ANNUAL REPORT

2023-24

भाकृअनुप
ICAR

Indian Council of Agricultural Research
Department of Agricultural Research and Education
Ministry of Agriculture & Farmers Welfare
Government of India
New Delhi
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INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Institutes, Bureaux, Directorates, National Research Centres and ATARIs

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• 71 Research Institutes • 6 Bureaux • 13 Directorates • 12 National Research Centres • 11 ATARIs

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Foreword

भारतीय कृषि के जीवंत भूदृश्य में भारतीय कृषि अनुसंधान परिषद (भाकृअनुप), नवाचार और प्रगति का प्रतीक बना हुआ है। वर्ष 2023 में परिषद द्वारा अपना 95वां स्थापना एवं प्रौद्योगिकी दिवस मनाया गया जिसमें अपनी उत्कृष्ट उपलब्धियों पर प्रकाश डाला गया। इन गतिविधियों के परिणामस्वरूप भारतीय कृषि क्षेत्र में नवाचार, प्रगति एवं संधारणीयता हासिल की गई है। भाकृअनुप द्वारा किए गए प्रयास कृषि को अधिक उत्पादक बनाने, उत्तरदायी कृषि पद्धतियों के लिए वैश्विक आह्वान के साथ कहीं अधिक टिकाऊ और अनुरूप बनाने का भरोसा दिलाते हैं।

भारत की पहल पर संयुक्त राष्ट्र संघ द्वारा वर्ष 2023 को 'अंतर्राष्ट्रीय मिलेट्स वर्ष' (अंतर्राष्ट्रीय श्रीअन्न वर्ष) घोषित किया गया था। भाकृअनुप द्वारा परिवर्तनशील जलवायु परिस्थितियों के अंतर्गत खाद्य एवं पोषणिक सुरक्षा की अनूठी क्षमता पर प्रकाश डालने हेतु अनेक कार्यक्रमों का आयोजन करते हुए मिलेट्स वर्ष मनाया गया। मिलेट्स अथवा श्रीअन्न में अनेक स्वास्थ्यवर्धक लाभ हैं और साथ ही ये आहार, चारा तथा जैव ईंधन के प्रमुख स्रोत भी हैं। उन्नत उत्पादन तथा प्रसंस्करण प्रौद्योगिकियों को अपनाकर किसानों की आय को बढ़ाया जा सकता है। भाकृअनुप ने दिनांक 26 जनवरी, 2023 को गणतंत्र दिवस समारोह में लगातार तीसरी बार भाग लेते हुए संयुक्त राष्ट्र संघ द्वारा घोषित 'अंतर्राष्ट्रीय मिलेट्स वर्ष' विषय पर एक झांकी प्रस्तुत की। भाकृअनुप ने किसानों को श्रीअन्न की खेती से अधिक आय अर्जित करने में समर्थ बनाने तथा श्रीअन्न को लोकप्रिय बनाने के उद्देश्य से अपनी गणतंत्र दिवस झांकी में श्रीअन्न का प्रदर्शन किया जैसा कि संयुक्त राष्ट्र संघ द्वारा देश के बड़े भाग में उगाये जाने वाले भारत के सुपर फूड का समारोह मनाया जा रहा है। खाद्य के लिए लगातार बढ़ रही मांग, बढ़ती भुखमरी एवं कुपोषण, प्रतिकूल जलवायु परिवर्तन के प्रभाव की दृष्टि से खाद्य एवं कृषि उत्पादन प्रणालियों को विश्वभर में अप्रत्याशित चुनौतियों का सामना करना पड़ रहा है। इसे देखते हुए ''एक पृथ्वी, एक परिवार, एक भविष्य'' विषय पर भारत की जी–20 अध्यक्षता के अनुरूपण में, कृषि मुख्य वैज्ञानिकों की बैठक (MACS) 2023 का आयोजन ''स्वस्थ मानव एवं ग्रह के लिए टिकाऊ कृषि एवं खाद्य प्रणालियां'' विषय पर वाराणसी में किया गया। इस बैठक में विशेषकर 'अंतर्राष्ट्रीय मिलेट्स वर्ष' के संदर्भ में खाद्य सुरक्षा, जलवायु अनुकूल कृषि के माध्यम से संकट के प्रति लचीलापन एवं एक स्वस्थ दृष्टिकोण, डिजिटल कृषि तथा अनुसंधान एवं विकास के लिए सार्वजनिक–निजी भागीदारी से जुड़े प्रासंगिक मुद्दों पर चर्चा की गई। बैठक में विशेषकर कृषि जैव विविधता, खाद्य एवं पोषण सुरक्षा के लिए श्रीअन्न आधारित स्थानीय खाद्य प्रणाली पर बल देते हुए 'मिलेट्स एंड अदर एनसिएंट ग्रेन्स इंटरनेशनल रिसर्च इनीशिएटिव (MAHARISHI)' पर ध्यान केन्द्रित किया गया।

वर्ष के दौरान, व्यावसायिक खेती प्रयोजन हेतु कुल 283 किस्मों/संकर किस्मों को अधिसूचित एवं जारी किया गया। इनमें कुल 35 जैव प्रबलित किस्में तथा सूखा, जल की कमी, बाढ़, जलभराव, लवणता, सोडियमयुक्त मृदा तथा कम तापमान जैसे विभिन्न अजैविक दबावों का मुकाबला करने हेतु 32 जलवायु अनुकूल किस्में शामिल हैं। प्रेसीजन प्रजनन टूल्स जैसे कि मार्कर सहायतार्थ चयन का उपयोग 10 गुण विशिष्ट किस्मों के प्रजनन कार्य में भी किया गया। बागवानी में उच्च उपज क्षमता वाली तथा जैविक एवं अजैविक दबावों की सहिष्णु फलों एवं रोपण फसलों, सब्जी फसलों, मसालों, फूलों, औषधीय पौधों तथा खुम्ब की अनेक नई किस्मों को खेती के लिए जारी किया गया। भाकृअनुप–केन्द्रीय गोपशु अनुसंधान संस्थान, मेरठ में साहीवाल नस्ल की पांच गायों में सुपर डिम्बोत्सर्जन किया गया। सुपर डिम्बोत्सर्जन के प्रति चार गायों में प्रतिक्रिया देखने को मिली और इनसे 17 भ्रूण हासिल किए गए। अच्छी गुणवत्ता वाले छह भ्रूणों का स्थानांतरण फ्रिजवाल नस्ल की छह गायों में किया गया जिनमें से भाकृअनुप–केन्द्रीय गोपशु अनुसंधान संस्थान, मेरठ में पहली बार साहीवाल नस्ल के तीन नवजात बछड़े/बछड़ियों उत्पन्न हुईं। भारत की पहली क्लोन्ड गाय (नामतः गंगा) का जन्म हुआ जिससे भारत में गोपशु क्लोनिंग की संभावनाएं प्रदर्शित होती हैं। राष्ट्रीय जीन बैंक में दीर्घावधि भंडारण के लिए परम्परागत बीज प्रजातियों की कुल 4,246 प्राप्तियों को शामिल किया गया जिससे कि राष्ट्रीय जीन बैंक में इनका आधारीय संकलन बढ़कर 4,67,254 प्राप्तियां हो गया। पशुधन की दस पंजीकृत नस्लों को गजट में अधिसूचित किया गया जिनमें कठानी (महाराष्ट्र), संचोरी (राजस्थान), मसिलम (मेघालय) गोपशु, पूर्णाथाडी भैंस (महाराष्ट्र); सोजत (राजस्थान), करौली (राजस्थान) तथा गुजरी (राजस्थान) बकरी तथा बांदा (झारखंड), मणिपुर ब्लैक (मणिपुर), वाक चैम्बिल (मेघालय) शूकर सम्मिलित हैं। इन नस्लों को शामिल करने के उपरांत अभी तक सरकार द्वारा कुल 212 स्वदेशी नस्लों को अधिसूचित किया जा चुका है। इनमें गोपशु की 53, भैंस की 20, बकरी की 37, भेड़ की 44, अश्व व टट्टू की 7, ऊंट की 9, शूकर की 13, गधे की 3, श्वान की 3, याक की 1, कुक्कुट की 19, बत्तख की 2 तथा गीज की 1 नस्ल को सरकार द्वारा अधिसूचित किया जा चुका है।

उच्चतर समग्र प्रणाली उत्पादकता प्राप्त करने, संसाधन–उपयोग दक्षता बढ़ाने और जलवायु अनुकूलन को मजबूत करने के लिए मिट्टी के स्वास्थ्य में सुधार लाने के उद्देश्य से एक फसलचक्र मृदा प्रणाली विकसित करने के लिए शुरू किए गए इस क्षेत्र प्रयोग ने प्रणाली उत्पादकता में सुधार

और 100% से अधिक उच्च शुद्ध लाभ का संकेत दिया है। भारतीय राष्ट्रीय मृदा पुरालेख (आईएनएसए) की स्थापना के लिए एक पहल की गई है जो डिजिटल मृदा मानचित्रण, मृदा स्पेक्ट्रोस्कॉपी और विशेष स्थान में वर्तमान मिट्टी की स्थिति की तुलना तथा परिवर्तनशील जलवायु परिस्थितियों से उत्पन्न अन्य परिस्थितियों से जुड़े अध्ययन में सहायक होगी। आईएनएसए में एक मृदा नमूना भंडारण कक्ष शामिल है जहां मृदा नमूनों को क्यूआर कोड स्तरों के साथ रखा जाता है। इसमें मृदाओं के डेटाबेस को सृजित करने, उसे अपडेट करने तथा क्यूआर कोड एवं रिपोर्ट सृजित करने के लिए एक वेब ऐप तथा किसी विशेष नमूने की रिपोर्ट तैयार करने हेतु क्यूआर कोड को स्कैन करने में एक एंड्रोएड मोबाइल ऐप शामिल है। भाकृअनुप–भारतीय जल प्रबंधन संस्थान, भुबनेश्वर में रोपाई की गई चावल फसल में एक स्वचालित एडब्ल्यूडी प्रणाली विकसित की गई है और इसका मूल्यांकन किया गया है। इसके परिणामों से पता चला है कि निरंतर बाढ़ और स्वचालित एडब्ल्यूडी के तहत चावल दाना उपज क्रमशः 4.43 और 4.21 टन प्रति हैक्टर थी। निरंतर बाढ़ परिस्थिति में जल की आवश्यकता (सिंचाई एवं वर्षा को मिलाकर) 1,340 मि.मी. थी जबकि स्वचालित एडब्ल्यूडी प्रणाली के साथ यह 1,100 मिमी. थी। इस प्रकार स्वचालित एडब्ल्यूडी प्रणाली के अंतर्गत सिंचित जल में 240 मि.मी. (18%) तक की बचत हुई। निरंतर बाढ़ वाली परिस्थिति में जल उत्पादकता जहां 0.33 किग्रा./घन मीटर थी वहीं स्वचालित एडब्ल्यूडी प्रणाली के अंतर्गत यह 0.38 किग्रा/घन मीटर थी। जलवायु भिन्नता और जलवायु परिवर्तन से जुड़ी समस्या को कम करने के लिए फसल–विशिष्ट जलवायु स्मार्ट प्रौद्योगिकियों को प्रारंभ करने हेतु मध्य प्रदेश के भोपाल जिले में एक गांव–मोमनपुर को चुना गया। इस गांव में 30 किसान परिवार रहते हैं और इसमें लगभग 152 एकड़ कृषि भूमि है। निक्रा द्वारा अंगीकृत किए गए गांव के लिए चावल, चना, गेहूं, सोयाबीन और मूंग के लिए अनेक जलवायु स्मार्ट हस्तक्षेप आधारित तकनीकों की पहचान की गई।

अग्रिम पंक्ति प्रसार के लिए जिला स्तरीय बहु विषयी वैज्ञानिक संस्थानों के रूप में स्थापित कृषि विज्ञान केंद्रों को नई प्रौद्योगिकियों का ऑन–फार्म परीक्षण करके देशभर की विभिन्न परिस्थितियों के अंतर्गत प्रौद्योगिकियों का प्रयोग और क्षमता–निर्माण करने के लिए प्रौद्योगिकी मूल्यांकन एवं प्रदर्शन हेतु अधिदेशित किया गया है। इसका प्रयोजन विभिन्न कृषि प्रणालियों में स्थान–विशिष्ट प्रौद्योगिकियों की पहचान करना, प्रौद्योगिकियों की उत्पादन क्षमता का प्रदर्शन करने के लिए अग्रिम पंक्ति प्रदर्शन लगाना तथा किसानों, कृषिरत महिलाओं, ग्रामीण युवाओं तथा प्रसार कार्मिकों का क्षमता–निर्माण करना है। इसके साथ ही कृषि विज्ञान केंद्र विभिन्न हितधारकों को प्रौद्योगिकीय जानकारी, सूचना एवं ज्ञान भी प्रदान करते हैं और देश में जिला स्तर पर ज्ञान एवं संसाधन केंद्रों के रूप में काम करते हैं। इन गतिविधियों के अतिरिक्त, प्राकृतिक खेती की आउट–स्केलिंग, क्लस्टर आधारित व्यावसायिक संगठनों (सीबीबीओ) के रूप में किसान उत्पादक संगठनों (एफपीओ) के गठन और प्रोत्साहन, एफपीओ के लिए प्रौद्योगिकीय बैक–स्टॉपिंग, एग्री–ड्रोन के माध्यम से प्रदर्शन, फार्मर फर्स्ट, कृषि में युवाओं को आकर्षित करना और बनाए रखना (आर्या), दलहनी व तिलहनी फसलों के क्लस्टर अग्रिम पंक्ति प्रदर्शन लगाना, दक्षिण एशिया के लिए अन्न प्रणाली पहल (सीएसआईएसए), दलहन बीज हब, *मेरा गांव–मेरा गौरव* और सरकारी योजनाओं के प्रति जागरूकता लाने जैसे महत्वपूर्ण कार्यक्रमों पर गतिविधियां चलाई गईं ताकि कृषि में युवाओं को जोड़े रखना, दलहन एवं तिलहन में आत्मनिर्भरता लाना तथा टिकाऊ कृषि आदि जैसी विभिन्न चुनौतियों और राष्ट्रीय प्राथमिकताओं का समाधान किया जा सके।

अंततः भाकृअनुप की उल्लेखनीय उपलब्धियों ने कृषि अनुसंधान, प्रसार, शिक्षा तथा क्षमता–निर्माण को प्रोत्साहन देने तथा खाद्य सुरक्षा में अपना योगदान करते हुए भारत के कृषि क्षेत्र का विकास करने में उल्लेखनीय योगदान दिया है। द्विपक्षीय एवं बहुपक्षीय परियोजनाओं में परिषद की भागीदारी से प्रजनन प्रणालियों को आधुनिक बनाने, चावल आधारित फसलचक्र प्रणालियों का सघनीकरण एवं विविधीकरण करने और चावल मूल्य शृंखलाओं में सुधार लाने की दिशा में सहयोग की सुविधा मिली है। मैं आशा करता हूं कि वर्ष 2023–24 के लिए भारतीय कृषि अनुसंधान परिषद का *वार्षिक प्रतिवेदन,* भारतीय कृषि के बहुआयामी विकास में विभिन्न हितधारकों के लिए सहायक सिद्ध होगा।

(अर्जुन मुंडा)
अध्यक्ष, भाकृअनुप सोसायटी

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Indian Council of Agricultural Research

President, ICAR Society, and Union Minister of Agriculture and Farmers Welfare	:	**Shri Arjun Munda (From 7 December 2023)** **Shri Narendra Singh Tomar (Till 6 December 2023)**
Senior Vice President, ICAR Society, Union Minister of Fisheries, Animal Husbandry and Dairying	:	**Shri Parshottam Rupala**
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The Mandate of the Indian Council of Agricultural Research

- Plan, Undertake, Coordinate and Promote Research and Technology Development for Sustainable Agriculture.
- Aid, Impart and Coordinate Agricultural Education to enable Quality Human Resource Development.
- Frontline Extension for Technology Application, Adoption, Knowledge Management and Capacity Development for Agri-based Rural Development.
- Policy, Cooperation and Consultancy in Agricultural Research, Education and Extension.

1. Overview

The accomplishments and progress towards achieving the strategic objectives, key performance indicators (KPIs) and output framework articulated during the year are presented in this report. ICAR ensures that groundbreaking discoveries and technologies reach our farmers, producers and consumers. ICAR solves societal challenges through collaboration with other partners, including academic and science organizations; small business and industry; agencies from all levels of government; and non-government, public, and private organizations. ICAR continued strong collaboration with other agencies to become more efficient and competitive, to sustain natural resources and the environment, to enhance the sustenance of food supply and improve nutrition. We at ICAR are working towards self-reliant agriculture and fulfilling ICAR's strategic objectives to ensure the agricultural and rural prosperity. ICAR has focused on different aspects of agricultural research such as food system transformation; food, nutrition and human health promotion; climate and energy needs; sustainable use of natural resources; food safety; small business innovation and product development; agricultural education and workforce development. ICAR has played a major role in promoting excellence in higher education in agriculture and coordinating education in all state agricultural universities and central agricultural universities. ICAR vigorously pursued the deployment of digital platforms in agriculture and the application of ICT for farmers' empowerment.

ICAR's commitment to food security is evident in the development of 283 varieties of food-grains and 99 varieties of horticultural crops during the year. By optimizing agricultural production and resource management, these efforts promise to usher in an era of sustainability and resilience in Indian agriculture. The establishment of fertigation schedules for 24 crops is a leap forward in nutrient management, promising enhanced crop productivity. ICAR's development of 28 new equipments and machineries is a giant stride towards the mechanization and modernization of agricultural practices. The establishment of breeding protocols for new fish breeds is a significant contribution to the aquaculture and fish production sector. ICAR's forward-thinking approach promises to elevate fisheries to new heights, ensuring a sustainable and thriving industry. ICAR's foray into robotics research is a pioneering move that is set to revolutionize agriculture. By pushing the boundaries of robotics in farming practices, ICAR is not only embracing innovation but also paving the way for a future where technology plays a pivotal role in sustainable agriculture. ICAR's dedication to the grassroots is evident in the extensive 47,088 on-farm trials and 2.99 lakh frontline demonstrations. These initiatives bridge the gap between scientific advancements and on-field application, ensuring that farmers across the nation can adopt innovative practices seamlessly. The salient achievements of the Council during 2023-24 are enumerated below.

Crop Improvement: During the reporting period, a total of 283 crop varieties/hybrids have been notified and released for commercial cultivation, which include 35 biofortified varieties and 32 varieties to combat the various abiotic stresses like drought, water scarcity, flood, waterlogging, salinity, sodicity, low temperature etc. Use of precision breeding tools has helped in breeding 10 traits specific varieties. Detailed break-up of the developed crop varieties is as follows: One hundred and twenty-five high yielding varieties/hybrids of cereals comprising 47 of rice, 21 of maize, 24 of wheat, 9 of sorghum, 4 of pearl millet, 6 of little millet, 5 of finger millet, 3 of proso millet, 2 each of kodo millet and foxtail millet, one each of brown top millet and barnyard millet were released for cultivation in different agro-ecologies of the country. Fifty two high yielding oilseeds varieties comprising 13 of Indian mustard, 10 of soybean, 7 of linseed, 8 of groundnut, 5 of sesame, 3 of safflower, 2 each of sunflower and gobhi sarson and 1 each of niger and yellow sarson were released for different agro-ecological regions. Similarly, fifty-nine high-yielding varieties of pulses comprising 15 of urdbean, 13 of chickpea, 8 of mungbean, 6 each of pigeonpea and field pea, 4 each of cowpea and lentil, 2 of rajmash and one of cluster bean were released. Twenty-nine high-yielding varieties/ hybrids of commercial crops including 13 of cotton, 11 of sugarcane, 2 of jute and 1 each of sunhemp, mesta (Roselle) and mesta (Kenaf) were released for different agro-ecological regions. Likewise, eighteen high yielding varieties/hybrids of forage and other crops comprising 2 of forage oats, 3 of forage pearl millet, 10 of forage sorghum and 1 each of forage cowpea, Dinanath grass and grain amaranth were released for cultivation in different agro-ecologies. Maleic enzyme (ME)-transgenic lines showed reduced leaf malate content and enhanced photosynthesis performance under water deficit conditions. Plants depend on the rhizospheric microbiome for nutrient uptake, and environmental stress alleviation. A small subset of the rhizospheric microbiome called the core microbiota constitutes a specific set of microbial communities that are consistently associated with the plant species. A total of 186 taxa were identified as core microbiota of wheat rhizosphere in middle IGP, and 163 taxa were identified as core microbiota in trans-IGP.

In horticultural crops, 99 varieties including 12 new

varieties of fruit and plantation crops, viz. avocado, custard apple, bael, tamarind, coconut, cocoa and cashew were identified and released for cultivation. In vegetable crops, varieties of chilli, faba bean, okra, pointed gourd, winged bean, water spinach, palak or spinach beet, radish, brinjal, tomato, amaranth, watermelon, long melon, round melon, bottle gourd, bitter gourd, garden pea, spine gourd, drumstick, Indian bean (sem), yard long bean, ridge gourd, potato and tuber crops having high yield potential and tolerant to biotic and abiotic stresses were released. In spices, varieties of black pepper, ginger, small cardamom, dill and star anise were developed. High yielding varieties were identified in flowers (9), medicinal plants (1) and mushrooms (3).

Livestock Improvement: India's first cloned cow (Gir cattle named Ganga) was born, showcasing the feasibility of cattle cloning in India. This achievement opens new avenues for India's dairy sector, offering advanced reproductive technologies to produce high-quality indigenous dairy animals. A total of 36,270 doses of semen of Sahiwal breed were frozen, and 11,520 doses were utilized for breeding. Through the interventions of Field Progeny Testing programme, the average first lactation 305-day milk yield in adopted villages has increased. ICAR-Central Institute for Research on Buffaloes (ICAR-CIRB), Hisar has successfully generated a male buffalo calf named "Veer Gaurav" utilizing the cutting-edge Ovum Pick Up and *In-Vitro* Embryo Production (OPU-IVEP) Technology. The analysis of data on growth and prolificacy traits of *inter-se* mated Avishaan sheep over the four generations revealed that the prolificacy in Avishaan sheep over the four generations ranged from 59.5 to 71.4% with litter size from 1.66 to 1.81 at birth. During the year, a total of 5,85,374 chicken germplasm was distributed to 4,819 farmers/beneficiaries from different centres. A total of 3,58,588 improved chicken varieties have been distributed by the Poultry Seed Project centres in their respective regions/states. Next-generation sequencing technology was utilized to sequence the genome of the Kadambri variety of Guinea fowl with 20x coverage in an Illumina platform (150 bp paired end reads).

Fish Improvement: Successful induced breeding was achieved in captivity in >2 years matured male and female fishes of goldlined seabream (*Rhabdo sargussarba),* a euryhaline species, during second week of December 2022. Standardization of induced breeding and seed production technology of *Hypselobarbus kolus*, an indigenous Peninsular carp was carried out. The breeding technologies of 3 marine ornamental fishes, viz. black bar chromis (*Pycnochromis retrofasciatus)*, caerulean damsel (*Pomacentrus caeruleus)* and Maldives damselfish (*Amblyglyphidodon indicus*) including protocols of broodstock development, breeding, and larval rearing were achieved. ICAR-CIFA, Bhubaneswar imparted hands-on training and technical guidance to farmers from across the country on catfish broodstock management, induced breeding, hatchery management, seed production and live feed culture. After obtaining training, the three fish farmers successfully established catfish hatchery and produced catfish seeds. ICAR-NBFGR, Lucknow, created sustainable livelihood opportunities for the women of Lakshadweep Islands by establishing a marine ornamental aquatic organisms germplasm resource centre at Agatti island for propagation of indigenous marine ornamental shrimps/ fishes. Training was provided to the self-help group clusters, and the community aquaculture units are being successfully operated for rearing ornamental shrimps and fishes.

Genetic Resources: A total of 4,246 accessions of orthodox seed species were added to the National GeneBank for long-term storage, bringing the base collection of National GeneBank to the total of 4,67,254 accession. A total of 39 accessions of fruits, tubers, bulbs and medicinal plants were added to the *in vitro* Genebank, making the total collection of 2,001 accessions in the form of ~40,000 *in vitro* cultures of 68 genera and 167 species. In the Cryogenebank, 378 accessions of seeds and pollen genomic resources of different crop species were successfully cryopreserved, making the total collection of 12,858 accessions belonging to 885 species, besides 2,194 genomic resources. I visited the National GeneBank and *in vitro* culture facility of ICAR-NBPGR on 14 August , 2023 and interacted with the scientists. A total of 29,706 accessions of various agri-horticultural crops comprising chickpea (5,084), linseed (2,576), wheat (2,534), chilli (1,100), wild *Cicer* (513), rapeseed and mustard (402), maize (244), yard long bean (210), and other crops (572) were characterized/evaluated for various traits. Core set was developed in linseed comprising 259 accessions. Unique accessions such as pea germplasm (IC220286) with waxiness, prolific maize accessions (KG/VK/SKT-222), pre-harvest sprouting tolerant blackgram accessions (IC485425 and IC250220), chilli accession (EC769427) with 12 flowers per inflorescence were identified. National Agriculturally Important Microbial Culture Collection (NAIMCC) currently holds 7,866 microbial accessions, which include fungi (4,339), bacteria and actinomycetes (3,161), and cyanobacteria (366). The culture collection has received 14 new microbial genera.ICAR-NBAIR Museum has been designated by the Ministry of Environment and Forests and Climate Change as the "National Repository" under the Biological Diversity Act, 2002 for agriculturally important insects, mites and spiders. The National Insect Museum now holds around 2.40 lakh specimens with addition of 4,786 insect specimens**.**

A total of 1,053 germplasms of different horticultural crops including fruit crops (248), flowers and other ornamental plants (271), vegetables (525) and medicinal and aromatic plants (38) were collected. In addition to the above, a total of 90 accessions of vegetable germplasm (cultivated and wild relatives of *Luffa* sp, *Abelmoschus* sp, *Trichosanthes* sp and *Cucumis* spp) were collected

from the Sundargarh district of Odisha. In addition to the cultivated germplasm, a total of 83 germplasms of vegetables belonging to 42 species including 30 species of wild relatives were collected. Herbarium specimens (20) were also deposited in National Herbarium of Cultivated Plants (NHCP), ICAR-NBPGR, New Delhi. A total of 1,081 location specific collections of mushroom strains were also collected, of which 333 specimens/cultures were deposited at the ICAR-DMR Gene Bank with passport data and accession numbers were given to 92 cultures. A total of 15 germplasms have been registered at ICAR-NBPGR, New Delhi for different unique traits in fruits, vegetables, flowers and medicinal and aromatic plants.

Ten registered breeds of livestock were Gazette notified. These breeds included Kathani (Maharashtra), Sanchori (Rajasthan), Masilum (Meghalaya) cattle; Purnathadi buffalo (Maharashtra); Sojat (Rajasthan), Karauli (Rajasthan) and Gujari (Rajasthan) goat and Banda (Jharkhand), Manipur Black (Manipur), Wak Chambil (Meghalaya) pig. After including these breeds, total 212 indigenous breeds (53 of cattle, 20 of buffalo, 37 of goat, 44 of sheep, 7 of horses and ponies, 9 of camel, 13 of pig, 3 of donkey, 3 of dog, 1 of yak, 19 of chicken, 2 of duck and 1 of goose) have been notified by the Government, till date. ICAR-NBAGR in August 2021 initiated a mission approach for identifying new homogenous population in various states through institute projects and 40 new potential populations have been identified till now since initiation of mission activities. During the period, 18,050 semen doses of 4 cattle breeds (Malnad Gidda, Hariana, Gir, Gangatiri); 3 buffalo breeds (Nili Ravi, Mehsana, Surti) and 2 goat breeds (Osmanabadi, Sangamneri) have been cryopreserved. Also, 2,240 somatic cell vials of 19 native breeds- Ladakhi, Siri and Sahiwal cattle; Changthangi, Bhakarwali, Gaddi and Teressa goat; Gurez, Bonpala, Karnah and Gaddi sheep; Agonda Goan, Wak Chambil, Niang Megha, Mali, Banda and Nicobari pig; Mewati camel and Kathiawadi horse were cryopreserved for long term conservation. At present, National Gene Bank has repository of 61 native breeds/ populations of livestock and poultry in form of Semen and 47 in form of Somatic cells. Further, 122 oocytes (vitrified) of 5 native breeds were also cryopreserved. ICAR-NBFGR discovered new fish and shrimp species from marine waters along the coast of Tamil Nadu, Kerala and Lakshadweep islands. Marine fish species discovered were *Gymnothorax tamilnaduensis, Congerm melanopterus, Rhynchoconger bicoloratus, Ophichthus nigroventralis* and *Macrocephenchelys sumodi.* Marine shrimps detected were *Cuapetes purushothamani* and *Alpheussul cipalma.* Mangrove red snapper, *Lutjanusargenti maculatus,* a marine food fish of economic and aquaculture importance was found to comprise genome of 1.04 Gb length containing 521 scaffolds with N50 metric of 32.5 Mb. The mangrove red snapper genome has been predicted to contain 31,969 protein encoding genes. The whole genome of Indian oil sardine (*Sardinella longiceps*), a popular marine food fish was decoded. The decoded genome is 1.077 Gb in size and contains 46,316 protein coding genes. Genetic and genomic investigations showed that Indian oil sardines exist in two highly distinct stocks, one in the Indian waters and another in the Gulf of Oman. National Fish Museum and Repository established at the ICAR-NBFGR, Lucknow, was dedicated to the nation on 14 April, 2023. The newly developed museum displays finfish and shellfish voucher specimens of freshwater, marine, and brackish water environments. The museum also holds a radiographic facility to comprehensively understand fish morphological features. National Repository of Fish Cell lines with 81 cell line accessions is also located in this museum.

Crop Management: Legume integration with cereals has proved superior in productivity and beneficial to the environment. Temporal integration of maize + blackgram (raised bed) + soybean (furrow)-chickpea (raised bed) + wheat (furrow) (3:2)-greengram (raised bed) + sunflower (furrow) (5:1) was found economically feasible by recording higher productive efficiency (175%) concerning maize-wheat systems with the lowest greenhouse gases intensity (GHGI). An IFS model (1-acre area) consisting of polyhouse cultivation of vegetables (600 m^2 area for cultivation of tomato, capsicum, and cucumbers), mushroom production (50 m^2 area), agri-horti system (1,200 m^2 area), apiculture and open field cultivation of vegetables, flowers, cereals, oilseeds and pulses on 2,200 m^2 area was developed for small and marginal farmers. The IFS model is economically efficient and environmentally robust and has the potential to generate a net income of ₹1,75,650 per year. A sugarcane cultivation model combining nine improved sugarcane cultivation practices named as Sugarcane Settling Transplanting Technology (STT) was established at ICAR-Sugarcane Breeding Institute, Coimbatore.

Four full length *vip3*-type genes, viz. *vip3Aa44, vip3Aa67*, *vip3Aa69* and *vip3Aa70* (NCBI GenBank Accession Numbers HQ650163, MN120477, MN120479 and MN120481, respectively) were isolated from *Bt* subsp *thuringiensis* (A6) and *Bt* isolates SK-792, SK-986 and SK-851, recovered from diverse habitats in India. These *vip3Aa* genes have potential for lepidopteran pest control. A pool of 373 entopathogenic fungal isolates (EPFs) was evaluated for their bioefficacy against whitefly (*Bemisia tabaci*) under polyhouse. Overall, EPF strains *Beauveria bassiana* (Bb)-4511, *Cordyceps javanica* (Cj)-102, and *Metarhizium anisopliae* (Ma)-1299, were found compatible with full and half doses of the chemical and botanicals and showed highest nymphal mortality (80-95%). A Systemic Acquired Resistance (SAR) inducer molecule was developed as coated nano formulation for smart delivery in plants, for prolonged release and tested for its plant immune inducer property in field against red rot, smut and wilt diseases of

sugarcane. In field experiments, application of nano formulation significantly reduced red rot, smut and wilt incidences by 79.4%, 80.8% and 75.8%, respectively over pathogen inoculated control.

The mango-based cropping system with dragon fruit and pineapple as component crops exhibited higher production efficiency (85.21 kg/day/ha), economic efficiency and sustainable yield index under Bhubaneswar conditions. Spray schedule for flower/fruit drop in pomegranate was standardized. An integrated nutrient management schedule in sweet orange was standardized. Integration of coconut with pasture crops (Cumbu Napier hybrid + *Desmanthus*), fodder trees (*Sesbania grandiflora* + *Leucaena leucocephala* + *Glyricidia)* and Tellicherry breed of goats recorded net income of ₹ 2,54,206/ha with B:C ratio of 3.16 as compared to ₹ 1,51,312/ha with B:C ratio of 2.25 in the monocrop of coconut. "Onion Crop Advisor" mobile application—a comprehensive tool was designed and developed. Three chrysanthemum genotypes, viz. OPCH 12-7; OPCH Double White and DFR C-2 were identified as highly attractive, floriferous and rewarding genotypes for honeybees. These genotypes can be used for preparation of floral calendars to improve pollinator's health and habitat restoration. Technology for the Vitamin D enrichment of *Hypsizygus ulmarius* (Elm oyster) mushroom was developed.

An algorithm based on object detection approach with an accuracy of 84.3% for surveillance of rhinoceros beetle infestation in coconut using unmanned aerial vehicle (UAV) has been developed. A total of 67 pest species were documented on cashew inflorescences. Damage symptoms, seasonal incidence and influence of weather factor on pests, natural enemies for different pests were also documented. Reduction in nut set up to 47.06 % has been recorded in NRCC Sel-2 due to damage by the inflorescence pests. A technology for management of the beetle *Lanka ramakrishnai* with low-risk insecticides has been developed in black pepper. Three rounds of spray application with chlorantraniliprole 18.5% SC at 0.3–0.5 ml/L of water during July–September has been found effective for the management of this pest. BSV free (episomal BSMYV) tissue culture banana cv. Poovan revealed that use of virus free tissue cultured elite Poovan clone significantly reduced incidence of streak disease and increased yield over local Poovan in Karnataka, Kerala, Odisha, Maharashtra, Tamil Nadu and West Bengal. The disease reduction is to a tune of 56-75% and yield enhancement is to a tune of 23-28% with a B:C ratio of 1.51 to 1.89. *In-vitro* compatibility analysis showed that *Trichoderma afroharzianum* was compatible to azoxystrobin, kresoxim methyl, meptyldinocap, fluxapyroxad and pyraclostrobin and formulations of sulphur. The field evaluation for compatibility of biocontrol agents with registered fungicides in controlling the powdery mildew of grapes revealed that the *Trichoderma asperelloides* alternated with azoxystrobin, kresoxim methyl, meptyldinocap, fluxapyroxad + pyraclostrobin and sulphur was effective against powdery mildew. An integrated management schedule for management of blight and aphids in cumin was developed. Three foliar sprays of kresoxym methyl 44.3 SC @ 0.044% (First with initiation of disease and subsequently at 15 days interval) and two foliar sprays of thiamethoxam 25WG @ 0.0084% (First with the initiation of aphid infestation and the second after 10 days) were found effective for obtaining a higher yield (677 kg/ha) and incremental benefit-cost ratio (1.98) with less blight (PDI=16.06%) and aphid incidence (Aphid Index=0.96) under Jagudan (Gujarat) conditions.

Livestock Management: A total number of 74,582 serum samples from various NADEN units and State Animal Husbandry Departments were screened for major livestock diseases for sero-surveillance and recommendations were provided to the state governments. A total of 517 samples were analyzed for AMR pathogens (MRSA, ESBLs) and the prevalence of antimicrobial resistance was documented from livestock, environment and humans. The whole genome sequencing (WGS) of bacterial (n=1458) isolates for AMR surveillance was carried out. Complete genome sequence of 12 H5N1 highly pathogenic avian influenza (HPAI) viruses (2 from Bihar, 1 from Jharkhand and 7 from Kerala) isolated from chickens, ducks, quails and wild birds during October 2022 to April 2023 in different epicentres was determined. Under FMD sero-surveillance, 72,308 bovine serum samples collected across the country were analyzed using the r3AB3 NSP-ELISA (DIVA) to determine the apparent prevalence of NSP-antibody (NSP-Ab) in the bovine population. For post vaccination sero-monitoring, a total of 92,306 serum samples were examined using Solid Phase Competitive ELISA (SPCE) under NADCP to assess the efficiency of immunization. A competitive ELISA kit for detection of bovine viral diarrhoea (BVD) p80 antibodies has been developed which is intended for serological diagnosis of BVD in cattle. It is based on the recombinant NS3 antigen of an Indian BVDV-1 isolate and anti-NS3 monoclonal antibody. A two-step CRISPR/Cas 12a based diagnostic test was developed for rapid detection of African swine fever virus in samples of porcine origin. A urine-based pregnancy diagnosis kit 'Preg-DM' was developed and validated in collaboration with ICAR-CIRB, Hisar. The kit helps to detect pregnancy as early as days 30 to 35 post breeding for achieving high lifetime productivity. A technology entitled "SARS-CoV-2 nucleic acid detection LFA kit" was released by Hon'ble Union Minister of Fisheries, Animal Husbandry and Dairying and Hon'ble Minister of State for Agriculture and Farmers Welfare and myself on ICAR Foundation and Technology Day on 16 July, 2023. Three laboratories, Meat Species Identification (MSIL), Food Microbiology and Meat Nutrient and Residue Analytical Laboratory have been accredited as per ISO/IEC 17025:2017 by National Accreditation Board for Testing and Calibration Laboratories (NABL). The AgriInnovate has commercialized the India's first

Lumpy Skin Disease Vaccine (Lumpi-ProVac^{Ind}) to four major vaccine manufacturers, Biovet Pvt Ltd, Bengaluru; Indian Immunological Limited, Hyderabad; Hester Biosciences, Ahmedabad and Institute of Veterinary Biological Products, Pune. A horse foal Raj Himani was produced using frozen semen technology and embryo transfer technology. A healthy female foal was born on 4 October 2023. The weight of the foal at birth was 35 kg. Artificial limb for large animals was designed and developed.

Fisheries Management: ICAR-Central Marine Fisheries Research Institute (CMFRI) provided valuable insights into the health of India's marine fisheries. Overall, 135 marine finfish and shellfish stocks were assessed using marine fish landings and species-specific biology data from 1,168 landing centers from the Northwest, Southwest, Northeast, Southeast and Lakshadweep regions. Of the 135 fish stocks assessed (Northeast–16, Northwest–37, Southeast–39, Southwest–41, Lakshadweep–2) in 2022, 91.1% were healthy. The report also identifies management measures that could be applied to the fish stocks/species that are of concern with regional approaches that will ensure their sustainability. ICAR-CMFRI and CSIR-Central Salt and Marine Chemical Research Institute (CSMCRI) have identified potential sites for seaweed farming in 9 coastal states and 4 Union Territories of our country. Sites identified (384) were categorized into green zones (> 1 km from CRZ-IA), amber zones (up to 1 km from CRZ-IA), and blue zones (within CRZ-IA and ESA), with 24,707 ha identified as suitable for seaweed farming. ICAR-CMFRI has brought out a document on good management practices to promote and support sustainable farming of seaweeds in India.

ICAR-CIFRI, through intensive surveys, estimated fish catch and related information from some of the major rivers. In River Mahanadi, the annual total catch was estimated to be 15,134 tonnes with catch per unit effort (CPUE) ranging between 0.18 kg and 18.88 kg/fisher/day. The 32 bacterial isolates recovered in this study were from Bacillaceae, Burkholderiaceae, Enterobacteriaceae and Aeromonadaceae families; species, viz. *Lysinibacillus fusiformis*, *L. macroides*, *Bacillus subtilis*, *B. safensis* and *Citrobacter freundii* exhibited ability to remove ammonia.

ICAR-CIFRI has developed the RiverAquaMap, a national web application, for navigating river aquatic environment based on information from primary and secondary sources. The backend water quality data comprises DO, BOD, water temperature, pH, specific conductivity, nitrate, and nitrite. All the parameters are navigable on spatio-temporal scale on 2,667 locations distributed over the Indian river system for the period from 2007 to 2020. ReportFishDisease App developed by ICAR-NBFGR, Lucknow under National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) was launched on 28 June, 2023. ICAR-CIFA developed a vaccine, "CIFA-brood-Vac" for vaccinating female Indian major carps and catfish brooders in order to enhance the production of disease resistant spawns up to 30%. ICAR-CIFRI developed circular HDPE cages having 16 m diameter and 5 m depth and 900 cubic meter water area. These cages were used to rear adult hilsa *Tenualosa ilisha* and Indian major carps in river Ganga. A solar powered fish feed dispenser unit was designed and built on the Internet of Things (IoT) framework with a Radiofrequency (RF) module for wireless data transmission using a single board microcontroller.

Soil and Water Productivity: Agricultural land use plan based on the potential of soil enhances the land productivity. Based on the spatial soil information, suitability of major crops was assessed using the Analytical Hierarchical Process (AHP), to suggest a crop plan and soil-based management measures to improve land productivity within the limitations of bio-physical factors and available resources. The proposed crops were Groundnut/Cluster bean/Pulses/Pearl millet/Sorghum for Bikaner and Churu districts of Rajasthan. Most suitable crop combinations for Sri Ganganagar were Cluster bean/Pulses/Pearl millet/Sorghum or Cotton/Groundnut/Cluster bean/Pulses. Similarly, land resource inventory at 1:10,000 scale covering the arable lands of the North and Middle Andaman district was prepared. About 2.5% of the area is under agricultural lands, 0.60% under plantation and tree clads, and about 2% area is under homestead farming. Soil suitability assessment indicated that 65% area could be used to grow arecanut while 72.0% area is suitable for cultivating coconut.

Soil saturated hydraulic conductivity map of India has been generated and represents an indicative value of Ks of the top 30 cm of the soil. The essential data for India were accessed from the International Soil Reference and Information Centre (ISRIC) soil grid data (grid size 250 m). The map shows a total of six classes having a defined range of saturated hydraulic conductivity presented in millimeter per hour.

Analytical hierarchy process (AHP) and GIS were used to prepare the flood susceptibility maps of the Baitarani River basin. Analysis showed that nearly 87% of the river basin area is under intermediate flood hazard zones and 10% area is under high flood hazard zone. The effects of severe flooding in the Baitarini River basin are visible in three blocks in Jajpur district, two blocks in Bhadrak district and Anadapur block in Keonjhar district of Odisha. Occurrence of floods over the period of time has resulted 8% decline in agricultural land during 1995 and 2020. Hence, it is necessary that integrated flood management measures along with watershed management approaches in the upper catchment areas are suggested to minimize the risk of flooding in the basin. *Diggi* is an indigenous micro-hydrological structure for water management at field scale. Remote sensing satellite images of three years at an interval of 10 years were used to create GIS maps (3) and database for extent of irrigated croplands, farm ponds (*diggi* structure) and wind erosion affected

area of Jaisalmer. It was found that number of diggies increased 10 times during 2021 compared to the year 2001 and irrigated area expanded about 4.5 times. The wind erosion affected area was reduced by 1,63,371 ha. Sand-based runoff filter, comprising coarse sand, gravel and pebble, has been developed to harvest runoff from farmers' fields for artificial groundwater recharge in semi-arid region of Gujarat. The intervention resulted in rise in groundwater table in the village by 1.84 m and farmers were able to give full irrigation to *rabi* crops. To address the availability of quality gypsum for reclaiming sodic soils, three categories of sulphur-based formulation (RFS) were developed suitable for different soil sodicity conditions. These formulations are highly reactive and get oxidized within one crop season by the soil microorganisms to help in alleviating the stress caused due to excess of the alkaline salts present in soils. A salt tolerant Indian Mustard CS 64 variety has been notified after release by CVRC for salt affected areas of the Haryana, Punjab, Rajasthan, Delhi, Uttar Pradesh, and Plains of Jammu and Kashmir and Himachal Pradesh.

Mechanization and Energy Management: An Economy seeder was developed for *in-situ* crop residue management technology suitable for heavy soils. It performs three operations simultaneously, namely chopping of the crop residue, tilling and mixing the chopped residue and sowing. Small tractor operated sugarcane base cutter has been developed for cutting and windrowing the whole cane in field. Base cutter is powered by tractor PTO through pulley with V-belt drive. A tractor operated whole-cane harvester has also been developed with a base cutter unit, crop gathering unit, cane walker, de-topper and cane collection trolley. All these mechanisms are hydraulically operated and can be mounted on a tractor three-point links. The average field capacity of the unit is 0.11 ha/h and field efficiency of the unit is 0.70%. The equipment saves 71% in cost when compared to manual harvesting.

A manual harvesting tool has been developed for okra harvesting. It eliminates the complete hand touch of okra pod. A long-handle pineapple leave pruner has been developed. The field capacity of the pruner is 0.005 ha/h. A computer vision based bird identification system has been developed to count the birds and can be used to calculate the amount of feed to be dispensed. The computer vision approach is effective in detecting birds and can be effectively integrated into the automatic feed dispenser for poultry birds. An automatic spraying system has been developed for chemical application inside the polyhouse. The developed system has two units, i.e. automatic spraying unit (ASU) and DC motor-operated row changing unit (RCU).

Animal drawn single row automatic feeding type potato planter-cum-fertilizer applicator has been developed. It also performs the function of furrow opening and covering of the seed tuber there by making ridges. The actual field capacity was 0.09 ha/h with field efficiency of 74%. A bullock drawn 8-row pre-germinated paddy seeder-cum-herbicide applicator has been developed for simultaneous application of line sowing of pre-germinated paddy seeds and application of pre-emergence herbicide. The cost of operation of bullock drawn 8-row pre-germinated paddy seeder-cum-herbicide applicator is ₹1,032/ha. A flue-cured Virginia tobacco leaf stringing machine has been developed. This unit can produce one stick per 20 s (@4 kg of fresh tobacco leaves/stick) with a stringing capacity of 730±100 kg/h. Anagro-residues based bio-sorbent for the treatment of Bulk Milk Chiller (BMC) effluents has been developed. The bio-sorbent was prepared through pyrolysis of agro-residue under controlled environment. The hanging type plastic feeder has been developed with help of mild steel, PVC pipes and FRP sheet. The feeder is designed in such a way that no feed/*bhusa*/green will fall outside the tray, so that feed/fodder loss is reduced to negligible.

Post-harvest Management and Value-addition: *Hawaijar* is a traditional fermented food of North-East India prepared from soybean. *Hawaijar* making mechanized system was developed and unit operations considered in the mechanized system are soaking, steaming and incubation. The designed capacity of the developed mechanized batch type system is 10 kg. A low cost ready-to-use kit was designed and developed for its application in retail packets as well as household level metallic drum storage to manage major storage insect-pests of chickpea. A portable, electronic, and hand-held device for lac colour index analysis has been developed based on the principle of colorimetry. ICAR-CIRCOT has designed and developed a compact, and energy efficient direct heating type 'Cotton Seed Dryer' on PPP basis. It is designed using innovative collapsible MS belts that allow heating of cotton seed twice (one on top and another on bottom side) on each conveyor leading to development of energy efficient compact drying system. A new process for menthol crystal production from mint oil was developed to reduce the time of production.

Climate Resilient Agriculture: Pusa Sanjeevni, a bacterial formulation with 6 months of shelf-life was developed based on the results of phytotron and field trials were carried out at farmers' field at NICRA adopted villages. The formulation was evaluated in rice-wheat cropping system at the farmers' field. The four bacteria in consortium assisted in better germination, vegetative growth, and increased yield under low moisture. Several climate-smart interventions for rice, chickpea, wheat, soybean, and greengram have been identified for the NICRA-adopted village using the CCAF-mitigation option tools.

Application of dichorionic di-amniotic (DCDA), resulted into reduction in the GWP (Global Warming Potential) by 33.2 and 4.9% under higher and medium carbon strata, respectively under conventional tillage practice, while the reduction of GWP by 25.0 and 9.7% under high carbon and medium carbon, respectively under zero tillage practice. Integrated Farming System

models have been established through AICRP on Integrated Farming Systems and All India Network Programme on Organic Farming in the country for improving the income of the farmers and sustainability, besides addressing the climate change. Till now, a total of 71 prototype IFS models (including 8 integrated organic farming system models), 63 on-farm farmer participatory refined farming systems and 32 bankable models have been developed, suitable for 26 States and UTs.

Human Resource Development: The Education Division, ICAR helps to ensure quality assurance of 76 AUs and various agricultural colleges with private universities through accreditation process. Various training programmes under the plan scheme of Agricultural Education Division as well as NAHEP and NAARM helped enhance the capabilities of the faculties and students in various upcoming areas and improved the nature of publications out of PG research. AUs were also provided assistance for encouraging holistic development of students, as well as limited support for Agribusiness Incubation Centres. A total of 42 new applications for accreditation of degree programmes, colleges and agricultural universities were received in the year 2023-24. Ten Agricultural Universities including backlog of previous year, were granted accreditation.

A total of 583 and 292 students were awarded ICAR PGS and ICAR JRF/SRF for Master's and Doctoral studies, respectively. Krishikosh, a digital repository (https://krishikosh.egranth.ac.in/) of valuable documents in the field of agriculture and allied sciences, has been created and strengthened. Currently this digital repository has 50 million digitized pages in more than 3,00,000 digital items (volumes) like old books, old Journals, reports, proceedings, reprint, research highlights, training manuals, historical records, which includes more than 1,90,000 theses digitized from various NARES Institutes/SAUs. A tool has been developed for Important Keywords extraction along with its frequency in different years from the metadata of theses titles available in Krishikosh repository. The key components of NHAEP, viz. Centres for Advanced Agricultural Sciences and Technology (CAAST), Institutional development Plan (IDP), and Innovation Grants have contributed to enhanced entrepreneurship opportunities and other reforms in AUs. NAHEP is benefitting 74 institutions in the ICAR-AU System, including 63 State-level agricultural universities, 4 Deemed Universities, 4 Central Universities with agricultural faculties, and 3 Central Agricultural Universities.

Social Science: Sustaining the momentus in pulses production requires a technological breakthrough and restriction on imports to incentivise farmers to produce more. The strategy to enhance pulse production should be built around bridging the yield gap, effecting a technological breakthrough, and adopting a crop-neutral price policy. A meta-analysis of some important sustainable agricultural practices showed that these interventions produce several ecosystem services and the monetary value of such non-tradable services ranges from ₹ 3,742 to ₹15,142 per ha, accounting for 34-77% of the total value of the ecosystem services.

An Artificial Intelligence (AI) based android mobile application, called AI-DISC (Artificial Intelligence Based Disease Identification for Crops) has been developed that can automatically identify plant diseases with visible symptoms. KCC-CHAKSHU (Kisan Call Centre-Collated Historically Aggregated Knowledge based System using Hypertext User Interface) has been developed. To implement an intelligent online platform for supporting agriculture, Kisan SARATHI implemented and strengthened in association with Digital India Corporation, Ministry of Electronic and Communication Technology (MeitY), Government of India. This is an on call advisory services for farmers of India, where any farmer can call or record their query in his own language automatically directed to respective KVK/ATARI for query redressal.

KVK portal (Krishi Vigyan Kendra Knowledge Network) has been strengthened by adding new functionality to add information on yield gap index and to view state and district wise report in the portal. E-Learning portal has been developed with an objective to strengthen the Agriculture Higher Education in India by developing and disseminating the e-courses for undergraduate and postgraduate courses. At present, E-contents for 70 postgraduate and 141 undergraduate courses are available on this portal. Experimental Data Repository and Infographics Dashboard of KRISHI (Knowledge based Resource Information System Hub for Innovations in Agriculture) were enriched with more information systems. ICAR Geo-Portal was updated. Area Production and Yield Information System was developed. A machine learning–based computational model for prediction of miRNAs associated with four specific abiotic stresses such as cold, drought, heat and salt was developed. An online prediction server "ASmiR" (Abiotic stress responsive miRNA prediction in plants) was developed. For Empowering Women in Agriculture, ICAR-CIWA is actively engaged in a range of research projects addressing gender issues in agriculture and related fields. It is operating across 12 states in India, in collaboration with 13 State Agricultural Universities, as AICRP on Women in Agriculture. Two Custom Hiring Centre focusing on Spice Processing and Mushroom were established in Puri district of Odisha for Farm women mobilization and empowerment. To enhance the efficiency of agricultural operations, Women Self-Help Group (SHG)-based Custom Hiring Centers (CHC) and Farmers' Interest Groups (Ananya Mahila Bikas Samiti) were established.

Basic and Strategic Research: During the reporting period, NASF has approved 12 new projects on novel aspects. NASF also invited the pre-proposals for new research projects for Call X under seven strategic areas. Total 737 pre-proposals have been received

under these strategic areas. Gene editing with CRISPR-Cas9 technology was employed to develop mutants of the *DST* (Drought and Salt Tolerance) gene, a zinc finger transcription factor in rice cultivar MTU 1010. Genome-wide association studies (GWAS) conducted using phenotyping data for agro-morphological and stress tolerance traits identified numerous genes related to these traits. The fine mapping studies provided the precise map position of important alternative dwarfing loci *Rht14* and *Rht18* in wheat. After annotation and based on domain search analysis, five lipases and two lipoxygenases were identified and cloned.

Marker assisted stacking of yellow mosaic disease resistance, null kunitz trypsin inhibitor, null *lipoxygenase-2* genes, and broadening the genetic base of soybean was done. A survey was done for the identification of genomic regions for fall armyworm *Spodoptera frugiperda* resistance in maize, a parental polymorphism was done using 531 sequence-tagged microsatellites (STMS) markers. A volatile biomarker(s) was identified for the screening of scab resistant apple germplasm at early stage non-destructively. To manage the pest whitefly, *Bemisia tabaci,* RNAi silencing mediated control was done. A prototype "MEGH" (Measuring Essential Good Hydration) was developed for field deployment and estimation of the moisture from soil in a non-contact manner. Microbial consortium package has been standardized for *in situ* decomposition of paddy straw. An integrated seeder cum microbial inoculum applicator machine was developed for *in situ* rice-residues management. Artificial Intelligence and IoT based Smart Vet Ecosystem for animal health, patient care and precision livestock farming was developed including the prototypes of Electronic Health Records for Animals (eHRA) and Electronic Veterinary Medical Records (eVMR). Health and Medical Data Architecture Modules and data panels were developed. To detect SARS-CoV-2 antigen in animals, a RPA-CRISPR based point-of care kit 'SARS-CoV-2 nucleic acid detection LFA kit' has been developed for detection of SARS-CoV-2 antigen in clinical samples. Development of a Cocktail Vaccine with Omicron and Delta Strains was carried out by isolation and genetic characterisation of the Omicron and Delta variants of SARS-CoV-2. A protocol was made after standardising all the features related to capturing the facial image of the animals for Traceable value chain for safe pork in the North Eastern Region of India. A sensing device (IMAGinE) was developed for detection of Chromium (Cr^{6+}) in water with very trace level detection limit. The developed Cr^{6+} sensing device IMAGinE was found to very precise and robust with very low values of LOD and LOQ, 0.0037 ppm and 0.0112 ppm, respectively.

Information and Communication Technology: Smart Performance Appraisal Report Recording Window (SPARROW), an online system for electronic filling of Annual Performance Appraisal Report (APAR) of officers was started. A total of 17,691 APARs have been generated. Agricultural Research Management System (ARMS), an the online portal for all ICAR scientists to submit their significant research achievements, has been developed and implemented. ICAR eOffice software developed by NIC has been implemented across 113 ICAR institutes along with their regional stations/sub-stations. The ICAR eOffice is hosted at ICAR data centre and is running successfully. ICAR-Data Centre, Advanced Supercomputing facility for Omics Knowledge in Agriculture (ASHOKA) and ICAR-Disaster Recovery Centre (ICAR-DRC) are established to provide support in accessing unified communication system, email services, web applications/websites hosting, e-Office, ICAR-ERP, Agricultural Research Management System, Foreign Visit Management System, Personnel Management System, eHRMS, SPARROW, Super Computing facility, and many more digital applications and platforms. In order to provide seamless ICT support to ICAR users across country, a centralized help desk in the form of web application has been developed and implemented to address the issues and concerns related to use of these web applications and services. ICAR-Network Program on Precision Agriculture (NePPA) is focused on exploring potential applications of recent developments on technologies related to sensors, IoTs, drone and ICTs, variable rate technologies (VRTs) for precision smart agriculture. The major objective is to bring precision in monitoring and managing soil fertility, crop health, livestock farming, post-harvest operations, aquaculture and upscaling in farmers' field to enhance input use efficiency and optimal production system.

Technology Assessment, Demonstration and Capacity Development: A total of 6,036 technological options in various crops were assessed by the KVKs at 15,180 locations by carrying out 33,128 trials in farmers' fields in order to provide technological alternatives to the identified problems across the country. The KVKs assessed 1,099 technological options pertaining to different thematic areas of production and management of cows, buffalo, sheep, goat, poultry, pig and fish at 3,633 locations through 6,771 trials. As part of technology assessment, 339 technologies pertaining to farm women were assessed through 3,066 trials at 1,344 locations with the aim to promote women empowerment. Division of Agriculture Extension, ICAR, New Delhi implemented Cluster Frontline Demonstrations (CFLDs) programme through KVKs on major pulse and oilseed crops under National Food Security Mission (NFSM) of Department of Agriculture and Farmers' Welfare, Government of India, New Delhi to demonstrate the production potential of different technologies of these crops. Under capacity development, a total of 23.16 lakh farmers/farm women, rural youth and extension personnel were trained on various aspects through 74,065 training programmes including the sponsored training courses.

Besides these activities, important programmes namely Out scaling of Natural Farming, Formation and Promotion of Farmer Producer Organizations (FPOs)

as Cluster Based Business Organizations (CBBOs), Technological backstopping to FPOs, Demonstrations through Agri-drones, Farmers FIRST, Attracting and Retaining Youth in Agriculture (ARYA), Cluster Frontline Demonstration of pulses and oilseeds, Cereal Systems Initiatives for South Asia (CSISA), National Innovations in Climate Resilient Agriculture (NICRA), Pulses Seed hubs, *Mera Gaon Mera Gaurav* were taken up to address various challenges. During the reporting year, KVKs organized a total of 6.19 lakh extension programmes using various methods and means. These included advisory services, celebrations of important days, diagnostic and clinic services, exhibitions, exposure visits, ex-trainees sammelan, farm science club conveners' meetings, farmers' seminars, farmers' visits to KVK, field days, film shows, group meetings, kisan ghosthi, kisan melas, lectures delivered as resource persons, mahila mandal conveners' meetings, method demonstrations, plant/animal health camps, scientists' visits to farmers' fields, self-help group meetings, soil-health camps, soil-test campaigns, workshops, and other activities, wherein latest technologies related to agriculture and allied sectors were disseminated among 204.61 lakh participants including 200.58 lakh farmers and 4.54 lakh extension personnel. Additionally, KVKs are in the forefront for effective utilization of electronic and print media to have wider coverage of technology dissemination. KVKs produced technological products like seeds and planting materials of improved varieties and hybrids, bio-products and elite species of livestock, poultry and fish which benefited 11.18 lakh farmers in the country. In addition to ICAR institutes, 55 Directorates of Extension Education (DEEs) in the SAUs/CAUs played pivotal role in technological backstopping to KVKs of the country. Timely and need based information to the farming community was provided by 594 KVKs by using mobile advisory services. Based on weather forecast, farmers were alerted and advised on suitable farm operations. Technology Demonstration Component (TDC) of National Innovations in Climate Resilient Agriculture (NICRA) which aims at enhancing resilience of Indian agriculture and making Indian farmers more adaptive to climatic vulnerabilities has been implemented through 151 KVKs in climatically most vulnerable districts of the country as per the latest risk categorization.

ICAR has stated Agri-Drone project, with funding support from Department of Agriculture and Farmers' Welfare, Government of India, with objective of creating awareness among the farmers and other stakeholders and demonstrating the use of drone in agriculture in farmers' fields. The innovative initiative "*Mera Gaon Mera Gaurav*" aimed to promote the direct interface of scientists with the farmers to hasten the lab-to-land process. The objective of this scheme is to provide farmers with required information, knowledge and advisories on regular basis by adopting villages particularly small and marginal farmers. Farmer FIRST is a flagship programme initiated by ICAR to move beyond production and productivity; to privilege the smallholder agriculture; and complex, diverse and risk prone realities of majority of the farmers through enhancing farmers-scientists interface. A total of 28,995 demonstrations were conducted, 2,972 extension programmes were organized, 1,03,492 animals (livestock and poultry) were benefited and 86,197 farm families were covered in all modules during the reporting period. Nutri-Sensitive Agricultural Resources and Innovations (NARI) Programme is a flagship programme initiated by ICAR at national level. Nutrition-sensitive agriculture puts nutritionally rich foods, dietary diversity, and food fortification at the heart of overcoming malnutrition and micronutrient deficiencies.

Research for Tribal and Hill Regions: During the period under report, 17.453 tonnes breeder seeds of 49 released varieties/inbreds of 15 crops were produced and 16.054 tonnes breeder seeds were supplied to different seed producing agencies for downstream multiplication to foundation and certified seed. Around 1,433 kg nucleus seed of 40 released varieties of 15 crops were also produced following standard methods of maintaining genetic purity. In addition to this, 401 kg Truthfully Labelled (TL) seed of 09 varieties of 07 crops were produced and 258 kg TL seeds were supplied to different stakeholders. The central varieties, viz. VL Cookies wheat, VL Mandua 400 finger millet, VL Soya 99 soybean, and VL Uphar and VL Madhuri field pea; and state varieties, viz. VL Masoor 150 lentil and VL Matar 64 field pea were released for cultivation in north-west Himalayas.

An IOFS model comprising different enterprises, i.e. cereals, pulses, oilseeds, vegetable crops and climbing vegetables on protective structure all along the farm pond, fruits, dairy, fodder crops, central farm pond, duckery, farmyard manure (FYM) pit and vermicomposting unit was designed and tested on long term basis. The solid waste from dairy unit and farm was used for making FYM and compost. The model consists of a total area of 0.34 ha and a farm pond (0.046 ha) that can be put to use for aquaculture and duckery, and support crops with lifesaving irrigation whenever needed. The model was demonstrated to 330 households in three villages, viz. Mynsain, Pynthor and Umden Umbathiang covering an area of about 300 ha. Results from beneficiaries who adopted the model showed that by merely investing an amount of ₹60,000 on IOFS, the farmers realized a net income of ₹65,000/annum compared to rice mono-cropping or improved rice-vegetables cropping system.

IP, Organization and Management: Administration- During the year, following posts were filled up under the promotion quota: 4 Director/CAO (Senior Grade), 2 Director (F)/Comptroller, 6 Deputy Secretary/CAO, 6 Deputy Director (Finance)/CFAO, 4 Under Secretary, 7 Senior Administrative Officer, 6 Senior Finance and Accounts Officer, 1 Law Officer, 2 Principal Private Secretary, 7 Administrative Officer, 7

Finance and Accounts Officer, 5 Section Officer (Hqrs), 16 Assistant (Hqrs) and 3 LDC (Hqrs). During the year, 21 eligible Officers and Staff of ICAR were granted the benefits of financial up-gradation at ICAR Headquarters under the Modified Assured Career Progression scheme.

Finance: The Revised Estimates in respect of DARE/ ICAR for 2022-23 were of ₹8,658.89 crores. Internal resources of ₹355.13 crores (including interest on Loans and Advances, income from Revolving Fund Schemes and interest on Short Term Deposits) were generated during the year 2022-23. The total allocation Budget Estimates for 2023-24 are of ₹9,504.00 crores.

During the period under report, 88 new Patent Applications were filed in different subject domains of agricultural sciences at Indian Patent Office (IPO). The cumulative figure of patent applications at ICAR has now risen to 1,543 applications. IPO had granted 81 patents, which made ICAR's cumulative number of granted patents to 536. To protect the Plant Varieties, 23 varieties were filed at Plant Varieties and Farmers' Rights Authority (PPV&FRA). For applications filed earlier, 73 varieties were granted registration certificates during this period; which raised the cumulative figure of registered varieties to 1,454. During the period under report, 141 applications were filed for copyrights by 32 ICAR institutes. A total of 601 filed copyrights have been thus recorded from different ICAR institutes. Eighteen applications were filed for Designs by 9 ICAR institutes, which has risen the cumulative figure to 105. Thirty seven trademark applications were filed by 18 ICAR institutes for different products and processes. Till date a total of 255 trademark applications have been filed. ICAR has celebrated "World Intellectual Property Day" on 26 April, 2023, as per World Intellectual Property Organization's (WIPO) theme for Day in 2023 was "Women and IP: Accelerating Innovation and Creativity". World IP Day was an opportunity to highlight the importance of IP rights, such as, patents, copyrights, designs, trademarks, and plant varieties for encouraging innovation and creativity among scientific fraternity of the Council. This year, 691 such partnership agreements were developed with 463 public and private organizations and farmers/entrepreneurs. In this process 64 ICAR institutes were involved from different Subject Matter Divisions, and transferred 381 technologies in different disciplines which include; Animal Production Technologies; Crop Production Technologies; Farm Machinery and Tools; Fish Farming and Processes; Food Processing Technologies; Plant Protection Technologies; Seed and Planting Material; Textile Process; and four technologies from allied sectors.

Various useful programmes for public utility and farmers were organized by the institutions of the Council in Hindi and Regional Languages. All activities including agriculture extension related to KVKs located in Hindi speaking areas were also performed in Hindi and Regional Languages. Various publications on different subjects like Agricultural Science, Animal and Fishery Science and Horticultural Science were brought out in Hindi and Regional Languages by the Council and its institutes from time to time. With a view to provide Knowledge of various technologies on agriculture and wider publicity thereof, monthly Hindi magazine *Kheti* was published regularly. *Rajbhasha Aalok*, in-house Hindi magazine of ICAR Headquarters, was published regularly. This magazine includes articles on scientific subjects and government schemes in simple Hindi, besides reports of various schemes and programmes being organized by the Council and its institutes from time-to-time. Total number of notified subordinate offices of the Council under Rule 10(4) of Official Languages Rules, 1976 has increased up to 149.

The following activities by Technical Coordination Unit were conducted during reported period: Preparation of Monthly Cabinet Summary for Cabinet Secretary; Grant of financial assistance to Scientific Societies and Academic Institutions for holding of National/ International Conference/Seminars etc., and publication of Scientific Journals; Organizing Director's Conference; Coordination of the ICAR Regional Committee Meetings; Coordination and collaboration with Department of Science and Technology, Department of Biotechnology, Department of Scientific and Industrial Research, CSIR, ICMR, Bureau of Indian Standards etc.; To deal with the references received from Prime Minister's Office, President's Secretariat, Members of Parliament and VIPs etc.; Preparation of draft for DARE and ICAR Annual Reports and Audited Accounts to be laid down in Parliament; Parliament Questions of inter-divisional nature; Nodal point for e-samiksha portal for DARE/ICAR; Releasing funds for Lal Bahadur Shastri (LBS) and Norman Borlaug Award projects; To handle and promote the Swachhta Action Plan (SAP): releasing of funds, uploading of approved quarterly report on SAP portal; Collecting and compiling the Swachhta Pakhwada Daily reports and uploading on the portal; To handle the Swachh Bharat Mission: organization of Swachhta Pakhwada/Swachhta Hi Sewa; Development and circulation of data-wise Action plan for Swachhta Pakhwada to all ICAR establishments, preparation of daily pakhwada report, uploading the daily approved report on portal, selection of the Swachhta Pakhwada Ranking, etc., To collect, compile and provide the agenda to the Ministry of Home Affairs for Zonal Council Meetings, Arranging the Review Meetings of ICAR Institutes under the Chairmanship of Hon'ble AM; Various Campaigns from Government of India; Inter-ministerial assignments; Convergence of various Central Government Schemes and Organization of various important events.

The 95th Foundation and Technology Day of ICAR was celebrated during 16 to 18 July 2023. On the occasion, certificates of 5 new technologies related to products from SMDs and books were released. The award for Hackathon Winners were also presented, and exhibition on all the three days was also organized. Apart

from the Senior Officers of ICAR, and other departments about 500 Farmers and 500 School Children visited the Exhibition during 16 to 18 July 2023. Sh. Narendra Singh Tomar, Former Union Minister of Agriculture and Farmers Welfare and President of the ICAR Society, on this occasion congratulated the ICAR and dignitaries.

Training and Capacity Building: Twelve specialized online/offline training programmes, viz. Executive Development Programmes for Newly Recruited Research Managers of ICAR; Advances in Simulation Modelling and Climate Change Research towards Knowledge Based Agriculture; Management and Utilization of Plant Genetic Resources; Capacity Building Programme for Effective Implementation of Training Functions in ICAR by HRD Nodal Officers/ Co-Nodal Officers; Training Workshop for Vigilance Officers; Automobiles Maintenance, Road Safety and Behavioural Skills; Pension and Retirement Benefits; National Pension Scheme; Capacity Builing Programme for CJSC members; Agrometeorological Data Collection, Analysis and Management; Farm Management and Principles and Production Techniques of Hybrid Seed in Vegetables were organized by 08 Competent ICAR-Institutes. In these programmes, 433 employees of various categories as per programme participated.

During the reporting period, scientists (1,137), technical (686), administrative including finance (422) and SSS (161) were trained constituting a total of 2,406 employees. Compared to 2013-14, there was considerable improvement in number of employees undergone trainings where improvement was 85.4 and 302.5% in Technical and Skilled Support Staff, respectively. The training programmes organised for scientists, technical, administrative including finance, and skilled support staff were 229, 50, 24 and 16, respectively with 319 total number of training programmes. ICAR also nominated 548 employees of various categories in training and capacity building programmes organized by various ICAR/non-ICAR Institutes, out of which 369 employees attended the training programmes. Impact assessment of trainings attended by 2,171 employees of various categories of 90 ICAR-Institutes during 2020-21 was done as per proforma developed by DoPT. It indicated that the overall impact of training was assessed as Considerable-Great Extent with average rating of 4.05/5.00 by the trainees while it was rated as Considerable-Great Extent with average rating of 3.96/5.00 by their Reporting Officers.

Publications, Social Media and Public Relations: With the advent of ICT, the research journals were made available online (https://epubs.icar.org.in: Indian Agricultural Research Journals) and placed in open access. This platform was developed under NAIP and now hosts 55 journals belonging to ICAR funded societies. Its facilities include online article processing system, peer-review system and archives. The portal has archives of back volumes of research journals till 1994 pertaining to *Indian Journal of Agricultural Sciences* (280 issues) and *Indian Journal of Animal Sciences* (292 issues). Whereas the popular journals namely *Indian Farming* (106 issues) and *Indian Horticulture* (60 issues) are also hosted. About 37,000 articles are available online globally in open access. A new OJS version 3.3.0-14 (https://epubs.icar.org.in) was developed and implemented for the journals. *The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences*, the flagship research journals of ICAR having international fame have a wide clientele. These journals received a total of 3,697 (*The Indian Journal of Agricultural Sciences*) and 1,547 (*The Indian Journal of Animal Sciences*) submissions during the reporting period. Out of these submissions, 285 articles in *The Indian Journal of Agricultural Sciences* and 280 articles in *The Indian Journal of Animal Sciences* were published. The user base of the journals is expanding and has reached to 41,410 users in *The Indian Journal of Agricultural Sciences*) and 22,610 users in *The Indian Journal of Animal Sciences*. The journal website was visited nearly 45,000 times with audience belonging to 143 countries. The journals have considerable metrics, viz. impact factor and H index are 0.37 and 29 for *The Indian Journal of Agricultural Sciences* and 0.31 and 23 for *The Indian Journal of Animal Sciences* despite the fact that these are multi-disciplinary in nature.

The total submissions in the *Indian Farming* and *Indian Horticulture* were 380 and 148, respectively. The registered users were 5,610 in the *Indian Farming,* whereas 3,710 in *Indian Horticulture.* A total of 180 articles were published in the *Indian Farming* and 76 in *Indian Horticulture*. Special issues of the *Indian Farming* were brought out on the themes like Rich in Heritage, Full of Potential on the occasion of International Year of Millets 2023 and on the G20 Meeting of Agricultural Chief Scientists. Similarly special issues of the *Indian Horticulture* on Vegetable Crops (March-April 2023), Medicinal and Aromatic Plants (September-October 2023) and Horticulture in North-East Region (November-December 2023) were brought out.

During the year, Digital Object Identifier (DOI) number allotment to the more than 5,000 articles for both the research journals was continued for the benefit the authors as well as journal immensely. To provide authentic knowledge to readers of the research journals, plagiarism checker software iThenticate was subscribed. For facilitating publication of the books, e-book platform was developed. Under the books publication programme of the English Editorial Unit, seven new titles were published namely Textbook of Watershed Hydrology, Textbook on Cheese Technology, Importance of Millets and Improved Production Technologies, Fundamentals of Soil Science, Fundamentals of Soil and Water Conservation Engineering, Textbook of Entomology and Textbook on Veterinary Extension. The in-house publications like *ICAR Reporter* and *ICAR News* are also available on ICAR website for wider global reach. These were viewed in about 140 countries world over.

The ICAR flagship Hindi monthly journal *'Kheti'* and bimonthly horticulture journal *'Phalphul'* were published by HEU timely on regular basis. During the reported period, 4 special issues of *Kheti* were published namely *'Pashu Aahar Visheshank', 'Dalhan par Vishesh Samagri', 'Matsyiki Visheshank', 'Sasya Vigyan Congress Visheshank'*. Similarly three special issues of *'Phalphul'* namely *'Phal Sabji Prasanskaran', 'Paudh Nursery'* and *'Videshi Evam-Alpdohit Bagwani Fasal Visheshank* were published. Apart from journals, a booklet *Ullekhniya Uplabdhian (2014-2023): Amritkal mein Viksit Bharat ki Akanchha ke Saath Badhte Kadam* was also published.

To disseminate information in real-time, the ICAR website was updated on a regular basis, and in total 4,613 pages were updated with a total of 41,89,432 page views from more than 200 countries were recorded. Knowledge seekers across the globe visited the Website. The top five countries visiting the Website include India, United States of America, United Kingdom, United Arab Emirates and Nepal. A newly designed and more user-friendly ICAR website was developed and hosted with more than 19,000 pages. The New Website has a Publication Cart through which the stakeholders can purchase ICAR Publications online. During the reporting period, DARE website (dare.gov.in) was certified with GIGW certification from STQC. On ICAR Facebook, a total of 519 Posts were published during the year and it has 2,29,171 Followers. ICAR Twitter Handle has more than 2,28,458 Followers. On an average, 3 Tweets were posted every day and a total of 1,114 Tweets were posted during the year and Tweets earned 2,161.29K impressions. The YouTube Channel of ICAR has Video Films, Animations, Lectures/Interviews by dignitaries and Eminent Scientists, Proceedings of National and International Events, etc. It has 72,700 subscribers. ICAR participated in Republic Day Celebrations third time on 26 January 2023 with a tableau on the theme of International Millets Year declared by UN. The council participated in and coordinated about 51 National and International level exhibitions annually like the Exhibition during ICAR foundation day; Indian Science Congress at Nagpur; Vision Rajasthan at Sirohi; 19thAgro organic world expo etc. The revolutions witnessed in the dairy and fisheries sector due to ICAR's efforts has far-reaching implications. Beyond economic growth, these developments contribute significantly to the food, nutrition, and livelihood security of the country. ICAR's research does not merely address immediate challenges but actively contributes to building a resilient and sustainable future.

In the grand tapestry of regional agriculture, ICAR's research emerges as a key player. Its role in feeding a growing population, providing a healthy diet, protecting the environment, and addressing the climate crisis cannot be overstated. As we salute ICAR's excellence in agricultural research, we also look forward to a future where its research continues to be a driving force in shaping a sustainable and prosperous agricultural landscape in India and beyond. I hope that the *ICAR Annual Report 2023-24* will enlighten myriad of stakeholders for research and development in agriculture hitherto inconceivable.

(Himanshu Pathak)
Secretary, Department of Agricultural Research & Education
and Director General, Indian Council of Agricultural Research, New Delhi

2. Crop Improvement

CROPS

Crop varieties released and notified

Since 1965, more than 6,000 improved field crops varieties (6,226) have been developed which include 3,059 of cereals, 1,021 of oilseeds, 1,136 of pulses, 250 of forage crops, 553 of fiber crops, 157 of sugarcane and 50 of potential crops. During the reporting period, a total of 283 varieties/hybrids have been notified and released for commercial cultivation, which include 35 biofortified varieties and 32 varieties to combat the various abiotic stresses like drought, water scarcity, flood, waterlogging, salinity, sodicity, low temperature etc. Use of precision breeding tools, i.e. marker assisted selection has also been done in breeding 10 traits specific varieties. The details of these varieties are given below:

Cereals: One hundred and twenty-five high yielding varieties/hybrids of cereals comprising 47 of rice, 21 of maize, 24 of wheat, 9 of sorghum, 4 of pearl millet, 6 of little millet, 5 of finger millet, 3 of proso millet, 2 each of kodo millet and foxtail millet, one each of brown top millet and barnyard millet were released for cultivation in different agro-ecologies of the country.

List of released varieties/hybrids of cereals

Variety	Area of adoption	Salient features
Rice		
Pant Sugandh Dhan 27	Uttarakhand	Suitable for plains of Uttarakhand under irrigated conditions, grain yield 49.3 q/ha, maturity 125 days, aromatic, long slender grains, resistant/ moderately resistant to bacterial leaf blight (BLB) and stem borer.
NPH-242	Assam	Suitable for medium duration, *kharif* and *boro* cultivation of Assam state, grain yield 49.2 q/ha, maturity 125 days, aromatic, long slender grains, resistant/moderately resistant to BLB and leaf blast.
Swarna Shusk Dhan (RCPR 56-IR93827-29-1-1-4) (IET 27962)	Uttar Pradesh	Suitable for rainfed and aerobic conditions, grain yield 22.3 q/ha (rainfed), maturity 115 days, long slender grains, moderately resistance to leaf and neck blast, drought tolerant.
Swarna Purvi Dhan 1 (RCPR 19-IR 84899-B-179-13-1-1-1) (IET 24660)	Jharkhand	Suitable for aerobic and rainfed conditions, grain yield 45.0 q/ha, maturity 120 days, short bold grains, moderately resistant to leaf blast, drought tolerant.
Swarna Purvi Dhan 2 (RCPR 46-IR93827-29-1-1-2) (IET 26767)	Jharkhand	Suitable for early-irrigated conditions, grain yield 55.0 q/ha, maturity 120 days, long slender grains, moderately resistant to leaf and neck blast, drought tolerant.
MCM Rice 103 (IET 23407)	Andhra Pradesh	Suitable for salt affected areas of Andhra Pradesh, grain yield 50.5 q/ha under saline conditions, maturity 140 days, medium slender grains, moderately resistance to leaf and neck blast, BPH and sheath blight.
MTU Rice 1232 (IET 26422)	Andhra Pradesh	Suitable for flood prone areas of Andhra Pradesh, seed yield 38.0 q/ha under stress and 60.0 q/ha under normal conditions, maturity 140 days, medium slender grains, moderate resistant to leaf blast and sheath blight.
MTU Rice 1318 (IET 28527)	Andhra Pradesh	Suitable for irrigated late ecology, grain yield 65.0 q/ha, maturity 150 days, medium slender grains, non-lodging, tolerant to leaf and neck blast.
Jagtiala Vari-2 (JGL 28545 (IET 27448)	Telangana	Suitable for irrigated mid ecology, grain yield 75.0 q/ha, maturity 135 days, medium slender grains, moderate resistant to BLB, neck blast, YSB and sheath rot.
Jagtiala Vari-3 (JGL 27356 (IET 30064)	Telangana	Suitable for irrigated medium duration conditions, yield 62.2 q/ha, maturity 135 days, short slender grain, moderate resistant to neck blast, sheath rot and YSB.
Rajendranagar Vari-3 (RNR 15459 (IET 28567)	Telangana	Suitable for irrigated medium duration conditions, grain yield 40.2 q/ha, maturity 140 days, aromatic short bold grains, moderate resistant to leaf and neck blast and BLB.
Rajendranagar Vari-4 (RNR 21278 (IET 27107)	Telangana	Suitable for irrigated mid early conditions, yield 40.2 q/ha, maturity 120 days, aromatic short bold grain, moderate resistant to leaf and neck blast and sheath rot.
Rajendranagar Vari-5 (RNR 29325 (IET 29789)	Telangana	Suitable for irrigated mid early conditions, grain yield 40.2 q/ha, maturity 125 days, aromatic short bold grains, moderate resistant to BPH and leaf blast.

Variety	Area of adoption	Salient features
Luchai Selection 1 (Luchai (IET 27015)	Madhya Pradesh	Suitable for rainfed and irrigated conditions, grain yield 40.2 q/ha, maturity 145 days, aromatic short bold grains, moderate resistant to BLB and leaf blast.
Kali Kamod Selection 1 (Kali Kamod (IET 27029)	Madhya Pradesh	Suitable for rainfed and irrigated conditions, grain yield 30.0 q/ha, maturity 145 days, aromatic short grain, late duration variety medium slender grains, moderate resistant to BLB and leaf blast.
Shalimar Rice-6 (SKUA-485)	Jammu and Kashmir	Suitable for irrigated hilly conditions, grain yield 40.0 q/ha, maturity 125 days, marker assisted selection (MAS) derived variety in the background of Mushk Budji rice with introgression of *Pi54+Pi1+Pita* genes for blast resistance.
PR 130 (RYT 3797)	Punjab	Suitable for lowland irrigated ecology, grain yield 74.3 q/ha, maturity 120 days, long slender grains, moderately resistant to bacterial blight, leaf folder and stem borer.
PDKV Sadhana (SKL-3-1-41-8-33-15)	Maharashtra	Suitable for irrigated early duration conditions, grain yield 50.0 q/ha, maturity 120 days, long slender grain type, moderate resistance to leaf blast and stem borer.
PAC 837 Plus	Assam	Suitable for irrigated medium duration conditions, grain yield 54.0 q/ha, maturity 130 days, long bold grains, moderately resistant to leaf and neck blast.
Mandya Jyothi (KMP-220)	Karnataka	Suitable for irrigated and mid early conditions, grain yield 60.0 q/ha, maturity 130 days, long bold grains, moderate resistance to leaf and neck blast, and sheath rot.
Samruddhi (Mandya Source Nursery 99) (MSN 99)	Karnataka	Suitable for irrigated early duration, grain yield 60.2 q/ha, maturity 120 days, medium slender grain type, moderately resistant to neck blast, leaf folder and stem borer.
28P67 (IET 24879)	Punjab and Haryana	Suitable for irrigated condition, grain yield 70-75 q/ha, maturity 130- 135 days, moderately resistant to leaf blast and tolerant to neck blast and brown spot.
Malviya Sugandhi Dhan-156 (HUR 156- IET25419)	Uttar Pradesh and West Bengal	Suitable for irrigated condition, grain yield 49.0 q/ha, maturity 130-135 days, aromatic short slender grains, tolerant to leaf blight (LF), brown plant hopper (BPH), moderately resistant to gloom discoloration, brown spot, sheath rot and bacterial leaf blight.
CR Dhan 323 (Jyotsna) (CRAC 3994-2-1 IET 25992)	Odisha	Suitable for irrigated and shallow lowland ecosystem both in *kharif* and *rabi* seasons, grain yield 5.0-5.5 t/ha (*kharif*) and 55-60 q/ha (*rabi*), maturity 135-140 days, moderate resistant to leaf blast, neck blast, bacterial blight, grain discoloration, RTD and resistant to false smut and gal midge.
CR Dhan 324 (Abhaya Paushtik) (CRAC 3994-2-5, IET28698)	Odisha	Suitable for irrigated lands both in *kharif* and *rabi*, grain yield 45-55 q/ha, maturity 115-120 days, moderate resistance to leaf blast, neck blast, brown spot, grain discoloration and false smut, leaf folder and gal midge.
CR Dhan 326 (Panchatatva) (CR 4202-298-2-2-1, IET28491)	Odisha	Suitable for irrigated medium duration, grain yield 61.62 q/ha, maturity 132 days, resistance to bacterial blight, brown spot and sheath rot.
CR Dhan 327 (Madhumita) IET 27689 (CR 3516 -1-1-2-1-1-4)	Odisha	Suitable for early sowing, grain yield 67.5 q/ha, maturity 132 -135 days (*kharif*), 140-142 days (*rabi*) season, non-lodging, moderately resistant to leaf blast and neck blast, intermediate grain shattering.
CR Dhan 328 (IET 26420)	Odisha	Suitable for irrigated late conditions in wet season, grain yield 67.7 q/ha, maturity 140-145 days, tolerance to major diseases, highly resistance to leaf folder, stem borer.
CR Dhan-704 (Shyamdev) (CRHR-150, IET 28187)	Odisha	Suitable for both *kharif* and *rabi* in irrigated, rainfed shallow-lowland and DSR condition, grain yield 70-75 q/ha, maturity 125-130 days (*kharif*), 130-135 days (*rabi*), moderate resistance to false smut, leaf blast, neck blast, brown spot, sheath rot and glume discoloration.
CR Dhan 805 (Naveen Shakti) [IET 29203]	Odisha	Suitable for irrigated medium early situations, grain yield 48.3 q/ha, maturity 125-130 days, semi-dwarf, resistance to brown spot.
CR Dhan 806 (Varsadhan Sub I)	Odisha	Suitable for rainfed and submergence-shallow lowland and semi-deep water condition, grain yield 39.3 q/ha, maturity: 160-165 days, moderately resistant to neck blast, false smut and stem borer (dead heart) and BPH.
CR Dhan 911 (Basudev) IET 28414)	Odisha	Suitable for irrigated conditions, grain yield 45-55 q/ha, maturity 120-125 days, moderate resistance to leaf blast, brown spot, grain discoloration, leaf folder and gall midge and resistant to false smut.
Pusa Narendra KN I (Pusa 1638-07 -130-2- 67-1-I) (IET26204)	Uttar Pradesh	Suitable for irrigated conditions, grain yield 36 q/ha, maturity 145 days, medium slender grains, improved semi-dwarf version of traditional *Kalanamak*, moderately resistant to BLB and blast.

Variety	Area of adoption	Salient features
Pusa CRD KN 2 (Pusa I 638-07-171-1- 81-1-2) (IET 26213)	Uttar Pradesh	Suitable for irrigated conditions, grain yield 35 q/ha, maturity 145 days, medium slender grains, improved semi-dwarf version of traditional *Kalanamak*, moderately resistant to BLB and blast.
ADT 58 (AD 12132) (IET 291211)	Tamil Nadu	Suitable for irrigated conditions, grain yield 60.9 q/ha, maturity 125-130 days, tolerant to low temperature during reproductive stages, moderately resistant to blast, sheath rot and sheath blight, tolerance to stem borer, leaf folder and BPH.
CO 56 (CB 12132) (IET 27408 and IET 25531)	Tamil Nadu	Suitable for irrigated conditions, grain yield 63.7 q/ha, maturity 130-135 days, medium slender grains, moderately resistant to stem borer, gall midge, blast, BLB, brown spot, sheath rot, sheath blight and rice tungro disease (RTD).
OUAT Kalinga Rice 8 (Suryashree) (IET 27737)	Odisha	Suitable for irrigated medium lands, grain yield 46.2 q/ha, maturity 120-125 days, long bold grains, moderately resistant to sheath blight blast and gall midge.
OUAT Kalinga Rice 7 (Barunei) (IET 23666)	Odisha	Suitable for irrigated medium land conditions, grain yield 53.5 q/ha, maturity 135-140 days, long bold grain, moderately resistant to sheath rot blasts and BPH.
JR 21 (JR 81-01) (IET 28388)	Madhya Pradesh	Suitable for rainfed and irrigated ecology, grain yield 54.6 q/ha, maturity 128-130 days, good for processing and poha making, moderately resistant to leaf blast, leaf folder and gall midge.
OUAT Kalinga Rice I (Kolab) (IET 25295)	Odisha	Suitable for irrigated medium conditions, grain yield 53 q/ha, maturity 130-135 days, moderately resistant to leaf blast, neck blast, brown leaf spot, grain discoloration, sheath rot, BPH and gall midge.
OUAT Kalinga Rice 2 (Salandi) (IET 28444)	Odisha	Suitable for irrigated medium condition, grain yield 64 q/ha, maturity 130-135 days, moderately resistant to leaf blast, neck blast, sheath rot, bacterial blight, stem borer and leaf folder, white backed plant hopper (WBPH) and gall midge.
OUAT Kalinga Rice 5 (Nabanna) (IET 25140)	Odisha	Suitable for rainfed uplands and similar agro-ecosystems experiencing frequent droughts/dry spells, grain yield 28 q/ha, maturity 83-90 days, moderately resistant to blast, sheath rot false smut, BLB and bacterial leaf streak (BLS), tolerant to rice sheath blight.
OUAT Kalinga Rice 6 (Bhargavi) (IET 23565)	Odisha	Suitable for rainfed lowland ecosystem, grain yield 48 q/ha, maturity 150-160 days, moderately resistant to sheath rot, blasts, brown leaf spot and leaf folder.
ASD 21 (AS 15024) (IET 29799)	Tamil Nadu	Suitable for irrigated early Karl/late Pishanam season in Tamil Nadu, grain yield 63.3 q/ha, maturity 120 days (116-124 days), moderately resistant to stem borer, leaf folder, gall midge, blast, sheath blight and bacterial leaf blight.
AAU-TTB-Dhan-42 (TTB-238) (Patkai) (IET 29034)	Assam	Suitable for irrigated ecosystem, grain yield 50-55 q/ha, maturity 150-160 days, MAS derived variety (improved version of Ranjit *sub1*) having bacterial blight resistance genes *Xa5*, *Xa13* and *Xa21*, moderately resistant to sheath rot, blast, brown leaf spot and leaf folder.
AAU-TTB-Dhan-43 (TTB 1048-60- 1) (Shatabdi) (IET 29087)	Assam	Suitable for plains under irrigated conditions, grain yield 49.3 q/ha, maturity 125 days, aromatic, long slender grains, resistant/moderately resistant to BLB and stem borer.
AAU-TTB-Dhan-44 (TTB I041-204-1) (Prachur) (IET 29075)	Assam	Suitable for medium duration, *kharif* and *boro* cultivation, grain yield 49.2 q/ha, maturity 125 days, aromatic long slender grains, resistant/ moderately resistant to BLB and leaf blast.
Wheat		
PBW 872	North Western Plain Zone (NWPZ) - Punjab, Haryana, Delhi, Rajasthan (excluding Kota and Udaipur division), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu & Kashmir, Paonta Valley and Una district of Himachal Pradesh and Tarai region of Uttarakhand	Suitable for irrigated, early sown and high fertility conditions, grain yield 75.2 q/ha, maturity 152 days, biofortified wheat variety with high iron (42.3 ppm), zinc (40.7 ppm) content, good chapati quality score (8.2/10), resistant to brown rust.

Variety	Area of adoption	Salient features
PBW 833	North Eastern Plains Zone (NEPZ)-Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Assam and Plains of NE States	Suitable for irrigated, late sown condition, grain yield 42.75 q/ha, maturity 115 days, good chapati quality score (8.2/10), protein content (12.9 %), resistant to brown rust.
PBW 826	NWPZ - Punjab, Haryana, Delhi, Rajasthan (excluding Kota and Udaipur division), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh and Tarai region of Uttarakhand. NEPZ - Eastern Uttar Pradesh, Jharkhand, Odisha, West Bengal, Assam and plains of NE States	Suitable for irrigated, timely sown condition, grain yield 63.6 q/ha (NWPZ) and 49.7 q/ha (NEPZ), maturity 146 days (NWPZ), 123 days (NEPZ), tolerant to brown rust, wheat blast, resistant to yellow rust.
Pusa Ojaswi (HI 1650)	Central zone (CZ) -Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur Divisions of Rajasthan and Jhansi Division of Uttar Pradesh	Suitable for irrigated, timely sown condition, grain yield 57.2 q/ha, maturity 117 days, high zinc content (42.7 ppm), resistant to black and brown rust.
Pusa Jagrati (HI 1653)	Punjab, Haryana, Delhi, Rajasthan (Except Kota and Udaipur Division), Western Uttar Pradesh (Except Jhansi Division), Jammu and Kathua district of Jammu and Kashmir, Una district and Paonta Valley of Himachal Pradesh and Tarai region of Uttarakhand	Suitable for restricted irrigation, timely sown condition, grain yield 51.1 q/ha, maturity 149 days, high sedimentation value (57.7 ml), resistant to yellow rust, brown rust, wheat blast.
Pusa Aditi (HI 1654)	Punjab, Haryana, Delhi, Rajasthan (Except Kota and Udaipur Division), Western Uttar Pradesh (Except Jhansi Division), Jammu and Kathua district of Jammu and Kashmir, Una district and Paonta Valley of Himachal Pradesh and Tarai region of Uttarakhand	Suitable for restricted irrigation, timely sown condition, grain yield 51.8 q/ha, maturity 151 days, good biscuit spread factor (10.6), resistant to yellow rust, brown rust, wheat blast.
Pusa Harsha (HI 1655)	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur Divisions of Rajasthan and Jhansi Division of Uttar Pradesh	Suitable for restricted irrigation, timely sown condition, grain yield 38.8 q/ha, maturity 118 days, good chapati quality score (8.4/10), resistant to leaf and black rust.
Pusa Kirti (HI 8830) Durum	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur Divisions of Rajasthan and Jhansi Division of Uttar Pradesh	Suitable for restricted irrigation, timely sown condition, grain yield 40.4 q/ha, maturity 119 days, high yellow pigment content (7.4 ppm), resistant to black and brown rust.

Variety	Area of adoption	Salient features
Pusa Poshtik (HI 8826) Durum	Maharashtra, Karnataka and Plains of Tamil Nadu	Suitable for irrigated, timely sown condition, grain yield 48.8 q/ha, maturity 109 days, high yellow pigment content (7.0 ppm), good pasta acceptability (6.6), resistant to black and brown rust.
Karan Vrinda (DBW 371)	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur division) and Western Uttar Pradesh (except Jhansi division), parts of Jammu and Kashmir (Jammu and Kathua distt.) and parts of Himachal Pradesh (Una distt. and Paonta Valley) and Uttarakhand (Tarai region)	Suitable for irrigated, early sown, high fertility condition, grain yield 75.9 q/ha, maturity 150 days, biofortified wheat variety with high protein (12.2%), high iron (44.9 ppm), low phenol (2.8), resistant to brown rust.
Karan Varuna (DBW 372)	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur division) and Western Uttar Pradesh (except Jhansi division), parts of Jammu and Kashmir (Jammu and Kathua distt.) and parts of Himachal Pradesh (Una distt. and Paonta Valley) and Uttarakhand (Tarai region)	Suitable for irrigated, early sown, high fertility condition, grain yield 75.3 q/ha, maturity 151 days, biofortified wheat variety with high protein (12.2%) and high zinc (40.8 ppm), resistant to brown rust.
Karan Vaidehi (DBW 370)	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and Western Uttar Pradesh (except Jhansi division), parts of Jammu and Kashmir (Jammu and Kathua distt.) and parts of Himachal Pradesh (Una distt. and Paonta Valley) and Uttarakhand (Tarai region)	Suitable for irrigated, early sown, high fertility condition, grain yield 74.9 q/ha, maturity 151 days, good *chapati* quality score (8.3), protein content (12.0%) and resistant to brown rust.
Karan Prema (DBW 316)	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Assam and Plains of North-Eastern States	Suitable for irrigated, late sown condition, grain yield 41 q/ha, maturity 114 days, high protein content (13.2%), resistant to wheat blast.
Unnat (HD 2932) (HD 3407)	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh	Suitable for irrigated, late sown condition, grain yield 46.75 q/ha, maturity 109 days, high grain protein (12.1%), chapati score (8.1/10), developed through marker assisted back cross breeding involving (HD 2932+*Lr19 / Sr25+Lr24/Sr24+Yr10*) genes, resistant to leaf and brown rust.
Unnat (HD 2967) (HD 3406)	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu and Kashmir Una district and Paonta Valley of Himachal Pradesh and tarai region of Uttarakhand	Suitable for irrigated, timely sown condition, grain yield 54.73 q/ha, maturity 146 days, high protein content (12.25%), developed through marker assisted back cross breeding involving (HD 2967+ LrTrk/ YrTrk) genes, tolerant to yellow rust, brown rust, and Karnal bunt.

Variety	Area of adoption	Salient features
MACS SAKAS (MACS 6768)	Madhya Pradesh, Chhattisgarh, Gujarat, Rajasthan (Kota and Udaipur Division), and Western Uttar Pradesh (Jhansi Division)	Suitable for irrigated, timely sown condition, grain yield 56.6 q/ha, maturity 116 days, bio-fortified wheat variety with high protein (12.0%), high iron (41.2 ppm), high zinc (45.1 ppm), good chapati quality (8.3), resistant to black rust.
Pusa Wheat 3369 (HD 3369)	Punjab, Haryana, Delhi, Rajasthan, (except kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division), parts of Jammu and Kashmir (Kathua district), parts of Himachal Pradesh (Una district and Paonta valley) and Uttarakhand (tarai region)	Suitable for restricted irrigation, timely sown condition, grain yield 50.6 q/ha, maturity 149 days, high iron (40.6 ppm) and high sedimentation value (61.8 ml), resistant to yellow and brown rust.
Nicra Pusa Wheat 3411 (HD 3411)	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Assam and plains of NE States	Suitable for irrigated, timely sown condition, grain yield 46.75 q/ha, maturity 127 days, high protein content (12.4%), developed through marker assisted back cross breeding, drought tolerant and resistant to brown rust.
DDW55 (d) (Karan Manjari) Durum	Madhya Pradesh, Gujarat, Rajasthan and Chhattisgarh	Suitable for restricted irrigation, timely sown condition, grain yield 35.6 q/ha, maturity 116 days, high zinc (43.3 ppm), resistant to brown rust.
Macs Jejuri [(MACS 4100 (d)] Durum	Maharashtra and Karnataka	Suitable for irrigated, timely sown condition, grain yield 45.8 q/ha, maturity 103 days, yellow pigment (7.1 ppm), moderately resistant to brown rust.
VL Cookies (VL 2041)	Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Manipur and Meghalaya	Suitable for rainfed/irrigated, timely sown conditions, grain yield 29.6 q/ha (rainfed), 49.8 q/ha (irrigated), maturity 189 days, suitable for biscuit making, resistant to brown rust.
Vidhya (CG 1036)	Madhya Pradesh, Gujarat, Chhattisgarh, Kota and Udaipur division of Rajasthan and Jhansi division of Uttar Pradesh	Suitable for restricted irrigation, timely sown conditions, grain yield 39.3 q/ha, maturity 114 days, good chapati score (8.5/10), resistant to black rust.
Shalimar Wheat 3 (SKW-356)	Jammu and Kashmir	Suitable for rainfed, timely sown conditions, grain yield 34.0 q/ha, maturity 225 days, protein content (11.9%), resistant to brown rust.
Phule Anupam (NIAW 3624)	Maharashtra	Suitable for restricted irrigation condition, grain yield 30.56 q/ha, maturity 106 days, protein content 11.4%, resistant to brown rust.
Maize		
KMH 005	Punjab, Haryana, Delhi and Uttar Pradesh	Suitable for *kharif* irrigated conditions, grain yield 100 q/ha, maturity 101-110 days (late), moderately resistant to *Chilo partellus,* maydis leaf blight.
RMH 4118 (Rasi 4118)	Odisha, Jharkhand, Bihar eastern Uttar Pradesh and West Bengal	Suitable for *rabi* season irrigated conditions, grain yield 115 q/ha, maturity 156-165 days (late), moderately resistant to turcicum leaf blight, charcoal rot, *Chilo partellus, Sesamia inferens*, maydis leaf blight.
NMH 4140	Punjab, Haryana, Delhi, Uttarakhand (plain), Western Uttar Pradesh, Bihar, Jharkhand, Odisha, Eastern Uttar Pradesh and West Bengal	Suitable for *rabi* season irrigated conditions, grain yield 107 q/ha, maturity 145-155 days (medium), moderately resistant to maydis leaf blight, turcicum leaf blight, charcoal rot, common rust, fall armyworm.
NMH 4144	Bihar, Jharkhand, Odisha, Eastern Uttar Pradesh and West Bengal	Suitable for *kharif* irrigated and rainfed conditions, grain yield 73 q/ha, maturity 91-95 days (medium), moderately resistant to turcicum leaf blight, charcoal rot, *Chilo partellus* and fall armyworm.

