×3	3	PB, AB, MEB
47	Ultrasound Sonicator	2×3	6	PB, AB, MEB
48	UV Transilluminator	2×3	6	PB, AB, MEB
49	UV Stratalinker	1×2	2	PB, AB
50	Vacuum Concentrator	1×3	3	PB, AB, MEB
51	Water Bath - Shaking	2×3	6	PB, AB, MEB
52	Computers	-	50	PB, AB, MEB
53	Computer for Bioinformatics Section	40	40	Bioinformatics
54	Major Softwares- to handle genomics, transcriptomics and proteomics	APR	APR	Bioinformatics
55	Internet Facility	-	-	Central facility

Annexure-I

Abbreviations

ICAR	Indian Council of Agricultural Research
ABC	Academic Bank of Credit
ABM	Agribusiness management
AEC	Ability Enhancement Courses
AI	Artificial Intelligence
CAU	Central Agricultural University
CCFU	Curriculum and Credits Framework for Undergraduate
CGPA	Cumulative grade point average
CU	Central University
DDG	Deputy Director General
DG	Director General
DU	Deemed University
ELP	Experiential Learning Program
GER	Gross Enrolment Ratio
HAEI	Higher Agriculture Education Institute
MDC	Multi-disciplinary courses
MOOC	Massive Open Online Courses
NAEAB	National Agricultural Education Accreditation Board
NCC	National Cadet Corps
NEP	National Education Policy
NG	Non-gradial
NGO	Non Government Organization
NHEQF	National Higher education Qualification Framework
NSS	National Service Scheme
OGPA	Overall Grade Point Average
PG	Postgraduate
PSSB	Professional Standards Setting Body
RAWE	Rural Agriculture Work Experience
READY	Rural Entrepreneurship Awareness Development Yojna
SAU	State Agricultural University
SEC	Skill Enhancement Courses
UG	Undergraduate
UGC	University Grants Commission
VAC	Value added courses

Annexure III

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Natural Farming

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