Variety	Area of adoption	Salient features
NK 6801 (SYN 916801)	Penninsular (PZ) - Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu and Telangana. NEPZ - Bihar, Jharkhand, Odisha, West Bengal and Eastern Uttar Pradesh	Suitable for *kharif* irrigated conditions, grain yield 93 q/ha, maturity 101-110 days (late), moderately resistant to maydis leaf blight, turcicum leaf blight, charcoal rot, banded leaf, sheath blight, *Chilo partellus* and fall army worm.
KMH 8322	Punjab, Haryana, Delhi, Western Uttar Pradesh, Bihar, West Bengal, Odisha, Chhattisgarh, Jharkhand, Andhra Pradesh, Telangana, Karnataka, Maharashtra and Tamil Nadu	Suitable for *kharif* irrigated conditions, grain yield 94 q/ha, maturity 96-105 days (late), moderately resistant to sorghum downy mildew, *Chilo partellus* and field corn.
Him Palam Maize Composite 2 (L 316)	Himachal Pradesh, Jammu and Kashmir, Uttarakhand and North East Hills	Suitable for *kharif* rainfed conditions, grain yield 66 q/ha, maturity 91-95 days (medium), moderately resistant to turcicum leaf blight, bacterial stalk rot and *Chilo partellus.*
Megha Maize 1 (RCM 1-61)	Jammu and Kashmir, Himachal Pradesh, Uttarakhand (Hilly region), Northern Eastern Hill Regions (Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur and Arunachal Pradesh)	Suitable for *kharif* rainfed conditions, grain yield 54 q/ha, maturity 100-105 days (late), moderately resistant to turcicum leaf blight, bacterial leaf, fall army worm, sheath disease, fusarium stalk rot and maydis leaf blight.
Megha Maize 2 (RCM 1-76)	Jammu and Kashmir, Himachal Pradesh, Uttarakhand (Hilly region), Northern Eastern Hill Regions (Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur and Arunachal Pradesh)	Suitable for *kharif* rainfed conditions, grain yield 54 q/ha, maturity 96-105 days (late), moderately resistant to turcicum leaf blight, banded leaf, sheath and maydis leaf blight, fall army worm.
NMH 51	Assam	Suitable for *kharif* and *rabi* in irrigated conditions, grain yield 83 q/ha, maturity 91-95 days (medium), moderately resistant to charcoal rot field corn, resistant to turcicum leaf blight, sorghum downy mildew, banded leaf and sheath blight.
SJPC 1	Jammu Province of Jammu and Kashmir	Suitable for *kharif* and *rabi* in irrigated conditions, grain yield 83 q/ha, maturity 91-95 days (medium), moderately resistant to charcoal rot, turcicum leaf blight, sorghum downy mildew, banded leaf and sheath blight.
Shalimar Maize Hybrid 5 (IMH-221) (DMRH-1417)	Kashmir Valley	Suitable for *kharif* rainfed and irrigated conditions, grain yield 80 q/ha, maturity 80-85 days (early), moderately resistant to maydis leaf blight, turcicum leaf blight, charcoal rot, fusarium stalk rot, *Chilo partellus* and curvularia leaf spot.
Gujarat Dantiwada Yellow Maize Hybrid 101 (GDYMH-101) (BYMH-13-5)	North Gujarat	Suitable for *kharif* irrigated conditions, grain yield 54 q/ha, maturity 81-85 days (early), moderately resistant to maydis leaf blight and *Chilo partellus*.
Siata Mimpui (MZM 11)	Mizoram	Suitable for *kharif* irrigated conditions, grain yield 41 q/ha, maturity 96-105 days (late), moderately resistant to turcicum leaf blight, banded leaf, sheath blight and *Chilo partellus.*
Mizo Popcorn 1 (MZM 17)	Mizoram	Suitable for *kharif* irrigated conditions, grain yield 19 q/ha, maturity 101-110 days (late), popping 95%, grain colour red, moderately resistant to turcicum leaf blight, banded leaf, sheath blight and *Chilo partellus*.
Punjab Baby Corn 1 (JH 32434)	Punjab	Suitable for *kharif* irrigated conditions, grain yield 21 q/ha, maturity 81-85 days (early), baby corn, moderately resistant to maydis leaf blight.
GH-150125 (Dharma) (CAH-152SE)	Karnataka	Suitable for *kharif* irrigated conditions, grain yield 79 q/ha, maturity 96-105 days (late), moderately resistant to turcicum leaf blight, common rust.

Variety	Area of adoption	Salient features
HT 5l l0 (HT 519074)	Bihar, Jharkhand, Odisha, West Bengal, Eastem Uttar Pradesh	Suitable for *kharif* irrigated conditions, grain yield 79.32 q/ha, maturity 110-115 days, moderately resistant to maydis leaf blight, *Chilo partellus* and fall army worm.
Pusa Jawahar Hybrid Maize-2 (AH-4271)	Madhya Pradesh	Suitable for *kharif* irrigated conditions, medium to heavy soil under rainfed condition, grain yield 74.35 q/ha, maturity 94 days, moderately resistant to charcoal rot and bacterial stalk rot, stem borer, resistant to polysora rust.
Jawahar Maize 1014 (HMM 1014)	Madhya Pradesh	Suitable for *kharif* rainfed and *rabi* irrigated conditions, grain yield 66.28 q/ha, maturity 94 days, resistant to turcicum leaf blight and maydis leaf blight.
COH (M) 11 (CMH 12-686)	Tamil Nadu	Suitable for growing under irrigated and rainfed ecosystem in all seasons under medium to high fertility level, grain yield 81.08 q/ha, maturity 100-110 days, moderately resistant to charcoal rot and tolerant to fall army worm.
Sorghum		
CSH 48 (SPH 1938)	Karnataka, Tamil Nadu, Telangana, Madhya Pradesh, Gujarat and Rajasthan	Suitable for *kharif* rainfed situation, yield grain 38.76 q/ha, early maturity (104 days), moderately resistance to grain molds and shoot fly, non-lodging.
CSV 50 Red (SPV 2612)	Karnataka, Telangana and Maharashtra	Suitable for *kharif* rainfed and *rabi*, grain yield 35 q/ha, fodder yield 138 q/ha, maturity is 110 days, tolerant to grain mold.
CSV 51 (SPV 2683)	Karnataka, Tamil Nadu and Telangana	Suitable for *kharif* rainfed situations, grain yield 43.20 q/ha, fodder yield 138 q/ha, maturity 110-115 days, dual-purpose variety, moderately resistant to pests and diseases.
Phule Yashomati (RSV 1910)	Maharashtra	Suitable for *rabi* rainfed shallow soils, grain yield 9.2 q/ha, fodder yield 42.6 q/ha, maturity 112-115 days, moderate tolerant to charcoal rot and shoot fly.
TRJP1 5 (SPV 2538)	Karnataka	Suitable for *rabi* rainfed area of zone 2 and 3 of Karnataka state, grain yield 14-15 q/ha, fodder yield 78 q/ha, maturity 115-120 days, moderately resistant to shoot fly and charcoal rot.
Trombay Akola Suruchi (TAKPS 5)	Maharashtra	Suitable for *rabi* rainfed area of Vidharbha region of Maharashtra state, green hurda yield 43 q/ha, green fodder yield 114 q/ha, maturity 108 days, tolerant to shoot fly.
Raj Vijay Jowar 2357 (RVJ 2357) (SPV 2357)	Madhya Pradesh	Suitable for timely sown conditions of *kharif* season, grain yield 43 q/ha and fodder yield 143 q/ha, maturity 111 days, tolerant to leaf spot, moderately tolerant to shoot fly (*Atherigona soccata*), grain mold and stem borer (*Chilo partellus*).
K 13	Tamil Nadu	Suitable for cultivation in rainfed conditions, grain yield 25.75 q/ha, maturity 95-100 days, moderately resistant to leaf blight, anthracnose, highly resistant to ergot, resistant to shoot fly, stem borer, downy mildew, grain mold and rust, tolerant to drought.
Parbhani Vasant (PVRSG 10l)	Maharashtra	Suitable for *rabi* season in rainfed medium to high fertility condition, green hurda yield of 32-35 q/ha, green fodder yield 130-132 q/ha, maturity 96 days, moderately tolerant to shoot fly, stem borer and charcoal rot.
Pearl millet		
GHB 538 (EDV:DM) (Marua Sona)	Gujarat	Suitable for dual purpose early maturity conditions, grain yield 26 q/ha, fodder yield 63 q/ha, resistant to blast, ergot, smut, brown rust, moderately resistant to insect pests, highly resistant to downy mildew, relatively tolerant to salt and drought, highly tolerant to temperature fluctuations.
PCB 166 (FBL 4)	Punjab	Suitable for dual purpose late maturity, grain yield 41.0 q/ha, green fodder yield 722 q/ha, dry matter yield 126.5 q/ha, late maturity (50% flowering after 89 days), high crude protein content (9.6%), resistant to downy mildew and moderately resistant to leaf blast.
Pearl Millet Hybrid COH 10 (TNBH 1 6l9)	Tamil Nadu	Suitable for irrigated as well as rainfed conditions, grain yield 30.13 q/ha (irrigated), 20.49 q/ha (rainfed), maturity 85-90 days, high Fe (59 ppm) and Zn (37 ppm) content, moderately resistant to shoot fly and resistant to downy mildew.
VPMH 14	Zone-3 of Karnataka	Suitable for both early/late sown conditions, grain yield 37.62 q/ha, maturity 88-90 days, high Fe (70 ppm) and Zn (45 ppm) content.
Little millet		
Kalinga Suan 18 (CLMV 2)	Odisha, Andhra Pradesh and Karnataka	Suitable for early sowing rainfed uplands during *kharif* season, grain yield 16-17 q/ha, maturity 92 days, resistant to leaf blight, brown spot, tolerant to shoot fly; non-lodging and non-shattering.

Variety	Area of adoption	Salient features
GV 4 (Ambika)	Gujarat	Suitable for rainfed *kharif* season, grain yield 32-34 q/ha, maturity 120-125 days, moderately resistant to pests and diseases, non-lodging and non-shattering.
Hagari Same 1 (HS 1) (IIMR LM-8437-17)	Karnataka	Suitable for *kharif* sowing conditions, grain yield 15-16 q/ha, maturity 90-95 days, contains high Fe (31 ppm), Zn (18 ppm) and crude fiber (9%), non-lodging.
GPUL 6	Karnataka	Suitable for *kharif* and summer seasons, grain yield 15-20 q/ha, maturity 85-90 days, moderately resistant to leaf blight, brown spot diseases.
DHLM 28-4 (Prakruti) (LMV 513)	Madhya Pradesh, Maharashtra, Tamil Nadu, Gujarat, Jharkhand, Andhra Pradesh	Suitable for rainfed during *kharif* season, grain yield 17.1 q/ha, maturity 93-96 days, resistant to grain smut, brown spot and leaf blight and tolerant to shoot fly.
JK 95 (Jawahar Kutki 95) (DLM 95)	Madhya Pradesh	Suitable for rainfed, timely sown condition, grain yield 16.2 q/ha, maturity irrigated, early sown, high fertility conditions, yield 75.2 q/ha, maturity 152 days, contains Fe (42.3 ppm), Zn (40.7 ppm) and good chapati making quality, resistant to brown rust.
Finger millet		
VL Mandua 400 (CFMV 5)	Madhya Pradesh, Karnataka, Chhattisgarh, Bihar, Jharkhand, Gujarat and Andhra Pradesh	Suitable for rainfed conditions during *kharif* season, grain yield 34.76 q/ha, maturity 100-102 days, high protein (8.5%), and calcium (399.5 mg/100g) content.
CFMV 4 (FMV 1166)	Andhra Pradesh, Maharashtra and Tamil Nadu	Suitable for *kharif* and *rabi* seasons under late sown conditions, grain yield 39 q/ha, maturity 110-115 days, moderately resistant to neck blast, brown spot, banded sheath blight, foot rot and resistant to leaf blast.
Gosthani (VR 1099)	Andhra Pradesh	Suitable for *kharif* and *rabi* seasons, grain yield 35-38 q/ha, maturity 110-115 days, contains high iron (57.9 ppm) and zinc (36.2 ppm), resistant to finger and neck blast.
SIRI (KMR 316)	Karnataka	Suitable for *kharif* and late *kharif* rainfed conditions, grain yield 30 to 35 q/ha (rainfed), 45-50 q/ha (irrigated), maturity 100-105 days, resistant to leaf, neck and finger blast, foot rot diseases, tolerant to aphids, stem borer, shoot fly, grass hopper and *Myllocerus* weevil, and moderately tolerant to ear head caterpillar.
Shreeratna (OUAT Kalinga Finger Millet I) (OEB 601)	Odisha	Suitable for *kharif* and irrigated in summer, grain yield 23.5 q/ha, maturity 117 days, contains high protein (12.9%), good *chapati* making quality, resistant to brown spot, foot rot, moderately resistant to blast disease, moderately tolerant to stem borer, aphid and grass hopper; non-lodging and non-shattering; responsive to fertilizer up to 60 kg/ha N.
Kodo millet		
Dahod Kodo 1 (CKMV 3)	Andhra Pradesh, Chhattisgarh, Jharkhand, Madhya Pradesh and Tamil Nadu	Suitable for *kharif*, rainfed condition, grain yield 30.30 q/ha (grain), 66.90 q/ha (fodder), moderately resistance to head smut, banded blight, leaf blight and brown spot; moderately tolerant to shoot fly; and non-lodging.
JK 9-I (Jawahar Kodo 9-I (DPS 9-I)	Madhya Pradesh	Suitable for rainfed, timely sown conditions, grain yield 27.4 q/ha, maturity 104 days (medium group), moderately resistant to shoot fly, resistant to head smut, tolerance to drought and shattering.
Barnyard millet		
ATL I (TNEf 3 1 7) (Kudiraivali)	Tamil Nadu	Suitable for drought prone areas and value addition with consumer preference, grain yield 21.2 q/ha, maturity 90-95 days, moderately resistant to grain smut, shoot fly, stem borer and tolerant to drought.
Proso millet		
Hagari Barugu 1 (HB 1)	Karnataka	Suitable for *kharif* season, grain yield 12-14 q/ha, maturity 65-70 days, contains high iron (55 ppm), zinc (35 ppm) and crude fiber (11%).
GPUP 28	Karnataka	Suitable for both *kharif* (June-July), rainfed and summer (January) seasons, grain yield 17-20 q/ha, maturity 80-85 days, moderately resistant to leaf blight and resistant to brown spot diseases.
ATL 2 (TNPm 238) (Pani Varagu)	Tamil Nadu	Suitable for mechanical harvesting, grain yield 21.40 q/ha, maturity 65-73 days, contains high protein (12.9%), moderately resistant to leaf blight and resistant to brown spot, moderately tolerant to shoot fly, non-lodging, uniform maturity.

Variety	Area of adoption	Salient features
Foxtail millet		
Mahanandi (SiA 3159)	Andhra Pradesh	Suitable for rainfed *kharif* and irrigated *rabi* and summer season, grain yield 31.8 q/ha, maturity 80-85 days, contains high protein (12.8 g/100 g grain), calcium (440 ppm); moderately resistant to leaf blast and downy mildew, tolerant to shoot fly.
GPUF 3	Karnataka	Suitable for *kharif* (June-July), summer (January) seasons, grain yield 15-20 q/ha, maturity 85-90 days, moderately resistant to rust and leaf blight.
Brown top millet		
Hagari Browntop-2 (HBr-2)	Karnataka	Suitable for *kharif* season, grain yield 18-20 q/ha, maturity 95-100 days, contains high Fe (70 ppm), zinc (42 ppm) and crude fiber (13%).

Oilseeds: Fifty two high yielding oilseeds varieties comprising 13 of Indian mustard, 10 of soybean, 7 of linseed, 8 of groundnut, 5 of sesame, 3 one of safflower, 2 each of sunflower and gobhi sarson and 1 each of niger and yellow sarson were released for different agro-ecological regions.

List of improved released varieties/hybrids of Oilseeds

Variety	Area of adoption	Salient features
Indian mustard		
Pusa Bold WRR2	Punjab, Haryana, Delhi, Northern Rajasthan and Uttar Pradesh	Suitable for timely sown irrigated conditions, seed yield 18.15 q/ha oil content 34.3%, maturity 148 days, resistant to white rust.
Rohini WRR2	Punjab, Haryana, Delhi, Northern Rajasthan and Uttar Pradesh	Suitable for timely sown irrigated conditions, seed yield 15.71 q/ha, oil content 42.8%, maturity 147 days (Zone-II), resistant to white rust.
Varuna WRR2	Punjab, Haryana, Delhi, Northern Rajasthan and Uttar Pradesh	Suitable for timely sown irrigated conditions, seed yield 21.07 q/ha, oil content 39.1%, maturity 144 days, resistant to white rust.
RH 1424	Jammu, Punjab, Haryana, Delhi and northern Rajasthan	Suitable for timely sown rainfed conditions, seed yield 26.13 q/ha, maturity 139 days, oil content 40.5 %, tolerant to aphid, moderately resistant to *Alternaria* leaf blight, white rust and *Sclerotinia* rot.
RH 1706 (RH (0E) 1706)	Jammu, Punjab, Haryana, Delhi and northern Rajasthan	Suitable for timely sown irrigated conditions, seed yield 26.90 q/ha, maturity 140 days, oil content 38.0%, tolerant to aphid, moderately resistant to *Alternaria* leaf blight, white rust and *Sclerotinia* rot.
Pusa Mustard 34 (LES 60)	Rajasthan (Northern and Western parts), Punjab, Haryana, Delhi, Western Uttar Pradesh Plains of Jammu and Kashmir and Himachal Pradesh	Suitable for timely sown irrigated conditions, seed yield 26.90 q/ha, maturity 147 days, oil content 38.0%, tolerant to aphid, moderately resistant to powdery mildew, downy mildew, *Alternaria* blight and *Sclerotinia* rot.
CS 61(CS 13000-3-2-2-5-2)	Uttar Pradesh	Suitable for timely sown salt affected soil conditions, seed yield 20.46 q/ha, maturity 132 days, oil content 39.0%, highly responsive to fertilizers, resistant to *Alternaria* blight and tolerant to salinity.
CS 62 (CS 15000-1-1-1-4-2)	Uttar Pradesh	Suitable for timely sown salt affected soil conditions, seed yield 19.59 q/ha, maturity 136 days, oil content 39.0%, highly responsive to fertilizers, resistant to *Alternaria* blight and tolerant to salinity.
CS 64 (CS 2005-143)	Haryana, Punjab, Rajasthan, Delhi and Uttar Pradesh, Plains of Jammu and Kashmir and Himachal Pradesh	Suitable for irrigated salt affected soils (salinity/alkalinity) conditions, seed yield 22.30 q/ha, maturity 138 days, oil content 40-41%, tolerant to white rust, downy mildew, *Sclerotinia* rot, aphids, tolerant to soil and water salinity, resistant to *Alternaria* blight.
Gujarat Mustard 8 (Anand Hema) (ANDM 14-09)	Gujarat	Suitable for timely sown irrigated condition, seed yield 27.91 q/ha, maturity 94 days, oil content 38.4%, crude protein 26.6% and free fatty acid (0.40%), tolerant to powdery mildew and aphid.
Pant Rai 22 (PRL-2013-17)	Uttarakhand	Suitable for irrigated conditions of *rabi* season, seed yield 16.48 q/ha, maturity 130 days, oil content 38.9%, moderately resistant to *Alternaria* blight, white rust and downy mildew and immune for stag head formation.
Sampoorna (OUAT Kalinga Mustard I)	Odisha	Suitable for timely sown irrigated conditions, seed yield 13.37 q/ha, maturity 110-115 days, oil content 40.3%, moderately resistant to aphid.
Gujarat Mustard 6 (Banas Sona) (SKM 1328)	Gujarat	Suitable for timely sown irrigated conditions, seed yield 25.41 q/ha, maturity 111 days, oil content 38.9%.

Variety	Area of adoption	Salient features
Yellow sarson		
Pant Pili Sarson 2 (PYS-2016-8)	Uttarakhand	Suitable for irrigated conditions, seed yield 13.86 q/ha, maturity 109 days, oil content 45.1%, tolerant to *Alternaria* blight, resistant to white rust.
Gobhi sarson		
Shalimar Gobhi Sarson 1 (KGS-32)	Jammu and Kashmir	Suitable for timely sown condition with adequate moisture at critical growth stages like germination, flowering and seed development, seed yield 13.07 q/ha, maturity 221 days, oil content 38.5%, resistant to *Alternaria* blight.
Him Palam Sarson 2 (AKGS-19-8)	Himachal Pradesh, Punjab and Jammu and Kashmir	Suitable for irrigated, timely sown condition, seed yield 18.5 q/ha, maturity 158 days, oil content 39.5%, resistant to white rust and downey mildew.
Groundnut		
GG 40 (Gujarat Groundnut 40) (ICGV 16668)	Rajasthan, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu and Telangana	Suitable for *kharif* cultivation, pod yield 33.21 q/ha, kernel yield 21.03 q/ha, maturity 113 days, oil content 51%, high oleic acid (80.72%) and high oleic acid to linoleic acid ratio (22.67), resistant to rust, stem rot, collar rot, early leaf spot (ELS), peanut bud necrosis disease (PBND), thrips, leaf hopper, spodoptera and leaf miner.
Raj Mungfali 4 (RG 638)	Rajasthan, Uttar Pradesh, Punjab and Haryana	Suitable for *kharif* cultivation, pod yield 36.98 q/ha, kernel yield 27.81 q/ha, maturity 121 days, oil content 49%, higher shelling percent (74%), tolerant to collar rot, leaf hoppers and thrips.
Visishta (TCGS 1694)	Andhra Pradesh	Suitable for rainfed and irrigated situation during early *kharif, kharif* and *rabi* seasons, pod yield 24.89 q/ha, kernel yield 16.57 q/ha (*kharif*), pod yield 29.75 q/ha, kernel yield 20.45 q/ha (early *kharif*), pod yield 24.95 q/ha, kernel yield 16.88 q/ha (*rabi*), maturity 100-105 days (*kharif*), 105-110 days (*rabi*), oil content 50%, shelling percent 72-75%, tolerant to leaf spots and rust.
Gujarat Groundnut 37 (Sorath Gaurav) GG 37	Gujarat	Suitable for summer irrigated situation, kernel yield 23.50 q/ha, oil yield 11.48 q/ha, maturity 112 days, higher shelling percent (73%), oil content 48.86%, resistant to tikka, stem rot and collar rot and tolerant to thrips.
Gujarat Groundnut 38 (Sorath Navin)	Gujarat	Suitable for *kharif* rainfed situation, kernel yield 21.46 q/ha, oil yield 10.50 q/ha, maturity 106 days, oil content 48.91%, shelling 72.35%, resistant to tikka, rust, stem rot, collar rot and leaf defoliators.
Improved JL 24 (DBG 3)	Karnataka	Suitable for *kharif* rainfed condition, pod yield 18-22 q/ha, maturity 95-100 days, oil content 53.83%, developed through marker assisted backcross (MABC) using JL 24 as recurrent parent, resistant to late leaf spot (LLP).
Super TMV 2 (DBG 4)	Karnataka	Suitable for *kharif* rainfed condition, pod yield 17-22 q/ha, maturity 100-105 days, oil content 51.50%, developed using MABC using TMV 2 as recurrent parent, maturity100-105 days, resistant to LLP.
Groundnut VRI l0 (VG 17008)	Tamil Nadu	Suitable for irrigated and rainfed cultivation, pod yield 25.35 q/ha (*kharif*), 24.48 q/ha (*rabi)*, maturity 90-95 days (early), oil content 46-48%, shelling 70%, moderately resistance to LLP, rust, sucking pests and defoliators.
Soybean		
VL Soya 99 (VLS 99)	Uttarakhand and Himachal Pradesh	Suitable for timely sown rainfed condition of *kharif* season, seed yield 23.59 q/ha, maturity 113-121 days, oil content 20.18%, promising against frog eye leaf spot, pod blight diseases, field resistance against defoliators, aphids and white flies.
JS 21-72 (Jawahar Soybean 21-72)	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat and Vidarbha and Marathwada regions of Maharashtra	Suitable for medium to high rainfall conditions and medium to heavy soils, seed yield 21.39 q/ha, maturity 94-100 days, oil content 20%, resistant to yellow mosaic virus, charcoal rot, blights, bacterial pustules, leaf spots, stem fly, stem borers and tolerant to defoliators.
Him Palam Soya 1, Himso 1689	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat and Marathwada and Vidarbh region of Maharashtra	Suitable for rainfed conditions during *kharif* season, seed yield 20.77 q/ha, maturity 95-103 days, oil content 20.4%, moderately resistant to Rhizoctonia aerial blight (RAB), low to moderate resistance against girdle beetle and defoliators.

Variety	Area of adoption	Salient features
NRC 150	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat and Vidarbha and Marathwada regions of Maharashtra	Suitable for rainfed conditions of *kharif* season, seed yield 17.58 q/ha, maturity 90.6 days, oil content 21.05%, developed through marker assisted selection (MAS) (free from lipoxygenase-2 (LOX2)), highly resistant to Charcoal rot and yellow mosaic disease (YMD).
NRC 152	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat and Marathwada and Vidarbha regions of Maharashtra	Suitable for rainfed conditions of *kharif* season, seed yield 18.23 q/ha, maturity 89 days, oil content 21.17%, highly resistant to Charcoal rot, moderately resistant to YMD, target leaf spot (TLS), anthracnose, defoliators, stem and pod borer, insect pest complex and stem fly, free from LOX2 and Kunitz Tripsin Inhibitor (KTI).
Umiam Soybean 1 (RCS 1-9)	Meghalaya	Suitable for rainfed conditions of *kharif* season, seed yield 24.70 q/ha, maturity 96-105 days, oil content 19.4%, moderately resistant to soybean leaf rust and frog eye leaf spot.
Shalimar Soybean 2 (SKUA-WSB-101)	Jammu and Kashmir	Suitable for rainfed and irrigated conditions, seed yield 23.2 q/ha, maturity 134-140 days, oil content 19.78%, moderately resistant to white fly, pod borer and aphids, resistant to soybean mosaic virus and *Ascochyta* blight.
MAUS 725	Maharashtra	Suitable for timely sown rainfed conditions of *kharif* season, seed yield 22.07 q/ha, maturity 92-95 days, oil content 20%, resistant to bacterial pustule, moderately resistant to YMD.
Indore Soy 131 (IS 131) (NRC 131)	Madhya Pradesh	Suitable for rainfed and irrigated conditions, seed yield 14.51 q/ha, maturity 91-97 days, oil content 18%, moderately resistant to charcoal rot, pod blight, *Spodoptera litura* and resistant to stem fly, girdle beetle and defoliators.
NRC 157	Madhya Pradesh	Suitable for rainfed conditions of *kharif* season, seed yield 16.5 q/ha, maturity 94 days, oil content 18.07%, moderately resistant to target leaf spot, resistant to *Alternaria* leaf spot, bacterial pustules.
Linseed		
Varsha Alsi 2 (RLC-171)	Himachal Pradesh, Jammu and Kashmir, Punjab, Jharkhand, Uttar Pradesh, Assam, Bihar and Nagaland	Suitable for rainfed situation in *rabi* season, seed yield 11.75 q/ha, maturity 127 days, oil content 34.27%, moderately resistant to rust, wilt and budfly.
Birsa Tisi 2 (BAU 14-09)	Jharkhand	Suitable for irrigated condition, seed yield 13.83 q/ha, maturity 129 days, oil content 36.76%, resistant to budfly, wilt, *Alternaria* blight, powdery mildew and rust.
DLV 6 (Prabhakanth)	Karnataka	Suitable for rainfed condition, seed yield 8.00 q/ha, maturity 105 days, oil content 40.5%, moderately resistant to powdery mildew.
Sabour Tisi 4 (BRLS 121)	Uttar Pradesh (Excluding Bundelkhand), Bihar, Jharkhand, West Bengal, Assam and Nagaland	Suitable for irrigated condition, seed yield 15.23 q/ha, maturity 127 days, oil content 32.1%, resistant to wilt and powdery mildew; and moderately resistant to *Alternaria* blight.
Shuats Alsi 4 (SH 4)	Uttar Pradesh	Suitable for irrigated and timely sown condition, seed yield 10.35 q/ha, maturity 135 days, oil content 35.1%, moderately resistant to bud fly, resistant to rust and powdery mildew.
Jawahar Linseed Sagar 122 (JLS 122) (SLS 122)	Madhya Pradesh	Suitable for irrigated condition, seed yield 8.74 q/ha, maturity 116 days, oil content 39.2%, moderately resistant to wilt, budfly, tolerant to rust and powdery mildew.
Azad Pragya (LCK 1516)	Uttar Pradesh	Suitable for irrigated and timely sown condition, seed yield 13.45 q/ha, maturity 128 days, oil content 34.6%, moderately resistant to wilt, resistant to rust and powdery mildew.
Safflower		
Parbhani Suvarna (PBNS 154)	Maharashtra	Suitable for irrigated and rainfed conditions, seed yield 15.79 q/ha, maturity 124-126 days (rainfed), maturity 134-136 days (irrigated), oil content 30.9%, moderately resistant to *Fusarium* wilt, aphid, tolerant to *Alternaria* leaf spot disease.
Rajvijay Safflower 18 3 (RVSAFF 18-3)	Madhya Pradesh	Suitable for irrigated condition, seed yield 17.26 q/ha, maturity 127-132 days, oil content 33.29%, resistant to wilt.

Variety	Area of adoption	Salient features
ISH 402	Telangana, Andhra Pradesh, Maharashtra, Karnataka, Chhattisgarh and Madhya Pradesh	Suitable for rainfed and irrigated conditions; CGMS based hybrid, yield 23.25 q/ha, maturity 121-125 days (hot regions), 139-145 days (cooler regions), oil content 31.2%.
Sesame		
Jagtiala Til 1 (JCS 1020)	Telangana	Suitable for cultivation during late *kharif* and summer seasons, seed yield 10.5-11.3 q/ha (summer under irrigated) and 7.0-8.0 q/ha (late *kharif* with lifesaving irrigations), maturity 85-95 days during summer and 95-100 days during late *kharif*, oil content 46.0-49.0%, moderately resistant to powdery mildew, *Cercospora* leaf spot and phyllody.
Phule Purna (JLT 408-2) (JLS 408-2 (Summer)	Maharashtra	Suitable for summer cultivation, seed yield 7.05 q/ha, maturity 84-97 days, oil content 49.0%, FFA 0.81%, resistant to *Cercospora* leaf spot, *Alternaria* leaf spot, powdery mildew, moderately resistant to phyllody and macrophomina stem/root rot.
Gujarat Til 7 (Banas Gaurav) (SKT l50l)	Gujarat	Suitable for cultivation during *kharif* season, average seed yield 8.5-9.5 q/ha, maturity 88-94 days, oil content 49.06%, high linoleic acid (44.69%) and linolenic acid (0.32%) content, moderately resistant to powdery mildew and *Cercospora* leaf spot, resistant to leaf webber, mite and phyllody.
VRI 5 (VS 19036)	Tamil Nadu	Suitable for cultivation during *rabi* and summer seasons (both irrigated and rainfed conditions), seed yield 7.95 q/ha, maturity 75-80 days, oil content 48-52%, moderately resistant to stem and root rot, phyllody, powdery mildew and sucking pests.
Ashrit (OUAT Kalinga Sesame l)	Odisha	Suitable for irrigated condition in summer season, seed yield 8.50-9.50 q/ha, maturity 87-93 days, oil content 45.0-48.0%, moderately resistant to *Alternaria* leaf spot, phyllody, powdery mildew bold reddish brown coloured, *Macrophomina* stem/ root rot, *Cercospora* leaf spot, leaf roller, capsule borer, leaf hopper and mealy bug.
Niger		
GNNIG 4 (Kasturi) NMBP 1907	Gujarat	Suitable for *kharif* /late *kharif* season, seed yield 5.5-6.0 q/ha, maturity 109-133 days, oil content 37.7%, resistant to caterpillar, semi looper; and *Alternaria* and *Cercospora* leaf spot diseases.
Sunflower		
RSFH-700	Karnataka	Suitable for rainfed/ irrigated conditions, seed yield 16-17 q/ha, maturity 90-95 days, oil content 39%, tolerant to powdery mildew and lodging.
Sunflower COH 4 (CSH 15020)	Tamil Nadu	Suitable for rainfed/irrigated condition, seed yield 21.82 q/ha (*kharif*), *rabi* 18.98 q/ha, maturity 90-95 days, oil content 41%, moderately resistant to powdery mildew, *Alternaria*, sucking pest and leaf feeders.

Pulses: Fifty-nine high-yielding varieties of pulses comprising 15 of urdbean, 13 of chickpea, 8 of mungbean, 6 each of pigeonpea and fieldpea, 4 each of cowpea and lentil, 02 of rajmash and one of clusterbean were released for different agro-ecological regions.

List of improved released varieties/hybrids of Pulses

Variety	Area of adoption	Salient features
Chickpea		
Nandyal Gram 776 (NBeG 776)	Andhra Pradesh	Suitable for rainfed timely sown condition, average seed yield 15.4 q/ha, maturity 90-105 days, resistant to *Fusarium* wilt, amenable to mechanical harvesting.
Kanchan (IPCK 2009-145)	Uttar Pradesh	Suitable for irrigated condition, seed yield 12.49 q/ha, maturity 135 days, moderately resistant to wilt.
Kuber (IPC 2010-142) (Desi Chickpea)	Uttar Pradesh	Suitable for irrigated and timely sown condition, seed yield 16.09 q/ha, maturity 136-139 days, resistant to *Fusarium* wilt.
Shalimar Chickpea 2 (SKUA-WCKP-101/RVSSG68)	Jammu and Kashmir	Suitable for rainfed as well as irrigated conditions, seed yield 15.5 q/ha, maturity 99 days, stay green type with protein content 27%.
Gujarat Kabuli Gram 1 (Sorath Kabuli 1) GJGK 1617	Gujarat	Suitable for irrigated condition, seed yield 13.83 q/ha, maturity 144 days, protein content 18%, moderately resistant to wilt.
L 558 (GLK 17301)	Punjab, Haryana, North Rajasthan and plains of Uttarakhand	Suitable for irrigated condition, seed yield 13.86 q/ha, maturity 146 days, owl head shaped seeds.

Variety	Area of adoption	Salient features
Pusa JG 16 (BGM 10221 (DTIL)	Madhya Pradesh, Maharashtra, Gujarat, Chhattisgarh, Southern Rajasthan, and Bundelkhand region of Uttar Pradesh	Suitable for timely sown rainfed condition, seed yield 13.51 q/ha, maturity 111 days, resistant to *Fusarium* wilt, marker assisted backcross breeding (MABB) derived drought tolerant variety with 'QTL *hotspot'* from ICC 4958.
Kota Kabuli Chana 4 (RKGK 13-416)	Andhra Pradesh, Telangana and Kamataka	Suitable for timely sown conditions, seed yield 16.59 q/ha, maturity 98 days, protein 20.08%, moderately resistant to wilt and dry root rot.
ADVTKA (NC 7)	Gujarat, Maharashtra and Madhya Pradesh	Suitable for timely sown and rainfed conditions during *Rabi*, seed yield 16.18 q/ha, maturity 107 days, protein 22.7%, marker-assisted backcross breeding (MABB) derived introgression line of JG 16, resistant to *Fusarium* wilt and tolerant to drought.
GNG 2461	Punjab, Haryana, Delhi North Rajasthan western Uttar Pradesh, Plains of Uttarakhand and Jammu and Kashmir	Suitable for rainfed condition, seed yield 21.40 q/ha, maturity 140 days, moderately resistance to wilt, *Ascochyta* blight, collar rot, dry root rot, Botrytis Gray Mold and stunt.
JG l8 (Jawahar Gram 2019-155-118)	Madhya Pradesh	Suitable for timely as well as late sown conditions, seed yield 21.0 q/ha, maturity 110 days, protein 18.0-19.0%, resistant to multiple diseases, good parching quality.
JG 52 (Jawahar Gram 2018-52)	Madhya Pradesh	Suitable for rainfed timely sown condition, seed yield 23.0 q/ha, maturity 110 days, protein 18-20 %, multiple disease resistant.
Pusa Chickpea Vijay (BGM 10217)	Uttar Pradesh	Suitable for irrigated timely sown condition, seed yield 18.52 q/ha, maturity 128 days, protein 21.2%, resistant to *Fusarium* wilt.
Pigeonpea		
Gujarat Tur 107 (GT 107: Banas Abhay) (SKNP 1608)	Gujarat	Suitable for rainfed/irrigated condition, seed yield 18.50 q/ha, maturity 160-165 days, resistant to wilt disease.
Gujarat Tur 108 (GT 108: Banas Ujjwal) (SKNP 1614)	Gujarat	Suitable for rain fed/irrigated conditions, seed yield 24.0 q/ha, maturity 170-180 days, resistant to sterility mosaic disease.
Phule Kaveri (Phule Tur 11-4)	Tamil Nadu, Karnataka, Andhra Pradesh, Telangana and Odisha	Suitable for rainfed/irrigated conditions, seed yield 16.0 q/ha, maturity 160-165 days, moderately resistant to sterility mosaic and wilt diseases.
Phule Trupti (Phule Tur 10-1)	Maharashtra, Gujarat, Madhya Pradesh and Chhattisgarh	Suitable for rainfed/irrigated conditions, seed yield 22.0 q/ha, maturity 165-175 days, tolerant to pod borer and pod fly, moderately resistant to wilt and sterility mosaic diseases.
Renuka (BDN 2013-2)	Maharashtra, Gujarat, Madhya Pradesh, Rajasthan and Chhattisgarh	Suitable for rainfed/irrigated conditions, seed yield 20.0 q/ha, maturity 165-170 days, moderately resistant to wilt and sterility mosaic diseases.
PDKV Ashlesha (AKTM 1637)	Maharashtra, Madhya Pradesh, Gujarat and Chhattisgarh	Suitable for rainfed/irrigated conditions, seed yield 19.5 q/ha, maturity 175-180 days, moderately resistant to wilt and sterility mosaic diseases.
Cowpea (Grain)		
GC 7 (Banas Tejas) GC 1501	Gujarat	Suitable for *kharif* season, seed yield 10.11 q/ha, maturity 65-70 days, protein 21.18%, tolerant to root rot, yellow mosaic virus, *Cercospora* leaf spot diseases, white fly and resistant to powdery mildew.
Phule Sonali	Maharashtra	Suitable for multiple cropping system in rainfed and irrigated conditions, seed yield 13-14 q/ha, early maturity (72-75 days), resistant to dry root rot and moderately resistant to YMV, non-trailing.
Shalimar Cowpea 2 (SKUA-WCP-149)	Jammu and Kashmir	Suitable for *kharif*, seed yield 11-12 q/ha, maturity 105-110 days, resistant to cowpea mosaic virus and *Ascochyta* blight, tolerant to drought stress.
VBN 4 (VCP 14-001)	Tamil Nadu	Suitable for cultivation under both irrigated and rainfed conditions, seed yield 13.77 q/ha, seed yield (irrigated) and 10.35 q/ha (rainfed), maturity 70-75 days, protein 18.61%, fibre 5.60%, moderately resistant to *Maruca vitrata*, non-shattering pods.
Rajmash		
Shalimar Rajmash 4 (SKAU-WB- 341)	Jammu and Kashmir	Suitable for maize intercropping based farming systems with an additional feature of disease tolerance, seed yield 12-13 q/ha, maturity 85-90 days, resistant to bean common mosaic virus (BCMV).

Variety	Area of adoption	Salient features
Shalimar Rajmash 3 (SKAU-WB-1634)	Jammu and Kashmir	Suitable for maize intercropping based farming systems, seed yield 13.14 q/ha, maturity 80-85 days, tolerant to moisture stress and resistant to BCMV.
Cluster bean (Guar)		
Karan Guar 14 (RGR 18-1)	Rajasthan, Gujarat, Haryana and Maharashtra	Suitable for *kharif*, seed yield 12-13 q/ha, maturity 92-100 days, resistant to major diseases and insect pests, good gum content with high viscosity profile.
Lentil		
IPL 230	Uttar Pradesh	Suitable for irrigated and rainfed timely sown conditions, seed yield 16-17 q/ha, maturity 111-126 days, resistant to major diseases of lentil including *Fusarium* wilt and rust.
VL Masoor 150 (VL 150)	Uttarakhand	Suitable for irrigated and rainfed timely sown conditions, seed yield 14-15 q/ha, maturity 156-161 days, moderately resistant to wilt.
LL 1613	Haryana, Punjab, Northern Rajasthan, Plains of Uttarakhand, Delhi. Western Uttar Pradesh and part of Jammu and Kashmir	Suitable for irrigated and rainfed timely sown cultivations, seed yield 16-17 q/ha, maturity 115-120 days, moderately resistant to rust and wilt.
Pant Lentil l2 (PL 245)	Uttarakhand	Suitable for cultivation in hills under timely sown conditions, seed yield 77.30 q/ha, maturity 159 days in the hills of Uttarakhand, moderately resistant to pod borer, resistant to rust.
Field pea		
VL Matar 64 (VL 64)	Uttarakhand	Suitable for rainfed and irrigated conditions, seed yield 11-13 q/ha, maturity 154-165 days, moderately resistant to wilt, resistant to powdery mildew.
Shikhar (IPFD 19-1)	Bihar, Jharkhand, Assam, West Bengal and eastern Uttar Pradesh	Suitable for cultivation in rainfed and irrigated conditions, seed yield 19.17 q/ha, maturity 121 days, moderately resistant to rust, resistant to powdery mildew.
Pant Pea 462 (Pant P 462)	Jharkhand, Bihar, West Bengal, Assam, West Bengal and eastern Uttar Pradesh	Suitable for rainfed and irrigated conditions, seed yield 18.60 q/ha, maturity 120 days, protein content 24.12%, moderately resistant to rust, resistant to powdery mildew.
Arpan (IPFD 19-3)	Eastern Uttar Pradesh, Bihar, Jharkhand, Assam and West Bengal	Suitable for cultivation in rainfed and irrigated conditions, seed yield 17.67 q/ha, maturity 122 days, protein content 20-22%, Fe 91.5 ppm; Zn 50.5 ppm, moderately resistant to rust, resistant to powdery mildew.
HFP 1426	Eastem Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam	Suitable for rainfed and irrigated conditions, seed yield 18.05 q/ha, maturity 120 days, protein 23.35%, resistant to powdery mildew and moderately resistant to rust.
AAU SPC 101 (AAU SHN Motor 0l) (Xeuti)	Assam	Suitable for rainfed condition relay cropping with rice, seed yield 15.0 q/ha, maturity 105 days, resistant to powdery mildew and tolerant to rust.
Mungbean		
Lam Pesara 574 (LGG 574)	Andhra Pradesh	Suitable for *rabi* season for both rice-fallows and upland conditions, seed yield 15-16 q/ha, maturity 65-70 days, tolerant to mungbean yellow mosaic virus (MYMV), Urdbean Leaf Crinkle Virus (ULCV), web blight and *Cercospora* leaf spot diseases.
Lam Pesara 607 (LGG 607)	Andhra Pradesh	Suitable for *kharif* and *rabi* seasons for both rice fallows and upland conditions, seed yield 15-17 q/ha, maturity 60-65 days, resistant to MYMV and tolerant to other viral diseases, ULCV and Leaf Curl Virus and fungal diseases, web blight, *Cercospora* leaf spot and powdery mildew.
TRCRM 147	Karnataka	Suitable for summer cultivation, seed yield 8.9 q/ha, maturity 63-65 days, resistant to MYMV.
Malaviya Jankranti (HUM 27)	Uttar Pradesh	Suitable for timely sown and irrigated conditions during spring season, seed yield 9.03-9.95 q/ha, maturity 68 days, protein content 28.9%, resistant to MYMV, ULCV, stem necrosis, Cercospora leaf spot, powdery mildew and tolerant to prevalent insect pests of mungbean.
VBN 6 (VGG 15-030)	Tamil Nadu	Suitable for rice fallow cultivation, seed yield 7.60 q/ha, maturity 70-75 days (early maturity 65-70 days), protein content 20.63%, moderately resistant to MYMV, powdery mildew and ULKV diseases, non-shattering pods.

Variety	Area of adoption	Salient features
OUAT Greengram (Shreejan) (OBGG 58)	Odisha	Suitable for *kharif* season, seed yield 9.30 q/ha, maturity 68-70 days, rich in protein and minerals (protein 21.4%, Zn 33.0 mg, Fe 215.8 mg, Cu 11.8 mg, Mn 15.8 mg), moderately resistant to web blight, *Anthracnose*, root rot, powdery mildew and *Macrophomina* blight.
Co-9 (COGG 13-19)	Tamil Nadu (except Kanyakumari and Nilgiris Distt.)	Suitable for rainfed cultivation, seed yield 16.75 q/ha, duration 65-70 days, moderately resistant to major pests, MYMV, yellow mosaic disease.
SGC 20 (AAU SHN Mung 02) (Buroi)	Assam	Suitable for timely sown *kharif* under rainfed conditions, seed yield 13.14 q/ha, maturity 65-68 days, moderately resistant to pod borer, aphids, leaf roller and stored insect pests.
Urdbean		
Mash 1190 (SUG 1190)	Punjab, Haryana, Uttar Pradesh and Uttarakhand	Suitable for summer season, seed yield 13.14 q/ha, maturity 70-82 days, resistant to MYMV, *Cercospora* leaf spot and powdery mildew.
Lam Minumu 884 (LBG 884)	Andhra Pradesh	Suitable for *kharif*, *rabi* (uplands) and rice fallows, seed yield 10.11 q/ha, maturity 80-85 days, resistant to MYMV.
Madhira Minumu 01 (MBG 1070)	Telangana	Suitable for *kharif, rabi* and summer seasons, seed yield 14-15 q/ha, maturity 75-80 days, resistant to ULCV, leaf curl virus, web blight, *Cercospora* leaf spot, bacterial leaf spot, anthracnose, MYMV, moderately resistant to *Alternaria* leaf spot.
BDU 12	Karnataka	Suitable for *kharif* season, seed yield 10.12 q/ha, maturity 72-78 days, moderately resistant to powdery mildew.
DBG 16 (DBGV 16)	Karnataka	Suitable for *kharif* season, seed yield 10.12 q/ha, maturity 80-85 days, moderately resistant to powdery mildew and leaf crinkle virus.
TRCRU 22	Karnataka	Suitable for summer season, seed yield 8.9 q/ha, maturity 73-77 days, resistant to MYMV.
Phule Vasu (PU 0609-43)	Maharashtra	Suitable for *kharif* season, seed yield 13.14 q/ha, maturity 67-81 days, resistance to powdery mildew and MYMV.
Mash 883 (KUG 883)	Punjab	Suitable for *kharif* season, seed 11.12 q/ha, maturity 68-83 days, resistant to yellow mosaic disease (YMD).
Pant Urd 11 (PU 13-05)	Uttarakhand	Suitable for rainfed/irrigated conditions of *kharif* season in Uttarakhand plains, seed yield 10.57 /ha, maturity 87 days, tolerant to whitefly, thrips, resistant to MYMV, moderately resistant to ULCV and leaf curl virus.
TJU 339 (Trombay Jawahar Urd 339)	Madhya Pradesh	Suitable under *kharif* and summer season cultivation, seed yield 14.18 q/ha, maturity 65-70 days (medium), nutri-rich with high grain protein (25.58%) and Fe (104.60 mg/kg), resistant to MYMV, leaf curl virus, *Cercospora* leaf spot, *Anthracnose* and powdery mildew.
TJU 130 (Trombay Jawahar Urd 130)	Madhya Pradesh	Suitable for spring/summer season cultivation, seed yield 14.18 q/ha, maturity 60-65 days (early), nutri-rich with high protein (24.93%), resistant to MYMV, *Anthracnose*, powdery mildew, having capability of saving one or two irrigations (water restricted condition).
Dristi (IPU 17-2)	Madhya Pradesh	Suitable for normal sown condition, seed yield 6.92-13.69 q/ha, maturity 73 days (early), highly resistant to MYMV, resistant to ULCV, leaf curl virus, web blight, bacterial leaf blight, powdery mildew, *Cercospora* leaf spots, white fly, pod borer and pod bug.
Narmada (IPU 19-10)	Madhya Pradesh	Suitable for normal sown rainfed condition, seed yield 8.02-21.30 q/ha, maturity 74 days (early), highly resistant to MYMV and resistant to ULCV, leaf curl virus, web blight, bacterial leaf blight, powdery mildew, *Cercospora* leaf spots, white fly, pod borer and pod bug.
SBC 47 (AAU SHN Urd 02) (Pabhoi)	Assam	Suitable for timely sown during *kharif* season under rainfed condition, seed yield 14.16 q/ha, maturity 75-80 days, protein 25.20%, moderately resistant to pod borer, aphids, leaf rollers and stored insect pests.
Blackgram ADT 7 (AD) (TR) BG 14003	Tamil Nadu	Suitable for rice fallow condition of Cauvery Delta Zone of Tamil Nadu, seed yield 7.24 q/ha, maturity 65-70 days, moderately resistant to MYMV and powdery mildew diseases, tolerant to sodicity.

Commercial crops: Twenty-nine high-yielding varieties/ hybrids of commercial crops including 13 of cotton, 11 of sugarcane, 2 of jute and 1 each of sunnhemp, mesta (Roselle) and mesta (Kenaf) were released for different agro-ecological regions.

List of improved released varieties/hybrids of commercial crops

Variety	Area of adoption	Salient features
Cotton		
Nandyal Cotton 25 (NDLH 2035-5)	Maharashtra, Madhya Pradesh, Odisha, South Rajasthan and Gujarat, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, seed cotton yield 14.71 q/ha, maturity 160 days, moderately tolerant to jassids, and moderately resistant to bacterial leaf blight (BLB) and grey mildew (GM).
Phule Satpuda (JLA-1207)	Maharashtra, Madhya Pradesh, Odisha, South Rajasthan and Gujarat	Suitable for rainfed condition, seed cotton yield 14.14 q/ha, maturity 165-170 days, moderately resistant to grey mildew, resistant to jassids, and BLB.
Gujarat Cotton 46 (G.Cot-46: Sorath Swet Hem)	Maharashtra, Madhya Pradesh, Gujarat and Odisha	Suitable for the cultivation under high fertility and irrigated conditions during *kharif* season, seed cotton yield 19.0 q/ha.
CICR B Cotton 55 (CCB 51-2)	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for irrigated condition, seed cotton yield 13.17 q/ha, maturity 165-170 days, moderately resistant to rust, BLB, Alternaria leaf spot (ALS) and resistant to GM, extra long staple (ELS) variety.
Bt Cotton		
Pushpa (Hy. Cotton Daftari 2244 BG II	Maharashtra, Madhya Pradesh and Gujarat	Suitable for rainfed condition, seed cotton yield 16.19 q/ha, maturity 140-160 days, resistant to BLB and GM; and good fibre quality.
GBCH 1801 BG II	Karnataka, Andhra Pradesh, Telangana and Tamil Nadu	Suitable for rainfed and irrigated situation, seed cotton yield 18.01 q/ha, maturity 140-165 days, Bt cotton hybrid, resistant to BLB, ALS and GM.
Rocky (Hy. Cotton Daftari 3434 BG II)	Maharashtra, Madhya Pradesh and Gujarat under irrigated condition	Suitable for irrigated condition, seed cotton yield 18.11 q/ha, maturity 130-150 days, Bt cotton hybrid, resistant to BLB, ALS and Myrothecium leaf spot (MLS) and moderately resistant to GM.
SP7686 BG II	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed conditions, seed cotton yield 18.59 q/ha, maturity 160-170 days, Bt cotton hybrid, resistant to BLB, GM, rust and moderately resistant to ALS.
SP7674 BG II	Haryana, Punjab and Rajasthan	Suitable for irrigated conditions, seed cotton yield 33.19 q/ha, maturity 160-170 days, Bt cotton hybrid, resistant to BLB and moderately resistant to FFS and cotton leaf curl disease (CLCuD).
SP7679 BGII	Telangana, Karnataka, Andhra Pradesh and Tamil Nadu	Suitable for irrigated conditions, seed cotton yield 25.87 q/ha, maturity 160-170 days, Bt cotton hybrid, resistant to ALS, GM and rust.
CCH-03 BG II (CCH-333 BGII)	Telangana and Andhra Pradesh	Suitable under rainfed condition, seed cotton yield 22.43 q/ha, maturity 150-160 days, Bt cotton hybrid, resistant to BLB, GM and rust and moderately resistant to ALS.
PAU Bt 5 (PBH Bt 21)	Punjab, Haryana and Rajasthan under irrigated condition	Suitable for irrigated condition, seed cotton yield 25.72 q/ha, maturity 160-165 days, Bt cotton variety, resistant to FFS and BLB and moderately resistant to CLCuV.
ARCH 3106 BGII	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu, Madhya Pradesh, Maharashtra and Gujarat (Irrigated conditions)	Suitable for irrigated condition, seed cotton yield 25.27 q/ha, maturity 160-170 days, BG II hybrid.
Sugarcane		
Phule 11082 (CoM 11082)	Maharashtra	Suitable for growing under medium and high fertile soil under irrigated condition, commercial cane sugar (CCS) yield 12.85 t/ha, cane yield 98.91 t/ha, mature (early) in 10th month (300 days), sucrose 18.60%, least susceptible against early shoot borer, inter-node borer, scale insects, a non-lodging variety.
Co 11015 (Atulya)	Andhra Pradesh, Telangana, Kerala, Tamil Nadu, Karnataka, Gujarat, Maharashtra and Madhya Pradesh	Suitable for growing under medium and high fertile soils of under irrigated condition, CCS yield 16.22 t/ha, cane yield 108.33 t/ha, matures (early) by 8 to 10 months (300 days), sucrose 21.33%, tolerant to drought and salinity conditions, less susceptible to early shoot borer, top borer and scales, resistant to red rot.
Co 14005 (Arunima)	Tamil Nadu, Kerala, Andhra Pradesh, Telangana, Karnataka, Gujarat, Maharashtra and Madhya Pradesh	Suitable for growing under medium and high fertile soils under irrigated condition, CCS yield 16.64 t/ha, cane yield 118.33 t/ha, matures (mid-late) in 360 days, sucrose 20.18%, tolerant to waterlogging, drought and salinity conditions, less susceptible to early shoot borer, top borer and scales, resistant to moderately resistant to red rot.

Variety	Area of adoption	Salient features
Phule Sugarcane 13007 (MS 14082)	Maharashtra, Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh, Madhya Pradesh and Chhattisgarh	Suitable for growing under medium and deep fertile soil under irrigated condition and autumn and spring planting seasons, CCS yield 17.58 t/ha, cane yield 128.60 t/ha, matures (mid-late) in 360 days, sucrose 19.47%, less susceptible to woolly aphid, tolerant to water stress and drought, resistant to moderately resistant to red rot.
CO 16030 (Karan l6)	Haryana, Punjab, Rajasthan, Uttarakhand, Central and Westem Uttar Pradesh.	Suitable for growing under medium and high fertile soil under irrigated condition in autumn and spring seasons, CCS yield 11.96 t/ha, cane yield 94.97 t/ha, maturity (mid-late) in 12th month (360 days), sucrose 17.88%, tolerant to winter and salinity stress, less susceptible to early shoot borer, top borer and stalk borer, resistant to moderately resistant to red rot.
Ikshu 10 (CoLK 14201)	Punjab, Haryana, Rajasthan, Uttar Pradesh (Western & Central) and Uttarakhand	Suitable for normal irrigated/waterlogged conditions, CCS yield 11.39 t/ha, cane yield 91.34 t/ha, maturity (early) in 10 months (300 days), sucrose 18.11%, non-lodging, non-flowering, better ratooning and nutrient responsive, resistant to moderately resistant to red rot and smut, less susceptible to the main insect pests.
Ikshu 14 (CoLK 15206) (LG 07584)	Punjab, Haryana, Rajasthan, Uttar Pradesh (Western & Central) and Uttarakhand (North West Zone)	Suitable for normal irrigated/waterlogged conditions, CCS yield 11.64 t/ha, cane yield 89.81 t/ha, maturity (mid-late) in 12 months (360 days), sucrose 18.42%, non-lodging, non-flowering, better ratooning and nutrient responsive, resistant to red rot, less susceptible to major insect-pests.
Ikshu 15 (CoLK 16466)	Uttar Pradesh, Bihar and West Bengal and Assam	Suitable for waterlogged/normal irrigated conditions, CCS yield 10.19 t/ha, cane yield 85.35 t/ha, sucrose 17.31%, maturity (early) in 10th month (300 days), non-lodging, non-flowering, better ratooning and nutrient responsive, resistant to moderately resistant to red rot, less susceptible to major insect-pests.
Rajendra Ganna 5 (CoP 11438)	Uttar Pradesh, Bihar and West Bengal and Assam	Suitable for irrigated condition, CCS yield 9.46 t/ha, cane yield 78.20 t/ha, maturity (early) in 10 months (300 days), sucrose 17.37%, non-lodging, non-flowering, moderately resistant to moderately susceptible to red rot, less susceptible in reaction of major insect-pests.
Sugarcane Co 18009 (Punnakai)	Tamil Nadu	Suitable for normal recommended practices and ecological conditions, CCS yield 20.71 t/ha, cane yield 160.30 t/ha, sucrose 18.78%, maturity (mid-late) in 12 months (360 days), moderately resistant to prevalent pathotype/races of red rot.
CoA 17321	Andhra Pradesh	Suitable for assured irrigated, limited irrigated and rainfed condition for East Coast Zone, CCS yield 13.44 t/ha, cane yield 114.30 q/ha, early maturity (early) in 10 months (300 days), sucrose 16.93%, resistant to red rot, smut and tolerant to moisture stress.
Fibre crops/Jute and allied crops		
Jute		
JROBA 3 (CRIJAF Mukunda)	West Bengal, Assam, Odisha and Bihar	Suitable for mid and high land rainfed agro-ecological conditions for sowing between March (1st week) to April (2nd week) owing to pre-mature flowering resistance, fibre yield 31.84 q/ha, fibre maturity 120 days (normal sowing) and seed to seed maturity 135-150 days (if sown in last week of July to first fortnight of August), highly resistant to stem rot, root rot and tolerant to stem weevil, semilooper, Bihar hairy caterpillar and yellow mite.
Tosa jute		
ICAR-CRIJAF Jute JRCP-5 (Pankaj) (JRCP-5)	West Bengal, Odisha, Bihar, Uttar Pradesh, Tripura and Assam	Suitable for all the *capsularis* jute growing regions for March-April sowing, fibre yield 28.81 q/ha, fibre maturity 110-120 days, seed to seed maturity 110-130 days (if sown in July-August), red stem colour, resistant to stem rot, root rot, yellow mosaic diseases, tolerant to yellow mite, semilooper, can withstand waterlogging condition.
Mesta (Roselle)		
HSLC 1	Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra, Bihar, Odisha, West Bengal and North Eastern States.	Suitable for growing under mid and high land soils under rainfed sowing (July–August) conditions for exclusive production of edible fresh calyx, fresh calyx yield 42.60 q/ha, maturity 120-130 days, seed crop maturity 160-175 days, fresh calyx harvest at 10 days interval, calyces are rich in minerals like K, Ca, Mg, Na, Fe and vitamins like C, B1, B3, B5.
Mesta (Kenaf)		
JBMP 5 (Vibhav) (JRK 2016-5)	West Bengal, Bihar, Andhra Pradesh, Odisha, Maharashtra and North-Eastern States of India	Suitable for summer (April-May) sowing, fiber yield 28.91 q/ha, maturity in 125-135 days, *Hibiscus sabdariffa* mesta with coppery red stem, tolerant to YVM and foot and stem rot diseases and major insects like semilooper, mealy bug and whitefly, stronger and finer fiber suitable for production of JDPs.

Variety	Area of adoption	Salient features
Sunnhemp		
ADT I	Tamil Nadu	Suitable for irrigated and rainfed agro-ecological conditions, exclusively released as green manuring crop variety, green biomass yield 207.9 q/ha, as green manuring crop of 45–50 days, seed to seed maturity 120 days, tolerant to sunnhemp hairy caterpillar, flea beetle and spiny pod borer.

Forage and other crops: Eighteen high yielding varieties/ hybrids of forage and other crops comprising 2 of forage oats, 3 of forage pearl millet, 10 of forage sorghum and 01 each of forage cowpea, Dinanath grass and grain amaranth were released for cultivation in different agro-ecologies.

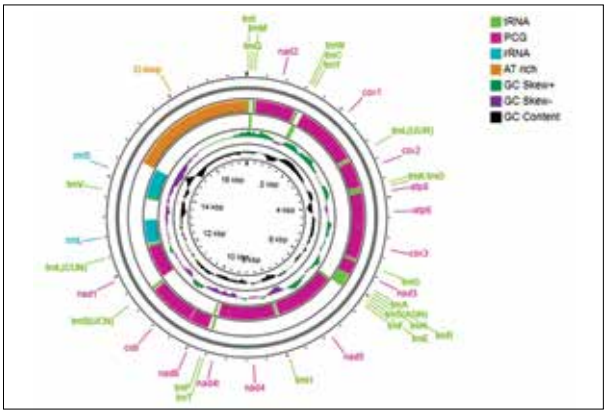
List of improved released varieties/hybrids of forage and other crops

Variety	Area of adoption	Salient features
Forage oats		
Narendra Jaypee 1101 (NDO 1101)	Uttar Pradesh	Suitable for normal and salt affected soils under irrigated condition, green fodder yield 318 q/ha, grain yield 12.2 q/ha, maturity 130-140 days, dual purpose, resistant to *Alternaria* blight, *Sclerotium* root rot and aphids.
JWGO 01 (Jawahar Wellington Grain Oats-01) (V 8)	Madhya Pradesh	Suitable for limited irrigated, timely sown condition, yield 33.73 q/ha, maturity 109 days, crude protein (16.78%), crude fibre (1.45%), crude fat (6.77%), β-glucan (4.58%), resistant to crown rust, stem rusts, powdery mildew and tolerant to moisture stress.
Forage sorghum		
SL 45 (SCL 1)	Punjab	Single-cut forage sorghum variety suitable for irrigated conditions, green fodder yield 687.8 q/ha, dry fodder yield 166.7 q/ha, resistant to red leaf spot and moderately resistant to zonate leaf spot diseases.
Haryana Jowar Hybrid 1513 (HJH 1513) (SHH 1513) (SPH 1513)	Haryana	Single-cut forage sorghum hybrid suitable for *kharif* season, green fodder yield 716 q/ha, dry fodder yield 181 q/ha, moderately tolerant to stem borer, resistant to major foliar diseases.
Haryana Jowar 1514 (HJ 1514) (SH 1514) (SPV 2951)	Haryana	Single-cut forage sorghum hybrid suitable for *kharif* season, green fodder yield 664 q/ha, dry fodder yield 160 q/ha, seed yield 8 q/ha, tolerant to shoot fly, stem borer, resistant to major foliar diseases.
CSV 53F (SPV 2705)	Gujarat, Rajasthan, Punjab, Haryana, Uttarakhand, Karnataka and Tamil Nadu	Suitable for *kharif* rainfed/irrigated conditions, dry fodder yield 152.67 q/ha, green fodder yield 482.81 q/ha, resistant to grey leaf spot, sooty stripe, moderately resistant to *Anthracnose*, leaf blight, zonate leaf spot, moderately tolerant to shoot fly.
CSV 52SS (SPV 2697)	Maharashtra, Telangana, Tamil Nadu and Punjab	Suitable for *kharif* rainfed/irrigated conditions, fresh stalk yield 470-550 q/ha, juice yield 15,244 L/ha, maturity 120-123 days, tolerant to grain molds and leaf blight.
CSV54HB (SPV 2714)	Telangana, Gujarat, Punjab and Uttarakhand	Suitable for *kharif* rainfed/irrigated conditions, fresh biomass yield 500 q/ha, dry biomass yield 250-300 q/ha, maturity 125 days, high biomass variety suitable for lingo-cellulosic biofuel production, ethanol yield (2G) 360 l/tonnes dry biomass, tolerant to leaf spot diseases.
Pant Chari l2 (UTFS 79)	Uttarakhand	Single-cut forage sorghum variety suitable for irrigated spring/summer (May-June) sowing and *kharif* (June-July) sowing in medium to high fertility soils, green fodder yield 528 q/ha and dry fodder yield 201 q/ha.
Pant Chari 13 (UTFS 83)	Uttarakhand	Single-cut forage variety suitable for rainfed *kharif* cultivation in plains of Uttarakhand in medium to high fertility soils, green fodder yield 521 q/ha and dry fodder yield 193 q/ha, tolerance to foliar diseases.
Pant Chari 14 (UTMC 545)	Uttarakhand	Multi-cut forage sorghum variety suitable for irrigated spring/summer (March-April sowing) and *kharif* (June-July) sowing in medium to high fertility soils, green fodder yield 737 q/ha and dry fodder yield 206 q/ha.
Pant Chari 15 (UTMC 559)	Uttarakhand	Multi-cut forage sorghum variety suitable for irrigated spring/summer (March-April) sowing and *kharif* (June-July) sowing in medium to high fertility soils, green fodder yield 843 q/ha and dry fodder yield 242 q/ha, better tolerance to shoot pests and foliar diseases.

Variety	Area of adoption	Salient features
Forage pearl millet		
Milkon (Dev 1)	Tamil Nadu, Telangana, Andhra Pradesh and Karnataka	Single-cut fodder suitable for *kharif* timely sown, rainfed situation, green fodder yield 421 q/ha, dry matter yield 88 q/ha, seed yield 14.3 q/ha, maturity 85-100 days (seed to seed), stay green foliage, *in vitro* dry matter digestibility 53%, resistant to moderately resistant to leaf blast and resistant to leaf defoliation.
BAIF Bajra 7	Tamil Nadu, Telangana, Andhra Pradesh and Karnataka	Single-cut fodder suitable for *kharif* timely sown rainfed condition, grain fodder yield 409 q/ha, dry matter yield 82.0 q/ha, seed yield 10.0 q/ha, moderately resistant to leaf blight, high biomass yield, *in vitro* dry matter digestibility 51%.
ADV 955 (I6ADV 0055)	Punjab. Haryana, Rajasthan, Gujarat, Chhattisgarh, Madhya Pradesh, Maharashtra, Uttar Pradesh, Tamil Nadu, Telangana, Andhra Pradesh and Karnataka	Suitable for irrigated/rainfed *kharif* and summer seasons, green fodder yield 456 q/ha, DMY 89.6 q/ha, seed yield 15.6 q/ha, maturity 90-110 days, stay green succulent fodder, resistant to leaf blast.
Forage cowpea		
IGFRI DC – 215	Karnataka	Single cut timely sown fodder suitable for *kharif* rainfed condition, green fodder yield 248 q/ha, dry matter yield 53 q/ha, maturity 85-90 days, moderately resistant to leaf rust and aphids.
Dinanath grass		
Bundel Dinanath-3 (JHD-le-4)	West Bengal, Jharkhand, Odisha, Assam, Bihar, Madhya Pradesh, Uttar Pradesh	Perennial grass suitable for *kharif* (June-July) rainfed sowing in medium to high fertility soils condition, green fodder yield 288 q/ha, dry matter yield 62 q/ha, maturity 160 days, moderately resistant to leaf spot, leaf defoliators.
Other Crop		
Grain amaranth		
Charu (KBGA 15)	Karnataka	Suitable for late *kharif* (July-August) and *rabi* (October-November) sowing in Eastern Dry Zone (Zone-V) and Southern Dry Zone (Zone-VI) of Karnataka, grain yield 16-18 q/ha under rainfed condition, 22-24 q/ha under protective irrigation, maturity 90-95 days, tolerant to leaf rust, phyllody, leaf spot and insect pests.

Other Achievements in Crop Improvement

Genome organization and comparative evolutionary mitochondriomics of rice earhead bug: The complete mitochondrial genome of rice earhead bug, *Leptocorisa oratoria* from India was sequenced for the first time. The mitogenomes of *L. oratoria* are 17,584 bp long with 73.57% AT content. The results indicated that the Coreoidea superfamily differentiated from Lygaeoidea, Aradoidea, and Pentatomoidea. Further, *L. oratoria* from the present study formed a separate subclade from previously reported *Leptocorisa* sp. This study was the first attempt to provide a reference mitogenome for *L. oratoria* that may be applied to study the population genetics, individual differences, and phylogeography of hemipterans.



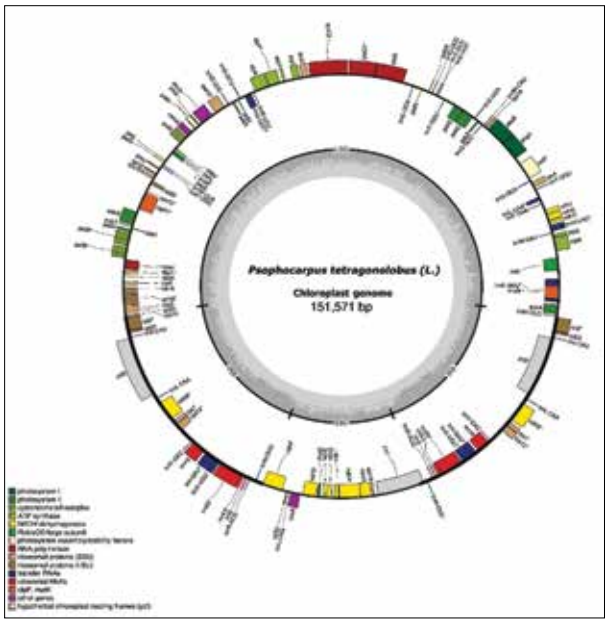
Leptocorisa oratoria mitochondrial genome map (PCGs, rRNA, tRNAs and CR) is indicated in the first outer circle. GC content and GC skew is represented in second and third circle, respectively.

Improvement of photosynthetic efficiency of rice through transgenic approaches: Maleic enzyme (ME)-transgenic lines showed reduced leaf malate content and enhanced photosynthesis performance under water deficit conditions. To evaluate the effect of C4 enzymes in rice, transgenic rice lines were developed by introducing *Setaria italica* ME [SiME] gene constructs under the control of the green tissue-specific maize PPDK promoter. Rice lines for both constructs were screened using the PCR, Southern hybridization and expression analysis. The average photosynthetic efficiency of transgenic plant lines carrying NADP-ME genes increased by 12%, and was positively correlated with the increased accumulation of photosynthetic pigment. SiME-transgenic plants displayed reduced leaf malate content and superior performance under water deficit conditions. The transgenic plants showed yield enhancement by exhibiting increased plant height, panicle length, panicle weight and thousand grain weight.

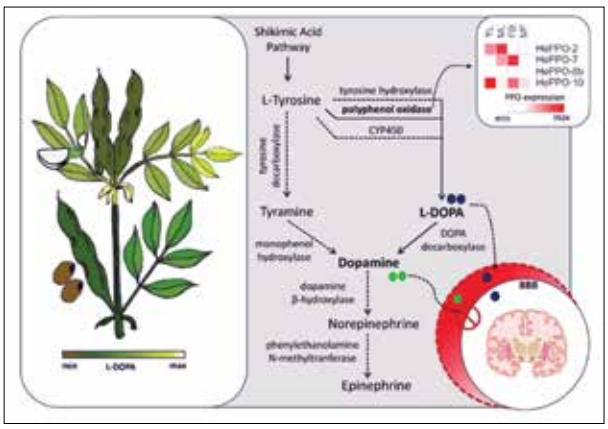
Sequencing of the whole chloroplast genome of winged bean: Winged bean (*Psophocarpus tetragonolobus*) is an underutilized legume of the phaseoloid clade of the family Fabaceae. It is diploid

(2n=2x=18) having a genome size of 710 Mb. Complete chloroplast genome of 151 kb size of winged bean was sequenced. It has a typical quadripartite structure, with the Cp genome divided into LSC and SSC of 82,736 bp and 17,777 bp in size, respectively, and a pair of IRs of 25,529 bp. The GC content of the winged bean chloroplast genome has a 35.26%, and the GC content of LSC, SSC, and IR regions was 32.63, 28.55 and 41.86 %, respectively. A total of 130 genes are found in the winged bean Cp genome; among these 85 protein-coding genes, 37 tRNA genes, and 8 rRNA genes. There are 61 protein-coding and 22 tRNA genes located in the LSC region, 12 protein-coding and 1tTRNA genes located in the SSC region, 6 protein-coding, 7 tRNA, and 4 rRNA genes located in the IRA region gene, and a similar set of genes as present in IR-A is duplicated in IRB. The *ycf2* is the largest protein-coding gene having 6,869 bp in size, while *rps2* is the protein-coding smallest gene having 68 bp in size. *trnK-UUU* is the largest tRNA gene having 2657 bp in size, while *trnC-GCA* is the smallest tRNA gene having 78bp in size. A total of 8 rRNA genes were present in the winged bean chloroplast and resided in the IR region of the Cp genome. The *rrn23* is the largest rRNA gene 2,820 bp in size and is present in both IRA and IRB regions. A total of 14 protein-coding genes, 8 tRNA genes, and 2 rRNA genes possess introns. All the intron-containing genes have a single intron and two exons except *pafI* and *clpPI* contain two intron and three exons. A trans-spliced gene *rps12* is located at three positions of the Cp genome, 1st exon is located in the LSC region, whereas 2nd and 3rd exons are located in duplicated copies in both the IRs. The phylogenic analysis of the chloroplast genome of legume species revealed that the winged bean is formed by a unique clade in the phylogeny as it may be an ancestral species in the legume. The whole Cp genome was analyzed for the identification of simple sequence repeats (SSRs) using MIcroSAtellite Identification tool (MISA). A total of 53 SSRs were predicted genome-wide. Of these, 49 are mononucleotide repeats and 3 are dinucleotide repeats. The localization study of SSRs revealed that 5 (9.61%) SSRs reside in the IR, 15 (28%) SSRs reside in the SSC and the rest of the 32 (61.54%) reside in the LSC region of the chloroplast.

Dynamics of L-DOPA accumulation in faba bean: Faba bean (*Vicia faba*) is a rich source of the anti-parkinson drug, L-3,4-dihydroxyphenylalanine (L-DOPA). The biosynthesis of L-DOPA in plants is not uniform and remains largely unexplored. While the hydroxylase activities of Tyrosine Hydroxylase (TH), the Cytochrome P450 (CYP450) class of enzymes, and Polyphenol Oxidases (PPOs) on tyrosine substrate have been reported in plants, only the roles of PPOs in L-DOPA biosynthesis have been recently established in velvet bean (*Mucuna pruriens*). To understand the differential accumulation of L-DOPA in different tissues of faba bean, profiling of L-Tyrosine, L-DOPA, Tyramine, and Dopamine in different tissues was performed. Differential accumulation of L-DOPA depended on tissue type and maturity. Furthermore, dopamine biosynthesis through L-DOPA from L-Tyr was confirmed in faba bean. The expression analysis of PPOs in leaf and flower tissues revealed the selective induction of only four (*HePPO-2*, *HePPO-7*, *HePPO-8b*, and *HePPO-10*) out of 10 genes encoding different PPOs mined from the faba bean genome. Higher accumulation of L-DOPA in young leaves and flower buds than in mature leaves and flowers was accompanied by significantly higher expression of *HePPO-10* and *HePPO-7*, respectively. The role of various transcription factors contributing to such behaviour was also predicted.



Map of *Psophocarpus tetragonolobus* plastid genome. Genes shown on the outside of the map are on the + strand, while the genes that are shown on the inside are on the complement strands. The innermost darker grey corresponds to GC content, whereas the lighter grey corresponds to AT content. LSC: large single copy region; SSC: small single copy region; and IR: inverted repeat. *Genes with introns.



A proposed regulatory pathway of L-DOPA biosynthesis in faba bean. L-tyrosine is converted to L-DOPA via tyrosine hydroxylase, polyphenol oxidase or cytochrome P450 (CYP450), which upon decarboxylation, produces dopamine. L-DOPA content in various faba bean tissues and PPO expression patterns has been denoted by colour codes. YL: young leaves, ML: mature leaves, FB: flower bud, MF: mature flower.

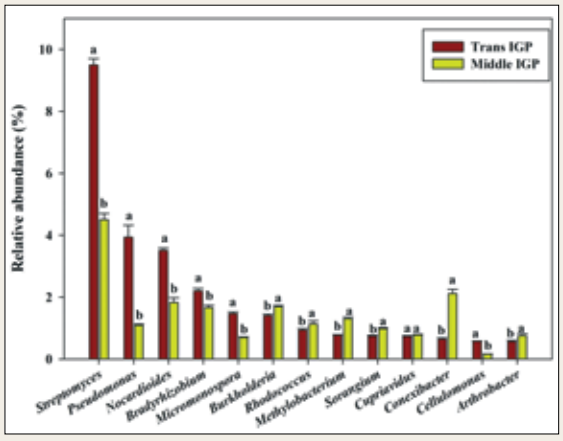
Putative role of lncRNA and microRNA in Fusarium resistance in legume: Long non-coding RNA (lncRNA) and microRNAs responsive to fusarium wilt were mined in pigeonpea and chickpea using NCBI SRA retrieved database for root transcriptome using ICP 2376 (susceptible) and ICP 8863 (resistant) genotypes, at a time point of 36 hr post inoculation in pigeonpea and KWR 108 (resistant) and GL13001 (susceptible) lines in chickpea. A total of 3,243 transcripts/genes as microRNA targets and a substantial 15,776 transcripts/genes as lncRNA targets were identified within the pigeonpea genome while 4,063 transcripts/genes were targeted by the identified micro-RNAs, and a substantial number of 13,339 transcripts/genes were targeted by the identified lncRNAs in chickpea. The combined analysis of lncRNAs, miRNAs, and their respective targets offers a comprehensive regulatory perspective on the mechanisms underlying fusarium wilt disease in pigeonpea and chickpea. The differential regulation of lncRNAs and miRNAs in response to fusarium infection in legumes could potentially elucidate the intricate interactions between host R genes and fungal effectors during the pathogenic process.

Variations in *Efl1* gene in chickpea and development of gene construct for genome editing: Chickpea productivity is affected by unpredictable climate variations leading to early completion of winter and sudden onset of terminal heat and drought stress. Early maturing chickpea varieties can align their reproductive phase with more favorable environmental conditions resulting in improved yield and overall crop performance. Early flowering locus 1, *Efl1* (homolog of *Arabidopsis EFL3*) protein is transcriptional repressor associated with circadian clock and early flowering. A deletion mutation (11 bp) leading to a truncated or non-functional protein was associated with early flowering in chickpea. Allele mining of the *ELF3* gene, associated with flowering time in chickpeas, was conducted using whole-genome resequencing data from 254 chickpea genotypes within the chickpea reference set, utilizing the GATK tool. A total of 671 genetic variants were identified within the *ELF3* genic region, encompassing not only its genic region but also its 1 kb promoter region and intergenic regions. Among these, biallelic SNPs were predominant (641), followed by multialleic InDels (19), multi-allelic SNPs (9) and least of biallelic Indels (2). Out of these 641 biallelic SNPs, 44 SNPs were located across 4 exons of *ELF3* gene [exon 2 (16), exon 5 (10), exon 1 (9) and exon 4 (9)] while exon 3 displayed no genetic variants.

The single copy *Efl1* gene (ID: 101489432; 5217 bp) is located in chromosome 5 and generates two isoforms during developmental stages in chickpea. Guide RNAs (gRNAs) were designed using CRISPOR (http://crispor.tefor.net/) and two guides (located in exon 1 and exon 2) were selected based on *in vitro* cleavage efficiency. gRNAs were cloned in binary vector p201N-Cas9 (Addgene#59175) using *InFusion* cloning (E1: Single guide and E2: Dual guide). *Agrobacterium tumefaciens* mediated genetic transformation was attempted in two long duration genotypes of chickpea (*cv.* GNG

Core rhizosphre microbiome of wheat growing in Indo-Gangetic Plains deciphered

Wheat is widely cultivated in the Indo-Gangetic plains of India and forms the major staple food. India ranks second in terms of the production of wheat with an annual production of 109.59 million tonnes. Understanding microbial community structure in wheat rhizosphere and its association with soil properties can be an important base for developing strategies for microbial formulations. Plants depend on the rhizospheric microbiome for nutrient uptake, and environmental stress alleviation. A small subset of the rhizospheric microbiome called the core microbiota constitutes a specific set of microbial communities that are consistently associated with the plant species. To identify the core microbiota of wheat rhizosphere in the IGP of India, soil samples were collected from wheat rhizosphere from 15 sites in the middle IGP and eight sites from trans-IGP. Metagenomes were isolated and a shotgun whole metagenome sequence-based approach was used to identify the microbiota in the rhizosphere. A total of 186 taxa were identified as core microbiota of wheat rhizosphere in middle IGP, and 163 taxa were identified as core microbiota in trans-IGP. A total of 65 core taxa identified were present in both middle IGP and trans-IGP soil which can be considered as true core microbiota as they are prevalent across a wide area of the study sites. Identification of core taxa can narrow down the focus on these taxa for better management of wheat cultivation in IGP. *Streptomyces*, *Pseudomonas*, *Nocardioides*, *Bradyrhizobium, Micromonospora, Burkholderia, Sorangium, Rhodococcus, Methylobacterium, Cupriavidus, Conexibacter, Cellulomonas* and *Arthrobacter,* are the top genera with relative abundance more than 0.5%, in both middle and tans IGP. β diversity analysis showed a distinct grouping pattern with respect to the sampling site under middle IGP, similarly a distinct grouping was observed with respect to the sampling and varietal differences under trans IGP. The β diversity analysis showed that microbial diversity is more affected by sampling sites and underlying soil properties as compared to the wheat varieties.



Relative abundance of the most prominent core genera.

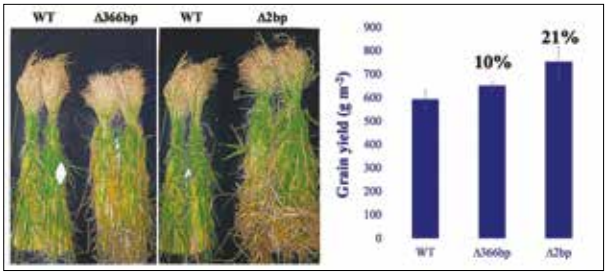
2171 and IPC 2011-112) using re-constructed vectors independently. Independent chickpea lines (*ca*. 41) were selected based on kanamycin selection and healthy green shoots were grafted onto root-stocks to establish mature fertile plants. Targeted mutation of *Efl1* gene should result in early flowering chickpea genotypes, that can avoid terminal stress and also the shorter duration chickpea genotypes for rice-fallow ecosystem.

Metabolome of *Amycolatopsis keratinophila*: Analysis of the metabolome of *Amycolatopsis keratinophila*, a rare actinomycete genus, identified several bioactive metabolites produced by the isolate in the culture supernatant having antibacterial, antifungal, anthelminthic, antitumor and antiviral properties. The isolate also produced gibberellins and siderophores with the potential for plant growth promotion.

***De novo* sequencing of genome of *Trichoderma erinaceum* (NRRI-T2):** The number of unique genes predicted by Glimmer HMM were 18,815. Tandem Repeat Finder identified 5,532 micro/mini satellite loci which is 1.53% of the genome. Protein prediction for the identified genes with Blast2GO Pro version 5.2.5 resulted in 13,877 genes (74%) and 1,219 genes were mapped to proteins of which 62 (5%) were mapped to predicted proteins and rest 95% were annotated. The maximum number of hits were mapped to *Trichoderma gamsii* (53%) followed by *Trichoderma atroviride* (25%).

Genome editing in rice: Gene editing with CRISPR-Cas9 technology was employed to developed mutants of the *Drought and Salt Tolerance* (DST) gene, a zinc finger transcription factor, in rice cultivar MTU 1010 during last year. Five different mutants were generated, and from this two SDN1 type mutants free from introduced exogenous DNA were identified. For DBT SOPs for regulatory review of genome edited plants under SDN-1 and SDN-2 categories, data were generated. Exemption of DST mutants from Rules 7-11 of Rules 1989 were obtained from IARI IBSC on 12 April 2023, and was noted in 259th RCGM on 31 May 2023. These two mutants identified produced significantly higher grain yield in Summer 2023 under transgenic field condition in irrigated environment. Two mutants of *DST* gene free from exogenous introduced DNA are being evaluated in AICRIP 2024.

Volatile organic compounds (VOCs) markers linked with rancidity in the flours of pearl millet: Twelve diverse cultivars of pearl millet (6 landraces and 6 elite cvs.) were used for the volatile estimation using GC/MS and PCA based analysis. The abundance of volatile compounds like 2-Propenal, 9, 12- Octadecadienoic acid, Hexadecanoic acid, Dodecane, Hexadecanol, etc. were observed in landraces like Chadhi Bajri, Chanana Bajra-2, Doodhasar Local, Damodhar Bajri, Jafrabadi and Garwal Ki Dhani-3. Similarly, elite cultivars like MPMH-17, PC-701, HHB-67, 86M94, Pusa-1803, and ProAgro 9001 showed abundance of Ethyl propanoate, Ethyl benzene, 9-Octadecenamide, Octadecanoic acid,

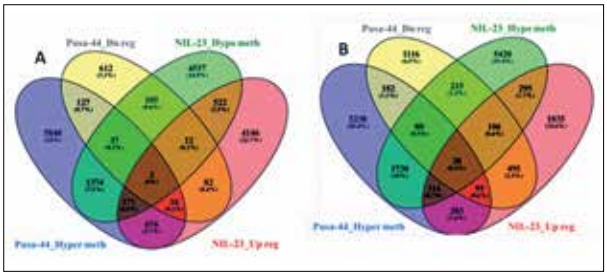


DST gene edited mutants (D366bp and D2 bp) produce significantly higher grain yield than WT MTU 1010 under irrigated conditions.

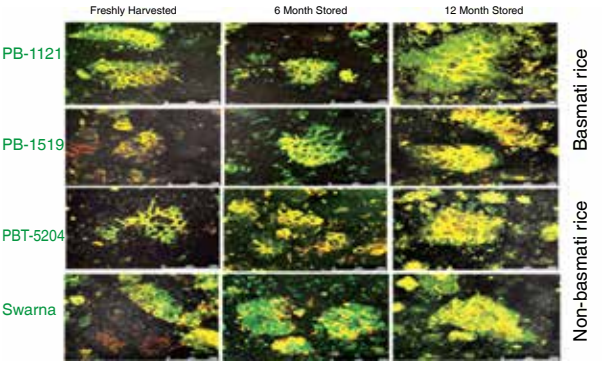
Tetradecanoic acid, 1,2-Dimethylcyclopentane, etc. in the flour. 2-Propenal, Hexadecanol, Propanoate and Octadecanoic acid are recommended as potential volatile markers for analysing the rancidity in pearl millet flour. The VOCs generated indicate the four most significant metabolic pathways, i.e. fatty acid, cutin, suberine and wax biosynthesis pathways.

Epigenomics of phosphorus use efficiency in rice: Whole methylome analysis of a pair of contrasting rice genotypes [Pusa 44 (P deficiency sensitive) and NIL 23 (P deficiency tolerant)] in different contexts indicated that CG methylation comprised the highest percentage (54%) of differentially methylated cytosine (DmCs) in both leaf and root tissues, followed by methylation at CHG (~24%) and CHG (~6%) contexts. Allocation of DmCs to genomic regions revealed ~77% of DmCs in upstream, ~6% in gene body and ~17% mapped to downstream region. Context-specific analysis of methylome data revealed a major change in methylation to occur in leaf tissue of NIL-23 in CG context with increase in methylation. In roots of the P-deficiency tolerant (NIL-23) genotype, no significant change was observed in any of the (CG, CHG, and CHH) contexts, but a decrease in methylation was observed in all three contexts in P deficiency sensitive genotype (Pusa 44).

Physico-chemical analysis of aged rice for improved quality traits: Viscosity profiling, texture analysis and matrix interaction analysis of freshly harvested Basmati (PB 1121 and PB 1509) and Non-basmati (BPT 5204 and Swarna) rice varieties were compared with one year aged (06 and 12 months stored) rice grain. Further, the confocal laser scanning microscopy (CLSM) images of the cooked rice slurry revealed that



Correlation between DNA methylation (in CHH context) and gene expression at variety level in the contrasting rice genotypes, (A) in shoot, and (B) in root. Plants were grown hydroponically with 0 ppm Pi or 16 ppm Pi for 45 days.



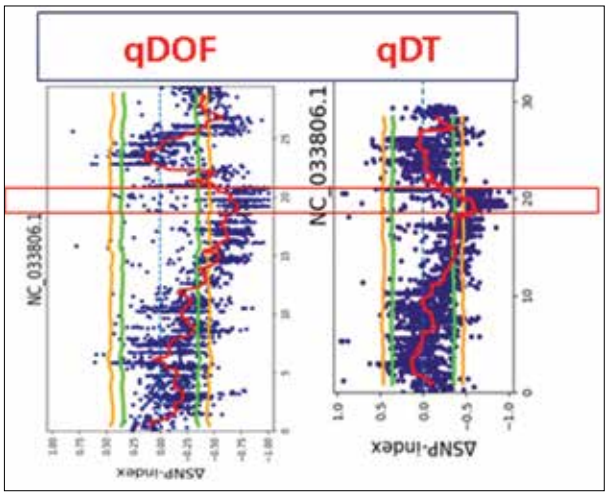
CLSM images of the cooked rice slurry stained with both FITC (green), Rhodamine B (yellow) and Nile blue (red). Starch is labelled by FITC in green, protein labelled by Rhodamine B and lipids are labelled with Nile blue dye.

matrix component interaction was more in 6 and 12 month aged samples of all the rice varieties (PB-1121, PB-1509, BPT-5204 and Swarna) as compared to freshly harvested rice. Protein and lipid interact with starch by being embedded within the internal starch matrix**.**

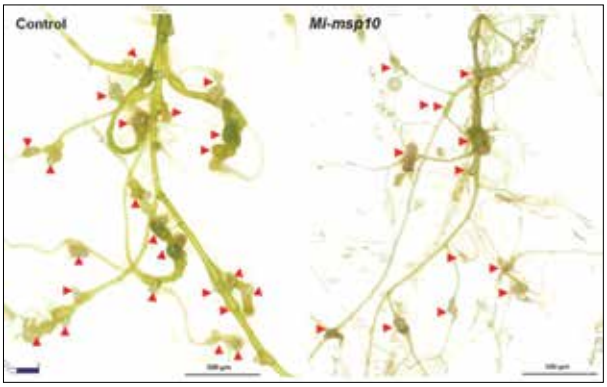
Identification of candidate genes and markers for early flowering and determinacy in pigeonpea: Pigeonpea (*Cajanus cajan*), is a highly nutritious grain legume. The duration of cultivated pigeonpea ranges from 5 to 8 months. Early flowering and determinacy are desirable traits in pigeonpea as early maturity allows crop rotation and facilitates mechanical harvesting. QTLs responsible for early flowering and determinacy traits in pigeonpea were mapped in a mapping population derived from the cross ICPL 20338 × Malvi 3. The QTL-Seq analysis of the 4 bulks for DTF (days to flowering) and DT (determinacy) led to the identification of overlapping QTL regions for both the traits on chromosome 3. The genomic region was narrowed down to 87 genes. In addition, 52 genic and high confidence SNPs/indels were identified. Parallely, 96 F_2 plants representing all flowering intervals were selected along with the parents for GBS. Reference based assembly and variant calling identified a total of 7,987 SNP markers grouped into 11 linkage groups. A total of 8 QTLs for DTF were identified with LOD cut off of 2.5. Similarly, 6 QTLs were identified for determinacy trait, which were located on six different chromosomes (chr 1, 2, 3, 7, 8 and 10). A subsequent fine mapping superimposed with transcriptome data will enable further narrowing of some of these QTLs.

RNAi-mediated silencing of the root-knot nematode effector genes, *Mi-msp10* and *Mi-msp23*: Root-knot nematodes (RKNs) are the most damaging pathogens severely affecting global food production. Two novel subventral gland and dorsal gland-specific effectors, *Mi-msp10* and *Mi-msp23*, were characterized to determine their potential effectiveness in controlling *Meloidogyne incognita* by impairing their reproductive ability. The functional evaluation of *Mi-msp10* and *Mi-msp23* dsRNA cassettes were performed using host-delivered RNAi (HD-RNAi) in *Arabidopsis*. The transgenic lines were examined against *M. incognita*, and the phenotypic effect of HD-RNAi was evident with a 61% and 51% reduction in gall formation in the *Mi-msp10* and *Mi-msp23* RNAi lines, respectively. The gene expression analysis showed a significant decrease in the transcript level by up to 72% (*Mi-msp10*) and 66% (*Mi-msp23*) in *M. incognita* females feeding on RNAi lines, providing further evidence of effective gene silencing. The findings provide a proof of concept for the development of RNAi-based strategies for controlling root-knot nematodes.

^{15}N influx-based identification and functional validation of a high-affinity nitrate transporter gene (*TaNRT2.1*-B6) of bread wheat : High-affinity nitrate transport systems of wheat can be a target for nitrate uptake mediated improvement of nitrogen-use efficiency (NUE) even under a limited supply of N-fertilizer. This will minimize the wastage of applied nitrogen (nitrate) in the wheat fields. Based on ^{15}N influx, one high-affinity nitrate transporter gene *TaNRT2.1*-B6, which is highly expressed in root tissues, was identified and functionally characterized by complementation studies in *Arabidopsis* knockout mutant of *AtNRT2.1* (*At1g080900*). *AtNRT2.1* is impaired in nitrate uptake activity under nitrate limiting condition. The complemented lines showed recovery of ^{15}N influx by 1.56 times and 1.49



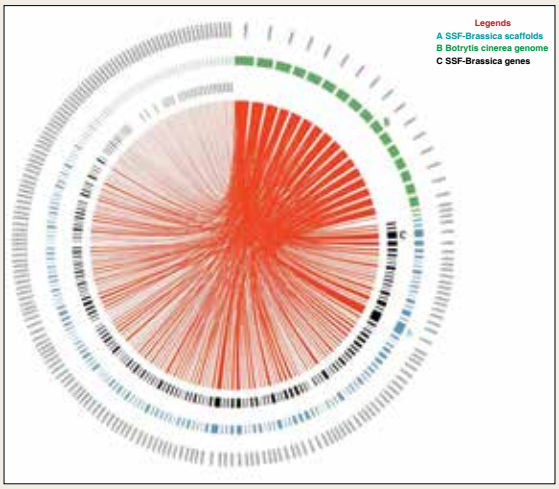
QTL Seq analysis in pigeonpea for early flowering/determinacy.



Meloidogyne incognita infection assay in roots of *Arabidopsis* control plants and RNAi lines *(Mi-msp10).* Roots of a control plant showed more galls compared to RNAi line of *Mi-msp10.* Arrowheads indicate the galls. (Kumar *et al.*, 2022).

Genome sequencing of *S. sclerotiorum*

Sclerotinia sclerotiorum commonly known as white mold causes stem rot disease and has emerged as one of the major fungal pathogens of oilseed *Brassica* across the world. For identifying the target genes and the molecular mechanism of virulence a consistently virulent isolate ESR-01 of *S. sclerotiorum* was sequenced. The filtered high-quality paired-end (PE) and mate-pair (MP) reads of 23,191,545 and 11,569,965, respectively, were *de novo* assembled into 328 scaffolds with an N50 scaffold size of ~ 447.13 kb. The assembly resulted in a total size of 40.98 Mb with an overall coverage of 129X. Total 9,469 protein-coding genes with an average length of 1,587 bp were predicted from the whole genome assembly. Functional annotation revealed that 9,412 genes had homologous sequences in NR (non-redundant protein) database, whereas the remaining 57 genes were unannotated. Further, 156 genes essential for the pathogen-host interactions were also identified and of these 30 were found to be novel effector genes. Eleven effector candidates were validated experimentally through expression profile of the ESR-01 isolate of *S. sclerotiorum*. The study led to better understanding of the *S. sclerotiorum* genome, secretome, and its effector repertoire which will help in refining the present knowledge on *S. sclerotiorum-Brassica* interactions and necrotrophic lifestyle of the phytopathogen.

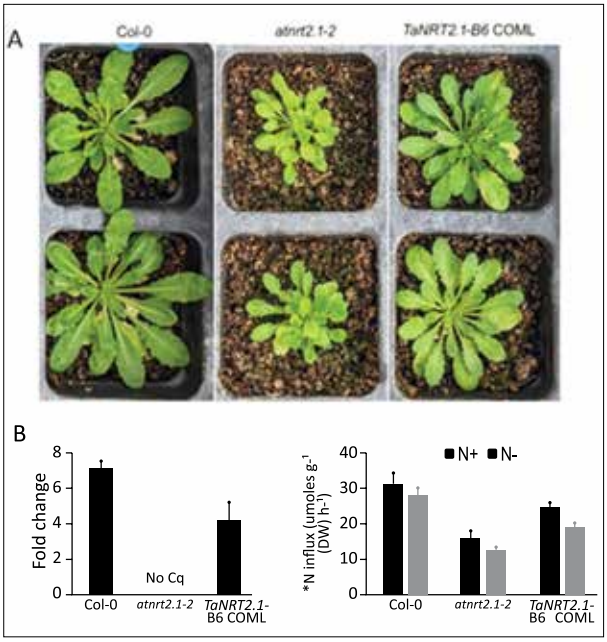


CIRCOS plot of the assembled scaffolds of *S. sclerotiorum* ESR-01 isolate against *Botrytis cinerea* displaying comparative genomic and secretory proteins features.

times in N+ and N- conditions respectively. The study provided leads for understanding the mechanism of nitrate uptake in bread wheat.

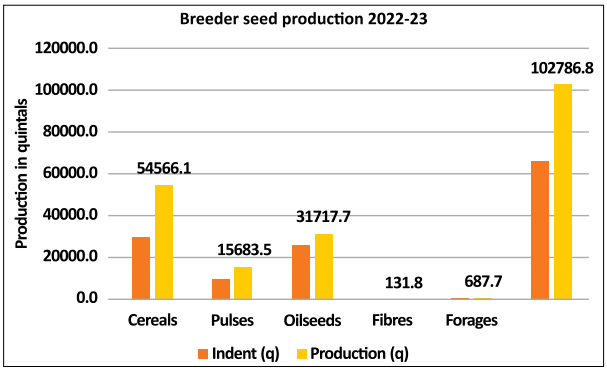
Seed production

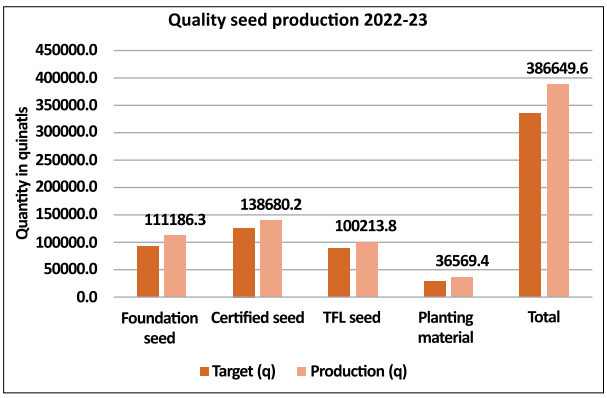
Breeder seed production: During 2022-23, total breeder seed production of more than 2,000 varieties of 58 field crops was 1,02,786.8 q against the indent of 66,091.3 q. The major share in total breeder seed production is of cereal crops, i.e. 54,566.1 q against indent of 30,022.9 q. A total of 15,683.5 q breeder seed was produced against the indent of 9,595.1 q in case of



Functional characterization of *TaNRT2.1-6B* by complementation of *atnrt2.1* mutant. (A) phenotype of wild type, mutant, and complemented lines; (B) qPCR expression and ^{15}N influx analysis of wild-type, mutant, and the complemented lines.

pulses. In case of oilseeds, total breeder seed production was 31,717.7 q against the indent of 25,760.4 q. Breeder seed produced in case of fiber crops was 131.8 q against the indent of 96.7 q; 687.7 q breeder seed was produced in forage crops against the indent of 616.3 q.





Quality seed production: During the year 2022-23, total production of quality seed including all classes was 3,86,649.6 q against the target of 3,34,507.9 q.

Production comprises 1,11,186.3 q of foundation seed, 1,38,680.2 q of certified seeds, 1,00,213.8 q of truthfully labelled seed and 36,569.4 q of planting material of field crops. In addition, 194.7 lakh planting material and 7.9 lakh tissue culture plantlets were produced against the targets of 162.8 and 3.2 lakh, respectively.

HORTICULTURE

A total of 99 improved varieties/hybrids were identified for notification by the Central Sub-committee on Crop Standards, Release and Notification of Horticultural Crops, Government of India. These varieties include four of spices, eight of potato and tropical tuber crops, 12 of fruits and plantation crops, 12 of flowers and ornamental crops and 63 of vegetable crops. Besides these, several imporoved varieties were identified during last year for release and notification for cultivation. Some of these are briefly described below.

Fruit and plantation crops

Avocado

Arka Coorg Ravi: It is a regular bearer and high yielding with moderate tolerance to scab. It has B type flowering behaviour (flowers open first in the afternoon as functionally female, close and then reopen the next morning as functionally male) with fruit weight of 450-600 g and fat content of 12 to 14%.

Custard apple

Arka Neelachal Vikram: It has been released for cultivation in Odisha. It has 14-15 kg fruits/tree productivity with low seed (20/100 g pulp) content and high keeping quality (5-6 days).

Bael

Thar Gauri: The trees have spreading growth with small spines. Fruits ripen in 320 days from fruit set in May. The yield potential of variety is 133.7 kg/tree equivalent to 272.75 q/ha (11th year) having fruit weight 1.37-1.45 kg. The pulp TSS is 42.50^{0}Brix.

Thar Bhavya: It is semi-spreading in growth having compact canopy with small spines. Fruits ripen in 280 days from fruit set in month of April. It has 97.18 kg/tree productivity equivalent to 233.23 q/ha at 7 m × 7 m spacing in 10th year of planting. The fruits weigh 0.65-0.78 kg with 32.47-34.15°Brix pulp TSS. The TSS in mucilage reaches 49.50°Brix, acidity (0.33%) and Vitamin C 21.63mg/100 g.

Tamarind

Thar Rashmi: The trees have upright growth, early, precocious, cluster bearer with curved pod and suitable for high density planting (5 m × 5 m). Fruit ripens in 290-320 days from fruit set and pods are uniform in shape. It has 107.23 kg/plant (167.27 q/ha) productivity (15-year-old tree) with 25 g fruit weight, 70.20 degree brix TSS, acidity 14%, total sugar 59.90%, Vitamin C 17.5 mg/100 g, protein 3.3 mg/100 g, calcium 177.72 mg/100 g, magnesium 44.19 mg/100 g and phosphorus 70.8 mg/100 g.

Coconut

Dweep Haritha: This coconut variety has been recommended for coconut growing tracts of Andaman and Nicobar Islands and Kerala. The palms attain height of 6.92 m in 38 years after planting. The palms are categorized as dwarf with no bole at the base. The palms are regular bearers and commence flowering in 3-4 years months after planting under rainfed conditions of Andaman and Nicobar Islands. Water quantity in tender nut ranges from 300 to 450 ml/nut. The palms are self-pollinating with intra- and inter-spadix overlapping of male and female phases. Owing to the tender nuts having more water with good taste of tender nut water and tender endosperm, nut yield, dwarfness and regular production, it is a preferred variety for plantations and home gardens.

Dweep Sona: This coconut variety recommended has been for coconut growing tracts of Andaman and Nicobar Islands and Kerala. It yields 88 nuts/palm/year under rainfed conditions of Andaman and Nicobar Islands. It contains 470 ml water in tender nut. This is regular bearer variety and commences flowering in two and a half years to four years after planting.

Kalpa Suvarna: It is dwarf, suitable for both copra and tender nut production (97 nuts/palm/year). Quantity of tender nut water is around 430 ml and very good in taste with TSS of 5.8°Brix. It is recommended for cultivation in Karnataka and Kerala.

Kalpa Vajra: It is tall, hybrid, amenable for cultivation in root (wilt) disease prevalent tracts.

Cocoa

VTLCH 1 and VTLCH 2: These two high yielding cocoa hybrids have recorded average yield of 1.5 kg dry beans/tree/year. The variety VTLCH 1 is recommended for cultivation in Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. The variety VTLCH 2 is tolerant to black pod rot, tea mosquito bug, low moisture stress and adapted to different agroclimatic conditions of Karnataka, Kerala, Andhra Pradesh and Gujarat.

Cashew

Nethra Ubhaya: It is a dual-purpose cashew variety with initial 10 years cumulative nut yield of 20.1 kg/tree and cashew apple yield of 233.3 kg/tree with shelling percentage of 34.6%. It has juice recovery 75.6%, TSS 14.93^{0}Brix, ascorbic acid 255.6 mg/100 g, acidity 0.63%, phenol 142.20 mg GAE/100 g, flavonoid 0.11 mg CE/100 g, tannin 3.43 mg TAE/100 g, antioxidant 124.23 mg AEAC/100 mg. The number of nuts per panicle is 6 to 8 with 7.66 g/nut weight. The kernels are bold with 2.44 g weight and fit in to kernel grade W 210.

Vegetable crops

Chilli

Arka Neelachal Prabha: It is a mid-season chilli variety. The fruits mature in 65-75 days. Fruits are medium long (5-6 cm), with high capsaicin content. Green fruit yield is 10-12 t/ha. Adaptable to tropical humid climatic conditions and recommended for cultivation in Odisha.

Arka Dhriti and Arka Nihira: These are suitable for dual medium and dual thick market segments, respectively. Both F1 hybrids Arka Dhriti and Arka Nihira are high yielding with 30-35 t fresh and 7.5-8 t/ha dry produce and have combined resistance to *Phytophthora* root rot and chilli leaf curl virus (ChLCV) Raichur–isolate. The fruits of Arka Dhriti are green and turn dark red (80-90 ASTA value) on maturity and pungent (80,000-90,000 SHU). In Arka Nihira, fruits are dark green and turn dark red (110-120 ASTA value) on maturity with medium pungency (35,000-40,000 SHU).

Kashi Garima: This is CMS-based hybrid for table purpose with robust plant type, attractive green fruits suitable for export and recommended for cultivation in Uttar Pradesh. The fruits are of 7-9 cm length, 0.8-1.0 cm width and thin pericarp. The yield potential of this hybrid is 20-25 t/ha green fruits in 7-8 months duration. It has field tolerance against ChiLCV disease.

Arka Dhriti F1 hybrid

Arka Nihira F1 hybrid

Faba bean

Kashi Sampada: This is recommended for cultivation in Uttar Pradesh. Plants are tall (90-100 cm) with 6-8 primary branches, 6-7 cm long pods with 1.3-1.5 cm pod width, each node having 3-4 pods with 4 ovules per pod. Pod bearing is erect with flattened seeds inside the pod. Green pods as well as seeds are rich source of L-DOPA and suitable for table purpose. The average yield of green pods is 9-10 t/ha. The bean yield is about 2 to 2.5 t/ha.

Okra

Kashi Utkarsh: This okra variety has been identified for release and notification for cultivation in Uttar Pradesh. It is resistance to both YVMV (PDI: 0.00%) and OELCV (PDI: 0.00%). Fruits are easily harvestable by single bending. Plant height of this variety ranges from 110-115 cm, flowering starts at lower node (5-6) and fruiting period is 48-120 days. Yield potential of this variety is 165-170 q/ha.

Pointed gourd

Kashi Parwal 141: This has been identified for cultivation in Uttar Pradesh. Attractive light green fruit without any white stripe tapper slightly toward both the ends with spindle shape. Harvesting starts at 85-90 days after transplanting (fruiting start from March and continue up to October end). Fruits are soft, 8-9 cm long, 2.5-3 cm thick and contain soft seeds and amenable for processing as kalaunji. Yield potential is 225-235 q/ha.

Winged bean (*Psophocarpus tetragonolobus*)

Kashi Annapurna: It has been identified and recommended for cultivation in Uttar Pradesh. It is amenable for cultivation both under rainfed and irrigated as well as high and low fertility conditions during *kharif/ rabi*. First picking starts 60-65 days after seed sowing and remains at edible stage up to 26 days after anthesis. Green pod productivity ranges from 350 to 400 q/ha.

Water spinach (*Ipomoea aquatica*)

Kashi Manu: It has been identified and recommended for cultivation in Uttar Pradesh. It is fast growing and amenable for round the year pot/wet/upland field cultivation. It has potential productivity up to 693 q/ha.

Spinachbeet or palak (*Beta vulgaris* subsp. *vulgaris*)

Kashi Baramasi: It has delayed bolting habit, high temperature tolerance (38-44 °C), faster plant growth and wide adaptability (suitable for round the year cultivation). The leaves are attractive, smooth, succulent, dark-green with entire margin. The marketable yield potential for August to November sowing is 500-900 q/ha and December to August sowing is 150-250 q/ha. Dry

matter is about 15-16% and vitamin C content is 65-75 mg/100 g fresh weight.

Radish

Kashi Rituraj: It is a CMS-based hybrid with dark green sinuate leaves and white tubers. It can tolerate high temperature (39-43 ˚C max during mid-April to mid-June), 350-675 q/ha yield potential and wide adaptability (winter, spring, summer and autumn sowing).

Brinjal

Kashi Uttam: It has high yield (50-52 t/ha) potential with round, purple, shiny fruits and soft pulp suitable for *Bharta* making. It can tolerate waterlogging for 3-4 days after 2 weeks of transplanting. Fruits are ready for first harvest in 70-75 days after transplanting. It has been identified for cultivation in Uttar Pradesh.

Tomato

Kashi Tapas: This hybrid has semi-determinate growth and amenable for summer cultivation (up to mid-June). Fruit sets at day temperature of up to 35-37°C. Fruit size: 40-50 g; 40-50 fruits/plant; yield 40-45 t/ha.

Kashi Adbhut: This hybrid has determinate growth and amenable for summer cultivation (up to third week of June). Fruit sets at day temperature of up to 35-37°C. Fruit size: 50-60 g and fruit colour (red) is retained during May-June (38 ± 2°C); TSS: 5°Brix. Potential productivity is 35-40 t/ha with fruit storability for 5-7 days at room temperature during May-June.

Amaranth

Kashi Chaulai 1: It has 40-45 cm plant height, cordate, soft and succulent leaves: 8.22 cm long and 8.06 cm wide. Leaf veins prominent, upper leaf surface greenish purple and lower light purple with purple veins. First green harvest starts at 4-5 weeks after sowing with overall 350-400 q/ha yield potential.

Watermelon

Kashi Mohini: This variety has 13°Brix TSS. Besides summer, it is amenable for cultivation during *kharif* under open condition in eastern Uttar Pradesh. It has 54-56 t/ha yield potential with early maturity (80 days after sowing).

Long melon

Kashi Vidhi: This is an early variety, harvesting starts at 45-48 DAS. Long (25-35 cm) and light green fruits are free from carpel separation. High yield potential (34-36 t/ha) in 70 to 80 days crop duration. Field tolerant to viruses and downy mildew.

Round melon

Kashi Hari: This is early variety having light green and round fruits, suitable for both *kharif* and *zaid* cultivation. High yield potential (15-16 t/ha). Fits well in intensive cropping system due to its short (70-80 days) growing period.

Bottle gourd

Kashi Shubhra: It has cylindrical, green, attractive and medium long (28-30 cm) fruits with high yield (60.31 t/ha) potential and medium maturity (first harvest at 55 DAS). It is field tolerant to anthracnose, downy mildew and leaf mosaic.

Bitter gourd

Kashi Pratistha: This has high pistillate flowers (1:23). Fruits are uniform green long (25-30 cm) with continuous ridges and less seeds (15-18 seeds/fruit). It is tolerant to anthracnose, downy mildew and leaf mosaic.

Garden pea

Kashi Purvi: It belongs to early maturity group. The plants bear 11-13 pods/plant with 110-117 q/ha yield potential. The shelling percentage is 50% with 13.9ºBrix TSS and protein content is 26.5% (dry basis).

Kashi Tripti: In this edible podded variety, first picking starts at 90-95 DAS. TSS of whole pod is 11º brix and that of fresh green seed 13.9º brix. Ascorbic acid content: 33.4 (mg/100 g). Protein content (pods): 2.44 g/100 g (FW). It is resistant to powdery mildew.

Spine gourd

Thar Varsha: Fruits are attractive green, medium round with soft spine. It attains harvestable maturity at 71-79 days after planting (1st year) and 44-50 days (after onset of monsoon from 2nd year onwards). Fruit yield varies from 1.6-2.8 kg/plant (5.5 t/ha).

Drumstick

Thar Tejas: It is dual purpose (pod and leaf) variety with 30.22 kg/plant (306.85 q/ha) yield. Pods are rich in protein (18.0 mg/100 g), phosphorus (118.62 mg/100 g), calcium (1810.29 mg/100 g), iron (35.17 mg/100 g) and zinc (13.20 mg/100 g). The leaves are rich in ascorbic acid (502.57 mg), total phenols (9780.16 mg GAE/100 g).

Indian bean or sem

Arka Pradhan: It is pole-type variety identified for cultivation in Punjab, Uttar Pradesh, and Jharkhand. This is photo insensitive variety suitable for both *kharif* and *rabi.*

Pod yield is 35 t/ha and it has field tolerance to rust and mosaic.

Thar Lakshmi: This is pole type with first harvest of fresh pods starting at 90-95 days after sowing. Total of 800-1240 pods/plant with yield of 6.5-6.7 kg/plant (45-50 t/ha) under rainfed conditions. It is rich in proteins (4.2 g/100 g), vitamin C (8.8 mg/100 g), beta carotene (11.8 mg/100 g), flavonoids (36.2 mg cat.equi/100 g) and total antioxidants (227.86 mg cat. equi/100 g).

Thar Vinaya: It is pole type with cluster bearing. Pods are long (14 cm) with pod 8.5 g weight. It takes 90-91 days for first flowering and 102-105 days after sowing for first harvest. Its productivity ranges from 1,000-1,265 fresh pods/plant (6.5-7.5 kg/plant equivalent to 50.5 t/ha. Pods are rich in nutrients such as proteins (4.2 g/100 g), Vitamin C (7.7 g/100 g), beta carotene (7.2 mg/100 g), total phenols (138.2 mg GAE/100g) and total antioxidant (158.65 mg AAE/100 g).

Yard long bean (*Vigna unguiculata* var. *sesquipedalis*)

Thar Surya: It is pole-type, anthocyanin rich (190-200 mg/100 g) variety with early maturity (35-36 days for first flowering and 44-46 days for first harvesting) of fresh tender pods. The pods have 52.5 cm length, 2.5 cm girth and 23 g pod weight. The number of pods per plant varies from 180 to 200 with 2.5 to 3 kg/plant (30.2 t/ha) productivity.

Thar Deeksha: It is an early maturing pole-type variety with attractive long and light green pods. It takes 29-30 days for first flowering and 36-38 days after sowing for first harvesting of fresh tender pods. The pods have 52 to 54 cm long, 3.3 cm thick and 28-30 g weight. It bears 150-180 pods/plant with yield of 3 kg/plant (38.15 t/ha).

Thar Prateeksha: It has attractive long light green pods with early flowering (38-40 days) and early maturing (45-48 days). Pods are 66 cm long, 3.4 cm thick and 32 g weight. It bears 120-150 pods/plant with 3 kg/plant (35.2 t/ha) productivity of fresh pods. It is moderately resistant to cowpea mosaic virus disease under field conditions.

Arka Priya: It is mid-season variety. Pods mature in 60-65 days, seeds are round, medium bold, dark green and sweet. Pod yield is 12 t/ha in 90 days. It is resistant to powdery mildew and rust. Recommended for cultivation in Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Punjab, Uttar Pradesh, Bihar, Jharkhand, Karnataka, Tamil Nadu, Goa and Kerala.

Ridge gourd

Arka Vikram: It is an early flowering hybrid for cultivation in Punjab, Uttar Pradesh, Bihar, Jharkhand, Karnataka, Tamil Nadu, Puducherry and Kerala. The fruit are green, long, tender and have excellent cooking quality. It has yield potential of 34-35 t/ha in 120-135 days duration.

Potato and tuber crops

Potato

Kufri Daksh: It is recommended for cultivation in central plains (Gujarat, Madhya Pradesh and Chhattisgarh) and eastern plains (Odisha and Uttar Pradesh). It is medium maturing (90 days), high-yielding clone (32 t/ha), moderately resistant to late blight, and has a substantial yield advantage over the check varieties. It produces creamy-white, ovoid tubers with shallow eyes and creamy flesh and has good storability under ambient storage condition.

Kufri Chipsona 5: It is a medium maturing (90-100 days), high-yielding (35 t/ha) variety recommended for cultivation in Northern, Central and Eastern plains of India (Haryana, Uttar Pradesh, Uttarakhand, Madhya Pradesh, Gujarat, Rajasthan and Chhattisgarh) for processing into chips. It has acceptable quality traits, viz. tuber dry matter 20-21%, reducing sugars (60-75 mg/100 g fresh weight) and chip colour score (3). It produces creamy-white, ovoid tubers with shallow eyes and cream flesh and has very good storability under ambient storage conditions. It is moderately resistant to late blight.

Kufri Bhaskar: It is heat tolerant with 34 t/ha tuber yield in 75 days. It produces white cream round-ovoid

Leaf, inflorescence, sprout and tubers of Kufri Chipsona 5.

tubers with shallow eyes and cream flesh. The variety is early medium to medium (85-90 days) maturing and has very good storability under ambient conditions. It has very good taste, aroma, mealy texture, excellent tubers and no tuber cracking. The new variety performed well in Uttar Pradesh, Haryana, Punjab, Uttarakhand (early crop planting) and Chhattisgarh, Gujarat, Rajasthan and Odisha (main crop planting), therefore, it has been recommended for potato production as the early crop in northern plains and as the main crop in central and plateau regions of the country.

Cassava

Sree Kaveri: It is resistant to cassava mosaic disease. The recorded average tuber yield was 51 t/ha with 27-28% starch content. It has high Drought Tolerance Index (1.54) with additional income (₹ 30,000/ha).

Spices

Black pepper

IISR Chandra: This hybrid (HP 1117 × Thommankodi) has been recommended for cultivation in Kerala. It has fresh yield potential of 7.5 kg/vine with dry recovery of 33.5%. The variety is also having good quality profile of piperine (5.10%), oleoresin (8.71%) and essential oil (3.2%).

Ginger

IISR Amrit: It has been recommended for cultivation in Kerala. It produces bold and plumpy rhizomes, high yield potential (45.75 t/ha) with light yellow core, desirable flavor, 55.54% myrcene content and 0.32% essential oil content.

Small cardamom

IISR Manushree: It is tolerant to moisture stress.

Dil

Ajmer Dill 3: It is suitable for early and mid-sowing (05 and 15 October). Seeds are dark brown and bold. The average seed yield of this variety is 22.9 q/ha under irrigated condition having 2.03% essential oil content rich in carvone content (54.8%).

Small cardamom

Ajmer Dill 3

Star anise

Ajmer Anise 2: It is medium dwarf and early maturity variety (150 days) suitable for early and mid-sowing (5 and 15 November) in arid and semi-arid regions. Seeds are dark brown and bold. The average seed yield is 9.4 q/ha under irrigated condition with 2.53% essential oil content rich in anethole.

Flowers and medicinal plants

Chrysanthemum

A total of seven varieties in chrysanthemum, viz. Arka Anirudh, Arka Dhaval, Arka Manohar, DFR C-1/DFR-Pallavi, DFR C-2/DFR Megha, DFR C-3/DFR Swarna and DFR C-4/DFR-Swarna Bindu were identified for pot culture and bedding purposes.

Arka Anirudh: This is a half-sib seed selection from the variety Lal Pari. Plants are dwarf, semi-erect growth habit with early flowering (62.77 days). Suitable for pot culture/bedding, flowers are semi-double, maroon-yellow (RHS colour: 17A, Yellow 7 Orange Group, Fan 1) having 5 to 6 rows of ray florets and resistant to white rust disease (*Puccinia horiana*).

Arka Dhaval: This is a half-sib seed selection from the variety White Prolific. Plants are dwarf, spreading growth habit with early flowering (69.17 days), suitable for pot culture/bedding, flowers are semi-double, pinkish white colour (RHS colour: 3D, Yellow Group, Fan 1) with 3 to 4 rows of ray florets.

Arka Manohar: This is a half-sib seed selection from the variety Sunil. Plants are dwarf with erect growth habit with early flowering (66.52 days), suitable for pot culture/bedding, semi-double flowers, deep pinkish-purple (RHS colour: 71B, Red-Purple Group, Fan 2) with 5 to 6 rows of ray florets.


Arka Manohar


Arka Anirudh


Arka Dhaval


DFR Pallavi


DFR Megha


DFR Swarna

DFR Pallavi: Attractive pink coloured double type flowers which can be used for loose flower, beds and border purpose. The average plant height is 83.41 cm with good spread (79.54 cm). The plant bears good number of flowers per plant (174.2). The average flower size is 6.88 cm and the field life of flower is 8.6 days.

DFR Megha: It is suitable for garden/loose flower production. The flowers are creamy, with visible disc and possess mild fragrance. The average plant height is 65.93 cm, plant spread 55.90 cm, flower diameter 6.83 cm and bears approximately 181 flowers per plant.

DFR Swarna: It is highly suitable for pot mums and appears like a ball when in full bloom. It is single Korean type and bears yellow coloured ray florets. The whole plant appears like a leafless yellow ball in peak bloom. The average plant height is 52.10 cm, plant spread 43.53 cm, flower diameter 5.80 cm and bears 166.33 flowers per plant.

DFR Swarna Bindu: It is suitable for pot culture and gardening. The plants are dwarf, spreading and appear in a dome shape during flowering. It produces yellow flower with a prominent black dot at the tip of petals. The plant gives an appearance of leaflessness during flowering.

Gladiolus

DFR Amrit: Early maturing variety producing long and robust spikes with 15-17 florets each measuring about 10.58 cm in diameter. Spikes are straight and long with good rachis length (about 50-55 cm). Florets are pale yellow with reddish spots at the base of inner tepals on background of pale yellow florets make it more attractive. Good multiplier producing about 1-2 corms and about 20-25 cormels.

DFR Soham: It is an early maturing variety producing long and robust spikes with 15-17 florets each measuring about 9.61 cm in diameter. Spikes are straight and long with good rachis length (about 45-50 cm).

validated in purple and green parents of ornamental bananas as well as their progenies. Musa R gene database could serve as the primary resource of information on R genes in bananas and their relatives. R genes from other allele mining studies are also incorporated which will


DFR Amrit


DFR Soham

Florets are pale yellow and are arranged in two rows with semi-upright position having long spike (81.97 cm), longer rachis length (47.24 cm) and more number of florets per spike (15.81). Good multiplier producing about 2-3 corms and about 20-25 cormels.

Bhringraj (*Eclipta alba*)

Arka Bhringaraj: It has biomass yield of 6 to 6.5 t/ha and wedelolactone content of 0.5 to 0.6%. It has field tolerance to downy mildew disease (*Plasmopara sphagneticolae*).

Mushroom

In mushrooms, three strains were identified. In button mushroom, strain A-63 performed best with 14.01% yield increase over control and was released for commercial cultivation. The strains of *V. volvacea*, Vv-05-19 (DMRO 1213) was released with overall average biological efficiency of 15.85 kg/100 kg of dry substrates. Based on multilocation trial, the milky mushroom strain CI-22-204 was released with overall average biological efficiency of 67.26 kg per 100 kg dry substrate.

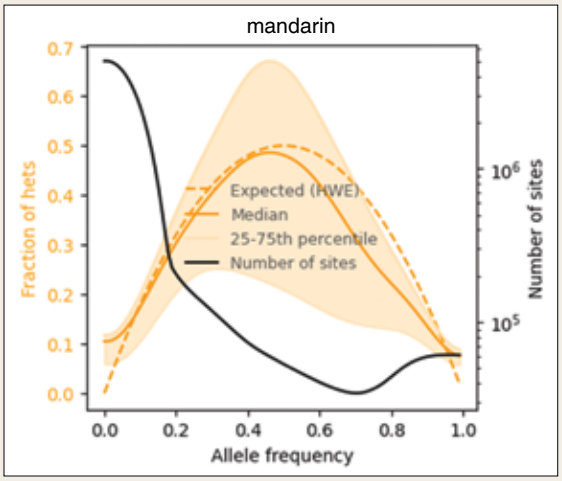

A-63 strain in fruiting.


Volvariella volvacea Vv-05-19 in fruiting.

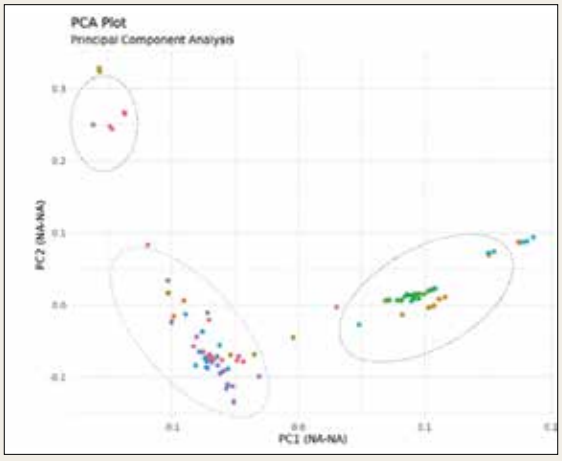

Milky mushroom strain CI-01 in fruiting.

A comprehensive study of resequenced Indian mandarin varieties and global population analysis

It was taken up in Nagpur Mandarin, Sikkim Mandarin, Khasi Mandarin, and Coorg Mandarin, employing state-of-the-art Next-Generation Sequencing (NGS) technology using *Citrus sinensis* v3.0 (sweet orange) as a reference. The mandarin genome size ranged from 340-380mb, through resequencing, 70% genome was assembled at contig level in all the four accessions. A total of 1,36,38,900 single nucleotide polymorphisms (SNPs) were identified. Furthermore, phylogenetic analysis involving 106 mandarin accessions of diverse origins, revealed that all the four Indian accessions were different from each other and are closely related to Ponkan mandarin. These four accessions are also grouped with MD2 population.



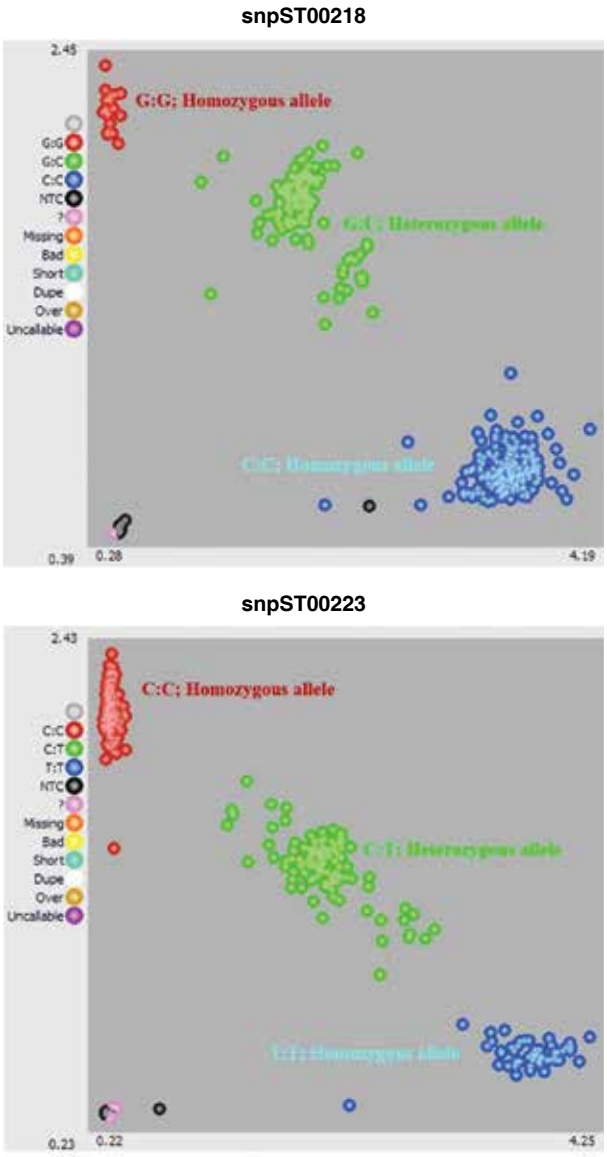
Allele frequency in the mandarin population.



PCA of 106 mandarins based on the 1,36,38,900 genomic SNP dataset.

Biotechnology

Development of markers for clonal fidelity testing and database of Musa R gene in banana: A PCR based marker (Ant-FH-11) was developed which is observed to be associated with purple colour and able to differentiate the red banana and its virescent variant and hence useful in clonal fidelity testing. This marker was further



Scatter plots for two kompetitive allele-specifc PCR (KASP) marker assays for homozygosity evaluation of diploid lines in different selfing generations. Red and blue dots represent two homozygotes while green dots represent the heterozygous genotypes.

enable the identification of its homolog in related *Musa* spp.

Comparative study of transcriptome and transcription factors in Ambri (CITH Ambri-1) apple: Ambri apples are indigenous *Bharteeya* clones having excellent aroma and shelf life of fruits. To explore the molecular mechanisms underlying differences in flavour, colour and crispiness between Ambri and Red Delicious. RNA-sequencing (RNA-Seq) was utilized to obtain genome-wide gene expression profiles during fruit development. Comparative transcriptome analysis between Red Delicious and Ambri revealed 2,180 upregulated and 2,105 downregulated genes. In comparison to the Red Delicious, DEGs encoding PAL, 4CL and CHS were observed to be upregulated in Ambri. Dihydroflavanols can be oxidized by flavanol synthase (FLS) to form flavanols. Subsequently,

Whole genome sequence of cassava variety Sree Kaveri and Accession 9S-127

A high-quality draft genome assembly of two cassava genotypes, Sree Kaveri and 9S-127, was developed through whole-genome sequencing. Analysis of the draft genome assembly revealed presence of 77,89,154 and 71,30,986 SNPs in Sree Kaveri and 9S-127, respectively. Comparative analysis showed presence of 11,04,776 and 9,43,104 InDels in Sree Kaveri and 9S-127, respectively. A database 'CasGVD' was developed for accessing and downloading the genomic datasets of Sree Kaveri and 9S-127 for molecular marker studies. These are the first genomes of cassava sequenced in India.

expression of FLS was observed to be upregulated in Ambri in comparison to Red Delicious. Compared to Red Delicious, DEGs encoding HMG-CoA synthase (HMGS), Mevalonate Kinase (MVK), iso pentenyl-diphosphate delta-isomerase (IDI) exhibited higher expression levels in Ambri. However, DEG encoding an enzyme of MEP pathway, 2-C-methyl-D-erythritol 4-phosphate reductoisomerase (DXR) was observed to be upregulated in Red Delicious in comparison to Ambri. In Red Delicious, DEG encoding sugar transporter protein, SWEET 12 was observed to be highly expressed. In contrast, Sugar transporter proteins *SWEET 7, SWEET 15, ST 2, ST7* and *SS4* were more expressed in Ambri. Red Delicious and Ambri exhibit distinct expression of DEGs related to ethylene and auxin signaling pathway. Most auxin related genes *ARF*, *AUX/IAA, SAUR* and *GH3* were highly expressed in Ambri. In contrast, ethylene related genes *ACS*, *ACO, ERS, ERFs* were expressing more in Red Delicious. Cell wall related genes are also associated with the texture of apple fruit. DEGs encoding cellulose synthase, β-galactosidases, pectin methyl esterase were differentially expressed in Ambri and Red Delicious. One of the candidate genes involved in fruit ripening, *JMT* was upregulated in Ambri. Expression changes in several aroma related genes and transcription factors were observed. The expression level of DEG encoding an aroma related transcription factor, *ERF* 9 was upregulated in Ambri.

***Sli*KASP™ markers for screening of homozygosity in potato:** A total of 50 KASP markers were developed and used for high throughput screening of homozygosity at different loci in diploid germplasm of potatoes. Of these, 49 markers used for the degree of homozygosity evaluation of 357 diploid clones in different selfing generations revealed average homozygosity distributed across all the chromosomes of the potato genome was 60% in founder diploid clones, while different selfing generations, i.e. S_0, S_1, S_2 and S_3 had 65, 70, 75 and 81% average homozygosity, respectively. ❑

3. Livestock Improvement

Cattle

Multiplication of superior indigenous cattle germplasm through multiple ovulation and embryo transfer (MOET) technology: Five Sahiwal cows were super-ovulated at ICAR-Central Institute for Research on Cattle (ICAR-CIRC). Four cows responded to the super-ovulation and 17 ova/embryos were retrieved. Six good quality embryos were transferred into six Frieswal recipients of which three Sahiwal calves were obtained for the first time at ICAR-CIRC, Meerut. The optimal response of FSH-P (Stimufol™) in Sahiwal cows was obtained at a total dose of 250 µg, but in Kankrej cows, the optimal response was found at a total dose of 330 µg. The overall conception rate with sex-sorted semen in the field was 27.22 % (49/180), which was lower than the conventional semen at 44.17% (106/240).

Sahiwal calf born to Frieswal recipient

Raj-Himani: India's First horse foal produced through frozen semen and embryo transfer

Through embryo transfer, a horse foal was produced using frozen semen technology and embryo transfer technology. A healthy female foal was born on 4th October 2023. The weight of the foal at birth was 35 kg.

All India Coordinated Research Project on Cattle

Genetic improvement of indigenous cattle breeds through progeny testing: A total of 26,280 semen doses were produced from the second (500), third (2,460), fourth (17,145) and fifth (6,175) set of Gir bulls. A total of 16,820 frozen semen doses of Kankarej were produced from 9 bulls of fifth set, and 11,095 doses were utilized for insemination. A total of 36,270 doses of Sahiwal breed were frozen, and 11,520 doses were utilized for breeding.

Genetic improvement of crossbred cattle under field conditions: Through the interventions of Field Progeny Testing programme, the average first lactation 305-day milk yield in adopted villages increased by 76.29% in KVASU, Trichur; 43.80% at GADVASU, Ludhiana; 21.40% at BAIF, Pune and 44.30% at GBPUA&T, Pantnagar units. Similarly, age at first calving of Frieswal progenies had reduced by 13.80% in KVASU, Trichur; 19.80% at GADVASU, Ludhiana; 1.60% at BAIF, Pune and 12.84% at GBPUA&T, Pantnagar.

Buffalo

OPU-IVF success and establishment of center of excellence at ICAR-CIRB, Hisar: ICAR-Central Institute for Research on Buffaloes (ICAR-CIRB) in Hisar had successfully generated a male buffalo calf named 'Veer Gaurav' utilizing the cutting-edge Ovum Pick up and *in-vitro* Embryo Production (OPU-IVEP) technology. This achievement involved the utilization of semen from a cloned bull known as 'Hisar Gaurav' and an elite female buffalo. OPU-IVEP technology represents a highly advanced reproductive method that facilitates the rapid multiplication of superior female germplasm. This ground-breaking technique enables a substantial

GANGA: India's first cloned cow belonging to Gir breed

On 16th March 2023, India's first cloned cow (named Ganga) was born, showcasing the feasibility of cattle cloning in India. Gir cattle, known for their hardiness and disease resistance, are popular globally. This achievement opens new avenues for India's dairy sector, offering advanced reproductive technologies to produce high-quality indigenous dairy animals.

Official release of cloned cow–Ganga by the Hon'ble President of India in presence of Hon'ble Union Minister of Agriculture and Secretary (DARE) and DG (ICAR)

Male buffalo calf 'Veer Gaurav' produced using OPU-IVEP technology at ICAR-CIRB, Hisar

increase in the number of progenies produced by an elite female animal over its lifetime, with the potential to yield between 18 and 24 calves from an elite bovine female in a single year.

Sheep

The analysis of data on growth and prolificacy traits of *inter-se* mated Avishaan sheep over the four generations revealed that the prolificacy in Avishaan sheep over the four generations ranged from 59.5 to 71.4% with litter size from 1.66 to 1.81 at birth. Average ewe productivity efficiency (EPE) at 3-month of age of lambs was 21.6 kg (19.7 to 24.2 kg in four generations), whereas, corresponding figure for the same period was 15.1 kg in monotocous Malpura. Under multi-location field testing programme, a total of 152 (74 male and 78 female) Avishaan sheep possessing *Fec*B gene were provided to farmers and government agency of Rajasthan, Haryana, Himachal Pradesh and Karnataka.

Network Project on Sheep Improvement (NWPSI): Presently, there are six ongoing centres including four farm units (annual target of 50 rams sale/ distribution) and two field units (annual target of 100 rams sale/distribution) located at different states of the country. Coordinating cell is located at ICAR-CSWRI, Avikanagar, Rajasthan. A total of 461 male and 230 female sheep of different breeds were sold for genetic improvement of farmer's flock.

Mega Sheep Seed Project (MSSP): The major objective of the project is improvement of indigenous sheep breeds by propagation of superior germplasm in the farmers' flock by production and distribution/sale of 70 superior breeding rams to cover at least 2500 breeding ewes of farmers annually by each of the four units.

Poultry

AICRP on Poultry Breeding: During the year, a total of 585,374 chicken germplasm was distributed to 4,819 farmers/beneficiaries from different centres. The Mannuthy centre evaluated the S-33 generation of IWN and IWP strains of White Leghorn. AAU, Anand centre evaluated native chicken, i.e. Ankaleshwar and White Leghorn strains. The Bangalore and Ludhiana centres evaluated PB-1 (male line), PB-2 (female line) and native chicken populations. MPUAT, Udaipur centre evaluated Mewari and Pratapdhan populations. AAU, Guwahati centre evaluated the Kamrupa variety, indigenous chicken and Dahlem Red populations. The Palampur centre evaluated the performance of Himsamridhi. The Jabalpur centre evaluated G-2 population of Jabalpur colour and Kadaknath breed. Agartala centre evaluated the performance of Tokbari and in the E-6 evaluation, the 72 weeks egg production was 159.3 and 138.8 eggs under farm and field conditions, respectively. Pedigreed random bred control populations were maintained at ICAR-DPR, Hyderabad.

Poultry Seed Project: The PSP centres are located at BASU, Patna; ICAR-RC for NEH region, Nagaland centre, Jharnapani; ICAR-RC for NEH region, Gangtok; ICAR-RC for NEH region, Imphal; TANUVAS, Hosur; ICAR-CCARI, Panaji; ICAR-CIARI, Port Blair; SKUAST, Srinagar; PVNRTVU, Warangal;

Genetic resources of sheep

Genetic resources maintained at farm				Sheep covered by field units			
Breed	Rams	Ewes	Total	Details	Madras Red	Magra	Total
Marwari	145	384	529	No. of sheep breeders	86	65	151
Muzaffarnagari	139	404	543	No. of sheep registered	6,400	7,068	13,468
Deccani	153	298	451	No. of breedable ewes	5,004	4,425	9,429
Nellore	124	258	382	No. of animal identification	1,944	2,412	4,356
Total	561	1,344	1,905	No. of performance recording	4,875	1,436	6,311

Distribution/sale of superior breeding rams and ewes covered

Unit	No. of rams			Breedable ewes covered
	Distributed/ Redistributed	Sold	Total	
Mandya	50	81	131	2,312
Mecheri	31	110	141	2,496
Sonadi	64	00	64	2,010
Malpura	21	91	109	796
Total	166	282	445	7,614

SVVU, Tirupati; ICAR-RC for NEH region, Umiam and WBUAFS, Kolkata. A total of 358,588 improved chicken varieties have been distributed in their respective regions/states.

Shelf-Life of CARI poultry semen diluent: The investigation to extend the chicken semen storage period in native and exotic breeds revealed that the fertilizing ability of exotic chicken breed (94.61%) and that of native chicken (Aseel - 91.65% and Kadaknath - 92.57%) was in the acceptable range (>90%). Thus, CARI poultry semen diluent can be used to store the chicken semen up to 48 h at low temperature (8°C) for obtaining good fertility following collection eggs from 2-6 days post insemination.

Whole genome sequencing of guinea fowl: Next-generation sequencing technology was utilized to sequence the genome of the KADAMBRI variety of Guinea fowl with 20× coverage in an Illumina platform (150 bp paired end reads). The KADAMBARI Guinea fowl population exhibited an average genome heterozygosity of 0.47. A total of 420 candidate genes governing cellular response to stress, 35 as thermo-tolerant candidates and 18 as immune tolerant genes were identified. Functional annotation of these candidate genes revealed 58 molecular functions (MF), 800 biological processes (BP), 31 cellular components (CC), and 8 KEGG pathways among the highly connected differentially expressed genes.

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4. Fish Improvement

Breeding and rearing of fishes under controlled conditions: Goldlined seabream (*Rhabdosargus sarba),* a euryhaline species, belonging to Sparidae family has a better potential for farming both in the ponds and cages. Successful induced breeding was achieved in captivity in >2 years matured male and female fishes during second week of December 2022. Batch spawning was observed continuously for next four days from the same pair of fishes and spawning occurred in five batches. Fertilization and hatching rates were estimated to be 71 and 40%, respectively. Incubation time was 16 hours at 35‰ salinity and 25ºC water temperature. Newly hatched larvae were 1.96 mm in length. They were reared on *Chlorella* and *Artemia nauplii* feed up to 18th day post hatching (dph) and thereafter on artificial feed. The larvae metamorphosed into juveniles in 35 to 37 dph at water temperature of 26-27°C.

Goldlined seabream, *Rhabdosargus sarba*

26 dph fry of goldlined seabream

Fingerlings of goldlined seabream

Standardized the induced breeding and seed production technology of *Hypselobarbus kolus*, an indigenous Peninsular carp. This fish breeds during October-November months with average fecundity of 15,060 eggs/kg and 62% rate of hatching.

Hypselobarbus kolus

Achieved the breeding technologies of three marine ornamental fishes, viz. Black bar chromis (*Pycnochromis retrofasciatus)*, Caerulean damsel (*Pomacentrus caeruleus)* and Maldives damselfish (*Amblyglyphidodon indicus)* including protocols of broodstock development, breeding, and larval rearing. The adult fishes were maintained in circular HDPE tanks. Fishes were spawned in the early morning and the eggs were attached to the PVC pipes provided as substratum. The number

Maldives damsel fish (*Amblyglyphidodon indicus*)

Caerulean damsel (*Pomacentrus caeruleus*)

SUCCESS STORIES

Catfish seed production: An emerging source of livelihood

ICAR-CIFA, Bhubaneswar imparted hands-on training and technical guidance to farmers from across the country on catfish brood stock management, induced breeding, hatchery management, seed production and live feed culture. After obtaining training, the fish farmers explored the possibilities of establishing catfish hatchery and producing seeds. Some of the successful farmers were:

A view of catfish hatchery in West Bengal

Catfish seeds

(i) Shri Kantu Giri from Baghmari, Purba Medinipur, West Bengal established a catfish hatchery in his farm for production of magur (*Clarias magur*) and singhi (*Heteropneustes fossilis*) seeds. From September to December 2022, he was able to produce 4.8 lakh catfish seeds of magur (3.0 lakh) and singhi (1.8 lakh). He sold these seeds to different states viz. West Bengal, Bihar, Odisha and Assam and was able to earn a net profit of ₹4.28 lakhs.

A view of catfish hatchery in Odisha

Catfish seeds

(ii) Shri Rahamatulla Shah from Nirakarpur, Khordha, Odisha established a catfish hatchery. By the end of December 2022, he was able to produce about 70,000 magur and 90,000 singhi seeds and was able to earn a net profit of ₹2.5 lakhs from magur and singhi seed sales.

(iii) Shri Safir Ahmad, A&F AGRO Partnership Firm, Jagiroad, Morigaon, Assam established catfish hatchery for mass-scale seed production of catfishes like singhi, magur, cavasius (*Mystus cavasius*) and pangas (*Pangasius pangasius*) with financial support from the District Fisheries Department under PMMSY. During the year 2023, he was able to produce fingerlings of singhi (1.6 lakh), magur (0.4 lakh), cavasius (0.75 lakh) and pangas (4.6 lakh) which he sold to the fish farmers of Assam and Arunachal Pradesh. He also produced 6 tonnes of market size pangas and sold it in the local market. He earned net profit of ₹ 6.84 lakh from sale of catfish seeds and market size fish.

(iv) Shri Bijon Kanti Bairagi from Maheshchandrapur, Nadia, West Bengal was provided a portable FRP Pabda Hatchery consisting of a cylindro-vertical breeding/incubation unit and a rearing unit, developed by the ICAR-CIFA Centre of AICRP on PEASEM. The farmer successfully operated the hatchery and produced about 40,000 seeds of pabda (*Ompok bimaculatus*) in 2022. Again, in August 2023, he was imparted hands-on training on operation of the FRP pabda hatchery for seed production by 'semi-natural induced breeding method' and he was able to produce around 33,000 seeds of pabda by September 2023.

Black bar chromis (*Pycnochromis retrofasciatus*)

of eggs per spawning ranged from 50-200 numbers. The newly hatched larvae were small with very less yolk and started feeding from 2 dph onwards. The larvae were exclusively fed using selected copepods as live feed till the completion of the flexion stage and completed the metamorphosis by the 45 dph.

ICAR-NBFGR model for creation of sustainable livelihood opportunities for the women of Lakshadweep Islands

Her Excellency Smt. Droupadi Murmu, Hon'ble President of India appreciated the efforts of ICAR-NBFGR in providing additional source of livelihood to the women of Lakshadweep islands during her visit on March 18, 2023. ICAR-NBFGR has established a marine ornamental aquatic organisms germplasm resource centre at Agatti island for propagation of indigenous marine ornamental shrimps/ fishes. Training was provided to the self-help group clusters, and the community aquaculture units are being successfully operated for rearing ornamental shrimps and fishes. The adaption of technology resulted in the creation of sustainable livelihood among the local population with a subsistence income.

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5. Genetic Resources

PLANT GENETIC RESOURCES

Germplasm exploration: During the period, a total of 19 explorations were undertaken and 1,407 accessions (887 cultivated and 520 wild) were collected from different parts of Assam, Arunachal Pradesh, Bihar, Gujarat, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Odisha, Rajasthan, Sikkim, Tamil Nadu and Telangana. Significant collection includes landraces and crop wild relatives of cereals, pulses and vegetables. In addition, important wild edible fruits and medicinal plants were also collected.

A total of 639 herbarium specimens were processed and added to National Herbarium of Cultivated Plants (NHCP), New Delhi bringing the holding to a total of 26,197 specimens (as on Sept 30, 2023). The processed herbarium includes 21 new taxa.

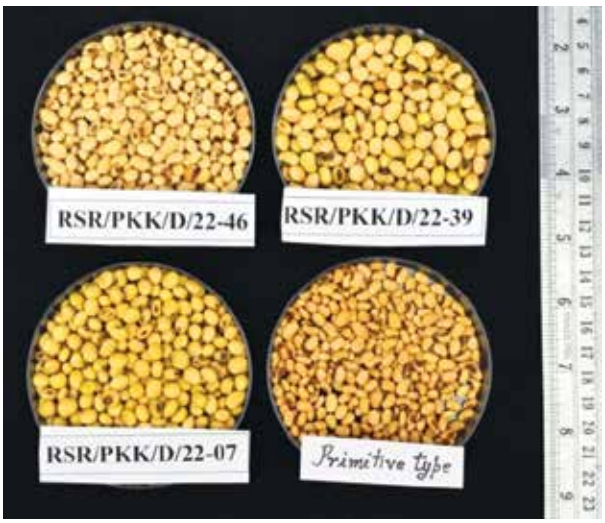
Germplasm conservation: Total 4,246 accessions of orthodox seed species were added to the National Genebank for long-term storage, bringing the base collection of National Genebank to 4,67,254 accessions (as on 30th September, 2023). A total of 39 accessions of fruits, tubers, bulbs and medicinal plants were added to the *in vitro* Genebank, making the total collection of 2,001 accessions in the form of ~40,000 *in vitro* cultures of 68 genera and 167 species (as on 30th September, 2023). In the Cryogenebank, 378 accessions of seeds and pollen genomic resources of different crop species were successfully cryopreserved, making the total collection of 12,858 accessions belonging to 885 species, besides 2,194 genomic resources (as on 30th September, 2023). Dr Himanshu Pathak, Director General, ICAR and Secretary, DARE visited the National GeneBank and *in vitro* culture facility of ICAR-NBPGR on August 14, 2023 and interacted with the scientists.

Variability in cucurbits collected from Kutch district of Gujarat

Variability in wild edible fruits collected from Uttarkashi district of Uttarakhand

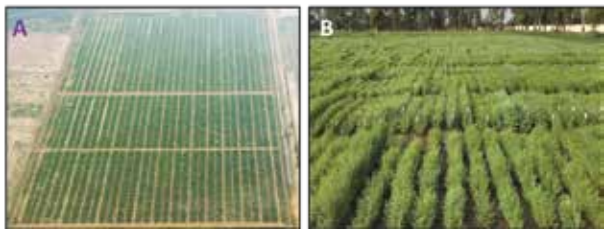
Germplasm exchange: A total of 47,629 accessions were imported from 38 countries. Additionally, 16,257 entries (1,46,999 samples) were imported in trials/nurseries from CG Centres. A few important introductions including trait specific germplasm are as follows: Wild species and elite lines of pea (EC1178132-1178172); chickpea (EC1184575-1184648); lentil (EC1178452- 1178524); soybean (EC1154362-1154486) and sesame (EC1176050-1176111) from USDA, USA; promising varieties of kiwi fruit (EC1160667-1160689); persimmon (EC1165953-1166003) and citrus namely Budhas hand, Daisy, Limoneria, Lisbon, Meiwa, Marumi (EC1180567-1180575) from USA; elite lines and promising varieties of temperate fruit crops, viz. plum, peach, almond, apricot, pear, walnut, cherry, apple, quince, currant (EC1170534-1170690) from Uzbekistan under Collaborative Research Projects.

Besides this, 717 samples of temperate fruit crops to Uzbekistan and 45 accessions of cowpea were exported to Namibia under Collaborative Research Projects.



Variability in soybean collected from East Kameng district of Arunachal Pradesh

Germplasm characterization/evaluation: A total of 29,706 accessions of various agri-horticultural crops comprising chickpea (5,084), linseed (2,576), wheat (2,534), chilli (1,100), wild *Cicer* (513), rapeseed and mustard (402), maize (244), yard long beam (210), and other crops (572) were characterized/ evaluated for various traits. Core set developed in linseed comprised of 259 accessions. Unique accessions such as pea germplasm (IC220286) with waxiness, prolific maize accessions (KG/VK/SKT-222), pre-harvest sprouting tolerant blackgram accessions (IC485425 and IC250220), chilli accession (EC769427) with 12 flowers per inflorescence were identified.



Field view of wheat (A) and linseed (B) germplasm characterization at ICAR-NBPGR, Issapur Farm, New Delhi

Mega germplasm characterization programme for sorghum germplasm accessions at Washim, Maharashtra

Mega germplasm characterization programme for sorghum germplasm accessions conserved in National Genebank was undertaken. A total of 24,950 sorghum germplasm accessions were sown and characterized for 24 agro-morphological traits which include 9 quantitative and 15 qualitative traits.

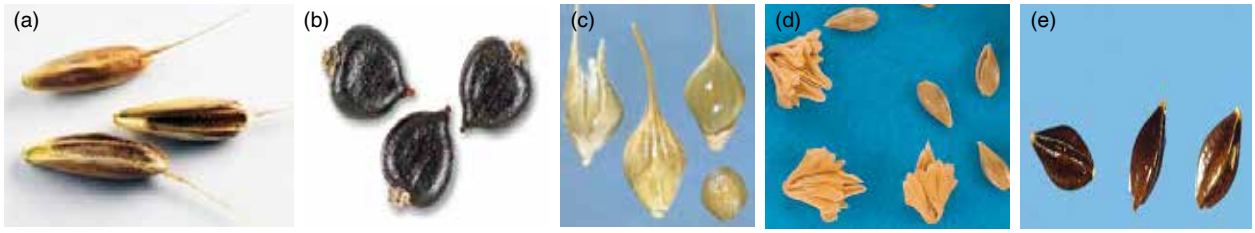
Plant quarantine: A total of 1,26,704 imported samples were processed for quarantine clearance. Total 1,257 samples found infested/ infected with different pest, out of which 17 samples were rejected due to fungal pathogens of quarantine importance. Important interceptions included fungi (*Fusarium graminearum, Phoma exigua, Tilletia barclayana*), insects (*Bruchus dentipes*, *Callosobruchus subinnotatus*, *Trogoderma variabile*), six viruses and five noxious weeds which are not reported from India.

In addition, a total of 2,685 samples were processed for export issuing 8 Phytosanitary Certificates. Likewise, at ICAR-NBPGR Regional Station, Hyderabad, a total of 89,401 samples (import and export) were processed for quarantine clearance and 34 phytosanitary certificates were issued.

DNA fingerprinting

Plant: During the period under report, 56 samples of agri-horticultural crops were DNA profiled from different public and private sector organizations, and generated resources to the tune of ₹3,36,300. GMO testing services were provided for 56 samples of 23 consignments of six crops (banana, maize, papaya, rice, soybean, tomato) and 10 species of ornamental plants and generated ₹4,00,560 for the service. Current status of National Genomic Resource Repository is 13,873 samples belonging to 46 species (as on September 30, 2023). A web server 'Germplasm Duplicate Identification and Removal Tool' (G-DIRT) has been developed to identify germplasm duplicates using SNP genotyping data which is accessible at http://webtools.nbpgr.ernet.in/gdirt/. Designed and validated genic and intergenic SNP-based 64K SNP chip for diversity study, molecular core development, association mapping, and molecular breeding in Amaranthus. The draft whole genome sequence of small cardamom (*Eletaria cardamomum*) has been *de novo* assembled and developed public database on information and utilization of SSR loci ('cardamomSSRdb'). Developed and validated KASP markers associated with Spot Blotch resistance, QTLs identified through GWAS in bread wheat (*Triticum aestivum*). Visual and Real-time loop-mediated isothermal amplification (LAMP) based GM detection technology was developed for rapid on-site detection of Proteinase inhibitor (T-pinII) terminator sequence with limit of detection (LOD) up to 0.01%. A total 30 stable Quantitative Trait Nucleotides (QTNs) were identified for test seed weight (thousand seed weight) trait using Multi-locus Genome Wide Association Study (ML-GWAS) in a linseed core panel.

Microbes: To ascertain the authenticity of biopesticides and to restrict the flow of spurious and



Exotic weed species, *Bromus secalinus* (a), *Polygonum lapathifolium* (b), *Echinochloa crus-pavonis* (c), *Phalaris paradoxa* (d), *Polygonum cuspidatum* (e) intercepted in imported germplasm.

substandard products, the Central Insecticide Board and Registration Committee has included molecular identification and DNA fingerprint as mandatory requirement for registration of microbes as biopesticides. ICAR-National Bureau of Agriculturally Important Microorganisms has been recognized as the nodal agency for developing DNA fingerprints of microorganisms to be registered as biopesticides. More than 380 samples from 106 private companies and government organizations were processed to generate fingerprint and establish identity at the Bureau. The samples mainly contained *Lecanicillium lecanii*, *Verticillium chlamydosporium*, *Purpureocillium lilacinum*, *Metarhizium anisopliae*, *Trichoderma harzianum*, *T. asperallum*, *Beauveria bassiana*, *Pseudomonas fluorescens*, *Bacillus amyloliquefaciens, B. subtilis*, *B. thuringiensis,* etc.

Insects: DNA barcode for 127 insect species and whole genome sequencing for 11 species including two insects, four Bt and 5 EPN strains were generated. Thirty three stage /age/ tissue specific transcriptomes (15 insects, and 18 EPN samples) were generated and analysed for the characterization of different genes and gene families. Important gene families of insects, EPNs and entomopathogenic microbes (Bt) were mined from the genome and transcriptome datasets and many novel genes were observed as a target for RNAi and genome editing.

Plant germplasm registration: A total of 157 special trait germplasm/donor of 64 species were registered during the period of report taking the tally of total trait specific germplasm registered in the National Genebank to 1,775 for use in the trait based breeding by the scientists working in National Agricultural Research System.

Summary of trait specific germplasm registered during October 2022 to September 2023 with current status of donors registered by Plant Germplasm Registration Committee

Crop group	No. of germplasm entries registered	Presents status
Cereals and Pesudocereals	64	762
Millets	26	155
Fibre and Forages	05	130
Grain legumes	15	214
Vegetables	07	137
Oilseeds	12	258
Commercial crops	05	119
Medicinal and Aromatic Plants, Spices and Masticatory	05	132
Fruits and Nuts	09	69
Tubers	02	56
Ornamentals	06	92
Narcotics	01	09
Agro-forestry	00	08
Total	157	2141

Trait-specific germplasm registered at ICAR-NBPGR during October 2022 to September 2023

Crop/Botanical name	National Identity	INGR No.	Novel/Unique features
Rice (*Oryza sativa)*	IC645766	22100	High protein content (10.5%) in polished rice
	IC350549	22101	Resistant to leaf blast (2-3 score). Mid-early duration with long bold (LB) grain type along with early seedling vigour traits
	IC645772	22102	Tolerance to acidic soils (pH 4.3 – 5.2) and sodic soil conditions (without gypsum amendment; pH 8.5–10.0) across field locations under AICRIP testing in terms of stable grain yield and toxicity score (3.67)
	IC646825	22103	Complete panicle emergence in elite genetic background of Samba Mahsuri
	IC646826	22104	Tolerance to leaf folder in elite genetic background of Samba Mahsuri
	IC646827	22105	Excellent resistance for leaf and neck blast and tolerance to sheath blight. Germplasm has elite genetic background (PR114)
	IC626285	22106	The germplasm is an EMS mutant of Nagina 22. It exhibits higher root biomass, number of tillers and grain yield than Nagina 22 under low phosphorus soil conditions. NH 787 shows higher photosynthetic rate, pollen fertility, and the activities of antioxidant enzymes are carried out in low phosphorus soil
	IC646829	22107	Highly tolerant to submergence. High anaerobic germination potential
	IC645856	22108	Tolerant to vegetative stage drought stress. Possess low transpiration rate and high water-use efficiency
	IC645857	22109	Tolerant to vegetative stage drought stress with low transpiration rate, high ROS scavenging activity and high WUE. Tolerant to submergence and salinity stress at vegetative stage
	IC645858	22110	Tolerant to vegetative stage drought stress with low stomatal density and high WUE

Crop/Botanical name	National Identity	INGR No.	Novel/Unique features
	IC352909	22111	Leaf and Neck and blast resistance
	IC647170	22112	Highly resistant to leaf and neck blast
	IC647171	22113	Highly resistant to leaf and neck blast
	IC647172	22114	Leaf and Neck and blast resistance
	IC647174	22115	Leaf and Neck and blast resistance
	IC128335	22116	Drought tolerance with higher antioxidant (1.8 fold) activity
	IC646830	22117	Highly resistant to wheat blast. Resistant to leaf rust and Karnal bunt
	IC640204	22118	Resistant to stripe rust. Resistant to leaf rust. Tolerant to stem rust
	IC646831	22119	Resistant to wheat blast. Resistant to stem and leaf rust
	IC646832	22120	Immune or complete adult plant resistance against yellow rust disease at 9 different host spot locations
	IC416188	22121	Terminal heat tolerance
	IC533742	22122	High level of salt tolerance
	EC178071	22123	High level of salt tolerance
Barley (*Hordeum vulgare)*	IC632077	22124	High-anti-oxidant activity (72.3%) with unique black colour grains
	IC646833	22125	Higher wort free amino nitrogen content with higher malt diastatic power
	IC118689	22126	Hulled landrace with resistance to corn leaf aphid
	IC646835	22127	Six rowed barley with low grain protein content and high malt diastatic power
	IC356122	22128	Hulless six-row landrace with high β-glucan (6.4%) and starch (65.4%)
	IC646836	22129	Naked (hulless) barley genotype. Adult plant resistant (APR) to yellow rust at the stage (ACI = 0.1 and highest score = TMR) and APR to leaf rust (highest score=TMS).This genotype (BHS 485) also has low protein content of 10.3% (dry weight) and starch content (64.3% dw basis) making it suitable for malt purpose
	IC646839	22130	Possesses adult plant resistance to yellow rust (ACI less than 15, i.e. 5.1) and leaf rust (highest score = 5MS). Resistant to all the pathotypes of brown rust at seedling stage except H4 race. Resistant to all pathotypes of yellow rust at seedling stage except for M and Q race
	IC646840	22131	Naked (hulless) barley genotype. Adult plant resistance (APR) to yellow rust (ACI = 4.7 and highest score = 10S) and leaf rust (highest score = 0). BHS483 (BBM833). Moderately resistant to all pathotypes of yellow rust at seedling stage (except for 24 and Q race showing MS reaction). Promising source of malt barley in relation to protein content (10% dw basis)
	IC138120	22132	High test weight (hundred grain weight of 6.359 g) coupled with early maturity (114.4 days) in two-rowed barley
Barnyard millet (*Echinochloa frumentacea)*	IC472387	22133	Early flowering (42 days). Early maturity (85 days)
Finger millet (*Eleusine coracana*)	IC646842	22134	Resistant to neck blast and finger blast diseases
	IC642429	22135	Early flowering (65 days). Early maturing (99 days)
	IC308859	22136	Early flowering (68 days). Early maturing (103 days)
	IC331688	22137	More number of productive tillers (4.7 cm). Greater plant height (119 cm)
	IC413273	22138	Early flowering (45 days)
	IC479598	22139	High number of productive tillers (6.2)
	IC480408	22140	Longer panicle (20.9 cm)
Kodo millet (*Paspalum scrobiculatum)*	IC647175	22141	Early flowering (63 days). Early maturity (99 days)
	IC404607	22142	Early flowering (64 days). Early maturity (101 days). Shoot fly resistance
Sorghum (*Sorghum bicolor*)	IC646841	22143	High total fresh biomass (59.6 t/ha), and high juice yield (19654 l/ha)
	IC546931	22144	High total fresh biomass (53.8 t/ha) and high juice yield 14318 t/ha)
	IC618406	22145	High Brix content (17.4%). High fresh stalk yield (4203 t/ha) and high juice content (14533 l/ha)
Wild Jute (*Corchorus fascicularis)*	IC340358	22146	Highly resistant to stem rot
Jute & Allied Fibres *(Corchorus aestuans)*	IC646844	22147	Highly resistant to stem rot and Bihar hairy caterpillar. Resistant to root knot nematode
Black gram (*Vigna mungo)*	IC530491	22148	Tolerant to waterlogging
	IC519933	22149	Tolerant to waterlogging
Mung bean (*Vigna radiata*)	IC639816	22150	Resistant to MYMV. Photo insensitive, early and synchronous maturity. Top bearing pods and shining seeds

Crop/Botanical name	National Identity	INGR No.	Novel/Unique features
Blackgram (*Vigna mungo*)	IC639815	22151	Resistant to MYMV. Photoinsensitive with medium maturity period. Hairy pod with shining seed.
Urd bean (*Vigna mungo* var. Mungo)	IC251387	22152	Resistant against bruchid species *Callosobruchus chinensis*
Chickpea (*Cicer arietinum)*	IC647176	22153	Highly resistant NIL against Fusarium wilt caused by *Fusarium oxysporum* f. sp.*ciceri*, race2 (Foc2), developed through MABC approach. High yield and wider adaptability
	IC117744	22154	*Ascochyta* blight resistance
Pigeonpea (*Cajanus cajan)*	IC646849	22155	Closed flower structure until complete fertilization. Independent anther filaments (Absence of diadelphous condition). Indeterminate high yielding genetic background
Rice bean (*Vigna umbellata)*	IC251439	22156	Resistant against bruchid species *Callosobrochus maculatus*
Wild bean (*Vigna vexillata)*	IC248326	22157	Resistant against bruchid species *Callosobruchus chinensis*
Chilli (*Capsicum annuum*)	IC646850	22158	Heat tolerant. The genotype can set fruits at maximum temperatures above 40°C and night temperatures above 25°C
	IC646851	22159	Heat tolerant. The genotype can set fruits at maximum temperatures above 40°C and night temperatures above 25°C
Carrot (*Daucus carota)*	IC623137 and IC642958	22160	IC623137 (VRCAR-214) is a petaloid-CMS line of red carrot with better heterotic potential for root yield, uniformity & lycopene content. The CMS line α and its maintainer (IC642958; Kashi Arun) are synchronous in flowering/ pollination. The roots of VRCAR-214 are good source of lycopene (7.3-7.5 mg/100g FW) and beta-carotene (3.25-3.50 mg/100g FW)
Bitter gourd (*Momordica charantia* var. muricata)	IC642345	22161	Resistant to powdery mildew (*Podosphaera xanthii*. Dark green, deeply lobed leaves. Fruit is small, dark green with discontinuous ridges
Indian mustard (*Brassica juncea*)	IC646857	22162	Resistant to white rust disease caused by *Albugo candida*
	IC646856	22163	High temperature tolerance at seedling stage
	IC640189	22164	High tolerance to soil sodicity (upto pH2 9.4) stress
Indian mustard (*Brassica juncea* var. yellow sarson)	IC422166	22165	Resistance against white rust disease of mustard
	IC645775	22166	Highly tolerant to *Sclerotinia* stem rot disease
Rapeseed (*Brassica napus*)	IC646858	22167	*Sclerotinia* stem rot disease resistance
African mustard (*Brassica carinata)*	IC646859	22168	*Sclerotinia* stem rot disease resistance. Dark purple stem
Soybean (*Glycine max)*	IC646860	22169	Waterlogging tolerance
Banana (*Musa* spp.)	IC628011	22170	Resistant to root lesion nematode
	IC628037	22171	Resistant to root lesion nematode
Jackfruit (*Artocarpus heterophyllus)*	IC438858	22172	Highest number of fruits (107 fruits/tree) bearing per plant
	IC24351	22173	Dwarf canopy
	IC24369	22174	Extra early fruit bearing: December (earlier by 60 days)
Noni (*Morinda citrifolia)*	IC641340	22175	Cluster bearing habit. 4 to 5 obovate elongate fruits are borne at each of the alternate nodes. Large sized fruits weighing 307 g each attain average maximum length of 11.70 cm and width 5.9 cm
Lemon basil (*Ocimum* × *citriodorum)*	IC646862	22176	Broadly ovate leaf shape. Rich in citral A and B content
Shrubby basil (*Ocimum gratissimum*)	IC646864	22177	Leaf shape is narrow ovate. Rich in β-Copaene (20.48%) and α-Bergamotene (15.23%)
Lisianthus (*Eustoma grandiflorum*)	IC646867	22178	Violet rose shaped double flower. Produce more than 24 flowers per plant. Long sturdy stem of >82 cm, suitable for cut flower production
	IC646868	22179	Pure white rose shaped double flowers. Produce more than 18.0 flowers per plant. Long sturdy stem, suitable for cut flower production
Chrysanthemum (*Chrysanthemum morifolium*)	IC636418	22180	Flower colour (RHS colour: 3D, Yellow group, Fan1). Early flowering (69.17 days). Dwarf (20.27 cm) and spreading plant growth
	IC645570	22181	Flower colour (RHS colour: 71B, Red-purple group, Fan2). Early flowering (66.52 days). Dwarf (30.17 cm)
	IC636415	22182	Flower colour (RHS colour: 17A, Yellow Orange Group, Fan1). Early flowering (62.77 days) and dwarf (25.51cm). Resistant to White Rust (*Puccinia horiana*)
Sugarcane (*Saccharum* sp.)	IC646869	22183	High cane and sugar yield (14.50 t/ha) under tillering phase drought stress
	IC646870	22184	High millable canes 74.68 (000/ha) and cane yield under tillering phase drought
	IC646871	22185	High cane thickness (3.00 cm)

Crop/Botanical name	National Identity	INGR No.	Novel/Unique features
	IC646872	22186	Developed from a rare fifth generation inbred. Potential source for red rot resistance combined with smut resistance and yellow leaf disease resistance. A high yielding genotype can be used in the sugarcane improvement without any further backcrossing
Sugarcane (*Saccharum officinarum)*	IC646873	22187	Red rot resistance
Potato (*Solanum tuberosum*)	IC645767	22188	High nitrogen use efficiency traits such as NUE, agronomic NUE (AgNUE), nitrogen uptake efficiency (NUpE), and nitrogen utilization efficiency (NUtE). High tuber yield under low nitrogen fertilizer input under field conditions
Mango (*Mangifera indica*)	IC646861	22189	Disease free. Possesses high Vitamin A content (11338 IU) in comparison to commercial varieties. Bears high (14) number of fruits per bunch and average fruit weight is 232 g. High (2000) number of fruits/plant
Rice (*Oryza sativa)*	IC648583	23001	High combined resistance to leaf blast (score 2 on SES scale) and neck blast (score 1 on SES scale)
	IC648978	23002	High nitrogen use efficiency (NUE) under N-Low and N-50 input
	IC648592	23003	Increased root length and root volume. Better seedling vigour index
	IC640862	23004	Tolerant to submergence with high anaerobic germination potential
	IC648977	23005	High photosynthetic rate. High seedling vigour
	IC648593	23006	Biotic resistance genes *Xa4, BPH3, GM4, Pita*. Can be detected with QTL markers (*AG9.1, qDTY3.1, qGY6.1, qGY10.1, qNR4.1* and *qNR5.1*)
	IC648594	23007	Biotic resistance genes *GM4, Pita*. Can be detected with QTL marker for anaerobic germination (*AG9.1*) and other traits (*qDTY3.1, qDTY12.1, qGY6.1* and *qNR5.1*)
	IC648595	23008	Biotic resistance genes *Xa4, xa5, Xa21, BPH3, Pi9, Pita*. Can be detected with QTL markers (*AG9.1, qDTY3.1 ,qNR5.1, qRHD1.1* and *qEMM1.1*)
	IC648596	23009	Biotic resistance genes *xa5, Xa21, BPH3, Pita*. Can be detected with QTL markers (*AG9.1, qDTY2.1, qDTY3.1, qNR5.1, qRHD1.1* and *qEMM1.1*)
	IC648597	23010	Biotic resistance genes *Xa4 + xa5 + xa13 + GM4 + Pita*. Can be detected with QTL markers (*AG9.1, qDTY3.1, qRHD1.1* and *qEMM11.1*)
	IC648598	23011	Biotic resistance genes Xa4, Xa21, BPH3, GM4. Can be detected with QTL markers (*AG9.1, qDTY3.1, qDTY12.1, qRHD1.1, qRHD5.1* and *qEMM11.1*)
	IC648599	23012	Biotic resistance genes *Xa4, xa5, Xa21*, Pi9, Pita. Can be detected with QTL markers (*AG9.1, qDTY3.1, qDTY12.1* and *qEMM11.1*)
	IC648600	23013	Biotic resistance genes *Xa4, xa5, Xa21*, *Pita, Pita2*. Can be detected with QTL markers (*AG9.1, qDTY3.1* and *qNR5.1*)
Rice (*Oryza sativa* var. *indica*)	IC648601	23014	Submergence tolerance
	IC648602	23015	Resistance to brown plant hopper
Rice (*Oryza sativa)*	IC648979	23016	Tolerance against soil sodicity
Wheat (*Triticum aestivum)*	IC648603	23017	Resistant to leaf rust
	IC648604	23018	Possesses high zinc content (47.3 ppm)
	IC112049	23019	Terminal heat tolerance. High productive tiller numbers, thousand grain weight and harvest index
	IC648605	23020	Resistant to yellow rust due to the presence of gene *Yr5*
	IC648606	23021	Possesses genes for resistant to Leaf rust-stripe rust (*Lr57-Yr40*) Stripe rust (*Yr15*)
	IC648607	23022	Resistance to leaf rust (*Lrtri*) and stripe rust
	IC648608	23023	*Glu-B3/GliB1* locus transfer on 1RS chromosomal arm. Resistant to stripe rust with transfer of gene *Yr5*
	EC787008	23024	Possesses high grain protein (16.7%), iron (45.7 ppm) and zinc (47.8 ppm) content
	EC787015	23025	Possesses high grain protein (17.1%), iron (53.3 ppm) and zinc (54.2 ppm) content
	IC642305	23026	Possesses high zinc content (47.0 ppm)
	IC648609	23027	Resistant to all pathotypes of brown rust. Presence of *Lr24*/*Sr24*
Barley (*Hordeum vulgare)*	IC646834	23028	Higher malt betaglucanase activity (384 Units/kg malt). Lower wort betaglucan content (130 ppm)
	IC646838	23029	Resistant to all the pathotypes of leaf rust and stripe rust at the seedling stage (except for race24).
Finger millet (*Eleusine coracana)*	IC647589	23030	Early duration (98.8 days). Neck and finger blast resistance

Crop/Botanical name	National Identity	INGR No.	Novel/Unique features
	IC647590	23031	Banded blight resistance
	IC647592	23032	Resistant to neck and finger blast resistance
	IC595249	23033	Non-lodging having uniform maturity
	IC648610	23034	High number of fingers/earhead (>10 numbers). Longer ear head length (13.4 cm)
	IC648611	23035	Longer finger length (13.3 cm)
	IC648612	23036	Longer leaf length (83.1 cm). Wider leaf width (8.39 cm)
	IC648613	23037	Longer leaf length (85.5 cm) and leaf width (7.32 cm)
	IC648614	23038	Hurda sorghum with free threshability, high hundred tender grain weight (4.12 g) and excellent fragrance
	IC647559	23039	Hurda sorghum with earliness (50% flowering in 67 days) in dough stage (89 days), free threshability and excellent fragrance
	IC286441	23040	Possesses high zinc (Zn) (30.61 ppm) and iron (Fe) (37.14 ppm) content
	EC488403	23041	Possesses high Zn (29.78 ppm) and high Fe content (35.51 ppm)
	IC643984	23042	Early flowering (67 days) and early maturity (110 days) line
Cotton (*Gossypium arboreum)*	IC646843	23043	High ginning per cent (40%)
	IC648615	23044	Salinity stress tolerance up to 9 dS/m. High seed cotton yield (16.41 q/ha)
	IC648616	23045	Salinity stress tolerance up to 9 dS/m. High seed cotton yield (14.65 q/ha)
Chickpea *(Cicer arietinum)*	IC275447	23046	Possesses Ascochyta blight resistance
Pigeonpea (*Cajanus cajan)*	IC648617 & IC648618	23047	Cytoplasmic male sterility. A2 Cytoplasmic source. Early maturing (140-150 days)
Clusterbean (*Cyamopsis tetragonolobus*)	IC648619	23048	Early maturing (82 days). Determinate growth type and unbranched. All node clusters pod bearing and synchronous maturity
	IC648620	23049	Test weight more than 45 g. Long fleshy pod more than 10 cm. Glabrous leaves, stem and pods
Cucumber (*Cucumis sativus*)	IC646853	23050	Highly stable tropical gynoecious lines for hybrid breeding. Donor for Flocus introgression into elite genotype
	IC646854	23051	Tropical gynoecious line for use in hybrid breeding. Only female flower even at higher temperature > 40°C. It can be used as female parent in developing high yielding and early F1 hybrids
Sponge gourd (*Luffa aegyptiaca*)	IC630886	23052	Characteristic aroma which resembles with the typical aroma of 'Basmati rice' in its various plant parts. The compounds responsible for Basmati rice-like aroma constituents found are mainly hexanal, 1-octen-3-ol, 3-octanone and limonene
Indian mustard (*Brassica juncea)*	IC648622	23053	It possesses a novel white rust resistant gene, which is not discovered and mapped yet, other than two independent loci, AcB1-A4.1 and AcB1-A5.1 governing resistance against *Albugo candida* (White Rust pathogen) in Indian mustard
Linseed (*Linum usitatissimum)*	IC384578	23054	Possesses high number of capsules (280.26 per plant)
Soybean (*Glycine max)*	IC596520	23055	Early flowering (32 days) as well as early maturity (87-89 days)
Sesame (*Sesamum indicum)*	IC205471	23056	Tolerance to deficit soil moisture stress
Avocado *(Persea Americana)*	IC626510	23057	Pulp recovery >70%. Tolerant to anthracnose
Rambutan *(Nephelium lappaceum)*	IC642755	23058	Red colour fruit, free stone, bigger fruit size (about 40-45 g)
Tamarind (*Tamarindus indica)*	IC647019	23059	Pod size (length > 25 cm), (breadth > 3 cm). Pulp recovery >40%
Lemon basil *(Ocimum × citriodorum)*	IC646865	23060	High leaf size 7.45 cm^2. High fresh herbage yield (298 q/ha)
Basil (*Ocimum basilicum*)	IC646866	23061	Richin *Methyl eugenol* (30%) content of essential oil
Tuberose *(Polianthes tuberosa)*	IC642158	23062	Single type flowers and green tinge flower buds. Resistance to root knot nematode (*Meloidogyne incognita*). Tolerant to leaf burn disease (*Alternaria polianthi*)
Potato (*Solanum tuberosum)*	IC648625	23063	Highly resistant to Bacterial Wilt (*Ralstonia solanacearum*)
Arecanut; Betelnut *(Areca catechu)*	IC648626	23064	Noticeably short internodes, dark green leaves, shorter inflorescences and highly fragrant flowers
Rice *(Oryza sativa)*	IC646828	23065	Tolerant to yellow stem borer
Barley *(Hordeum vulgare)*	IC646837	23066	Resistant to all pathotypes of leaf and stem rust at the seedling stage (except for race 11)
Urd bean *(Vigna mungo* var. *Mungo)*	IC251385	23067	Highly resistant against *Callosobruchus chinensis*

Microbial genetic resources

National Agriculturally Important Microbial Culture Collection (NAIMCC) currently holds 7,866 microbial accessions, which include fungi (4,339), bacteria and actinomycetes (3,161), and cyanobacteria (366). The culture collection has received 14 new microbial genera, viz. *Achromobacter* sp., *Amycolatopsis* sp., *Aneurinibacillus* sp., *Caballeronia* sp., *Citricoccus* sp., *Fictibacillus* sp., *Ignatzschineria* sp., *Kitasatospora* sp., *Komagaetibacter* sp., *Kosokonia* sp., *Pantoea* sp., *Photorabdus* sp., *Providencia* sp., and *Rahnella* sp. during the reporting period. The fungal diversity collection has enriched with 11 new genera namely, *Actinomortierella* sp., *Athelia* sp., *Calonectria* sp., *Coryceps* sp., *Corynespora* sp., *Lasiodplodia* sp., *Nortierella* sp., *Scopulorioposis* sp., *Stemphylium* sp., *Talaromyces* sp., and *Trametes* sp. under the general deposit category. The total revenue generated was ₹ 5,67,600 during 2022-2023 for culture supply to the different stakeholders across Indian states, including private and public sectors. A total of 46 microbial cultures have been accessioned under safe deposition from various government and private institutions, which has generated a revenue of ₹ 4,53,000. The ICAR-NBAIM has started a service for registering microorganisms with novel traits under which a total of 6 microorganisms viz. *Piriformispora indica*, *Bacillus thuringiensis* subsp. *kenyae*, *Bacillus thuringiensis* subsp. *israelensis*, *Trichoderma asperellum*, *Trichoderma afroharzianum*, and *Chryseobacterium sediminis* were registered.

Insect resources

ICAR-NBAIR National Insect Museum now holds around 2.40 lakh specimens with addition of 4,786 insect specimens during 2023. Forty-four species of insects and one species of entomopathogenic nematode which are new, were collected and described. The list of new species (44) includes 35 species of parasitic wasps and an entomopathogenic nematode apart from other pest insect species. Majority of these species were recovered from the biodiversity rich hotspot areas such as Western Ghats, North Eastern states and Andaman and Nicobar group of islands. All these new discoveries were formally named and described in scientific journals. The new discoveries are important since millions of insect species on the planet are on the brink of extinction due to profound anthropogenic impacts. The discoveries help greatly in understanding the biodiversity and managing the insect pests in India.

The Bureau is maintaining 137 live insect species germplasm including 106 parasitiods, 14 predators, 16 host insects/pests and 1 detritivore for supply to various stakeholders.

PGR Policy

ICAR-NBPGR and PPV&FR Authority, New Delhi organized First Global Symposium on Farmer Rights during September 12-15, 2023. Policy inputs were provided for Kumming Montreal Global Biodiversity Targets (KM-GBF). Agenda items for 10th GB of ITPGRFA focused mainly on enhancement of MLS, sustainable use, compliance; draft Document ISO 17317: Biodiversity: Guidance for the characterization of products based on native species (SSD 20); Second Report on Compliance submitted to FAO (online). ICAR-NBPGR participated in 5th meeting of the Compliance Committee of the ITPGRFA from March 28-29, 2023 at Rome, Italy and also in ITPGRFA Consultative Process on Enhancement of MLS from May 30-June 1, 2023 at Pranrgins, Geneva and from July 10-14, 2023 at Rome.

IC Allotment Information System

IC Allotment Information System was launched for public use by Dr Mangala Rai (Former DG, ICAR) and Dr Himanshu Pathak (DG, ICAR) on Aug 1, 2023 on the occasion of 48th Foundation Day of NBPGR. IC Allotment Information System is the online system (http://pgrinformatics.nbpgr.ernet.in/ic) developed, maintained and hosted by ICAR-NBPGR for the purpose of digitization of IC number requisition and allotment. The objective of this system is to make the process of IC number requisition and allotment easy, quick, transparent and paperless. Status of IC requisition can be tracked by the users.

HORTICULTURE

Collection of new germplasm

A total of 1,053 germplasm of different horticultural crops including fruit crops (248), flowers and other ornamental plants (271), vegetables (525) and medicinal and aromatic plants (38) were collected. The crops-wise number of collections are presented as below.

In addition to above, a total of 90 accessions of vegetable germplasm (cultivated and wild relatives of *Luffa* sp, *Abelmoschus* sp, *Trichosanthes* sp and *Cucumis* spp) were collected from the Sundargarh district of Odisha in collaboration with ICAR-NBPGR RC, Cuttack.

Collection of wild and uncultivated germplasm

In addition to the cultivated germplasm, a total of 83 germplasm of vegetables belonging to 42 species of different crops including 30 species of wild relatives were collected. These were collected from varied agro-climatic regions such as Malia, Somakhiali, Bhachau, Bhuj, Kharoi, Mandvi, Naliya, Kothara, Narayan Sarovar, Lakhpat, Nakhat Rana, Khadir, Ratanpur, Balasar, Rapar, Santalpur, Radhanpur, Patan, Unjha, Vadgam, Danta, Dantiwada, SK Nagar, Ranitunk, Deesa, Tharad, Adesar, and Kandla areas of Banaskantha, Kutch and Patan districts of Gujarat.

Herbarium specimens (20) were also deposited in National Herbarium of Cultivated Plants (NHCP), ICAR-NBPGR, New Delhi. Some of the accessions collected

New germplasm of horticultural crops collected

Crop	Number of germplasm collected
Fruit crops	
Phalsa	01
Manila tamarind	02
Ber	08
Acid lime	02
Karonda	02
Ker	01
Lasoda	01
Pilu	08
Mango	09
Guava	10
Bael	25
Aonla	24
Jamun	69
Rose apple	10
Wood apple	26
Tamarind	23
Wild fruits	06
Avocado	01
Passion fruit	20
Banana	11
Total fruit	248
Flowers	
Rose	37
Gladiolus	32
Chrysanthemum	24
Orchids	38
Anthurium	07
Tuberose	06
Marigold	20
Tulip	24
Lilium	17
Dahlia	05
Specialty flowers	21
Ornamental fillers and florist greens	40
Total flowers	271
Vegetable crops	
Okra	10
Chilli and sweet pepper	22
Indian bean (sem or *Dolichos* bean)	06
French bean	42
Cluster bean	01
Ridge gourd	180
Bitter gourd	08
Radish	08
Carrot	06
Onion	42
Curry leaf	05
Cucumber	124
Pumpkin	20
Drumstick	51
Total	525
Medicinal and aromatic plants	
Brahmi *(Bacopa monnieri*)	19
Mandukaparni (*Centella asiatica*)	03
Betel vine (*Piper betel*)	06
Gymnema sylvestre	10
Total	38
Grand total	**1053**

included *Citrullus lanatus* (Matira/white pulp water melon) (1), *Cucumis melo* subsp. *melo* var. alwarensis (1), *Cucumis melo* var. momordica (5), *Cymopsis tetragonolobus* (2), *Abelmoschus tetraphyllus)* (1), *Abelmoschus tuberculatus* (3), *Abelmoschus ficulneus* (1), *Amaranthus spinosus* (1), *Citrullus colocynthis* (1), *Cucumis melo* var. agrestis (2), *Cucumis melo* var. callosus (1), *Cucumis prophetarum* (3), *Luffa actangula* var. amara (7), *Momordica balsamina* (2), *Momordia charantia* var. muricata (2), *Solanum coagulans* (3), *Solanum incanum* (6), *Solanum virginianum* (4) and *Trichosanthes cucumeria* var. cucumerina (2).

Germplasm from exotic sources

A total of 57 germplasm accessions comprising 17 improved lines of tomato from AVRDC, World Vegetable Centre (WVC), Taiwan, and WVC, Hyderabad center besides 40 advance lines from Tomato Genetics Resource Centre (TGRC), University of California, Davis, USA were received.

Mushroom strains collected

A total of 232 new wild edible mushroom accessions were collected from forest areas of different parts of Himachal Pradesh by the ICAR-Directorate of Mushroom Research, Solan. Out of these, 200 were identified up to genus level and 100 specimens up to species level. Among these collections, some of the interesting specimens were *Bovista colorata*, *Coprinellus micaceus*, *Cruentomycena viscidocruenta*, *Dacymyces lacrymalis, Dacryopinax spathularia, Hygrophorus eburneus, Laccaria amythstina, Laccaria laccata, Laccaria torsilis, Scleroderma citrinum, Singerocybe humilis* etc. Culturing of 11 specimens namely *Agrocybe agereta*, *Beauveria* sp.*, Inocybe, Strobilomyces strobilaceus*, *Ganoderma lucidum*, *Scleroderma* sp., *Pisolithus tinctorius*, *Bovista colorata*, *Macrocybe gigantia, Xylaria curta* etc. was done. All the specimens have been deposited in herbarium of ICAR-Directorate of Mushroom Research, Chambaghat, Solan (Himachal Pradesh).

Location specific collections of mushroom strains

A total of 1,081 location specific collections of mushroom strains were also collected, of which 333 specimens/cultures were deposited at the ICAR-DMR Gene Bank with passport data and accession numbers were given to 92 cultures. Some important ones are *Lentinus squarrosulous*, *Pleurotus cystidiosis*, *Agrocybe pediades*, *Calocybe gambosa*, *Podaxis pistillaris*, *Volvariella volvacea*, *Daedalea querecina, Podoscypha multizonata, Schizophyllum commune, Marasmiellus ramealis, Terminotomycetes fuliginosus, Agaricus compestris, Macrocybe crassa, Thelephora palmata, Chlorophyllum molybidites, Panaeolus foenisecii, Tyromyces chioneus, Leucocoprinus rhodolepsis, Lepiota cristata, Gymnopilus purpureosquamulosus* etc.

Characterization and identification of germplasm

Potential ashwagandha landrace 'Nagori Ashwagandha' for root yield and starch content: Nagori Ashwagandha is a unique landrace /local variety

Hohenbuehelia petaloides

Hygrophorus eburneus

Laccaria amethystina

Laccaria torsilis

Ramaria stricta

Singerocybe humilis

Lentinus squarrosulus

Schizophyllum commune

Agaricus augustus

Calocybe gambosa

Podaxis pistillaris

Amanita flavoconia

Cantherellus cibarius

Macrocybe crassa

Mushroom Strains

native to Rajasthan's central to western regions, thriving in distinct climate and soil conditions. Its roots are economically valuable, characterized by straight, thick, unbranched tubers, with a maximum length of ~ 46.67 cm, thickness of ~3.46 cm, and high starch content (~ 44.51%). These superior physical attributes are unique and different from other ashwagandha varieties, making it a boon for agriculture and local industry. Cultivating Nagori Ashwagandha in region-specific conditions significantly benefits local farmers by ensuring high-quality raw materials and sustainability.

Dwarf coriander: A unique dwarf (25-30 cm) coriander genotype with early maturity (20-25 days early) suitable for intercropping in vegetable has been identified. Sowing of dwarf coriander at 20 cm row spacing with 20 and 30 kg/ha seed along with 125% of RDF gave significantly superior seed yield of 17.2 and 16.8 q/ha, respectively. This genotype of coriander has also been validated at farmers' field at different locations in Rajasthan.

Kasuri methi (*Trigonella corniculata*): Nagouri pan methi genotype of kasuri methi has been identified

for higher leafy yield (2.25 kg/6 m^2 plot). Plant height goes up to 15-20 cm as compared to traditional Pusa Kasuri (20-30 cm) and leaf yield (1.53 kg/plot) in same plot size (6 m^2). This genotype has also been validated at farmers' field at different locations in Rajasthan.

Registration of germplasm for unique traits

A total 15 germplasm have been registered at ICAR-NBPGR, New Delhi for different unique traits in fruits, vegetable, flowers and medicinal and aromatic plants. The unique traits and other details are given below:

Germplasm having unique traits

Crop name	Germplasm name and IC No.	INGR No.	Unique traits
Lemon basil (*Ocimum × africanum*)	DLB-7 (IC 646862)	INGR22176	Broadly ovate leaf shape and rich in citral A (40.59%) and B (48.59%) content
Lemon basil (*Ocimum × africanum*)	DLB-10 (IC 646865)	INGR23060	Maximum leaf size and herbage yield (298 q/ha)
Clove basil (*Ocimum gratissimum*)	DOGr-2 (IC 646864)	INGR22177	Narrow ovate leaf and rich in β-Copaene (20.48%) and α-Bergamotene (15.23%)
Sweet basil (*Ocimum basalicum*)	DIB-1 (IC 646866)	INGR23061	Upward leaf folding with severe puckering and rich in methyl eugenol (30%)
Avocado (*Persea americana*)	IC0626510	INGR 23057	Late maturity. Pulp recovery >70%. Tolerant to anthracnose
Rambutan (*Nephelium lappaceum*)	IC0642755	INGR 23058	Red fruit. Free stone. Bigger fruit size (40-45 g)
Tamarind (*Tamarindus indica*)	IC0647019	INGR 23059	Large pods (length > 25 cm), (breadth > 3 cm). Pulp recovery >40%
Banana (*Musa* sp.)	NPL 30 (IC0628037)	INGR 22170	Resistance to root lesion nematode
Banana (*Musa* sp.)	PNG115 (IC0628011)	INGR 22171	Resistance to root lesion nematode
Chrysanthemum (*Chrysanthemum morifolium*)	IC0636418	INGR 22180	Flower colour (RHS colour: 3D, Yellow Group, Fan 1). Early flowering (69.17 days), dwarf (20.27 cm) and spreading growth
	IC0645570	INGR 22181	Flower colour (RHS colour: 71B, Red-Purple Group, Fan 2). Early flowering (66.52 days) and dwarf (30.17 cm)
	IC0636415	INGR 22182	Flower colour (RHS colour: 17A, Yellow Orange Group, Fan 1). Early flowering (62.77 days) and dwarf (25.51 cm). Resistant to white rust (*Puccinia horiana*)
Tomato (*Solanum lycopersicum*)	VRT4-55-20 (HCP/YSR-6/) IC0637253	INGR21216	Broad spectrum resistance to Tomato leaf curl virus (ToLCV). *Ty-2* and *Ty-3* gene pyramided line. Plum-shaped fruits with distinctive thick green shoulder
Carrot (*Daucus carota*)	VRCAR-214	INGR22160	A petaliod-CMS line of red carrot with better combining ability and higher heterotic potential for root yield (10-15%), uniformity and lycopene content (8-10%)
Bitter gourd (*Momordica charantia* var.*muricata*)	IC0642345	INGR 22161	Resistant to powdery mildew (*Podosphaera xanthii*). Fruit is small and dark green with discontinuous ridges

Sweet basil (*Ocimum basalicum*) IC 646866

Bitter gourd (*Momordica charantia* var. *muricata*) IC0642345

Tomato IC0637253

Petaliod-CMS line of red carrot INGR22160

Nagori Ashwagandha

Dwarf coriander

Nagori pan methi (*Trigonella corniculata*)

LIVESTOCK

Gazette Notification of newly registered animal breeds

Ten registered breeds of livestock were Gazette notified by the Ministry on February 13, 2023 [No. 3589 (S.O.680(E))]. These breeds included Kathani (Maharashtra), Sanchori (Rajasthan), Masilum (Meghalaya) cattle; Purnathadi buffalo (Maharashtra); Sojat (Rajasthan), Karauli (Rajasthan), Gujari (Rajasthan) goat; Banda (Jharkhand), Manipur Black (Manipur), Wak Chambil (Meghalaya) pig. After including these breeds, total 212 indigenous breeds (53 of cattle, 20 of buffalo, 37 of goat, 44 of sheep, 7 of horses and ponies, 9 of camel, 13 of pig, 3 of donkey, 3 of dog, 1 of yak, 19 of chicken, 2 of duck and 1 of geese) have been notified by the Government till date.

New breeds

CARIBROSAMRIDHI: The Central Avian Research Institute in Izatnagar has developed a coloured desi broiler chicken variety known as CARIBROSAMRIDHI for meat production. This variety produces high-quality meat under local rearing and feeding practices. The salient features of the developed variety are attractive-multi coloured plumage and feather patterns as rural people like coloured birds from aesthetic point of view and better looking; adaptability to the local climatic environment; grow faster and attain a flavour profile in the meat that closely resembles that of desi chicken; better dressing percentage to align more closely with that of commercial broiler chickens and higher meat: bone ratio.

CARIBROSAMRIDHI Male

CARIBROSAMRIDHI Female

Wak Chambil

Banda

Manipuri Black

Pig: Three indigenous pig breeds, i.e. Manipuri Black (Manipur), Banda (Jharkhand) and Wak Chmabil (Meghalaya) were registered. The breeds were characterized phenotypically as per the guidelines of ICAR-NBAGR. Whole genome of indigenous (Ghungroo and Mali) and exotic (Hampshire and Large White Yorkshire) was undertaken and the mean size of the genome was about 2.55 GB.

Mission towards zero non-descript AnGR of India

ICAR-NBAGR in August 2021 initiated a mission approach for identifying new homogenous population in various states through institute projects. A total of 15 Interface Meets have been completed under the mission till date in different states/UTs and 40 new potential populations from 16 have been identified till now since initiation of mission activities. Further, these identified potential populations are being characterized by the country-wide centres (ICAR institutes, SAUs/SVUs, State AHD, NGO etc.) under the Network Project (NWP) on Animal Genetic Resources of the ICAR. A total of 27 NWP centres in 21 states and 2 Union Territories have been approved to characterize newly identified populations and documentation of native AnGR in their respective states.

Ex-situ conservation of AnGR

During the period, 18,050 semen doses of 4 cattle breeds (Malnad Gidda, Hariana, Gir, Gangatiri); 3 buffalo breeds (Nili Ravi, Mehsana, Surti) and 2 goat breeds (Osmanabadi, Sangamneri) were cryopreserved. Also, 2,240 somatic cell vials of 19 native breeds, viz. Ladakhi, Siri and Sahiwal cattle; Changthangi, Bhakarwali, Gaddi and Teressa goat; Gurez, Bonpala, Karnah and Gaddi sheep; Agonda Goan, Wak Chambil, Niang Megha, Mali, Banda and Nicobari pig; Mewati camel and Kathiawadi horse were cryopreserved for long term conservation. At present, National Gene Bank has repository of 61 native breeds/populations of livestock and poultry in form of semen, 47 in form of somatic cells. Further, 122 oocytes (vitrified) of 5 native breeds were also cryopreserved. The germplasm of nearly 50% of the registered breeds as well as breeds at risk have been cryopreserved in the National Gene Bank.

Phenotypic characterization

Belona buffalo is distributed in Yavatmal district of Vidarbha region of Maharashtra. It is a medium sized buffalo. Coat colour is black with irregular white patches spreading from forehead to muzzle. Buffaloes have walled type eyes. Tail switch is also white. Forehead is broad between horns and slightly bulging, head is markedly long and tapering towards the muzzle. Horns are of medium size, with backward and upward orientation and pointed at end, giving 'sickle' shape appearance. The buffaloes have good milking potential with a high-fat percentage of milk. Daily milk yield varies from 5-8 kg with high milk fat of around 8%.

Khamgaon cattle is distributed in Buldhana district of Vidarbha region of Maharashtra. It is a medium sized cattle. The bullocks are reared for draught purpose and

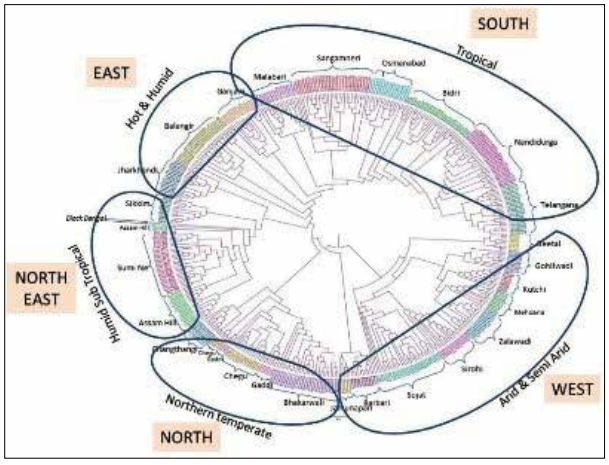
are well suited for heavy agricultural work on black cotton soil. Typical Khamgaon cattle has unique body coat colour as brown (chocolate), mixture of brown and white which gives the animal a mottled appearance. Head is straight and horns are of medium length and thick at the base. Hump is medium sized.

Genetic characterization

Pashmina fibre from Changthangi goats: The Changthangi breed stands out prominently for its production of Pashmina – the world's most luxurious natural fibre. The skin transcriptome profiles of Changthangi goats from Ladakh were compared with non-Pashmina Barbari goat. Pashmina-producing goats displayed significantly higher transcript levels of genes related to keratins, keratin-associated proteins, and key transcriptional regulators for hair follicle keratin synthesis, such as GPRC5D, PADI3, HOXC13, FOXN1, LEF1, and ELF5. Additionally, the Wnt signalling pathway, crucial for initiating hair follicle development and subsequent morphogenesis and differentiation, was enriched in Changthangi goats.

Construction of transgenic cassette for producing therapeutics in chicken egg: The human tissue plasminogen activator (htPA) cDNA of 1689 bp was synthesized and cloned in a transgenic construct consisting of chicken ovalbumin promoter, ovalbumin poly A tail and chicken histone gene. The whole construct was cloned in pUC57 vector for further multiplication of the construct.

Population stratification of indigenous goats: Goats are the supporting pillars of rural economy contributing significantly to meat and milk production in India. About 443 samples from 26 indigenous goat breeds/populations were genotyped using high-density (HD) SNP chip designed at NBAGR. The results revealed 95.83% markers to be highly informative and polymorphic in Indian goats. Multivariate analysis indicated population structuring, as 15 breeds could be segregated using the designed array. Phylogenetic analysis suggested stratification of breeds by geographic proximity.



Phylogenetic tree of different goat breeds using the HD SNP array

FISHERIES

New records of fishes and shellfishes from the Indian waters

ICAR-NBFGR discovered seven new fish and shrimp species from marine waters along the coast of Tamil Nadu, Kerala and Lakshadweep islands. Marine fish species discovered were *Gymnothorax tamilnaduensis, Conger melanopterus, Rhynchoconger bicoloratus, Ophichthus nigroventralis* and *Macrocephenchelys sumodi.* Marine shrimps detected were *Cuapetes purushothamani* and *Alpheus sulcipalma.*

Gymnothorax tamilnaduensis is a new species of short brown unpatterned moray eel, described, based on specimens collected from the trawl bycatch landings at Mudasalodai fish landing centre, off Cuddalore coast, Tamil Nadu, southeast coast of India.

Conger melanopterus is described from specimen collected from Coachel, off Kanyakumari, Southwest coast, Tamil Nadu, Arabian Sea.

Rhynchoconger bicoloratus is described based on specimens collected from the deep-sea trawlers landing at Kalamukku fishing harbour, off Kochi, Kerala,

Gymnothorax tamilnaduensis

Conger melanopterus

Rhynchoconger bicoloratus

Ophichthus nigroventralis

Macrocephenchelys sumodi

Cuapetes purushothamani

Alpheus sulcipalma

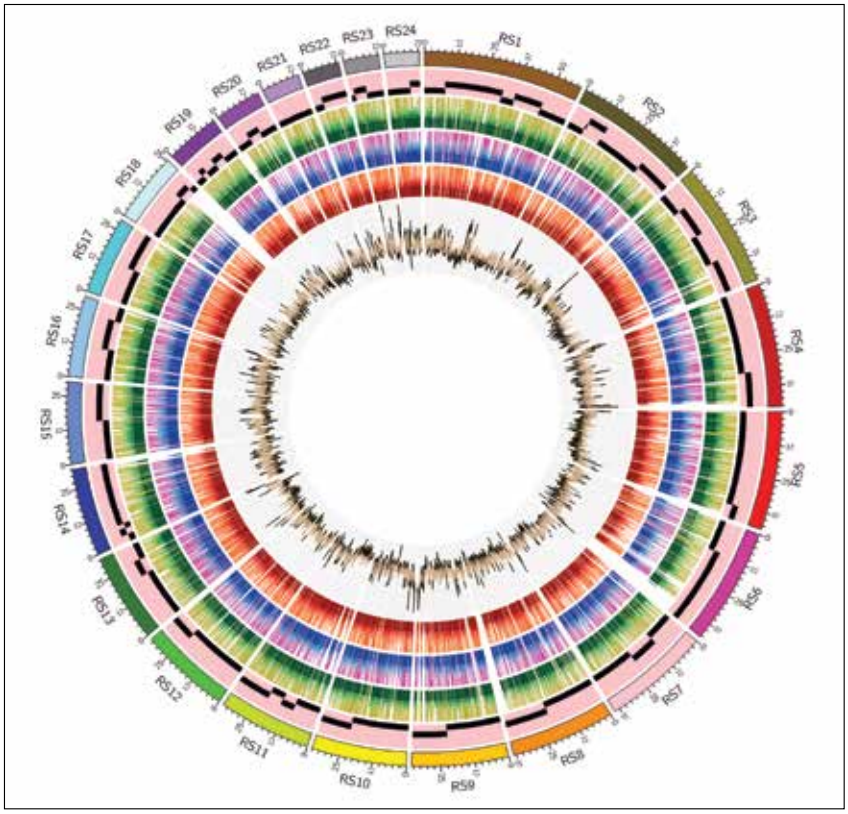
Arabian Sea, from a depth beyond 200 m.

Ophichthus nigroventralis has been described based on five specimens collected from the deep-sea trawl landings at Kalamukku fish landing centre, Kochi, Kerala.

Macrocephenchelys sumodi is described based on specimen collected from the deep-sea trawl landing at Kalamukku fish landing centre, Kochi, Kerala, Arabian Sea.

Cuapetes purushothamani is described based on specimens collected from dead coral and rocky shore regions of eastern lagoon of Agatti Island (0.5-1.0 m), Lakshadweep, India.

Alpheus sulcipalma is described based on the specimens collected from the intertidal zone of Agatti Island, Lakshadweep, India at 0.5-1.0 m depth.



Genome assembly of mangrove red snapper. Track 1 (outermost) – representation of assembly scaffolds; Track 2 – contigs in corresponding scaffolds; Track 3 – predicted genes and their lengths; Track 4 – isoform sequences supporting genes; Track 5 – short RNA sequence reads supporting genes; Track 6 (innermost) – GC content.

Characterization of whole genome assembly

Mangrove red snapper, *Lutjanus argentimaculatus,* a marine food fish of economic and aquaculture importance was found to comprise genome of 1.04 Gb length containing 521 scaffolds with N50 metric of 32.5 Mb. The longer 24 (equal to haploid chromosome number) scaffolds covered about 768 Mb of genome length. Further, the mangrove red snapper genome has been predicted to contain 31,969 protein encoding genes. The whole genome information provides a new perspective for the genomics studies of cultivable mangrove red snapper with potential applications in the management and selective breeding programmes in future.

Decoded the whole genome of Indian oil sardine (*Sardinella longiceps*), a popular marine food fish. This is the first time that the genome of a marine fish species from the Indian subcontinent has been decoded. The decoded genome is 1.077 Gb in size and contains 46,316 protein coding genes. This fish is a trans-boundary resource and the whole genome information can also be utilised for certification of the fishery and identification of the origin of catch for monitoring clandestine trade and tracking the movement of this enigmatic fish.

Genetic and genomic investigations showed that Indian oil sardines exist in two highly distinct stocks, one in the Indian waters and another in the Gulf of Oman. The genome assembly of the sardines is a valuable tool for studying how fish adapt to climate change. Also identified the genes involved in biosynthesis of polyunsaturated fatty acids (PUFA) of the oil sardine, offering insights into the genomic mechanisms behind the high nutritional quality of these sardines.

Mangrove red snapper, *Lutjanus argentimaculatus*

National Fish Museum and Repository at ICAR-NBFGR, Lucknow

National Fish Museum and Repository dedicated to the Nation

National Fish Museum and Repository established at the ICAR-NBFGR, Lucknow, was dedicated to the nation on 14 April, 2023 by the Hon'ble Secretary, DARE and Director General, ICAR. The newly developed museum displays finfish and shellfish voucher specimens of freshwater, marine, and brackishwater environments for research and education. The museum also holds a radiographic facility to comprehensively understand fish morphological feature. The museum presently holds specimen of 1,200 finfish and 250 mollusc species found in India and aims to hold voucher specimens of all finfish and shellfish resources of India in future. The DNA and Tissue repository at museum contains 19,000 tissue accessions belonging to commercial/prioritized fish species useful in retrieval of genetic information as well as beneficial genetic manipulation in future, with technological advancements. It also developed houres cryopreserved fish sperms of 31 fish species that can be used to retrieve the endangered species and also for supplying it to different commercial hatcheries upon request, for captive or artificial breeding of fishes. National Repository of Fish Cell lines which is world's largest collection of fish cell lines with 81 cell line accessions is also located in this museum as a valuable resource for supporting fishery research in a non-invasive manner for enhancing fishery production across the country.

❑

6. Crop Management

CROPS

Crop Production

Diversified pulse-inclusive conservation agriculture (CA) module (s) for northern Indo-Gangetic Plain: A field experiment was initiated to develop a cropping system aimed at achieving higher overall system productivity, enhancing resource-use efficiency, and improving soil health to bolster climate resilience. The experiment included 10 diversified upland cropping systems: rice (DSR)-wheat (R-W), rice (DSR)-wheat-mungbean (R-W-Mb), rice (DSR) + dhaincha–wheat–mungbean (R+Dh-W-Mb), rice (DSR)–chickpea + mustard (in a 6:2 ratio) (R-C+Md), Rice (DSR)–mustard–mungbean (R-Md-Mb), maize-wheat (M-W), maize–wheat–mungbean (M-W-Mb), maize–chickpea + mustard (in a 6:2 ratio) (M-C+Md), pearl millet – lentil + linseed (in a 4:2:2 ratio) (Pm-L-Ls), and maize + dhaincha (*In-situ* GM)–chickpea–mungbean (M+Dh-C-Mb). In terms of system productivity, as measured by mungbean equivalent yield (MbEY), the highest yields were observed in the R+Dh-W-Mb system (4,499 kg/ha), followed by M+dhaincha-C-Mb (4,344 kg/ha). The results further indicated that system productivity can be significantly improved by incorporating summer mungbean into rice-wheat and maize-wheat systems under conservation agriculture (CA). Net returns and benefit-cost ratios were maximized in the M+Dh-C-Mb system (₹ 2,35,788/ha), followed by M-W-Mb (₹ 2,06,650/ha). More than 100% increase in net return was recorded in recommended cropping systems over rice-wheat and maize-wheat cropping systems under CA practices. Soil quality parameters (physical, chemical and biological) have shown improvement over traditional practice of rice/maize-wheat system.

Herbicides for efficient weed control in mungbean: A new-generation ready-mix herbicide, Clodinafop-propargyl + Na-acifluorfen (CPNaA), found promising for post-emergence weed control, has demonstrated increased efficacy in mungbean. In a field experiment conducted during the 2020-2022, this herbicide (24.5 EC: ready-mix) was tested at three different doses (122.5, 183.5, and 245 g a.i./ha) and applied at four different times (10, 15, 20, 25 DAS). The study also included unweeded control (UWC) and weed-free check (WFC) treatments to optimize dosage and timing. The application of Clodinafop-propargyl + Na-acifluorfen (CPNaA) at 183.5 g/ha between 15-20 days after sowing significantly improved results in terms of weed control efficiency, mungbean yield, and economic returns compared to the other treatment combinations.

Development of sub-surface drip fertigation system in maize-wheat system: The lateral with built-in drippers at 30 cm interval have been established 45 cm apart a depth of 20 cm below the soil surface. In maize, sub-surface drip fertigation (SSDF) of 50% recommend phosphorus in 3 splits resulted in similar yield as 100% RDP, either fertigated or conventionally applied. Skipping P caused 20–30% yield reduction.

In wheat, NDVI values were similar among 50% RDP given in 2 splits, 75% RDP and 100% RDP under SSDF; all were better than 100% RDP applied in conventional way under surface (border irrigation). Fifty percent RDK applied through SSDF resulted in 9.5% higher grain yield over 100% RDK in conservation tillage and about 20% higher than 100% RDK under conventional tillage. Under sub-surface drip fertigation (SSDF), an increase in K dose beyond 50% RDK did not bring significant yield improvement, hence a 50% K saving is possible through SSDF. Highest AE_K and KUE were also found with 50% RDK through SSDF. Giving 50% DRK in 3 splits stood at par with 75 and 100% RDK applied in 3

Sub-surface drip fertigation system in maize-wheat system

Precision irrigation in field pea under conservation tillage practices

Improving resourc-use efficiency, with a specific focus on water management, stands as a top priority in sustainable crop production research. A fixed plot field experiment showed that adopting zero tillage (ZT) in both crops in combination with sprinkler irrigation during branching and pod development stages of field pea led to enhanced productivity, profitability, and water-use efficiency in the maize-field pea system. It is worth noting that ZT outperformed conventional tillage (CT) in terms of grain yield, biomass production, and the overall economics of the system. Zero tillage resulted in significantly higher water-use efficiency (119.5 kg/ha-cm) and water productivity (1.37 kg of crop biomass per 1,000 L of water), both of which were markedly superior to the RT and CT practices. Additionally, ZT led to a notable 17.6% increase in soil organic carbon compared to the CT.

Selected rice genotypes with contrasting GI values and variable AC and RS

Rice genotypes	Glycemic index	Amylose content (%)	Resistant starch (%)
IG 40 (Kohila)	56.00	24.52	1.89
IG 23 (Shamjira)	52.49	15.65	2.28
IG 72 (UPR 3506-7-1-1)	63.00	12.25	0.64

or 4 splits for water productivity. Applying 50% RDK in 4 splits was significantly superior to 100% RDK applied without drip under CA under CT.

Designing biointensive cropping system for profit maximization and environmental sustainability: Legume integration with cereal proves superiority over other combinations. Temporal integration of maize + blackgram (raised bed) + soybean (furrow)-chickpea (raised bed) + wheat (furrow) (3:2)-greengram (raised bed) + sunflower (furrow) (5:1) was found economically feasible by recording higher productive efficiency (175%) concerning maize-wheat systems with the lowest greenhouse gases intensity (GHGI).

Designing biointensive cropping systems

Identification of determinant for low glycemic index rice: Generally, rice with high amylose content (AC) exhibits slower starch digestion resulting in slow rise of postprandial blood glucose level. In addition to AC, linear chains of amylopectin also affect the rate of starch digestibility. The values of glycemic index (52.49-63.0), resistant starch (RS) (0.64%-2.28%) and AC (3.82-24.52%) were found to vary widely in 110 rice genotypes. Genotypes IG 23 and IG 40 with contrasting AC revealed that amylose alone did not affect digestion rate. Starch morphology, bio-accessibility and pasting properties differed noticeably between the genotypes. Starch debranching enzyme pullulanase assay indicated the role of linear amylopectin chain in crystallized RS formation within the grains. This is probably the first report on the natural presence of high RS (crystallized) in rice (IG 23) with lower AC exhibited low GI value (52.49).

Chilli and turmeric as promising alternate crops to tobacco in Andhra Pradesh: Among different crops/ cropping systems studied system productivity in terms of tobacco leaf equivalent yield (TLEY) was high in chilli (2,416 kg/ha) followed by turmeric (2,172 kg/ha) compared to fallow-tobacco (1,645 kg/ha) and other

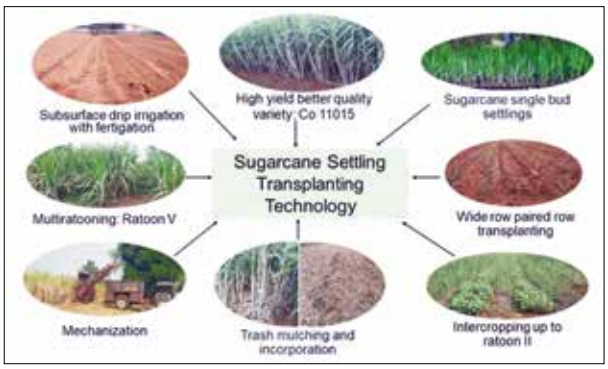
Development of economically efficient and environmentally robust Integrated Farming System model

An IFS model (1-acre area) comprises polyhouse cultivation of vegetables (600 m^2 area for cultivation of tomato, capsicum, and cucumbers), mushroom production (50 m^2 area), agri-horti system (1,200 m^2 area), apiculture and open field cultivation of vegetables, flowers, cereals, oilseeds and pulses on 2,200 m^2 area was for small and marginal farmers developed. The IFS model is economically efficient and environmentally robust and has the potential to generate a net income of ₹ 1,75,650 per year.

Integrated farming system model

tobacco based cropping systems. Gross returns (GR) and net returns (NR) were also high in chilli (GR-₹ 3,96,297/ ha and ₹ 2,06,297/ha) followed by turmeric (GR-₹3,56,180/ha and NR- ₹1,76,180/ha) compared to fallow tobacco (GR- ₹ 2,69,698/ha and NR- ₹ 1,44,498/ha).

Sugarcane settling transplanting technology: A sugarcane cultivation model combining nine improved sugarcane cultivation practices named as Sugarcane Settling Transplanting Technology (STT) was established at ICAR-Sugarcane Breeding Institute, Coimbatore, and was evaluated for reducing cultivation cost, improving productivity, increasing profitability and ensuring sustainability in sugarcane agriculture over conventional method.



Sugarcane settling transplanting

Iron deficiency management in Sugarcane: Drone spraying of 2.5% $FeSO_4$ in 25 litres ha^{-1} is recommended to correct the iron deficiency symptoms during tillering phase in sugarcane. If the deficiency symptom reoccurs, one more foliar spraying is recommended at 30 days intervals.

Spraying of $FeSO_4$ using drone

Sugarcane 21 days after spraying of $FeSO_4$

Evaluation of CAM variants for salinity tolerance and expression of CAM: To understand the phenomenon of CAM (Crassulacean Acid Metabolism) involved in imparting salinity tolerance, an experiment was undertaken with groundnut variety TG37A and two of its C3-CAM transited and drought tolerant variants with soil salinity level of around 3.95 at harvest. It was found that while imposition of salinity at 3.95 of soil EC reduced the biomass production in the cultivar TG37A by almost 48% (6,143 kg/ha in normal soil condition to 3,208 kg/ha in around 3.95 soil EC in TG37A), the over-expressive C3-CAM transited variants of TG37A like DGRMB19 minimized the biomass reduction (6,787 kg/ha on normal condition to 4,777 kg/ha) and maintained at 30% level of reduction. Both the CAM transited genotypes performed significantly superior than TG37A.

Long-term effect of sewage water irrigation on heavy metal accumulation in soil-fodder-animal continuum: The soil, fodder, animal milk and blood samples were collected from long-term sewage water-irrigated peri-urban areas of Kanpur, Varanasi and Bhopal. Soil, fodder, milk, and blood samples of animals were analyzed for heavy metals, viz. chromium (Cr), nickel (Ni), cadmium (Cd), and lead (Pb) using an Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES). The heavy metal contents in the sewage water-irrigated soil were within the safe limit except for the sewage water-irrigated surface soil of Varanasi, while Ni content has crossed the maximum permissible limit (20 mg/kg) in the soil at all the locations. Irrespective of locations, heavy metals accumulation was higher in fodder bajra (Cr, Ni and Pb, 8.36-13.17, 7.78-9.20, 7.53-7.54 ppm, respectively), followed by fodder sorghum (Cr, Ni and Pb, 10.66-10.29, 5.21-5.36, 5.62-6.60 ppm, respectively), berseem (Cr, Ni and Pb, 9.46-9.51, 4.28-4.43, 5.17-6.65 ppm, respectively) and fodder maize (Cr, Ni and Pb, 9, 4.13, 5 ppm, respectively). Furthermore, the residue levels of Cd and Pb in animal milk (0.189-0.199 and 0.267-0.296 ppm Cd and Pb, respectively) and blood (0.088-0.257 and 0.520-2.486 ppm Cd and Pb, respectively) samples were found to be higher than the maximum permissible limit in Kanpur and Bhopal, except for Cr in blood samples in both locations, which was lower than the maximum permissible limit (1.0 mg/L). Irrigation with sewage water increases fodder yield and the quality because of its high nutrient content. At the same time, heavy metals were significantly taken up by the fodder crops, which was evident from the Cr and Pb contents being higher than the maximum permissible limit in fodder crops, animal milk and blood. Therefore, based on this study, a combination of lesser heavy metal accumulating fodder crops (Fodder Oat, Berseem and Fodder Maize) and suitable dilution ratio of sewage water (1:3 ratio, sewage water: ground water) practices should be adopted for long term irrigation with sewage water to minimize heavy metals accumulation in the soil-fodder-animal continuum.

- The seed yield of castor was significantly influenced due to different tillage practices and

PGR Technology to augment Sugarcane Crop and Sugar Yield

A technology to augment sugarcane crop and sugar yield has been developed at ICAR-IISR, Lucknow through exogenous interventions of plant growth regulators, viz. GA_3 and Ethrel at four critical stages of crop growth cycle that resulted in faster germination of cane setts, enhanced shoot population, development of smart canopies and robust root system, more number of millable canes and increased cane height, weight and yield.

intercropping systems under rainfed conditions in Alfisols. Significantly, the highest seed yield and equivalent yield of castor, was realized under conventional tillage (1,758, 2,452 kg/ha) which was at par with reduced tillage (1,652, 2,294 kg/ha) and lowest seed yield was recorded in zero tillage (1,244, 1,972 kg/ha). Among intercropping systems, the highest CEY was registered in castor + groundnut intercropping (2,640 kg/ha) followed by castor + redgram (2,389 kg/ha) and sole castor (1,907 kg/ha).

- Soil organic carbon (SOC) was significantly influenced due to tillage practices and the highest SOC content was found under reduced tillage (0.64%) followed by the zero tillage (0.63%) and the lowest was observed in conventional tillage (0.56%). Among the intercropping system highest soil carbon content was found in castor + redgram (0.67%) followed by castor + greengram (0.65%), castor + groundnut (0.60%) and lowest SOC was found in sole castor (0.57%).

Dose-dependent impact of zinc oxide nanoparticles on chickpea: Zinc (Zn) is an essential element for maturity and development of plants. It also controls the production of oxidative free radicals and detoxifies biological processes. Coating of important compounds around seed is one of the successful and established delivery methods of agricultural inputs. Study was undertaken to assess the nanoparticle delivery through seed coating (polymer-based method) in chickpea (*Cicer arietinum*). The study was initiated with chemical driven synthesis, characterization and coating of ZnO NPs. The work was further followed by evaluation of coated NPs' impact on germination and growth of chickpea along with influence on rhizospheric bacteria. In this context, the impact of nano-based seed coating on Zn responsive gene expression was also assessed. The size of the synthesized ZnO NPs was 79 nm determined through Dynamic Light Scattering (DLS) technique. To study the germination percentage (%), a dose ranged between 25 to 250 ppm was considered. Amongst these doses, 25 ppm of ZnO NPs exhibited 100% germination with the highest root and plumule length. In the same dosage, the microbial consortia in rhizospheric soil exhibited sustainable profiling and highest antioxidant activity in SOD and CAT enzyme assay, i.e. 5.50 and 0.30 units/mg. Leaves and seeds coated with 25 ppm of ZnO NPs showed highest accumulation rate, i.e. 0.035 and 0.04 mg/g estimated through ICP-OES and exhibited higher expression of zinc responsive genes (*SOD*, *ZIF-1*, *HMA3*, *VOZ*). Based on these findings, this ZnO NPs dose can be recommended for the improvement of yield and germination in chickpea.

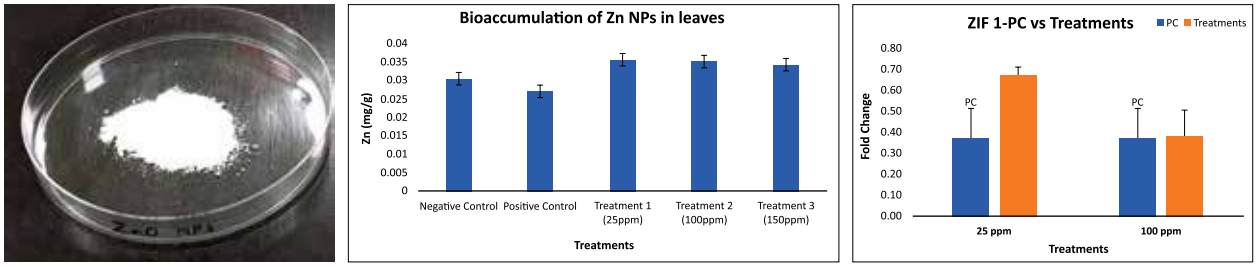
Efficacy of Vip3Aa proteins for the control of agronomically important lepidopteran pests

Four full length *vip3*-type genes *vip3Aa44, vip3Aa67*, *vip3Aa69* and *vip3Aa70* (NCBI GenBank Accession Numbers HQ650163, MN120477, MN120479 and MN120481, respectively) were isolated from *Bacillus* subsp *thuringiensis* (A6) and Bt isolates SK-792, SK-986 and SK-851, recovered from diverse habitats in India. These genes were overexpressed in *E. coli* and the efficacy of these proteins was evaluated. The Vip3Aa proteins showed LC_{50} ranging from 0.91 µg/g to 10.59 µg/g to *Helicopverpa armigera* (cotton bollworm, pod borer) and LC_{50} of 3.53 µg/g to 20.18 µg/g towards *Spodoptera litura (*cotton leafworm). These Vip3Aa proteins caused growth retardation and sub-lethal effects such as malformed, decreased, delayed pupation and adult formation at different developmental stages in the whole life cycle of *H. armigera* and *S. litura*. These *vip3Aa* genes have potential in deployment for crop protection for lepidopteran pest control.

Growth retardation and reduction in larval weight of *S. litura* larvae upon treatments of different toxins at 10 ppm as compared with control in laboratory bioassays on semi-synthetic diet under controlled condition (temperature 25±2°C, RH 50±10%).

Crop Protection

Novel oil-based entomopathogenic fungal bio-insecticide formulations for management of CLCuD vector *B. tabaci*: Entomopathogenic fungal isolates (EPFs) were collected from whitefly cadavers through the survey in the North cotton-growing zone of India and from NBAIM and ITCC. A pool of 373 EPFs was evaluated for their bioefficacy against whitefly (*Bemisia tabaci*) under polyhouse. The most virulent EPFs were also evaluated for their compatibility with 17 insecticides



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(a) Chemically synthesized zinc nanoparticles; (b) Bioaccumulation of ZnO nanoparticles in chickpea leaves; and (c) Comparison between dose 1 (25 ppm) and dose 2 (100 ppm) vs PC in *ZIF-1* gene.

recommended for the management of cotton whitefly in the laboratory and field conditions. Overall, EPF strains *Beauveria bassiana* (Bb)-4511, *Cordyceps javanica* (Cj)-102, and *Metarhizium anisopliae* (Ma)-1299, were found compatible with full and half doses of the chemical and botanicals and showed highest nymphal mortality (80-95%) at on-station polyhouse and field trials (2017-18 and 2020-21). The oil-based formulations of Cj-102, Ma-1299, and Bb-4511 were developed and further evaluated for three consecutive seasons under AICRP on Cotton at multilocation trials (2020-21 to 2022-23) under IPM and Biomodule treatments. These three bioinsecticide formulations exhibited better bioefficacy in terms of insect mortality; their compatibility with chemical/botanical insecticides can cause increased stress, immunocompromise and alteration in insect physiology (mortality and fecundity) under field conditions. These novel oil-based formulations are water-dispersible liquid bio-insecticides having >1 × 10^8 cfu/ml with good tank mixing/stability (48 hr), and a shelf life of >12 months. Upto 86.3%, reduction in whitefly nymphal and adult population, 15-30% reduction in CLCuD severity and 20-50% increase in seed cotton yield was recorded under conventional, IRM/IPM and organic/natural cotton cultivation systems. The ICBR on net income under IPM and biomodule ranged from 1.9 to 2.2.

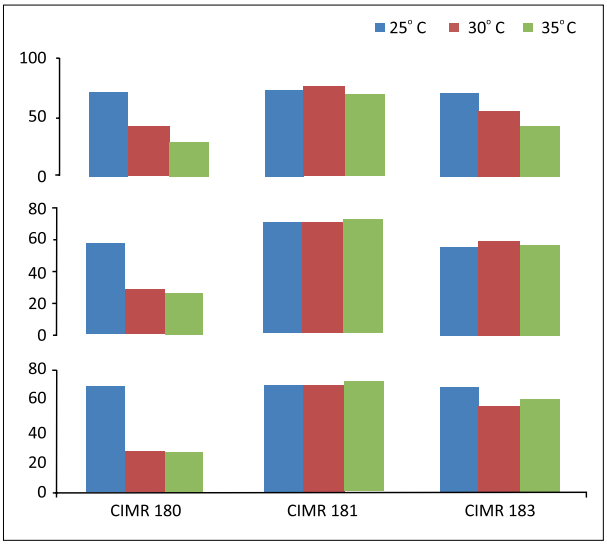
The formulations have the scope as an alternative solution for whitefly CLCuD vector in cotton under IPM and organic farming system. The following three ICAR-CICR technologies of the above mentioned formulations can be commercialized after the generation of toxicological data: *ICAR-CS-CICR-Technology-2023-025*: Oil-based entomopathogenic fungal bio-insecticide formulation (*Beauveria bassiana* CICR RS-Bb-4511 @10^8 cfu/ml): CICR Cotpest Guard-2 (NAIMCC-F-04402); *ICAR-CS-CICR-Technology-2023-026*: Oil-based entomo-pathogenic fungal bio-insecticide formulation (*Cordyceps javanica*–CICR-RSS-Cj-0102 @10^8 cfu/ml): CICR Cotpest Guard-1 (ITCC-10499.17) and *ICAR-CS-CICR-Technology-2023-027:* Oil-based entom-opathogenic fungal bio-insecticide formulation (*Metarhizium anisopliae CICR-RS-Ma-1299* @1×10^8 cfu/ml): CICR Green Guard-1 (NAIMCC-F-04455).

CICR Cotpest Guard-2

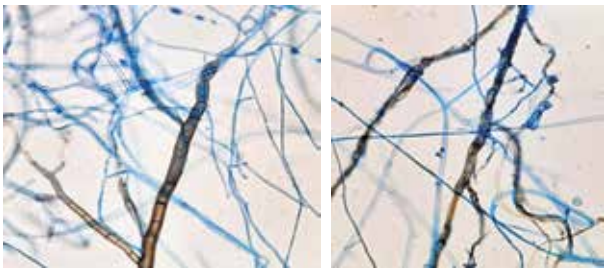
CICR Cotpest Guard-1

CICR Green Guard-1

Effect of temperature on growth inhibition of *Trichoderma* isolates: On the basis of antagonistic effects, CJMR180, CJMR191, and CJMR193 isolates of *Trichoderma* were found promising against *M. phaseolina, Rhizoctonia* sp. and *Sclerotium* sp., causing diseases in flax and jute. These isolates maintained the antagonistic property at higher temperatures, although CJMR180 and CJMR193 were more sensitive than the others. At elevated temperatures up to 35°C, CJMR191 maintained its pathogen inhibition efficiency. Moderately effective isolates, viz. CJMR180 and CJMR193, possess some special characteristics, such as plant growth promotion. The compatibility of the selected isolates was maintained under variable temperatures; hence, they are suitable for consortium development. The effect of *Trichoderma* on *M. phaseolina* mycelia indicated that the bioagents caused de-melanisation, breakage at the cross wall, and disintegration of the pathogen's mycelia.



Growth inhibition of *M. phaseolina*, *Rhizoctonia* sp. and *Sclerotium* sp. by *Trichoderma* isolates *in vitro* at varying temperatures

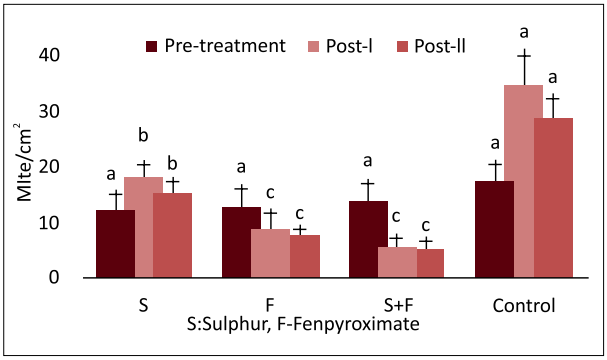


Broken and disintegrated mycelia of *M. phaseolina* due to interaction with *Trichoderma* isolates

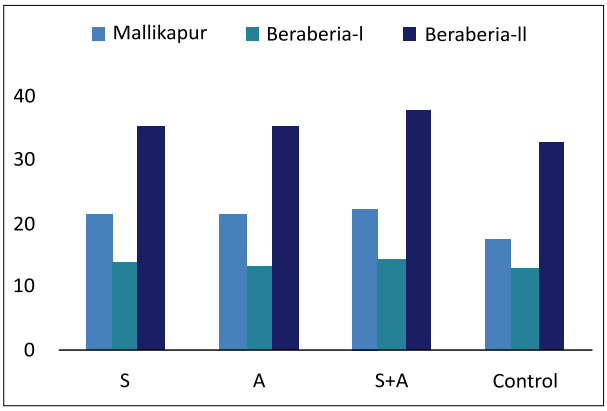
Integrated management of yellow mite of jute: The integrated effect of the moderate mite-tolerant jute variety (JRO 204) along with preventive soil sulphur nutrition and foliar sprays of acaricide was evaluated under farmers' field conditions at Beraberia (2 locations) and Mallikapur, North 24 Parganas. The role of soil-applied sulphur @ 45 kg/ha at the time of sowing and foliar application of fenpyroximate 5EC @ 1.5 ml/l (45

and 55 DAS) individually and in combination could significantly suppress the population of yellow mite under farmers' field conditions, indicating a significant role for these components in regulating the mite population. Sulphur alone was also effective, reducing mite infestation by 50% compared to the untreated control. The pest management components, comprising soil sulphur and acaricide application, exhibited superior performance on yield. Among the three villages, the highest yield of 37.70 q/ha was obtained with this treatment at Beraberia II village. In this village, the yields in the control plot was 32.80 q/ha.

Risk assessment through modeling of major pests and diseases of jute: Different models were fitted to obtain the development rate r (T) of different immature stages (egg, larva, and pupa) of the indigo caterpillar, a polyphagous pest of jute. The Sharpe and DeMichele models were used for estimating the nonlinearity of egg development. The Logan model was used to estimate the nonlinearity in larvae development rate, and a modified version of the Janish-1 model was used to describe the effect of temperature on pupae development rate. A GIS map of the generation index (GI) and establishment risk index (ERI) of the indigo caterpillar under different climate change scenarios, viz. RCP 2.6, RCP 4.8, RCP 6.0, and RCP 8.5, was developed for the periods 2021–40 and 2061–80. From ERI for the period 2021–40 under different climate change scenarios it was observed that due to the increase in temperature, infestations of indigo caterpillars will be more common in the future under all the climate change scenarios, and the occurrence of indigo caterpillars can be observed in different areas where at present the pest is not that significant.

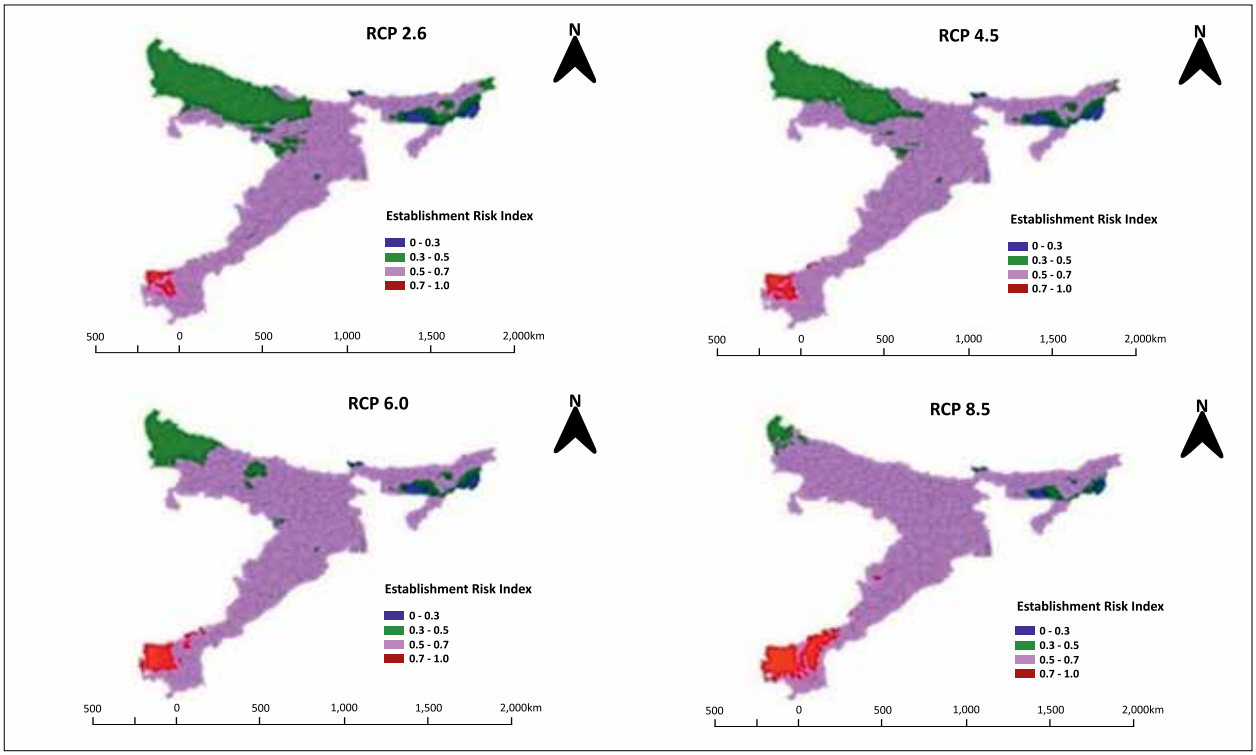


Mean yellow mite infestation trend in farmers' field of three locations



Village-wise fibre yield (q/ha) of jute

Monitoring of pesticides in small streams adjacent to paddy fields of Odisha: Small streams situated close to agricultural landscape could be contaminated with pesticides and may hamper the aquatic biodiversity. The highest mean concentration of fenobucarb (272 ng L^{-1})



Establishment risk index (ERI) of indigo caterpillar under different climate change scenarios during 2021-40

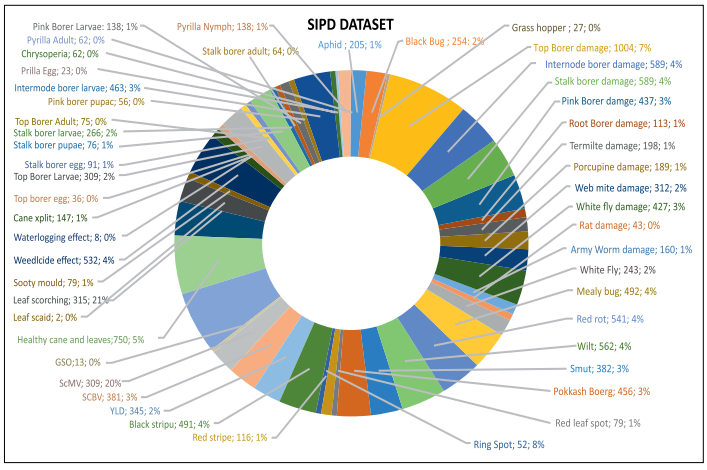
Mass multiplication of pupal parasitoid, *Tetrastichus howardi* on stored top borer pupa

Sugarcane top borer pupae stored for 10-30 days were found suitable for mass multiplication of pupal parasitoid Tetrastichus howardi, in terms of adult emerged/pupa, female emergence and number of progeny/pupa for sugarcane borer management by ICAR-IISR, Lucknow, solving thereby, the problem of obtaining large numbers of suitable hosts at the time of mass multiplication.

Stored pupae of top borer as host

Emergence of *T. howardi* from top borer pupa

was detected, followed by thiamethoxam (199 ng L^{-1}). The highest detection frequency was recorded for insecticide fenobucarb (80.00%) followed by herbicide pretilachlor (79.00%). Maximum number of pesticides were detected in October followed by September. The highest RQmax values were observed in case of fenpropathrin (1,347) followed by cyfluthrin (589). The present study reveals that small streams are polluted with pesticides and there is an urgent need to develop strategies for reducing the pesticide pollution in small streams and their harmful effects on non-target organisms.



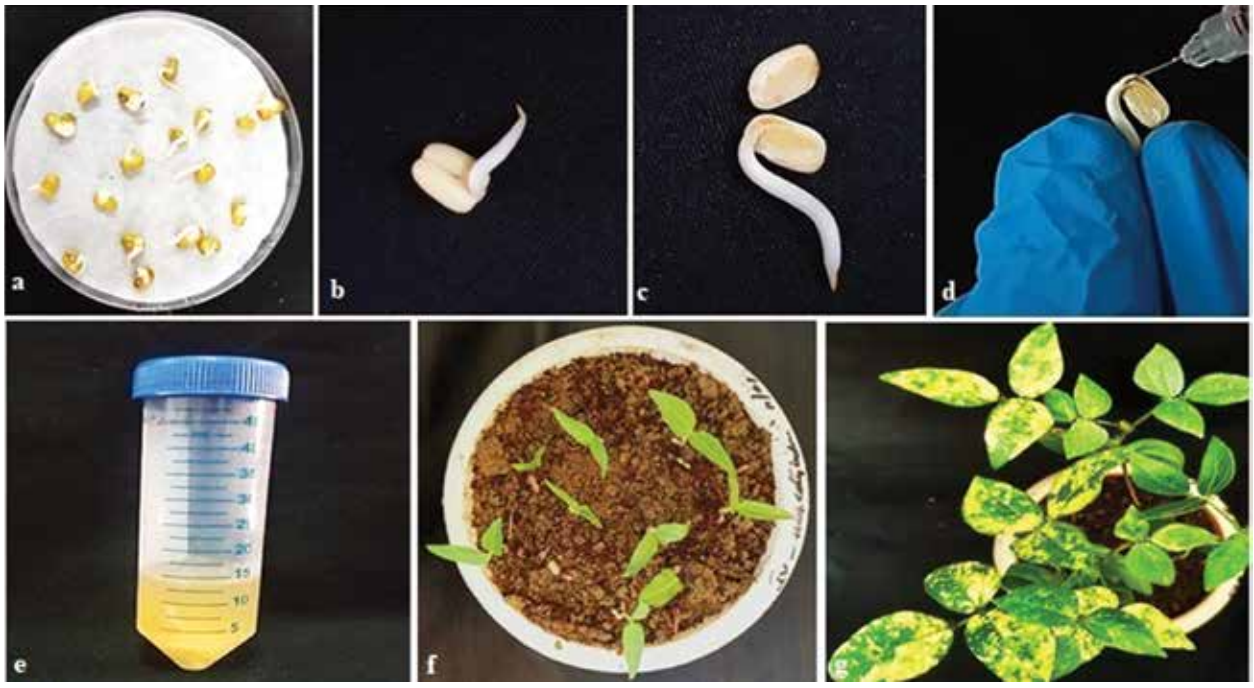
AI-based detection of pests and diseases in sugarcane

Artificial intelligence-based detection of insects, pests and diseases of sugarcane: In order to develop an AI based detection system for insect pests and diseases of sugarcane, >2,500 RGB images of healthy sugarcane plants as well as with injured symptoms of insects, pests, diseases, and physiological disorder symptoms have been captured at ICAR-IISR, Lucknow.

Improved agroinoculation method for begomovirus infection in mungbean and urdbean: An efficient and reproducible agroinoculation method for achieving maximum (100%) efficiency using infectious agro-constructs of DNA A and DNA B of MYMIV. Among the various tissues selected for the inoculation on the epicotyl region showed maximum infectivity. Further, to enhance the infectivity of MYMIV, different concentrations of acetosyringone, incubation time and Agrobacterium cell density were also standardized. Pin-pricking on the epicotyls region of detached one cotyledon of sprouted seeds of mungbean and incubated in 1.0 OD of agroculture containing repeat construct of MYMIV for 2-4 hr without acetosyringone followed by sowing in soil showed 100% infection of MYMIV within 10-12 days on the first trifoliate leaf. This standardized method is reproducible and has potential to screen germplasm lines and will be useful in mungbean biological/virological studies and breeding programmes.

Leaf damage-based phenotyping technique against fall armyworm (FAW) in maize: A screening technique to identify the resistance source against FAW under artificial infestation has been developed. The technique involves the description of leaf damage rating (LDR) in 1-9 scale by comparing injury levels among maize genotypes. Exposure to 20 neonate FAW larvae at V_5 phonological stage coupled with the adoption of LDR on a 1-9 scale aided in preliminary characterizing maize genotypes as resistant, moderately resistant and susceptible rating scale describes the proportion of damaged leaves and elongated lesions so that fine differences in damage levels can be estimated.

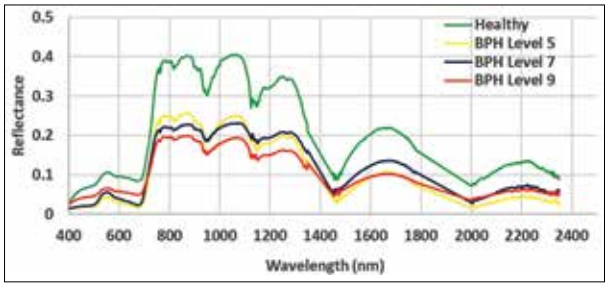
A portable device for LAMP-based detection of pathogens: Molecular diagnosis outside a laboratory set up is very difficult, especially in the agriculture sector. Farmers often notice visible disease symptoms on crops but since laboratory accesses are limited, such situations go unnoticed resulting in huge losses in crop production. Timely and cost-effective detection of such symptoms on the field scale may be a boon to the farmers. ICAR-NBAIM has developed a low-cost portable device to be used in field conditions. It is a compact electronic device with a temperature control system that can heat water to a desired temperature and maintain optimum reaction temperature for performing isothermal amplification reactions in the field



Stepwise procedure of agroinoculation method by detached one cotyledon of sprouted seeds using dimer constructs of MYMIV DNA A and DNA B. (a) Germinated seeds after incubation for 24 h, (b) germinated seed after removal of seed coat, (c) detachment of one cotyledon from the seed coat removed germinated seeds, (d) pin-pricking at the site of epicotyl, (e) incubation of pin-pricked with agroculture containing MYMIV (both DNA A and DNA B) at 180 rpm, 28 °C for 2 h, (f) sowing and growing of agroinoculated seedlings, (g) development of yellow mosaic symptoms.

as well as in laboratories. Isothermal amplification reactions (40-70°C) can be completed within 30-60 min under field conditions using the device. It is cheap as the whole assembly costs only about ₹ 300. This device was developed keeping in mind all agricultural and allied sectors where molecular diagnosis is needed.

Identification of sensitive bands for brown planthopper in rice using hyperspectral remote sensing: Combination of derivative approach of continuum removal (CR) using ENVI software package, and sensitivity analysis (SA) were used to identify peaks and dips in the sensitive region. Bands at 519, 670 and 718 nm gave maximum accuracy of about 83.66%, which indicates that the green, red and red edge regions, were mostly responsible for the detection of BPH in rice.



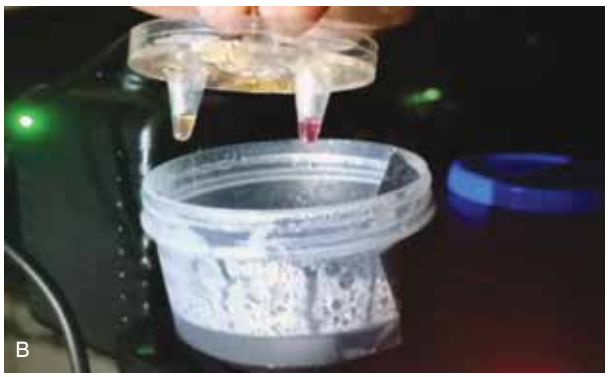
Spectral signature of Healthy vs BPH infested rice at different damage level.

Identification of resistance source for powdery mildew in sesame: A field experiments was conducted to evaluate the germplasm (n=446) of sesame including USDA germplasm. Among 446 germplasm evaluated, IC-500445 was found to be resistant to powdery mildew under natural infection. The same was confirmed with molecular methods which showed that susceptible germplasm (infected powdery mildew) was amplified than resistant germplasm (IC-500445).

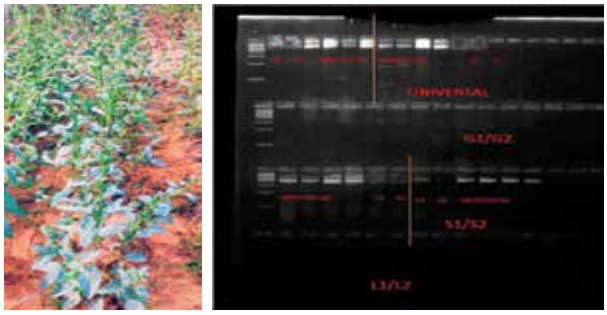
Artificial intelligence-based system for detection of leaf blight of wheat

An image analysis system using a deep learning technique has been developed to automatically identify and classify leaf blight symptoms in wheat crop. The system was trained on a large dataset of digital images of healthy and infected wheat leaves (n=1000), allowing it to accurately differentiate between different types of leaf blight complex symptoms. The results demonstrated that the AI-based image analysis system using deep learning models was able to accurately detect and classify leaf blight complex symptoms in wheat crops with high accuracy (> 90%). The study demonstrated the potential of AI-based deep learning models using image analysis for the early detection and management of wheat leaf blight complex. This technology can help farmers identify leaf blight complex infections at an early stage, enabling them to take timely management measures to prevent the spread of the disease and minimize crop losses. The proposed system offers a fast and accurate alternative to traditional visual inspection methods, ultimately improving crop yield and food security.

Image acquisition (RGB) for healthy and diseased samples (n=1000)



A) The device is connected to the power source. B) The colorimetric assay was executed with the help of the designed device for LAMP-based detection of pathogens. Yellow colour marks the presence of *Rhizoctonia solani* AG 1 IA in rice sheath, whereas pink colour denotes no template control.



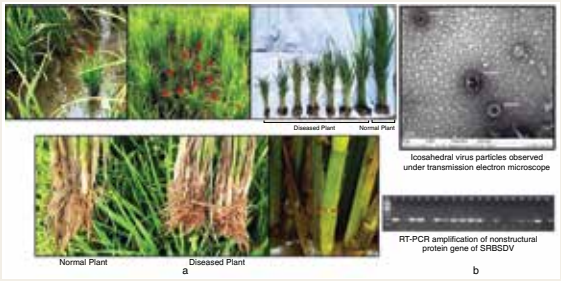
(a) Germplasm, IC-500445 showed resistance to powdery mildew and (b) amplification of powdery mildew in susceptible germplasm

Mechanisms of diapause in spotted stem borer, *Chilo partellus* : The *C. partellus* undergo in hibernation in North Indian and aestivation under South Indian agroecological conditions. The diapause has been found to have deleterious effects on post-diapause development, reproductive physiology and population build-up, and is governed by overdominance gene effects in *C. partellus*. Further, the diapause in *C. partellus* is governed by overdominance gene effects, and this information will be helpful in devising mating disruption techniques in suppressing stem borer population. The biochemical profiles are differently regulated during diapause, some of them could be constituent of heat-shock proteins and help in maintaining development during hibernation and aestivation in *C. partellus*. The hormonal regulation studies found significant increase in α-Ecdysone and Juvenile hormone, reduction in β-Ecdysone in hibernation, while no change in α-Ecdysone, and increase in β-Ecdysone and Juvenile hormone during aestivation as compared to non-diapause *C. partellus*. This information will be helpful in developing JH or Ecdysone agonist-based insecticides. The studies revealed that four different biotypes of *C. partellus, viz.* Hisar, Hyderabad, Parbhani and Coimbatore exist in India, suggesting that sorghum and maize genotypes need to be tested against these populations to identify stable sources of resistance. The first ever whole genome sequencing of *C. partellus* was carried out with genome size ≈ 332.2 Mb, which will help to identify and knockdown functional diapausing genes.

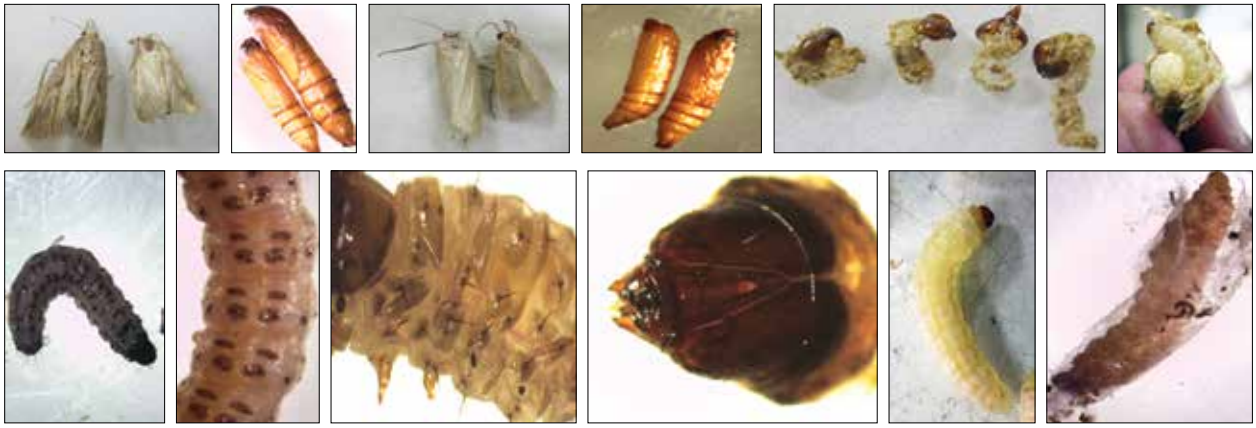
Amphiphilic polymer based controlled release formulation of chlorantraniliprole: Functionalized amphiphilic polymers based on poly (ethylene glycols) (PEGs, molecular weight of 600, 1,000, 1,500, and 2,000) and dimethyl 5-hydroxyisophthalate followed by O-alkylation with bromohexane and bromooctadecane

Deciphering the etiology of newly emerged stunting disease of rice

The concurrent reports on emergence of stunting disease of rice across the North-West Indian rice growing areas attracted attention for elucidating its etiology. Surveys of different rice fields (63.4 acres) recorded an incidence of stunting disease in the range of 1-20% in the affected fields. A systematic investigation employing three independent methods was undertaken. Under electron microscope, icosahedral virions of ~65-75 nm were observed. Based on the shape and size of virion particles and symptoms of the disease, reverse transcription-PCR and quantitative-RT-PCR of stunted rice plants and prevalent white-backed plant-hopper (WBPH) were performed using specific primers targeting two genomic components (S9 and S10) of Southern rice black-streaked dwarf virus (SRBSDV), a double stranded RNA virus of genus *Fiji virus* and the results indicated its specific association with stunting disease of rice. Sequencing of the amplified S9 and S10 genomic components showed maximum identity of 97.90-100.00% and 98.04-99.48%, respectively with SRBSDV isolates from South Korea and Vietnam. The complete genome sequence of all the 10 genomic segments (S1-S10) of SRBSDV was obtained by high throughput RNA sequencing. A high copy number of S1-S10 genomic ranging from 3,158.5-1,38,851.9 was obtained. This is the first conclusive evidence of association of SRBSDV with stunting disease of rice from India.



(a) Severely stunted rice plants under field conditions at different locations of Haryana; (b) Icosahedral particles under TEM and RT-PCR amplification of non-structural protein gene of SRBSDV

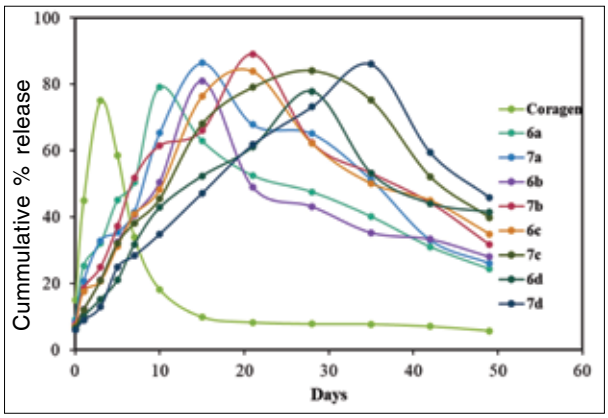


Mechanism of diapause in spotted stem borer

were synthesized. Controlled release (CR) formulations of chlorantraniliprole (CAP) were developed by encapsulating it in functionalized amphiphilic polymer. Release kinetics study suggested that maximum amount of CAP was released on 35th day for formulation 7d, 28th day from 6d and 7c, 21st day from 6c and 7b, 15th day from 6b and 7a and 10th day from 6a than 3rd day from the commercial formulation Coragen 18.5% SC. The $t_{1/2}$ of CAP release from the developed formulations ranged from 7.2-18.1 days in water while it was 1.9 days from Coragen 18.5% SC. All the developed CRFs were evaluated. *In-vitro* bioassay for insecticidal activity against *Spodoptera frugiperda* (Fall armyworm) revealed that CRF 6b formulation showed highest activity with LC_{50} value of 0.069 ppm and performed better than the commercial formulation Coragen 18.5% SC (LC_{50} = 0.072 ppm).

Bio-intensive integrated pest management in groundnut: Insect pests and diseases of groundnut can be managed with the combined practices involving (1) Border crop with 4 rows of jowar; (2) use of resistant/ tolerant variety; (3) Seed treatment with *Trichoderma asperellum* @ 10 g/kg seed; (4) Basal application of FYM (250 kg) based *T. asperellum* @ 4 kg/ha and *Pseudomonas fluorescens* @ 4 kg/ha at 30 DAS; (5) Foliar application of neem seed kernel extract (2 %) at 20, 40, 60 and 80 DAS; (6) Foliar application of *Metarhizium rileyi* @ 1 kg/ha at 30 DAS; (7) Need based foliar application of 10 % aqueous leaf extracts of *Ocimum lawsonia* and Neem at 40, 50 and 60 DAS respectively; (8) Erection of pheromone traps for *Spodoptera*, *Helicoverpa* separately @ 10 no./ha and leaf miner @ 20 no./ha ; (9) Erection of Blue and yellow sticky traps @ 25 /ha; (10) Trap crops, viz. castor and cowpea and marigold. This practice was recommended for *kharif* season crop of groundnut in Karnataka and Tamil Nadu. There was reduction in incidence of Late leaf spot by 20%; Soil-borne diseases by 15-47%; Thrips by 18%, *Helicoverpa* by 32% and *Spodoptera* by 27%, along with increase in pod yield from 9-37%, and ICBR of 1.4-2.1.

Deciphering of pod borer resistance in wild pigeon pea, *Cajanus platycarpus*: Pod borer (*Helicoverpa armigera*) is the most damaging pest of pigeon



pea (*Cajanus cajan*). Identification of resistance sources is essential for crop productivity. Our multiomics analysis in *Cajanus platycarpus*, a wild species of pigeonpea, revealed involvement of flavonoid biosynthesis pathway for pod borer resistance in *C. platycarpus.* The transcripts in pod borer-challenged *C. platycarpus* showed dynamic upregulation (up to 11-fold) of pivotal pathway genes with a concomitant increase (up to 4-fold) in the respective metabolites. Further, *H. armigera* diet overlaid with the over-produced flavonoids (100 ppm) showed deleterious effects on growth leading to a prolonged larval period. Thus the study demonstrated that flavonoid biosynthesis pathway in the wild relative plays a significant role in conferring resistance against pod borer.

- An invert emulsion formulation, viz. IIPR Lep-KILL® EW from an indigenous *B. thuringiensis* strain for managing polyphagous lepidopteran pest like pod borer (*Helicoverpa armigera*) and Bihar hairy caterpillar (*Spilosoma obliqua*) has been developed by ICAR-IIPR, Kanpur.
- Dalhanderma, a talc based multi-trait formulation of *Trichoderma asperallum* (IIPRTh-31) developed by ICAR-IIPR, Kanpur, registered (Reg No. NAIMCC-R-5) with ICAR-NBAIM, Mau for the commercialization for wilt and root rot diseases management and plant growth promotion in major pulse crops. Application of Dalhanderma @ 10 g per kg of seed give significantly increased seed germination (8% to 18.90%), shoot length (12%

Alien invasive insect pests threat to Indian Agriculture

Alien invasive insect pests are of great concern to countries in terms of affecting food supplies, disturbing ecosystem functions, posing risk to human health to economic losses. India has witnessed accidental entry and establishment of not less than 37 agriculturally important alien insect pests so far. Recently, two invasive insect pests, apple leaf blotch miner, *Leucoptera malifoliella*, (Lyonetiidae: Lepidoptera) on apple in Union territory of Jammu and Kashmir and mango soft scale, *Fistulococcus pokfulamensis* (Coccidae: Hemiptera) on mango, jamun and blueberry in and around Bengaluru have been detected. Both have firmly established and continue to spread further.

AICRP on Biological Control Centre located at SKUAST, Srinagar and ICAR-NBAIR could molecularly (NCBI accession no. OR244421), confirm the presence of apple leaf blotch miner (ALBM), *Leucoptera malifoliella* (Costa) (Lyonetiidae: Lepidoptera) as a new invasive insect pest that threaten apple production in the Country. Severe defoliation of apple (20-50%) was observed in the apple orchards during the surveys taken up in Jammu and Kashmir UT. It is suspected that ALBM might have gained entry into India along with the imported rootstock / germplasm from European nations or from any of the neighbouring Asian countries. In Asia, the occurrence of apple leaf blotch miner has been already reported and recorded in Armenia, China, Iran, Russia, Kazakhstan, Turkey, Turkmenistan and Uzbekistan.

The invasive soft scale insect, *Fistulococcus pokfulamensis* (Hemiptera: Coccidae) has been reported initially on an umbrella tree–*Heptapleurum actinophyllum* during 2022 in Bengaluru, but now it has moved to other host plants like mango, jamun and blueberry, causing significant damage on these crops both in Karnataka and Tamil Nadu.

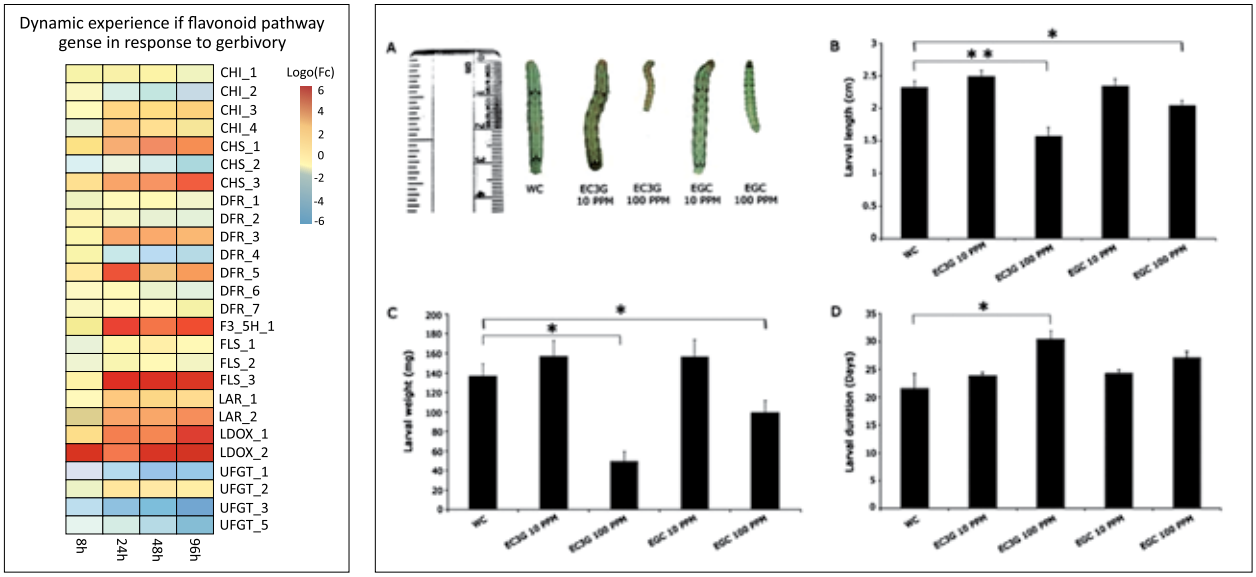
The strategies for preventing further spread and management advisories for these two new invasive pests were worked out and forwarded to the Directorate of Plant Protection, Quarantine and Storage (DPPQ and S), Government of India for further necessary action.

Damage caused by apple leaf blotch miner: a. Damaged apple tree; b. Larva inside the blotch; c. Adult male and female moths

Field appearance of *Fistulococcus pokfulamensis*: a. Females covered in a dusting of white wax; b. Females after removal of wax duct

to 38.54%), root length (15.64% to 53.76%) and plant height (5.66 to 30.49%) and reduced wilt and root rot diseases incidence (5.66 to 26.49%) and increased grain yield (10-12%) in pigeonpea, chickpea and lentil under field condition.

- A Systemic Acquired Resistance (SAR) inducer molecule was developed as coated nano formulation for smart delivery in plants, for prolonged release and tested for its plant immune inducer property in field against red rot, smut and wilt diseases of sugarcane. In field experiments, application of nano formulation significantly reduced red rot, smut and wilt incidences by 79.4%, 80.8% and 75.8%, respectively over pathogen inoculated control. The



Dynamic response of flavonoid biosynthesis pathway genes in *C. platycarpus* under continued herbivory; Response of *H. armigera* larvae to artificial diet feeding assay incorporated with water-soluble flavonoids

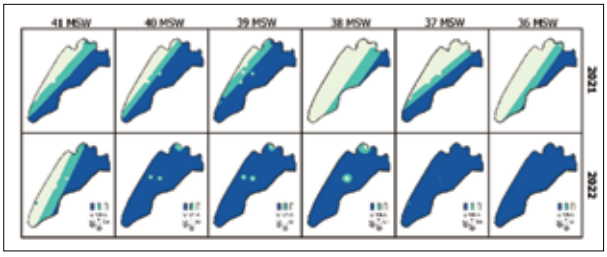
formulation applied field also registered significantly higher germination, number of millable canes and yield over pathogen inoculated control.

- A low-cost technology for mass production of white grub specific Bt isolate *Bt*-62 was developed using agro-industrial by-products and sugarcane products like juice, jaggery, trash, and by-products such as bagasse and molasses. The liquid formulation using dimethyl sulfoxide (DMSO) 0.5% and glycerol 0.5% retained maximum number of colonies for more than 300 days. Toxicity of the product observed in laboratory studies and efficacy demonstrated in field trials against *H. serrata* illustrated that the formulation can be mass-produced and used for the control of the white grub.

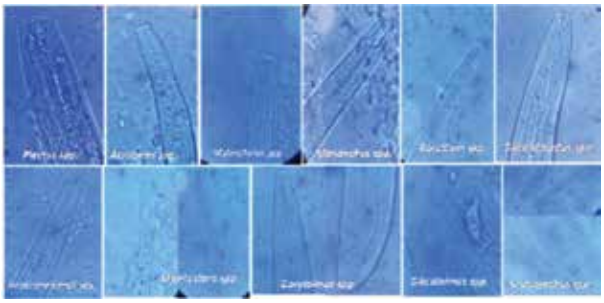
Seasonal patterns and forecasting rice pest in coastal ecosystem: Spatial and temporal distribution maps were generated for yellow stem borer (YSB) damage, leaf folder (LF) damage and Brown Planthopper (BPH) over six villages, *viz.* Ponnampeta, Batteru, Naira, Karajada, Bhyri and Singupuram in Srikakulam tehsil, Andhra Pradesh covered approx. 2,302 ha. of rice crop. A spatial autocorrelation of 260 m, 370 m and 403 m in YSB, LF and BPH population was identified in sampling area.

Application of Dalhanderma increased grain yield in pigeonpea, chickpea and lentil.

Diversity of plant parasitic and beneficial nematodes in coastal rice ecosystems: Nematode genera belonging to 21 different nematode families were identified and nematode abundance was higher at soil pH ranging from 6-6.5. Diversity index and evenness index of all locations were estimated and a high nematode diversity was observed at sampling location Selagapeta village of Santhabommalimandal, Srikakulam, Andhra Pradesh with soil pH of 5.36.



Spatial distribution map of YSB damage dead hearts.



Different nematode genus identified from north coastal district of Andhra Pradesh.

Horticulture

Crop Production

Mango-based cropping system: The mango-based cropping system with dragon fruit and pineapple as component crops exhibited higher production efficiency (85.21 kg/day/ha), economic efficiency and sustainable yield index under Bhubaneswar conditions.

Thinning of grapes: For overcoming the problem of uneven ripening in grape variety Gulabi**,** retention of 40 to 50 bunches per vine followed by the treatment of bunches with 300 ppm of ethrel at Veraison stage (berry softening) was standardized.

Uniform and uneven ripening in bunches of var. Gulabi.

Regulation of crop load in mango: Regulation of crop load @ 0.5 fruit/cm^2 of TCSA improved the fruit weight (218.5 g), proportion of Grade A fruit (56.34%) and pulp content in mango at Bhubaneshwar condition.

Fruit drop management in mango: In mango variety Banganapalli, foliar application of triacontanol (3-5 ppm) at panicle initiation stage, pea stage and marble stage increased the fruit retention,

fruit yield (36.27 kg/tree) and TSS (19.71°B).

Yield stability models for mandarins: On the basis of observations on fruit yield stability, models were developed for mandarin from the database of five centres, viz. Akola, Ludhiana, Nagpur, Sriganganagar and Tinsukia. The fruit yield per tree in Mudkhed Seedless (48.1 kg), Nagpur Seedless (47.3 kg), Nagpur Mandarin (47.3 kg), Kinnow Mandarin (62 kg), Coorg Mandarin (44.6 kg), and Darjeeling Mandarin (37.9 kg) were stable and ideal for all locations.

Crop load optimization through thinning in Solapur Lal pomegranate: Solapur Lal produces profuse flowers and surplus fruits throughout the tertiary branches, resulting in medium sized fruits. Light thinning of fruits resulted in optimum number of fruits (114.2 fruits/tree), fruit size (275.2 g/fruit) and optimum yield (31.43 kg/tree), which is superior over the control. The export quality fruits were highest in light thinning over others and was lowest in control.

Management of flower/ fruit drop in pomegranate: Spray schedule for flower/fruit drop in pomegranate was standardized. Spray application of 2, 4-D@20 ppm resulted in minimum fruit drop (19.8 flowers/ tree), percent fruit drop (10.67%), and highest fruit set (59.12%) and number of fruits (97.90 fruits/tree) besides highest yield (26.59 kg /tree).

Integrated nutrient management in sweet orange: An integrated nutrient management schedule in sweet orange was standardized. Application of 50% N (Inorganic source) + 50 % N (Organic source - Vermicompost) + 100 % P and K (100 % Inorganic - P and K supplied through Vermicompost) in sweet orange planted at 6 m × 6 m spacing resulted in significantly maximum canopy volume (20.94 m^3), plant height (3.45 m) and fruit weight (180.69 g) under Rahuri, Maharashtra conditions. However, by reducing the spacing between plants by 40 % (6 m × 4 m), significantly maximum number of fruits per tree (300), fruit yield (18.56 t/ ha) and B:C ratio (1.48) was recorded by using 75 % N (Inorganic source) + 25% N (FYM) + 100% P and K (through FYM) under Tirupati, Andhra Pradesh conditions.

Control 2,4-D@20ppm

Effect of 2, 4-D on control of flower drop in pomegranate

Nutrient management in mandarin through organic sources: Application of 75% vermicompost (on N equivalent basis of RDF) + *Trichoderma harzianum* (30-40 ml/plant) + Azadirachtin (1% at 3-4 ml/l as spray) + *Pseudomonas fluorescence* (30-40 ml/plant) recorded maximum fruit yield (77.62 kg and 58.13 kg/tree), number of fruits (433.3 and 483 fruits/ tree), fruit weight (180.19 and 120.25 g), productivity (21.53 t/ha and 23.25 t/ha) and B:C ratio (2.82 and 4.57) under Sriganganagar (Rajasthan) and Tinsukia (Assam) conditions, respectively.

Pollen storage in date palm

The date palm pollen stored under refrigerated condition and defreezed can be used up to 12 months for pollination with 65-80% fruit set as against 89 to 91% due to fresh pollen and minimum (45-55%) due to pollen stored at normal temperature.

Fruit thinning for improvement in quality of apple fruits under tall spindle training System: Two varieties (standard and spur) of apple, viz. Gala Redlum and Super Chief on M9-T339 rootstock planted at 3 m × 1 m spacing, trained in tall spindle system were manual thinned. Maximum fruit weight (171.10 g), fruit length (67.21 mm), fruit diameter (72.31 mm) and firmness (63.26 RI) was observed by retaining one fruit per cluster in variety Gala Redlum. Similarly, maximum fruit weight (198.15 g), fruit length (68.21 mm), fruit diameter (77.02 mm) and firmness (76.93 RI) was recorded in Super Chief variety by retaining one fruit per cluster.

Coconut-based integrated farming system: Integration of coconut with pasture crops (Cumbu Napier hybrid + *Desmanthus*), fodder trees (*Sesbania grandiflora* + *Leucaena leucocephala* + *Glyricidia)* and Tellicherry breed of goats recorded net income of ₹ 2,54,206/ha with BC ratio of 3.16 as compared to ₹ 1,51,312/ha with BC ratio of 2.25 in the monocrop of coconut under Aliyarnagar conditions.

Integrated nutrient management in coconut: Site Specific Nutrient Management with secondary ($CaSO_4.2H_2O$ @ 1 kg and $MgSO_4$@ 500 g/palm per year) + Micronutrient mixture ($FeSO_4$, $MnSO_4$, $CuSO_4$, $ZnSO_4$, Borax and ammonoium molybdate) @ 1 kg/palm/year + Coconut frond mulching + *Azospirillum*@ 100 g + *Phosphobacteria* @100 g + VAM@100 g/palm/year enhanced productivity by 32 % over farmers' practice in tender nut variety Chowghat Orange Dwarf. Net returns and benefit cost ratio were ₹ 4.38 lakhs/ha and 2.99 in INM package as against ₹ 3.10 lakhs/ha and 2.66 in farmer's practice, respectively.

Simulation study using INFOCROP – Potato model: A simulation study in Bankura, Hooghly, Jalpaiguri, Malda and Midnapur distrcts of West Bengal using INFOCROP – Potato model to develop adaptation strategies, i.e. the agronomic practices, to minimize/ offset the negative impact of climate change on potato varieties were used; Kufri Badshah (Long duration), Kufri Jyoti (Medium duration) and Kufri Pukhraj (Early bulking) for two climatic scenarios; RCP 4.5 and RCP 6.0 of IPCC AR5, for three-time series (years 2030, 2050 and 2080). Under RCP 4.5 scenario the mean tuber yield for Kufri Jyoti, across the location, is likely to be reduced

2 Fruits/Cluster

Control

Apple cultivar Gala Redium

2 Fruits/Cluster

Control

Apple cultivar Super Chief

by 7.5, 10.4 and 13.3% under farmer's practice (50 mm irrigation at an interval of 8 days and 200 kg N/ha in two equal splits at planting and 26 days after planting) during 2030, 2050 and 2080 future climate scenario of temperature and CO_2 regime, respectively.

Aquacrop simulation model for forecasting the potato productivity under changing climatic conditions: It was observed that potato tuber yield increased with rate of water application from 50 to 150% of ETref under both mulch and no mulch condition. Paddy straw mulching (@ 5 t/ha) led to maximum increase in tuber yield under most water-limited environment (28.3% higher), whereas under non-limiting water condition, yield gain was only 4.3%. Among the dynamic plant parameters, plant height under paddy straw mulch was significantly higher (p<0.05) as compared to control during early as well as late tuber bulking phases.

Intercropping in elephant foot yam: Organic package of practices for intercropping elephant foot yam with vegetables such as cucumber and amaranth comprising FYM, poultry manure, vermicompost, neem cake, groundnut cake and PGPR were developed. The equivalent yield of elephant foot yam corm was highest when intercropped with cucumber under 75% organic + 25% inorganic (28.28 t/ha) in the first year amaranth under 100% organic (33.29 t/ha) in the second year.

Fertigation in taro: Fertigation technique in taro has been standardized. Application of N, P_2O_5 and K_2O @ 50% (60:25:75 kg/ha) within 90 DAP, 25% during 90-120 DAP and the rest 25% during 120-150 DAP was optimum and economical for fertigation in taro with 25% saving of N and K nutrients and 123% higher cormel yield (16.1 t/ha) over soil application (7.2 t/ha).

Nutrient management under High Density and Ultra High Density Planting in cashew: The fertilizer dosage for high density planting (4 m × 4 m) in cashew has been standardized as 195:75:115 g N: P_2O_5 : K_2O/ tree. The recommended optimum dose for Ultra High Density Planting (2.5 m × 2.5 m) system in cashew was 70:22.5:40 g N:P_2O_5:K_2O/tree (112 : 36 : 64 kg/ha) with 3.2 kg/tree equivalent to 5.12 t/ha raw nut productivity.

Cryopreservation and *in-vitro* pollen germination in cashew: *In-vitro* pollen germination media and methodology for Cashew were standardized. Two different media were tried such as Sucrose (5, 10 and 30%) and PEG with Boric acid, Calcium Nitrite and Magnesium sulphate. Pollen grains were collected from 9:30 AM to 11:30 AM. The pollen germination was observed with PEG (Polyethylene glycol) media when the pollens were collected between 9:30 to 11:30 AM, 'Hanging drop' technique was followed for successful pollen germination. PEG @15% elicited significant pollen germination.

Jaw-type cashew fruit and nut collector: A jaw-type cashew fruit and nut collector with container unit

Elephant foot yam + amaranthus

Elephant foot yam + okra

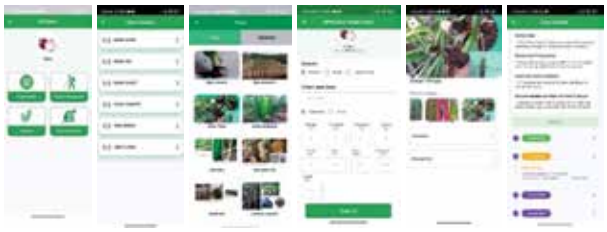
Elephant foot yam + cucumber

A single harvest of vegetables

Intercropping in elephant foot yam

was developed and evaluated. The developed tool's average collecting capacity was determined to be 38.81 kg/h with < 2.5% debris.

Development of Decision Support Systems for onion cultivation : "Onion Crop Advisor" mobile application—a comprehensive tool was designed and developed. The mobile application offers a variety of features to support onion farmers. It provides text and video-based advisories, giving farmers valuable guidance and recommendations on various aspects of onion cultivation. These advisories cover topics ranging from seed sowing to harvesting and post-harvest operations. Furthermore, the application includes blogs and a crop calendar, keeping farmers informed about the latest happenings, events, and programs. This ensures that farmers stay updated with relevant information and stay connected to the larger farming community. The mobile application also serves as a decision support system, offering tools and features that help farmers manage nutrients, pests, and diseases effectively. It provides recommendations and solutions based on scientific research and best practices, empowering farmers to make the right choices for their crops necessary for successful onion farming.



Onion Crop Advisor App

Pollination efficiency of Indian bees and *Braunsapis mixta*, a native bee in cashew: Cashew is andromonoecious and is pollinator dependent for the nut set and bees are important pollinators. Enhancing the bee visits helps to overcome the pollination deficiency in cashew. Observations revealed species of bee such as *Braunsapis* spp., *Apis cerana indica* (Indian bee), *Pseudapis oxybeloides*, *Ceratina* spp., *Tetragonula* sp. etc are common pollinators in Puttur, Karnataka region. Nectar is the major foraging reward for Indian bees, while for other bees both pollen and nectar are the foraging rewards. Pollination efficiency of Indian bee (using 4 framed small bee hive) and *B. mixta* (using the artificial bee nests) under 24 M UV stabilized nylon net cages (10 m × 3.5 m) covering the cashew trees (cv. VRI 3) inside was satisfactory. When compared to the honey bee pollinated ones, the nut and apple weight were 20% and 72% higher, respectively in *B. mixta* pollinated trees. The nut yield per tree was 1.22 to 1.43 kg in *B. mixta* pollinated trees, while it was 0.72 to 0.85 kg/tree under Indian bee pollination. The open pollinated trees (without net cages) yielded between 0.53 and 1.50 kg/tree.

In-vitro pollen germination and pollen tube growth of cashew varieties in response to high temperature stress

The pollens of five cashew varieties comprising three early (VRI 3, Vengurla 4 and Ullal 3), one mid (Bhaskara) and one late (Madakkathara-2) season flowering were screened in field (*in vivo*) as well as at controlled temperatures (*in vitro*) from 5 to 50°C. The pollen germination under *in vivo* was high for early types with 25°C as optimum temperature (Topt) while it was low in mid and late types with 30°C (Topt).

Fertigation in tomato: In protected condition, the fertigation quantity of NPK was optimized in indeterminate tomato based on leaf tissue analysis at different stages. Application of 125% estimated doses of fertilizers (EDF), was observed best in terms of yield and other yield associated traits, such as number of clusters (25.3), fruit weight (70.5 g), fruit size (4.47 cm) and TSS (4.8), whereas maximum antioxidant activities in fruits was registered with 75% EDF.

Plant growth regulators in bitter gourd: Plant growth substances such as, NAA, GA_3, Melatonin, Epibrassinolide and Zeatin sprayed with lanolin paste enhanced the number of fruits per plant (54.74) than hand pollination (34.54) in bitter gourd varieties Kaashi Pratishtha and Pusa Rasdar. However, PGRs application reduced the fruit weight by about 35%. Nevertheless, it also had registered 28% less seed contents than hand pollination, which is a desirable trait from the consumers' perspective.

Hand pollination PGR-lanolin PGR-spray

Organic production of vegetables: During *kharif*, application of nitrogen @ 150 kg/ha through FYM registered at par yield to inorganic fertilizers in bottle gourd (299.5 1/ha), whereas, application of 120 g N/ha through NADEP compost produced highest yield (218.3 q/ha) in sponge gourd which was *at par* with inorganic treatment under weed mat mulching. In okra, highest yield (132.4 q/ha) was recorded by application of 180 kg N through inorganic fertilizer followed by Vermicompost and FYM.

During *rabi*, the highest yield (331.45 q/ha) and curd weight (1.504 kg) in cauliflower was noted under weed mat mulching coupled with N 200 kg/ha. Among organic manures, maximum yield (324.31 q/ha) was recorded with vermicompost prepared from radish residue followed by Pea straw.

Bio-priming of tomato seeds with *Trichoderma* + M44 increased the tomato yield significantly. Spray of humic acid @ 10 ml/l twice at 45 and 60 days after transplanting increased tomato yield by about 19%. The response of humic acid was more pronounced under NADEP and FYM organic sources.

The quality of vegetables in terms of vitamin C content was better under organic system as compared to inorganic system. In cauliflower, the ascorbic acid (41.28 mg/100 g), antioxidant (24.2%) and total phenol content (38.22 mg/100 g) were higher in organic system than the inorganic treatment. The quality of tomato was also improved under organic farming as compared to inorganic treatment.

Enhancing water productivity in okra: In spring-summer okra, drip irrigation scheduling and mulching significantly enhanced the leaf area, dry matter production, number of fruits/plant and fruit yield. Maximum fruit yield of 121.96 q/ha was recorded with drip irrigation twice a day at 100% ET + bicolour (black-white) mulch with an improvement of 106.25% than control (surface irrigation without mulch).

Grafting technology in vegetable crops: Inter-specific grafting in cucumber revealed that maximum no. of fruits (15.1/plant) and fruit yield (2.835 kg/plant and 168.78 q/ha) was obtained when grafted over Summerfit rootstock (a hybrid of snap melon × acid melon).

Graft combination of IVBR-17 + Kashi Chayan was the best combination with least reduction in yield (25.39%) under high salinity stress (8 dS m^{-1}) followed by IVBR 17 + Kashi Adarsh (28.57%) and IC 111056 + Kashi Chayan (29.96 %).

Improving drought stress tolerance in okra: The okra genotypes VRO 128 and VRO 160 showed comparatively lesser decrease in relative water content (12.1% and 15.31%), membrane stability index (14.0% and 16.46%) and total chlorophyll content (13.5% and 17.0%) as well as lesser increase in MDH content (10.0% and 12.9%), H_2O_2 content (87.3% and 107.8%) and proline content (206.8% and 231.3%) under moisture deficit condition. These genotypes showed higher increase in peroxidase (2.36 and 1.92 Mm/g/min) and catalase (1.67 and 1.36 92 Mm/g/min) activity under moisture deficit stress and lesser reduction in root surface area (11.18%) and root volume (8.72%) and yield (9.7% and 10.5%, respectively) under moisture deficit condition.

Drought stress tolerance in okra

Organic cultivation of teasel gourd: Application of 5 kg FYM and 1 kg neem cake as basal dose for 1 m bed and periodic soil drenching of Jeevamrut (500 ml/plant)

Micronutrients and plant growth regulators in vegetable crops

Application of Micromix D in bottle gourd registered maximum fruit yield (525.27 q/ha), whereas in cowpea, no significant differences were observed among different formulations. In pea and French bean, Micromix C proved better, and registered 13.39% more fruit yield in pea (134.13 q/ha) and 11.93% in French bean (237.84 q/ha). Accordingly, the best performing formulation (Micromix C) was named as 'Kashi Sookshma-Shakti Plus'. The present formulation is an improvement over the existing product "Kashi Sookshma-Shakti" as it contains essential plant growth regulators (PGRs), besides micronutrient combinations.

Natural farming of vegetables

Under natural farming, there was reduction of 68.7% in curd yield in cauliflower and 67.4% in tomato as compared to organic farming. Similarly, there were 78.3 to 112.2% reduction in yield of Indian beans, water spinach and pea under natural farming.

Teasel gourd

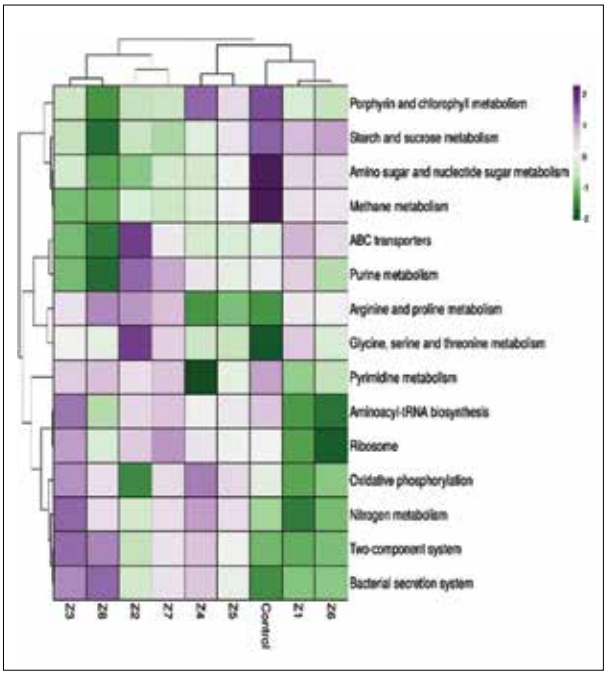
+ Arka Microbial Consortium (10 g/plant) from the 20th day of planting (DAP) repeated 10-12 times was ideal for realizing higher yields and fruit quality.

Microbial management of deficit stress irrigation in Tomato: Arka Microbial Sahishnu is a carrier based formulation of the endospore forming osmotolerant bacterial strain *Bacillus amyloliquefaciens* strain P-72. Under *in vitro* osmotically stressed conditions, this bacterium solubilizes tri calcium phosphate and zinc phosphate and produces IAA and GA_3 and the cytokinins Z- Zeatin; DHZR- Dihydrozeatin riboside; ZR- Zeatin Riboside; iP- Isopentynyl adenine; iPA- Isopentenyl adenoside. Under field conditions, inoculation of Arka Microbial Sahishnu@ 5 kg/ha as a suspension (20 g/l) on the seventh day of transplantation followed by another application on the 30th day, improved the marketable yield levels of tomato by 23.79 % over un-inoculated plants irrigated at 40% of Pan Evaporation (PE). This formulation is a promising technology for the alleviation of deficit irrigation stress in tomato.

Decision Support System for soil test-based fertilizer recommendation for targeted yield of spices (Spice FeRT): The soil test and crop response-based fertilizer recommendation model for NPK for different yield targets (q/ha) of black pepper, ginger, turmeric and cardamom was developed. This software was developed on php-MySQL platform with different input parameters (soil test values for N, P and K, pH), crop yield targeted (as fresh/dry yield in q/ha) and per ha recommendations for lime, N, P_2O_5 and K_2O were calculated using the designed STCR models for the crops and the results were expressed in per bed (for ginger and turmeric) and per plant (for pepper and cardamom) basis for different fertilizer inputs.

The fertilizer recommendations based on these established equations when validated for varying yield targets in the major spice crops at different soil fertility levels result in realized yield levels with a minimum deviation of the recorded yield levels with the positive mean deviation of -2.9 to 55%, respectively over the fixed target levels in all the crops.The technology was validated for 3 years at farmers' fields in Wayanad, Kozhikode and Madikeri. Based on the validated results, the equations were normalized and the final response equations designed.

Effect of nano ZnO on bacterial community structure and associated functional pathways: The changes in bacterial community structure and associated functional pathways were determined through predictive meta genomic profiling and subsequent validation through Quantitative Real Time PCR in soil spiked with nZnO (0, 50, 200, 500 and 1,000 mg Zn/kg) and similar levels of bulk ZnO. The results revealed that the alpha diversity decreased with increasing ZnO level, with more impact under nZnO, while beta diversity analyses indicated a distinct dose-dependent separation of bacterial communities. The dominant taxa including Proteobacteria, Bacterioidetes, Acidobacteria and Planctomycetes significantly increased in abundance, while Firmicutes, Actinobacteria and Chloroflexi decreased in abundance with elevated nZnO and bZnO levels. Redundancy analysis indicated that changes in bacterial community structure instilled a greater dose- rather than size-specific response on key microbial parameters. Predicted key functions did not show a dose- specific response, and at 1000 mg Zn kg^{-1}, methane metabolism as well as starch and sucrose metabolism were attenuated, while functions involving two component systems and bacterial secretion systems were enhanced under bZnO indicating better stress avoidance mechanism than under nZnO. Real Time PCR and microbial endpoint assays confirmed the metagenome derived taxonomic and functional data, respectively. Taxa and functions that varied substantially under stress were established as bioindicators to predict nZnO toxicity in soils. Taxon-function decoupling indicated that the soil bacterial communities deployed adaptive mechanisms under high ZnO, with lesser buffering capacity and resilience of communities under nZnO.



Dominant functional pathways in soils amended with nZnO and bZnO. (a) Cluster heat map of top 15 pathways. Control -No Zn, Z1- 50, Z2- 200, Z3-500, Z4-1000 mg Zn kg^{-1} as nZnO; Z5-50, Z6-200, Z7-500, Z8-1000 mg Zn kg^{-1} as bZnO.

Rapid method for multiplication of Guggul *(Commiphora wightii):* Air layering was standardized

in guggul. Pencil-sized shoots were ringed, wrapped in coco peat and moss, and enclosed in polyethylene sheets. Air layering showed faster and more successful rooting (30 days) compared to semi-hardwood cuttings (65-70 days) in both seasons. The rooted layers were transferred to nursery bags and then to the main nursery, making air layering a simple and quick method for guggul conservation.

Air layering in guggul

Authentication of *Tinospora cordifolia*-based herbal supplements: A high-resolution mass spectrometry (HRMS) method was developed to distinguish *Tinospora cordifolia* from closely related species, *T. crispa* and *T. sinensis*, for authenticating herbal supplements. UNIFI software facilitated automatic metabolite identification. Chemometric models like OPLS-DA and PLS-DA confirmed species identity. Pair-wise OPLS-DA models for *T. cordifolia* against *T. crispa* and *T. sinensis* were created. Seven biomarkers, including jatrorrhizine, corydine, and ecdysterone, differentiated *Tinospora cordifolia* from other species. The models were validated with test and market samples to ensure authenticity.

Polyphenolics/antioxidants and biochar from waste biomass of *Ocimum* sp.: A process for dual utilization of distillation as a source for polyphenolics/ antioxidants and biochar from tulsi was standardized. By-products from distillation (biomass waste and deodorized water) of two *Ocimum* species, *O. sanctum* and *O. basilicum* were repurposed. Phenolic compounds were extracted using different solvents with 50% aqueous methanol yielding the highest extraction yield, total phenol and flavonoid content. This extract exhibited the strongest antioxidant activity (IC50 of 94.02 µg/mL for *O. sanctum* and 89.48 µg/mL for *O. basilicum*). After extracting bioactive compounds, the remaining biomass was pyrolyzed to create biochar with a porous structure, providing a high surface area for soil microbiota support and acting as a potential soil amendment.

Vitamin D enrichment in *Hypsizygus ulmarius* (Elm oyster) mushroom: Technology for the Vitamin D enrichment of *Hypsizygus ulmarius* (Elm oyster) mushroom was developed. Fresh mushrooms, when subjected to 5 minutes of UV light (100 W), had a

Pollinators in chrysanthemum

Three chrysanthemum genotypes, viz. OPCH 12-7; OPCH Double White and DFR C-2 identified as highly attractive, floriferous and rewarding genotypes for honeybees. The genotypes can be used for preparation of floral calendars to improve pollinator's health and habitat restoration. Pollens from bee-friendly flora can be used as a dearth-season diet for honey bees. Multiplication and marketing of such bee-friendly flower crops would also offer an entrepreneurship opportunity and a new source of income for rural youths and farm women. These varieties are ideal for higher seed production in cross pollinated crops. These are suitable for gardens to conserve the biodiversity and off-season flora for apiculture farmers also and useful to support pollinator's network in pollination-dependent crop.

OPCH 12-7	DFR C-2	OPCH Double white
Attract *Apis cerana, A. florea* and *A. dorsata* Relative abundance of bees: 39.5 bees/ m^2/min Foraging rate of bees: 4.5 flowers/min Foraging speed of bees: 23.67 seconds	Attract *Apis cerana* and *A. florea* Relative abundance of bees: 58.33 bees/m^2/min Foraging rate of bees: 6.83 flowers/min Foraging speed of bees: 20.33 seconds	Attract *Apis cerana* and *A. florea* Relative abundance of bees: 55.67 bees/m^2/min Foraging rate of bees: 5.5 flowers/min Foraging speed of bees: 17.2 seconds

Pollinator-friendly genotypes of chrysanthemum

Culture of Turkey tail mushroom

concentration of 1.74 µg/g of ergocalciferol, while a 10-minute exposure resulted in a concentration of 57.61 µg/g of ergocalciferol, compared to the control sample with a very low concentration of 0.06 µg/g. To obtain 100% of the recommended daily allowance (RDA) of vitamin D (18 µg/day), 20-28 g of fresh Elm Oyster mushrooms exposed to 5-second UV pulse generator light is required.

Culture of Turkey tail mushroom (*Trametes versicolor*): Cultivation technology for medicinal mushroom *Trametes versicolor* (Turkey tail mushroom) was standardized. Combination of 90% wheat straw and 10% wheat bran was identified as the best substrate formulation. Total crop yield was estimated to be 7.5% BE.

Crop Protection

Biological control of tea mosquito bug in guava: Biological control of tea mosquito bug (*Helopeltis antonii*) by application of *Beauveria bassiana* WP @ 10 g/l (10^9 CFU/g - 4 sprays) recorded best results in reducing fruit damage (81%) and equally effective as chemical spray on guava with good yield, benefit cost ratio and least effect on natural enemies.

Management of hoppers and thrips: Oil-based formulation of *Metarhizium anisopliae* revealed that *M. anisopliae* when sprayed at one ml/l showed best results in reducing hoppers population after every spray with higher productivity at Bengaluru (89.71 kg/tree), Mohanpur (78.09 kg/tree), Pantnagar (50.61 kg/plant), Paria (39.9 kg/tree), Periyakulam (67.03 kg/plant), Sangareddy (30.02 kg/tree) and Vengurla (29.46 kg/tree).

Evaluation of different botanical formulations for management of sucking pest complex in mango revealed that for Karnataka, Panjab, Gujarat and Maharashtra neem soap spray @ 10 g/l (five sprays at 15 days interval starting from panicle initiation) was the most effective, whereas, in West Bengal and Telangana application of azadirachtin 10,000 ppm @ 3 g/l (five sprays at 15 days interval starting from panicle initiation) was the most effective and for Uttarakhand a combination treatment comprising first spray of azadirachtin 10,000 ppm @ 3 ml/l at panicle initiation stage followed by second spray of neem soap @ 10 g/l followed by third spray of pongamia soap @ 10 g/l followed by forth spray of aavya @ 4 g/l at 15 days interval was the most effective for management of sucking pest complex in mango.

Algorithm for rhinoceros beetle: An algorithm based on object detection approach with an accuracy of 84.3% for surveillance of rhinoceros beetle infestation in coconut using unmanned aerial vehicle (UAV) has been developed.

Inflorescence pests of cashew: A total of 67 species were documented on cashew inflorescences. Damage symptoms, seasonal incidence and influence of weather factor on pests, natural enemies for different pests were also documented. Reduction in nut set up to 47.06 % has been recorded in NRCC Sel-2 due to damage by the inflorescence pests. Eight botanical formulations/preparations comprising aqueous leaf or seed extracts tested against flower caterpillars and TMB showed no effective management like insecticidal treatment.

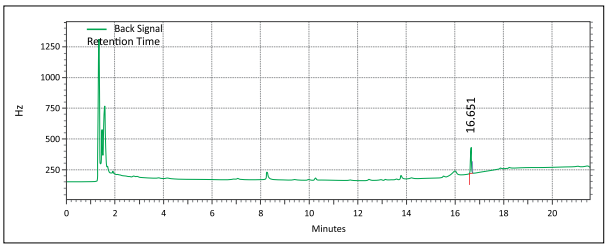
Weather based prediction model for cucurbit fruit fly: The cucurbit fruit fly, *Zeugodacus* (=*Bactrocera*) *cucurbitae* (*Coquillett*) (Diptera: Tephritidae) is a polyphagous and a major pest of cucurbitaceous vegetables. Six year mean data on adult fruit fly caught in cue-lure traps installed in different cucurbits revealed that there were two major peaks of fruit fly incidence in Varanasi, Uttar Pradesh, i.e. the first (90.33 adult fruit fly/trap) occurred during last week of March (13 standard meteorological week-SMW) and the second (96 adult fruit fly/trap) during third week of November (46 SMW). The maximum temperature (r =+0.447**), sunshine hour (r= +0.448**) and evaporation rate (r= +0.439**) showed highly significant positive correlations with this fruit fly abundance in the region whereas, morning and evening relative humidity (r= -0.570** and r= -0.724**), rainfall (r= -0.266*) and wind velocity (r= -0.08) adversely affect the population build up.

Based on stepwise forward regression, it was observed that maximum temperature played significant role explaining 25.2% fruit fly abundance followed by minimum temperature sharing 20.1% abundance. Morning relative humidity accorded 13.1% share of

this polyphagous pest followed by evening relative humidity and sunshine hours (5% each). All the eight meteorological parameters together contributed about 77.8% abundance of fruit fly under Varanasi conditions. A weather-based prediction model has also been developed with different weather indices as given below:

Y=-216.70+9.95x1-4.85x2+2.60x3-2.11x4-12.66x5+0.69x6+0.56x7-0.14x8

Persistence of chlorantraniliprole residue: Method for estimation of chlorantraniliprole residue in cowpea was standardized and dissipation kinetics, food safety evaluation and decontamination recorded.The residue analysis of chlorantraniliprole in cowpea pods was done through solid phase extraction method followed by gas chromatography analysis. The analytical method was standardized and validated according to international standard for estimation of chlorantraniliprole in cowpea pods and soil. The half–life of chlorantraniliprole in cowpea pods was estimated in the range of 2.79- 2.33 days in the year-I and 2.51–2.32 days in the year-II for single dose (SD) and double dose (DD) respectively. Similarly, half-life of the chlorantraniliprole in leaves was 2.43–2.27 days, whereas 1.94–1.70 days in case of soil. The exposure of the residues in pods were less than maximum permissible intake (MPI). The RQ values revealed that there could be negligible risk to earthworms and arthropods. Washing with boiling water was observed the most effective decontamination treatment to remove residue from cowpea pods.



Chromatogram of the chlorantraniliprole at LOQ level in cowpea pods.

Integrated management of root and stem borer: The integrated practices involving application of entomopathogenic nematode (EPN) and *Metarhizium anisopliae* for management of cashew stem and root borer were standardized. The EPN suspensions with infective juveniles (IJs) could induce >90% mortality up to 150 days when soil samples were baited with CSRB grubs.

Management of pollu beetle (*Lanka ramakrishnai*) in black pepper: A technology for the management of the pollu beetle with low-risk insecticides has been developed. Three rounds of spray application with chlorantraniliprole 18.5% SC at 0.3–0.5 ml/l of water during July–August, August, and September has been found effective for the management of this pest in black pepper.

Management of root lesion nematode *Pratylenchus* spp in turmeric: The lesion nematode *Pratylenchus* spp., is a migratory endoparasite and causes typical brown lesions in the root and rhizomes, the economical part of turmeric crop. It is emerging as a serious pest in major turmeric growing of India and affects the crop quantitatively and qualitatively. Drenching with Fluopyram 34.48 SC (400 g/l) @ 0.5 ml/l on turmeric beds at 15 days after planting was effective in managing nematode population in soil and rhizome of turmeric.

Midge fly infesting tuberose: A blossom midge (*Contarinia maculipennis*) infesting tuberose buds was recorded which causes huge losses in tuberose yield by induced deformities and rotting of buds. Midge fly infestation ranged from 5.67 to 88% during July to September 2022 in different tuberose-growing areas of Maharashtra, Telangana and Andhra Pradesh.

Damaged florets of tuberose

Midge, *C. maculipennis*

Midge fly larva

Biological control of shoot borer

A technology for the management of shoot borer (*Conogethes punctiferalis*), infesting ginger and turmeric using entomopathogenic fungus, *Metarhizium pingshaense*, was standardized. The technology involves spraying *M. pingshaense* at a dose of 1 × 10^7 conidia/ml, starting from the second fortnight of July (or 45 days after planting) till the first fortnight of November at 21-day intervals. This technology can be adopted for organic production of ginger and turmeric.

Metarhizium pingshaense infected shoot borer larvae

Diagnosis and management of diseases

Casual organisms of avocado root rot/wilt: On the basis of morphological and molecular characterization and re-confirmation through challenge inoculation, the prime casual organism of avocado wilt in South India has been identified as *Phytophthora cinnamomi*.

Impact of banana streak virus (BSV) free tissue cultured plants: BSV free (episomal BSMYV) tissue culture banana cv. Poovan revealed that use of virus free tissue cultured elite Poovan clone significantly reduce

incidence of streak disease and increase yield over local Poovan in Karnataka, Kerala, Odisha, Maharashtra, Tamil Nadu and West Bengal. The disease reduction is to a tune of 56-75% and yield enhancement is to a tune of 23-28% with a B:C ratio of 1.51 to 1.89.

Integrated management of post-harvest diseases: Integrated management of post-harvest diseases (anthracnose, shoulder browning, stem end rot and *Aspergillus* rot) of mango fruits revealed that the incidence of shoulder browning disease is mainly confined to northern states but other diseases occurred at multiple locations across the country. Pre-harvest spray with difenoconazole 25 EC @ 0.5 ml/l 25-30 days before onset of monsoon was highly effective in managing the shoulder browning disease. Pre-harvest spray with difenoconazole 25 EC followed by post-harvest hot water treatment of fruits at 52 ±1 ˚C for 10 min was effective in management of all the diseases with C:B ratio of 1:2.43 to 1:10 at different locations.

Development and refinement of integrated protection technologies in grape: *In vitro* compatibility analysis showed that *Trichoderma afroharzianum* was compatible to azoxystrobin, kresoxim methyl, meptyldinocap, fluxapyroxad and pyraclostrobin and formulations of sulphur. The field evaluation for compatibility of biocontrol agents with registered fungicides in controlling the powdery mildew of grapes revealed that the *Trichoderma asperelloides* alternated with azoxystrobin, kresoxim methyl, meptyldinocap, fluxapyroxad + pyraclostrobin and sulphur was effective against powdery mildew.

The *Bacillus licheniformis* and *Bacillus subtilis* were observed compatible with azoxystrobin, kresoxim methyl, sulphur and hexaconazole. Two promoter formulations, viz. Arka Miracle and Arka Actino plus performed better when applied in alteration with biocontrol agents and vermiwash for powdery mildew control.

Spatial and temporal distribution of ApMV and ApNMV associated with mosaic disease in apple : Diagnostics in apples using RT-PCR revealed that both apple mosaic virus (ApMV) and apple necrotic mosaic virus (ApNMV) were present in all the plant parts except roots during spring. During summer, both viruses were not detected in leaves, bark and fruits; however, in autumn both ApMV and ApNMV were detected in leaves but not in fruits and buds. The RT-qPCR analysis showed variation in expression of ApMV and ApNMV in different parts during different seasons. Results confirmed that during Spring season the ApMV and ApNMV expression was higher in leaves followed by whole flower. During all the three seasons, both ApMV and ApNMV were detected in leaves in measurable titre using RT-qPCR, however via RT-PCR, both the viruses remained undetected during summer. Periodic detection of these viruses in different plant parts during all the three seasons revealed varied virus titre from one season to another in the same plant. Hence leaves during spring season can be directly used as detection material for their early and rapid detection of both the viruses.

Management of leaf blight in coconut: Root feeding with propiconozole @ 5 ml in 100 ml of water at three months' intervals during January, April, July and October reduced the leaf blight incidence by 27% after 36 months of treatment. This treatment also recorded the highest nut yield of 138 nuts/palm/year and the B:C ratio of 3.7 as against 97 nuts/palm/year in the untreated control.

Etiology of Leaf spot disease in arecanut: On the basis of morphological and molecular characterization using multi-gene phylogeny etiology of arecanut leaf spot disease was established as the associated pathogen was identified as *Colletotrichum kahawae* subsp. *ciggaro*. Field evaluation of fungicides against emerging arecanut leaf spot disease could arrive at two rounds of spraying of propiconazole 25% EC and propineb 70% WP at 25 days intervals.

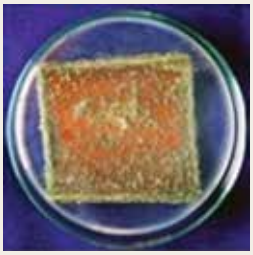
Bioformulation for multiplication of *Trichoderma*: A *Trichoderma harzianum* (CPTD28) based arecanut leaf sheath formulation with enhanced bio efficacy and shelf-life up to 24 months has been developed. The formulation could be used for regular multiplication and also for the long term preservation of nucleus culture of *T. harzianum*.

Integrated pest and disease management in cumin

An integrated management schedule for blight and aphids in cumin was standardized. Three foliar sprays of kresoxym methyl 44.3 SC was developed @ 0.044% (First with initiation of disease and subsequently at 15 days interval) and two foliar sprays of thiamethoxam 25WG @ 0.0084% (First with the initiation of aphid infestation and the second after 10 days) were found effective for obtaining a higher yield (677 kg/ha) and incremental benefit-cost ratio (1.98) with less blight (PDI=16.06%) and aphid incidence (Aphid Index=0.96) under Jagudan (Gujarat) conditions.

Standard Operating Procedures (SOP) for drones in coconut and arecanut plantations

The Standard operational procedure for drone based spray using specially designed nozzles was developed, test validated and demonstrated in more than 15 ha plantations of coconut and arecanut.



Trichoderma culture in growth media

Drone spraying in coconut plantation

Identification of growth promoting *Trichoderma*: A plant growth promoting isolate of native *Trichoderma asperellum* (isolate AT172) having antagonistic activity against arecanut basal stem rot pathogen *G. lucidum* was identified and characterized.

Characterization of *Phytophthora infestans:* The population of *Phytophthora infestans,* the causal agent of late blight in potato was characterized using both biological and molecular markers and results revealed that isolates are still resistant and intermediate resistant to metalaxyl fungicide while sensitive to new molecules such as cymoxanil, dimethomorph, fenamidone and amisulbrom) and the population in India is EU_13_A2 clonal lineage only. Besides, homothallic isolates of *Phytophthora infestans* were observed in potato fields.

Epidemiology and forecasting of potato pathogens: Indo-Blightcast model was used pan-India for prediction of late blight and the model predicted late blight accurately across agro-ecologies and accordingly agro-advisories were issued for its management. Incidence of common scab, caused by *Streptomyces* species, is increasing across agro-ecologies and isolates possess one to three pathogenicity genes and are mild to severe in aggressiveness. Dry rot caused by *Fusarium* species is another emerging storage disease of potato. *Fusarium* species associated with dry rot was characterized and it was observed that certain species such as, *Fusarium sambucinum* and *Fusarium verticilloids* could grow and sporulate even at 4°C storage temperature thus imposing a serious threat of dry rot even in cold storages.

Management of pathogens and pests of potato: Results of insecticide sensitivity studies revealed that *Myzus persicae* population is resistant to neonicotinoids namely imidacloprid, thiamethoxam and clothianidin. A spray schedule consisting of chlorothalonil 75% @ 0.2% (before the appearance of disease) followed by flupicolide 62.5 + propamocarbhydrochlorid 625 SC @ 0.3% (at onset of the disease) and one more spray of flupicolide 62.5 + propamocarbhydrochlorid 625 SC @ 0.3% (after 7 days of second spray) was observed effective for the management of late blight. Besides, for the management of black scurf, seed tuber treatment at the time of planting with thifluzamide @0.35% (spray method) and penflufen @0.1% (dip method) was observed effective.

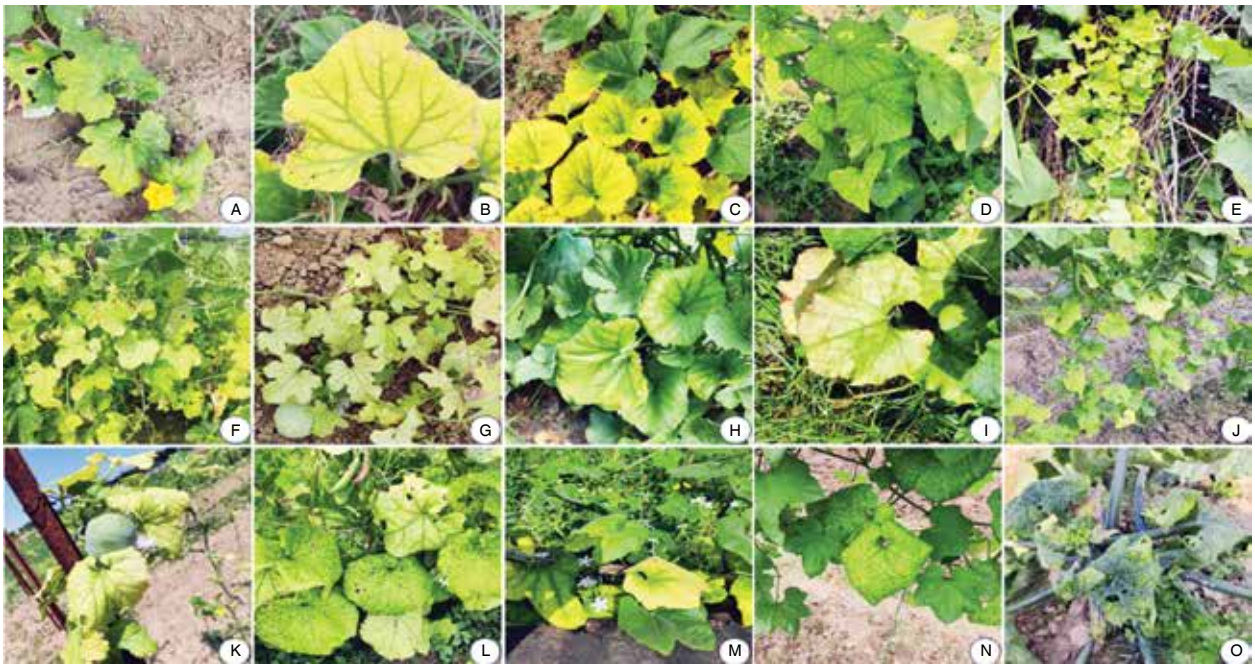
White grubs could be effectively managed by the soil application of Clothianidin 50 DWG @ 250 g/ha. *Steinernemachola shanense,* an entomopathogenic nematode was observed compatible with the recommended agrochemicals and can be readily combined and used under the field conditions for the management of potato tuber moth (*Phthormea operculella*). Results of four years crop rotation for the management of potato cyst nematodes (PCN) revealed that Oat-Oat-Mustard-Trap crop sequence resulted in highest reduction (61.4%) of PCN population followed by Potato-Rajmash-Trap-Rajmash (48.7%) crop sequence.

Control of postharvest rot in elephant foot yam corms

Nematode management in elephant foot yam: Farmer participatory integrated plant parasitic nematodes management showed significant reduction in the nematode infestation in elephant foot yam. Soil application of *Trichoderma harzianum* (CPTD-28) enriched neem cake (1:100) @ one kg/pit during pre-monsoon and post-monsoon season significantly suppressed the build-up of root-knot nematode, *Meloidogyne incognita* population and reduced yellowing of vines.

Management of postharvest rot in elephant foot yam corms (culinary use): Treating the elephant foot yam corms in water containing turmeric powder or crushed garlic @10 g/l for 10 min, draining, shade drying and storing in a ventilated place was observed satisfactory for management of post-harvest rot.

Identification of viruses in cucurbit vegetables: On the basis of sequence analysis of amplified product, two Crinivirus (Cucurbit chlorotic yellow virus - CCYV and Cucurbit yellow stunting disorder virus - CYSDV) and two Polerovirus (Cucurbit aphid-borne yellow virus - CABYV and Luffa aphid-borne yellow virus - LABYV) species were characterized. Phylogenetic analysis revealed less genetic distance among the Indian isolates of CCYV, CYSDV and LABYV, whereas CABYV closely related to China isolate. This study documents infection of CCYV on cucumber, round melon and muskmelon; CYSDV on satputia and sponge

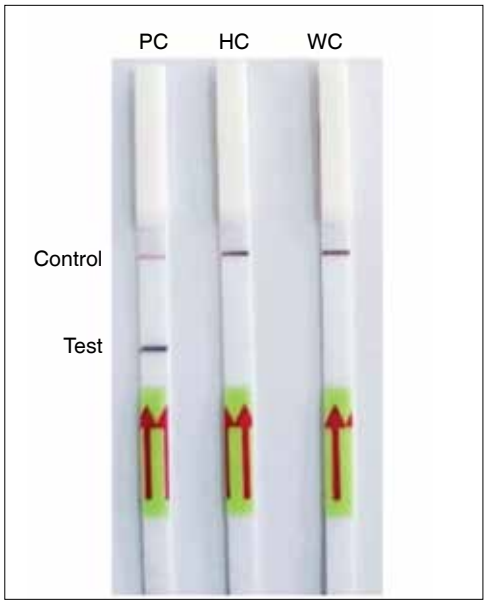


Identification of viruses in cucurbit vegetables

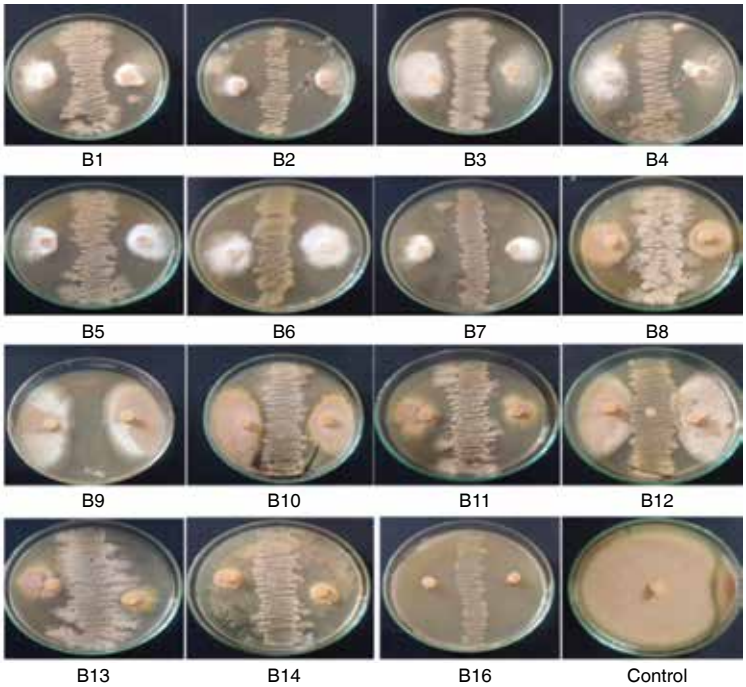
gourd; CABYV on ivy gourd; and LABYV on ridge gourd, satputia and muskmelon for the first time in India.

Integrated management of *Ganoderma* induced basal stem rot: *In-vitro* evaluation of new generation fungicides against *Ganoderma lucidum* revealed that Propiconazole 13.9% + Difenoconazole 13.9%, Fluopyram 17.7% w/w + Tebuconazole 17.7% w/w, Tebuconazole 50% + Trifloxystrobin 25% w/w WG, Hexaconazole 5% SC, Propiconazole 25% EC, Azoxystrobin 8.3% + Mancozeb 66.7% WDG and Copper Sulphate 47.15% + Mancozeb 30% WDG have 100% inhibition in mycelial growth at five different doses (250, 500, 1000, 2000, 4000 ppm) tested.

Oil palm based bi-products for culture of *Trichoderma* sp.: Evaluation of aqueous extracts of different oil palm products (mesocarp, empty fruit bunch fibre and decanter cake) and organic amendments (neem cake) proved the synergistic effect of neem cake and mesocarp on the mycelial growth of *Trichoderma longibrachiatum* with mean growth increment of 28% and 33.12% as compared to potato dextrose agar. Neem cake followed by mesocarp was identified as suitable substrates among 10 different agro-based wastes for mass multiplication and delivery of *Trichoderma* within the oil palm cropping system. This farmer friendly mass production technology was standardised across different



Detection of piper yellow mottle virus by recombinase polymerase amplification-lateral flow assay (RPA-LFA). PC: Infected plant, HC: healthy plant, WC: water control



The pure culture of bacterial isolates B-1 to B-16

seasons, *Trichoderma* strains and doses.

***Ganoderma* induced basal stem rot:** Molecular PCR detection of *Ganoderma* was developed and standardised using *Ganoderma* specific primers. Screening of five Ganoderma specific primers was done for their specificity. Specificity of two primers was confirmed across different species of *Ganoderma boninense, G. zonatum, G. casuarinicola, G. adspersum, G. lucidum.* Primers proved to be nonspecific against other pathogens such as *Lasiodeplodia theobromae, Curvularia lunata, Pleurotus, Helminthosporium, Colletotrichum* and *Trichoderma.*

Detection of piper yellow mosaic virus (PYMoV) infecting black pepper: The basic RPA method for the detection of piper yellow mottle virus in black pepper was standardized using TwistAmp DNA amplification kit. Different reaction conditions of the assay such as concentration of magnesium acetate, reaction incubation time and temperature were optimized. The RPA-lateral flow assay **(**LFA) method was standardized for the on-site detection of the piper yellow mottle virus. The sensitivity of the assay was compared with RPA and PCR. Validation of the assay was performed along with PCR using field samples of black pepper representing different varieties and regions.

Mushroom: The pure cultures of 16 bacterial isolates B-1 to B-16 were isolated from button mushroom compost and casing on malt extract agar medium at 25±2°C. The antagonistic potentialities of bacterial isolates were tested against the growth of *M. perniciosa* using dual culture technique by keeping pathogen on both the sides. Perusal of the data revealed that all the tested bacterial isolates inhibited the growth of *M. perniciosa* over control. B-16 registered the highest growth inhibition of *M. perniciosa* (91.89%) followed by B-14 (77.78%) and B-7 (76.39%). B-2 and B-4 showed same level of growth inhibition of *M. perniciosa* (75%). Other isolates B-1, B-3, B-5, B-6, B-8 to 13 and B-15 showed 60.28 to 72.55% growth inhibition of *M. perniciosa*.

❑

7. Livestock Management

Nutrition

Development of antioxidant-enriched agro-waste-based maize replacer (AEMR): Antioxidant-enriched agro-waste-based maize replacer (AEMR) was developed by subjecting agro-wastes like apple pomace, spent mushroom compost, and wheat straw to self-fermentation under controlled conditions. The level of maize replacement in the concentrate mixture was assessed to be 32% under *in vitro* and *in vivo* trials. AEMR feeding to *Gaddi* goats improved their feed conversion ratio (FCR; 10.61) without exhibiting any adverse impact on total body weight gain and average daily weight gain compared to the control (12.89). The feeding also resulted in beneficial shifts in LDL and HDL serum levels, and significantly enhanced serum oxidative stability. Furthermore, the meat obtained from AEMR-fed *Gaddi* goats showed higher oxidative stability as indicated by lower TBARS values and higher antioxidant activity.

Agro-waste antioxidant-enriched maize replacer (AEMR)

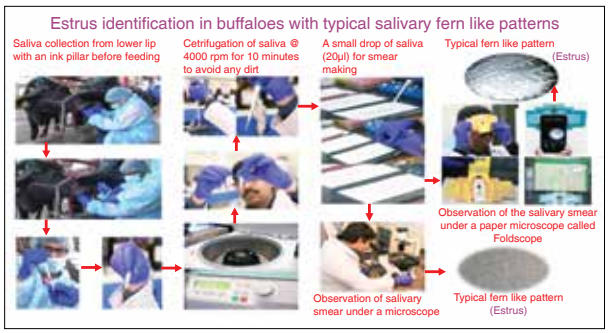
Effect of postbiotics in broiler diets: The administration of postbiotics significantly increased the production parameters. Administration of postbiotics performance in reducing oocyst shedding was comparable to coccidiostat (diclazuril) fed birds but there was a 50% reduction in oocyst shedding than untreated groups. *Eimeria* oocyst was gradually decreased from 5 to 11 dpi with lower counts in diclazuril followed by postbiotics and control. The performance of postbiotics at 0.6% supplementation in reducing the severity of *Eimeria* is comparable to commercially available coccidiostat 0.1% diclazuril without compromising the production and economics of broiler production.

Improved bioreactor prototype for cattle waste management was designed and fabricated for handling cow dung for biogas production.

Dietary herbal supplementation improved bull semen quality: Dietary supplementation of herbal mixture containing semal musli, mulathi, kaunch seeds, gum arabic, gongura flower/calyx, malabar haldi, gulab petals and bel giri @ 70-140 g/head/d in Frieswal breeding bulls for 4-6 months improved sexual performance and semen quality parameters. Another formulation containing herbs, viz. ashwagandha, gokhru, shatawari, safed musli, shia musli, bidarikand and sahajan seeds @ 35-70 g/head/day for 120 days also improved semen quality parameters in Frieswal bulls.

Physiology

Identifying estrus in buffaloes through salivary fern-like patterns: A potential non-invasive biomarker from saliva was explored and a microscopic method was developed. The applicability of this method was tested on 582 potential estrus events in various field scenarios, confirming its accuracy at a remarkable 91% in detecting early estrus right at farmers' doorsteps, with the assistance of Foldscope. To facilitate the recognition of these microscopic salivary patterns, a computer vision-based mobile app called 'Mahishee Mitr' (beta version) was developed.



Estrus in buffaloes through salivary fern-like patterns

CRYODIL: An egg yolk-free, ready-to-use semen extender developed for buffaloes

Synthetic (egg yolk free) semen extender for cryopreservation of buffalo semen: The post-thaw progressive motility of cryopreserved buffalo sperm in

Designing and development of artificial limb for large animals

For the preparation of the limb socket, 5 mm HDPE (high density polyethylene) sheet of suitable size was kept in hot air oven at 250 to 300°C till it gets completely loose and was wrapped over the stump dye. A steel rod of suitable length was attached from the distal end of the socket. A rubber foot on a steel plate was connected to the distal end of the extension rods. Leather straps with locking buckle were attached at the proximal end of the socket to firmly attach the socket with the amputated stump of the limb.

Preparation of POP cast positive dye

HDPE

Measurement of normal limb length to assess the length of extension rod

Lateral view of designed limb prosthesis

Padding of the stump with cotton and bandages

Animal adapted with artificial limb on 10th day

the newly developed egg yolk-free semen extender was significantly higher as compared to that in traditional egg-yolk-based semen extender (42.1±2.11% vs. 26.3±2.18%). The shelf-life this egg yolk-free, ready-to-use, semen extender at 4°C is ≥18 months.

Development of buffalo bull fertility diagnostic chip based on sperm transcripts signatures: The SpermXFert is a gene expression-based microarray chip (8×60k format) for predicting fertility status of the bulls for artificial insemination. This will help in identifying and removing sub-fertile bulls from the breeding population. Such measure will ultimately improve overall field fertility and economic status of the farmers.

Pig MSY genes: Characterization and expression profiling of Pig MSY genes in male pigs has been done. The results indicated that MSY genes may be used as a marker for selection of boar for breeding purpose.

Improvement of camel for dairy potential: Among 4 different camel breeds, Kachchhi breed was found to have highest lactation yield, followed by Mewari and Jaisalmeri breeds.

Establishment of Mithun conservation units: Mithun conservation units were established at Thevopishu, Phek District and Khonoma, Kohima District of Nagaland for promoting semi-intensive mithun farming. FSSAI approved Mithun as food animal.

Mithun conservation unit established at Khonoma, Kohima district, Nagaland

Arunachali yak Churpi got GI tag to boost its conservation: The slightly sour and salty, a naturally prepared soft cheese prepared from milk of Arunachali Yak, reared in high altitude recently got the Geographical Indication (GI) tag which will boost for the conservation of the hairy bovine species living in Himalayan belts of the country.

Consideration of yak as food animal: On recommendation of DAHD, scientific panel of FSSAI approved Yak as food animal. It is widely believed that

declaration of yak as a food animal by FSSAI will pave the way for its commercial rearing and consumption by adopting the yak rearing model developed by NRC-Yak.

Livestock protection

Animal Health Informatics: A total of 6,889 predictions for major livestock diseases of varying levels of risk were generated by the National Animal Disease Referral Expert System v2 (NADRESv2), a dynamic geographic information and remote sensing-enabled expert system. Reports were sent to the State Animal Husbandry Departments (including NADEN centers), Department of Animal Husbandry and Dairying, GoI and other government stakeholders in the form of risk maps, monthly forewarning bulletins, and post-prediction maps for necessary preparation.

Nation-wide sampling plans for sero-surveillance and sero-monitoring of FMD, Brucellosis, CSF and PPR for each state/ UTs were formulated and provided to DAHD, GoI, for strengthening the surveillance system. The district-wise sampling plan for 14 diseases for sero-surveillance was provided to evaluate the status of these diseases in the country. The Cattle Disease Diagnosis Expert System (CaDDES) web application was developed.

Sero-epidemiology and diagnosis: A total number of 74,582 serum samples from various NADEN units and State Animal Husbandry Departments were screened for major livestock diseases for serosurveillance and recommendations were provided to the state governments.

A total of 517 samples were analyzed for AMR pathogens (MRSA, ESBLs) and the prevalence of antimicrobial resistance was documented from livestock, environment and humans. The whole genome sequencing (WGS) of bacterial (n=1458) isolates for AMR surveillance was carried out.

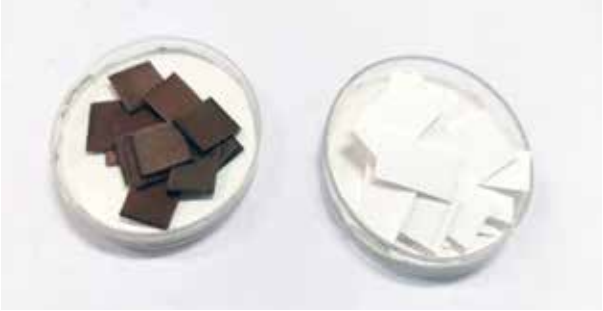
Post-vaccination sero-monitoring: A total of 13,093 livestock serum samples collected post-vaccination from different states were screened and 70.8% of the samples were found positive for anti-*Brucella* antibodies.

Diagnostics

- **Development of competitive ELISA kit for detection of bovine viral diarrhoea (BVD) p80 antibodies in cattle:** A competitive ELISA kit for detection of bovine viral diarrhoea (BVD) p80 antibodies was developed which is intended for serological diagnosis of BVD in cattle. It is based on the recombinant NS3 antigen of an Indian BVDV-1 isolate and anti-NS3 monoclonal antibody.
- **Development of CRISPR/Cas 12 based diagnostic test for rapid detection of African Swine Fever (ASF) virus:** A two-step CRISPR/Cas 12a based diagnostic test was developed for rapid detection of African swine fever virus in samples of porcine origin. The test was evaluated using DNA extracted from 115 known ASFV positive (n=79) and negative (n=36) field samples. WOAH recommended real time qPCR assay was taken as the gold standard test. The sensitivity was estimated to be 97.47% and specificity of 83.33%.
- A SARS-CoV-2 nucleic acid detection LFA kit developed was released by Hon'ble Union Minister of Fisheries, Animal Husbandry & Dairying and Hon'ble Minister of State for Agriculture and Farmers Welfare along with Secy. (DARE) & DG (ICAR) on ICAR Foundation Day (July 16, 2023).
- A reverse transcription-multiplex PCR strategy devised for concomitant detection and differentiation of FMDV serotypes where in three assays with unique combinations of serotype specific primers targeting the VP1 region were developed to differentiate FMD virus serotypes O, A and Asia 1. The relative diagnostic sensitivity was 99.69%, 98.78% and 99.08% for primer combinations 1, 2 and 3, respectively. The validated novel mPCR assays show promise to be included in the routine diagnostic toolbox to augment the efficiency of diagnosis of FMD virus serotypes that display extreme genetic diversity and a tendency of transboundary dispersal.
- A TaqMan-probe-based one-step multiplex real-time RT-PCR assay for pan-serotype detection of FMDV was developed and found to be sensitive and specific. The diagnostic sensitivity was 100% (95% CI; 99-100), and specificity was 100% (95% CI; 94-100%).
- A sandwich ELISA was developed using rabbit polyclonal anti-FMDV/O serum and MAb #FMDV-O-5B6 for detection of FMDV/O antigen in clinical samples. The diagnostic sensitivity and specificity of the new assay was 100% and 98.89% respectively compared to the conventional polyclonal antibody-based assay. Further, the MAb-based ELISA showed better analytical sensitivity than polyclonal antibody-based ELISA.
- **Development of the pregnancy diagnosis kit for Mithun:** A urine-based pregnancy diagnosis kit 'Preg-DM' was developed and validated in collaboration with ICAR-CIRB, Hisar. The kit helps to detect pregnancy as early as days 30 to 35 post breeding for achieving high lifetime productivity.
- **Development of paper-based discs for detection of sorbitol in milk:** Test can be performed as platform test to detect sorbitol on the milk reception dock or at BMC level.
- **Strip for the detection of antimicrobial resistant *Escherichia coli* in mastitis milk:** A strip assay was developed to detect antimicrobial resistant *E. coli* in mastitis milk using a specific enzyme-substrate reaction principle. This will be helpful for field-based *E. coli* infection detection and assessing AMR profiles in mastitis milk.
- A Latex agglutination test was developed for

Development of India's first Lumpy Skin Disease vaccine (Lumpi-ProVac^{Ind})

The Agrinnovate has commercialized the vaccine to four major vaccine manufacturers, Biovet Pvt Ltd, Bengaluru; Indian Immunological Limited, Hyderabad; Hester Biosciences, Ahmedabad and Institute of Veterinary Biological Products, Pune.



Development of paper-based discs for detection of sorbitol in milk

detection of *B. anthracis* spores from soil and animal feed supplements.

Equines

Glanders surveillance: A total of 29,393 equine sera received from 17 states under glanders surveillance programme were tested. Out of these, 130 glanders positive cases were reported from Uttar Pradesh, Haryana, Uttarakhand, Madhya Pradesh, Himachal Pradesh, Jammu & Kashmir, Gujarat, Delhi, Maharashtra and Rajasthan.

Surveillance and monitoring of equine infectious diseases in India: A total of 2,567 equine serum samples from 11 states were tested for various diseases like equine infectious anaemia (EIA), equine influenza (EI), equine herpes virus-1 (EHV-1), Japanese encephalitis/ West Nile virus (JEV/WNV), *Trypanosoma evansi* (Trypanosomiasis), *piroplasmosis*, Salmonealla *Abortus equi* and Brucellosis Table 2. Highest sero-prevalence were observed for equine *piroplasmosis* (26.13%) followed by EHV-1(12.07%), JE/WNV (4.28%), and *Trypanosoma evansi* (1.98%).

Foot and mouth disease

Sero-surveillance and sero-monitoring: Under FMD sero-surveillance, 72,308 bovine serum samples collected across the country were analyzed using the r3AB3 NSP-ELISA (DIVA) to determine the apparent prevalence of NSP-antibody (NSP-Ab) in the bovine population. For post vaccination sero-monitoring, a total of 92,306 serum samples were examined using Solid Phase Competitive ELISA (SPCE) under NADCP to assess the efficiency of immunization. In addition, 10,515 serum samples received from various Breeding Bull stations and surrounding villages were also tested to assess the herd immunity.

***In vitro* assay for FMD vaccine quality control:** A universal *in vitro* antigen-quantification test for quality check of FMD vaccines using a pan-serotypic VP4 antibody was optimized. The assay is specific for 146S and does not react with the poorly immunogenic disintegrated antigen (12S). Altogether, VP4 based assay (for type O and A) and 146S specific mAb assay for type Asia 1, have the potential application in the quality control of FMD vaccine, and as in-process control during the vaccine manufacturing.

Alternative methods for FMD vaccine potency testing: The use of guinea pig (GP) model and serological assays were evaluated. Experiments on synchronized cattle and guinea pig were carried out, using 10 batches of FMD vaccine to generate data. The challenge infection of cattle with homologous FMDV serotype O Indian vaccine strain was carried out in an animal bio-containment laboratory for three batches of vaccine. Challenge-based protection status of each calf was correlated with antibody titre before to establish cattle antibody titre required for at least 75% of expected protection. The results showed a positive correlation between antibody titre and protection against FMDV serotype O. The established cattle cut-off was used to establish the corresponding cut-off titre in guinea pigs for use as batch release assay.

Software development: To estimate the state and national level FMDV seroprevalence rate, one R software package, namely FMDSeroSurv (GPL-3.0 license), was developed for the users, which is freely available at https://github.com/sam-NIFMD/FMDSeroSurv. This software provides functions to estimate the sero-prevalence rates along with various errors and number of animals having history of infection at the population (i.e., state and national) level using NSP-based serological survey data.

Supply of diagnostic kits: The state FMD centers were supplied with three primary test kits (3AB3 indirect DIVA ELISA for 1,20,481 samples, Solid Phase Competitive ELISA (SPCE) for 145,000 samples, and Sandwich ELISA for 1,450 samples) for undertaking disease surveillance and sero-monitoring.

Thermotolerant properties of FMDV serotype A IND 27/2011 variant selected through heat-resistant method was evaluated. The selected variant was characterized for its thermotolerant capacity by incubating the virus at different temperature-time combinations. In all the tested conditions, the thermally selected variant had better stability than the parental counterpart. After the thermotolerant O serotype, this will a step forward for developing thermotolerant A serotype vaccine candidate.

Exotic/Emerging diseases

Genetic diversity in avian influenza viruses (H5N1 subtype) isolated in India: Complete genome sequence

Lumpy skin disease virus in wild Indian gazelles (*Gazella bennettii*)

In Rajasthan, two free-ranging female Indian gazelles (*Gazella bennettii*) with skin lesions resembling LSD were rescued and quarantined. A capripoxvirus (CaPV)-screening real-time PCR showed positive results for skin samples. A lumpy skin disease virus (LSDV) wild-type strain specific real-time PCR showed positive results for skin samples confirming natural LSDV infection. Further, genetic and phylogenetic analysis of LSDV GPCR, RPO30 and EEV sequences revealed that the LSDV from Indian gazelle clustered with the LSDV wild-type strains of SG1-lineage (sub-cluster 1.2.1), circulating commonly in Africa, Middle East, Europe and Russia. LSDVs in Indian gazelles and local domestic cattle were genetically similar, reinforcing that susceptible wildlife can become infected with LSDV circulating in cattle in the region.

of 12 H5N1 highly pathogenic avian influenza (HPAI) viruses isolated from chickens, ducks, quails and wild birds during October 2022 to April 2023 in different epicentres was determined. In the hemagglutinin gene phylogeny, H5N1 viruses were distributed in two genetic clades, viz. 2.3.2.1a and 2.3.4.4b. Within clade 2.3.4.4.b, the Indian isolates grouped with contemporary isolates circulating in Eurasia, Africa and North America indicating recent introduction of the virus. However, the H5N1 viruses from clade 2.3.2.1a isolated during 2023 grouped with contemporary H5N1 viruses isolated from SAARC regions including India, indicating cross-border movement and persistence of the H5N1 virus, which highlights the need for continuous active surveillance.

Complete genome analysis of African swine fever viruses isolated from domestic pigs in Mizoram, India: Complete genome analysis of an African Swine Fever virus (ASFV) (IND/NIHSAD/SD/21_49), isolated from domestic pigs during the first outbreak in Mizoram in 2021 showed nucleotide identity of 99.99% with two previously reported Indian ASFV isolates (IND/AS/SD-02/2020 and IND/AR/SD-61/2020). Sequence analysis revealed that the Mizoram isolate (MZ-314/IND/2021) exhibited eight single nucleotide polymorphisms (SNPs) at different genomic coordinates compared to other Indian isolates, specifically IND/AS/SD-02/2020 and IND/AR/SD-61/2020. Two SNPs were observed in both the 3' ITR and intergenic regions, and one SNP each was identified in different genes, namely, K205R, EP1242L, B263R, and E199L, when compared

National Centre for Veterinary Type Cultures (NCVTC)

With 16 network centres across the country, the NCVTC is operating in network mode. A total of 377 microorganisms were added to the NCVTC repository.

to other reported Indian isolates. Complete genome based phylogenetic analysis showed that Indian ASFV isolates belong to genotype II and grouped with ASFV/Wuhan/2019 in a separate clade when analysed with only P72-genotype II viruses. Complete genome analyses showed the continuous evolution of genotype-II ASFV with accumulation of SNPs, deletions and insertions in various regions in the genome of ASFV in India.

Whole genome sequence based evolutionary analyses of HoBi-like pestiviruses: Results revealed that HoBiPeV had a recent origin and most likely originated in India and provide first evidence of negative selection in HoBiPeV evolution.

The HoBi-like pestivirus (HoBiPeV), classified under *Pestivirus H* species of genus *Pestivirus* is one of the causative agent of bovine viral diarrhoea-mucosal disease (BVD-MD) in cattle. But the origin and evolution of HoBiPeV is not very clear due to lack of full genomic sequences from diverse clades. Full genome sequences of HoBiPeV strains of three novel clades (c, d and e) circulating in India were determined and full-genome based genetic and evolutionary analyses were performed. The length of HoBiPeVs was determined to be 12372, 12251, and 12259 nt, respectively, for strains of HoBiPeV-c (IndABI15385/2012), HoBiPeV-d (IndBHA5309/2012), and HoBiPeV-e (HoBiPeVInd/TN-1214/19). Bayesian phylogenetic analyses revealed the existence and independent evolution of four main HoBiPeV clades (a, c, d, and e) globally, with genetic divergence ranging from 13.0% to 18.2%.The Bayesian molecular clock estimates revealed that HoBiPeV most likely originated in India before its emergence in other parts of the world with a dated tMRCA of 1938 (1762–2000), evidencing a more recent origin of HoBiPeV. The evolution rate of HoBiPeV was estimated to be 2.133×10^{-3} subs/site/year at full-genome level, but varied widely among individual genes. Selection pressure analyses identified most of the positively selected sites in E2. Additionally, 21.8% of the ORF codon sites were found under strong episodic diversifying selection, providing first evidence of negative selection in HoBiPeV evolution.

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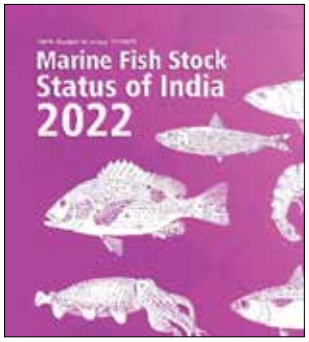
8. Fisheries Management

Marine Fish Stock Status of India: ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI) provides valuable insights into the health of India's marine fisheries and is the first endeavour of its kind in the Asian Region using biology-based data. Overall, 135 marine finfish and shellfish stocks were assessed using marine fish landings and species-specific biology data from 1,168 landing centers from the Northwest, Southwest, Northeast, Southeast and Lakshadweep regions. The study reveals that of the 135 fish stocks assessed (Northeast – 16, Northwest – 37, Southeast – 39, Southwest – 41, Lakshadweep – 2) in 2022, 91.1% of them were healthy. The highest percentage of healthy stocks was observed in Lakshadweep followed by Southeast region (97.4%), Southwest (92.7%), Northeast (87.5%) and Northwest (83.8%). The report also identifies management measures that could be applied to the fish stocks/ species that are of concern with regional approaches that will ensure their sustainability. This report will set the stage for a Management Strategy Evaluation (MSE) framework for marine fisheries in the country. It will also form a valuable resource for fishery managers, policymakers, researchers and other stakeholders who are working to ensure the sustainability of India's marine fisheries.



Marine Fish Stock Status of India (2022)

Identification of potential areas for seaweed farming along the Indian coast: Seaweeds (Marine macroalgae) are important coastal resources valuable both for society and the environment. Seaweed farming is a green technology with zero input which can act as an important mitigation measured for reducing the adverse impact of climate change and has the potential to earn carbon credits for our country. Growth of seaweed farming is constrained primarily by the absence of proper marine spatial plans. In order to address this issue, the ICAR-CMFRI, and CSIR-Central Salt and Marine Chemical Research Institute (CSIR-CSMCRI) have identified potential sites for seaweed farming in 9 coastal states and 4 Union Territories of our country. Sites identified (384) were categorized into green zones (> 1 km from CRZ-IA), amber zones (up to 1 km from CRZ-IA), and blue zones (within CRZ-IA and ESA), with 24,707 ha identified as suitable for seaweed farming, including 3,999.37 ha classified as green zones, 14,076.77 ha as amber zones, and 6,631 ha as blue zones. The seaweed production potential of these sites has been estimated as 10 million tonnes (Net weight/year).

Good management practices in seaweed farming: Seaweeds are valued commercially for their cell wall polysaccharides such as agar, align, carrageenan, etc. and for bioactive metabolites, manure and fodder. They have a variety of commercial applications in food, pharmaceutical, cosmetics and mining industries. India has a seaweed production potential of 9.88 million tonnes wet weight per year while the current production stands at merely 52,107 tonnes wet weight per year. Keeping in view the immense potential in seaweed farming in the country, ICAR-CMFRI has brought out a document on good management practices to promote and support sustainable farming of seaweeds in India, while paving the way for economic security of the stakeholders, primarily women. Information and easy-to-use guide are made available on species available in the country, culture methods for native seaweed species, potential areas for seaweed farming, farming techniques (materials, methods, do's and don'ts), farm management, post-harvest handling, economics of seaweed farming and integrated multi-trophic aquaculture (IMTA).

Sea ranching of *Penaeus semisulcatus* to enhance wild shrimp stocks: 'Green tiger shrimp' or 'Mandapam flower shrimp,' accounts for more than 70% of the total shrimp landings in Tamil Nadu and approximately 5% of the total Indian marine penaeid landings ~8,500-9,000 tonnes/year fetching around ₹ 320 crores annually. *Penaeus semisulcatus* is harvested mainly by the trawl nets operated by mechanized and non-mechanized boats. ICAR-CMFRI, Mandapam Regional Centre had developed the technology of hatchery seed production and larviculture of *P. semisulcatus* in late 1980s and sea ranching of hatchery produced shrimp seeds (post-larvae - PL20) was done to replenish the natural stock and to enhance the shrimp stocks in Palk Bay and Gulf of Mannar. In 2022, the *Pradhan Mantri Matsya Sampada Yojana* (PMMSY) of the Department of Fisheries, Govt. of India (DoF-GoI) supported the sea ranching programme of ICAR-CMFRI, with an objective to conserve and

maintain a sustainable stock of the green tiger shrimp in the wild. It is expected that this will benefit more than 35,000 fishermen who are directly involved in the Green tiger shrimp fishery and the ancillary sectors. Annually, 50 million PL20 of *P. semisulcatus* are ranched into the seagrass beds of the Palk Bay and Gulf of Mannar with a target of releasing 200 million of PL20 in 4 years. Following this, the shrimp landings showed an increasing trend in the region (with an average increase of 17.51% compared to the base figure of 2017) during 2018-2022. The current (2022) harvest of the species from the region is about 10,600 tonnes (having a value ₹ 380 crores per year).

Fish catch estimates of Mahanadi, Krishna and Tapti rivers: Riverine fisheries, providing livelihood to uncountable number of riparian fishers, are under immense stress from damming and reduced headwater discharge, pollution, erratic rainfall, and excess fishing pressure, etc. However, quantitative information on fish catch from major rivers are lacking since decades. ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI), through intensive surveys, estimated fish catch and related information from some of the major rivers. In River Mahanadi, the annual total catch was estimated to be 15,134 tonnes with catch per unit effort (CPUE) ranging between 0.18 kg and 18.88 kg/fisher/day. Catfishes, namely, *Wallago attu, Sperata aor, S. seenghala, Eutropiichthys vacha* and *Silonia silondia* dominated the catch (36.4%) followed by major carps (22.6%) and murrels (12.5%). The annual fish catch of the River Tapti and River Krishna were estimated at 6,946 tonne, and 18,902 tonnes with CPUE of 0.69-9.45 and 2-6.84 kg/fisher/day, respectively. Carps, catfishes, eels and small indigenous fishes (SIFs) contributed majorly to the total catch in both the rivers. The data showed significant contribution of the rivers in inland fish production.

Weed-based fish aggregating devices for heavy metal amelioration in Loktak Lake

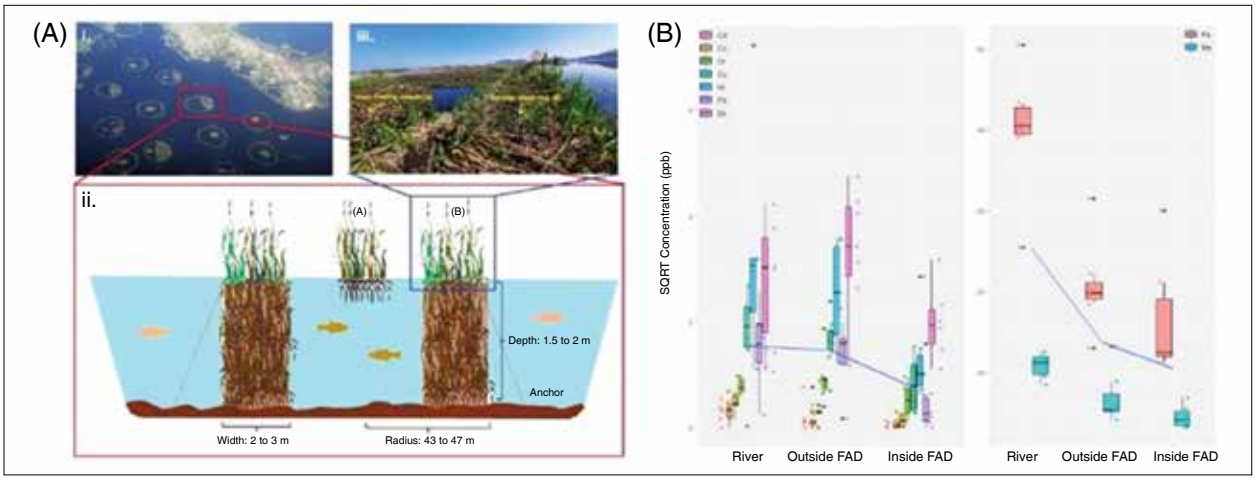
Increasing pollution loads pose serious threats to inland open water fisheries. With aim towards pollution amelioration, ICAR-CIFRI examined effect of natural floating islands as fish aggregating devices (FADs), on distribution of heavy metals in the abiotic and biotic compartments in Loktak Lake. Concentrations of Cd, Pb, and other metals (Cr, Cu, Ni and Zn) in water inside the FADs were 73.91, 65.22 and 40.57-49.16% less, respectively as compared to outside the FADs. The fish species inside the FADs were also less contaminated (24.07-25.07% reduction in metal levels) with low health risk indices. The study signifies the role of natural floating islands in ameliorating the effect of heavy metals pollution towards better ecosystems and fish and human health.

Microbial consortium for remediation of ammonium in contaminated waterbodies

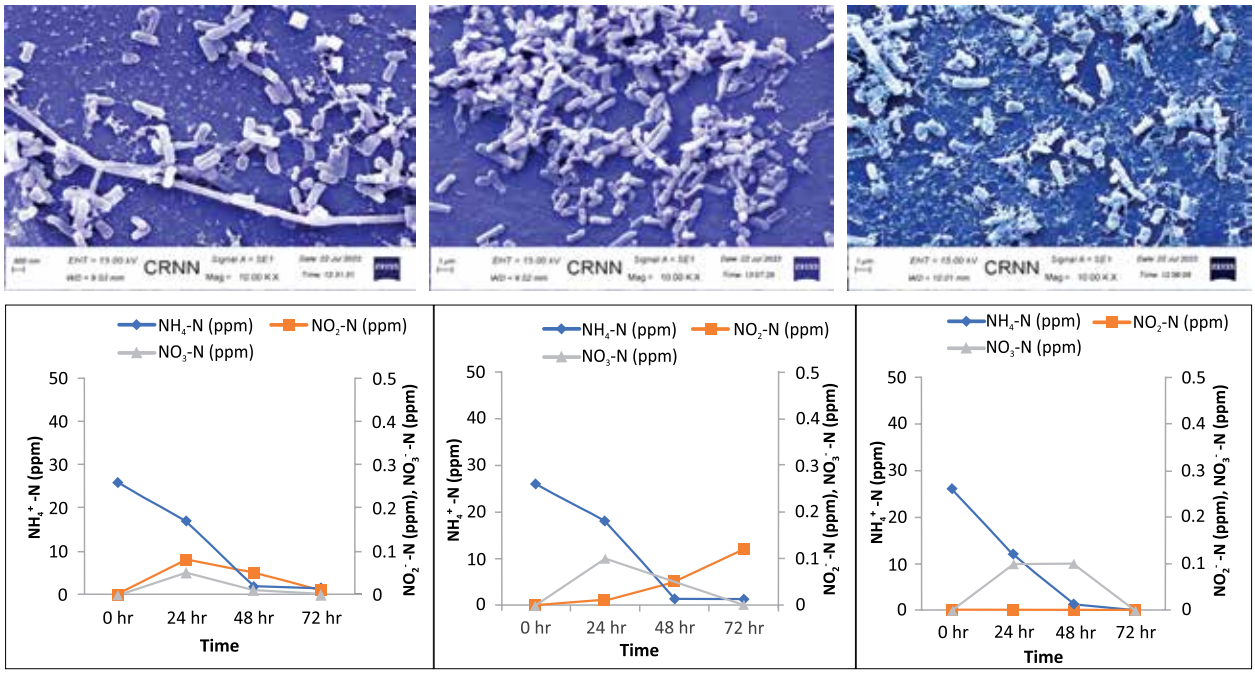
Microbial-based bioremediation represents a promising strategy for sediment reclamation, yet it frequently fails due to poor knowledge of diversity and dynamics of the autochthonous microbial assemblages. An integrated approach including environmental characterization, high-throughput sequencing and culturing to identify autochthonous bacteria with bioremediation potential in the sediments of East Kolkata wetland (West Bengal, India), a sewage-fed Ramsar site, was followed. The 32 bacterial isolates recovered in this study were from Bacillaceae, Burkholderiaceae, Enterobacteriaceae and Aeromonadaceae families; species, viz., *Lysinibacillus fusiformis*, *L. macroides*, *Bacillus subtilis*, *B. safensis* and *Citrobacter freundii* which exhibited ability to remove ammonia. These isolates were non-pathogenic and could grow together without displaying inhibitory effects. The work provides valuable insights into microbial-based environmental bioremediation, which could be used to combat eutrophication in aquatic ecosystems.

Nation-wide web-based map of river environment

ICAR-CIFRI has developed the RiverAquaMap, a national web application, for navigating river aquatic



Fish aggregating devices (FADs) in the Loktak lake, Manipur. Structure of a typical FAD made of floating weed biomasses (A); Average surface water heavy metal content (µg/L) in river, outside and inside of FADs of Loktak lake (B).



Lysinibacillus fusiformis *L. macrolides* *Bacillus safensis*

Cell morphology and ammonia degradation ability of some isolated bacteria

environment based on information from primary and secondary sources. The backend water quality data comprises DO, BOD, water temperature, pH, specific conductivity, nitrate, and nitrite. All the parameters are navigable on spatio-temporal scale on 2,667 locations distributed over the Indian river system for the period from 2007 to 2020. The key highlights of RiverAquaMap are Online GIS-based data presentation of individual water quality parameter, online spatio-temporal map of hypoxic stress of Indian river systems and online spatio-temporal map of DO driven hypoxia of fishes of Indian river system. The generated map would help decision makers for devising location-specific strategies of riverine fisheries.

Launching of Report Fish Disease (RFD) App

Report Fish Disease App developed by ICAR-National Bureau of Fish Genetic Resources (ICAR-NBFGR), Lucknow under National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) was launched by Shri Parshottam Rupala, Union Minister for Fisheries, Animal Husbandry and Dairying in presence of Dr L. Murugan, Minister of State, Ministry of Fisheries, Animal Husbandry and Dairying; Dr Himanshu Pathak, Secretary, DARE and DG, ICAR; Dr J.K. Jena, DDG (Fisheries Sciences) and other senior Officers from DARE, ICAR on 28 June, 2023 at Krishi Bhawan, New Delhi. The App is expected to strengthen the farmer-based fish disease reporting system and improve the reporting of aquatic animal diseases in the country.

Development of next generation shrimp larval feed, Larvi^{+A}

ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) upgraded its existing shrimp larval feed by novel additives and growth promoters and developed the improved next generation shrimp larval feed, Larvi^{+A}. It was tested in 16 commercial hatcheries of Andhra Pradesh and Tamil Nadu in collaboration with start-up entrepreneurs. Larvi^{+A} performance revealed good water stability, palatability and excellent growth and survival up to 92%. Larvi^{+A} feed can serve as a cost-effective option for shrimp hatcheries.

Vaccine for production of disease resistant spawns, CIFA-brood-Vac

ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA) developed a vaccine, 'CIFA-brood-Vac' for vaccinating female Indian major carps and catfish brooders in order to enhance the production of disease resistant spawns up to 30%.

Circular cage for inland open waters

ICAR-CIFRI developed circular HDPE cages having 16 m diameter and 5 m depth and 900 cubic meter water area. These cages were

used to rear adult hilsa *Tenualosa ilisha* and Indian major carps in river Ganga at Farakka. The cage is structurally sturdier and therefore can withstand a higher degree of wave action with water velocity of 0.8 to 1.0 m/s. The product has been commercialized through Agrinnovate India Ltd.

Circular cage for inland open waters

Solar-powered fish feed dispenser

A solar powered fish feed dispenser unit was designed and built on the Internet of Things (IoT) framework with a Radiofrequency (RF) module for wireless data transmission using a single board microcontroller. The device can move around the pond and dispense 6 kg of feed in 5 min.

Solar-powered fish feed dispenser

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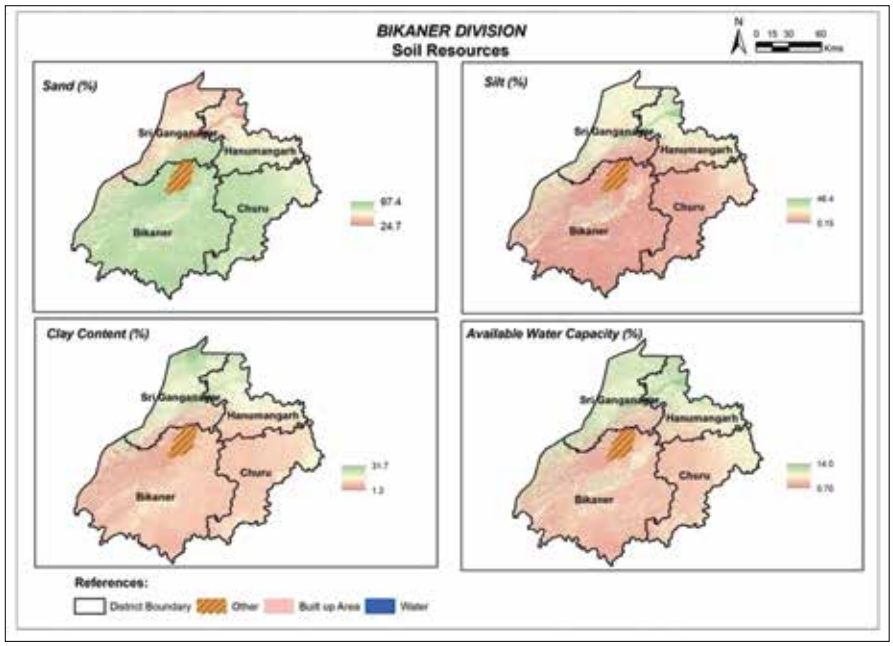
9.
Soil and Water Productivity

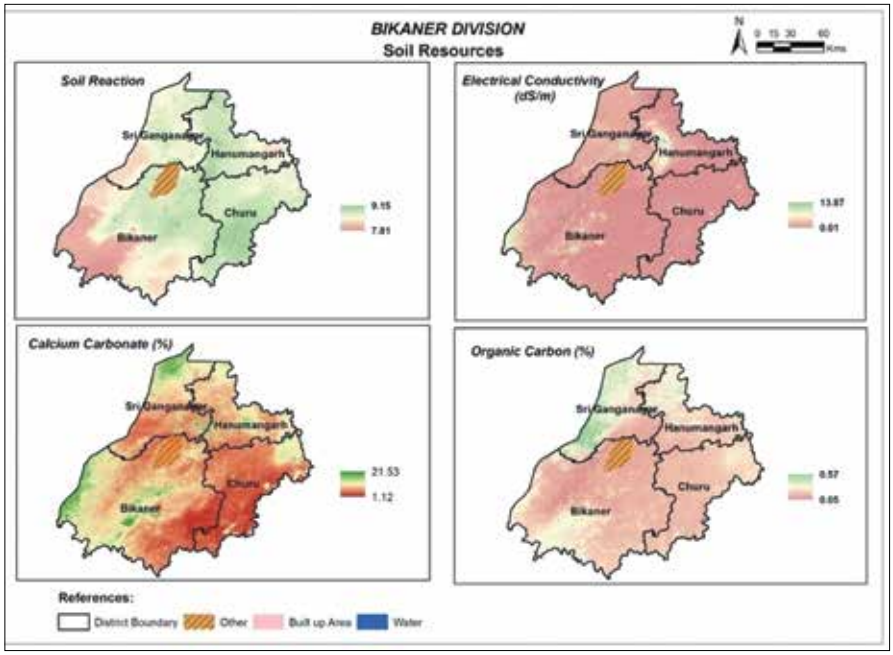
Agricultural land use plan of Bikaner Division: Agricultural land use plan based on the potential of soil enhances the land productivity. Bikaner division of Rajasthan represents arid agro-ecosystem with land degradation issues including wind erosion. A total of 2108 soil samples were collected from 531 geo-tagged soil profiles, processed, and analysed for soil properties. Digital soil mapping technique was used to develop soil spatial maps of eight key soil properties, viz. sand, silt, clay, available water capacity (AWC), *p*H, electrical conductivity (EC), soil organic carbon (SOC), and calcium carbonate ($CaCO_3$) content.

Based on the spatial soil information, suitability of major crops was assessed using the analytical hierarchical process in the GIS environment, to suggest a crop plan and soil-based management measures to improve land productivity within the limitations of bio-physical factor and available resource. The proposed crops are Groundnut/Cluster bean/ Pulses/Pearl millet/ Sorghum for Bikaner and Churu districts. Most suitable crop combinations for Sri Ganganagar are Cluster bean/ Pulses/Pearl millet/Sorghum or Cotton/Groundnut/Cluster bean/Pulses. Cluster bean/ Pulses/Pearlmillet/Sorghum and Cotton/Cluster bean/ Pulses/Pearl millet/Sorghum are suggested for Hanumangarh district during *kharif* season. Similarly, for *rabi* season, Taramira/Mustard/Chickpea is proposed as the most suitable crop plan for Bikaner and Churu districts, whereas Barley/ Mustard/Oat and Chickpea/ Taramira/Mustard/Barley are the major crop plan for Sri Ganganagar and Hanumangarh, respectively.

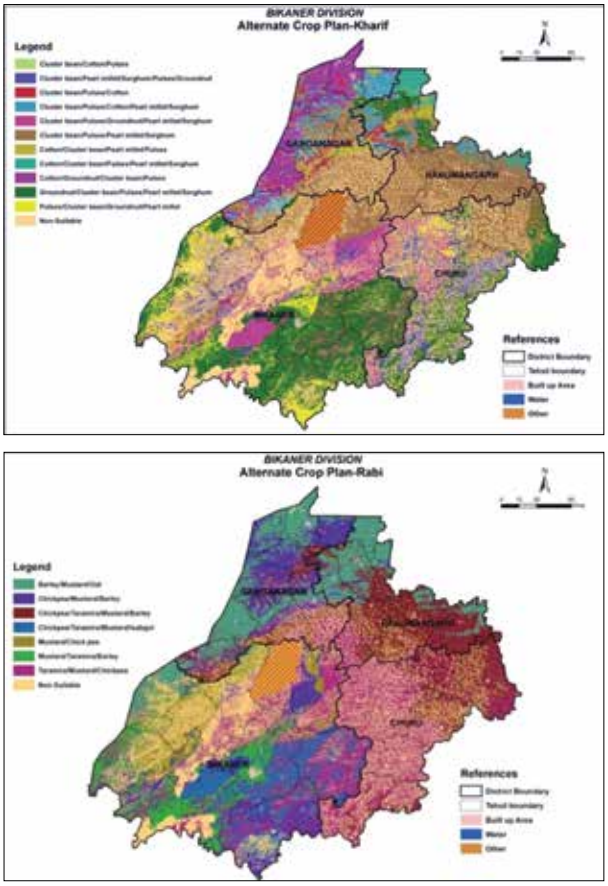
Land resource inventory of Andaman and Nicobar Islands: Similarly, land resource inventory at 1:10,000 scale covering the arable lands of the North and Middle Andaman district was prepared. About 2.5% of the area is under agricultural lands, 0.60% under plantation and tree clads and about 2% area is under homestead farming. Valley and coastal plain are the major landforms. Mudflat occupies 0.80% of area confined in Baratang (Rangat block) and Shyamnagar (Diglipur block) areas. Soil suitability assessment indicated that 65.0% area could be used to



Digital maps of key physical properties of soil samples



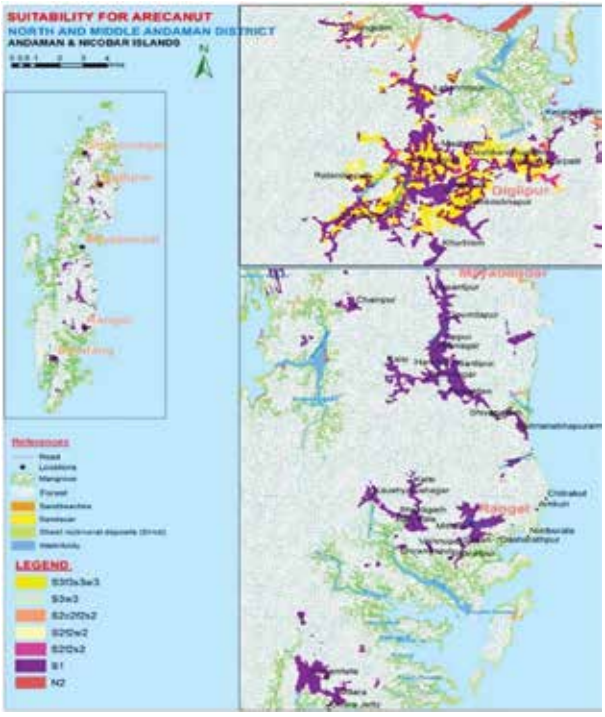
Digital maps of key chemical properties of soil samples



Agricultural land use plan for Bikaner division

grow arecanut while 72.0% area is suitable for cultivating coconut.

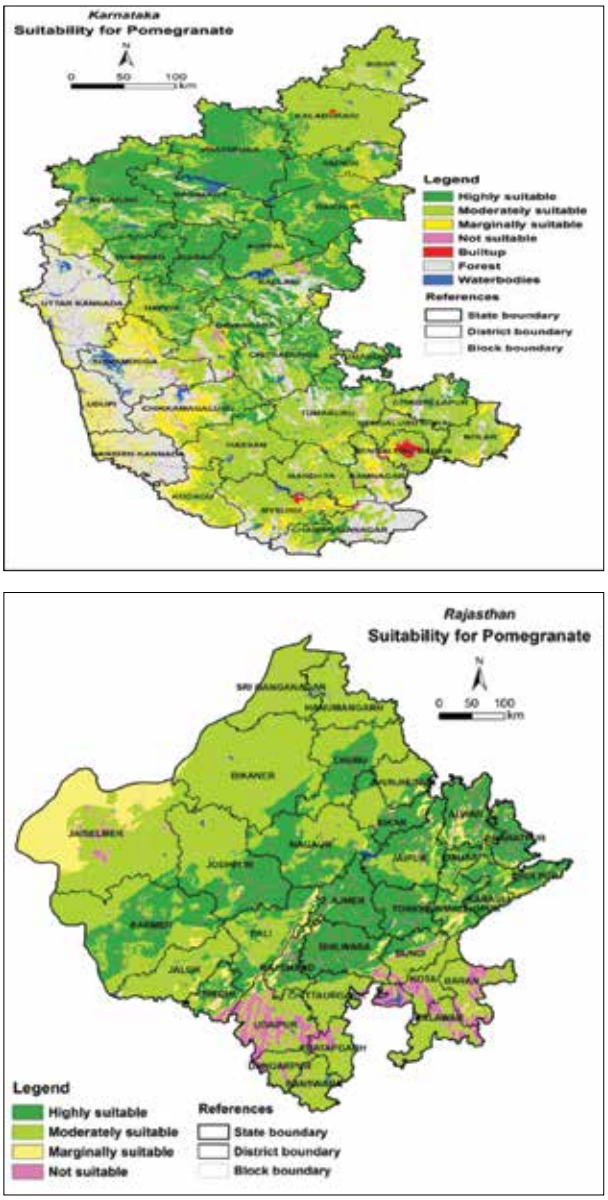
Soil-site suitability for Pomegranate: Suitability maps for pomegranate for 15 states have been revised



Soil-site suitability map for arecanut

with the help of latest data in climate, terrain and soil parameters in the GIS based multi-criteria model. The maps were finalized and validated. This will greatly improve the resource-use efficiency and productivity.

Development of soil spectral library: More than 3,500 soils were characterised for their spectral signature



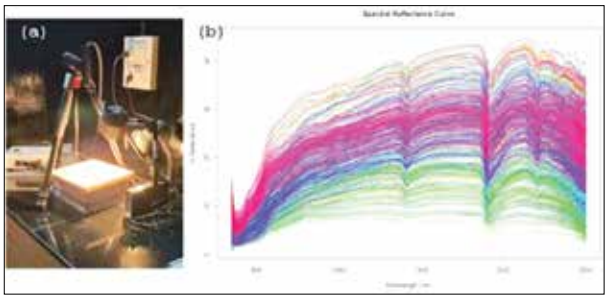
Revised soil-site suitability maps of pomegranate

from Maharashtra, Madhya Pradesh, and Gujarat. The predicted models for soil properties were developed using Partial least square regression. The most relevant wavelengths for differentiating soil properties in the soils of the study area were found to be 560 and 1900 nm in the case of clay content, 2,220 nm in the case of *p*H, 2,250 and 480 nm in the case of SOC, and 380 and 420 nm for $CaCO_3$. This information can be used for faster characterisation of soil properties.

Indian National Soil Archive: An initiative was taken to establish Indian National Soil Archive (INSA) which will be helpful in studies related to Digital soil

mapping, soil spectroscopy, comparison of current soil conditions in particular location to that of past, and other studies arising from the changing climatic conditions. INSA consists of: a soil sample storage room where soil samples are kept with QR code levels, a web application to create and update database on the soils and generation of QR codes and reports, and an android mobile application to scan the QR code to generate reports of a particular sample. Developed with the help of HTML, JavaScript, CSS, php, MySQL and GeoServer, the INSA also shows the user the availability of soil samples and database in a particular region on spatial maps.

Hyper-spectral and multi-nutrient extractant based rapid assessment of soil properties: Optimal sampling design was developed to collect samples representing different Agro-ecological sub-regions (AESRs) of India by using conditioned Latin hypercube sampling (cLHS) approach. 3410 sampling locations within India representing different AESRs, soil types, landforms, terrain features,etc were selected and 886 surface soil samples from different locations were collected as per the sampling protocol established through cLHS design (ICAR-CAZRI: 305, ICAR-IISS: 105, ICAR-IARI: 69, ICAR-NBSS&LUP: 84, BCKV: 203, TNAU: 120). Collected soil samples (n=501) were analyzed for various soil properties including *p*H, electrical conductivity (EC), soil organic carbon (SOC), available nitrogen (N), phosphorus (P), potassium (K) and DTPA extractable micronutrients (Fe, Mn, Zn and Cu). Result from descriptive analysis revealed a wide variation in soil properties, e.g. *p*H ranged from 9.6 to 9.36, EC ranged from 0.01 dS/m to 1.94 dS/m, SOC content ranged from 0.02 to 3.78%, available N content ranged from 80.0 to 596 kg/ha, available P content ranged from 0.99 to 124 kg/ha and available K content ranged from 36.0 to 1198 kg/ha. Similarly, DTPA extractable Zn, Fe, Mn and Cu content in soil samples varied from 0.11 to 13.6, 1.39 to 57.0, 1.94 to 118 and 0.16 to 9.13 mg/kg, respectively. Hyperspectral signatures of collected soil samples (n=628) from different AESRs were measured using spectroradiometer facility. Variation in spectral signatures of collected soil samples were noted. Overall height of the spectra, absorption features of the spectra and slope of the spectra at different spectral regions depend on the inherent composition of soil and thus these spectral signatures act as proxy of different soil property.



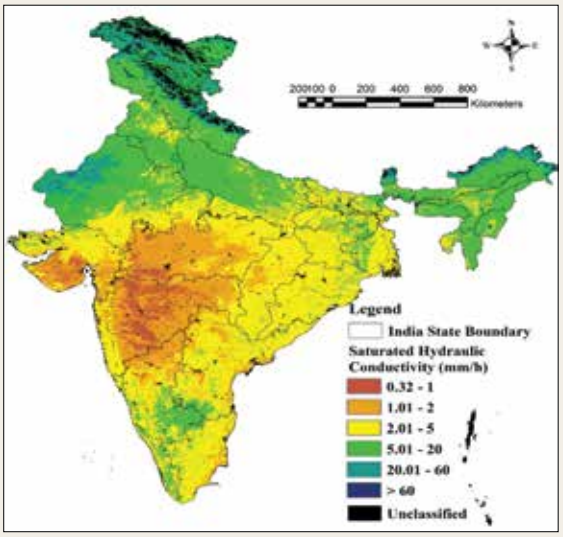
Spectroradiometer (VIS-NIR-SWIR) instrument facility in ICAR-CAZRI, Jodhpur (a) and Hyperspectral signatures of soil samples collected from different Agro-Ecological Sub-regions of India (b).

Databases for geospatial mapping of multiple components under Abiotic Stress Information System: The Soil Chemical Quality Index has been calculated at village level for India using weighted sum approach. In this approach, each of the 12 nutrients were given weightage based on expert option for its categorization into low, medium and high levels and cumulated to calculate the Soil Chemical Quality Index. Further refining the methodology particularly for Haryana, the farmer level geo-referenced datasets were first reduced by removing duplicates, imposing threshold limits and geofencing approach. Machine learning models were developed for amputation of missing values. Among the several Interpolation techniques used, those exhibiting lowest RMSE (Root Mean Square error), were used to develop interpolated Raster maps of each individual nutrient. Further, these raster maps were used to calculate the Soil nutrient scoring based on linear and non-linear scoring functions and integrated into a

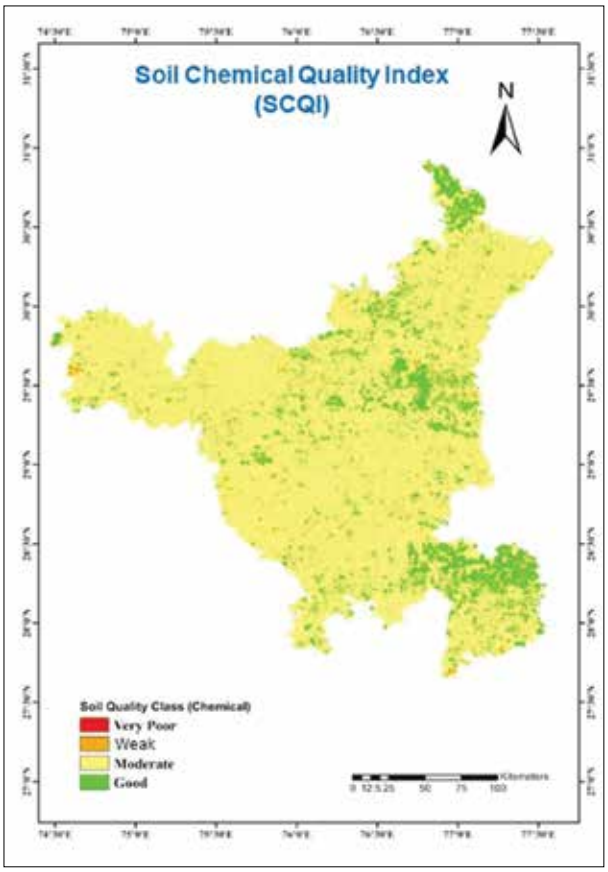
Soil saturated hydraulic conductivity map of India

Saturated hydraulic conductivity (Ks) largely depends on soil texture (sand, silt, and clay), gravel, organic carbon, and salinity. Saturated hydraulic conductivity map for the country has been generated from the data on these parameters, and represents an indicative value of Ks of the top 30 cm of the soil. The essential data for India were accessed from the International Soil Reference and Information Centre (ISRIC) soil grid data (grid size 250 m).

The map shows a total of six classes having a defined range of saturated hydraulic conductivity presented in millimetre per hour (mm/h). The area under the class having a lower value of Ks may be suitable for water harvesting and storage, whereas an area having a high value of Ks is suitable for percolation ponds and water spreading for groundwater recharge. This map can be used by researchers, hydrologists, and line department's for hydrological modelling and planning soil and water conservation measures.



Soil saturated hydraulic conductivity map of India



Soil chemical quality index of Haryana

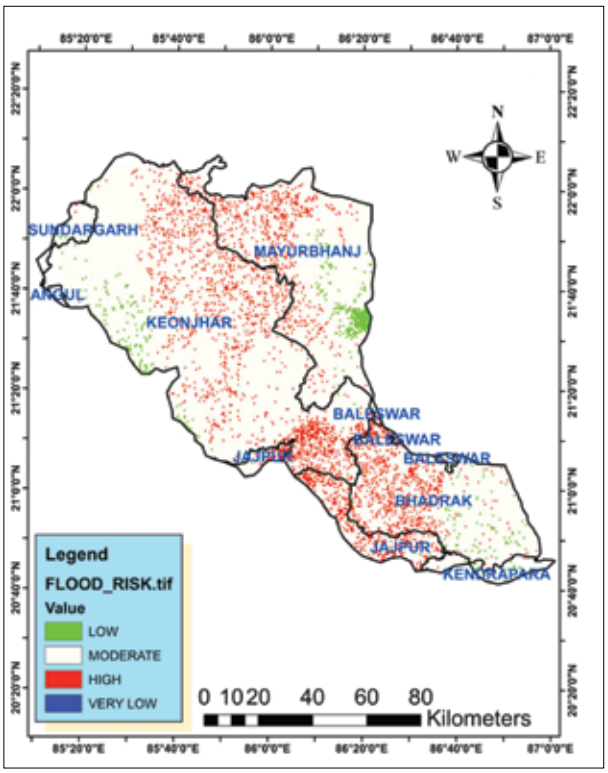
Automation of irrigation pump for enhancing water productivity in transplanted rice

Automatic on and off irrigation pumps can avoid overuse of water and save energy. In alternate wetting and drying (AWD) of transplanted rice, periodic irrigation up to 5 cm ponding is provided after the water level falls to a critical depth (10 cm) below the soil surface in the designated pipe. An automated AWD system was developed and evaluated in transplanted rice at ICAR-IIWM, Bhubaneswar. The results revealed that rice grain yield was 4.43 and 4.21 t/ha under continuous flooding and automated AWD, respectively. In continuous flooding, 1340 mm of water (irrigation and rainfall combined) was required, while under automated AWD, 1100 mm of water was required. Thus, there was a saving in irrigation water use by 240 mm (18.0%) in automated AWD. Water productivity was only 0.33 kg/m^3 with continuous flooding, while it was 0.38 kg/m^3 with the automated AWD system.

Field view of automated AWD irrigation

single Soil Chemical Quality index using Numero, Additive and Weighted approaches. This Index classifies the soil into four levels of fertility classes that can used for getting insights into fertility status at sampled and unsampled locations.

Mapping of flood susceptible zones in Baitarani River basin: Analytical hierarchy process (AHP) and GIS were used to prepare the flood susceptibility maps of the Baitarani River basin. Analysis showed that nearly 87.0% of the river basin area is under intermediate flood hazard zones and 10.0% area is under high flood hazard zone. Lower catchment areas with flat topography, near to the coastline are highly prone to flooding. The effects of severe flooding in the Baitarini River basin are visible in three blocks in Jajpur district (Jajpur, Dasarathpur, Korei blocks), two blocks in Bhadrak district (Dhamnagar and Bhandaripokhari blocks) and Anadapur block in Keonjhar district of Odisha. Occurrence of floods over the period of time has resulted 8.0% decline in agricultural land and a 13.9% increase in fallow land within the basin during 1995 and 2020. Hence, it is necessary that integrated flood management measures along with watershed management approaches in the upper catchment areas is suggested to minimize the risk of flooding in the basin.



Spatio-temporal change assessment for *diggi* based canal water use, expanding irrigated croplands and reduced wind erosion in IGNP area of Jaisalmer district: *Diggi* is an indigenous micro-hydrological structure that has become quite popular strategy for water management at field scale. Such structures are man-made and are constructed in farmers' field where farmers transfer the nearby canal water into these ponds

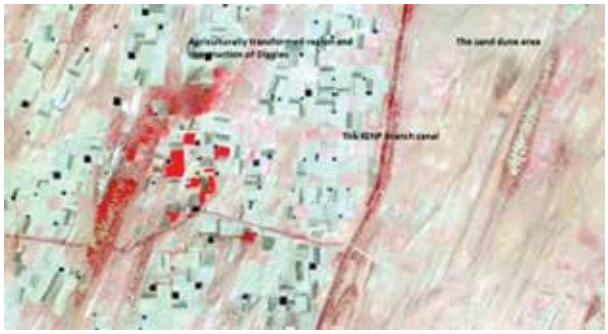
using solar energy, electricity or diesel based pumping. The structures are geometrically rectangular in shape, thus, are clearly visible and can be mapped on the False Colour Composites of remote sensing satellite images, especially in IRS-LISS III or more high resolution LISS IV image. Remote sensing satellite images of three years at an interval of 10 years; 2000, 2010 and 2020 were used and created GIS maps and database for extent of irrigated croplands, farm ponds (*diggi* structure) and wind erosion affected area.

Three GIS maps were created. Wind erosion affected area extracted from desertification map of Jaisalmer for the year 2018 at 1:50k scale, spatial distribution map of diggi structures (digitized from Sentenel-2 A satellite images with 10 m spatial resolution and Google earth images) and extent of irrigated croplands (extracted generating a NDVI from Landsat 5(TM) satellite images for 2001, 2011 and 2021 year).

It was found that number of diggies increased 10 times during 2021 compared to the year 2001. The irrigated area expanded about 4.5 times between the year 2000 and 2021 . The wind erosion affected area was reduced by 163371 ha. As per agricultural statistics database of Jaisalmer district for the year 2019-20, 56.0% area is irrigated through tube wells, 43.0% is canal irrigated and 1% area is irrigated through open wells. Considering the extent of culturable wastelands which occurs in 55.0% area, there is scope for more transformation of this region in agriculture and also in combating wind erosion activities using *diggi* based irrigation system.

Temporal changes in irrigated crop area, *diggi* number and wind erosion affected areas

Year	Irrigated crop area	No. of *Diggi* structures	Year	Wind erosion affected area
2001	13798 ha	395	2003	863696 ha
2011	19631 ha	509	2010	762116 ha
2021	80514 ha	4478	2020	700325 ha



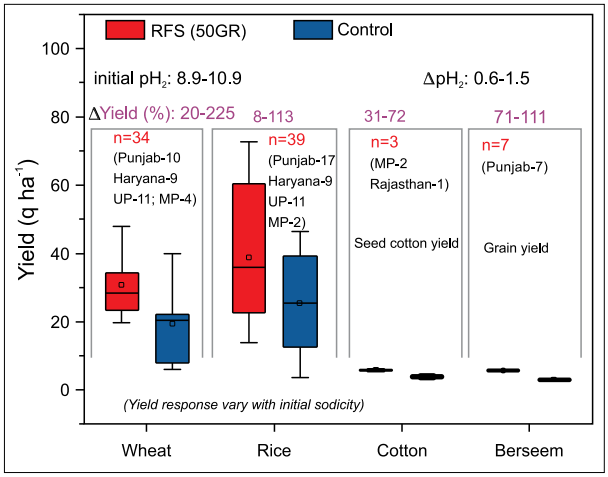
IRS-LISS IV satellite images shows the Duny landscape, *diggi* structures and canal in Ramgarh-Dhanana area of Jaisalmer district

Modified sand-based runoff filters for artificial groundwater recharge in semi-arid region of Gujarat: Sand-based runoff filter, comprising of coarse sand, gravel and pebble, has been developed to harvest runoff from farmers' fields for artificial groundwater recharge in Semi-arid region of Gujarat. The intervention resulted in rise in groundwater table in the village by 1.84 m and farmers were able to give full irrigation to *rabi* crops. The crop productivity has increased by 0.8 t/ha in the Bhadroli Khurd-Karada watershed, Taula-Kalol, district, Panchmahal and increased the farmers' income by ₹16,000/ha. Benefit to Cost ratio varied from 1.65 to 2.89 with payback period of 2-3 years. The runoff filters had also increased the additional command area of nearby open wells to 12 ha in the village.

Modified sand-based runoff filters for artificial groundwater recharge

Sulphur based formulations-New reclamation agents for sodic soils: To address the availability of quality gypsum for reclaiming sodic soils, three categories of sulphur-based formulation (RFS) were developed suitable for different soil sodicity conditions. Elemental sulphur (S) based formulation increased wheat and berseem grain yield by 20-25% and 71-111%, respectively in sodic soils. The elemental S based formulation evaluated at 83 locations in Punjab, Haryana, Uttar Pradesh, Madhya Pradesh and Rajasthan showed 8% (very low sodicity)–225% (high sodicity) increase in yield of wheat, rice, cotton and berseem (fodder crop). These formulations are highly reactive and get oxidized within one crop season by the soil microorganisms to help in alleviating the stress caused due to excess of the alkaline salts present in soils and also provide conducive environment for root proliferation. It has quick response, is about six times less bulky and has consistent quality with >90% purity compared to mined gypsum and recommended for use in sodic soils popularly known as *usar*/*kallar* soils, likely to catalyze the circular economy of byproducts from petroleum industries.

Salt tolerant Indian mustard variety CS 64: The salt tolerant Indian Mustard CS 64 was released by Central Sub-Committee on Crop Standards, Notification and Release of Varieties (CVRC) for salt affected areas of the Haryana, Punjab, Rajasthan, Delhi and Uttar Pradesh, Plains of Jammu and Kashmir and Himachal Pradesh. The productivity of this variety under normal soils is 25-28 q/ha, while under salt affected soil and irrigation water ($EC_{e/iw}$ 13 dS/m) and sodicity (*p*H 9.4), is 20-23 q/ha with 40.0% oil content.It matures in 130-



Performance of crops in sodic soils of different ecologies

Performance of S based formulations at farmers' field

138 days. This variety showed resistance to *Alternaria* blight, White rust, Powdery Mildew, Downy Mildew, Stag head, *Sclerotinia* stem rot and mustard aphid under field conditions also.

Mustard variety CS 64

CSR 65 (CSR B31) for sodicity tolerance in basmati background: Line CSR 65 (CSR B 31) is a basmati line, with high-yielding and long slender grain, developed from the cross of TRY 1/ Pusa Basmati 1. This dwarf culture has a medium duration (130–135 days), green foliage, slender grains, and full panicle exertion. It has a strong aroma, HRR (64.1%), ASV (7), AC (24.4%), GC (25 mm), and all basmati quality attributes. The line CSR 65 (CSR B 31) was found superior in yield over Pusa Basmati-1 (yield check), Pusa Basmati-1121 (yield check and quality check), Taroari Basmati (quality check), and Local check by 28.9%, 51.9%, 57.9%, and 34.9%, respectively across the two years (2018 and 2019). In sodic soils of Uttar Pradesh, line CSR 65 (CSR B 31) showed a yield advantage over CSR 36 (National check) and CSR 30 under sodic soils. The performance of CSR 65 (CSR B 31) was consistently high yielding for two successive years. Therefore, CSR 65 (CSR B 31) showed promise as basmati line with sodicity tolerance. CSR 65 (CSR B 31) could be used in further improvement in increasing basmati rice yields under salt-affected soils.

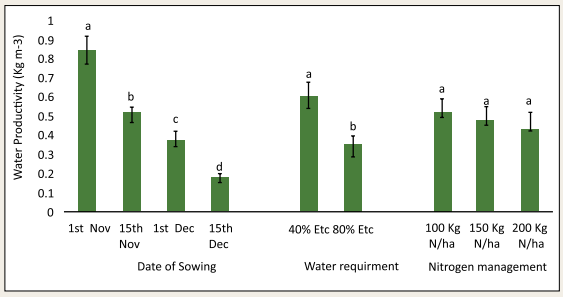
CSR 95 (CSR 189-11-122)-*Saltol*QTL introgressed line governing tolerance to salt stress: Tolerance at the seedling stage of a crop is essential for crop survival and establishment under salt-stress conditions. FL478 (RIL of IR29 × Pokkali) is a seedling stage salt tolerant variety having a major QTL called saltol. CSR 95 (CSR 189-11-122) was developed by a marker-assisted backcrossing approach with sensitive variety Sarjoo52 as a recurrent parent and FL478 as a donor for *saltol* QTL (Sarjoo52 / FL478 // Sarjoo52 *3). The NIL, CSR 95 (CSR 189-11-122) and seven sister lines positive for *saltol*QTL linked markers RM3412 and AP3206 were examined under glass house (EC_{iw} = 10.0 dS/m) and micro plot saline (ECe = 8.0 dS/m) environments from 2019 to 2021. CSR 95 (CSR 189-11-122) performed admirably throughout the season, with the lowest salt injury score (3.00), identical to FL478. In addition to seedling stage tolerance, it possesses desired agronomic qualities such as medium duration (130-135 days), dwarf culture, with green leaves, medium thin grains, and full panicle

Management of salt affected soils through Cut-Soiler technology

Cut-soiler is a machine that cuts and opens V-shaped furrow at desired depth and fills it back with burying surface scattered straw and residue lying and further covering with soil. Such cut-soiler operation lines serve as drainage channels and thus have potential to manage surface waterlogging and soil salinity. This technology can serve as remunerative option for management of salt affected soils and reduce adverse impacts of saline groundwater irrigation, and is also helpful in crop residue management in North West Indo-Gangetic plains. Results revealed the desalinization effect of cut-soiler in sandy loam saline (6.73 to 5.50 dS/m) and heavy textured soils (0.86 to 0.34 dS/m). The cut-soiler technology reduced the soil salinity by 18.0% and thereby improved yield of pearl millet and mustard crop by 23.0% as compared to control. In farmer's participatory trials in Punjab, soil ESP was decreased by ~ 18.3% up to 40 cm depth and up to a lateral distance of ~0.7 m from cut-soiler line.

Optimising agronomy of quinoa in water scarce shallow basaltic soil region

Optimising agronomy of quinoa (*Chenopodium quinoa*) in a new agro-ecological region needs strategies related to sowing time and management of water and nutrients. Under water scarce shallow basaltic regions, sowing of quinoa in the first week of November with 40% ETc and N dose of 100 kg/ha will give higher seed yield (14 q/ha), protein yield (217 kg/ha), water productivity (0.85 kg/m^3) with net return of ₹70,000/ha.



Water productivity in quinoa

exertion. As a result, line CSR 95 (CSR 189-11-122) was nominated to the AICRP AL and ISTVT trials on rice and assessed in saline (EC_{iw} = 10.0 dS/m) and alkaline ($pH_2$9.5) environments. This line CSR 95 (CSR 189-11-122) was found to give yield superiority over CSR 36 (alkali check), CSR 23 (inland saline check), CSR 10 (early duration saline check), FL 478 (saline tolerant check), Pusa 44 (sensitive check) and Local check by 3.80%, 18.15%, 44.61%, 38.76%, 68.99%, and 4.26%, respectively under various high salinity and alkaline conditions during 2021. This line CSR 95 (CSR 189-11-122) has *saltol* QTL and seedling stage salinity tolerance with excellent yield potential; hence, it may be exploited for the creation of salt-tolerant cultivars.

Evaluation of different cropping sequences for crop intensification under Conservation agriculture (CA) practices: Adoption of Conservation Agricultural practices brought build-up of significantly higher soil organic carbon content (43.6%), higher microbial population and saving in water by 18.3% in sugarcane (ratoon)-wheat-*Sesbania* cropping system over rice-wheat (conventional practice). Crop diversification with legumes (*Sesbania* and green gram) resulted in higher microbial population as compared to non-legume cropping sequences. Similar trends were also found for the carbon, nitrogen, phosphorus and sulphur cycling enzymes.

❑

10. Mechanization and Energy Management

Economy Seeder for *in situ* crop residue management in combine harvested paddy field: A Seeder was developed for *in situ* crop residue management technology, suitable for heavy soils. It performs three operations simultaneously, namely chopping of the crop residue, tilling and mixing the chopped residue and sowing. The machine has been evaluated in vertisols in a combine-harvested paddy field. The performance of the Economy Seeder has also been compared with existing straw incorporation machines such as the super seeder, mulcher integrated with a rotavator, and rotavator in a combine harvested paddy field. The field capacity of the Economy Seeder was 0.24 ha/h at field efficiency of 80%. The pulverisation index of the super seeder, mulcher integrated with rotavator, rotavator alone, and Economy Seeder were 9, 8.6, 10.2, and 8.4 mm, respectively, whereas the mixing index were 85.2, 91.2, 28.4, and 96.6%, respectively.

Tractor operated sugarcane base cutting unit: A small tractor operated sugarcane base cutter has been developed for cutting and windrowing the whole cane in field. Main frame was provided to support the PTO shaft pulley, dead weight, three-point hitch, base cutter and power transmission system. Three-point hitch system was designed for small tractor. Base cutter is powered by tractor PTO through pulley with V-belt drive. The base cutting unit consists of four blades and the provisions are provided to change the approach angle of cutting blades. The speed of the base cutter blade is 1050 rpm at 540 rpm of tractor PTO. A pipe attached to the main frame was used to windrow the harvested whole cane into right side of the tractor. The unit has been tested in fields at M/s Bannari Amman Sugars Ltd, and M/s Sakthi Sugars Ltd, Tamil Nadu. It has a field capacity is 0.26 ha/h with the field efficiency of 70%.

Tractor-operated whole-sugarcane harvester: A tractor-operated whole-cane harvester has been developed with a base cutter unit, crop gathering unit, cane walker, de-topper and cane collection trolley. All these mechanisms are hydraulically operated and can be mounted on a tractor three-point links. The de-topper unit is attached to left of the harvester main frame on a vertical supporting post, ahead of the base cutter to cut the top of the sugarcane leaf before base cutter cuts the stalk. The vertical supporting post is equipped with a telescopic arrangement to adjust the height of the de-topping unit as per the head height of the sugarcane crop. The height adjustment is carried out with the help of a hydraulic cylinder. A crop gathering unit is provided to separate and bend the sugarcane for gathering in a row; it is placed in front of the de-topper and base cutter unit. Cane walker unit is mounted on the harvester main frame above the base cutter, which is supported by the pneumatic tyre. It is provided for conveying the cut cane and guiding into the collection trolley. The tractor-operated whole cane harvester was field tested at Research farm of M/s Bannari Amman Sugars Ltd. and M/s Sakthi Sugars Ltd., Tamil Nadu. The average field capacity of the unit is 0.11 ha/h and field efficiency of the unit is 0.70%. The equipment saves 71% in cost when compared to manual harvesting.

Small tractor-operated raised bed former-cum-onion bulb planter: The developed planter consists of the main frame, raised bed former, seed metering mechanism, seed hopper, ground wheel, furrow opener and standard three-point hitch. The raised bed former was able to form one raised bed and plant onion bulb in four rows on each raised bed. The ground wheel extended the drive to the seed metering device by a chain and sprocket mechanism. A shoe type furrow opener was fitted to the planting frame in front of seed onion delivery tube. The planter can be used for making one bed (bed top width as 70 cm) and planting in four rows. The actual field capacity was recorded as 0.13 ha/h with a field efficiency of 73%. The equipment saves 7% of cost as compared to manual planting.

Power tiller-operated maize harvester: A power tiller-operated maize harvester has been developed for small and marginal farmers. It consists of snapping rollers which rotate in

opposite direction, cutting blades, basket for collecting cobs, transporting wheels for movement, gears and pulleys for providing drive to snapping rollers and blade shaft. The harvester has been operated at a forward speed of 1.00 km/h. The effective field capacity, fuel consumption, and snapping efficiency of the harvester are 0.05 ha/h, 0.9 L/h and 83%, respectively.

Multirow rotary weeder and sprayer attachment to ride on rice transplanter: A multi row weeder-cum-sprayer was developed as an attachment to the Yanmar Ride on Type transplanter to increase the utility of rice transplanter, reduce the labour requirement and drudgery in weeding and spraying operations. The field capacity of the weeder-cum-sprayer was 4.6-5.8 ha/day. It consists of main frame, gear box, main shaft, rotary weeding units, two floats, a tyne and boom sprayer attachment. The cost of operation for weeder-cum-sprayer was ₹2700/ha. The developed weeder-cum-sprayer can save 68% and 30% in time when compared to manual weeder with manual spraying with knapsack sprayer and weeding with power weeder and Knapsack sprayer, respectively. The saving in cost of operation can be achieved by 96% and 93% when compared to manual weeder with knapsack sprayer and weeding with power weeder and knapsack sprayer, respectively.

Self-propelled chilli harvester: India is the largest producer, consumer and exporter of chilli, which contributes about 40% of the world production. Hand picking is the most common harvesting method adopted by the farmers to harvest the chilli pepper, which requires 40-50 labours/day/ha. A self-propelled chilli harvester has been developed. It consists of crop guiding system, stripper reel mechanism, chilli conveying system, collecting box and an engine. The harvesting efficiency was found to be about 67% at a forward speed of 1.5 km/hr and rotational speed of 180 rev/min. It was also observed that the plant damage was superficial type and plant damage caused by picking unit did not affect the yield of chilli.

Tractor operated manure spreader: A tractor operated manure spreader for orchard has been developed. It consists of main frame, hitching arrangement, power transmission system, trailer with pneumatic wheels, chain conveyor, turbine wheel or turbine spreader disc and spreading disc. The chain conveyor mechanism steadily passes organic manure to the spreader unit where the organic manure is agitated and mixes properly then it is discharged through side gate at a side of a trailer where a spreading disc discharges the organic manure at a specific position. The spreading length of the organic manure can be changed by changing the speed of the spreading disc. A tractor 16.5 kW (22 hp) and above is suitable for operating this machine. The average field capacity and field efficiency of the spreader is 0.18 ha/h and 80.7%, respectively. The cost of machine and the operating rate is ₹3,55,000 and ₹3,262/ha, respectively. The net saving with this machine is about 35% over conventional manual spreading.

Tractor operated banana stem shredder: A tractor operated banana stem shredder has been developed. Simple cutting mechanism with four rotating blades in closed housing has been adopted for banana stem cutting. Provision of vertical outlet chute has been incorporated in the design for proper throw of the shredded banana stems. The effective field capacity and field efficiency of the shredder is about 0.2 ha/h and 82.3%, respectively. The shredding capacity of banana stem was 23.24 tonnes per hour. The cost of machine and the operating rate is ₹1,55,000 and ₹3,492/ha, respectively. The net saving with this machine is about 84% over conventional manual method. The machine is useful for the banana growers for *in situ* disposal of banana stems in the field.

Automation of sowing vegetable seeds in pro-tray: In the recent past, the commercial vegetable growers prefer pro-tray grown seedlings over conventional one for easy transportation and manual transplantation. In the conventional practices, initially, growing media is filled in pro-tray cells and single vegetable seeds like tomato, brinjal, chilly, etc. are sown in each cell of the pro-tray with the help of women labourers. Since, the size of seed is very small, it is difficult to separate them as a single seed, which makes the operation more monotonous and strenuous. A fully automatic vegetable pro-tray seeder has been developed. It consists of main frame, vacuum generating machine, seed picking box with needles, seed tray, pneumatic accessories, solenoids and PLC. The performance of the seeder was evaluated for sowing tomato seeds. About 110 pro-trays can be

sown in an hour, which could increase the capacity by 38%. The cost of the automatic pro-tray seeder is ₹2,50,000.

Small power thresher for buckwheat crop: Buckwheat is mostly cultivated at higher elevation and hilly areas. Threshing of buckwheat is a tedious job. A small power thresher suitable for buckwheat crop has been developed. It consists of frame, spike tooth cylinder, concave, aspirator blower, reciprocating sieve, shaft and power transmission system. At optimum conditions, threshing efficiency of 99.21%, cleaning efficiency of 97.25%, broken seeds percentage of 0.44% and total seeds losses of 1.13% were obtained at cylinder speed of 10.5 m/s, concave clearance of 25 mm and concave grade opening 16 mm. The throughput capacity of the thresher was 234 kg/h. The cost of threshing was ₹22.4 per quintal of the crop. The saving in threshing cost, time and man power requirement by using developed thresher was 60.2%, 82.9% and 65.6%, respectively as compared to the traditional manual threshing method.

Chickpea leaf harvester: Nipping in chickpea is one of the key practices for the improvement of yield and yield contributing factors. It also helps to improve the number of branches, pods and growth rate. A chick pea leaf harvester has been developed. It consists of engine, frame, cutting unit, conveying unit, storage and power transmission unit. The maximum harvesting efficiency was observed at forward speed 1.0 km/h, 150 mm cutting height and at blower air velocity of 4 m/s for chickpea. The field capacity of the machine was found as 0.051 ha/h. The harvesting efficiency, cleaning efficiency was 96.82% and 95.21%, respectively. The machine capacity was observed to be 0.127 tonnes/h, as compared to 0.013 t/h in traditional method. The chickpea yield was not affected by use of mechanical harvester. The cost of harvesting chickpea leaves using developed harvester was ₹3,259/ha with 90% labour saving.

Hand tool for okra (*bhindi*) harvesting: Harvesting of okra is difficult as it has filaments on the outer surface of pod which often pierce into hand while plucking and causes skin irritation and injury. To address these problems, a manual harvesting tool has been developed. A collecting box is provided which can collect about 200-250 g okra (15-20 pods). The average harvesting capacity is 13.6 kg/h with 99% cutting efficiency and 93.4% collecting efficiency. Moreover, the machine provides the comfort in hands and protects from the skin irritation. It eliminates the complete hand touch of okra pod.

Ergonomical pineapple leaf pruner: Pineapple leaves have thorns which pierce the skin during harvesting of fruits or during pruning. The traditional operation includes cutting older leaves with a *dao* (knife) resulting in poor posture due to the short length of the knife. To combat this, a long-handle pineapple leave pruner has been developed. The pineapple leaf pruner is operated by DC motor and battery. The battery of 12V, 20Ah can be used for 5 h on a single charge. It has been observed that the average number of leaves cut per minute are 90 with increase in productivity of 79%, whereas the number of plants cut per minute is 26 with increase in productivity of 85% as compared with the manual method. The field capacity of the pruner is 0.005 ha/h. The battery powered pineapple leaf pruner can reduce the musculoskeletal disorder (MSD) involved during pruning operation as well as increases the productivity.

Deep learning based bird identification for automatic feed dispenser: A computer vision based bird identification system has been developed to count the birds and can be used to calculate the amount of feed to be dispensed. The object detection algorithm used is Yolov7, an upgraded version in the YOLO family of object detectors, characterized by its fast detection, high precision, and easy training and deployment. The image acquisition has been conducted under the natural light condition from the farm using the digital camera (64 MP Camera). The model performed better with 100 epochs and IoU is set to 0.5. The batch size is set to 16 as it gives better performance compared to other combinations. The model converged successfully without any overfitting during the training phase after 80 epochs. The model achieved an overall precision of 84%, recall 83% and mean average precision (mAP) value of 84%. The results show that the computer vision approach is effective in detecting birds and can be effectively integrated into the automatic feed dispenser for poultry birds.

Spray droplet deposition characteristics of unmanned aerial vehicle simulation platform: The drone simulation platform provides a virtual environment for testing and optimizing drone spraying system. The platform can be used for evaluation of flow rates, spray patterns and droplets depositions characteristics of different nozzles. This system helps to study the effect of different operational parameters of drones such as speed, height, nozzle discharge rate and propeller rpm on droplets deposition. The system has been evaluated at different operating heights, discharge rates, propeller rpms and speeds. Before conducting the experiment, the spraying system is calibrated at different settings of pump control valve. Speed and propeller sensor such as optical and magnetic sensor are also calibrated. The water sensitive papers are placed at top and bottom sections of the plants. The spray droplets characteristics has been recorded at water sensitive paper and scanned in 600 dpi. The scanned images are processed in ImageJ software and Excel data are recorded. The effect of operating parameters has a significant effect on droplets characteristics. Droplet density (droplets/cm^2) increased with an increase in application rate, however, it decreased with increase in operating height and speed. The volume median diameter (VMD), coverage, droplets density and deposition of spray are in the range of 200-650 µm, 5-25%, 44-150 dots/cm^2, 0.3-0.8 µL/cm^2, respectively for the plants leaf surface.




Automatic spraying system for polyhouse: The polyhouse has high temperature and humidity that could be very severe and hazardous for workers who spray pesticides due to poor air circulation. To combat it, an automatic spraying system has been developed for chemical application inside the polyhouse. The developed system has two units, i.e. automatic spraying unit (ASU) which is battery-powered and DC motor-operated row changing unit (RCU). The automatic spraying system has been evaluated in polyhouse for tomato crop. The optimum operating parameters, viz. forward speed, spray distance and working pressure are 0.79 km/h, 250 mm and 0.4 MPa, respectively. The cost of spraying with the automatic spraying system is at par with knapsack sprayer and it saves 86% time and 88% labour as compared to spraying by knapsack sprayer.

Solar powered floating pump for small farms: A portable type floating pump has been developed for small and marginal farmers. It has a DC motor of size 250 W capacity, attached with an axial flow pump and operates on solar power. It has two solar panels each of 170 W rating. It is fitted with remote control switch to operate it from a distance of about 30 m, avoiding the need to go close to start the pump. The developed pump was tested in the pond. The average discharge of the pump was around 20,000 litres per day (Lpd) at 3 m head (0.7×10^{-3} m^3/s). The pumping efficiency of the developed solar pump varied from 50% to 27% for 1 m to 3 m pumping head, respectively.

Pesticide exposure and PPE kit for spraying with power sprayer: Pesticides deposition on the body has an adverse effect on health during pesticides spraying. Six different types of fabrics were evaluated for their suitability of adoption. A study of physiological parameters of workers during working with power sprayer in mango plantation wearing six different types of personal protective equipment (PPE) kits with eye protectors and masks showed that ΔHR is less than limit of continuous performance (LCP) for all six types of PPE kits. It was 21.2 beats/min for safety kit having highly repellent fabric (classified as Level C_2 with the upper limit for percent penetration less than 5% is fulfilled by 200-GSM fabric with penetration of 0.72%). Similarly, VO_2 max is less than 35%, i.e. acceptable work load (AWL) for all six types of PPE kits and for safety kit having C_2 level fabric apron is 22.3%. Study of wearing comfort based on modified Corlett and Bishop (1976) rating scale, shows that for 6 PPE kits the rating varied from 3.6 to 7.6. The wearing comfort for safety kit with C_2 level fabric was 7.6, indicating very comfortable rating. The increase in temperature inside PPE kits ranges from 3.9 to 11°C and it is 4.6°C for safety kit with C_2 level fabric. The cost of final PPE kit manufactured with C_2 level fabric is ₹610.

Ergonomic evaluation and modification of grass cutter-cum-harvester: A grass cutter-cum-paddy harvester has been developed based on various anthropometric dimensions of male workers from Konkan. The working heart rate, working oxygen consumption rate and ΔHR of the subjects for paddy harvesting with existing machine are 144 bpm, 1.4 l/min and 41.2 bpm, respectively and that for developed modified machine are 122.3 bmp, 1.1 l/min and 43.5 bpm, respectively. The average energy expenditure rate and work output for paddy harvesting with the existing machine are 31 kJ/min and 0.13 ha/h, respectively and that for the modified machine are 22 kJ/min and 0.12 ha/h, respectively. The modified grass cutter-cum-paddy harvester reduces the physiological work load of operator over the existing shoulder mounted grass cutter-cum-paddy harvester.

Animal drawn single row potato planter: Animal drawn single row automatic feeding type potato planter-cum-fertilizer applicator has been developed. It also performs the function of furrow opening and covering of the seed tuber there by making ridges. The draft required to operate the machine was 580 N with 2.2 km/h forward speed. The average depth of seeding was found 140 mm. The actual field capacity was 0.09 ha/h with field efficiency of 74% and damage of 1.66 to 1.86%.

Bullock drawn four-row seed drill for millets: Conventionally, manual dropping of seeds in a furrow behind a *desi* plough is practised for line sowing involving huge labour, time and cost, apart from drudgery. Bullock drawn four-row seed drill fitted with inclined plate metering technology has been developed for line sowing of small seeds such as finger millet, little millet, sorghum, etc. It is operated by a pair of medium size bullock. The actual field capacity of the seed drill was observed to be 0.15 ha/h with 64.5% field efficiency. The average speed of operation was found to be 1.95 km/h with average seed rate of 5.6 kg/ha.

Bullock drawn 8-row pre-germinated paddy seeder-cum-herbicide applicator: A bullock drawn 8-row pre-germinated paddy seeder-cum-herbicide applicator has been developed for simultaneous application of line sowing of pre-germinated paddy seeds and application of pre-emergence herbicide. This enhances the production as compared to manual line transplanting followed by herbicide application by a sprayer. The actual field capacity of the applicator was 0.13 ha/h with field efficiency of 58.3%. The seed rate was 35.4 kg/ha. The cost of operation of bullock drawn 8-row pre-germinated paddy seeder-cum-herbicide applicator is ₹1,032/ha.

Development and evaluation of Flue-cured Virginia tobacco leaves stringing machine: In India, Flue-cured Virginia (FCV) tobacco is cultivated mainly in the states of Andhra Pradesh, Karnataka, Odisha and Maharashtra. A minimum of 4000 kg of fresh leaves (900–1000 leaf sticks) need to be loaded into the curing barn or chamber for high-quality lemon yellow dried tobacco leaves. The curing takes place at linearly increasing temperature of 30–70°C for about 120 h (5 days). A flue-cured Virginia tobacco leaf stringing machine has been developed. This unit can produce one stick per 20 s (@4 kg of fresh tobacco leaves/stick) with a stringing capacity of 730±100 kg/h (i.e. 180±10 number of sticks/h) using an oval-shaped (3 mm) needle and yarn (34 counts) made of viscose material. The chain stitches hold the leaves properly and prevent the dropping of even dried leaves. To make the operation faster and continuous, it has been provided with three sets of loading trays.

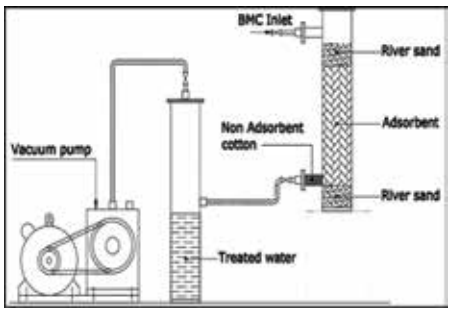
Animal lifting device

Findings in a trial revealed that the when animal is in lying down position due to restlessness and discomfort the physiological parameters show abnormality, but when the animal is supported with lifting machine and given therapeutic treatment the physiological parameters reach to normal condition. Traditionally, nearly 6-8 peoples are required to lift an animal and the task is full of drudgery. To ease the task, a low-cost and comfortable animal lifting device has been developed. Use of animal lifting device for physical support and one week of therapeutic treatment of sick animal is helpful in improvement of physiological parameters and healthy recovery. 60% recovery was noted in the test conducted for different sick animals.

Plasma based torrefaction of crop residues: The plasma-based torrefaction of mustard stalks was conducted in a non-thermal plasma reactor. The system generates free and charged radicals in plasma under different levels of vacuum and can generate the vacuum as high as 1000 kPa. Thermal degradation behaviour of plasma treated mustard stalks and raw mustard stalks biomass was analysed at four heating rates (10, 20, 30 and 40°C/min) with the help of TGA analyser. The rate of degradation of hemicellulose and cellulose was higher for 4 h treated materials as compared to raw mustard biomass. It is mainly because of weakening of bonds due to thermal degradation. Hemicellulose, cellulose and lignin bonds are weakened by plasma treatment which results in early degradation of bio-polymer.

Biomass based hot air generation system for crop drying: The developed hot air generator is equipped with biomass combustor, heat exchanger and drying chamber. The hot air generator unit was integrated with drying chamber (25 kg loading capacity). The trials have been performed for drying of 11 kg tomatoes in the developed system. After cleaning and sorting of tomatoes, they are cut into ring size (5 mm thick) and spread over the trays of drying chamber. 55 kg of biomass fuel was consumed during the drying process. The moisture content of the tomato was reduced from 95% to 15% in 14 h drying time. Drying temperature was maintained at 60-65ºC inside the drying chamber by controlling feed rate of fuel and regulating the flow of ambient air at the inlet. The drying efficiency was obtained around 31%.

Agro-residues based bio-sorbent for the treatment of Bulk Milk Chiller (BMC) effluents: An agro-residues based bio-sorbent for the treatment of Bulk Milk Chiller (BMC) effluents has been developed. The bio-sorbent was prepared through pyrolysis of agro-residue under controlled environment. The agro-residues such as sawdust, groundnut shell and cotton stalk are potential ingredients for preparation of bio-sorbents. Quality of the BMC effluent water in terms of COD (mg/l) has improved (1,300 mg/L to less than 250 mg/L) with the help of selected feedstocks. This treated effluent has shown the compatibility with the quality water specified by the Central Pollution Control Board (CPCB). The treatment using developed bio-sorbent through adsorption process is capable to convert the BMC effluent into the irrigation quality water. The cost of bio-sorbent prepared through pyrolysis of agro-residues is 33% less as compared to the commercially available adsorbent.



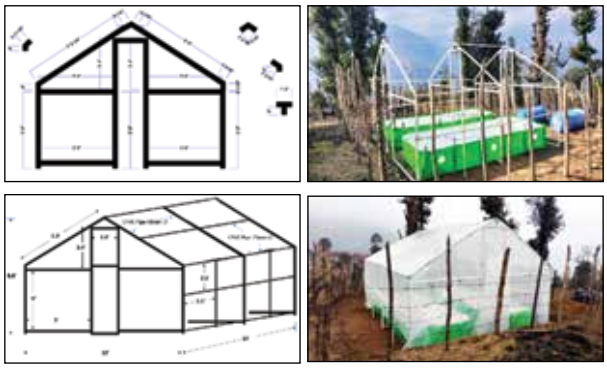
Ragi thresher-cum-pearler: This thresher is operated by a pair of bullocks in rotary mode. It can also be operated by a 1.0 hp electric motor. The average speed of rotation of the thresher and oscillating shafts were found to be 525 rpm and 422 rpm, respectively at bullock speed of 1.84 km/h. The average output of the thresher was 90.4 kg/h with a feed rate of 120.5 kg/h. The threshing and cleaning efficiencies were 92.18% and 92.40%, respectively. The thresher has been granted, Indian patent No.: 409589. The cost of operation was ₹0.33/kg as compared to ₹5/kg in conventional method.

Robotic arm for Apple harvest

For harvesting apple using robots/mechanical systems, it is imperative to detect apples at faster inference speed in real field conditions. Mini-robotic attenuator consisting robotic arm developed at lab level for picking and placing apples. The developed robotic arm is controlled by raspberry pi and supports 5-degree of freedom consisting of elbow, shoulder, wrist and neck. Gripper has the potential of handling 1-1.5 kg of products softly without damaging. System can operate 10-12 items in 1 min to pick and place. Artificial intelligence-based apple identification protocols are being developed to identify and detect apples in a real-world complex environment under different conditions of natural lighting. The developed models will be integrated into the robotic system for guiding robots to mechanically harvest apples.

Technology is adopted in the collaboration with Odisha Livelihood Mission, Odisha and around 979 threshers have been sold and supplied in 17 districts through Odisha Millet mission.

Vermi-composting unit for North-East hill region: Vermi-composting unit was developed for farm waste utilization at high altitude. A plastic based vermi-composting polyhouse unit of size 12 × 14 × 8.6 feet (W × L × H) was fabricated with CPVC pipes (40 mm and 25 mm diameter), GI anchoring pegs (32 mm diameter), CPVC pipe snap clamps (40 mm, 32 mm and 25 mm), CPVC pipe fittings with modifications and 5 layer UV stabilized polyethylene sheet (thickness 200 micron). The fabricated structure was pitched for keeping two-tier HDPE vermi-beds (size 3.6 m × 1.2 m × 0.6 m each; total 4 beds) for composting of farmyard waste into vermi-compost at high altitude cold climate.



Vermi-composting Polyhouse Unit

Plastic-based hanging type feeders suited for all breeds of Goats: The hanging type plastic feeder has been developed with help of mild steel, PVC pipes and FRP sheet. The feeder is designed in such a way that no feed/ *bhusa*/green will fall outside the tray, so that feed/fodder loss is reduced to negligible. The width at top portion as well as distance between iron rods were standardized to hold the *bhusa*. In this feeder, *bhusa* doesn't fall in feeding tray fully by itself like in two sided feeders. However, *Bhusa* will fall in the feeding channel. The plastic-based hanging type feeders is suited for the field conditions where there is space constraint. It can be hanged in one side of the shelter; adequate space can be saved in already overcrowded shelter. It is portable, can

Solar PV-operated ice cream hand cart for street vendor

A mobile hand cart (*Thela*) with ice cream box (100 L capacity) operated with solar Photo-Voltaic (PV) based refrigeration system has been developed for ice cream vendors. The developed four-wheel cart consists of three panels with a rated power of 165 W each connected in parallel, a charge controller of capacity 675 VA and two batteries of 12 V, 100 Ah rated capacity. During preliminary testing under on-load condition, a fully charged battery provides the backup period for about 16 h, and is able to maintain average temperature of -18°C. The technology will help in economic upliftment of vendors by reducing their dependence on the utility grid.

Disease free leave | SMV | YMV

Anthracnose (multiple spots) | FLS (multiple spots) | RAB (multiple spots)

Disease detection in soybean crop leaves

be shifted whenever required and height is adjustable so that same feeder can be used for different goat breeds by hanging it at different heights as per requirement. Total cost of plastic-based hanging type feeder with fiber sheet (iron mesh mounted) is ₹8000 and hanging type feeder without fiber sheet (wall mounted) is ₹6000.

Image-based disease identification in soybean: Anthracnose, frogeye leaf spot (FLS), rhizoctonia aerial blight (RAB), soybean mosaic virus (SMV) and yellow mosaic virus (YMV) are major common soybean diseases that seriously affect soybean yield in India. The symptoms of these diseases are also visible on soybean leaves which are detected with the help of experts or support systems, i.e. leaflets, etc. A deep learning algorithm for identification of the soybean foliar diseases has been studied. About, 3127 RGB images dataset of anthracnose, FLS, RAB, SMV and YMV-affected and disease-free leaves of soybean are collected from the agriculture fields. The Mask R-CNN detection algorithm is used for the detection of soybean leaf diseases by introducing the Resnet-50 module. The pre-processed images (512×512 pixels) are used as input in Mask R-CNN. The number of epochs, training step per epoch, training and validation, and learning rate are 80, 500, 8 and 0.001, respectively. The detection accuracy is more than 85% at 0.90 level of minimum detection confidence. The accuracy can be further improved by increasing the size of the image dataset.

❑

11.
Post-harvest Management and Value-addition

***Hawaijar* making mechanized system:** *Hawaijar* is a traditional fermented food of North-East India prepared from soybean. The steps involved in traditional method of making *hawaijar* are soaking, boiling and fermenting. The unit operations considered in the mechanized system are soaking, steaming and incubation. The designed capacity of the developed mechanized batch type system is 10 kg. The system consists of a circular structure integrated with different parts to accomplish all the unit operations in a single system. There are six trays with nine containers each for fermenting cooked soybeans. The parameters considered for designing of the system included physical properties of the soybean, increase in volume after soaking and boiling and operating temperature and pressure of the system. The increase in volume after soaking was 2.8 times whereas increase in volume after boiling was 3.25 times than that of fresh seed volume. The volume of the boiled soybean was considered for design of the process chamber. The developed hawaijar making system has the maximum operating temperature and pressure of 125°C and 2 bar, respectively.

Essential oil release kit to control insects in pulses: A low cost ready-to-use kit was designed and developed for its application in retail packets as well as household level metallic drum storage to manage major storage insect-pests of chickpea. The moisture content (% wet basis) of chickpea needs to be brought down prior to storage to 10% for a targeted storage periods of 6-12 months and to 8% for more than a year target period. Initially thermal treatment (60ºC in hot air oven) is given to the chickpeas for an hour. Then 50 mL of garlic essential oil is applied on the strip (5 cm × 1 cm) per 500 g capacity retail packet or container used to store chickpea. The dose may be increased or decreased according to the capacity of storage unit. The stored chickpea needs to be checked at regular intervals to avoid any kind of infestation caused by storage insects in between storage period. Repeat the application of EO on strip each time the drum is opened.

Cocoa butter extractor: The developed cocoa butter extractor comprises of feeding hopper, cylindrical barrel, helical screw, heating coil, temperature controller, cocoa butter outlet and cake outlet. The helical screw moves the cocoa nibs, compresses the mass leading to release of the oil and production of the cake. The heating coil which surrounds the barrel surface, enhances the oil extraction efficiency of the system. After pressing, the oil gets purified using a centrifugal separator. The cake is then grinded to get cocoa powder.

The independent parameters, viz. temperature (80, 100, 120°C), screw rotation speed (50, 70 and 90 rpm) and feed rate (2, 3 and 4 kg/h) were selected based on the results of the preliminary studies. The performance of the developed cocoa butter extractor was evaluated in terms of yield of cocoa butter, time of butter extraction, and extraction efficiency. The quality of cocoa butter and cocoa powder is evaluated in terms of free fatty acids, peroxide value, iodine number, fat content, moisture content and browning index. The maximum cocoa butter yield of 43% was obtained at a barrel temperature of 120°C. But the quality of cocoa butter and cocoa powder was maximum at a barrel temperature of 100°C. The maximum yield obtained at 100°C was 40%. Based on the quality evaluation of cocoa butter and cocoa powder, the process parameters, viz. temperature, screw rotation

speed and feed rate were optimized at 100°C, 50 rpm and 4 kg/h, respectively.

Lac Color Index Analyzer (LaCilyser): A portable, electronic, and hand-held device for lac colour index analysis has been developed based on the principle of colorimetry. The colour index is a commercially important quality parameter of lac which is a standardized numerical or categorical value that represents its colour characteristics. Colour index provides a simplified way to assess and communicate the colour properties of lac, allowing ease of comparison and specification compliance.

The existing method of colour measurement is as per Indian standard IS 6921:1973 which pertains to lac and lac-products, does provide guidelines for general quality assessment, including colour index. This comprises colour index estimation by visually comparing 10% solution of lac in alcohol with standard iodine solution. This method is time consuming, requires skilled manpower, consumes more solvent, with higher chances of human errors and hence often leads to compromise in the accuracy of analysis.

LaCilyser is an integrated device designed for precise measurement of the colour index of lac. The device offers accurate results across a wide range of lac colour index values with its pre-calibrated system and resolution of colour index ±1.0. Operating on a user-friendly interface, the device incorporates data acquisition and processing capabilities, providing quick and reliable measurements in just 30 seconds. The standardized preparation of the lac solution, , ensures consistency and adherence to recognized protocols. The LaCilyser is a valuable tool for industries requiring precise colour evaluation contributing to its quality control. The instrument has been developed jointly by ICAR-National Institute of Secondary Agriculture and CSIR-Central Scientific Instrument Organization supported by NABARD. Patent of this instrument has been filed (Indian Patent Application No. 202331062688 dated 18.09.2023).

Automatic fruit grading machine: An AI-enabled farm-friendly Automatic Fruit Grader of approximately 200 kg/h capacity for citrus fruits has been developed with the unique capability of carrying out washing, image-based sorting and weight-based grading of the fruits in one go. A custom lightweight CNN model called SortNet has been used to train the machine on the citrus fruits and the hyper parameters have been tuned to get the optimal performance. Using the DCNN technique, the machine correctly classified the fresh citrus fruits into two classes, viz. accept and reject, with a success rate of 98%, and could grade them into three weight categories light, medium and heavy with an accuracy of 91%. The ergonomic evaluation of Automatic Fruit Grader yields an average body part discomfort score (BPDS) value much lower (12.3±2.0) than the traditional method (30.9 ±3.3) with a percentage load on the muscles ranging from 28.7 to 34.3, reflecting that one can work for longer duration on the machine without fatigue as compared to the traditional manual operation.

Power operated baby corn grader: In order to improve the graded products quality and to alleviate the labour shortage a power operated baby corn grader has been developed. It consists of main frame assembly, grading unit, prime mover and collection unit. The main frame assembly has main frame, supports and cross-stay bars. The machine grades the baby corn into five grades: 10-12 mm, 12-14 mm, 14-16 mm, 16-18 mm and >18 mm. Two gear motors of 0.5 hp are used to operate the grader. The performance of the machine was evaluated in terms of grading efficiency and feeding capacity at four roller speeds 0.7 m/min, 1.1 m/min, 1.5 m/min and 1.9 m/min. The grading efficiency and feeding capacity of the grader were determined as 94.1%, 94.5%, 90.8% and 85.7%; and 258, 307, 437 and 650 kg/h, respectively at the above-mentioned roller speeds.

Design and development of a decorticator (multi-bast fibre extractor): An electric-operated Decorticator (multi-bast fibre extractor) was designed and developed and it comprised a frame, feeding chute, fibre extraction mechanism, ribbon conveying system, by-product delivery chute, power transmission system, Variable Frequency Drive (VFD), and a 7.5 hp prime mover. The throughput capacity of the machine was in the range of 850-1100 kg/h whereas the extraction efficiency was in the range of 85-92%. The average energy requirement of the machine was 0.28 kWh (at no load) and 1.34 kWh (at full load). The machine was demonstrated to more than 500 farmers of West Bengal through different FLD and training-cum-workshops in different parts of eastern region.

Multiple feed banana fibre extraction equipment: With an aim to increase the output capacity of banana fibre extraction and to make it safer in operation, multiple feed banana pseudo-stem fibre extractor has been developed in collaboration with ICAR-National Research Centre for Banana, Tamil Nadu. It comprises

of conveyer feed belt, beating roller assembly, gripper holder assembly and is powered by 1.50 kW motor to operate beater roller and 0.75 kW motor to operate conveyer belt and suitable pairs of proximity sensors. The banana sheaths are gripped on holder assembly and conveyed to beater roller assembly. The directions (forward/ reverse) of movement of conveyer are controlled using electronic controllers. A higher fibre output of 25-30 kg/h was obtained as compared to 10-12 kg/h and cleaner banana fibre with less scutcher waste.

High throughput profiled rotating drum needleless electrospinning system (PDES): High throughput Profiled Rotating Drum Needleless Electrospinning (PDES) System was designed and developed. The developed system has a higher production capacity of around six times compared to the conventional single-needle electrospinning system. It provides positive feeding of solution through drum profile arrangements. More than 800 profiles were created on the drum surface for the continuous production of nanofibers. Based on polymer viscosity, the drum speed can be controlled through an electronic control unit.

ICAR-CIRCOT compact and energy efficient cotton seed dryer: ICAR-CIRCOT has designed and developed a compact and energy efficient direct heating type 'Cotton Seed Dryer' on PPP basis in collaboration with M/s Bajaj Steel Industries Ltd. (BSIL), Nagpur for online drying of cottonseeds in ginneries. It is designed using innovative collapsible MS belts that allow heating of cotton seed twice (one on top and another on bottom side) on each conveyor leading to development of energy efficient compact drying system. The height of the developed dryer has been reduced to half by using the innovative conveying system. Three cottonseed dryers (5 and 7 TPH capacity) are commercially running in ginneries of Telangana and Maharashtra. The dryer is capable to bring down the moisture content from 40% to 9-10%, i.e. optimum moisture required for oil expelling. The designed heating capacities of dryers are 9 and 12 lakh kcal/kg for 5 and 7TPH capacity, respectively. It requires about ₹1500 for drying of 1 tonne cottonseed from 40% moisture content to optimum moisture content. It is observed that reduction of moisture in cottonseeds to appropriate level results in increase in oil recovery by 2%, improvement in cake protein content and reduction in energy requirement during oil expelling.

Millet-based gluten free muffins using hydrocolloid: The prolamins from gluten, for celiac disease affected persons, exert toxic effect and damage the villus of the intestine leading to poor digestion and poor absorption of nutrients in the gastrointestinal tract. Millets are nutritionally superior to the main cereal crops-wheat and rice owing to their comparatively higher protein, mineral, vitamins and fibre contents. Gluten free muffins were prepared using barnyard millet and foxtail millet with the addition of xanthan gum, a hydrocolloid to the level of 0-0.5% (flour wt. basis). The muffin samples were evaluated for height, crust colour, hardness and sensory acceptability. For barnyard millet based muffins, addition of xanthan gum significantly increased the muffin height and colour values. Addition of xanthan gum at 0.3% onwards significantly decreased the hardness of the barnyard millet based muffins. Addition of xanthan gum showed positive effect on the sensory acceptability, with highest overall acceptability score (OAA) of 7.25 at 0.5%. In case of foxtail millet muffins, the hardness of the muffins was significantly decreased at 0.3% addition of xanthan gum however, sensory acceptability was adversely affected. Also non-significant difference in muffin height and lightness was observed. It can be concluded that addition of hydrocolloid affects the quality traits of muffins depending on the type of millet flour used.

Process protocol for the preparation of Comminuted Hill lemon fruit juice RTS beverage: The peel of Hill lemon which comprises of 30% of the fruit, holds more ascorbic acid, phenolics, and minerals

Hesperidin and pectin from immature droppings of kinnow

The immature droppings of kinnow fruits (IDKF) previously considered as a farm waste, are now being considered of economic importance due to their phytochemical properties. Like other citrus fruits, IDKF is believed to contain considerable amounts of hesperidin, a well-known glycoside that is part of the flavanone subgroup but there is dearth of scientific literature about the quantity and quality of this bioactive compound. A number of properties, viz. antioxidant, anti-inflammatory, anti-tumor, antibacterial, anti-depressant, and neuroprotective activity, protecting the cardiovascular and gastrointestinal systems have been reported for this flavonoid compound. Similarly, IDKF may be a source of pectin, a naturally occurring heteropolysaccharide, generally extracted from kinnow peels. It also shows excellent gel properties and stability and thus finds applications in healthcare, pharmaceutical and food industry. Different solvents DMSO: Ethanol (1:1 v/v), NaOH and HCl, 50% Ethanol, methanol and acidified methanol have been evaluated for extraction of hesperidin. The best results were obtained from acidified methanol having hesperidin and pectin yield of 3.88% and 4.7%, respectively.

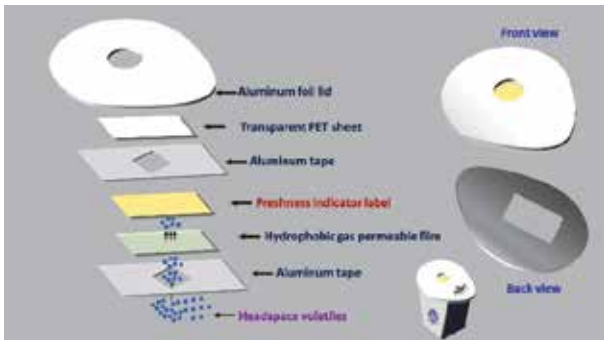
Extracted Hesperidin

Extracted Pectin

than fruit segments and is thrown away as waste after processing of fruit. Comminuted Hill lemon fruit juice containing both parts (peel and juice) can be used to enhance functional value of beverages. The process protocol for the preparation of comminuted Hill lemon juice RTS beverage was developed. The initial step involved washing and cutting of Hill lemon fruit into equal halves along with peel followed by removal of seeds and grating of halves by using a pulper. The resulting slurry was then transferred to hydraulic press to extract comminut Hill lemon juice. Afterward, extracted juice was filtered through muslin cloth and was used to develop RTS beverage. To achieve the desired acidity level of 0.3%, various combinations of comminuted Hill lemon juice were tested. Juice per cent of 7 displayed the highest scores for colour (8.2), body (8.0), flavour (8.5), and overall acceptability (8.3). Furthermore, comminuted drink exhibited significantly enhanced antioxidant activity (7.6%) and phenolic content of prepared RTS beverages than the resulting values obtained for RTS drinks made up from of Hill lemon juice (without peel).

Process protocol for preparation of jaggery based kulfi: Jaggery based kulfi was prepared by adding full fat milk, jaggery powder, cashews and almond pieces. The mix was heated to attain thick consistency. The mixture was poured into kulfi moulds and kept in a refrigerator (0-4°C for 8-10 h). Nutritional value of 100 g jaggery based kulfi is 698 kcal of energy, 16.6 g of protein, 76.4 g of carbohydrates, 3.94 mg of calcium and 5.2 mg of iron. Five different combinations were prepared, i.e. Jaggery kulfi, Jaggery powder kulfi, Almond jaggery kulfi, Coconut jaggery Kulfi, Custard powder jaggery kulfi. Sensory evaluation was carried out for above five combinations of jaggery based kulfi by using Fuzzy logic concept.

On-Package smart sensor as freshness indicator for set-type fermented dairy products: Developed for dahi and mistidahi.



Structural arrangement of freshness indicator of dahi

Ragi choco spread: In view of the "International Year of Millets 2023", a new composite dairy product "Ragi Choco Spread" was developed which is a good source of calcium (125 mg/100 g) and milk protein (6%).

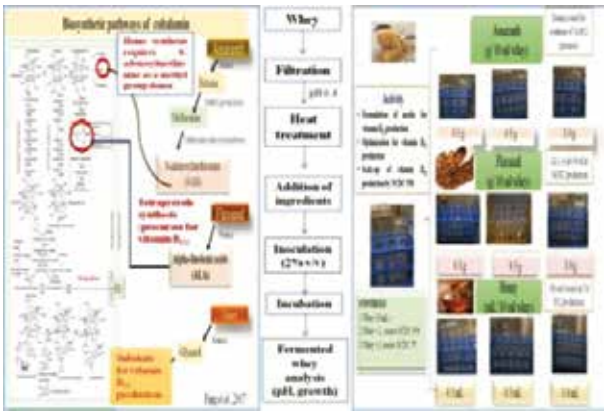
Milk-Millet-Malt-Mix: It is a composite dairy product containing Foxtail millet that was developed and commercialized. This product provides balanced nutrition to pediatric and geriatric segments of the society. A serving of 10 g provides 2.5 g of protein, 0.5 g of minerals (calcium, iron and zinc), and 0.5 g of dietary fibres.

Ragi choco spread

Milk-Millet-Malt-Mix

Characterization and bioprocess optimization for enhanced vitamin B12 production: Done by using *Limosilactobacillus reuteri* NCDC 958

Freeze dried probiotic DVS starters of *Lactiplantibacillus plantarum* CRD 7 and its performance in dahi preparation: A freeze drying process was developed for preparation of probiotic direct vat set (DVS) starters using Indigenous strains of aflatoxin M1 binding *L. plantarum* CRD 7 for preparation of dahi to reduce ameliorate AFM1 burden. This will be helpful in meeting the demand of indigenous probioitc dairy starters for manufacture of fermented milk products.



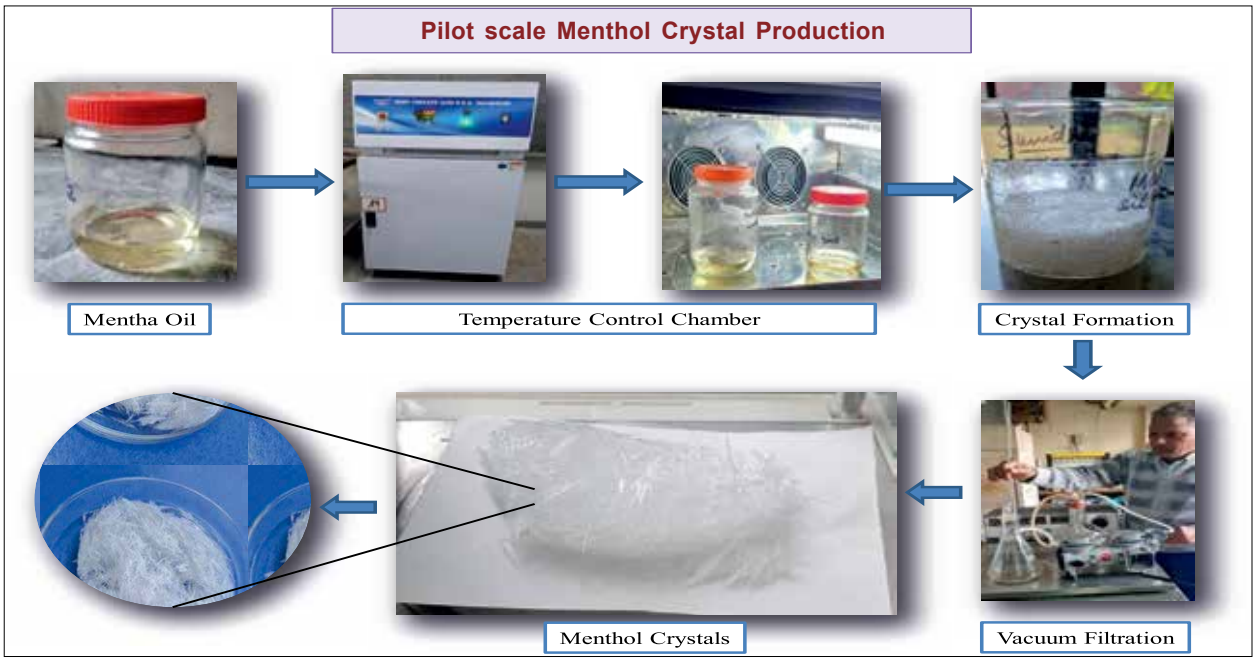
Preparation of whey based medium for the growth of vitamin B12 producing *L. reuteri* NCDC958

Freeze dried probiotic DVS starters of *Lactiplantibacillus plantarum* CRD 7

Production of menthol crystals from mint oil: Conventional process of menthol crystal takes 25-26 days cooling at -5°C to -35°C. Therefore a new process for menthol crystal production was developed to reduce the time of production. The mentha oil is incubated at 10°C for 15 days and then the material is filtered under vacuum to separate the crystals and residual liquid. Thereafter the crystals are dried and about 25% crystals of the total oil volume are obtained. The menthol crystals thus obtained are white in colour, thick flakes, and transparent. The size of crystals ranges from 1.06 to 1.66 cm. Based on the process developed for production of bold menthol crystals, an economically viable batch type pilot plant comprising of temperature controlled chamber for crystal formation and vacuum/centrifugation based filtration unit for separation of crystals was developed as shown here.

Cottonseed hull as substrate for production of thermostable and alkali tolerant microbial xylanase: Cottonseed hulls (CSH), an inexpensive by-product of cottonseed processing, was used as a substrate for production of thermostable and alkaliphilic xylanase by *Bacillus pumilus* and *Bacillus licheniformis* in a cost-effective way. During fermentation using CSH as a substrate, a considerable amount of extracellular xylanase was produced by *B. pumilus* (359.2 µ/mL) and *B. licheniformis* (360.8 µ/mL). Bacterial xylanase was stable at a higher temperature (55°C) and functional at alkaline *p*H (*p*H 9.0). In subsequent bio-bleaching trial, bacterial xylanase (Xylanase dose: 100%, Time: 120 minutes, enzyme-pulp incubation temp: 50°C and pulp consistency-1:10) significantly removed lignin compounds, hydrophobic compounds and reducing sugar from the cotton stalk and banana pseudo stem fibre-based biomass pulp. Xylanase application also improved the brightness level by 15% (in banana pulp) and by 5% in cotton stalk pulp. This cost-effective xylanase can be used for bleaching of agro-biomass to reduce the usage of bleaching chemicals and lessen environmental pollution in the pulp and paper industry.

Rosemary extract to improve the stability of refined cottonseed oil: Refined cottonseed oil is susceptible to oxidative degradation and rancidity due to its high level of unsaturation and loss of natural antioxidants present in it during the refining process. Therefore, approved chemical antioxidants are added to it to retard the oxidative degradation. Ethanolic extract of the rosemary leaves (RE) is a natural alternative with good antioxidant properties (total phenolic content of 106.22 gallic acid equivalent/g and IC50 value (Half-maximal inhibitory concentration) of 235.4 µg/mL for scavenging DPPH radicals). The potential of RE in retarding oxidative damage of commercial refined cottonseed oil was evident as RE addition reduced the peroxide formation and free fatty acids formation in the cottonseed oil during heat treatment (150°C) and during storage. The peroxide value (PV) of RE supplemented oil increased from 10 to 25 milli equivalents O_2/kg as



The developed process remarkably reduces the time of crystal recovery in comparison to the present practice of crystal production, thereby reducing the cost of crystal preparation.

compared to the control which showed a rise in PV from 11 to 35 milliequivalents O_2/kg. Thus, Rosemary extract can be a good natural antioxidant in retarding the peroxide formation in the refined cottonseed oil.

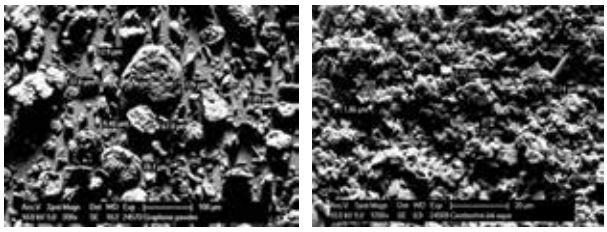
AI based prediction model for Highest Spinnable Count Index (HSC): Highest Spinnable Count (HSC) index, a single integrated value, can be used to rank cotton grown in India. HSC index is calculated after spinning cotton to 2 counts, namely under spun and over spun based on CIRCOT CSP (Count-Strength Product) standards and evaluating its lea strength. Today, machine learning is able to pick up knowledge from examples and it is able to code implicit knowledge. Cotton fibre parameters namely UHML (Upper Half Mean Length), strength, micronaire, elongation and uniformity were used in the development of machine learning models for predicting highest spinnable count. AutoML (Auto machine learning) GBM (Gradient boosting machine) algorithm was found to give least root mean square error of 3.0 and highest coefficient of determination of 0.97 when compared with generalized linear regression and deep neural network. The percentage of error reduction varied from 62 to 85% in comparison with multiple regression models depending upon error parameter used for evaluation of model. Important variables for determining the highest spinnable count of yarn are found to be UHML, and fibre strength in both the models (autoML and regression).

Puncture resistant fabric production: Puncture resistance is required in protective gear, safety equipment and in the products that need to resist bites and scratches. A multilayer fabric was developed consisting of three layer warp yarns (Dyneema in one layer and polyester in other two layers) and core-spun cotton/nylon as weft. The developed fabric possessed a puncture resistance of

Hand gloves made from Puncture resistant fabric

61 N (level 2). An optimized formulation made of shear thickening fluid with 1.5% (w/w) nano-cellulose, applied to the fabric, improved the puncture resistance to 199 N that meets the level 5 standards set by EN 388:2016. The cut-resistance fabric will be used to develop industrial gloves.

EMI shield fabric using graphite conductive paste: Mobile radiation protective fabric is designed to shield against electromagnetic radiation emitted by mobile devices such as smartphones, tablets, and laptops. Mobile radiation protective fabric and covers are an effective way to reduce exposure to harmful electromagnetic radiation emitted by mobile devices. Mobile devices, such as smartphones, emit electromagnetic radiation in the form of radiofrequency (RF) waves. The frequency range of RF waves emitted by mobile devices typically falls within the microwave portion of the electromagnetic spectrum, ranging from around 900 MHz to 2.4 GHz, depending on the wireless communication technology used (e.g. 2G, 3G, 4G, or 5G). The potential harm from mobile radiation is a subject of ongoing research and debate among scientists and health experts. An electrically conductive paste was developed at ICAR-CIRCOT, Mumbai using the



SEM images of the graphite powder and conductive paste

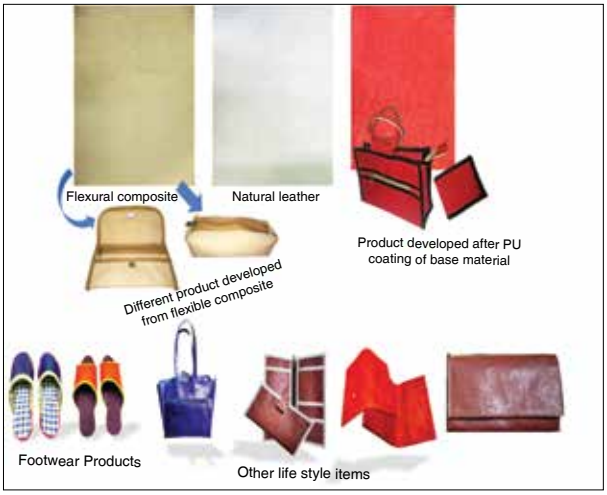
graphite powder and was used to coat the cotton fabric to develop radiation protective fabric.

Knitwear from jute fibre: Jute fabric is mostly confined to hessian and sackings bags due to its inherent rigid, low extension, rough surface and prickling properties. ICAR-NINFET has developed a protocol to induce softness and bulkiness of jute yarn. Jute yarn (6 lb/spindle) was scoured, subjected to woolenization treatment using sodium hydroxide and finished with a softener of 8-12% to introduce softness. The woolenized yarns were then bleached and dyed in different shades using reactive dyes for product diversification. The modified jute yarns have desirable softness, high bulkiness (diameter increased by 50%) and stretchability (extension >20% from 2%) similar to acrylic/woollen yarn. These woolenized jute yarns were utilized for production of sweater, stole, cap, socks and table/fruits cover. The development of soft and bulky jute-based textiles may open up a new diversified application in textile sector.

Sustainable and rigid packaging box from jute stick: A formaldehyde-free particle board was developed from jute stick by using polyvinyl alcohol resin by the conventional hot press method at 100 kg/cm^2 for 20 min at 140°C. The modulus of rupture of the developed particle board was 15 MPa and it satisfies the desirable property of Japanese Industrial standard for medium density particle boards for the development of packaging boxes. The developed packing box can hold about 5 kg of fruits and costs around ₹200-250 per piece. It is reusable and biodegradable and a good alternative to plastic crate for transport of fruits and vegetables.

Jute stick particle board based box

Natural fibre based vegan leather: A flexible bio-composite from Ramie, hemp and jute fibre as reinforcement and non-harmful plant latex-based polymer as matrix was developed. The flexible composite has 35-45% fibre content, 550-800 g/m^2 areal density, 5-10 mm thickness of 5-10 mm, and 0.4-0.5 gpcc density. Absorbency time and capillary movement are almost similar to the wet blue natural leather (chrome treated leather) and superior to polyurethane based artificial leather sheet. Performance properties like permeability, shrinkage, tensile strength, tear strength and flexing are



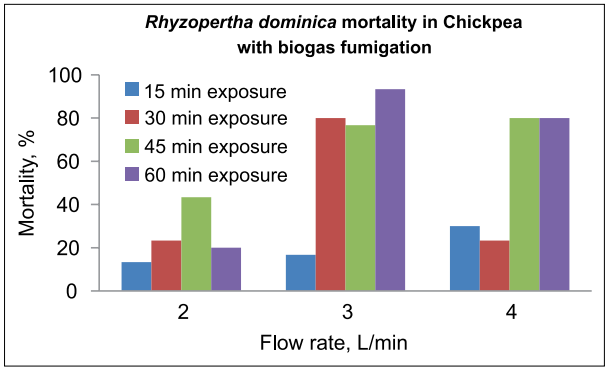
nearly matching those of natural leather. The product is breathable, flexible, resilient and biodegradable in nature and offers potential to develop high value fashion products from the under-utilized natural fibres.

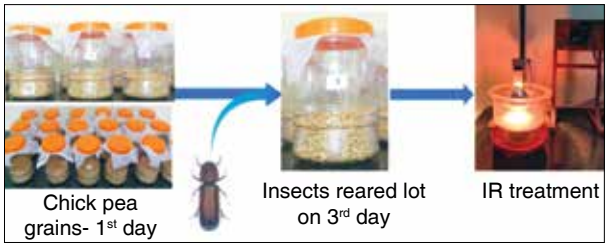
Food by-products based food grade coagulant mixture: Tofu or soybean curd, is mainly made by coagulating soymilk. Tofu whey, a by-product of tofu manufacturing, is currently discarded by the food industry. Tofu whey is highly perishable and needs quick treatment for effective utilisation. A tofu whey-based coagulant powder has been developed using overnight fermented tofu whey and tomato (TWTP). A tofu whey-tomato based hydrolysate mixture was prepared. Tomatoes were washed and ground in fermented tofu whey to make a slurry, which was further incubated for 7-8 h at 25°C. Titrable acidity, *p*H, and other physiochemical parameters were analysed during fermentation and incubation. TWTP was dried in an oven at 55°C for 48 h, then ground with a grinder. The powders obtained were packed in aluminium pouches and stored at 4°C in the dark until tofu production. Different coagulating conditions (concentrations, time, and temperature) had been used to optimise the coagulating parameters, and the optimal concentration of coagulation (OCC) at different temperatures was used for soymilk coagulation and tofu preparation. Each soymilk batch was prepared with coagulant, and the concentration of coagulant powder varied from 0.5% to 5.0% at temperature from 60°C to 95°C. Coagulated batches had been pressed to make tofu and measured for whey volume, *p*H, transmittance, tofu yield, and coagulant efficiency. The OCC value has been found to differ with coagulating conditions. The food-grade coagulant mixture has demonstrated optimal

coagulation conditions with a concentration of 4%, a temperature range of 92±2°C, time duration of 8±2 min, and a yield of 1.3 kg/kg soybean. Tofu prepared with tofu whey-tomato based (TWTP) powder was very similar to tofu prepared with citric acid coagulant (a common coagulant) in terms of yield, composition, texture, and other functional parameters.

Infrared treatment based disinfestation protocol for wheat grains infested with *Rhyzopertha dominica:* Application of appropriate disinfestation tool is mandatory requirement for the long-term safe storage of food grains with minimum storage losses. *Rhyzopertha dominica* is major insect found in wheat grains which has developed resistance against conventionally used chemical fumigants at recommended dose. Infrared heat based treatment has been explored for the surface disinfestation of the wheat grains as an alternative to chemical based disinfestation. IR treatment protocol was optimized for wheat grains infested with *Rhyzopertha dominica* (eggs and adults). The grain samples containing adult insects and young eggs were exposed to infrared treatments. The five different levels of heater to grain spacing, i.e. 45, 70, 95, 120 and 145 mm and four treatment durations, i.e. 30, 60, 90 and 120 s were used for treatment. The optimal values of 45 mm spacing between infrared heater to grain surface and 60 s of treatment time achieved 100% insect mortality, nil egg hatchability with minimum changes in the quality attributes in terms of weight loss (0.98%), grain surface temperature (99°C), protein content (11.30%), fracturability (118.34 N), hardness (118.34 N.mm) and crushing strength (55.78 N.mm).

Ozone and biogas fumigation protocol for chickpea: Chickpeas are most susceptible to insect damage by a number of primary and secondary insects. *Rhyzopertha dominica* is a primary pest in most cereals and a secondary pest of legume, attacking the broken or already invaded legume grains, causing irreverent damages in stored crops. A process protocol has been developed for disinfestation of chickpea grains with biogas and gaseous ozone treatment. Complete elimination of *Rhyzopertha dominica*, a secondary pest in chickpea could be achieved with an ozone dose of 500 ppm per 100 g sample for two consecutive days. Biogas, whose major composition is CO_2 and methane, has also been found to be effective against *Rhyzopertha dominica* for 60 minute exposure at a flow rate of 3 L/min. ❑





12.
Climate Resilient Agriculture

Development and evaluation of a bacterial formulation (Pusa Sanjeevni) for alleviating abiotic stress in rice-wheat cropping system: Pusa Sanjeevni, a bacterial formulation with 6 months of shelf life was developed based on the results of phytotron and field trials carried out at farmers' field at NICRA adopted villages. The formulation was evaluated in rice-wheat cropping system at the farmers' field at nine locations in IGP region of Uttar Pradesh and Haryana. Out of the nine locations, the formulation was used in zero till wheat and aerobic rice at three locations. At all other locations, farmers practiced normal water conservation agricultural practices. The four bacteria in consortium assisted in better germination, vegetative growth, and increased yield under low moisture. The formulation also provided nitrogen through biological nitrogen fixation, solubilize P, K, Zn and produced phytohormones like IAA. In March 2022, unexpected rise in temperature during wheat maturity resulted into yield reduction, however, farmers from northern IGP reported reduced effect of high temperature due to inoculation of Pusa Sanjeevni. Inoculated plots reported higher yields even at reduced inorgainc N input as compared to un-inoculated fields.

Pusa Sanjeevni

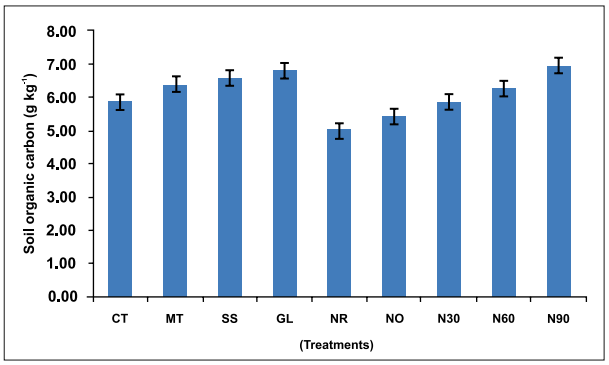
Adaptation to climate change through effective resource management practices in rainfed agriculture: The treatments include two tillage practices, i.e. MT-minimum tillage (plough planting) and CT-conventional tillage (two ploughings before planting + one plough planting + harrowing at planting), three residue levels: sorghum stover (SS) @2 t/ha (surface application), gliricidia loppings (GL) @2 t/ha (surface application), and no residue (NR), and four nitrogen levels, i.e. 0 N (N0), 30 kg N/ha (N30), 60 kg N/ha (N60) and 90 kg N/ha (N90). Crop rotation was sorghum-castor on yearly basis. The results showed that CT performed significantly well in terms of maintaining higher sorghum and castor grain pooled yield (12.21 and 7.95 q/ha) as compared to MT (11.27 and 6.76 q/ha). Among the residue levels, application of GL @2 t/ha (12.82 and 7.98 q/ha) and SS @2 t/ha (11.87 and 7.55 q/ha) significantly increased the pooled yield by 21.6 and 22% and 12.6 and 15% as compared to no residue application (10.54 and 6.54 q/ha) in sorghum and castor, respectively. The increase in sorghum grain pooled yield with N applied @30, 60 and 90 kg/ha over control were 54, 81, and 98%, respectively and increase in castor pooled yield with N applied @30, 60 and 90 kg/ha over control were 46, 70 and 91%, accordingly.

In case of the sorghum, CT maintained higher SYI compared to MT. The trend in residue application followed: GL>SS=NR. Application of N @90 kg/ha recorded higher SYI followed by N @60 kg/ha. Similarly, in castor, the SYI followed the order: CT>MT; GL>SS>NR; and N @90 kg/ha>60 kg/ha>30

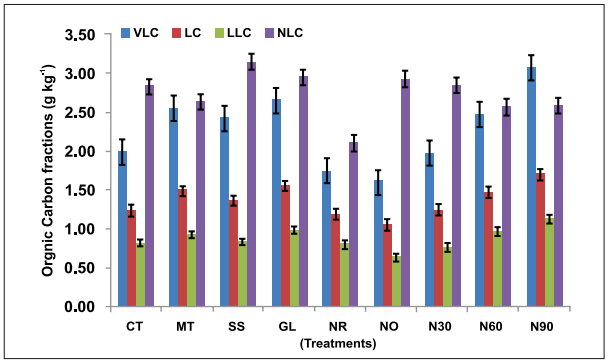
Influence of Pusa Sanjeevni on wheat and rice yield (t/ha) in farmer's fields at different locations during 2022-23

Location of farmers' field	Wheat grain yield (t ha^{-1})		Rice grain yield (t ha^{-1})	
	Un-inoculated Control (Rec. NPK)	Consortium inoculation	Un-inoculated Control (RD of NPK)	Consortium inoculation
Village Jagsi, Sonepat, Haryana	4.13	4.67 (25% less N)	3.42	3.89 (25% less N)
Village Sampla Khera, Kaithal, Haryana	4.03	4.45 (25% less N)	3.91	4.46 (25% less N)
Village Pirkhir, Mirzapur, Uttar Pradesh**	4.21	4.61 (25% less N)	4.15	4.69 (25% less N)
Village Kusmaur, Mau, Uttar Pradesh**	4.53	5.09 (25% less N)	4.08	4.52 (25% less N)
Village Badli, Jhajjar, Haryana*	4.30	4.91 (25% less N)	3.79	4.17 (25% less N)
Village Mumtazpur, Pataudi, Haryana	4.14	4.62 (100% Organic)	3.64	4.06 (25% less N)
Village Rasulpur, Mathura, Uttar Pradesh	4.09	4.79 (50% less N)	4.03	4.38 (25% less N)
Village Rohta, Meerut, Uttar Pradesh**	4.14	4.66 (25% less N)	3.39	3.79 (25% less N)
Village Risti, Block Sadat, Gazipur, Uttar Pradesh**	4.32	4.96 (30% less N)	4.73	5.13 (25% less N)

*Salty irrigation water; ** Practiced zero till wheat and aerobic rice on request in small area.



Effect of tillage, residues and N levels on soil organic carbon (g/kg)



Effect of tillage, residues and N levels on SOC pools (g/kg)

kg/ha> no-N application. The carbon fractions content (very labile carbon, VLC; labile carbon, LC; less labile carbon, LLC; and non-labile carbon, NLC) were studied. MT recorded significantly higher VLC, LC and LLC compared to CT, while, CT recorded significantly higher NLC compared to MT. Among the residue levels, the trend was GL>SS>NR, while in case of the nitrogen levels it was N @90 kg/ha>60 kg/ha>30 kg/ha>control. Higher percentage of the different aggregate indices such as water stable aggregates, water stable macro-aggregates, mean weight diameter and aggregate ratio showed the trend as MT>CT; GL>SS>NR, and N @90 kg/ha>60 kg/ha>30 kg/ha>control in different soil depths.

Minimum tillage showed significantly higher bacteria count as compared to conventional tillage. Among residue levels, GL and SS significantly increased the bacterial count as compared to no residue application. Similarly, highest increase in bacterial count was observed with N @90 kg/ha.

Climate-smart interventions to reduce GHG emissions in adopted villages: A village Momanpur in the Bhopal district of Madhya Pradesh was selected to introduce crop-specific climate smart technologies to mitigate the climate variability and climate change. The village comprises of 30 farmer families and total agricultural land is approximately 152 acres with major crops like rice and soybean in the *kharif* season, while wheat and chickpea in the *rabi* season. Several climate-smart interventions for rice, chickpea, wheat, soybean, and greengram have been identified for the NICRA-adopted village Momanpur using the CCAF-mitigation option tools.

Adaptation and mitigation potential of different cropping system/farming system: To assess the quantum of greenhouse gases emission from rice-wheat cropping system under the influence of different organic carbon strata (Medium and High) along with different establishment techniques and various sources of nitrogen, a field experiment was conducted during the year of 2020-21 at Modipuram under irrigated conditions. It was found that global warming potential (GWP) increased by 3.9% in zero tillage plot as compared to conventional practice under higher carbon strata. However, under medium carbon strata, it increased by 21.5%. The crop productivity was reduced to the tune of 8.3 and 4.4% in zero tillage practice as compared to conventional practice injunction with recommended

Climate-smart options for NICRA-adopted village Momanpur

Crop	Farmer practices	Intervention-1	Intervention-2	Intervention-3
Rice	Puddling + N 120 kg, P_2O_5 60 kg and K_2O 60 kg + residue burning (8080)	Puddling + N 120 kg, P_2O_5 60 kg and K_2O 60 kg + no residue burning (7327)	Puddling + N 120 kg, P_2O_5 60 kg and K_2O 60 kg+ multiple drainage + short drainage + no burning (3583)	Reduce tillage + N 120 kg, P_2O_5 60 kg and K_2O 60 kg+ multiple drainage + long drainage + residue not burned (2073)
Chickpea	Two tillage + N 40 kg + P_2O_5 60 kg + residue not burned (711.8)	One tillage + N 40 kg + P_2O_5 60 kg + residue not burned (354)	No-tillage + N 40 kg + P_2O_5 60 kg + residue not burned (104)	No tillage + N 40 kg + P_2O_5 60 kg + residue incorporation 2.5 ton + residue not burned (86.2)
Wheat	Two tillage + N 130 kg, P_2O_5 and K_2O 60 kg each + residue burning (2367)	Two tillage + N 120 kg, P_2O_5 and K_2O 60 kg each + no residue burning (1487)	Reduce tillage + N 120 kg, P_2O_5 and K_2O 60 kg each + no residue burning (1129)	No-tillage + N 120 kg, P_2O_5 and K_2O 60 kg each + no residue burning (879)
Soybean	Two tillage + N 40 kg, P_2O_5 60 and K_2O 20 kg + no residue burning (1111)	One tillage + N 40 kg, P_2O_5 60 and K_2O 20 kg + no residue burning (753)	No-tillage + N 40 kg, P_2O_5 60 and K_2O 20 kg + no residue burning (503)	No-tillage + N 40 kg, P_2O_5 60 and K_2O 20 kg + no residue burning + residue 2.5 t (309)
Green gram	Two tillage + N 40 kg, P_2O_5 60 and K_2O 20 kg + no residue burning (920)	One tillage + N 40 kg, P_2O_5 60 and K_2O 20 kg + no residue burning (562)	No-tillage + N 40 kg, P_2O_5 60 and K_2O 20 kg + no residue burning (313)	Two tillage + N 40 kg, P_2O_5 60 and K_2O 20 kg + no residue burning + compost 2.5 t + residue 2.5 t (-74.0)

Value in parenthesis indicates GHG potential kg CO_2 eq/ha.

doses of fertilizers (RDF) at higher and medium carbon strata, respectively. Application of dichorionic di-amniotic (DCDA), resulted into reduction in the GWP by 33.2 and 4.9% under higher and medium carbon stratas, respectively under conventional tillage practice, while the reduction of GWP by 25.0 and 9.7% under high carbon and medium carbon, respectively under zero tillage practice. Carbon equivalent emissions (CEE) of zero tillage (28.08 kg C/ha) was higher as compared to conventional (27.04 kg C/ha) under RDF with respect to higher carbon strata. N_2O flux fluctuated between 0.60 and 15.93 mg/m^2/day under zero tillage and 0.38 and 9.47 mg/m^2/day under conventional tillage with respect to high carbon strata, while it ranged between 0.38 and 9.16 mg/m/day under zero tillage and 0.46 and 4.23 mg/m^2/day under conventional tillage with respect to medium carbon strata.

Scaling up and impact evaluation of integrated farming system for income and climate resiliency: Prototype Integrated Farming System models have been established through AICRP on Integrated Farming Systems and All India Network Programme on Organic Farming in the country for improving the income of the farmers and sustainability, besides addressing the climate change. Till now, a total of 71 prototype IFS models (including 8 integrated organic farming system models), 63 on-farm farmer participatory refined farming systems and 32 bankable models have been developed, suitable for 26 States and UTs. The states of Jammu & Kashmir, Kerala, Odisha, Tamil Nadu, and Telangana have implemented specific schemes to promote IFS models among the farming community through financial and technical backstop. These schemes started in 2017-18 with a budgetary allocation of ₹22 crores in Tamil Nadu to cover 2490 units in 2018 and 4300 units in 2019 and covered 19,590 beneficiaries across 35 districts. Odisha initiated IFS as a pilot program in 2017 and covered 30 districts in 2021-22 with a budget outlay of ₹10 crores for establishing 942 models and ₹20 crores for 1884 models in 2022-23. Kerala under 'Re-build Kerala Scheme' promoted IFS for resilience and enhanced income generation of farmers in 2018 and covered 14 districts with 21,000 beneficiaries. Telangana has implemented IFS in about 3940 ha area with the involvement of 1270 farm households across 33 districts.

Multilayer integrated farming system for livelihood improvement in multiple abiotic stress regions: Multilayer integrated farming system (MLIFS) involves the cultivation and management of various components (vegetables, fruits, and poultry) at distinct levels. These components were strategically combined to address multiple abiotic stresses, including shallow basaltic soils, limited land size with inadequate irrigation resources, and the goal of creating a sustainable agricultural income in degraded lands. In this model (0.12 ha), integration of seasonal vegetables and fruit cultivation alongside the raising of backyard poultry was carried out. Micro-irrigation system was used for crop irrigation, and poultry birds were allowed to scavenge for food, which led to the production of both eggs and poultry. This approach aimed to reduce the cost of feeding poultry while simultaneously enhancing soil quality over time, ultimately resulting in a sustainable and steady income. The water productivity for crop, eggs and MLIFS was 54.0 (₹/m^3), 1.61 (No./m^3) and 36.71 (₹/m^3), respectively. The Land Equivalent ratio (LER) of MLIFS was 1.89.

Identification of *S. sisymbriifolium* and *S. torvum* as the potential rootstocks for drought tolerance in eggplant: Five wild eggplant species (*S. gilo*, *S. indicum*, *S. macrocarpon*, *S. sisymbriifolium*, and *S. torvum*) were used as rootstocks, with the commercial cultivar Suraj as the scion. Grafting was done under controlled conditions, achieving a success rate of over 85% and good graft compatibility. After proper healing, the grafted plants were tested in a greenhouse. They were allowed to establish for 35 days, and then subjected to drought stress for 20 days, while control plants were regularly irrigated at 80% field capacity. Results showed that eggplant cultivar Suraj grafted onto *S. sisymbriifolium* and *S. torvum* rootstocks outperformed other rootstocks. These rootstocks exhibited higher shoot fresh biomass, root dry biomass, and root-to-shoot ratio, even after 20 days without irrigation. Grafted plants on

Economics of multilayer integrated farming system (0.12 ha)

Component	Gross income (₹)	Cost of cultivation (₹)	Net income (₹)	B:C ratio
Vegetables and fruits	13794	13421	372	1.02
Poultry	46832	36425	10407	1.28
System (MLIFS)	60626	49846	10779	1.15

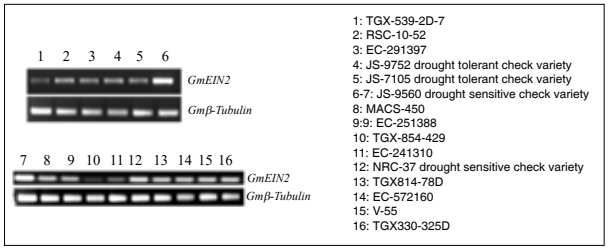
Development of multilayer integrated farming system established at ICAR-NIASM

these rootstocks also showed better physiological traits, such as leaf RWC, PS II efficiency, chlorophyll content, NDVI, and cooler canopy, indicating their sturdy and tolerant nature. In field conditions, it revealed that Eggplant grafted on *S. sisymbriifolium* rootstock gave 40% higher and *S. torvum* rootstocks gave 19% higher yield under water deficit stress (0.6 ETc) over non-grafted (2.90 kg/plant). Water-use efficiency of eggplant grafted on *S. sisymbriifolium* was 13.24 kg/m^3 and *S. torvum* was 11.22 kg/m^3, whereas in non-grafted plant it was 9.43 kg/m^3 at 0.6 ETc. Grafting eggplant on these rootstocks positively enhances the scion variety growth, yield and water-use efficiency in semi-arid Deccan plateau of India.

Greenhouse: Comparative performance of grafted and non-grafted eggplant

Field condition: Grafted eggplant evaluated in field conditions

Identification of promising soybean genotypes based on drought adaptive traits and drought responsive *GmEIN2* gene: A total number of 320 soybean genotypes were evaluated for drought adaptive traits under greenhouse conditions. Among 320 genotypes, 5 promising soybean genotypes (PSG) were identified for traits and genes contributing to drought stress tolerance. The level of water stress tolerance among these 5 genotypes were determined using drought adaptive traits and ethylene sensitivity indicator EIN2 gene expression analyses. Genotypes such as TGX539-2D-7, RSC10-52 and EC 291397 revealed considerably lower expression of *GmEIN2* gene, cooler canopy, more canopy greenness, higher shoot biomass and higher water status in terms of RWC as compared to drought sensitive check varieties JS-9560 and NRC-37 under well-watered conditions; PSG TGX539-2D-7, TGX-854-429 and EC-457475 exhibited efficient photosystem-II as compared to drought tolerant check varieties JS-9752, JS7105 and drought sensitive check varieties JS-9560 and NRC-37.



Promising soybean genotypes TGX-539-2D-7, RSC 10-52, EC-291397 showed lower expression of EIN2 gene as compared to drought sensitive check varieties (JS-9560) at depleted soil moisture (16-17%)

Performance of genotypes TGX539-2D-7, RSC10-52 and EC 291397 was found better under non-stress and water stress conditions.

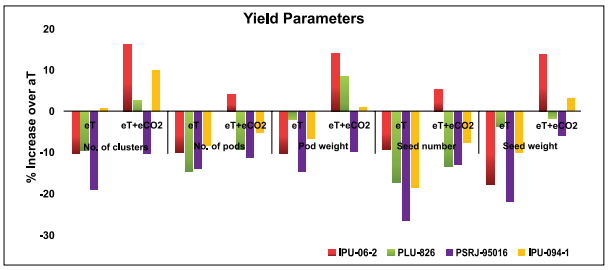
Productivity of rainfed crops under enhanced carbon dioxide and its interaction with water deficit and elevated temperature on black gram: The study aimed to quantify the influence of increased atmospheric carbon dioxide concentration and its interaction with elevated temperatures and moisture stress on the productivity and quality of black gram. This experiment evaluated the effects of elevated temperature (eT) and its interaction with elevated CO_2 (eT+eCO_2) on the phenology, physiology, biomass, and grain yield of four black gram (*Vigna mungo* (L.) Hepper) genotypes: IPU-06-2, PLU-826, PSRJ-95016, and IPU-094-1 under FATE facility. The eT conditions were maintained at 3.0±0.5°C above the ambient canopy temperature (aT), while eCO2 levels were kept at 550±50 ppm.

Elevated temperature (eT) significantly impacted biomass and yield components and the magnitude of response of individual genotypes varied. The reduction of total biomass at eT ranged from nil (PLU-826) to 10% (PSRJ-95016), while an increase in vegetative biomass ranged from nil (IPU-094-1) to 15% (IPU-06-2). The reduction in seed weight was highest with PSRJ-95016 under eT conditions, while the presence of eCO_2 reduced the impact of eT and IPU-06-2 recorded 14% higher seed yield than at ambient control.

Among the selected four black gram genotypes, the vegetative biomass of IPU-094-1 was less impacted at eT, while the highest improvement with eT+eCO_2 was recorded with PSRJ-95016 revealing that the presence of eCO_2 promotes more vegetative growth in this genotype. The genotype IPU-06-2 responded positively to eCO_2 for seed yield as it not only alleviated the ill effects of eT, but also registered a higher seed yield than aT. Though eCO_2 improved the overall biomass of the genotypes, its ameliorative capacity was higher for yield and yield components of this C3 pulse crop.

The harvest index varied significantly across the treatment conditions, with the greatest index was observed under eCO_2 conditions, whereas the harvest index was affected only by temperature.

Independent and interactive effects of eCO_2 and eTemperature on *Spodoptera frugiperda* on Maize-A major input for prediction of future pest



Impact of eT and eT+eCO_2 conditions on yield parameters of four black gram genotypes

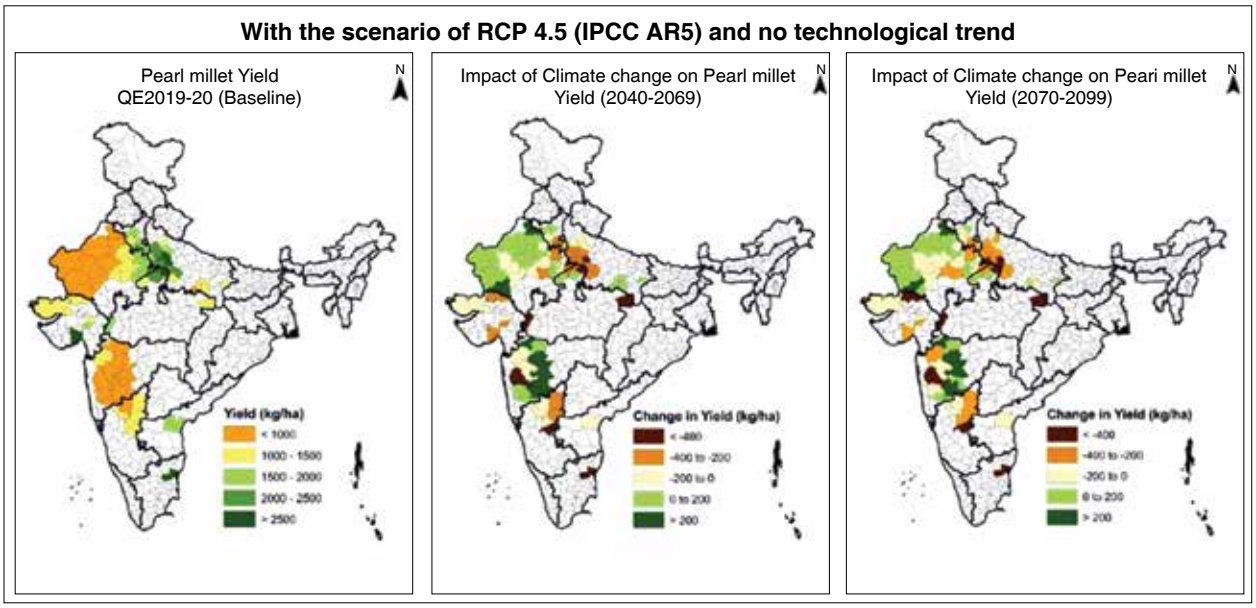
scenario: Climate change is now unequivocal and influences crops and the incidence of insect-pests. Understanding the spatially variable, species-specific, and complex effects of climate change is essential in developing an appropriate pest management strategy. The two dimensions of climate change, i.e. elevated temperature (eTemp.) and elevatedCO_2 (eCO_2) influence insect herbivores. In the present study, the growth and development of an invasive insect pest, fall armyworm, *Spodoptera frugiperda* on maize at eCO_2 and eTemp conditions using CO_2 and Temperature Gradient Chambers (CTGC) was estimated. Dilution of bio-chemical constituents was noted with lower leaf nitrogen (9%–14%), higher carbon (3%–11%), higher C:N (18%–26%), and higher tannins (13%) in maize foliage at eCO_2+eTemp. levels. A significant influence on primary parameters of insects, viz. higher total consumption by larvae (38%), extended larval duration (13%) with increased larval weights (17%), and differential pupal weights (14%) in successive generations were recorded at eCO_2+eTemp. compared to ambient conditions. Their effect was continued on various insect performance indices also, with higher relative consumption rate, RCR (40%); lower relative growth rate, RGR (11%); varied approximate digestibility (AD); efficiency of conversion of ingested food (ECI) and digested food (ECD) of *S. frugiperda* larvae. The interactive effect of eCO_2 and eTemp. led to a higher Potential Population Increase Index (PPII) (19%) due to higher fecund adults. The effect of eCO_2 offsets the impact of eTemp. when interacting together on some of the insect parameters. The present results indicate that eCO_2 and eTemp. play a key role in influencing the growth and development of *S. frugiperda*, indicating higher pest incidence in future climate change periods.

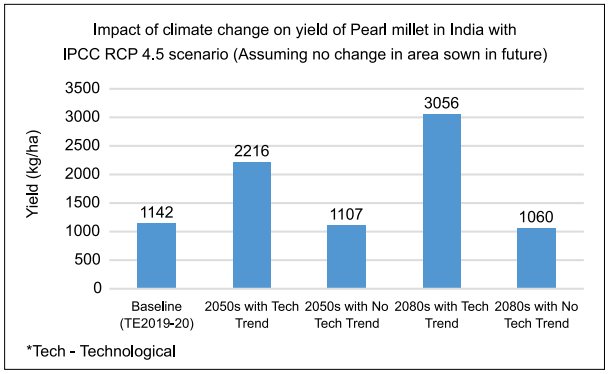
Impact of climate change on pearl millet yield: Climate indicators from historical data (from 1997-98 onwards) at district level relevant to pearl millet yield prediction were identified and derived. One-way fixed effect panel data regression model was fitted, taking pearl millet yield as dependent variable. Time invariant

Bio-engineering measures for the stabilization of ravine slopes and its productive utilization in Western India

The conservation measures such as (a) Bench terracing + Sapota (Bt); (b) Bench terracing + Sapota with crop cultivation (BtCr); (c) Continuous slope + Sapota (Sl) and (d) Continuous slope + Sapota with trenches (SlTr) were evaluated for stabilization of ravines slopes. Bench terracing and trenching brought in significant decrease in runoff (34% and 16%, respectively) and soil erosion (25% and 15%, respectively), and enhanced tree growth, biomass and carbon stock. The results indicated that bench terracing is the best conservation measure for the stabilization of slopes in ravine lands followed by trenching. These conservation measures could also be important strategies for climate change mitigation and adaptation for such highly degraded ravine lands.

Stabilization of ravine slopes





district-specific effects were estimated as coefficients of cross-sectional dummies. Technological trend was captured as coefficient of year effect. Sensitivities of pearl millet yield to weather aberrations were captured as slope of those indicators. Predictors used for fitting the model were derived with 2050s and 2080s with CMIP5 ensemble climate projections for RCP 4.5 scenario. Yield projections for pearl millet were made based on the fitted model for 2050s and 2080s. Impact of climate change on pearl millet yield at district level was assessed for 2050s and 2080s. Aggregations of impact were made at country level as well.

Technological trend was found significant and estimated as 30 kg/ha/yr. Though negative yield impacts are expected in few districts of almost all states, majority districts in Rajasthan and Maharashtra may witness positive yield impacts in future due to climate change. ❑

13.
Human Resource Development

The Agricultural Education Division, ICAR, provides financial assistance to all the ICAR accredited AUs under the scheme "Strengthening and Development of Higher Agricultural Education in India" to strengthen, modernise and upgrade the student and faculty amenities to attract talent. The uniformity, assessment and maintenance of standards and quality of higher agricultural education through institutional mechanism has been put in place in Indian Council of Agricultural Research (ICAR) for human resource development and quality reforms. The scheme also helps in promoting holistic higher agricultural education by blending knowledge and skill through Experiential Learning Modules, there by, promoting entrepreneurial capabilities of students. The financial assistance under the scheme is provided to all the State Agricultural Universities (SAUs), Deemed Universities (ICAR-DUs), Central Agricultural Universities (CAUs) and Central Universities (CUs) with agricultural faculty duly accredited by the Council.

Education and training in agriculture and allied areas can contribute towards development of quality human resources to address the myriad of challenges faced in this sector and to enable production of sufficient safe and nutritious food to meet the dietary needs of the population. This also helps to develop adoption of sustainable agricultural practices and mitigating the challenges of climate change.

Despite its importance, the agricultural education and training sector faces several challenges that can limit its effectiveness. It is necessary to address the issues in agricultural education and training are crucial for ensuring that developed human resources and farmers have the knowledge and skills they need to produce high-quality crops, livestock and protect the environment, and improve their livelihoods.

The effective functioning of National Agricultural Education and Research System (NARES) is because of close association with education and extension leading to contribution towards the rapid growth of agriculture in the country. The education and skills of agricultural people are significant factors in enhancing every aspect of agricultural performance.

Quality assurance of higher agricultural education

Accreditation of Agricultural Universities: A total of 42 new applications for accreditation of degree programmes, colleges and agricultural universities were received in the year 2023-24. Ten Agricultural Universities including backlog of previous year, were granted accreditation. Further based on requests during appeal committee meeting, one AU and programmes of two AUs were granted accreditation, separately, in addition to the Agricultural Universities. Among the private universities/colleges, 10 Universities/Colleges were granted accreditation, whereas, 13 Universities/ Colleges could not qualify for accreditation. Presently, 40 Applications are also under process at various level such as University, Regional centres, Peer review teams and Accreditation secretariat. About ₹ 61 lakh revenue was generated through accreditation fee during the period.

Teaching

Restructuring of undergraduate courses in agriculture and allied subjects as per guidelines of NEP-2020: The National Education Policy (NEP) 2020 document reasserted the need to reform the present Indian education system. ICAR constituted the 6th Deans Committee on 15th September, 2021 to restructure the existing course curricula so as to enable implementation of the NEP-2020. The restructured course curriculum aims at strengthening critical thinking, creativity, communication and collaboration among the students. A three weeks' immersion cum foundation programme is included at the start of the course, which is aimed at instilling life and social skills, social awareness, ethics and values, team work, leadership, creativity, etc. 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 4th year and also through online courses.

Provision has also been made for advanced skill development 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, provision for multiple exit and entry options have also been included. The Committee restructured the course curricula of all the approved disciplines of agriculture. The first draft of the report has been completed and the final report of the committee will be submitted in next three months after revisiting it in the line with recently released guidelines by UGC. The report will be implemented from the next academic session (2024-25).

Initiating a new UG degree in Natural Farming: A new initiative in the form of introduction of Natural Farming in the course curricula at under-graduate (UG) level has been developed by ICAR to reorient agriculture graduates for learning of our ancestral agriculture knowledge, employability and entrepreneurship. To address this initiative a committee was constituted for developing syllabus and curricula on Natural Farming at Undergraduate (UG) and Postgraduate (PG) level

under the chairmanship of Dr Anupam Mishra, Vice Chancellor, CAU Imphal, with the following ToR:

- Developing syllabus and curricula of Natural Farming for UG and PG level including theory and practical.
- Developing guidelines for entrepreneurship under student "READY" programme in the area of natural farming.

The syllabus and curricula developed was discussed in the 6th Deans Committee meeting held 6 September, 2022. The notification for starting a degree course in AUs from the current academic year was issued by Agricultural Education Division, ICAR on 31st March, 2023. The sub committee was also constituted to align the syllabus and curricula developed as per the guidelines and norms of NEP-2020 and Sixth Deans' Committee during the final meeting of the sub committee was held during 26-27 September, 2023. Development and restructuring of undergraduate programme 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.

Student READY programmes

Rural Agricultural Work Experience and Experiential Learning Modules (RAWE): This is one of the key components of the UG degree programme in agriculture and related areas, conducted in 7th semester. The main idea is to acquaint the students regarding the actual constrains/challenges by exposing them to the rural settings. Skills of students are improved as they learn to tackle the problems in field by multidisciplinary and participatory approach. An online portal for data recording under the Student "READY" programme has been developed. In this, students gets knowledge regarding latest developments in the agriculture and allied areas. Furthermore, apart from disseminating knowledge to farmers about latest technologies, crop protection methods, etc. students are exposed to managing commercial farms during visits to progressive farmers. Also, students are acquainted with various agri-industries and are provided with excellent opportunity to learn about varied businesses. The course therefore, helps convert theoretical knowledge to practical knowledge through hands on experience and practical training depending on the requirements of respective discipline. Regular interactions and presentations by students improve communication skills of the students. During last year, 16,261 students were trained under RAWE.

One module on "Skill Development in Natural Farming with Eco-friendly Marketable Product Generation' was provided to Faculty of Agriculture, SKUAST-Jammu, Chatha. The total number of modules supported across agricultural universities is now 492.

Students of AUs in KVKs and farmers fields for RAWE component under student READY

Commercially successful products from ELP Units

Students of ELP Unit "Value Addition of Horticultural Crops"

Students learning operation of fermentor in Biofertilizer Production Unit

Prodcution of vermicompost by students in the ELU module on Agriculture Waste Management through Vermicomposting

Human Resource Development

Research and capacity building

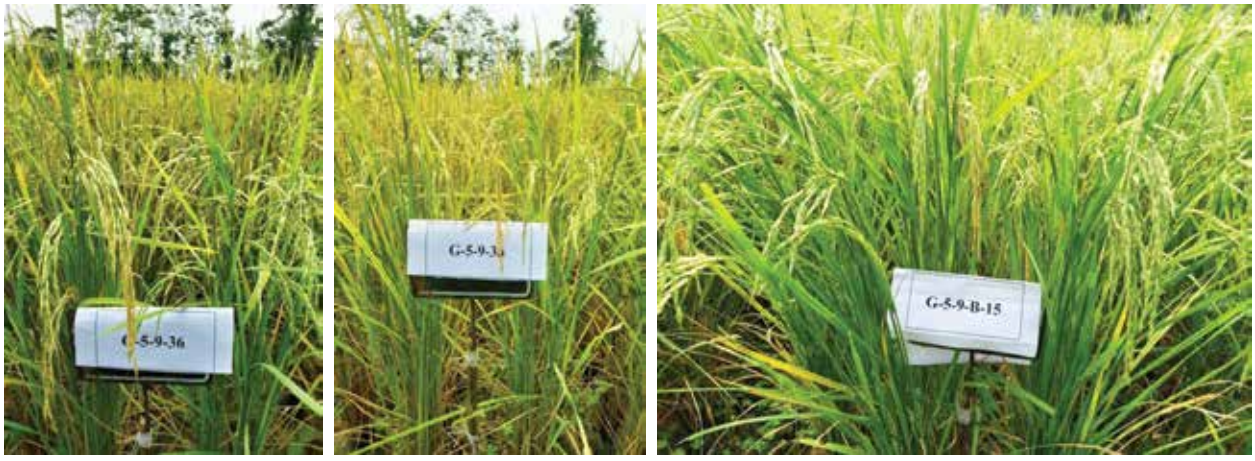
Niche Area of Excellence: The ongoing NAE programmes are being supported in areas, viz. assessment of heavy metals in crop plants, development of nanomaterial for tissue regeneration in animals, and development of blast resistance high yielding short grain aromatic rice variety for northern Bengal.

Significant achievements:

- In the ongoing program at ICAR-IVRI the protocols for isolation, culture and characterization of stem cells from different species of animals were standardized. Also, the centre standardized protocol for development of 3-D scaffold of silk-alginate for neural regeneration. It was also observed that mesenchymal stem cells possess therapeutic and tissue regenerative potential in treating chronic mastitis.
- In UBKVV, Coochbehar, development of non-basmati aromatic rice in Kalonunia background resistant to blast disease is under progress. F_7 and F_8 generations of Kalonunia × Pusa Basmati 1,637 were screened for the presence of Pi9 genes and plants with Pi9 genes were tagged in field.
- GC-MS volatile aroma compounds profiling of parents (PB 1637, Kalonunia) was done. Aroma compounds like 2 Acetyl-1-pyyroline (2-AP), hexanal, heptanal, octanol, pentanal, etc. were detected. Some compounds, viz. pentanal, cyclopropane, propyl- and 2-Decenal were present in Kalonunia but absent in PB-1637, This information is important for metabolite fingerprinting.
- In the ongoing programme at ICAR-IARI, the level of pollutants, viz. Ni, Pb, Cd, Cr, in basmati rice grains from 12 districts of Uttar Pradesh, 5 districts of Haryana and 3 districts of Punjab (Jalandhar, Patiala and Amritsar) were within the permissible limits.

The NAE centres organized 3 training programmes / awareness workshops/camps leading to capacity building of 54 faculty and 167 other stakeholders. Twenty students underwent internships. Four PG students completed degree programme and eighteen students are continuing research work and pursuing degree utilizing the facilities developed under NAE programmes. These centres published 6 papers in peer reviewed journals, including papers in journals assigned NAAS rating of 7 and above. Three technologies/methodologies have been developed and are under process for commercialization.

Summer/Winter schools and short courses: During the year, 43 summer winter schools/short courses comprising; 28 summer/winter schools of 21 days, and 15 short courses for 10 days and 33 Centre for Advanced Faculty Training (CAFT) were organized at various



Pi9 positive lines with aroma during *Boro* 2022-23

ICAR institutes and SAUs. The skills, knowledge and capacity building of 1786 (1268 M/ 517 F) faculty were enhanced. All the training programs sponsored by the Agricultural Education Division were monitored through a workflow-based online management system.

Attracting talent

All-India Entrance Examination for Admission (AIEEA) to UG: The 27th AIEEA to undergraduate (UG) programs for 4285 All India Quota (AIQ) seats including the award of National Talent Scholarship (NTS) was held on 13th and 14th September, 2022 in online (Computer Based Test-CBT) mode. Of these AIQ seats, 20% seats (100% seats at ICAR-IARI, New Delhi; ICAR-NDRI, Karnal; RLBCAU, Jhansi and Dr. RPCAU, Pusa) of degree programs in agriculture and allied subjects (12 disciplines) other than Veterinary Sciences were in the Agricultural Universities under ICAR-AU system. The examination attracted 89,413 applications, out of which 61,052 candidates (68.28%) appeared for the examination conducted by NTA. Of these, the number of female, male and transgender candidates were 29,209, 31,842 and 01, respectively. Among the categories, OBC (NCL) candidates were highest (26,795) followed by General (15,455), SC (8,999), General-EWS (5,043) and ST (4,760).

All-India Entrance Examination for Admission (AIEEA) to PG: The online examination for 27th AIEEA-2022 (PG) was conducted on 20 September, 2022 for admission to 30% seats (100% seats of ICAR-DUs; RLBCAU, Jhansi and Dr RPCAU, Pusa) in PG programs including award of ICAR-PG scholarship. Out of total 20,648 applicants; 18,332 (88.78%) appeared in the examination. Of these, the number of female candidates (9,025) was almost equal to the males (9,307). Among the categories, OBC (NCL) candidates were highest (6,842) followed by General (5,670), SC (2,889), ST (1,609) and General-EWS (1,322).

All-India Competitive Examination (AICE) for Ph.D. admission and award of Junior/Senior Research Fellowship: The online examination for 27th AICE-JRF/SRF (Ph.D.)-2022 was conducted on 20 September, 2022 for admission to 30% seats (100% seats of Dr RPCAU, Pusa, RLBCAU, Jhansi and ICAR-DUs-4No.) in Ph.D. programs including award of fellowships. A total of 11,001 candidates (84%) appeared in the examination out of 13,097 applicants. Of these, the number of female candidates (5,757) was higher than that of males (5,244). Among the categories, OBC (NCL) candidates were highest (3,815) followed by General (3,787), SC (1,769), ST (831) and General-EWS (799).

Award of fellowships

- **ICAR Fellowships for post graduate students**: To attract and retain the talent and promotion of merit in general, and for encouraging talented students to undertake higher agricultural education in particular, the ICAR awards ICAR-PG scholarships (PGS) and JRF/SRF to post-graduate (PG) and doctoral (PhD) students in different disciplines of agriculture and allied sciences. A total of 583 and 292 students were awarded ICAR PGS and ICAR JRF/SRF for Master's and Doctoral studies, respectively.
- **Internship Allowance**: Allowence to 5,037 veterinary graduates trained by Agricultural/ Veterinary Universities was provided.
- **National Talent Scholarship (NTS):** Merit-based support through the National Talent Scholarship to the under-graduates (UG) and master's degree students admitted in AUs through ICAR All India Entrance Examination (AIEE), was provided. During the year 10,010 UG and 3,376 PG students were provided NTS.
- **ICAR Post-Doctoral Fellowship (ICAR-PDF):** It is a new programme initiated to identify and support motivated young researchers for conducting research in frontier areas of agriculture and allied sciences to build the national capacity. It provides them a platform to develop as independent researchers capable of initiating a new programme in nationally important priority areas under the supervision of a mentor.

Merit-cum-means scholarship

Scholarships to meritorious undergraduate students belonging to below-poverty-line families to study agriculture, and allied subjects are awarded annually on the basis of merit-cum-means. During the year, 101 meritorious undergraduate students belonging to below-poverty-line families were awarded the scholarship.

Globalization of agricultural education

Netaji Subhas-ICAR International Fellowships: "Netaji Subhas-ICAR International Fellowships" for pursuing doctoral degrees in agriculture and allied sciences in the priority research areas is awarded to the, (i) Indian candidates for studying abroad in the identified overseas Universities/Institutions having strong research and teaching capabilities, and (ii) to overseas candidates for study in the Indian Agricultural Universities (AUs) in the ICAR-AUs system. The aim is to create a pool of scientist-envoys for enhanced future cooperation. As per guidelines, 30 fellowships are available every year. A total of 6 candidates were selected for the year 2022-23, of which 4 Indian and 2 overseas candidates were selected from Nepal for Ph.D. under this programme. To streamline the process online portal for the award of fellowships has been created and linked with the Education Portal.

Out of 224 candidates selected since 2009-10 to 2020-23, 114 candidates have completed their Ph.D under this programme. One hundred (100) candidates including 10 foreign national candidates are currently doing Ph.D in their identified universities.

Promotion of Excellence

ICAR National Professor/National Fellow/ Emeritus Professor/Emeritus Scientist: ICAR supports National Professor with the twin objectives of promoting excellence by recognizing outstanding scientists with proven output and outcomes for creating a culture of basic research through their project work in the National Agricultural Research System (NARS) and establishing and nurturing a novel school of thought around the recognized person. During the period under report, 4 National Professors, 14 National Fellows were in position. The aim of the Emeritus Scientist (37) and Emeritus Professor (39) programme is to complete the ongoing work for its fruitful conclusion, utilize their talent in teaching specialized courses, student research guidance, developing instructional material/textbooks including e-learning resources for use in National Agricultural Education Programme and distance education. In addition to research work, some Emeritus Scientists were engaged in teaching advanced courses at PG and Doctoral levels, guiding postgraduate students in their research pursuits, publishing books and developing practical and teaching manuals.

Salient research achievements

- *Technology for use of paclobutrazol in inducing flowering in mango*: Technology has been refined in terms of application schedule, best doses as per the orchard requirement for increasing productivity and without harming the plant health. The effectiveness of different doses (2-10 g a.i. per tree) of PBZ for promoting the flowering and fruiting in mango cv Dashehari was evaluated and was found to be very effective for increasing the mango yield (25 to 60%), besides controlling the biennial bearing habit in mango. Residual influence of paclobutrazol in soil on fruit yield was observed if applied continuously for two consecutive years. The dissipation rate in soil followed first-order kinetics with half-life values ranging between 57.75 to 77.00 days.

There was an altered community composition of the rhizospheric microbiome due to PBZ treatment.

The cost-effective recommendation of PBZ application is 4.0 g a.i./tree in soil in the first year and a half dose (2 g/tree) in the subsequent year due to its long persistency and needs to be integrated with good management practices.

Conducted awareness program and demonstrated the proper use of paclobutrazol at mango grower fields adjacent to the mango belt of Lucknow located at Sitapur, Bharawan kala, and Institute orchard (*https://cish.icar.gov.in/awareness.php*).

- *Development of an upgraded pyrolysis process for conversion of pine needle pyrolysis oil into liquid biofuel:* The pine needles were utilized for production of bio-oil through pyrolysis process to produce bio-oil, biochar and assess its feasibility as Compression Ignition (CI) engine fuel. The highest yield of pine needle bio-oil was found to be 27.6, 23.0 and 26.6 %, respectively when pine needle was pyrolyzed without catalyst and 10% ZSM, 10% CaO, as use of catalysts increased the aqueous phase in the bio-oil and decreased the organic phase. Fuel-grade refined pine needle bio-oil could be obtained by distilling the crude bio-oil between 180-240 °C by fractional distillation process. The performance of 3.73 kW constant speed diesel engine on the selected fuel blends supplementing refined pine needle bio-oil was in the range of 5-25% when compared at 100% load on the engine indicated; similar brake power-producing capability of the blends with that of HSD.

The fuel consumption of the engine on blends as well as diesel is also comparable though there is an increase in fuel consumption at 20 and 25% blending because of the high replacement of diesel.

The brake thermal efficiency of the engine on blends and diesel was found to be almost similar.

The emission of carbon monoxide, and unburnt hydrocarbon on blended fuels were higher compared to HSD.

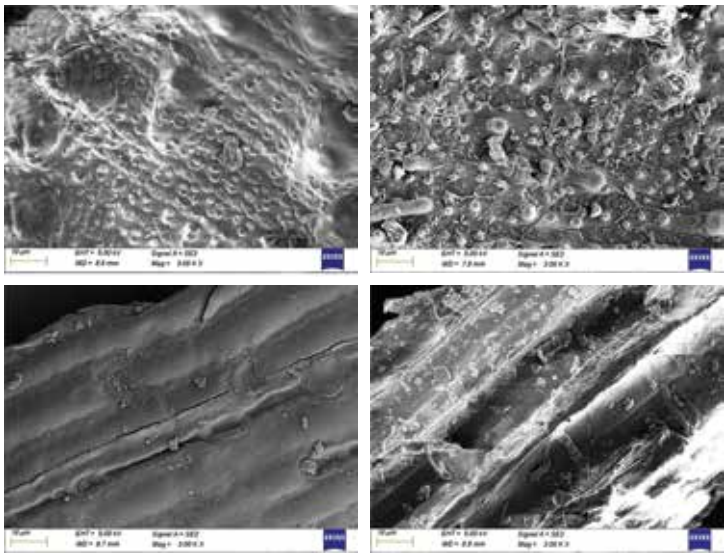
- *Development of an optimized stable ligninolytic enzyme complex effective in enhancing the digestibility of paddy and finger millet straws:* Treating crop residues with stable purified ligninolytic enzymes from WRF as a standardized formulation would increase the level of bio-delignification enhancing ruminant digestibility and making available the trapped energy for productive purposes.

SEM images showed the structural differences in the paddy and finger millet straws between the control and the enzyme-treated crop residues. The polymers in the control straws show a linear arrangement of network

Advanced flowering through paclobutrazol

Profuse fruiting in Dashehari with paclobutrazol

Interaction with the farmers in their orchards about the use of paclobutrazol



Scanning electron micrograph (SEM) images of control and enzyme-treated crop residues showing 10 µm magnification. a) Paddy control, b) Paddy straw treated with all the four enzymes, c) Finger millet control and d) Finger millet straw treated with all the four enzymes

structure closely arranged in a lattice. On the treatment of the crop residues with ligninolytic enzymes, clear distortion in the network is observed in the SEM images showing depolymerization of the lignin residues on enzymatic treatment both in the paddy as well as finger millet straws.

In vitro digestibility techniques provide a quick, inexpensive, and precise prediction of *in vivo* or conventionally determined digestibility in ruminants. There was a significant difference between the control and enzyme treated straws at 95% CI ($p<0.0001$). The model gave a mean square of 687.95 with an F value of 121.74 and a sum of squares of 4815.68. Use of biological enzymes for enhanced ruminant feed appears to be a sustainable choice of the decade and employing a plethora of modern genomic and proteomic approaches towards breaking down recalcitrant lignin improves the efficiency and production volume of stable enzyme catalysts.

Technologies developed

Enzymatic reactor prototype: Agarose beads were functionalized with amine and activated using glutaraldehyde before immobilizing the laccase enzyme on the surface of activated beads through covalent cross-linking. A working prototype of the enzymatic reactor was developed using polypropylene material to treat 10 g straw at a time using immobilized enzyme beads.

Identified diverse stripe rust resistance: One hundred seventy six (176) wheat lines comprising old, promising wheat accessions of Indian and exotic origin were selected. These lines were evaluated at the seedling stage using virulent and predominant pathotypes of *P. striiformis tritici* (causing wheat stripe rust), at IIWBR, Regional Station, Flowerdale. Five lines (Both, China 84, FH-11-6-24, Longreach and Altar) were resistant to all the pathotypes used in the study.

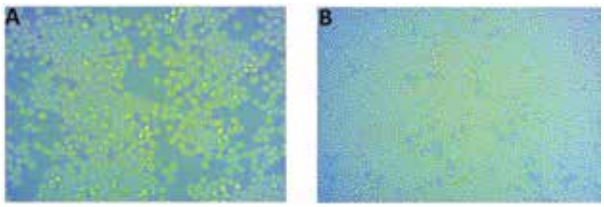
Indirect ELISA standardization using rabbit polyclonal antibody: Indirect ELISA was optimized using polyclonal antibodies against buIL-17A. The test was standardized for the determination of optimum dilutions of the bioreagents. ELISA plate wells were coated with the purified recombinant protein (antigen). Coated antigen captured the in-house polyclonal antibody raised in rabbits. The test was standardized for antigen as well as for polyclonal antibodies. After applying the chequerboard method, the optimized concentration of coating antigen was 5 µg/ml, polyclonal antibody was 1:1,600 and anti-rabbit conjugate was 1:5,000.

Production of hybridoma cells secreting monoclonal antibodies: Myeloma cell line, Sp2/0 Ag14, obtained from National Centre for Cell Science, Pune was used for fusion with spleenocytes harvested from BALB/c mice. After fusion of spleen and myeloma cells hybridomas were observed regularly for their growth.

High throughput sequencing (HTS) based virome analysis of apple and grape: It resulted in recoding of Grapevine virus D, grapevine virus H and GLRaV-7 for the first time in Indian grape cultivars. Infection of

Evaluation of wheat lines for stripe rust resistance

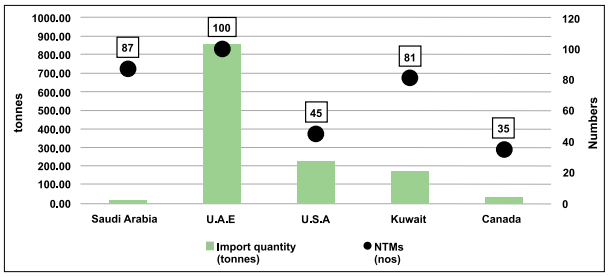
Aeciospores from Berberis released on wheat



Hybridoma cultures in 96-well culture plates (Wells showing multiple clusters in HAT medium for >4 weeks after fusion. A, 400× Mag; B: 100× Mag)

all these viruses was further confirmed through Sanger sequencing. Virome analysis of 15 exotic apple varieties collected from four different locations of Himachal Pradesh and Jammu and Kashmir revealed the infection by CCGaV was detected for the first time. Detection of new viruses could be possible because of HTS-based virome analysis. The study indicated the need for sound indexing programme for the production of clean certified planting materials in grapes and apple.

Product standards, farmers' practices and global trade: A critical analysis with respect to pesticide residue levels in Indian cardamom: Food quality specifications with respect to chemical pesticide residue levels form part of sanitary and phytosanitary measures under the WTO Agreement. Though the standards aid in safe food supply, domestically determined quality specifications vary with countries and cause restrictions in global trade, especially the exports from developing countries. The major potential market destination for Indian small cardamom is Saudi Arabia. The Indian exports of small cardamom is impacted by the MRL of chemical pesticides fixed by major importers like Saudi Arabia. Pesticide usage, handling and trade practices of the Indian cardamom in the major growing areas are unscientific, leading to a higher accumulation of pesticide residue.



Imports and import requirements of Indian cardamom in major importing countries (2020). *Source*: Estimated using data from ITC Market Access Map

Exploitation of heterotic groups for improving the performance of cotton hybrids: Developing and exploiting heterotic groups of cotton through reciprocal selection for combining ability, a procedure which is a modification of traditional reciprocal recurrent selection (meant for random mating crops) suitably modified for a self-pollinated crop like cotton. Two heterotic groups in cotton namely, Stay Green and High Relative Growth Rate (RGR) types were used for improving the performance of hybrids. Base populations involving four parents were developed and tested for ability to combine in F_4 and F_5 generations (termed as developmental phase) for their ability to combine with parents of opposite groups (set 1). Based on this evaluation of ten elite combiner lines of each group were selected and they were involved in 10×10 between group crosses in line × tester fashion (set 2) and this represented what is generally the culminating phase of any reciprocal recurrent selection program. Hence, the traditional method of reciprocal selection meant for random mating crops can be extended to even self-pollinated crops for improving combining ability reciprocally between two genetically diverse populations resulting in improvement in performance of hybrids.

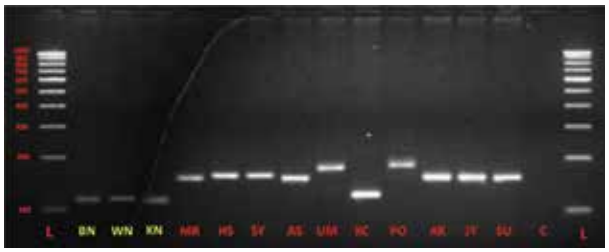
Development of naked seeded and compact cotton types: Stabilized new naked seeded types in cotton with improved productivity to match fuzzy types for commercialization. Many new compact cotton types have been developed which are suitable for high density planting ensuring high yield coupled with earliness and synchronous maturity.

Super compact and tall compact genotypes of cotton

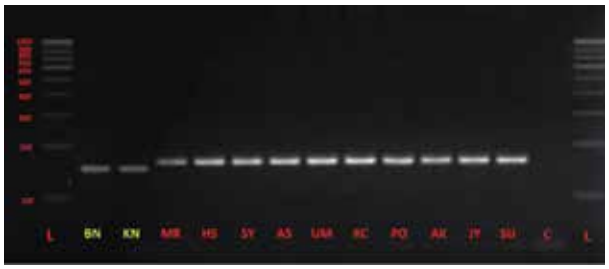
Mass scale seed production of the peninsular carp *Hypselobarbus pulchellus* and *Barbodes carnaticus* through Recirculatory Hatchery System (RHS): Standardization of water quality parameters such as alkalinity, dissolved oxygen and ammonia was performed. Designing and fabrication of the Recirculatory Hatchery System (RHS) in RRC of CIFA (Bengaluru) fish farm has been accomplished. Evaluation of water resources for suitability of eggs to hatch and survival of larvae, the analysis of important water quality parameters from different water sources such as borewell, commercial RO waters and their combinations for determining suitability for the hatching and development of eggs of peninsular carps has been achieved. The 90% RO and 10% borewell water resulted in the desired alkalinity 36.75 equivalent to rain water with survival rate of 76.4% similar to rain water (73.18%). Training of state fishery officials and farmers in seed production of the Peninsular carp *Hypselobarbus pulchellus* and *Barbodes carnaticus* and dissemination of the technology was also undertaken

DNA fingerprinting: DNA finger printing of the medicinal rice 'Njavara' by Simple Sequence Repeat (SSR) marker analysis was carried out. Three primers (RM 340, RM 274 and RM 10346) yielded polymorphic bands unique to Njavara types.

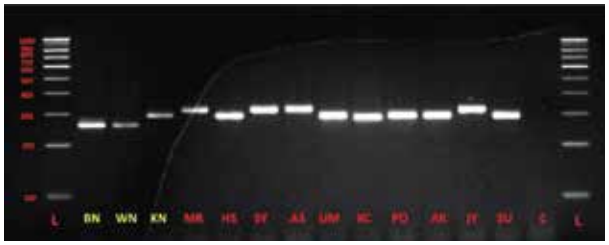
***In silico* and *in vitro* anticancer screening of selective phytocompounds as inhibitor of matrix metalloproteases:** Berberine is more cytotxic to MDA



RM 340



RM 274



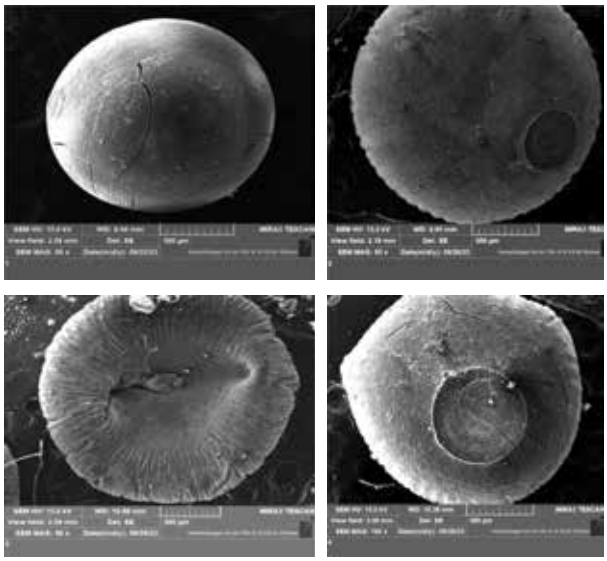
RM 10346

BN - BLACK NJAVARA
WN - WHITE NJAVARA
KN - KARANJAVARA
MR - MANURATNA
HS - HARSHA
SY - SAMYUKTHA
AS - AISWARYA
UM - UMA
KC - KANCHANA
PO - POURNAMI
K - AKSHAYA
JY - JYOTHI
SU - SUPRIYA
C - NEGATIVE CONTROL
L – 100 bp LADDER

MB 231 breast cancer cells in comparison to normal vero cells, induced apoptosis, inhibited cell migration and cell invasion thus suppressing metastasis of TNBC cells through inhibition of mRNA expression of MMP1, MMP7, MMP9 and MMP11 and by decreasing the activity of all MMPs. Anticancer and anrimetastatic activity are in order; Curcumin>Apigenin> Berberine> Ursolic acid.

Release of pre-emergence nano herbicide formulations for weed management in rainfed crops: Standardisation of the process for the controlled release pre-emergence diclosulam herbicide formulations. A smart release nanoencapsulated diclosulam pre-emergence herbicide formulation was developed using several encapsulating processes such as ion gelation, solvent evaporation, and direct way of creating core material to adsorb the herbicides and coating with hydrophilic polymers for smart release.

Characterization of microspheres: SEM micrographs confirmed the shape of microspheres of pectinate and alginate beads, where alginate beads under ferric chloride solution swelled at the center and others were spherical. The presence of relevant counter



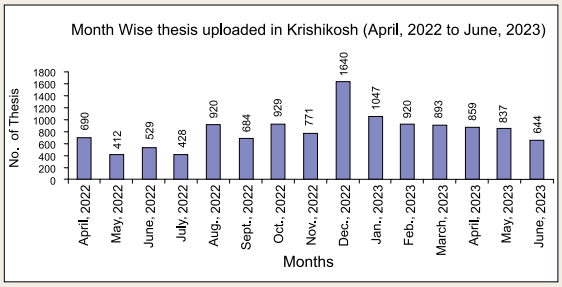
SEM micrographs of sodium alginate and pectinate beads, A) Pectin @6% with 2% $(CH_3COO)_2Zn$, B) sodium alginate @6% with 2% $CaCl_2$, C) sodium alginate @6% with 2% Fe_2Cl_3, D) Sodium alginate @6% with 2% $ZnSO_4$

ions peaks with diclosulam herbicide components was confirmed by EDAX data.

Management of phytophagous mites in apple orchards and poly houses in Himachal Pradesh: Survey of different fruit and polyhouse grown crops was conducted in different districts of Himachal Pradesh and dominance of the phytophagous mites was observed.

Information technology, digitization and library strengthening

Krishikosh is a digital repository (https://krishikosh.egranth.ac.in/) of valuable documents in the field of agriculture and allied sciences. Currently this digital repository (https://krishikosh.egranth.ac.in/) has 50 million digitised pages in more than ₹3 lakh digital items (volumes) like old books, old journals, reports, proceedings, reprint, research highlights, training manuals, historical records, which includes more than ₹1,90,000 theses digitized from various NARES Institutes/SAUs. During the year developed a tool for important keywords extraction along with its frequency in different years from the metadata of thesis titles available in Krishikosh repository (www.krishikosh.egranth.ac.in).



Month wise theses uploded

European red mite infestation on apple

Bioefficacy studies were standardised using different acaricides for the management of pests.

Education Portal

ICAR (https://education.icar.gov.in) has developed a single window platform for providing vital education information/announcements/events/schedules/ e-learning resources from AUs across the country.

The portal 2.0 has functional modules such as fellowship/ internship/ scholarship demands, filling demands under schemes, i.e. Development Grant, Experiential Learning, Library Strengthening, Niche Area of Excellence, North Eastern Hill Region, Schedule Caste Sub Plan, Tribal Sub Plan, Generate/Fill UC/AUC, Generate Sanction Letters, Generate Student Unique ID, University Ranking System, University Accreditation and information related to different schemes of Education Division, ICAR. Following functionalities have been strengthened along with many new functionalities during this year:

Bean mite infestation on primrose

PARTH (Primary Agricultural Rural Trained Human Resources): PARTH Program has been developed in education portal to monitor the blended group to be exposed to field-level project implementation along with residential training in the Agricultural Universities led by faculty coaches.

Financial Management: Nodal officers of AUs can fill and generate demand of various programmes in education portal directly. The demands under schemes are presented here.

Unique Faculty ID (UFID): Education portal is incorporated with Unique Faculty Identification functionality that ensures the uniqueness corresponding to the faculty records in various academic processes and associated online systems. UFID scheme ensures that each faculty has a unique ID associated with their name throughout their carrier in NARES system. Unique Faculty ID (UFID) code contains 15 character combinations (alpha numeric code) which is unique for each faculty throughout all agriculture universities under NARES system.

Integration with other applications: Application Programming Interfaces (APIs) has been developed and deployed in education portal for fetching information from other portals such as accreditation portal, academic management system, etc. Portal is also linked with the other portals such as e-learning portal, Agri-Diksha etc.

GIGW Compliant: Education portal is now GIGW (Guidelines for Indian Government Website) Compliant.

Grievance Redressal Mechanism

Grievance Redressal Mechanism in education portal is a system to address and resolve complaints, disputes, or issues raised by individuals or groups. Its goal is to ensure fair and impartial resolution of grievances in a timely manner. It is an important component for ensuring accountability and transparency in ICAR-AU system.

Direct Benefit Transfer

Department of Agricultural Research and Education (DARE) and the Indian Council of Agricultural Research (ICAR) under the Ministry of Agriculture and Farmers Welfare have 19 DBT on boarded central sector schemes. Most of the schemes are student centric, i.e. various scholarships and fellowships, in addition a few faculty and farmer centric schemes are also on boarded on the DBT Bharat portal. Out of the total 19 schemes, 18 are related to Agricultural Education/Research wherein the benefit type is cash, one is an in kind scheme. The schemes are implemented and monitored by different scheme managers at the ICAR headquarters and ICAR institute level. The schemes on serial number 1-15 are student centric schemes, whereas, 16-18 are faculty centric and agricultural extension is a farmer centric scheme.

Strengthening and modernizing teaching and learning facilities in agricultural universities

The support under the component 'Development and Strengthening' continued during the year. The ongoing new civil works, viz. one auditorium and hostels were supported along with the financial assistance for modernisation and upgradation of the infrastructure pertaining to teaching and learning. Teaching facilities have been further enhanced with additional support for 38 smart classrooms. Undergraduate and postgraduate laboratories were strengthened with necessary minor/ major equipments for enhancing the practical experience of students as well as research.

The hostel facilities for the students have been improved with support from the Council, attracts talented students. Placement cells helps students to obtain placement or advice on career. Support from the Council was also provided to AUs to take necessary initiatives so as to encourage holistic development of students through sports, self-defence, yoga, personality development talks by eminent people, through workshops, coaching and counselling for clearing competitive exams on all India basis, etc. Overall personality development and leadership programmes with the support from the Council guides students to become better persons and to grow as an individual.

Hostel

Smart class room

Upgraded laboratories facilities

Upgradation of sports facilities

Support under Schedule Tribe Component (TSP)

A total of twenty four (24) AUs were supported during the periad. Several activities were conducted by the Agricultural universities, viz. Trainings (Capacity Building/Skill Development, Awareness camps, Exposure visits, Front Line Demonstrations (FLDs), other demonstrations. Input distribution in form of seeds, field crops, high value crops, spices, root and tuber crops, nursery plants, mushroom spawns/bio-fertilizers packets. Animals, poultry chicks/duckling, fish spawns/fingerlings equipment's, infrastructure/civil works/ponds were developed. Also, fertilizers (NPK)/secondary fertilizers, micronutrients, FYM/ vermicompost, plant protection chemicals, plant growth promoter, etc. were provided. Facilitation of animal feed and fodder, animal medicines doses, services/facilitation, animal health camps, testing samples of soil, plant, water, feed, fodder, and livestock, promotion of IFS, IOFS, natural farming, nutrigarden, kitchen garden and orchards was undertaken. Distribution of literature was also done for over 27,000 beneficiaries.

Support under Scheduled Caste Sub Plan (SCSP)

During the periad the support under SCSP component was provided to 23 AUs. The assistance provided under this component ensures flow of targeted benefits for Scheduled Castes in the identified clusters. Under this component total ₹1806.00 lakh was released to agricultural universities, located in 13 states during 2022-23. The support was provided for training and capacity building programme, viz. tutorials classes, personality development, and preparation of competitive exams, entrepreneurship development, awareness programmes and funds for providing printed books and access of e-books/ and other resources to the scheduled caste beneficiaries at college/university level.

Support under North Eastern Hill Region (NEH)

During this year, ICAR through its scheme of Agricultural Education Division also supported the AUs established in NEH Region for infrastructural development and also for new civil works with ₹2,601.00 lakh, inclueding three new girls hostels. Financial assistance for one girls hostel was provided to AAU, Assam, and for two girls hostels to CAU Imphal. Ten new smart classrooms were developed in various colleges of all the three AUs in NEH region. Undergraduate and Post graduate laboratories have been modernised/ upgraded and equipped with new equipments. Support was also provided for training and capacity building programs, viz. tutorial and competitive classes, holistic development of students, library strengthening with additional printed books, reference books, e-books, ICT tools and accessories and other logistics have helped in better learning and advancing research.

Coordination with AUs

'The Annual Conference of Vice Chancellors', Directors and Industries' was held during 4-5 March, 2023 to provide an opportunity to the Vice-Chancellors of AUs to interact and to develop strategy for effective

Evidence of attribution of NAHEP grants leading to project outcomes (till October, 2023)

S. N	Indicators	Unit of measure	Baseline (2016-17)	Achievement
1.	Increase in AU on time graduation rate	%	77	95.7
2.	Increase in student placement rates	%	41	61.0
3.	Reduced student inbreeding	%	19.2	25.3
4.	Reduced faculty inbreeding	%	45	54.5
5.	Improved AU revenue generation	%	8.5	13.2
6.	Accredited agricultural universities with revised norms and standards	Number	55	71
7.	Direct project beneficiaries	Number	-	4,98,101
8.	Female beneficiaries	%	-	43

functioning in order to maintain quality standards in higher agricultural education in the country as well as for effective implementation of the newer initiatives.

National Agricultural Higher Education Project (NAHEP)

The Indian Council of Agricultural Research (ICAR) launched the National Agricultural Higher Education Project (NAHEP) in November 2017 with support from the World Bank. The main goal was to provide better and more practical education to students in AUs. This program aimed to improve the effectiveness and competitiveness of agricultural universities by making changes in their operations, enhancing teaching and research quality through better infrastructure and more competent faculty, and making agricultural education more appealing to talented students. NAHEP has four main parts; the Institutional Development Plan (IDP), the Centers for Advanced Agricultural Sciences and Technology (CAAST), ICAR's support for Excellence in Agricultural Universities, and ICAR Innovation Grants (IG) to universities. The program's success is expected to result in improved performance of AUs, better employment and entrepreneurship opportunities for graduates, non-accredited universities gaining ICAR accreditation, and reforms in the education sector of ICAR and universities.

NAHEP is benefitting 76 institutions in the ICAR-AU System, including 63 state-level AUs, 4 DUs, 4 CUs with agricultural faculties, and 3 CAUs. The primary beneficiaries of the project are students and faculty who directly benefit from the IDP, CAAST, IG, and activities in Component 2. As of October 2023, NAHEP has awarded 62 Agricultural Universities, with 22 under the IDP, 16 under CAAST, and 24 under the IG in Component 1. Additionally, two ICAR institutes, namely, ICAR-Indian Agricultural Statistics Research Institute (IASRI) and ICAR-National Academy of Agricultural Research Management (NAARM), have been implementing Component 2 of NAHEP.

Component-wise achievements

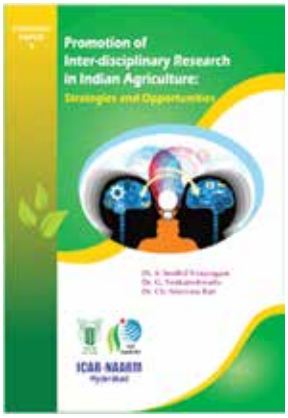
Under Institutional Development Programme (IDP) of NAHEP, ICAR awarded 22 sub-projects to Agricultural Universities (AUs) across the country to enhance the institutional and system management effectiveness. It also focused upon improving learning outcomes and enhancement in opportunities through raising the employability and entrepreneurial traits of students.

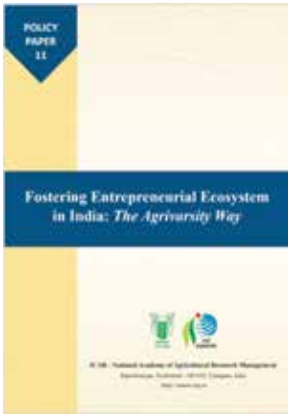
Very unique, innovative and next-gen amenities/ infrastructures, viz. Smart Class rooms/Virtual Class rooms, Digitalized Conference Halls, Acoustic studios, Geospatial Labs, Language Labs, Data Analytics Lab, Alumni Cell, Learning Assessment Centers (LAC), Placement cell, Counseling Cell, Industry Institute Interaction Cell, Sewage Treatment Plant, Rain Water Harvesting Structures, Up-graded Pilot Scale Dairy Plant and Central Instrumentation Facility, etc. have been created which have led the institutions to the new level of academic ambience.

The international trainings for faculty and students provided much-needed exposure and momentum under which 1,251 students and 613 faculty members have been benefitted across the different foreign countries at global level during the reporting period. A total of 23 Visiting Professors have visited in five Agricultural Universities (AUs), viz. RVSKVV, Gwalior; TNAU, Coimbatore; DUVASU, Mathura; SKUAST-Jammu and UHS, Bagalkot.

The project has made special efforts to enhance industry and start-up linkages and alumni connect across the universities and very significant outcomes have been achieved. To mention specifically, IDP-GBPUAT, Pantnagar organized Industry Startup Academia Interface with 40 industries providing paid-internship opportunity to 250 under graduate students and again organized National Start-up Conclave with 50 agri-startups interacting with 550 students to provide insights of entrepreneurship. Similar vibrant efforts like Hackathons, Alumni Workshops, Fund Mobilization, Vocational Trainings, Networking, Students' Job Placement, Waste to Wealth (W2W) transformation, etc. have come in many IDP centers across the country with significant impacts.

IDP has been successful in undertaking out-of-box initiatives for academic improvisation across the country. IDP-partner AUs have conducted 106 guest lecture series (7,000 beneficiaries) and 253 remedial course classes (3,000 beneficiaries) till date with remarkable impacts.





Multi-faceted efforts have been done for enhancing entrepreneurship skills. The educational technologies advents like the AR/VR gadgets and modules have been introduced. A seminal input is the E-content modules and Idea Labs in many universities. Among the 22 IDP-AUs Partners; GBPUAT, Pantnagar; and TNAU, Coimbatore showed their presence in world QS Ranking in Agriculture Category.

Under the CAAST component, 16 sub-projects have been awarded to AUs in 11 states across the country. Activities include strengthening teaching and research infrastructure, organizing Distinguished Lecture Series and Special Lectures to inspire students and faculty, conducting National and International training programs, and collaborating with the private sector to develop market-oriented programs. So far, 285 students and 152 faculty members have completed International training, and over 3,500 national-level training programs and seminars have been held to enhance students' scientific entrepreneurship and research effectiveness. Initiatives undertaken by CAAST partner universities include the development of climate-smart agriculture tools, innovative secondary agricultural technologies, and the establishment of innovative research labs.

The Innovation Grants (IG) projects have been awarded to select participating universities to help them achieve accreditation. Till date, 24 sub-projects have been awarded under this component. Key activities include national-level training for faculty enhancement, master's and Ph.D. sandwich programs, alumni connections, industry seminars, professional workshops, and e-enabled learning activities. It's noteworthy that, in the past four years, universities under the IG have achieved ICAR accreditation mainly due to support and interventions through NAHEP. A total of 47 faculty members from these institutions have completed International training.

The Component 2 aims to support ICAR in carrying out institutional reforms and enhancing its effectiveness in coordinating, guiding, and managing agricultural higher education in the country. Activities undertaken include strengthening key digital infrastructures within the ICAR-AU system, such as the establishment of virtual classrooms at AUs and the effective implementation of the Agri-DIKSHA web channel, which involves the development and upload of e-content by partner universities. Additionally, AR/VR labs have been established at ten partner universities, and the KVC-Alnet initiative has been launched and scaled up.

During the period, a strategic implementation plan was formulated for the phased rollout of blended learning platform (BLP) across 75 AUs and an exclusive single point of contact (SPoC) for BLP implementation. Over 60 SCROM compliant courses are currently in process of development under RAES. Concurrently, sensitisation workshops for Vice chancellors (83 participants), Deans and Directors (246 participants) and BLP SPoCs was carried out for better traction and co-ordination for capacity building.

Through-out the year, PIU NAHEP has also undertaken various initiatives to promote the overall program and its agenda at National level. Activities under '*Azadi Ka Amrut Mohatsav'*: 75-ICAR Lecture Series, International Conference on Blended Learning Ecosystem (ICBLE) 2023, Green and Clean Campus Award 22, KRITAGYA AgTech Hackathon 3.0 with specific focus on Speed Breeding for Crop improvement, Mainstreaming Agricultural Curriculum in School Education (MACE) 2022, etc. were successfully conducted during this period.

The major activities and achievements under the Monitoring and Evaluation includes updation and timely reporting of Results Framework Indicators, Knowledge Management, Learning and Documentation activities, developing Evaluation Plan in consultation with WB, Process Evaluation and Dipstick Surveys such as assessing the Graduate Income Index of one year graduate student from agri *vis-à-vis* non-agri background, assessment of the measurable intermediate outcomes, updation of AU Implementation Performance Scoreboard (AUIPS), related M and E advisories, Satisfaction Mapping of Direct Project Beneficiaries and organizing M and E visits to select AUs etc.

ICAR-National Academy of Agricultural Research Management (NAARM)

Research and Policy Advocacy: As a "Think Tank" of Indian Council of Agricultural Research (ICAR) in the field of agriculture, the Academy has contributed policy papers and strategy papers on Organic Farming in India, Fostering Entrepreneurial Ecosystem in India: The Agrivarsity Way and Promotion of Inter-disciplinary Research in Indian Agriculture. In the reporting year, 57 research papers, 9 book chapters, 1 popular article and 9 books were published. Three copy rights were filed and one was registered.

Training and capacity building: ICAR-NAARM organized 53 capacity building programmes benefitting about 3,941 participants to cater diverse capacity needs of professionals of Research Management, Scientific, Technical, and Administrative Cadres of ICAR and Agricultural Universities (AUs). Academy offers Foundation Courses for the newly recruited Agriculture Research Services and faculty of SAUs to improve teaching, research and extension competencies.

Academics: A total of 57 students for the 14th batch and 61 students for the 15th batch during October 2022-2023 joined PGDM-ABM programme of ICAR-NAARM, whereas, the 12th batch of PGDM-ABM got success in employment through campus placement with top agribusiness industries in India. The average package of this batch was ₹8.32 lakh per annum and the maximum was ₹12.56 lakh per annum secured by a female candidate. This year, PGDM-ABM programme of the Academy got the accreditation status after the visit of a three-member expert team from the National Board of Accreditation (NBA) to the Academy during 16th-18th December, 2022. The expert team appreciated the programme and expressed their satisfaction on the conduct of two-year residential programme.

Diploma in Technology Management in Agriculture (DTMA) and Diploma in Education Technology Management (DETM) are the other academic programmes offered by the Academy as one year distance education programmes in online mode. These programmes are being offered in collaboration with the University of Hyderabad (UoH). In these programmes, a total of 44 students took admission in 2022.

Foundation course for newly recruited faculty of Agriculture Universities (FOCFAU)

Foundation Course for newly recruited Agricultural Research Service Probationers (112 FOCARS)

Digital initiatives: Centre for Open and Lifelong Learning in Agriculture at NAARM has been organizing Massive Open Online Courses (MOOCs) in Education Management. Total 35 video modules of content have been developed for MOOC on Digital Teaching Techniques, MOOC on Digital Assessment and Evaluation Methodologies includes E-commerce, Bioinformatics and AI in Agriculture with interactivity. Academy has offered two MOOC programmes, benefitting about 3,870 learners across the country.

Start-ups and Agripreneurship: Association for Innovation Development of Entrepreneurship in Agriculture (a-IDEA) is one of the ICAR Agribusiness Incubator and Technology Business Incubator started in 2014 and still working on promoting startups and entrepreneur. The a-IDEA has organized various events for strengthening the start-up ecosystem and the ICAR-ABIC incubated six start-ups with the funding support from ICAR.

The NABARD also provided incubation support for 29 start-ups besides acceleration of 14 start-ups. The Aggnite 3.0 was organized to provide entrepreneurial spirit among the students and it provided financial support to three students. The flagship program of a-IDEA, i.e. AgriUdaan 5.0 was implemented by accelerating 14 start-ups and the start-ups raised the funds through pitching during the demo day on 28th April 2023 in presence of about 30 investors.

New initiatives, viz. Immersion program of start-ups and FPOs was organized at five locations where more than 300 FPOs and 25 start-ups participated to enhance the networking among each other. Two sensitization programs on Entrepreneurship Development for students of SAUs were organized covering 1,028 students.

The a-IDEA also supported 11 start-ups with the funding support of ₹50 lakhs each under BIRAC BIG and 10 start-ups with the funding support of ₹10 lakhs each under NIDHI PRAYAS. Sixteen startups were provided seed fund from the project of NABARD, DST and DBT.

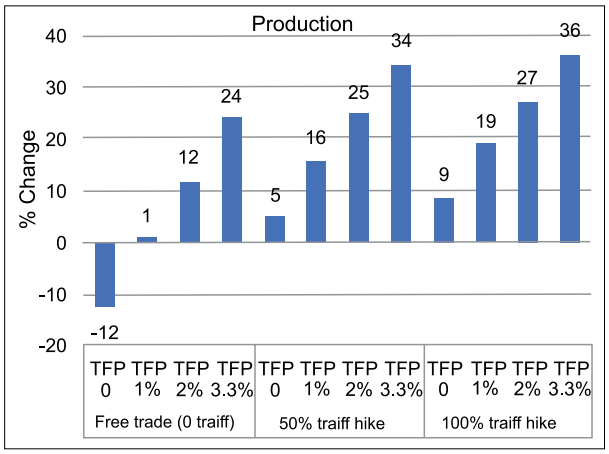
Memorandum of Understandings (MoU): In an effort to strengthen the Public-Private Partnership, ICAR-NAARM, Hyderabad signed a Memorandum of Understanding (MoU) with five private universities, viz. School of Agriculture Sciences, MRU, Hyderabad on 27 April, 2023; Bharatiya Engineering Science and Technology Innovation University (BESTIU), Gorantla, Andhra Pradesh on 17 July 2023; IES University, Bhopal, Madhya Pradesh on 31 July 2023; Sanskriti University, Mathura, Uttar Pradesh on 21 August 2023; and Vellore Institute of Technology, Vellore on 26 September 2023 to facilitate staff and student trainings and providing guidance in research work. These MoUs have been very important in the process of implementation of National Education Policy 2020.

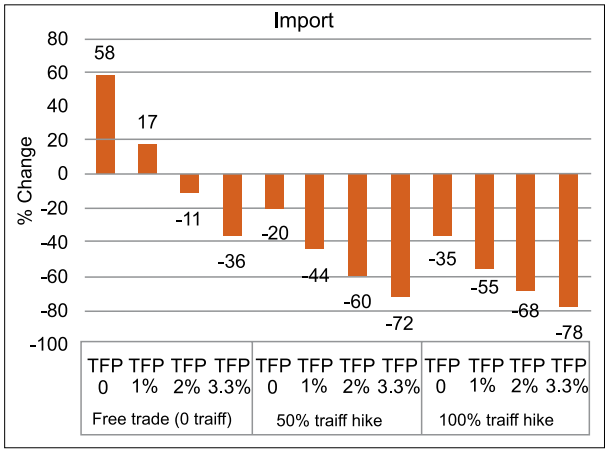
Memorandum of Association (MoA): The a-IDEA, ICAR-NAARM signed MoA with 63 ICAR Institutes and 10 other organizations like SAUs, Industries, Banks, etc. for providing support like co-incubation, co-events, technical mentoring and monitoring.

❑

14. Social Science

Technology and policy options for sustaining pulses production: The pulse production experienced a quantum jump from 16.32 million tonnes in 2015-16 to 23.13 million tonnes in 2016-17 and further to 25.42 million tonnes in 2017-18. Thereafter, stagnating for next three years, it increased to 27.5 million tonnes in 2022-23. The incremental production came from area expansion and yield improvements, leading to a signifcant reduction in imports. Neverthless, sustaining the momentum in pulses production requires a technological breakthrough and restriction on imports to incentivise farmers to produce more. The free trade, in the absence of the growth in total factor productvity (TFP), reduces pulses production. However, the acceleration in TFP growth even in the free trade regime leads to a continuous improvement in pulses production, and reduction in imports. The impact is much larger when acceleration in TFP growth is accompanied by an increase in import tariffs. For instance, if the TFP growth accelerates to 2% and import traiff is doubled, the pulses production is estimated to increase by 27% and the imports to decline by 68%.

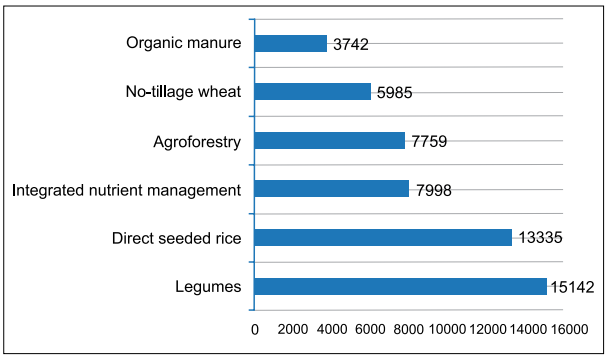




Impact of technology and import tariffs

Although the tariff or any trade measure can be an instrument to regulate pulses imports, it is the technology that will sustain growth in pulses production. The strategy to enhance pulses production should be built around bridging the yield gap, effecting a technological breakthrough, and adopting a crop-neutral price policy.

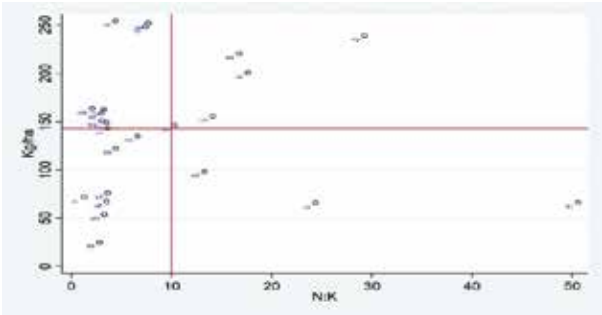
Economic valuation of ecosystem services from improved agricultural practices: Agriculture plays a multi-faceted role. Beyond its primary function of providing food, feed, fiber, and fuel, it provides ecosystem intangible services. These are non-tradable and hence, farmers remain uncompensated. A meta-analysis of some important sustainable agricultural practices, viz. direct seeded rice (DSR), no-tillage in wheat, incorporation of legumes in cropping system, organic manure, integrated nutrient management and agroforestry shows that these interventions produce several ecosystem services such as carbon sequestration, soil nutrient enhancement, biological nitrogen fixation, mitigation of greenhouse gas emissions, and water conservation. The monetary value of such non-tradable services is estimated quite large, ranging from ₹ 3,742 to ₹ 15,142 per ha, accounting for 34-77% of the total value of the ecosystem services, including the provisioning services. No-tillage, legumes, and integrated nutrient management produce win-win outcomes, while there is a trade-off between the tradable and non-tradable ecosystem services in case of others. Hence, to promote sustainable development of agriculture and conserve natural resources, there is a need to re-purpose current agricultural support, and evolve a system for payment for non-tradable ecosystem services.



Monetary value of non-tradable ecosystem services (₹/ha)

Enabling policies for sustainable use of fertilizers: Fertilizers have played a pivotal role in enhancing crop yields and food supplies in India. However, the fertilizer-use efficiency has remained low, forcing farmers to resort to their excessive application but with marginal gains in crop yields. Besides, their excessive and indiscriminate

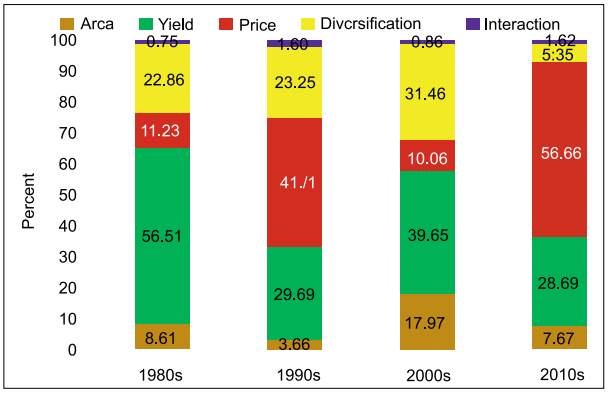
use has led to deterioration in the quality of land, water, and air. Furthermore, there is a huge fiscal burden of fertilizer subsidies in 2021-22, the Government of India has spent ₹140 crores towards fertilizer subsidy. There are considerable regional and inter-farm disparities in fertilizer use and also an imbalance in the use of different nutrients, viz. Nitrogen (N), Phosphorus (P), and Potash (K). Fertilizer use and nutrient imbalance is very high in favour of N, in the rice-wheat dominated Trans and Upper Indo-Gangetic plains. In contrast, fertilizer use is low in arid Rajasthan, but highly biased in favour of N. One of the reasons for excessive use of N is heavy subsidy on nitrogenous fertilizers. The nitrogen is estimated five times cheaper than potash.



Classification of states by nutrient use and imbalance. Note: AP-Andhra Pradesh, AS-Assam, BR-Bihar, CG-Chhattisgarh, GJ-Gujarat, HR-Haryana, HP- Himachal Pradesh, JH-Jharkhand, JK-Jammu & Kashmir, KA-Karnataka, KL-Kerala, MP-Madhya Pradesh, MH-Maharashtra, MN-Manipur, MZ-Mizoram, OR-Odisha, PB-Punjab, RJ-Rajasthan, TG-Telangana, TN-Tamil Nadu, TR-Tripura, UP-Uttar Pradesh, UK-Uttarakhand, WB-West Bengal.

The Government of India has taken several initiatives towards improving the nutrient use efficiency, and bringing a balance in nutrient use. This includes introduction of neem-coated urea, soil health based application of nutrients, natural farming, etc. Neem-coated urea has been found effective in improving nutrient-use efficiency. The recent announcement of PM-PRANAM (Programme for Restoration, Awareness, Nourishment, and Amelioration of Mother Earth) aims at promoting balanced use of chemical fertilizers, while creating awareness about regenerative agriculture. A new scheme of Green Credit has been launched to incentivise farmers for the adoption of sustainable agriculture practices. To achieve these objectives, the first step should be to identify the districts with high fertilizer use and unbalanced use of nutrients for targeting of different schemes. Further, there is also a need to correct distortions in nutrient prices artificially created by differential rates of subsidy for different nutrients. Additionally, fertilizer subsidies should be linked with the recommended application of different nutrients. There is also a need for investment in research to look for alternatives to chemical fertilizers. Finally, the existing fertilizer subsidy should be re-purposed to agronomic practices that generate ecosystem services beneficial for soil, water and environmental health.

Sources of growth in Indian agriculture: Understanding the sources of growth in agriculture is essential for devising strategies for sustainable and inclusive development of agriculture. Growth in agriculture may come from area expansion, crop diversification, price increases and technological change or yield improvements. Technology has been the main source of growth in Indian agriculture. Until recently, area re-allocation in favour of high-value crops have also contributed to growth. However, of late, price increases have emerged as the dominant source of growth. Price-driven growth cannot be sustainable growth in the long-run because of its inflationary pressure. The scope for bringing additional area under agriculture is also limited. Hence, the growth in agriculture in the long-run has to come from technological change and crop diversification. This suggests for more investment in agricultural research, and promotion of horticulture.



Sources of growth in Indian agriculture

What can substitute paddy– An economic perspective: Crop diversification is high on the policy agenda. The aim is to substitute water-guzzling paddy by other crops. Although there are several crops that technically can substitute paddy, but cannot because they are less remunerative as compared to paddy. Based on the economic criteria, i.e. the production costs and returns, the probability that paddy can be substituted by other crops (except horticultural crops) is extremely low in the Trans and Upper Gangetic plains. For example, in Haryana, the net returns from paddy are almost twice of that from cotton, and close to four times larger than that from pearl millet. Similarly, in Punjab the net returns from paddy are 25% more compared to cotton, and three times more than maize. Improving comparative advantage of alternative crops requires either significant improvement in their yields, or increase in their prices, or compensation to farmers for the revenue foregone from paddy. Nonetheless, there is a possibility of substituting paddy with jute in Assam, Bihar and West Bengal, maize in Bihar, Jharkhand and Tamil Nadu, cotton in Gujarat, Madhya Pradesh and Odisha, greengram in Bihar and West Bengal, pearl millet in Gujarat, tur and groundnut in Uttar Pradesh, and finger millet in Uttarakhand. Notably, the alternative crops have their own production niches and cannot be grown in all types of agro-ecologies.

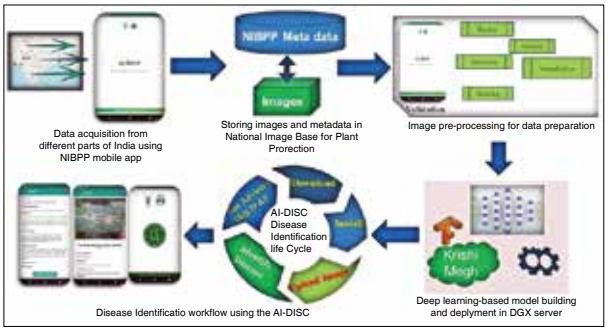
Hence, to promote diversification away from paddy, the need for crop planning with due consideration to economics of alternative crops at a granular level cannot be undermined.

Artificial intelligence based android mobile application: An Artificial Intelligence (AI) based android mobile application, called AI-DISC (Artificial Intelligence Based Disease Identification for Crops at https://play.google.com/store/apps/details?id= com.ai.ai_disc) has been developed that can automatically identify plant diseases with visible symptoms. User has to install the mobile app, capture the disease image in natural background and click to identify and get the remedy/advisory of the diseases. Presently the application is capable of identifying 50 diseases in 19 major crops (Rice, Wheat, Maize, Tomato, Mustard, Cotton, Brinjal, Apple, Peach, Kinnow, Mandarin, Assam Lemon, Chickpea, Green gram, Cluster bean, Moth bean, Chilli, Coriander, etc.) once the image in natural background is uploaded.

KCC-CHAKSHU (Kisan Call Centre-Collated Historically Aggregated Knowledge based System using Hypertext User Interface): KCC-CHAKSHU has been developed to provide insights and alerts based on 35 million+ queries call logs records with the 11 attributes received from KCC data (available through APIs on the open data platform).

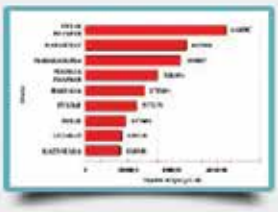
AgrIntel: A framework consisting of multiple artificial intelligence-based pipelines has been developed to process nationwide farmers' helpline data and to obtain spatio-temporal insights on plant protection.

e-LISS portal and mobile app: end-to-end solution for major livestock products: An android-based application-eLISS data collection app has been developed and made

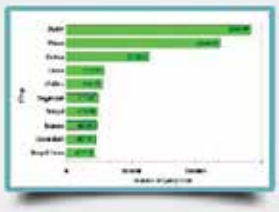


Artificial Intelligence Based Disease Identification for Crops (AI-DISC) App

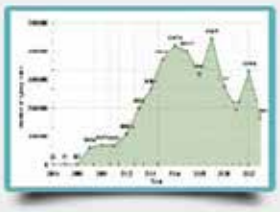
Kisan Call Center Insights



State-wise insights
From the dataset, it is noticed that the farmers from the states of Uttar Pradesh, Maharashtra, and Rajasthan asked the most questions in the past few years. Whereas, farmers from Nagaland, Arunachal Pradesh, and Mizoram have asked the minimum number at questions (Study period January 2006 to July 2022).

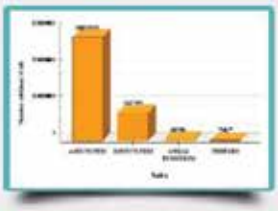


Crop-wise insights
It is noted that farmers from all over India asked most questions regarding the crops of Paddy (Dhan), Wheat, Cotton (Kapas), Chilies Onion, Brinjal, Sugarcane (Noble Cane), Tomato, Bengal Gram (Gram/Chick/Pea/Kabuli/Chana), and Groundnut (peanut/mung phalli). (Study period January 2006 to July 2022).

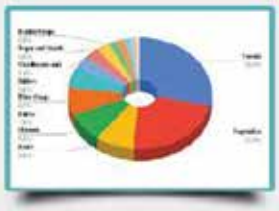


Year-wise insights
From the dataset, it is observed that the order of years with the increasing number of queries can be given as 2022, 2013, 2021, 2014, 2020, 2018, 2015, 2017, 2016, and 2019 (Study period January 2006 to July 2022).

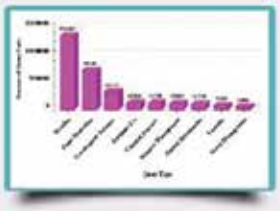
Month-wise insights
The order of months with the increasing number of query calls in the dataset is noted to be: May, February, November, April, December, January, March, June, October, August, July, and September. Therefore, it is observed that the highest number at query calls received is in the months of July, August, September, and October (Study period January 2006 to July 2022).



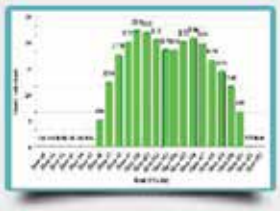
Sector-wise insights
After separating the dataset based on the sectors, it is noted that the most queries are received from the agriculture sector, whereas, Horticulture is in second place, followed by Animal Husbandry and Fisheries. The complete list of sectors along with the number at queries.



Category-wise insights
The farmers from all over India are observed to have asked queries regarding the following the most: Cereals, Vegetables, Fruits, Oilseeds, and Pulses, Moreover, the table containing the categories along with the corresponding number at queries in the



Query type-wise insights
The types of queries asked by the Indian farmers the most include Weather, Plant Protection, Government Schemes, Cultural Practices, Nutrient Management, Fertilizer Use, and Availability, Market Information, Varieties, Weed Management and Seeds. The complete



Hours-wise insights
From the collected data, it was observed that the peak hours before the afternoon is 9:00-11:00 am, and in the evening it is of hours along with the number of queries corresponding to them is given here (Study period March 2013 to

available on google play store to capture data from the field, which was used to be collected manually using paper-based schedules by the enumerators, to provide an end-to-end solution of estimating production for four major livestock commodities, viz. milk, meat, egg and wool. It is being widely used Pan India by Department of Animal Husbandry and Dairying, Government of India. The significant output of the study is that the ISS scheme under which voluminous data was being collected for entire India has now resulted into a paradigm shift from paper based survey to digital platform, which is fully functional across the country and huge volume of unit level data for all major livestock commodities and animals is now available on e-LISS portal through e-LISS app ensuring quality data. Twenty-two thousand (22,000) enumerators, 8,000+ supervisors and 730 district nodal officers, surveyed, 33,000 commercial poultry farms, 752 slaughter houses for 56,000 villages/ urban wards with 80 lakhs households/enterprises.

KISAN SARATHI (System of Agri-information Resources Auto-transmission and Technology Hub Interface): To implement an intelligent on-line platform for supporting agriculture, Kisan SARATHI is being implemented and strengthened in association with Digital India Corporation, Ministry of Electronic and Communication Technology (MEITy), Government of India. The services of Kisan Sarathi are available to all the States and UTs since June, 2022. This is an on call advisory services for farmers of India, where any farmer can call or record their query in his own language automatically directed to respective KVK/ATARI for query redressal. The queries are being responded in the same language by the concerned KVK either online or by call later on based on the recorder queries of the farmer. This platform supports multilingual messaging system where bulk or individual SMS can be sent to group of farmers based on the location of the crops they grow. This system provides the services through IVR based service on toll free number, i.e. 1800-123-2175 and a short number 14,426 to the farmers of all states. Presently, services of Kisan SARATHI are being provided by more than 3,000 agriculture experts from 731 KVKs across the country to more than 52 lakhs registered farmers which covered more than 1.48 lakhs villages. Till now more than 1.20 lakh calls have been made by the farmers to Kisan SARATHI, in which most of the calls have been resolved. Agricultural advisories have also been sent from time to time to the farmers through KVKs from Kisan SARATHI and so far more than 2.5 crore agricultural advisories have been sent through SMS.

KVK portal (Krishi Vigyan Kendra Knowledge Network): The portal has been strengthened by adding new functionality to add information on yield gap index and to view state and district wise report in the portal. Functionality have also been developed to view the month wise progress report (MPR) for the particular year in the portal. The report is added under the MPR menu at the KVKs level. Information of new KVKs and event category have been added in the master database tables. Month-wise KVK KPIs data is submitted in DARPAN dashboard for the following KPIs: Farmers Training, Mobile Agro Advisories and Agriculture Extension Activities. The data is also being shared with Kisan SUVIDHA App.

E-Learning portal

has been developed with an objective to strengthen the Agriculture Higher Education in India by developing and disseminating the e-courses for undergraduate and postgraduate courses. At present e-contents for 70 postgraduate and 141 undergraduate courses are available on this portal.

Experimental data repository: Developed the following information systems: (i) AICRP on Chickpea; (ii) AICRP on Pig and (iii) AICRP on Pigeon pea. Information System for AICRP on Weed Management was launched during XXX Annual Review Meeting of AICRP on Weed Management held at SKUAST-J Jammu during 26-27 May, 2023. Also strengthened the information system on ACIRP on Vegetable Crops by adding analysis module.

Infographics Dashboard of KRISHI Portal has been enriched by adding the following (i) Details of IPR design database; and (ii) Institutes, present NAAS Score.

ICAR geo-portal: Updated/Uploaded daily layers of (i) All India crops residue burning points for the period are regularly being depicted on India map by ICAR-IARI, New Delhi since 1 June, 2019 (latest depiction of points 15 October, 2023); (ii) Crop residue burning (Wheat) depicted on India Map latest by 30 May, 2023 and (iii) Paddy residue burning in five states till 15 October, 2023 in association with ICAR-IARI, New Delhi.

Area Production and Yield Information System: Website of Area Production and Yield Information System has been developed with the facility of selection-based search (like season, crop, state district). This website has separated specific search pages which contain filters like season, crop, state, district and from year-to-year. These filters work individually and in combination as per users requirement.

Virtual Reality (VR): Virtual reality facilities have been established in all Agricultural Universities. The virtual reality modules that have been developed are Phenomics facility, pusa farm sun fridge; protected cultivation technologies, hydroponics, fish dissection and anatomy; artificial insemination; paddy straw collector cum chopper; tractor simulation; Uterine torsion in Buffalo and Cattle; Nematology-Study of Nematodes, Assisted reproductive technologies (OPU-IVF and cloning) in dairy animals, advanced irrigation methods and technologies to improve water use efficiency, histo-biochemical and molecular studies in drought/salinity stress in sugarcane during various growth stages and

seed life cycle–genesis, science, seed parts.

Knowledge management system for DUS characteristics of crops: A web based knowledge management system for DUS characteristics of crops has been developed for implementation of functionalities followed in PPV&FRA and DUS Centers. Demonstration of the system was provided to the Registrar General, PPV&FRA. Meetings were conducted with the NIC team regarding data exchange through API and APIs were exchanged with NIC.

ASmiR (Abiotic stress responsive miRNA prediction in plants): An online production server 'ASmir', which is a machine learning–based computational model for prediction of miRNAs associated with four specific abiotic stresses such as cold, drought, heat and salt have been developed. The proposed generalized computational model and the developed prediction tool are expected to supplement the existing efforts for identification of specific abiotic stress-responsive miRNAs in plants.

ASLncR (A Novel Computational Tool for Abiotic Stress Responsive Long Non-coding RNAs Prediction in Plants): Abiotic stresses have played a significant role in limiting crop yield and productivity. Long non-coding RNAs (lncRNAs) serve a key part across multiple abiotic stress responses. Thus, identifying abiotic stress-responsive lncRNAs is vital in crop breeding programs in order to develop abiotic stress-resistant cultivars. ICAR-IASRI developed a machine learning-based computational model for predicting abiotic stress responsive lncRNAs. To develop this generalised model, the datasets covered 114 different plant species. The five-fold cross-validation accuracy, area under the receiver operating characteristic (AU-ROC), and area under the precision-recall curve (AU-PRC) were found to be 68.84%, 72.78%, and 75.86%, respectively. Further, the robustness of the developed model was evaluated using an independent test dataset, where the overall accuracy of AU-ROC and AU-PRC were found to be 76.23, 87.71 and 88.49 percentage, respectively. For easy accessibility, the developed computational approach "ASLncR" was established as an online prediction tool available at https://iasri-sg.icar.gov.in/aslncr/. "ASLncR" is applicable to cereals, pulses, oilseed, vegetables, fruits and commercial crops and can contribute to the development of abiotic stress resistance improved crop varieties.

RBPLight: A Computational Tool for RNA-Binding Protein Prediction in plants: Developed a machine learning-based computational tool for identification of plant specific RNA-binding proteins (RBPs). Five deep learning models and 10 shallow learning algorithms were utilised for prediction. Despite the fact that certain models have already been trained and assessed on the model organism *Arabidopsis*, this is the first comprehensive computational model for the discovery of plant-specific RBPs. The web server RBPLight was also developed, which is publicly accessible at https://iasri-sg.icar.gov.in/rbplight/, for the convenience of researchers to identify RBPs in plants.

SVM-Root: Developed a machine learning-based computational model SVM-Root for computational identification of root-associated proteins in plants. The support vector machine has been used as prediction algorithms by employing amino acid composition, di-peptide composition and composition-transition-distribution features of protein sequences.

Yield-Spike Seg Net-An extension of spike seg net deep-learning approach for the yield estimation in the wheat using visual images: High-throughput plant phenotyping integrated with computer vision is an emerging topic in the domain of non-destructive and non-invasive plant breeding. Analysis of the emerging grain spikes and the grain weight or yield estimation in the wheat plant for a huge number of genotypes in a non-destructive way has achieved significant research attention. A deep learning approach, "Yield-Spike Seg Net," has been developed for the yield estimation in the wheat plant using visual images. This approach consists of two consecutive modules: "Spike detection module" and "Yield estimation module." The spike detection module is implemented using a deep encoder-decoder network for spike segmentation and output of this module is spike area and spike count. In yield estimation module, machine learning models have been developed using artificial neural network and support vector regression for the yield estimation in the wheat plant. The spike segmentation and yield estimation performance reflect that the Yield Spike Seg Net approach is a significant step forward in the domain of high-throughput and nondestructive wheat phenotyping.

Nearly balanced treatment incomplete block designs (BTIB): In several experimental situations, the experimenter may be interested to compare a set of new treatments called test treatments with one established treatment called control. Often there may be a nuisance factor that needs to be taken care of during experimentation. Balanced Treatment Incomplete

Food Loss Index (FLI)

Food Loss Index (FLI) for India and food loss percentage under the project entitled "Study on reviewing the Food Loss Index (FLI) estimates for India was compiled. The assessment report for inclusion of the SDG Indicator 12.3.1 in the National Indicator Framework of India" funded by Food and Agriculture Organization of the United Nations (FAO), Rome through FAO-India using the FAO methodology and the data generated through three post-harvest losses surveys conducted during 2005-07, 2012-14 and 2020-21 was prepared. The statistics has been calculated using 12 commodities as per procedure of FAO and all the 45 commodities were common to all the three surveys. Stepwise and year wise decrement method has been suggested for imputing the index during intervening years. Moreover, some suggestions of weighting the imported quantities only for storage losses has been suggested.

Financial assistance management system for conference and journals (FAMSCG)

FAMSCJ is an online workflow-based system managing for financial grants given by ICAR to scientific societies for: (a) organizing national/international conferences/ seminars/symposia; (b) publication of scientific journals, online application, approval process and tracking of application's status by ICAR officials. The key-features of FAMSCJ are: (i) online financial assistance application (proposal) process, (ii) online application assessment process; (iii) online tracking of application's status; (iv) automatic sanction letter generation process; (v) downloading of sanction letter by concerned Society and (vi) online submission of report by concerned society. FAMSCJ has been developed in collaboration with technical Coordination Unit of ICAR. The System was launched by Honorable Secretary DARE and Director General ICAR on 1 January, 2023.

Block (BTIB) designs are quite popular for comparing test versus a single control treatment. The class of BTIB designs has been extended by introducing nearly BTIB designs. Nearly BTIB designs can act as a useful alternative to BTIB designs when the latter is not available for a given parametric combination. An algorithm is proposed to construct nearly BTIB designs and a list of such designs is also provided in a practically useful parametric range.

Two-part structurally incomplete designs: Two-part designs are helpful in selecting the best possible components in Integrated Farming System (IFS). They involve two groups of treatment arranged in incomplete blocks with respect to both groups, and the concurrence of treatment pairs within and between groups is constant. The fusion of two in complete block designs in a systematic manner can yield two-part designs. Further, for situations where certain experimental units are not available, two part structurally incomplete designs are obtained.

Rotatable mixed-level response surface designs: Under response surface model for mixed level factors of the form $2^n \times 3$, where experimental units experience the overlap effects from immediate left and right neighbouring unit's conditions have been derived for the orthogonal estimation of the parameters. A method of constructing rotatable mixed-level response surface designs of the form $2^n \times 3$ has been proposed. The method has been extended to the case of mixed-level rotatable designs of the form $2^n \times 3^n$. Further the work has been extended to $s_1^{n_1} \times s_2^{n_2}$.

Resolvable PBIB designs for multi-site varietal trials: Method of construction for a class of resolvable PBIB designs suitable for multi-site varietal trials has been developed and is based on newly defined four-associate class association scheme named as Dichotomized Split-Set (DiSS) association scheme.

Trend resistant balanced bipartite block designs (BBPB): Methods of construction for trend resistant designs are developed that are useful when the interest of the experimenter is in making comparisons between two disjoint sets of treatments, in the presence of systematic trend within a block.

Rescaling bootstrap technique for variance estimation in dual frame surveys: Multiple frames (MF) are preferably used when it is difficult to obtain a single sampling frame that covers the whole population. Dual frame (DF) surveys are a special case of MF surveys considering two frames covering the entire population. Unbiased variance estimation for estimation of various population parameters is difficult and complicated for multiple frame surveys as compared to sample from single frame. Therefore, three different rescaled unbiased variance estimation procedures for estimation of variance of population total unbiasedly under different cases of dual frame surveys namely, (i) Stratified Rescaling Bootstrap with Known Domain size (StRBKD), (ii) Post-stratified Rescaling Bootstrap with Known Domain size (PstRBKD) and (iii) Post-stratified Rescaling Bootstrap with Unknown Domain size (PstRBUD) methods have been developed.

R-Packages: Developed following 10 R-Packages (basically open-source programming codes that can be used by common users for performing specific statistical computations/procedures):

Polycross Designs: This package contains a function named PD which generates nine types of polycross designs suitable for various experimental situations. (https://CRAN.R-project.org/package= Polycross Designs)

PBt Designs: Partially Balanced t-Designs (https://cran.r-project.org/package=PBtDesigns)

Mixed Level RSDs: Mixed Level Response Surface Designs. (https://cran.r-project.org/web/packages/MixedLevelRSDs/index.html)

GETdesigns: Generalized Extended Triangular Designs. (https://CRAN.R-project.org/package=GETdesigns)

ResPBIBD: Resolvable Partially Balanced Incomplete Block Designs (PBIBDs). (https://CRAN.R-project.org/package=ResPBIBD**)**

slr: Semi-Latin Rectangles-A facility to generate balanced and partially balanced semi-Latin rectangles with cell size two. An R package *slr* has been developed to implement the proposed methods of constructions of balanced and partially balanced semi-Latin rectangles. The package is available on CRAN in the webpage https://CRAN.R-project.org/package=slr. It comes with two main functions namely *bslr(v)* and *pbslr(v)* which can be used for constructioning balanced SLR and a partially balanced SLR, respectively, for given number of treatments (*v*).

Tri.Hierarchical.IBDs: Tri- Hierarchical Incomplete Block Designs: It generates tri-hierarchical designs with six component designs under certain parameter restrictions. (Available at: https://CRAN.R-project.org/package=Tri.Hierarchical.IBDs).

TSSVM Time Series Forecasting using SVM Model:

(https://cran.r-project.org/web/packages/TSSVM/index.html).

ARIMAANN: Time Series Forecasting using ARIMA-ANN Hybrid Model. (https://CRAN.R-project.org/package=ARIMAANN).

ABSurvTDC: Survival Analysis using Time Dependent Covariate for Animal Breeding. (https://cran.r-project.org/web/packages/ABSurvTDC/index.html)

Biological databases/webservers/web resources developed: Following 08 Biological Databases/Web-Servers have been developed:

Microsatellite based Horse Breed Prediction: Webserver for breed identification using microsatellite DNA markers.(http://backlin.cabgrid.res.in/horse/)

Equine CNVs database (EqCNVdb): Web genomic resource created to provide data on identified CNVs in six equine breeds. (http://backlin.cabgrid.res.in/eqcnvdb/)

Bp2SSRdb: Black pepper polymorphic SSR database. (http://backlin.cabgrid.res.in/bp2ssrdb/index.php)

BpVarDB: Database for polymorphic variants (SNP/InDels) of black pepper extracted among 39 genotypes of black pepper found across India. (http://backlin.cabgrid.res.in/bpvardb/index.php)

AVR-AgDb: A web resources for Antiviral Agricultural crop produce for post COVID-19 world. (http://backlin.cabgrid.res.in/avragdb/).

CCncRNAdb: A web-based database called CCncRNAdb for common carp ncRNAs. (http://backlin.cabgrid.res.in/ccncrnadb/)

plantpathoppi-ml: A python package to predict protein-protein interaction between plants and pathogens based on ensemble-based machine learning model. (https://pypi.org/project/plantpathoppi-ml/)

Nut Trait Database: This database contains information about genes and gene families that directly or indirectly govern nutritional traits like mineral transportation and accumulation, vitamin biosynthesis and essential amino acid biosynthesis in field crops and flowering plants. (http://backlin.cabgrid.res.in/nutritrait/)

Institute received **eighteen Copyrights** and **sixteen Technologies-Certifications** were approved by the Headquarters.

Empowering women in agriculture

The ICAR-Central Institute for Women in Agriculture (ICAR-CIWA) is dedicated exclusively to research concerning women in agriculture. ICAR-CIWA envisions itself as a leading center for gender-focused research, acting as a catalyst for gender mainstreaming and the empowerment of women in agriculture. The institute's overarching goal is to enhance agricultural productivity and sustainability. To fulfill its mission, ICAR-CIWA is actively engaged in a range of research projects addressing gender issues in agriculture and related fields. Operating across 12 states in India, in collaboration with 13 State Agricultural Universities, as AICRP on Women in Agriculture. ICAR-CIWA seeks to empower women in agriculture. Additionally an AICRP centre on Ergonomics and Safety in Agriculture (ESA) also operates at the Institute. The institute's achievements during this period are as follows:

Participation and contribution of women in agriculture: A detailed analysis of the Time Use Study (TUS 2019) in India was conducted to understand the state-wise participation, time allocation, and contributions of men and women in agriculture and related activities. The findings of revealed significant gender disparities in rural areas. In rural India, the study found that 22.4%

Copyright received by ICAR-IASRI during October-2022 to October-2023 (Eighteen number)

S. N.	Title name	Diary no.	Registration no.	Received date in IASRI
1.	BrassicaSatDb: Brassica Microsatellite Database	26753/2021-CO/SW	SW-15347/2022	07/12/2022
2.	SmCarTDB: Small Cardamom Transcriptome Database	26756/2021-CO/SW	SW-15348/2022	07/12/2022
3.	Online generation of Incomplete Block Design	20424/2021-CO/SW	SW-15545/2022	07/12/2022
4.	Online generation of Orthogonal and Nested Orthogonal Latin Hypercube Designs	20436/2021-CO/SW	SW-15546/2022	07/12/2022
5.	VISTa app: Variety Identifying System for *triticum aestivum* (wheat) mobile application	15428/2022-CO/SW	SW-16057/2023	15/03/2023
6.	WBMSTDb: Water Buffalo Mastitis Database	15410/2022-CO/SW	SW-16058/2023	15/03/2023
7.	DARE-ICAR Foreign Visit Management System	20422/2021-CO/SW	SW-15526/2022	19/05/2023
8.	Online construction and analysis of Incomplete Split Plot Designs	20417/2021-CO/SW	SW-15337/2022	19/05/2023
9.	ICAR - Personnel Management System (PMS)	20429/2021-CO/SW	SW-15338/2022	19/05/2023
10.	TpGBNVDb: Thrips Palmi Transcriptome database in response to groundnut bud Necrosis virus	15425/2022-CO/SW	SW-16146/2023	19/05/2023
11.	BuffGR: Buffalo Genomic Resource	15412/2022-CO/SW	SW-16116/2023	19/05/2023
12.	ICAR Education Portal 1.0	20431/2022-CO/SW	SW-15339/2022	19/05/2023
13.	Agricultural Universities Ranking System – AURS	26747/2021-CO/SW	SW-17092/2023	13/09/2023
14.	Krishi Vigyan Kendra Knowledge Network Portal - KVK Portal	26749/2021-CO/SW	SW-17093/2023	13/09/2023
15.	Millet SSR Database	26755/2021-CO/SW	SW-17090/2023	13/09/2023
16.	BlackP2MSATDb: Black Pepper Polymorphic Microsatellite Database	15418/2022-CO/SW	SW-16210/2023	13/09/2023
17.	BPDRTDb: Black Pepper Drought Transcriptome Database	15422/2022-CO/SW	SW-16204/2023	13/09/2023
18.	Clusterbean SNPs and INDELs Repository (CbSIR)	8116/2023-CO/SW	SW-16175/2023	13/09/2023

ICAR-IASRI Technologies certified by ICAR in July 2023

S. N.	Name of the Technologies/Products	Developers	
		Lead	Associates
1.	Krishi Vigyan Kendra Knowledge Network Portal (KVK Portal) and KVK Mobile App. (2022)	Dr. Alka Arora	Dr. Sudeep Marwaha, Dr. A.K.Chaubey, Dr. S.N.Islam, Dr. Soumen Pal, Dr. Ajit, Dr. Rajnjit Kumar Paul, Dr. Sanchita Naha, Dr P. Adhiguru
2.	AI-DISC (Artificial Intelligence based Disease Identification Systems for Crops). (2022)	Dr. Sudeep Marwaha	Dr. R.C.Agrawal, Dr. Rajender Parsad, Dr. Ramasubramanian V., Dr. Alka Arora, Dr. Anshu Bharadwaj, Dr. Ajit, Dr. Shashi Dahiya, Dr. S.N. Islam, Dr. Chandan Kumar Deb, Dr. Md. Ashraful Haque, Dr. Sapna Nigam, Dr. Mrinmoy Ray, Dr. Achal Lama, Dr. Soumen Pal, Dr. Rajni Jain, Dr. Sujay Rakshit, Dr. P. Lakshmi Soujanya, Dr. Sumit Kumar Aggarwal, Dr. K.S. Hooda, Dr. Brejesh Lall, Dr. Lokesh Gupta, Dr. Kalpit Dipakkumar Shah, Dr. Prasannakumar MK, Dr. V. S. Acharya, Dr. Abhishek Shukla, Dr. Ladhu Ram Choudhary, Dr. Palash Deb Nath, Dr. Shubha Trivedi, Dr. Mehraj D Shah, Dr. Ravinder Singh Rana, Dr. Subrata Dutta, Dr. Vaibhav Kumar Singh.
3.	End-to-End solution: e Livestock Integrated Sample Survey (e-LISS) Web Portal and App. (2021)	Dr. Prachi Misra Sahoo	Dr. Tauqueer Ahmad, Dr. Anil Rai, Dr. Ankur Biswas, Mr. Chirag Vasudev
4.	Prediction server for discovery of DNA and RNA-binding proteins in plant. (2022)	Dr. Upendra Kumar Pradhan	Dr. Prabina Kumar Meher, Dr.Sanchita Naha, Dr. Ajit, Dr. Soumen Pal, Dr. Rajender Parsad
5.	ICAR-Technology Repository Ver 1.0 and ICAR Technologies Mobile App. (2021)	Dr. Rajender Parsad	Dr. Appavoo Dhandapani, Dr. Mukesh Kumar, Dr. Anshu Bharadwaj
6.	KCC-CHAKSHU: Collated Historically Aggregated Knowledge-based system with Hypertext User-interface (2022)	Mr. Samarth Godara	Dr. Madhu, Dr. Sanchita Naha, Dr. J.P.S Dabas, Dr. Rajender Parsad, Dr. Sudeep, Dr. R.S.Bana, Dr. Raju Kumar, Dr. Gograj Singh Jat, Dr. Abimanyu Jhajhria, Dr. Shashi Dahiya, Dr. Anshu Bharadwaj, Dr. Deepak Singh , Dr. Shbana Begam, Dr. Jatin Bedi,
7.	Prediction server for discovery of abiotic stress-responsive non-coding RNAs. (2022)	Dr. Prabina Kumar Meher	Dr. Upendra Kumar Pradhan, Dr. Sanchita Naha, Dr. Atmakuri Ramakrishna Rao, Dr. Ajit, Dr. Soumen Pal
8	Prediction server for multiple localisation of coding and non-coding RNAs. (2021)	Dr. Prabina Kumar Meher	Dr Atmakuri Ramakrishna Rao
9.	Web Generation of Generalized Row-Column designs (webGRC). (2022)	Dr. Anindita Datta	Dr. Seema Jaggi, Dr. Cini Varghese, Dr. Eldho Varghese, Dr. Arpan Bhowmik, Dr. Mohd Harun
10.	Sampling methodology for agriculture census. (2021)	Dr. Tauqueer Ahmad	Dr. Prachi Misra Sahoo, Dr. Anil Rai, Dr. Ankur Biswas
11.	Sampling methodologies for food loss measurement in horticultural crops, livestock and fish. (2020)	Dr. Tauqueer Ahmad	Dr. Anil Rai, Dr. Prachi Misra Sahoo, Dr. Ankur Biswas
12.	Web enabled phytochemical knowledge-based system for crop protection. (2021)	Dr. Sukanta Dash	Dr. Anupama Singh, Dr. Anil Kumar, Dr. Anirban Datta, Dr. Suman Manna, Dr. Abhishek Mandal, Dr. Rajesh Kumar, Dr. Aditi Kundu, Dr. Neeraj Patanjali, Dr. R Roy Burman, Dr. Supradip Saha, Dr. G A Rajanna, Dr. V. Shanmugam, Dr. Ramesh K Yadav, Dr. Bhagyashri S
13.	Software for identification of circadian genes in plants. (2021)	Dr. Prabina Kumar Meher	Dr. Tanmaya Kumar Sahu
14.	An information system to support therapeutic management of foot and mouth disease of cattle. (2021)	Dr. Tanmaya Kumar Sahu	Dr Prabina Kumar Meher, Dr. Atmakuri Ramakrishna Rao
15.	Abiotic stress-responsive genes, gene ontology and metabolic pathways of major cereal crops. (2020)	Mr. Sanjeev Kumar	Dr. Anil Rai, Dr. K.K Chaturvedi, Dr. S.B Lal Dr. Md. Samir farooqi, Dr. D.C Mishra, Dr. Jyotika Bhati, Dr. Arijit Saha, Dr. Pankaj Kumar Pandey, Dr. Anuj Kumar
16.	Web application for trait specific gene selection. (2021)	Dr. Md. Samir Farooqi	Dr. D.C.Mishra, Dr. K.K.Chaturvedi, Dr. Sudhir Srivastava

of women aged 6 and above are engaged in agriculture and allied activities, which encompasses both crop and livestock sectors. On an average, women dedicate 233 min. per day to these activities. In contrast, 34.6% of men aged 6 and above participate in these activities, devoting an average of 330 min. per day to them. Consequently, the agricultural workforce consists of 38.7% women and 61.3% men. To assess the contributions of men and women in agriculture, participation rates were projected to the overall population, and the resulting figures were multiplied by the daily time spent. Notably, in Uttarakhand, women's contributions were found to surpass those of men in both the crop and livestock sectors. On the other hand, Lakshadweep exhibited the lowest women's participation in agriculture, with only 6.3%, followed by Bihar at 13.2% and West Bengal at 13.2%. This information underscores the need for targeted interventions to promote gender equality in

the agricultural sector. The evaluation of livestock schemes revealed that there is a need to address the gender biasness in veterinary education, research and service delivery systems to upgrade the efficacy of women-oriented livestock development programmes. Subsidies-specific programmes to integrate farm women dairy entrepreneurs, cooperatives, etc. are required to be included in the different schemes to realize the goal of women empowerment in the sector. While evaluating the role of organised dairy sector on livelihood of women, major milk marketing channels were identified for the small holder women dairy farmers.

Gender-sensitive agri-nutrition: In the pursuit of entrepreneurship development, a significant milestone was achieved by establishing five successful small-scale poultry production units in the Nimapara block of Puri District, Odisha. In the goatery sector, strategic linkages were forged with three Farmer Producer Organizations (FPOs), Taradevi Farmer's Producer Company Limited in Jajpur, Maheera Farmer's Producer Company Limited in Khordha, and Manikstu Agro Private Limited in Kalahandi. These partnerships were established with the aim of improving the livelihoods of farm women. Furthermore, a Women Farmer Interest Group known as "Omm Sai" was established, and a Common Facility Centre (CFC) equipped with processing equipment was set up in Kanamana village, Astaranga. In another entrepreneurial endeavour, a Self-Help Group (SHG) formed by women in Sorana village, located in the Chilika block of Khordha district, launched 'ChilkaFoodline' and established a linkage with the Falcon Chilka Group for marketing their products.

Farm women mobilization and empowerment through Custom Hiring Centres

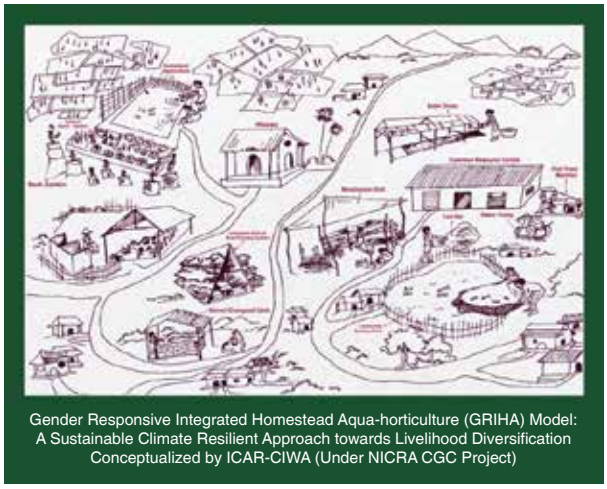
In the Puri district of Odisha, a Custom Hiring Centre focusing on Spice Processing has been established using a Multi Agency Participatory Model, with the primary goal of improving the livelihoods of women farmers. In the Nimapara block under Puri district, the 'Bhargabi Women Mushroom Producer Federation' has been created, comprising 631 farm women from 47 Women Self-Help Groups (WSHGs) across 22 villages in six Panchayats. This initiative, driven by a gender-sensitive approach, has brought about a significant transformation in the livelihoods of these women. Each group is now earning ₹ 2.40 lakh within one month, with a profit of ₹ 1.53 lakh through mushroom farming. To further diversify their livelihoods, women are also being introduced to alternative options like poultry farming.

Value added fish products prepared by SHGs

A Gender-Sensitive Agri-Nutri Farming System Model (G-SAN Model): This model was developed by identifying and addressing existing gender disparities through the use of specific technologies. These technologies include high-protein paddy, nutrient-rich vegetables, and improved feeding practices. The G-SAN Model has demonstrated a significant positive impact on various socio-technical and economic aspects, particularly in the realm of women's empowerment. To enhance the efficiency of agricultural operations, Women Self-Help Group (SHG)-based Custom Hiring Centers (CHC) and Farmers' Interest Groups (Ananya Mahila Bikas Samiti) were established. Development of nutrismart villages through participation of rural women has been conceptualised. This project entails the implementation of technological solutions to bridge nutritional gaps in 10 villages, benefiting 300 farming families across four districts in Odisha (Puri, Khorda, Cuttack, and Jagatsingpur). The primary goal is to raise awareness about nutrition and combat malnutrition by promoting homestead agriculture and the establishment of nutri-gardens. Three distinctive modules have been formulated as part of this endeavour: the Livelihood Enhancement Model, the Nutritional Security Model, and the Entrepreneurship Promotion Model. These modules have not only generated profits but have also created awareness among the farm women for cluster based production to bring equity, promote entrepreneurship and realisation of empowerment of farm women in agriculture.

Gender responsive climate-resilient agriculture: A concept on Gender Responsive Integrated Homestead Aqua-horticulture (GRIHA) has been developed as a sustainable climate resilient approach towards livelihood diversification. GRIHA emphasises the utilisation of available family resources to enhance nutritional security amidst changing climatic conditions. This concept also emphasises the formation of women's federations into Farmer Interest Groups, which enhances their capacity to manage homestead aqua-horticulture production and collectively cope with the challenges posed by a changing climate.

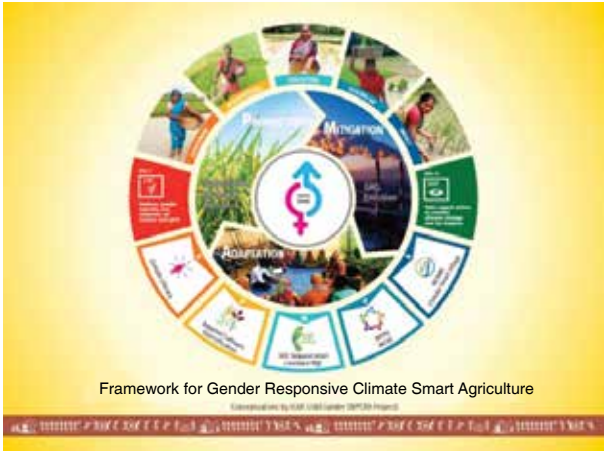
Under the theme of Climate-Resilient Agriculture, a range of women-friendly Climate-Smart Agriculture Technologies (CSAT) and practices have been demonstrated in 27 villages, spread across seven Minor Irrigation Projects (MIPs) in three blocks of Keonjhar, Odisha. These technological interventions have had a profound impact, empowering women by increasing their control over assets, promoting participation in decision-making, enhancing knowledge, altering behavior and attitudes, raising awareness, improving economic status, and advancing food security and nutrition.



Gender Responsive Integrated Homestead Aqua-horticulture (GRIHA) Model: A Sustainable Climate Resilient Approach towards Livelihood Diversification Conceptualized by ICAR-CIWA (Under NICRA CGC Project)

Integrated Vertical Nutri-Farming System (IVNFS) model

IVNFS model was formulated to cultivate nutritious vegetables alongside mushroom or poultry farming, ensuring year-round dietary diversity for rural households. Within this model, the combination of vegetables and mushrooms yields 80 kg of vegetables and 50 kg of mushrooms annually. Similarly, the combination of vegetables and poultry provides 80 kg of vegetables, along with 2016 eggs, 35 kg of meat, and 125 kg of litter per year. The technology was licensed to industry.



Framework for Gender Responsive Climate Smart Agriculture

All India Coordinated Research Project (AICRP) on Women in Agriculture

Under AICRP on Women in Agriculture, a database on the role of women in agriculture in three selected zones, viz. AEZ 4-Hot semi-arid eco-region with alluvium-derived soils (PAU centre), AEZ 7-hot semi-arid eco-region with red and black soils (PJTSAU centre) and AEZ 8-Hot semi-arid ecoregion with red loamy soils (TNAU centre) was developed. The database consisted of women's participation in agriculture, horticulture, forestry, livestock and dairy farming. The assessment of livelihood pattern of farm women revealed that the livelihood security levels were either low or moderate. With respect to entrepreneurial development, Paddy production was the major crop based enterprise for around 85.2% of respondent farmers from AEZ 7. In the AEZ 8, women farmers were involved in diversified livelihood activities like coir making, milk retailer and sericulture. However, manufacturing was the most preferred enterprise among women in AEZ 4. Lack of proficiency/competence was deduced as the basic constraint for enterprise development. Two technologies, i.e. finger guards (Nakhalya) and digging tool developed by Department of Family Resource Management, VNMKV, Parbhani and Punjab Agricultural University were tested and validated to identify the gaps in drudgery reduction. Integrated Pest Management (IPM), Integrated Nutrient Management (INM), mushroom cultivation, bee keeping, dairy, livestock, vermicompost, fodder cafeteria drudgery reducing technologies etc. were identified as some of the areas where women needed technological backstopping. Study on the impact of climate revealed both negative and positive changes such as increased incidence of wildlife attack, increased incidence of diseases, insect pests in crops and increased adoption of intercropping, off season cultivation of vegetables and adoption of mulching to reduce soil evaporation, respectively. ❑

15.
Basic and Strategic Research

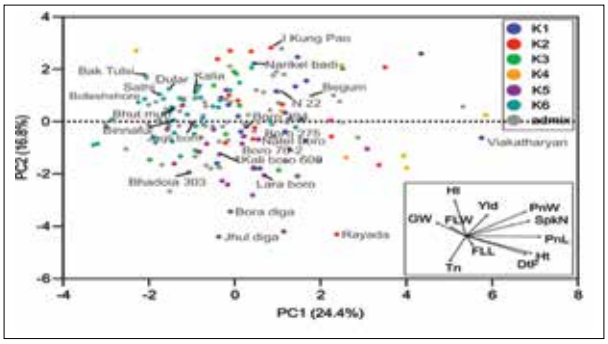
The National Agricultural Science Fund (NASF) supports for carrying out the research in the field of agriculture primarily for basic and strategic research along with Translational Research, Extramural Grant and International Collaboration for Research and Scientific Validation of Farmers' Innovations. The main objective of the NASF has been to build capacity for basic, strategic and cutting-edge application research in agriculture and address issues which can be solved by intensive basic and strategic research jointly by team of organisations/institutions. Out of the 62 projects currently in operation, 60 are multi-institutional in nature. NASF has also funded four projects on the theme of "Scientific Utilisation through Research Augmentation-Prime Products/Panchagavya from Indigenous Cows (SUTRA-PIC)". During the reporting period NASF has approved 12 new projects on novel aspects of application of CRISPR/Cas9, Artificial Intelligence, Sensors, Robotic Vehicles, Solar Powered Mover in the field of agriculture, etc. In addition, NASF also focused on other aspects like Agripreneuship for sustainable agricultural development, AI enabled Weather and Marketing Information-Based System, Labour Migration in marine fisheries sector, vertical farming and development of smart food.

NASF also invited the pre-proposals for new research projects for Call X under seven strategic areas, viz. Biotechnology, Genomics and Allele Mining in plants, animals and fisheries; Abiotic and Biotic Stresses and Quality Traits in plants, animals and fisheries; Nanotechnology in agriculture; Metabolomics in agriculture; Precision agriculture and Management of natural resources and Application of Sensors in crops, animals and fisheries; Farm Mechanization and Energy; Social Sciences and Policy in agriculture. Total number of 737 pre-proposals have been received under these strategic areas. The pre-proposals are under the process of evaluation and the shortlisted pre-proposals will be invited for full project proposals.

Salient Achievements

During 2022-23, NASF led to more than 55 research publications in reputed journals, in addition to filing of two patents and development of eight technologies. The research highlights of some selected projects are as follows:

Exploring *aus* rice for drought, submergence and phosphorus starvation tolerance, mining superior alleles and deciphering mechanism of tolerance: Under drought, submergence, and phosphorus starvation, phenotyping of 181 *aus* rice (of 3,000 Rice Genome Project) accessions was conducted. Population genetic analysis of the 181 *aus* germplasm revealed six subpopulations (*K*=1 to 6). The *boro* and *aus* seasonal ecotypes exhibited higher genetic similarity, while the group of Rayada cultivars from Bangladesh and *aus* accessions in central India, Sri Lanka, and other countries outside the Indian subcontinent were genetically distinct. A strong correlation between genetic and agro-morphological diversity was observed. Early maturing upland *aus* cultivars were clearly differentiated from *boro* and deep-water ecotypes. Genome-wide association studies (GWAS) conducted using phenotyping data for agro-morphological and stress tolerance traits identified numerous genes related to these traits. For yield and related traits, the GWAS analysis identified *LOC_Os01g48960* (also known as *OsNADH-GOGAT1* or *GLT1)*, annotated as *Glutamate synthase* or *NADH-dependent glutamate synthase 1*. Three haplotypes of this gene were found within *aus*, with Hap-2 present in 72% of the accessions. Hap-1 was represented by accessions from India, Bangladesh, and Sri Lanka, while Hap-3 was predominantly from Bangladesh and adjoining Assam, suggesting uniqueness to deep-water tall accessions. The stress-specific GWAS results were promising, revealing hits with previously reported genes and some potential new ones, such as *LOC_Os05g35480.1* (*Phosphor-ribosyl transferase*) and *LOC_Os07g08140.1* (transcription factor) for stomatal density under severe drought conditions. Potential genes identified for grain yield under low P were *Ospho1* (Chr2) involved in translocation of phosphate from root to shoot and *OsSPX1* (Chr6) controlling phosphorus homeostasis in rice.



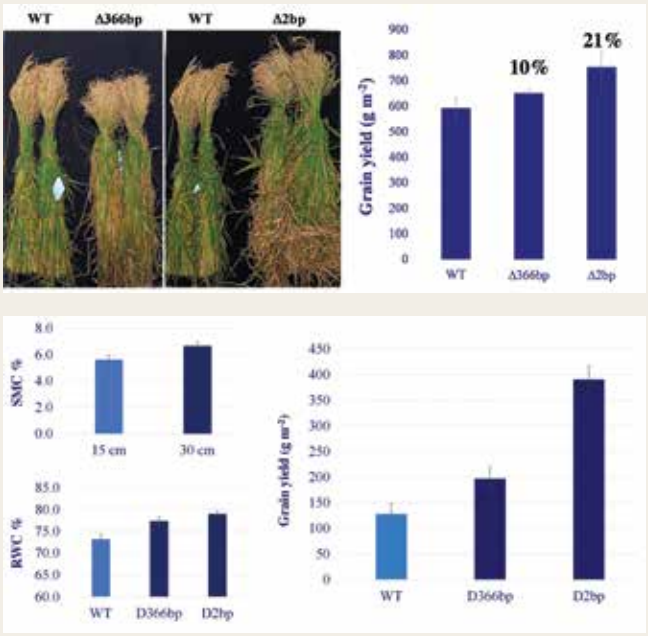
PCA biplot showing the grouping of 181 *aus* germplasm based on 11 agro-morphological traits. The loadings of the traits are shown in the set.

Fine mapping and marker-assisted breeding for alternative dwarfing genes *Rht14* and *Rht18* to develop semi dwarf wheat genotype suitable for conservation agriculture: The fine mapping was carried out to understand the molecular mechanism of alternative dwarfism in wheat. The *Rht18* region is delimited to

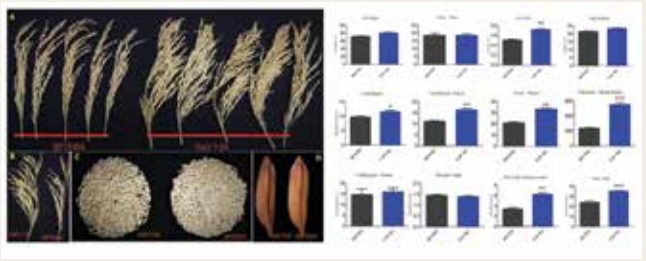
CRISPR Crop Network for targeted improvement of stress tolerance, nutritional quality and yield of crops by using Genome Editing

Gene editing with CRISPR-Cas9 technology was employed to develop mutants of the *DST* (Drought and Salt Tolerance) gene, a zinc finger transcription factor in rice cultivar MTU 1010. Five different mutants were generated, and from this and two SDN1 type mutants free from introduced exogenous DNA were identified. As per DBT, standard operating procedures (SOPs) for regulatory review of genome edited plants under SDN-1 and SDN-2 categories, data were generated. These two mutants identified produced significantly higher grain yield in summer 2023 under transgenic field condition in irrigated environment. Two mutants of *DST* gene free from exogenous introduced DNA are being evaluated in AICRIP.

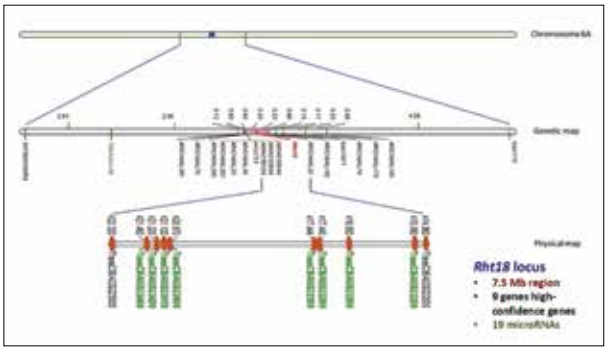
High yielding *CKX2* mutant lines of rice cultivar BPT 5204 (Samba Mahsuri) was developed earlier. Further molecular analysis led to the identification of one homozygous and transgene free edited line named as GeD7-26. Under transgenic network conditions, the GeD7-26 showed significant increase (>35%) in grain yield as compared to BPT 5204 (WT). The required molecular/physiological/morphological data has been generated. The mutants of *CKX2* gene free from exogenous introduced DNA are being evaluated in AICRIP. Thus, the *DST* and *CKX2* mutants are the first set of genome edited mutant lines that have been exempted from Rules 7-11 of Rules 1989 (noted in 259th RCGM on 31st May, 2023 and are evaluated under AICRIP.



Grain yield of *DST* gene edited mutants (D366 bp and D2 bp) produce significantly higher grain yield than WT MTU 1010 under irrigated (*top panel*) and drought stress (*bottom panel*) conditions



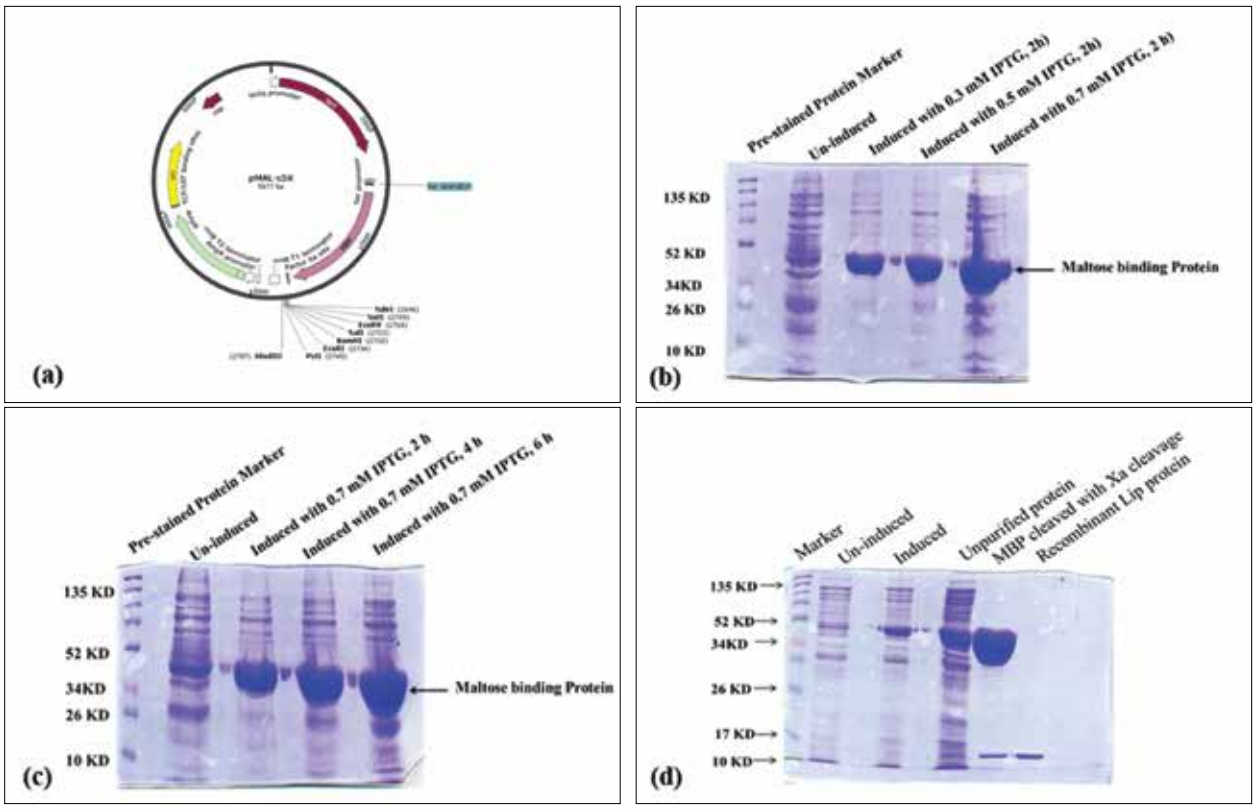
7.5 Mbp with closest SSR marker at 0.23 cM. Three new KASP SNP markers were developed for faster selection of *Rht18* in breeding lines. InDels and SNPs were identified as the potential candidate genes in *Rht18* locus, which was further used to confirm the candidate gene. The fine mapping studies provided the precise map position of important alternative dwarfing loci *Rht14* and *Rht18* in wheat. The closely linked markers are available for their deployment in wheat breeding programs. About 24 differentially expressed genes from *Rht18* and *Rht14* region were identified at two stem elongation stages. The RNAseq and the qRT-PCR results showed a significant correlation (r^2=0.82, P<0.01) between the methods. The data suggests that the results obtained by the RNAseq experiment are in agreement with qPCR, and hence considered reliable. Six miRNA with differential expression in dwarf phenotype were identified. BC_3F_4 seeds carrying alternative dwarfing genes *Rht14* and *Rht18* were obtained in the background of HD 2967, HD 3086, HI 1544 and HI 1500 by marker-assisted backcross breeding. Lines with improved coleoptile length, seedling shoot length, plant height and resistance to leaf and stripe rust were identified. These results provided advanced wheat breeding lines with alternative dwarfing genes and better seedling



Fine mapping of *Rht18* loci in durum wheat using SNP and SSR markers

establishment traits suitable for conservation agriculture.

Identification and cloning of putative genes involved in rancidity of pearl millet flour: To identify the putative genes and reconstruct the pathway linked with flour rancidity, de novo transcriptome sequencing of landraces (Damodhar Bajri and Chadhi Bajri), hybrid (Pusa 1201) and composite (PC-701) were carried out. After annotation and based on domain search analysis, five lipases and two lipoxygenases were identified and cloned. The expression analysis of *TAG-lipase* showed maximum relative fold expression during mealy-ripe

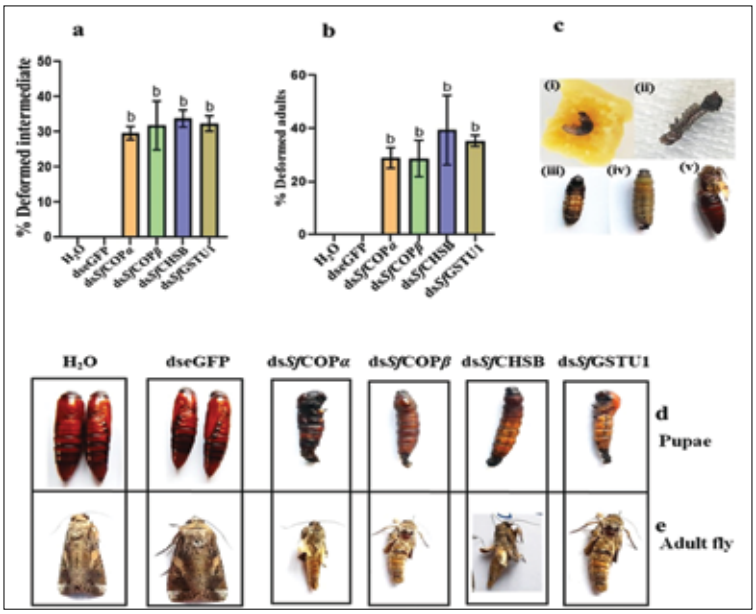


Heterologous expression of TAG-Lipase gene in *E. coli* system for the purification of recombinant protein. a) pMal c5X vector; b) induction of *E. coli* cells using IPTG; c) induced MBP with lipase protein; d) purified recombinant lipase protein.

stage of endosperm development in diverse genotypes of pearl millet. Similar pattern was observed in case of *lipoxygenase* (*LOX and LOX-6*) genes. A direct correlation was observed between the expression and activities of *lipase* and *lipoxygenase* in endosperm tissue of pearl millet. The open reading frame of putative *TAG-Lipase* gene cloned from Pusa 1201 was further mobilised in pMal c5X expression vector and was expressed by inducing with 0.8 mM IPTG. The *E. coli* cells were harvested and further recombinant lipase protein of ~14 kDa was purified using anion exchange column and ultra amicon column.

Marker assisted stacking of yellow mosaic disease resistance, null kunitz trypsin inhibitor, null *lipoxygenase-2* genes, and broadening the genetic base of soybean: Based on the multilocation evaluation of 322 germplasm accessions and zonal check varieties, diverse parents were identified for hybridization programme under AICRP on soybean. For different agroclimatic zones, hybridizations between the adapted variety of the zone and the diverse germplasm identified based on the D^2 analysis were conducted. A set of 250 inter-specific RILs of soybean (F_{10}) developed at IARI, New Delhi, were grown during *kharif* 2022. Data for all the DUS characters including yield and resistance to YMD were collected from all the lines. Wide variations were observed among the RILs for the traits studied. Several lines with a higher number of pods per plant, yield and resistance to yellow mosaic virus have been identified for crossing. Ten (10) accessions of landrace (*Glycine max*) and 2 accessions of wild-type soybean (*Glycine soja*) including 4 HYVs were collected and multiplied. About 200 F_1 seeds for various cross combinations were harvested and grown. Hybridity testing confirmed 90 true F_1 plants.

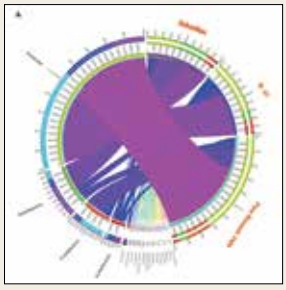
Development of sustainable management tools for the invasive pest, fall armyworm *Spodoptera frugiperda* in maize: A survey was done for the identification of genomic regions for FAW resistance, a parental polymorphism was done using 531 sequence-tagged microsatellites (STMS) markers between DMRE63 and BML6 and it was found that 155 (29.2%) markers were polymorphic, and out of 155 markers, 23 STMS markers could differentiate resistant and susceptible bulks against FAW and these markers were used for the screening of the 217 $F_{2:3}$ (DMRE63 × BML6) mapping population developed. Genotyping of the F_2 mapping population with all the identified putative markers was completed. To identify the genomic regions in the association mapping population, 300 lines were subjected to phenotypic screening as well as GBS sequencing. Association analysis of both the data led to the identification of 9 SNPs which are significantly linked to FAW resistance. RNAi-mediated resistance to FAW was explored using the genes, *SfCOPα*, *SfCOPβ*, *SfCHSB,* and *SfGST* as RNAi targets, as they play a critical role in *S. frugiperda* growth and development. The target genes' efficacy was tested *in planta* via soaking maize leaves in various dsRNAs solutions. The dsRNA-soaked maize leaves resist *S.*



Effect of target genes dsRNA on different developmental stages of *S. frugiperda*

Rice rhizosphere metabolome and microbiome functions for improved crop establishment, growth and yield

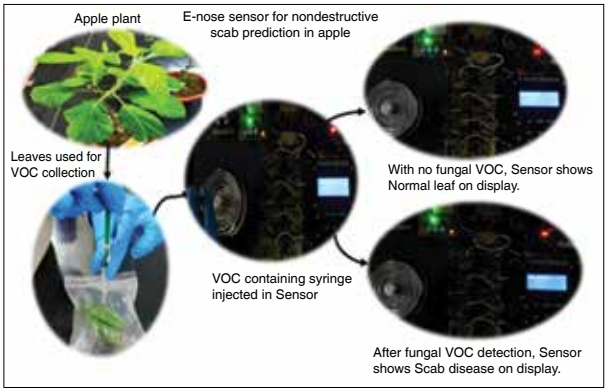
The metabolite profiling of seed exudates showed distinct differences among the genotypes tested (cv. Pusa Basmati 1509, cv. R-43, and cv. Sulendhas). The seed microbial diversity differed in these three contrasting rice genotypes, illustrated by the group-specific q-PCR assays, and metatranscriptomic analyses. The number of *Bacterial* 16S rRNA gene copies in cv. R-43 was significantly higher than other genotypes. The predominant endophytic bacterial morphotypes were isolated and purified from seed husks and grains of different rice cultivars. From a total of 144 isolates, 45 isolates that exhibited an equal or more than 5 bonitur values were chosen for characterising their environment adaptive functional traits. The metabolite profiles of rice rhizosphere under puddled-transplanted and dry direct-seeded experiments showed clear distinctions between the control and modified nitrogen environments by hierarchical clustering. Unique and common microbial genera involved in carbon (13), nitrogen (150), iron (63), phosphorus (33), and sulfur (231) cycles were analysed from the transcriptionally active members in the rhizosphere. In addition, the rice rhizosphere metabolites at seedling stage (15 days) were profiled to identify several sugars, amino acids, organic acids, and other metabolites along with unknowns. In another study, the rhizosphere microbial diversity of the scented rice (cv. Kunkuni Joha), characterised using amplicon sequencing analysis, showed that the relative abundance of microbial groups in aerobic and saturated conditions differed distinctly in response to low N and high N doses.



Relative abundance of top microbial phyla, equal or higher than 0.05% in at least one of the genotypes of rice seeds were plotted, var. Pusa Basmati 1509, var. Sulendhas and var. R-43

frugiperda feeding and enhance cannibalism in the larvae and thus, the novel target genes were identified as biopesticides for *S. frugiperda* management via a non-transgenic approach.

A comparative metabolomics approach for the analysis of scab-disease resistance in apple and development of a metabolite-based non-invasive sensor for early scab-disease diagnosis: The metabolic reprogramming in root tissues of scab-resistant (Prima) and scab-susceptible (Red Delicious) apple cultivars was carried out after being infected by *Venturia inaequalis*. Syringic acid, a root-derived metabolite, was identified as a key player in reducing scab fungus growth on aerial parts of plants, revealing a long-distance signalling system between shoot and root. Application of methyl jasmonate (MeJA) for inducing resistance in apple plants was investigated. Exogenous application of MeJA on leaf surfaces showed increased membrane stability and decreased malondialdehyde levels in the scab-susceptible Red Delicious, indicating its potential in protecting against

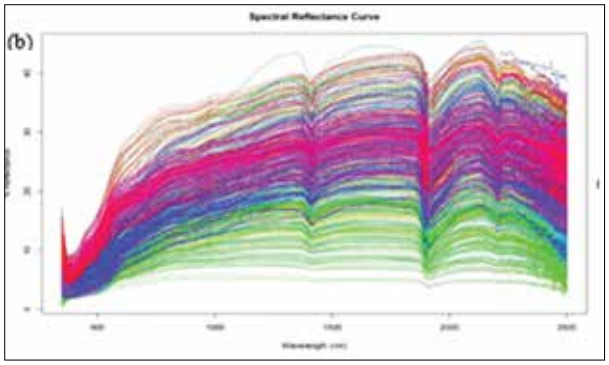


oxidative damage. A volatile biomarker(s) was identified for the screening of scab resistant apple germplasm at early stage non-destructively. Based on the biomarker(s) an e-nose sensor prototype for the early non-destructive screening of scab resistance germplasm was developed.

Identification and validation of newer approaches for the management of whitefly: To manage the pest whitefly, *Bemisia tabaci,* RNAi silencing mediated control was adopted. Twenty-four genes were selected for dsRNA mediated gene silencing for adult mortality, of which 4 genes (*Chitin synthase*, *vATPAseE*, *Sucrase* and *ECR*) with mortality of more than 85% were carried forward for the preparation of dsRNA nano formulation. Three different charge groups of nanoparticles (NPs) (chitosan, gelatin and silica gel) were used as a delivery system of dsRNA molecules for RNAi through oral delivery. The NPs-hydrogel was prepared and dsRNA with different ratios of NPs hydrogel was loaded in the nano-hydrogel and mortality of the nano formulation was assessed through parafilm feeding. The results showed

that the whitefly mortality rates were significantly increased with increasing concentrations at varied time points, whereas a maximum mortality rate of ≥80% was obtained around 70 at 72 h. Oral administration of hydrogel/dsRNA mixture reduced mRNA expression levels when compared to untreated control, and two dsRNA nano formulation *Chitin synthase* (ICAR-NBAIR) and ECR (ICAR-IIHR) were further selected for validation and field assessment at other co-operative centers of IARI, New Delhi and PAU, Ludhiana. A novel attractant trap (a sticky trap with a lure) developed by ICAR-IARI showed improved attraction efficiency of 102.88, 123.17 and 66.16% over control, respectively in mint, brinjal and cotton crops. Evaluation of the VOCs for repellence and oviposition deterrence showed 74.6 and 69.1% repellence in cage and net-house (semi-field) bioassays, respectively. These compounds were also found to be effective as ovipositional deterrents showing oviposition reduction of 67.2 and 64.4% and reduction in hatching to the tune of 76.6 and 74.1%, respectively.

Hyperspectral reflectance and multi-nutrient extractant based rapid assessment of soil properties for sustainable soil health in India: Optimal sampling design was developed to collect samples representing different agro-ecological sub regions (AESRs) of India by using conditioned Latin hypercube sampling (cLHS) approach. The sampling locations of 3,410 within India representing different AESRs, soil types, landforms, terrain features, etc. were indentified. Results from descriptive analysis revealed a wide variation in soil properties, i.e. *p*H ranged from 9.3 to 9.6, EC ranged from 0.01 dS/m to 1.94 dS/m, SOC content ranged from 0.02 to 3.78%, available N content ranged from 80 to 596 kg/ha, available P content ranged from 0.99 to 124 kg/ha and available K content ranged from 36 to 1198 kg/ha. Similarly, DTPA extractable Zn, Fe, Mn and Cu content in soil samples varied from 0.11 to 13.6, 1.39 to 57.0, 1.94 to 118 and 0.16 to 9.13 mg/kg, respectively. Hyperspectral signatures of collected soil samples (n=628) from different AESRs were measured using spectroradiometer facility. Variation in spectral signatures of collected soil samples was observed. Overall height of the spectra, absorption features of the spectra and slope of the spectra at different spectral regions depend on the inherent composition of soil and thus these spectral signatures act as a proxy for different soil properties.



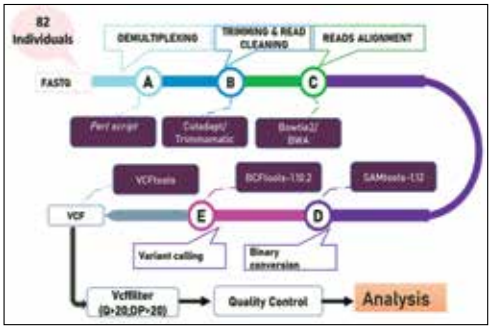
Hyperspectral signatures of soil samples collected from different agro-ecological sub-regions of India.

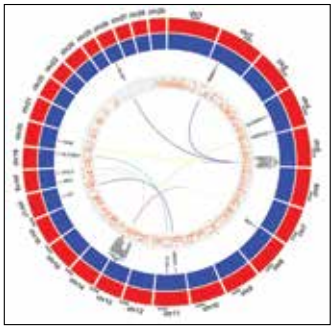
Risk assessment of nanoparticles accumulation in soils, effects of metal oxide nanoparticles on soil bacterial communities, soil microbial processes and evaluation of phytotoxicity using Genomic approaches: It was observed that ZnO spiked acidic and alkaline soil showed decrease in critical microbial endpoints (soil enzymes, microbial biomass -C, -N and -P and soil respiration) at highest level of 3,000 mg/kg. In SiO_2 and CaO, all parameters, except soil respiration and biomass carbon decreased at 4000 mg/kg. The threshold of ZnO toxicity on beneficial microorganisms (*Bacillus safensis, Raoultella terrigena*, *Acinetobacter* spp., *Bacillus amyloliquefaciens* and *Trichoderma asperellum*) varied depending on the bacteria. Changes in colony morphology, growth reduction and population reduction were observed at levels greater than 10 mg/kg. The threshold level of NP toxicity to rice plant (var. Swarna) was identified. Higher concentrations of the metal oxides had adverse effect on the growth of rice. Transcriptome analysis of rice grains indicated up regulation of stress response genes, viz. *pentatricopeptide repeat proteins*, *heavy metal transport/detoxification protein* and *glycoside hydrolase*. Heavy metals differentially affected the expression of dominant starch synthesis genes namely *ADP-glucose pyrophosphorylase* and *granule-bound starch synthase*.

Paddy straw residues management through *in-situ* microbial decomposition with mechanical interventions: Microbial consortium package has been standardized for *in situ* decomposition of paddy straw, application of either 2.0 kg solid or 10 numbers of capsule based NRRI microbial consortium per ha along with different additives was found efficient in decomposition of paddy straw under field condition. There was 38-41% and 31-35% degradation of paddy straw (in terms of C:N ratio reduction) was achieved in microbial consortium treatment after 21-25 days under Cuttack and Haryana conditions, respectively as compared to without microbial culture application. In all the three locations (NRRI, PAU and HAU), there was 4.0-9.0% increase in crop yield (rice-rice at Cuttack and rice-wheat during *rabi*) at Punjab and Haryana) in microbial consortium applied treatments (NRRI microbial consortium or Pusa decomposer) as compared to conventional practice. The GHGs emissions, i.e. methane and nitrous oxide flux from rice fields were measured during the *rabi* season at NRRI, Cuttack indicated that the order of emissions was; residue incorporation > residue retention > conventional tillage > zero tillage. An integrated seeder cum microbial inoculum applicator machine was developed for *in situ* rice-residues management. The technology facilitates cutting of rice residue, decomposing microbial culture application, residue incorporation and seeding in one go. The average straw size reduced to 12.78 cm after field operation.

Farmer-led extension strategy for enhancing farmers' income through millets-based farming system in hilly and tribal areas: About 10 farmer leaders "Millet Farmer Facilitators" (MFFs) were identified (5 each) in Koraput, Odisha and Kolli Hills, Tamil Nadu. Socio-economic status of millet farmers in hilly and tribal area of Koraput, Odisha and Kolli hills, Tamil Nadu was found to be poor. Millets were part of their farming and diet system and perceived that millets were economically viable and culturally acceptable. However, lack of assured price in market and severe crops damage by wild animals and birds were major problems faced by them. Decision making process was dominated by male farmers and there is need to empower women for more participation. Total 10 millet producer groups (MPGs) of farmers were formed under leadership of each MFF for millets promotion. Performance of interventions implemented through MFFs was found to be significant in terms of yield, net returns and knowledge enhancement over the base year. Diversified millets and allied farming interventions like improved millet production technologies, dairy farming and bee keeping were found to be profitable. One android app, "Millet Market" was developed for facilitating marketing of millets and to provide advisory on improved millets.

Identification of Unique Signatures of selective sweeps in indigenous dairy cattle breeds: About 82 samples of Sahiwal cattle were genotyped using by sequencing (72 own data+10 online data) subjected to quality filtering and the sequence reads were aligned to the *Bos taurus* reference genome assembly (ARS-UCD1.3) for variant calling, employing a range of bioinformatics tools. Several parameters were calculated to evaluate the genetic diversity within the Sahiwal population. Subsequently, a total of 146 regions were identified as undergoing selective sweeps. These regions were associated with improved immune systems and disease resistance (IFNL3, IRF8, BLK), as well as production traits (NRXN1, PLCE1, GHR). The gene interleukin 2 (IL2) located on Chr17: 35217075-35223276 was identified as being linked to tick resistance. Additionally, a cluster of genes (*HSPA8*, *UBASH3B*, *ADAMTS18*, *CRTAM*) associated with heat stress was observed. For Tharparkar cattle, several candidate genes that have undergone positive selection were revealed in the analysis. These genes were associated with various traits such as milk production (*ADARB*, *WDR70*, and *CA8*), reproductive traits (*PARN*, *FAM134B2*, and *ZBTB20*), and health-related characteristics (*SP110*, *CXCL2*, *CLXCL3*, *CXCL5*, *IRF8*, and *MYOM1*). Furthermore, research was extended to the investigation of copy number variations in Tharparkar cattle selection signatures in the MHC region and coat colour across various Indian cattle breeds.





Sequence to variant conversion and quality control circos plot showing distribution of genes related to production traits.

Development of Transgenic Chicken as bioreactor for easy and cost-effective production of human therapeutic proteins-tissue plasminogen activator (htPA) and erythropoietin (hERP): The gene construct for htPA and hERP was synthesised and transformed into the *DH5α*(*E. coli*) cells. Screening for positive colonies for both the constructs was carried out by broth PCR using the gene specific primers. Further screening of plasmids was also carried out using the PUC57 vector backbone primers and sufficient numbers of plasmids were isolated for further use. The magnum cell culture procedure was standardized. The positive plasmids of the hERP and htPA constructs were transfected using gene pulsator. For further confirmation of the transfected genes into the cell culture, isolation of DNA from control and transfected magnum cells has been carried followed by PCR confirmation.

Studies on host pathogen interaction and development of vaccine against zoonotic corona viruses: Development of a Cocktail Vaccine with

Development of Nano Sensor and its application through Cloud-Based Network for real time irrigation to soil and plant

A process technology was developed for coating of outer surface using PANI (Polyaniline) nano particles and other chemical concentration to modify soil moisture sensors to give maximum range and sensitivity. A set-up was developed for surface modification of MP 406 soil moisture sensor using nano particles of PANI material. A prototype "MEGH" (Measuring Essential Good Hydration) was developed for field deployment and estimation of the moisture from soil in a non-contact manner. The device calculates the relative humidity of the soil which is in equilibrium with the soil moisture. The device also acquires the temperature, humidity of the air and the soil moisture and stores the data in a library. The self-developed, IoT-enabled software uploads all data to cloud for future big-data analysis and thus make them available for prompt intervention. If required the proposed device MEGH is preloaded with an indigenously developed Arduino-based Interface for data acquisition and analysis. The acquired data were analysed by an intuitive algorithm which converts the spectroscopic information into the relative humidity based on the calibration equation fed to the software. The software is entirely developed in Arduino platform for automated data acquisition and output result generation.

Artificial Intelligence and IoT based Smart Vet Ecosystem for animal health, patient care and precision livestock farming

Developed the prototypes of Electronic Health Records for Animals (eHRA) and Electronic Veterinary Medical Records (eVMR). Health and Medical Data Architecture Modules and data panels were developed. QR Code based "Smart Contact" interface developed and tested for animal owner's usage and was successful with 60 to 75% adoption by animal owners. For Animal Medical Data Capture, five Medical Information Management Systems were developed and tested. E-vaccination records were evolved and tested for animal owner's usage. "IoT Integrator" for conventional milk testers was developed and further trials commenced for IoT enabled remote quality assessment and monitoring of milk. The conventional milk testers were successfully integrated with the IoT system, for remote testing and monitoring of milk quality. An APP has been built to act as an interface between testing unit and collection units for reading, transferring and analysing parameters of milk from collection units to research teams. AI tools development works involving prediction of body size measurements, extraction, and quantitative analysis using sheep and goats images with deep learning protocols, were initiated. Face and muzzle point images of 3 breeds- namely Sahiwal, Tharparkar, Vrindavani were collected. About 3,000 images of muzzle and face were collected. Images were analysed through a Hybrid Model of Residual Attention Network and Multi-Scale Context Aware Network. The model is being utilised further for classification of animals using digital images and with a plan to use similar model for classification of other breeds and other species.

Development of Diagnostic kits for detection of Covid-19 infection in animals

SARS-CoV-2 can infect multiple animal species including pet (dogs and cats) and wild animals (tiger, lion, minks and ferrets). To detect SARS-CoV-2 antigen in animals, a RPA-CRISPR based point-of-care kit 'SARS-CoV-2 nucleic acid detection LFA kit' has been developed for detection of SARS-CoV-2 antigen in clinical samples. The test can be performed within 1 h using a thermal block and results can be obtained using lateral flow strips. The kit is being validated using clinical samples. Further, to detect SARS-CoV-2 antibodies in pet animals (dogs and cats), an indirect ELISA kit 'SARS-CoV-2 Antibody detection ELISA Kit' has been developed. The kit is being validated using dog and cat sera. Similarly, a blocking ELISA kit 'Covid-19 Blocking ELISA' was developed to detect SARS-CoV-2 antibodies in multi-species (dog, cat, lion or tiger). Using this kit, number of serum samples collected from Covid-19 affected (RT-PCR positive) lions and tigers from Arignar Anna zoological park, Chennai during 2021 were found positive. The kit is being validated using serum samples collected from different species.

SARS-CoV-2 nucleic acid detection LFA kit | SARS-CoV-2 antibody detection ELISA Kit | Covid-19 blocking ELISA kit

Omicron and Delta Strains was carried out by isolation and genetic characterisation of the Omicron and Delta variants of SARS-CoV-2, revealing their classification as Delta (B.1.617.2) and Omicron (BA.2.10) variants. Three vaccine candidates, including inactivated Delta and Omicron vaccines, as well as a combination with an aluminium hydroxide adjuvant, were prepared. Preliminary evaluation in guinea pigs demonstrated promising immune responses. The challenge trials of the three inactivated vaccines have been completed in golden Syrian hamsters. Transcriptome analysis was done to assess disease progression and molecular factors related to susceptibility and resistance across species and time points. Host response and susceptibility to SARS-CoV-2 infection, lung explant cultures were established using lung tissues from cats and dogs (susceptible species). For the development of viral vectored vaccine, the SARS-CoV2 S1 gene was inserted into a recombinant NDV and a western blot revealed a 78 kDa band, confirming the presence of the immunogenic gene within the NDV framework. For evaluating the immune responses of NDV carrying the spike *S1* gene, a specific immunisation protocol was implemented. The mice were subjected to different virus doses and administration routes. For the development of viral vectored and mRNA-based vaccines the codon-optimised spike and nucleocapsid genes were designed for mRNA vaccines. Self-replicating mRNA constructs (sr-mRNA-S and sr-mRNA-N) were generated, verified, and transcribed *in vitro*. The expression of SARS-CoV-2 proteins was confirmed through western blotting. Additionally, liposome encapsulation of these constructs showed promising results in terms of size and encapsulation

efficiency, which are crucial for vaccine delivery. The immunogenicity study of developed mRNA vaccine candidates has been initiated in Balb/c mice.

Exploiting encapsulated Nanoparticle conjugated phytochemicals to combat antimicrobial resistance in poultry: The chitosan/alginate encapsulated nano silver entrapped with cinnamaldehyde (EAgC) and thymol (EAgT) were found to be effective both by *in vitro* and *in vivo* (*Galleria mellonella* larvae, Swiss Albino mice and broiler poultry) trials. The acute as well as sub-acute toxicity trials performed on broiler poultry revealed that both the compounds (EAgC and EAgT)-treated groups retained optimum feed-conversion ratio (FCR) between 1.40-1.60. No mortality was evident among the compound-treated groups. Also, significant changes were not observed in the serum biochemical parameters (total protein, blood urea, creatinine, ALT, AST and ALP values) in the treated as well as control groups. Detectable amount of silver residues could not be detected by atomic absorption spectroscopy in the tested tissues (liver, kidney and breast muscle) of birds after trials (acute and sub-acute toxicity studies, and also field trials.The results of this study inferred that both the molecules were safe for oral therapeutic application in poultry. Presently, the commercialization of the developed product for poultry industry use is in progress.

Unique innate-immunity genomic signatures identification in Sahiwal, Gir, Tharparkar, Kangayam, Karan Fries and Holstein Friesian cattle using immunoinformatics: The whole genome sequencing of 18 pooled DNA samples identified 3,733 SVs across the breeds. Specifically, Sahiwal (SW) harbored highest number (762) of SVs followed by Karan Fries (KF) (731), Tharparker (TP) (718), Kangayam (KG) (580), Holstein Friesian (HF) (578) and Gir (546). Maximum number of SVs belonged to deletion (1,650), followed by insertion (1,185), inversion (468), break-end (308) and duplications (304). The HF had highest number of breed-specific SV (59) followed by the SW (32), KF (25), TP (17), GIR (7) and KG (4). Maximum number of breed-specific SVs belonged to inversion (58) followed by deletion (48) type. Additionally, to understand the expression profiles of the genes in CNVs, peripheral blood mononucleated cells (PBMC) were isolated from four cattle breeds (SW, TP, Gir and KF), exposed to a bacterial PAMP, LPS (1 µg/ml), for four hours *in vitro*, and their RNA was sent for custom RNA-seq. Further, an in-house pipeline was developed to identify the innate immune genes related to CNVs using the publicly available genome sequences of Nellore and Hereford cattle. This analysis found that 203, 113 and 38 genes showed highest number of substitutions, insertions and deletions, respectively. Most of them are related to adaptive immunity. However, innate immune genes such as antimicrobial peptide NK-lysin showed CNVs.

Exploring medicinal and immunomodulatory properties of the urine of indigenous Badri cattle: The immunomodulatory properties of Badri bull urine distillate were studied in Wistar rats. The findings demonstrated that Badri bull urine distillate had immunomodulatory effects on humoral and cell-mediated immunity. In humoral immunity, significant increase in titer of HI antibodies (41.55%) and ELISA values (25.41%) was observed at 90th DPT. Significant increase in ΔOD of the B-lymphocyte proliferation assay (LPA) performed in splenocytes of the test and control rats using lipo-polysaccharide (LPS) as mitogen showed 26.69% and 45.85% enhancement of B-lymphocyte proliferation at 60th and 90th DPT, respectively. The results scientifically validate the immunomodulatory effect of Badri bull urine distillate which can be used in Ayurvedic preparations just like cow urine distillate. It was found in the study that all the CUD from Pahari and Jersey cattle had effect against CPV with fall in virus titre and inhibition of CPE, while no antiviral effect of the hexane and butanol fractions could be detected with cells getting infected by virus. Comparative analysis of Pahari and Jersey cattle urine (CUD were then done along with acyclovir to check the comparative antiviral effect against CPV. It was found that Pahari cattle urine CUD had virus inhibitory effect which was less than acyclovir with fall in virus titre but it was found better than Jersey cattle urine.

Isolation of proline-rich polypeptides from colostrum of select indigenous cattle breed and evaluation of their nutraceutical potential: Amino acid profile and sequence of proline-rich polypeptides (PRPs) indicated that the proline content is higher in colostrum of Sahiwal (24.5%) followed by Tharparkar (22.3%), Gir (21.91%), Holstein Friesian (18.25%) and Karan Fries (17.49%). De-novo sequencing of the peptides was done through LC-MS/MS for PRPs isolated from colostrum of Sahiwal and Holstein Friesian. Furthermore, sequence was annotated with UNIPORT data base. Total number of peptides identified was 2,199 and 2,724, respectively in Sahiwal and Holstein Friesian. Out of these, 26 and 33 sequences were annotated with UNIPORT data base, having expect (e) value less than 10^{-3}. Most of the annotated sequences located to caseins (69.2% in Sahiwal and 54.5% in Holstein Friesian), especially beta caseins (34.6% in Sahiwal and 36.4% in Holstein Friesian). Immunomodulatory activity of proline-rich polypeptides (PRPs) was studied and *in vitro* analysis indicated higher phagocytic activity and moderate lymphocyte proliferation index of PRPs from indigenous breeds. Furthermore, immunomodulatory effect of the PRP was evaluated through the *in vivo* studies in mice model. It revealed that serum of mice challenged with *E coli* has higher IgG and IgA concentrations when fed with PRP from indigenous breeds compared to PRPs of Karan Fries. Level of anti-inflammatory cytokines (IL-10) was higher and pro-inflammatory cytokines (TNF-α, IFN- γ) was lower in mice fed with PRPs from indigenous breeds.

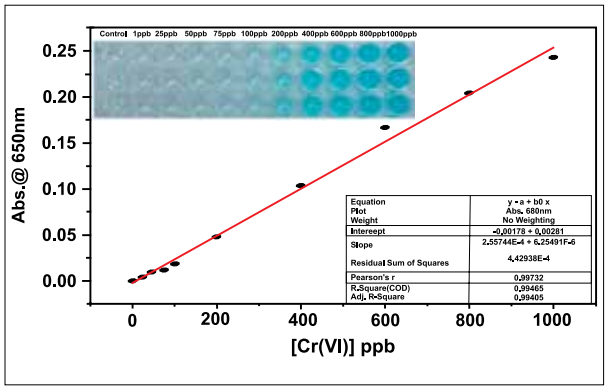
Development of nano-micro matrices for the delivery of bioactives, micronutrients and therapeutic: To develop compact core-shell microcap-

sules "NIMPOD" with *Kluyveromyces marxianus-lactobacillus casei probiotic consortium*, prebiotic fiber (within dual bio-polymeric layers) and bioactives in nanoliposomes, respectively, were optimised by employing layer-by-layer and coacervation techniques. Curcumin nanoemulsion using conjugate (particle size 134.53±1.27 nm and zeta potential -5.28±0.29 mV), under simulated GI conditions, showed slow release of curcumin. Curcumin encapsulation in skim milk using self assembly approach was also optimised. *Limosilactobacillus reuteri* SW27 and *Ligilactobacillus salivarius* RBL22 of indigenous cattle calves origin were selected and evaluated for *in vitro* and *in vivo* safety after producing spray dried microencapsulated probiotics. Nano ZnO, curcumin and its conjugates were evaluated for their *in vitro* antimicrobial, antioxidant and anti-inflammatory activities. Among the three nanoparticles, nano ZnO conjugate showed high antimicrobial activity against *E.coli*, *Staphylococcus* spp. and *Salmonella* spp. at 300µg/ml. Acute toxicity study was conducted in Wistar Albino rats. LC-MS analysis of buffalo milk isolated exosomes (100 nm, zeta potential of -20 mV), protein content of 21 mg/µl, identified approximately 2041 proteins, with 331 being consistently present across all samples. Gene ontology analysis revealed their functioning as immune response proteins.

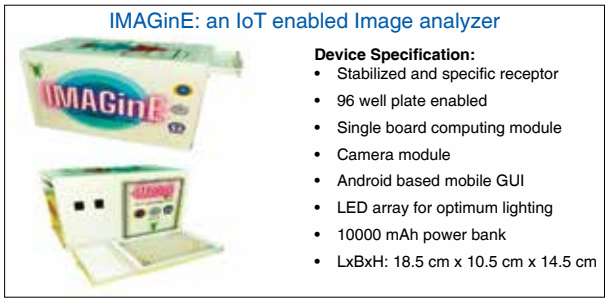
Scanning electron microscopy of *L. reuteri* before and after encapsulation

Traceable value chain for safe pork in the North Eastern Region of India: A protocol was made after standardising all the features related to capturing the facial image of the animals. Facial images of pigs from different pig breeds of different age groups after weaning were captured. Algorithms were developed to amplify certain hidden features in the face. The features-based image recognition algorithms like Local Binary Patterns Histograms (LBPH), Histogram of Oriented Gradients (HOG), Principal Component Analysis (PCA) and Support Vector Machine (SVM) was applied for individual pig recognition. Some machine learning algorithms were applied to same-breed image sets and the Support Vector Machine (SVM) has been given better prediction accuracy (97%) compared to others. Faster R-CNN was also applied on the same image sets for prediction of breeds and it produced 91% accuracy with a 94% confidence level. A total of 105 diseases of pigs with typical lesions were tabulated for the ante mortem exam (AM) of pigs and 83 diseases of pigs of either sex with typical lesions was tabulated for the Post-mortem exam (PM) of pigs for the Decision Support System (DSS) for pig slaughtering.

Development of biosensors for detection of fish pathogenic bacteria and hazardous metalloids in selected water bodies: A sensing device (IMAGinE) was developed for detection of Chromium (Cr^{6+}) in water with very trace level detection limit. Different image parameter values, such as R, G, B and S were extracted from the Cr-Detector system of IMAGinE for data analysis. When the G and B values were plotted against the Cr (VI) concentrations, the different Cr (VI) concentrations could not be clearly distinguished based on either G or B values, as both the G and B values for different concentrations appeared to be similar and thus no distinguishable pattern was observed. In contrast, the R-value and S-value expressed a distinguishable pattern. The R-value for each concentration of Cr (VI) appeared to be much more distinguished; the linear regression analysis provided an excellent R^2 value of 0.96. A similar pattern was observed for the S value vs. Cr (VI) concentration plot, where the linear fit with R^2 value is 0.96. The developed Cr^{6+} sensing device IMAGinE was found to very precise and robust with very low values of LOD and LOQ, 0.0037 ppm and 0.0112 ppm, respectively.

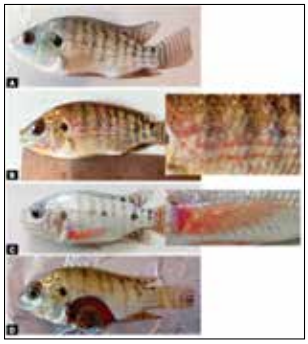


Calibration Curve of Cr (VI) developed

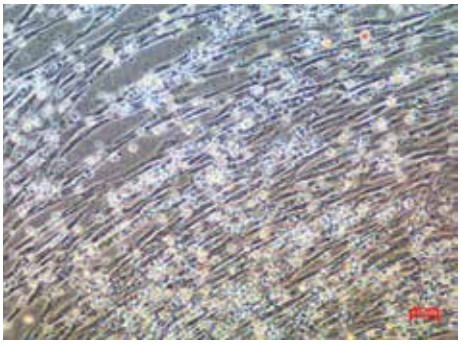


Cr6+ detection device (IMAGinE)

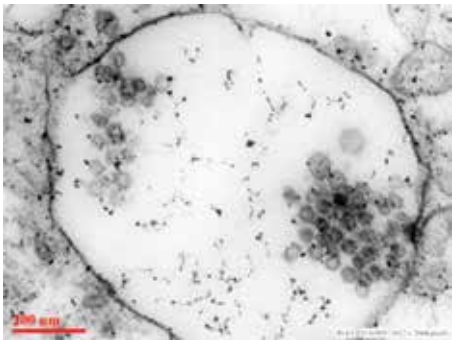
Novel approaches for disease free health certification in finfish and development of high health shrimp for sustainable aquaculture: For developing MAbs, serum immunoglobulins (sIgs) of three Indian major carps, *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala* were purified by affinity chromatography. Healthy fish were immunized with bovine serum albumin (BSA) to induce anti-BSA antibodies. Purified sIgs analysed by SDS-PAGE revealed two bands of ~80 kda and ~27 kDa, corresponding to heavy chains and light



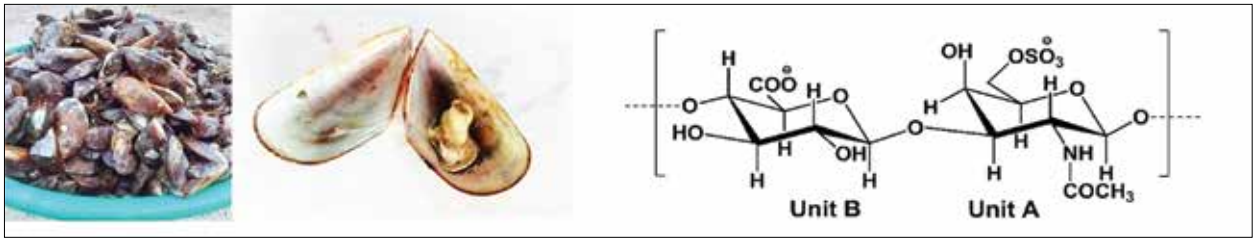
Lesions in Nile Tilapia co-infected with TiLV and TiPV



Isolation of TiPV in OnL cell line



TEM of OnL cells-infected with TiPV showing virus particles in both nucleus and cytoplasm



Sulfated glycosaminoglycan (PIP-2) isolated from brown mussel *Perna indica*

chains, respectively. Gel filtration chromatography of the sIgs revealed mixture of tetramers, dimers, monomers and half-mers in the purified preparation. These sIgs was used as an antigen to develop monoclonal antibodies. Effective dosage of prebiotic and inulin was determined for development of high health shrimp providing better growth and disease resistance. A dose of 20 g/kg inulin coated on the feed showed 22-32% higher growth and prolonged survival to WSSV challenge than control. Expression of immune and growth genes was higher in experimental group. Metagenome analysis indicated higher bacterial diversity in the gut of experimental animal than in control. *Bacillus subtilis* isolated from the GIT of healthy shrimp was evaluated as probiotic by two methods, either by coating the feed or as one of the feed ingredients. Feed coated with the bacteria showed higher growth and disease resistance.

Understanding molecular basis of host-pathogen-environment interaction of Tilapia Lake Virus disease: The Chitralada, GIFT and local strains of Nile Tilapia were evaluated for their susceptibility to Tilapia Lake Virus (TiLV) through experimental infection. All the strains exhibited susceptibility to TiLV, with lower mortalities in Chitralada followed by GIFT and local strain. The expression profiles of MX, IL1β, and HSP70 genes were studied following TiLV infection at different temperatures. Gut microbiome analysis of sub-clinically and clinically infected Nile tilapia revealed significant diversity, suggesting a potential role in TiLV disease development. Screening of wild tilapia populations from reservoirs displaying clinical signs yielded positive results for TiLV in one reservoir, indicating its presence in nature. A sensitive single-step SYBR Green chemistry-based qRT-PCR assay demonstrated excellent reproducibility, with low inter-assay and intra-assay variation. Efforts have been initiated for the commercialisation of this diagnostic assay. To identify risk factors associated with TiLV disease in Tilapia farms, epidemiological studies were conducted in West Bengal, Kerala, and Maharashtra, covering 69 Tilapia farms. A new viral pathogen, Tilapia parvovirus (TiPV) was detected in farmed Nile Tilapia from Maharashtra and Uttar Pradesh.

Development of small molecular weight bioactives and polysaccharides from marine and coastal bivalves to develop prospective nutraceutical products: Samples of marine/estuarine bivalves collected from Vizhinjam (8° N, 76° E) and Kozhikode (11° N, 75° E) were used to develop extracts/fractions, which were chromatographically fractionated to obtain oligosaccharide fractions. PIP-2 purified from brown mussel *Perna indica* was exemplified as [→1)-6-O-SO_3-*β*-GalNA*cp*-(3→1)-*β*-GlcA*p*-(4→], exhibited an anti-inflammatory effect on lipopolysaccharide (LPS)-induced macrophages. The sulfated glycosaminoglycan at different concentration ranges (10-50 µg/mL), downregulated the secretion of pro-inflammatory cytokines such as IL-1β (1.18-1.46 pg/mL), IL-6 (0.75-1.17 pg/mL), TNF-α (3.9-4.82 pg/mL) in LPS induced RAW 264.7 cells.

Purified polysaccharide (SCP-2) derived from *Saccostrea cucullata* yielded [→4)-*β*-GlcNS*p*-(1→4)-*α*-GlcA*p*-(1→3)-*β*-GlcNS*p*(1→]. SCP-2 downregulated nitric oxide production in LPS-stimulated RAW 264.7 macrophage cells with an IC_{50} of 5.4 µg/mL.A sulfated glycosaminoglycan, PVP-2, purified from the crude polysaccharide extract of *Perna viridis,* was established spectroscopically as [→4)-*β*-GlcNS*p*-(1→4)-*β*-GlcNS*p*-{(3→1)-*α*-GlcA*p*}-(1→].At 3 *µ*g/mL, PVP-2 effectively restores nitric oxide levels to homeostasis by downregulating excessive production. ❑

16. Information and Communication Technology

ICT Initiatives

Smart Performance Appraisal Report Recording Window (SPARROW): SPARROW is an online system for electronic filling of Annual Performance Appraisal Report (APAR) of officers. During the year ICAR has implemented SPARROW for scientific cadre in addition to administrative, technical and supporting cadres. A total of 17,691 PARs have been generated for the year 2022–23. Officials of ICAR Headquarters and its institutes including nodal officer/master trainer/custodian/admin/ scientists were given training to fill-up APAR. The data of scientific personnel were fetched from ARMS in sparrow through API for completing their APAR.

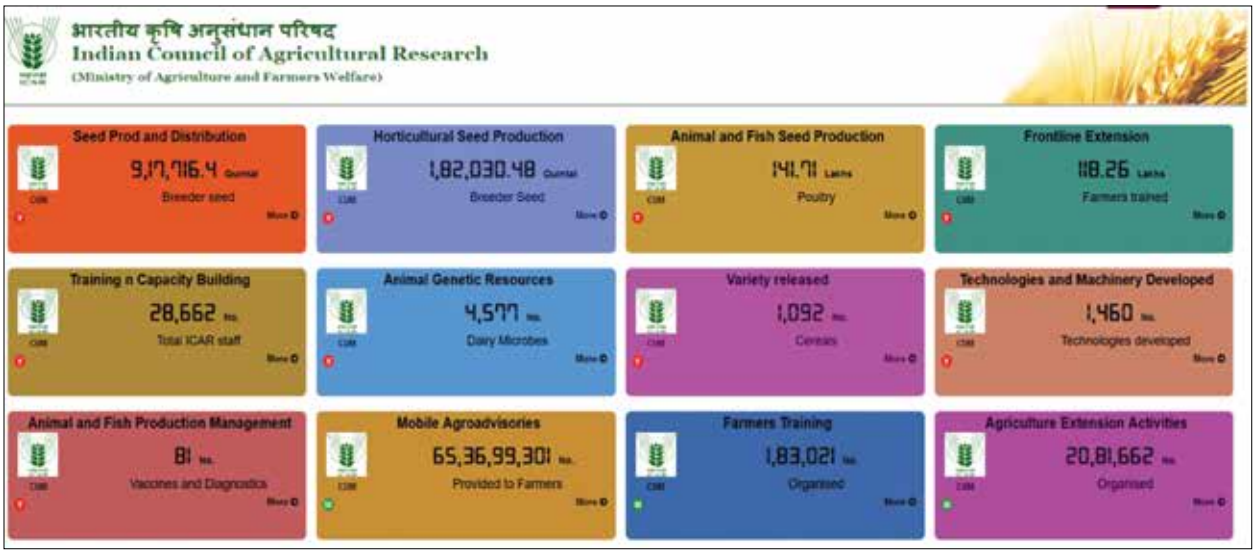
Agricultural Research Management System (ARMS): The online portal for all ICAR scientists to submit their significant research achievements, Agricultural Research Management System (ARMS) has been developed and implemented. This system will be used for reporting of various kinds of achievements and accomplishments of the scientists during the year in the council. These achievements are to be uploaded in by the respective scientist on monthly basis. The information submitted by scientists will be duly verified by reporting officer, PME in-charge and reviewing officer at various stages in a prescribed time period. An Application Programming Interface (API) (http://aparapi.icar.gov.in/) has been developed for sharing the achievement data filled by ICAR scientists with the Smart Performance Appraisal Report Recording Online Window (SPARROW) portal. These two online digital platforms have been linked to avoid multiple time submission of same information by the scientists. This also helps in maintaining consistency of information across different platforms of ICAR. Online evaluation workflow has been implemented for reporting officer and reviewing officer including final disclose of rating to the concern scientist. Two-way exchange of publication data between KRISHI portal and ARMS portal has also been implemented to avoid the duplicate reporting of publications in either of these digital platforms. The system is accessible from https://arms.icar.gov.in and team is providing regular support to ICAR scientists through email (support.arms@icar.gov.in) as well as support portal (support.icar.gov.in).

ICAR eOffice: eOffice software developed by National Informatics Centre (NIC) has been implemented across 113 ICAR institutes along with their regional stations/sub-stations. The ICAR eOffice is hosted at ICAR data centre and is running successfully. During this period 5,754 files has been created and presently 4,982 files are found to be in active state.

ICAR DARPAN Dashboard (http://icar.dashboard.nic.in): ICAR DARPAN Dashboard is customized using DARPAN portal developed by NIC to transform complex government data into compelling visuals. All ICAR schemes/projects are classified into 12 projects consisting of 45 Key Performance Indicators (KPIs). Out of these 12 projects, Mobile Agro-advisories, Farmer's Training and Extension Activities are dynamic and district level data have been pushed for them from KVK portal using API.

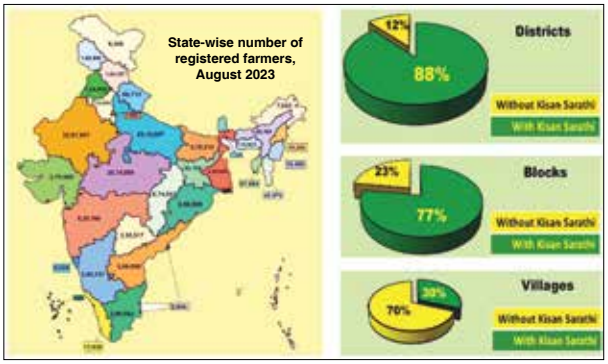
KisanSarathi: System of Agri-information Resources Auto-transmission and Technology Hub Interface: In order to support the emerging needs of multi ways and multilingual communication among various stakeholders, "KisanSarathi", an Information and Communication Technology (ICT) based interface solution has been launched on 93rd foundation day of Indian Council of Agricultural Research. The ultimate goal of this project is to implement an intelligent online platform for providing agricultural technological supporting at local niche with national perspective. Project intended to provide a seamless, multimedia, multi-ways connectivity to the farmers with the latest agricultural technologies, knowledge base and

Main dashboard of ICAR SPARROW



ICAR DARPAN Dashboard

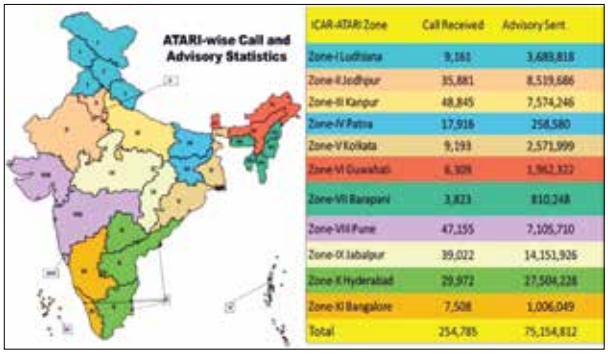
the pool of large number the subject matter experts. The project is developed by Indian Council of Agricultural Research, New Delhi and Digital India Corporation, MietY, Government of India under a MoU between ICAR and DIC, MietY. This has been implemented across country by Agriculture Extension Division, ICAR. Initially, the services have been piloted in four major states of India, viz. Bihar, Madhya Pradesh, Maharashtra and Uttar Pradesh, subsequently the services of KisanSarathi were made available to all the States and UTs of the country. Services of KisanSarathi for farmers are available through an IVR based calling system via toll free numbers 1800-123-2175 and a short number 14-426. Once a registered farmer calls to any of these numbers, his call directly gets connected to one of the agricultural scientists of associated KVK of his locality. Through this farmer-scientist can mutually discuss in their respective local language to resolve any issue related to agriculture or farming. All the calls made into the system are recorded in the MIS of KisanSarathi and are available for future reference. All KVKs across India and DATTC centres of Andhra Pradesh and Telangana are enrolled with the system, where, more than 4,000 agricultural scientists and subject matter experts are registered and extending their services to more than 1.5 crore farmers. These farmers are spread across 30% of total villages of India covering more than 77% of total blocks from 88% of districts of the country. Apart from receiving more than 2.5 lakh calls from the farmers, more than 7.5 crore advisories in the form of SMS has also been sent to the registered farmers by scientists of KVK using KisanSarathi platform. Monthly distribution (September 2022 to October 2023) of the country wide farmers' registration statistics with KisanSarathi and call received statistics from the farmers are shown by bar diagram. Further, to enhance the services of KisanSarathi, a new Interactive Voice Response System (IVRS), in 13 languages (11 major regional languages along with english and hindi), has



State wise numbers of the registered farmers

been implemented during the reporting period. Again, to support both ways multimedia exchange a Kisan-Sarathi Mobile App for Farmers (KS-App/F) has been made available to the farming community. KS-App/F in 13 (11+2) languages is available with UMANG platform of MeitY, Government of India at Google play store and supports following activities, viz. Registration of farmers; Advisory notification; Ask and track Query; Call from app etc. (https://play.google.com/store/apps/details?id=in.gov.umang.negd.g2c&pli=1)

Electronic-Human Resource Management System (e-HRMS 2.0): e-HRMS 2.0 is an online portal to provide end to end HR services. It is currently under



ATARI Zone wise calls received and SMS sent

implementation in various Ministries/Department/ Organization (MDOs). Various services such as deputation, leave/tour personalized prompts, real-time application status i-GOT trainings, reimbursements, profile update, single sign on training, vigilance, APAR/ IPR and other pay related issues and common services etc. can be availed in an easy, transparent and paperless manner by the employees.

The pre-requisite for availing services at e-HRMS 2.0 is that the employee profile needs to be updated by the employee and approved by the respective nodal officer nominated by director of the institute. This system can be accessed online (https://e-hrms.gov.in) by using NIC email credentials through Parichay platform. The leave module of e-HRMS 2.0 has been made operational for the employees of ICAR Headquarters in 2023. Onboarding of ICAR institutes on e-HRMS 2.0 is under process.

eSupport System for accessing various eGov applications in ICAR: ICAR-Data Centre, Advanced Supercomputing facility for Omics Knowledge in Agriculture (ASHOKA) and ICAR-Disaster Recovery Centre (ICAR-DRC) are established to provide support in accessing unified communication system, email services, web applications/websites hosting, e-Office, ICAR-ERP, Agricultural Research Management System, Foreign Visit Management System, Personnel Management System, eHRMS, SPARROW, Super Computing facility, and many more digital applications and platforms. In order to provide seamless ICT support to the ICAR users across country, a centralized help desk in the form of web application has been developed and implemented to address the issues and concerns related to use of these web applications and services. Any ICAR user by using their ICAR email (icar.gov.in) credentials can submit their request/ issue for resolution related to any of these ICT/digital service system. This system automatically generates a ticket with unique number. This helps in tracking and smoothly resolving issues along with its monitoring and management. Support personnel at the backend are resolving their issues and accordingly updating the users through this system. This requires

e-HRMS 2.0 portal

the title, specific issues, add attachment, if any with the relevant document/screenshots along with phone number. The users can also track the progress of their queries through the generated unique ticket number.

Information and communication management in ICAR: Information and communication management is important component for agricultural research management, education and extension in ICAR. The internet connectivity in ICAR was upgraded to 10-Gbps and extended to all the officials. The information and communication network in ICAR have been upgraded to 6-Generation Wi-Fi connectivity and secure wired network. National Agriculture Science Center (NASC) Complex of ICAR, which is used for hosting International and National Conferences has been equipped with latest 5G cellular connectivity through outdoor tower as well as in-building cells. For security of information resources and data security in agricultural research management the cyber security policy of government of India was implemented. An elaborate exercise of internal cyber

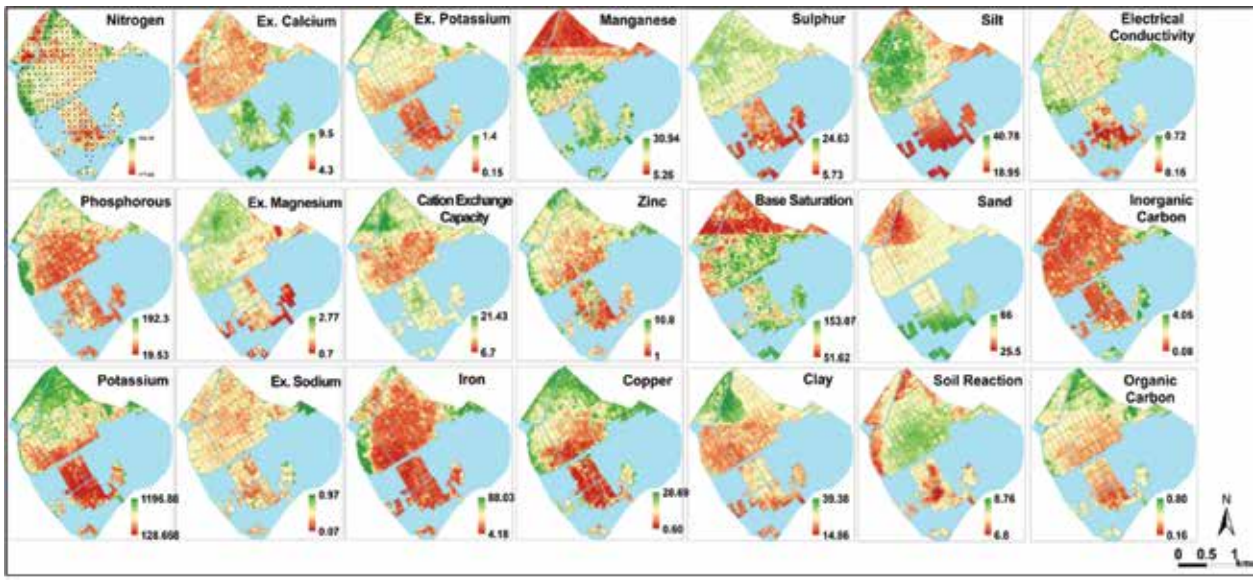
eSupport System

security audit was carried out to implement various tenets as proposed in policy document.

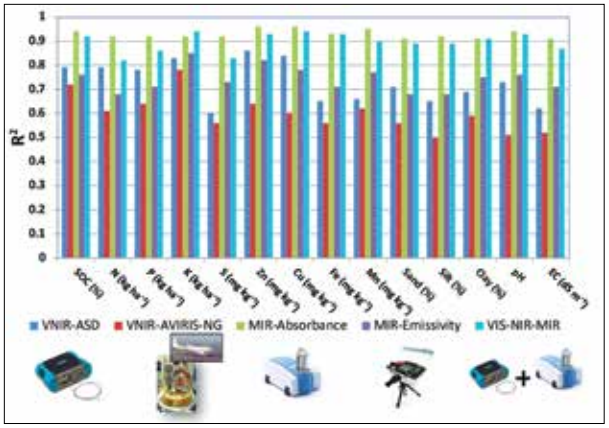
Information and communication technology unit of ICAR has provided essential services during important national conferences and meetings organized by ICAR. Some of the important National/International meetings which were attended by Hon'ble Prime Minister of India include 2nd National Conference of Chief Secretaries of Government of India, Annual Conference of Inspector Generals of Police held during January 2023, and Global Millets Conference (Shree Anna) organized in March 2023. 94th Annual General Meeting of the ICAR, Annual Conference of Directors of National Institutes and Vice Chancellors of State Agricultural Universities and International Conference on Blended Learning and Ecosystem of higher Education in Agriculture, Annual conference of ICAR Regional Committee of Zone-V, Agricultural Exhibition at National Agriculture Science Centre Complex for G20 leaders', spouses visit to Pusa, IARI and International research conference, From Research to Impact: Towards Just and Resilient Agri-food Systems hosted by the CGIAR GENDER Impact Platform and the Indian Council of Agricultural Research (ICAR) held during the year were also provided support for information and communication management of event in Online mode.

One of the important mandates of ICT unit is to create awareness about cyber security among the researchers, senior officers and other functionaries. All staff of ICAR across country were provided opportunity to be educated related to cyber security through number of online programmes coordinated by ICT unit and delivered by C-DAC Hyderabad. In this programme most of the ICAR staff from different institutes participated. This is continuous ongoing activity from ICT unit of ICAR-Headquarters. Also an exclusive interactive session-cum-training programme has been organized in Krishi Bhawan, ICAR on 23 May 2023 on the topic "Cyber Hygiene". More than 70 officials of ICAR and DARE participated in the session. Resource person and cyber security expert from Indian Cyber Crime Coordination Center (I4C), Ministry of Home Affairs, GoI were invited for deliberations during the training.

ICAR-Network Program on Precision Agriculture (NePPA): This programme is focused on exploring potential applications of recent developments on technologies related to sensors, IoTs, drone and ICTs, variable rate technologies (VRTs) for precision smart agriculture. The major objectives span its scope bringing precision in monitoring and managing soil fertility, crop health, livestock farming, post-harvest operations, aquaculture and upscaling in farmers' field scale to enhance input use efficiency and optimal production system. Some of the accomplishments ready to roll out in the field are briefly given as:

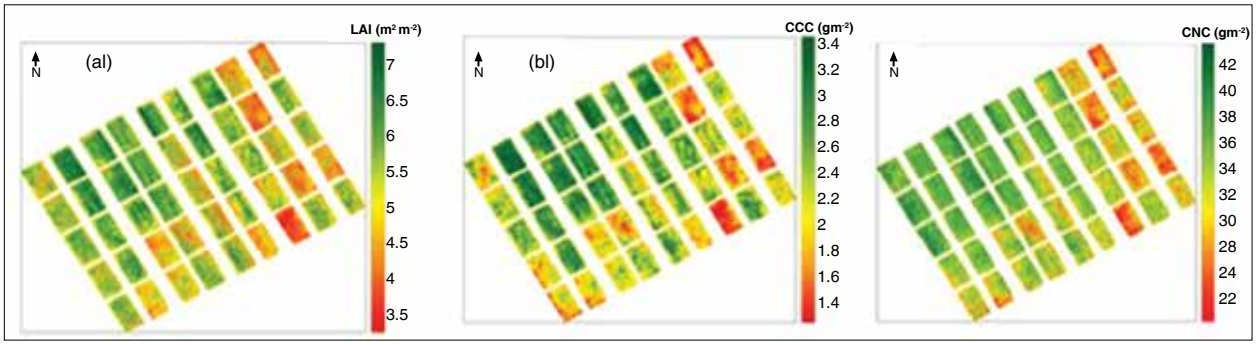


Digital soil map of ICAR-IARI for 21 soil fertility attributes



Prediction of soil fertility using different hyperspectral sensors

Drone based monitoring of crop condition



Biophysical parameters of wheat field derived from drone imaging

***Sensor based rapid assessment of soil fertility and digital soil mapping*:** Rapid sensor-based appraisal of soil health at field scale has been developed. Presently, soil health assessments are performed under laboratory conditions using wet chemistry with tedious and time-consuming sample preparation and analysis. This will accelerate the national soil health card programme by Government of India. Different hyperspectral sensors were used and evaluated for non-invasive rapid estimation of soil fertility attributes. The sensors used were spectroradiometer (VNIR-ASD) and JPL-NASA imaging sensor, i.e. AVIRIS-NG, both working in optical spectral range of 400–2500 nm, Spectrometers (FTIR) which records absorbance and emissivity values in Mid-Infra-Red (MIR) range of 2,000–16,000 nm. Predictive models were developed for 14 soil fertility parameter using different machine learning algorithms and evaluated results obtained from wet chemistry. The result revealed that MIR-absorbance based technology was found the best in prediction of soil fertility (with R^2 mostly above 0.85) one followed by the spectroradiometer-reflectance based for soil fertility assessment in laboratory conditions. However, Airborne imaging sensor (i.e. AVIRIS-NG) could also predict with R^2 mostly above 0.5 for field conditions which will be very useful for large scale prediction with moderate accuracy.

Digital soil mapping was also employed using remote sensing derived environmental co-variates, legacy soil test data and machine learning algorithms for developing predictive spatial maps of 21 soil fertility parameters for ICAR-Indian Agricultural Research Institute experimental fields with reasonable accuracy. Same procedures will be implemented in many other regions of the country for large scale use. Both these technologies developed will be very helpful for complimenting to national soil health card programme.

***Drone based near real monitoring of crop condition for precision farming*:** Drone remote sensing technology was developed to monitor near real time crop condition through quantitative assessment of plant biophysical parameters such leaf area index (LAI), canopy chlorophyll (CCC) and nitrogen content (CNC) of wheat crop for site specific nitrogen application using variable rate technology. This is quite cost effective and environment friendly technology which can be immediately used by the farmers.

***Mobile based nitrogen (N) management in rice crop*:** A mobile based RiceNXpert was developed which recommends timing and dose of N fertilizer based on 10 photographs of rice leaves.

❑

17. Technology Assessment, Demonstration and Capacity Development

Krishi Vigyan Kendras (KVKs), district level multidisciplinary scientific institutions for frontline extension, are mandated for technology assessment and demonstration for its application and capacity development under different farming situations across the country through on-farm testing (OFTs) of new technologies to identify location specific technologies in various farming systems; frontline demonstrations (FLDs) for exhibiting the production potential of the technologies and capacity development of farmers, farm women, rural youth and extension personnel. KVKs also provide technological inputs, information and knowledge to different stakeholders and serve as knowledge and resource centres at the district level in the country. Besides these activities, important programmes namely Out scaling of Natural Farming, Formation and Promotion of Farmer Producer Organizations (FPOs) as Cluster Based Business Organizations (CBBOs), Technological backstopping to FPOs, Demonstrations through Agri-drones, Farmers FIRST, Attracting and Retaining Youth in Agriculture (ARYA), Cluster Frontline Demonstration of pulses and oilseeds, Cereal Systems Initiatives for South Asia (CSISA), National Innovations in Climate Resilient Agriculture (NICRA), Pulses Seed hubs, Mera Gaon Mera Gaurav and Awareness creation on government schemes, etc. were taken up to address various challenges and national priorities like, engaging youth in agriculture, brining self-sufficiency in production of pulses and oilseeds, sustainable agriculture, etc.

Technology Assessment

One of the mandated activities of KVKs is assessment of the location specificity of technologies developed by National Agricultural Research System under various agro-ecological situations. Technologies assessed under various crops, livestock, enterprises and women empowerment during the year are briefly presented as:

Crops: A total of 6,036 technological options in various crops were assessed by the KVKs at 15,180 locations by carrying out 33,128 trails at farmers' fields in order to provide technological alternatives to the identified problems across the country. Major thematic areas were varietal evaluation; integrated nutrient management; integrated pest management; integrated disease management; integrated crop management; weed management; resource conservation technologies; farm machinery; cropping systems; post-harvest technology /value addition and small scale income generation enterprises. Technologies were also assessed in other thematic areas such as seed production; soil health management; integrated farming system; drudgery reduction; storage techniques; mushroom cultivation; information and communication technology; integrated pest and disease management; fodder and nursery raising; water management; biological control and protected cultivation. Varietal evaluation was the major theme of technology assessment with 1,583 technologies assessed through 7,597 trials at 2,970 locations. This thematic area was assessed by most KVK in the country (526 KVKs). Integrated nutrient management (999 technologies, 4,775 trials and 2,535 locations by 418 KVKs) and integrated pest management (837 technologies, 4,140 trials and 1,582 locations, by 370 KVKs) were the other major thematic areas on which technology assessment was carried out.

Livestock: The KVKs assessed 1,099 technological options pertaining to different thematic areas of production and management of cows, buffalo, sheep, goat, poultry, pig and fish at 3,633 locations through 6,771 trials. The thematic areas were nutrition management; animal disease management; livestock production management; feed and fodder management; evaluation of breeds; fish production; processing and value addition; small scale income generation and composite fish culture. Nutrition management (271 technologies assessed through 1,755 trials at 687 locations) and disease management (190 technologies assessed through 1,229 trials at 631 locations) were the major thematic areas.

Farm and non-farm enterprises: KVKs could test 657 technologies under farm and non-farm enterprises at 2,493 locations through 4,685 trials. Technologies belonged to major thematic areas such as processing and value addition; mechanization; resource conservation technology; organic farming; entrepreneurship development; mushroom cultivation; drudgery reduction; small-scale income generation; storage techniques; health and nutrition and post-harvest management. Processing and value addition (120 technologies assessed at 241 locations through 708 trials), health and nutrition (73 technologies assessed at 222 locations through 620 trials), mechanization (68 technologies assessed at 1,325 locations through 327 trials) and drudgery reduction (51 technologies assessed at 140 locations through 428 trials) were the dominant thematic areas chosen by the KVKs for assessment.

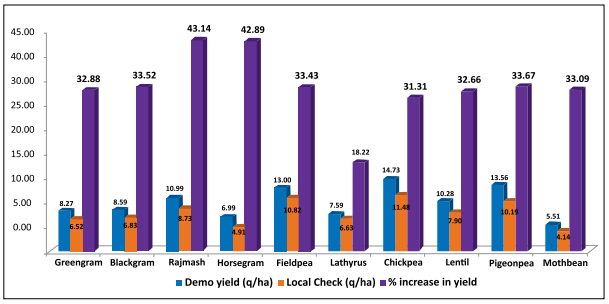
Women empowerment: As part of technology assessment, 339 technologies pertaining to farm women

were assessed through 3,066 trials at 1,344 locations. Value addition (143 technologies, 999 trials at 363 locations) and health and nutrition (70 technologies assessed through 875 trials at 240 locations) were the major thematic areas of technologies assessed with an aim to promote women empowerment.

Frontline Demonstrations

Cluster Frontline Demonstration

Division of Agriculture Extension, ICAR, New Delhi implemented Cluster Frontline Demonstrations (CFLDs) programme through KVKs on major pulse and oilseed crops under National Food Security Mission (NFSM) of Department of Agriculture & Farmers' Welfare, Government of India, New Delhi to demonstrate the production potential of different technologies of these crops. The CFLDs on pulses were executed on chickpea, pigeonpea, lentil, blackgram and greengram and those on oilseed crops were executed on sesame, groundnut, linseed, soybean, mustard, sunflower in pulse and oilseed growing states, viz. Andhra Pradesh, Bihar, Gujarat, Karnataka, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Madhya Pradesh, Uttar Pradesh and West Bengal.



Yield performance of pulse crops under CFLDs

Cluster Frontline Demonstration on Pulses: During the period under report, 31,515.46 ha area was covered under 72,807 demonstrations on pulse crops across the country. In *kharif* 12,811.79 ha area (30,912 demonstrations) was covered, while in *rabi* 14,854.27 ha (32,612 demonstrations) and in *summer* season 3,849.40 ha (9,283 demonstrations) area was covered.

At national level, the average yield advantage in pulse crops was 35.18% which ranged from 18.22% in lathyrus to 43.14% in rajmash. The yield advantage in other crops were 42.89% in horsegram, 33.67% in pigeonpea, 33.52% in blackgram, 33.43% in fieldpea, 33.09% in mothbean, 32.88% in greengram, 32.66% in lentil and 31.31% in chickpea. This was mainly due to suitable technological interventions, farmers' awareness and skill developed among farmers by the KVKs.

Cluster Frontline Demonstration on Oilseeds: During reporting period, 25,709 ha area was covered under 65,925 demonstrations on oilseed crops across the country. In *kharif* 8,306 ha (20,764 demonstrations), in *rabi* 14,929 ha area (39,021 demonstrations) and in *summer* season 2474 ha area (6,140 demonstrations) was covered.

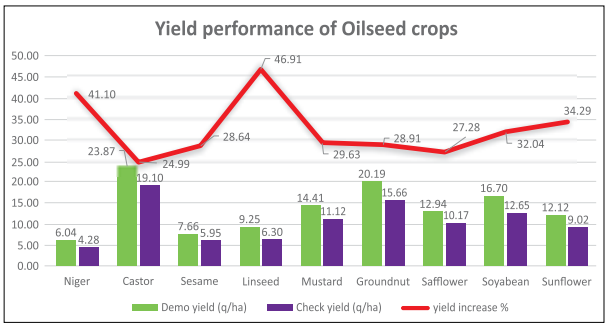
At national level, the average yield advantage in oilseed crops was 30.70% which ranged from 24.99 to 46.91%. It was highest in linseed (46.91%) followed by niger (41.10%), sunflower (34.29%), soybean (32.04%), mustard (29.63%), groundnut (28.91%), sesame (28.64%), safflower (27.28%) and castor (24.99%), respectably. This was possible due to farmers' awareness, suitable technological interventions and skill developed among farmers by the KVKs activities.

CFLD on blackgram (PU-31): KVK Imphal East, Manipur

CFLD on chickpea (CSJ-515): KVK Tonk, Rajasthan

CFLD on greengram (Shikha): KVK Rohtas (Zone-IV Patna)

CFLD on pigeonpea (PRG-176): KVK Nayagarh (Zone V, Kolkota)



Yield performance of oilseed crops under CFLDs

Field day on sunflower, KVK Ballari, Karnataka

Demonstration on sesame, KVK Sonitpur, Assam

Field day on linseed, KVK Raisen, Madhya Pradesh

Demonstration on mustard, KVK Auraiya, Uttar Pradesh

Other Frontline Demonstrations

A total of 1,37,007 Frontline Demonstrations (FLDs) other than CFLDs including 88,575 FLDs on crops covering 26,465.44 ha area, 18,656 demonstrations on farm machinery covering 9,017.46 ha area, 19,537 FLDs on livestock and fisheries, 4,404 demonstrations on other enterprises and 5,835 FLDs on gender-specific technologies for women empowerment were organized.

Cereals: Among 29,979 FLDs on cereal crops, 1,270 varietal and other technology options were demonstrated in 15,100 FLDs in 5,182.56 ha area on rice crop by 478 KVKs in which the average yield was under demostration plots 20.00% higher than the farmers' practice. A total of 9,263 FLDs were conducted on 537 technological options of wheat crop in 3,321.88 ha area by 274 KVKs. The Average yield in the demonstrations was 16.00% higher than the farmers' practice. In all, 366 technological options of maize crop were demonstrated by 177 KVKs conducting 3,909 FLDs in 1,250.75 ha area wherein the yield increase was about 21% in the demonstrations over farmer's practice. Demonstrations were also conducted on barley (731 FLDs), oats (791 FLDs) and buck wheat (165 FLDs).

Millets: Among 3,409 FLDs on millets, the highest number of 240 varietal and other technological options were demonstrated on sorghum (Jowar) by 40 KVKs consisting of 495 FLDs wherein the average yield was 26.08% higher than the farmers' practice. Besides, technologies of finger millet (191), pearl millet (70) and foxtail millet (28) were demonstrated in 811, 1,614 and 184 FLDs which showed 14.53, 20.41 and 34.45% higher average yield, respectively than farmers' practice. Demonstrations on barnyard millet, browntop millet, kodo millet and other millets were conducted in small numbers.

Pulses (other than CFLDs): Among the 10,504 FLDs on various technologies of pulses, 2,562 FLDs were on blackgram (25.70% higher average yield than farmers' practice), 2,027 on greengram (30.24% higher average yield than farmers' practice), 1,717 on chickpea (15.89% higher average yield than farmers' practice), 1,177 on Lentil (31.08% higher average yield than farmers' practice), 978 on pigeonpea (14.77% higher average yield than farmers' practice), 637 on rajmash (27.75% higher average yield than farmers' practice) and 506 FLDs were on field pea (40.47% higher average yield than farmers' practice).

Oilseeds (other than CFLDs): A total of 9,085 FLDs were conducted on 1,202 varieties and management technologies of oilseed crops out of which 2,015 FLDs were conducted on mustard (28.98% higher yield than farmers' practice), 1,371 FLDs on groundnut (23.03% higher yield than farmers' practice), 1,419 FLDs on brown sarson (39.82% higher yield than farmers' practice), 1,067 FLDs on soybean (21.71% higher yield than farmers' practice), 1041 FLDs on sesame (34.72%

higher yield than farmers' practice), 883 FLDs on toria (49.37% higher yield than farmers' practice) and 519 FLDs were on *gobhi sarson* (17.36% higher yield than farmers' practice).

Horticultural crops: In all, 27,969 FLDs were conducted on 5,520 varieties and technologies of horticultural crops comprising vegetables (17,824), fruits (4,349), spices (2,846), tuber crops (1,740), flowers (618), plantation crops (224) and medicinal and aromatic crops (71) in 5,864.24 ha area. The increase in average yields recorded in demonstrations as compared to farmers' practice was 23.13% in vegetables, 30.53% in fruits, 33.81% in flowers, 23.83% in spices and condiments, 73.32% in plantation crops and 21.65% in tuber crops.

Commercial crops: A total of 957 FLDs including 811 on sugarcane and 81 on mulberry were conducted in an area of 352.55 ha through 78 KVKs. The average yield increase in the demonstrations plots was 16.56% in sugarcane as compared to farmers' practice.

Fibre crops: A total of 2,232 FLDs were conducted on 573 cotton (1,370 FLDs) and 17 jute (862 FLDs) varieties and technologies wherein the average yield was 19.25% higher than the farmers' practice.

Fodder crops: Demonstrations on crops such as berseem, maize, sorghum, napier grass, etc. were conducted in 4,440 farmers' fields covering an area of 945.50 ha. The average yields in demonstrations was 36.22% higher than the farmer's practice.

Hybrids: To achieve higher harvest index in crops, KVKs conducted 7,614 FLDs on 1,179 hybrids covering an area of 2,387.61 ha in cereals, millets, oilseeds, pulses, fodder crops, commercial crops and horticultural crops. In cereals comprising rice and maize, 1,919 FLDs were conducted in an area of 751.9 ha to demonstrate the potential of various hybrids. Demonstrations on hybrids of oilseeds were conducted across the country covering 150 ha area. A total of 3,096 FLDs were conducted on various vegetables, fruits, flowers and spices in 554.3 ha area. In hybrid cotton 669 demonstrations were conducted in an area of 263.96 ha where the average yield increase was 24.22% over the farmers' practice.

Farm mechanization: A total of 18,656 demonstrations were conducted on 1899 technological options on improved tools and farm implements including drudgery reduction technologies covering an area of 9,017.46 ha. The highest number of 7,509 demonstrations were on sowing and planting machines and 2963 on plant protection machines and 2,524 were on intercultural operations tools and machines.

Livestock and fisheries: In all, 17,921 demonstrations on dairy animals, poultry, sheep and goat, poultry including chicken, quail, turkey, duck, piggery, rabbit, etc. were carried out on 5,364 technological options, and 1,616 demonstrations were conducted on 341 fisheries technologies.

Enterprises: A total of 4,404 demonstrations on 20 enterprises, viz. mushroom cultivation, apiary, sericulture, value addition, vermicompost, nursery, etc. were conducted in which 22,857 enterprise units were established. On women and children, 5835 demonstrations were conducted on various enterprises like value addition, kitchen garden, nutrition, etc. for 59,499 beneficiaries.

Capacity Development

A total of 23.16 lakh farmers/farm women, rural youth and extension personnel were trained on various aspects through 74,065 training programmes including the sponsored training courses.

Farmers and farm women: Training courses (57817) on various technologies benefitted 18.53 lakh farmers and farm women out of which 12.14 lakh (65.50%) participants were from other classes while 6.39 lakh (34.50%) were from SC/ST category. These courses targeted productivity enhancement and cost reduction of field crops (22.86%), horticultural crops (15.50%), plant protection (13.15%), empowerment of rural women including home science (11.85%), livestock production and management (10.82%), soil health and fertility management (8.37%), capacity building for group actions (5.05%), agricultural engineering (4.77%), production of inputs (3.44%), fisheries (2.75%) and others including agroforestry (1.43%). Out of these training courses 40.71% were organized on-campus while rest (59.29%) were organized off-campus. Within field crops, integrated crop management was the leading theme in which 23.05% of courses were organized followed by weed management (9.13%), seed production (7.81%), cropping systems (7.64%), resource conservation technologies (6.60), production of organic inputs (6.13%), integrated farming (5.32%), crop diversification (5.08%), water management (3.06%) and nursery management (2.97%). Among the training courses on horticulture, vegetable crops constituted 52.49% while proportion of courses on fruits was 26.83%. However, the respective share of training courses on medicinal and aromatic plants, spices, tuber crops, plantation crops and ornamental plants was less than 21%.

Rural youth: Training courses (11,106) for the skill development of rural youth were organized for 3.03 lakh participants out of which 1,15,672 (38.15%) were the young women during the reporting year. The highest proportion of training courses under this category were imparted on mushroom production (9.05%) followed by value addition (8.56%), nursery management of horticulture crops (4.79%), seed production (4.75%), vermi-culture (4.69), dairying (3.58%), bee keeping (5.69), production of organic inputs (5.33%) and integrated farming (5.19). There were a large number of other areas on which relatively smaller number of training courses were organized for the rural youth. These trainings were conducted mainly on-campus (65.89%).

Extension personnel: Capacity development of

1.60 lakh extension personnel was carried out through 5,142 courses in the country. The proportion of female participants in these programmes was 31.54%. Different extension functionaries working both in government and non-government organizations for the development of agricultural sector in the country were included in these trainings. The trainings mainly focused on agricultural technologies aimed at knowledge and skill upgradation on integrated pest management (12.85%), productivity enhancement in field crops (12.43%), integrated nutrient management (8.75%), production and use of organic inputs (6.01%), protected cultivation technology (4.67%), women and child care (4.57%), livestock feed and fodder production (4.01%), household food security(3066%), capacity building for ICT application (3.58%) and management in farm animals (3.15%). Group dynamics and farmers' organization, low cost and nutrient efficient diet designing, care and maintenance of farm machinery and implements, rejuvenation of old orchards, and information networking among farmers were other areas under such training courses. Higher proportion of trainings for extension personnel was organised on-campus (66.38) compared to the off-campus (33.62%).

Extension Programmes

KVKs in the country are actively involved in organization of various extension programmes in order to reduce the time lag between generation of technology at the research institution and its transfer to the farmer field for increasing production, productivity and income from the agriculture and allied sectors on a sustained basis. During the reporting year, KVKs organized a total of 6.19 lakh extension programmes using various methods and means. These included advisory services, celebrations of important days, diagnostic and clinic services, exhibitions, exposure visits, ex-trainees *sammelan*, farm science club conveners' meetings, farmers' seminars, farmers' visits to KVK, field days, film shows, group meetings, *kisan ghosthies, kisan melas,* lectures delivered as resource persons, *mahila mandal* conveners' meetings, method demonstrations, plant/animal health camps, scientists' visits to farmers' fields, self-help group meetings, soil-health camps, soil-test campaigns, workshops, and other activities, wherein latest technologies related to agriculture and allied sectors were disseminated among 204.61 lakh participants including 200.58 lakh farmers and 4.54 lakh extension personnel.

Additionally, KVKs are in the forefront for effective utilization of electronic and print media to have wider coverage of technology dissemination. KVKs, during the reporting period, organized 2.48 lakh extension activities in the form of TV programmes, radio talks, CDs/DVDs, extension literature, newspaper coverage, popular articles, research articles, training manuals, technical bulletins, leaflets, folders and books/booklets for the benefit of a significant number of farmers, extension personnel and other stakeholders.

Production of Technological Products

KVKs produced technological products like seeds and planting materials of improved varieties and hybrids, bio-products and elite species of livestock, poultry and fish which benefited 11.18 lakh farmers in the country.

Seeds: During the year, 1.86 lakh quintal seeds of improved varieties and hybrids of cereals, oilseeds, pulses, commercial crops, vegetables, flowers, fruits, spices, fodder, forest species, medicinal plants and fiber crops, were produced and provided to 2.85 lakh farmers.

Planting materials: A total of 464.29 lakh quality planting materials of elite species of commercial crops, vegetables, fruits, ornamental, medicinal and aromatic crops, plantation crops, spices, tuber crops, fodder and forest species were produced and provided to 5.21 lakh farmers.

Bio-products: Bio-products, viz. bio-agents (651.78 q), bio-pesticides (2,282.45 q), bio-fertilizers (35,094.81 q), vermicompost, mineral mixture etc. were produced and supplied to the extent of 42,060.53 q and benefiting 4.25 lakh farmers.

Livestock, poultry and fish fingerlings: A total of 343.08 lakh fingerlings, improved breeds of cow, sheep, goat, buffalo and breeding bull were produced and supplied to 1.75 lakh farmers. Different strains/ breeds/eggs of poultry birds (chickens, quails, ducks and turkey) were provided to 54,378 farmers. Improved breeds of pigs were provided to 822 farmers. KVKs also enabled 39 farmers to establish small rabbit rearing units by providing 213 rabbits. A total of 334.42 lakh fish fingerlings were produced and supplied to 6,922 farmers.

Soil, Water and Plant Analysis

KVKs in India tested 3.05 lakh samples including 2.62 lakh soil samples, 31,824 water samples, 9,739 plant samples, and 944 other samples like fertilizers, manures, food etc. benefiting 3.18 lakh farmers in 44,601 villages. An amount of ₹234.13 lakh was realized as analytical charges of which 203.2 lakhs was from soil testing services. A total of 1.70 lakh Soil Health Cards have been issued to farmers.

Technology Backstopping to KVKs

In all, 55 Directorates of Extension Education (DEEs) in the SAUs/CAUs played pivotal role in technological backstopping to KVKs of the country. During the period under consideration, the DEEs organized 806 workshops/meetings for capacity development and updating the technical knowhow of KVK personnel in India. The officials of these directorates made 22617 visits to the KVKs of their jurisdiction on various programmes like, training programmes, field days, farmer scientist interactions, soil health camps, *kisan melas/kisan gosthies*, technology week celebrations, *rabi* and *kharif* campaigns, animal health camps, diagnostic visits, technology exhibitions, etc. at KVKs to review

and monitor the technology dissemination process and provide technological backstopping.

Agricultural Technology Information Centre

Agricultural Technology Information Centres (ATICs; 51) are serving as single window delivery system in the country by providing technological information, advisory services and technological inputs to the farmers. During the reporting period, 3.20 lakh farmers visited ATICs for obtaining solutions related to their agricultural problems. ATICs provided information related to various aspects of farming to 2.82 lakh farmers, both through print and electronic media. Farmers (2.40 lakh) were provided 60,604.3 q of disease free seed of various crops, 10.01 lakh of improved planting material, 9985 poultry birds and 31,464 q of bio-products by the ATICs. Besides these, 5.51 lakh farmers benefited from the technological services provided by the ATICs. The ATICs also provided/facilitated various services, viz. Soil Health Cards (13,284 farmers), Kisan Call Centre (1,39,548 farmers' calls), Mobile Agro Advisory (37,707) and special extension programmes (7,870).

Mobile Advisory Services

Timely and need based information to the farming community was provided by 594 KVKs by using mobile advisory services. Based on weather forecast, farmers were alerted and advised on suitable farm operations. Alerts related outbreak of pest and disease incidence and their control measures were also given to farmers. Information related to market prices were also shared with farmers. As many as 4.15 lakh mobile advisories sent by KVKs benefitted 448.66 lakh farmers on various aspects of agriculture, horticulture and animal husbandry, weather forecast, and pest and disease.

Special Programmes and Projects

Attracting and Retaining Youth in Agriculture: Attracting and Retaining Youth in Agriculture (ARYA) project is operational in 100 KVKs. During the year, 4036 entrepreneurial units related to mushroom production, fruits and vegetable processing, horticulture nursery, protected cultivation, fish farming, poultry, goat farming, piggery, duck farming, bee keeping and vermicomposting were established benefiting 6,079 rural youth. KVKs have organized 815 training programs benefiting 19,870 youth. Nearly 30.59% trained rural youth established micro-entrepreneurial units in rural areas.

Walk-in tunnel off season vegetable production Unit, KVK Jaintia Hills, Meghalaya

Poultry unit established under ARYA program, KVK Bundi, Rajasthan

National Innovations on Climate Resilient Agriculture: Technology Demonstration Component (TDC) of National Innovations in Climate Resilient Agriculture (NICRA) which aims at enhancing resilience of Indian agriculture and making Indian farmers more adaptive to climatic vulnerabilities has been implemented through 151 KVKs in climatically most vulnerable districts of the country as per the latest risk categorization. Climate smart technologies encompassing Natural Resource Management, Crops and Livestock modules have been demonstrated in adopted villages as a package to suit the resource and weather related constraints of different farming system typologies of the village along with institutional interventions like Village Climate Risk Management Committee (VCRMC), Custom Hiring Centres (CHCs), fodder bank and seed bank. Capacity building and extension activities are also a part of TDC-NICRA to bring larger awareness on climate resilient technologies and to instill climate literacy among farmers.

During the year under report, 14,003, 23,034 and 10,635 demonstrations were conducted covering 4,809.79, 9,225.66 and 1,099.58 ha of area under NRM, Crop and Livestock modules, respectively. At the same time 1,667 capacity building programmes and 2,993 extension activities were taken up for the benefit of 50,202 and 73,727 farmers, respectively for brining awareness on climate resilient technologies and to enhance climate literacy. Under TDC-NICRA, emphasis has been laid largely on forging convergence with ongoing government schemes in the respective districts for saturating more number of villages with promising climate smart technologies. There is a shift in the focus from showcasing the potential of individual technologies to demonstrating the strength of a technology package customized to address resource constraints of farming system typology of the village. Households have been taken as units for quantifying impact of the technology package.

Demonstration of direct seeding of rice-Alleppey, Kerala

Demonstration of happy seeder in Faridkot

Out-scaling of Natural Farming through KVKs: Department of Agriculture and Farmers' Welfare, Government of India has sanctioned a project titled "Out-scaling of Natural Farming through Krishi Vigyan Kendras (KVKs)" of ₹9,555 lakh for 4 years (2022–26). The project is being implemented by 425 KVKs across 33 States and Union Territories from September 2022. The activities being carried out under the project are awareness, training and demonstrations on natural farming.

Being the novel area, National Workshop on Natural Farming was conducted at Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior on 03 December, 2022 for sensitizing the Subject Matter Specialists (SMSs) of KVKs and Nodal Scientists of Agricultural Technology Application Research Institutes (ATARIs) who are involved in implementing the project. Besides experts from different Agricultural Universities and ICAR institutes, farmers practicing natural farming also shared their experiences during the workshop. About 790 persons including SMSs of KVKs, nodal scientists of ATARIs, students, and farmers of Chambal and Gwalior divisions of Madhya Pradesh attended the workshop.

Besides, SMSs of KVKs and nodal scientists of ATARIs who are involved in implementing the project have been imparted training at State Natural Farming Training Centre, Gurukul, Kurukshetra, Haryana. In all, 436 persons attended the training programme. The

Workshop on Natural Farming at RVSKVV, Gwalior, Madhya Pardesh

KVKs under this project organized different activities namely, exhibitions*; gosthies*; camps; group meetings; poster presentation; debates; method demonstration on preparation of different inputs of Natural Farming; exposure visits of farmers to the successful Natural Farming practicing farmers and Natural Farming Blocks at KVK farms; placed hoardings and posters on Natural farming at the village level; and used audio-visual aids, mass media and social media for creating awareness among farmers. The KVKs organized 6,777 such awareness programmes involving 6.79 lakh farmers.

Training and drmonstration for natural farming

Awareness Programmes on Natural Farming

These KVKs organized 418 training programmes on different aspects of Natural Farming and trained 19,363 farmers. These KVKs also organized 3,325 demonstrations on Natural Farming at farmers' fields.

Training programmes on natural farming

Demonstrations on natural farming

Agri-Drone Project: There is growing need of using the inputs for agriculture with precision for enhancing the economic productivity, input use efficiency and environmental sustainability. Hence, Indian agriculture is transforming from the traditional to precision agriculture. The application of digital technologies has the major role for this transformation. The digital technologies that can be used for precision application of inputs in agriculture are sensors, drones, robotics, Internet of Things, Artificial Intelligence and Machine Learning and geo-informatics. Drone is one of the formidable technologies that have found potential application in agriculture. Drones can play important role for inputs applications in agriculture. The inputs such as nutrients, fertilizers, chemicals (insect and pest) can be sprayed with drones. It has some distinct advantages such as high field capacity and efficiency, less turnaround time and other field operational delays, wastage reduction of pesticide and fertilizers due to high degree of atomization, water saving due to ultra-low volume spraying technology, reduction in cost of spraying and fertilizer application etc. besides reduction of human exposure to hazardous chemicals. In this context, ICAR has started Agri-Drone project, with funding support from Department of Agriculture and Farmers' Welfare, Government of India, with objective of creating awareness among the farmers and other stakeholders and demonstrating the use of drone in agriculture at farmers' fields.

In all, 263 Agri-Drones have been procured under this project by 193 Institutions comprising 67 ICAR Institutes, 33 Agricultural Universities including State Agricultural Universities and Central Agricultural Universities and 93 KVKs across the country.

Total 287 personnel from the above-mentioned Institutions have been undergone Drone Pilot Training by the recognized Remote Pilot Training Organizations (RPTOs). The Institutions had carried out total 15,075 Agri-drone demonstrations on nutrients, fertilizers, chemicals (insect and pest) applications following Standard Operating Procedures (SOPs) covering 16,471 ha area. A total of 90,953 farmers participated in the Agri-Drone demonstrations and field interventions.

Line transplantation of paddy

Formation and Promotion of Farmer Producer Organizations (FPOs): Under the aegis of National Cooperative Development Corporation (NCDC), Government of India, ICAR is implementing a project namely "Formation and Promotion of FPOs by KVKs and ICAR Institutes as Cluster Based Business Organizations (CBBOs)" in 115 blocks of 55 districts, (105 blocks by KVKs and 10 by ICAR Institutes). Out of 115 FPOs, 114 FPOs have been formed, 51 FPOs have received management cost and 53 FPOs have received equity grant.

Summer greengram sowing

Demonstration on drone technology

Technological backstopping to FPOs: KVKs have also been entrusted with providing technological backstopping to the FPOs formed by other organizations.

During the reporting year, the KVKs provided technological backstopping to 1,866 FPOs by organizing 2,340 training programmes with participation of 85,291 members. The FPO members received training on value addition, packaging, branding, vegetables cultivation, INM, IPM, IDM, seed production, nursery raising, animal husbandry, poultry rearing, vermicompost production, mushroom cultivation, etc. KVKs also provided technical assistance in economic activities of 626 FPOs

Mera Gaon Mera Gaurav: The innovative initiative "*Mera Gaon Mera Gaurav*" aimed to promote the direct interface of scientists with the farmers to hasten the lab to land process. The objective of this scheme is to provide farmers with required information, knowledge and advisories on regular basis by adopting villages particularly small and marginal farmers. During interaction with scientists, farmers put forth their issues apropos technological availability, loans, market price, extension programmes and support provided by different agencies, etc.

The programme was implemented by 112 institutions (ICAR institutes and SAUs) and monitored by 11 ATARIs in the country. During the period, total 964 groups involving 3,618 scientists covered 3,048 villages and conducted 27,276 field activities including awareness, demonstrations, training, meetings, etc. and 49,528 message advisories were sent by which 5,63,863 farmers benefited.

Farmer FIRST: Farmer FIRST Programme is a flagship programme initiated by ICAR to move beyond production and productivity; to privilege the smallholder agriculture; and complex, diverse and risk prone realities of majority of the farmers through enhancing farmers-scientists interface. A total of 28,995 demonstrations were conducted, 2,972 extension programmes were organized, 1,03,492 animals (livestock and poultry) were benefited and 86,197 farm families were covered in all modules during the reporting period. Out of the total demonstrations conducted, highest number of demonstrations (10,721) were conducted in crop module followed by 9,937 demonstrations in horticulture; 4,282 demonstrations in livestock and poultry; 2,995 demonstrations in NRM and 1,060 demonstrations in IFS module.

Direct seeding of rice

Hi-tech horticulture

Out of the total farm families served, 14,564 farm families were in crop module; 13,362 were in horticulture module; 10,832 were in livestock and poultry module; 8,789 were in NRM module; 1,331 were in IFS module and 37,319 were in extension activities.

Skill Development Training in Agriculture: Skill development in agriculture sector is one of the priority areas of Government of India. With funding support from Department of Agriculture, and Farmers' Welfare, Government of India, KVKs/ICAR Institutes/ Agricultural Universities organized 52 National Skills Qualifications Framework (NSQF) aligned skills training programmes of 210 hr duration benefitting 1201 rural youth during the period under report. The highest number

Kadaknath farming

Chickpea (Var. Phule Vikram)

of trainings programmes were organized in the job roles of Garden Keeper/Assistant Gardener/Gardener/Nursery Worker (15) followed by Small Organic Cultivator/ Organic Grower (11), Backyard poultry farmer/Small Poultry Farmer (10), Small Mushroom Grower (7), Honey bee farmer/ Beekeeper (5), Small Dairy Farmer (3) and Vermi-compost Producer (1).

Knowledge System and Homestead Agriculture Management in Tribal Areas: Knowledge System and Homestead Agriculture Management in Tribal Areas (KSHAMTA) has been initiated to channelize the Tribal Sub Plan (TSP) fund of ICAR institutes for Development of Tribal Agriculture. KSHAMTA is being implemented in 164 tribal districts of the country through KVKs. The activities comprise training, On-farm Testing (OFT), Frontline Demonstrations (FLDs), extension activities, production of seeds, planting materials, livestock strain, fingerlings testing of soil, water, plants and manures etc. A total of 5,394 farmers trainings conducted, which were attended by 1,54,595 farmers. In addition to that, 2,253 training were organized exclusively for women farmers which benefitted 47,210 farm women. Apart from that 1,105 and 573 trainings were conducted for rural youths and extension functionaries which aided 26,850 and 15,587 rural youths and extension functionaries respectively. A total of 6902 farmers were involved in OFT, 33,311 were participated in Frontline Demonstrations and 36,00,732 mobile agro-advisory were disseminated to the farmers. They also produced planting materials (73.44 lakh), livestock strains (2.33 lakh) and fingerlings (162.80 lakh) and seeds (20,549.20 q) across the country. A total of 41,025 numbers of testing of soil, water, plant manures samples were identified all over India.

Nutri-sensitive Agricultural Resources and Innovation: Nutri-Sensitive Agricultural Resources and Innovations (NARI) Programme is a flagship programme initiated by ICAR at national level. Nutrition-sensitive agriculture puts nutritionally rich foods, dietary diversity, and food fortification at the heart of overcoming malnutrition and micronutrient deficiencies. This approach stresses the multiple benefits derived from enjoying a variety of foods, recognizing the nutrition rich food, social significance of the food and agricultural sector for supporting rural livelihoods. The overall objective of nutrition-sensitive agriculture is to make the global food system better equipped to address the problem of malnourishment in a sustainable way. Nutrition-sensitive agricultural approach aims to make food more available, accessible, diverse and nutritious through homestead nutrition garden.

During the reporting year, KVKs conducted on-farm testing, technology demonstrations, trainings and various extension activities under NARI programme. A total of 12,022 nutri-gardens were established with 21,056 beneficiaries. Bio-fortified varieties of different crops (cereals, millets, pulses, oilseeds, tubers and vegetables) were demonstrated in the area of 778.26 ha area and covered 2,711 beneficiaries to improve nutritional status of the farming community. KVKs also conducted 295 demonstrations on value addition of different crops, viz. cereal, millets, vegetables and fruits in which 5,382 beneficiaries participated.

KVKs organized different training programmes and extension activities under different areas like promotion of nutri-garden, nutri-*thali*, value addition, bio-fortified varieties, etc. A total 1,810 and 2,927 training programmes and extension activities were organized that benefitted 54,621 and 85,819 participants respectively, to increase nutrition literacy and develop nutritional related skills.

Scheduled Castes Sub Plan (SCSP): Scheduled Castes Sub Plan (SCSP) is sponsored by the Ministry with the objective to ensure flow of targeted financial and physical benefits for the development of Scheduled Castes. Under the strategy, States/UTs were required to formulate and implement Special Component Plan (SCP) for Scheduled Castes as part of their Annual Plans by earmarking resources. At present 20 States/ UTs having sizeable SC population were implementing Schedules Caste Sub-Plan. The activities comprises under SCSP were training, OFTs, FLDs, extension activities, production of seeds, planting materials, livestock strain, fingerlings testing of soil, water, plants and manures etc. A total of 5,811 trainings were conducted by the SCSP KVKs which were attended by 1,64,967 farmers. In addition to that, 1,750 training were organized exclusively for women farmers which

Training on kitchen garden

Value addition in aonla

benefitted 39,535 farm women. Apart from that 1,073 and 413 trainings were conducted for rural youths and extension functionaries which aided 27,218 and 10,486 rural youths and extension functionaries respectively. A total of 5,757 farmers were involved in on-farm trial, 45,261 were participated in Frontline Demonstrations and 12,05,524 mobile agro-advisory were disseminated to the farmers. The production of planting materials, livestock strains and fingerlings comprises 39.64 lakhs, 1.44 lakhs, 17.42 lakhs and also 15,917.67 quintals seeds were produced all over the country. A total of 20,925 numbers of testing of soil, water, plant manures samples were identified all over India.

Pulses seed-hubs: Seed-hubs have been set-up at 95 KVK for production of quality seeds of major pulse crops. During the year, 34,765.63 q seeds of pigeonpea, blackgram, greengram, lentil, chickpea, field pea and *lathyrus* were produced and made available to farmers.

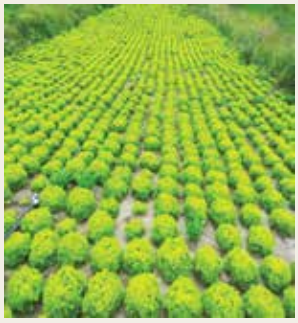
Crop Residue Management: The states of Punjab, Haryana and western Uttar Pradesh, also known as the birthplace of the Indian Green Revolution, are the major contributors to the national food basket for paddy and wheat. Most of the farmers of these states generally resort to the burning of paddy straw in the field itself due to the short window (15–25 days) for the timely planting of ensuing crops. The enormous burning, that too within a span of 15 days, leads to atmospheric pollution problems, massive nutritional losses and deterioration of the physical and biological health of the soil. Keeping, this in view, the Government of India 2018 decided to launch a Central Sector Scheme on "Promotion of Agricultural Mechanization for *in situ* management of crop residue in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi". The ICAR is entrusted to execute the Information, Education and Communication (IEC) component of this scheme through 60 KVKs of Punjab, Haryana, Delhi and Uttar Pradesh.

The different Information, Education and Communication (IEC) activities under crop residue management were carried out by 60 KVKs of Punjab, Haryana, Delhi and Uttar Pradesh. More than 64000 farmers participated in 669 awareness camps which were organized at different levels (district, block and village). Capacity building of 5,247 farmers, tractor and machine operators, and custom hiring centre owners developed by organising 197 training programmes of 5-day duration. More than one lakh farmers were mobilised in 113 *Kisan Melas* organized by KVKs on crop residue management theme. School and college students were recognised as prospective stakeholders to reach out to their farming parents, neighbours, and villagers to encourage them to use the latest agricultural residue management technology. There were many schools and colleges involved in creating awareness about crop residue *In situ* management and 49,098 students were sensitised by organising 308 activities like essay competition, painting, debate, etc. Demonstrations on crop residue management using CRM machinery organised at

CASE STUDY

Diversification through high-value exotic vegetable cultivation in the Kukumseri valley of Himachal Pradesh (KVK, Lahual and Spiti-I)

Shri Lal Singh, a farmer from the Lahaul and Spiti district of Himachal Pradesh, has been cultivating various crops on his 3.20 ha of irrigated land. Despite his hard work, he struggled to obtain good returns. He came into contact with KVK Lahaul and Spiti at Kukumsheri and attended various training programs. He is one of the FLD farmers of the KVK for cash crops. The KVK suggested him for crop diversification against single crop with low productivity and income. Consequently, he switched over to crop diversification and cultivation of high-value exotic vegetables from traditional farming. He cultivates vegetables, fruits, and *Lilium* flowers on his 1.88 ha while utilizing integrated pest and disease management. He also manages a small dairy unit, grows red clover and tall fescue as fodder crops, practices vermicomposting, and runs a trout fish farm to generate extra income. These changes have increased productivity and net returns on his farm. Shri Lal Singh's adoption of a diversified cropping system has resulted in the cultivation of high-value exotic vegetables, cauliflower, and flower crops by the farmers of neighbouring villages. With the introduction of training and demonstrations, the movement, which started with just 12-15 farmers, has grown to 175, significantly improving their economic status and living standards.



View of exotic vegetable nursery and field

Lilium flower field of Sh. Lal Singh and its post-harvest handling to make bundle of sticks for marketing

important locations on more than 17,000 ha whereas, more than 2,200 demonstrations were conducted on decomposer technology. KVKs also organized 216 exposure visits, and 218 field days/harvest days in which more than 9,800 and 14,000 farmers mobilised, respectively.

Integrated Farming System (IFS): Integrated Farming System (IFS) commonly refers to agricultural systems coupled or integrated with livestock, fisheries etc. and this is also referred to as integrated bio-systems. In this system, there exists an inter-relation between the different farming enterprises and it highly emphasises on waste management or resource management in such a way that the waste from one enterprise becomes an input for another enterprise. It was popularized all over the country because of the fact that it is highly feasible for small and marginal farmers which prevails over 82% of the total farming population in the country. IFS of different component combination were popularized through all the KVKs in the country and there are 9,645 IFS units established spanning an area of 852.11 ha during 2022–23. Under IFS, a total of 3,490 demonstrations and 3156 trainings were conducted for 36,808 and 60,908 farmers respectively during the year.

CASE STUDIES

Poultry farming as gainful self-employment in tribal area (KVK, Banswara)

Shri Sher Khan, a 24-year-old school dropout and unemployed youth with 2 acre land, was eager to start a new enterprise but lacked clarity on what to pursue. He approached KVK, Banswara and participated in vocational training on commercial poultry production under the ARYA Project. Equipped with knowledge and skills in poultry production techniques such as vaccination, weighing, cleaning, and feeding, he initiated a commercial poultry farming operation in 2022 with 1,800 chicks, all under the expert guidance of KVK Scientists.

Initially he received support from KVK, Banswara, in the form of 100 Kadaknath chicks (6 weeks old), a cage, a feeder, and a water drinker. The progress of his poultry venture was regularly monitored by KVK Scientists. As a result of his hard work and dedication, Mr. Sher Khan managed to achieve a net profit of ₹3,94,000 from his flock of 1,800 birds. Witnessing Khan's remarkable success, three other young individuals from the same village were inspired to establish their own poultry units.

Fish farming generates sustainable income (KVK, Chitrakoot)

Shri Dinesh Jaiswal, son of Sri Chotaka, is a young farmer having 2 ha of land in a joint family, residing in Itwa village, Ramnagar block, Chitrakoot district, Uttar Pradesh. He was previously unemployed and had been searching for a job everywhere. Finally, he decided to start fish farming along with crop farming. After receiving adequate training on composite fish farming techniques, pre and post stocking management, and other related practices at KVK Chitrakoot, he took the initiative to excavate a pond of 2,500 m^2. Mr. Dinesh commenced fish cultivation in 2021–22, under the expert guidance of KVK Scientists.

He stocked 5 g sized fingerling of Catla, Rohu, Nain, and Pungasius at a rate of 10,000/ha. He efficiently manages floating fish feed and water quality with application of lime and disinfectants by following recommended practice. He has harvested fish yield up to 118.40 q/ha with B:C ratio of 1.40. In the region, fish farming had traditionally been limited to select families from the Kewat, Raikwar, and Nishad communities. The training and demonstration motivated farmers to adopt fish farming in scientific way in available ponds in the district. Dinesh Jaiswal's success has become a source of inspiration for those seeking employment opportunities. Not only it increased his income, but it has also opened up employment prospects for others. He is enthusiastic to share his knowledge and success with others, spreading awareness about this system throughout the district and state. Under his guidance, 15–20 farmers came forward to adopt fish farming with pangasius variety.

Potato and banana chips proved as profitable enterprise (KVK, Piprakothi)

Smt. Sabya Devi, a 31-year-old leader of a Women's Self-Help Group (WSHG) hailing from Bathna village in the Areraj block of East Champaran, embarked on a transformative journey. She, along with her fellow group members, underwent training in processing and value addition at KVK Piprakothi, as part of the ARYA

View of poultry unit of Sh. Sher Khan

project. This training equipped them with valuable skills in slicing, peeling, and frying. With the guidance and support of KVK scientists, the group established a venture dedicated to producing potato and banana chips. They received essential equipment such as a potato peeler machine, potato slicer, and a potato variety known as Kufri Chipsona through KVK under the ARYA project. Previously, the WSHG primarily engaged in making papads and ladoos. However, with the help of critical inputs and newfound knowledge, they diversified their product range to include potato and banana chips, as well as masala, ladoo, and papad. Thanks to this venture, the WSHG now generates a commendable net income of ₹1,14,240 annually.

Integrated farming system in tsunami affected areas of Andaman and Nicobar Islands (KVK, South Andaman)

Shri M M Joydhar, a small-scale farmer with a family of five, manages a 2.5 ha landholding. Prior to December 2004, his land was dedicated to paddy cultivation during the rainy *kharif* season, and a portion of it was used for growing vegetables in the dry period, utilizing the limited water available from his pond. However, the devastating earthquake and subsequent Tsunami in 2004 led to seawater inundation, rendering the land unsuitable for cultivation. In April 2014, Scientists from KVK, south Andaman, engaged with Shri M M Joydhar to assess the resources available with him. They collected pre-adoption resource data and benchmark information, and devised a layout plan that covered 1.5 ha of land using an integrated approach, taking into account the land's topography. Activities included cleaning the pond using mahua oil cake and pond preparation through the addition of manure, specifically cow dung. Ducks were introduced to enhance fertility and aid in pond aeration, fostering optimal conditions for fish growth. Additionally, alongside coconut trees, saplings of fruit-bearing trees such as banana, guava, custard apple, sapota, lemon and pineapple were provided for planting on the pond's embankments. Shri M M Joydhar adopted a mixed farming system in his fields, implementing techniques like Broad Bed and Furrow (BBF) methods and ridge and furrow planting. These methods enabled the cultivation of aerial vegetables, with the use of machans (nylon fishing wire) on the furrows for support and growth.

Fishing activity

View of potato chips making

Initially Shri Joydhar's annual income was of ₹1,65,000 through fish farming, cultivating Indian major carps, bhendi, cucurbitaceous plants, and coconut, among other activities. Due to the interventions provided by KVK, including the implementation of ridges and furrows, integration of crops, crop rotation involving leguminous and leafy vegetables, and the introduction of intensive poultry farming, his annual income saw a substantial increase to ₹4,64,435. With the newfound benefits, he has constructed a small house near by the farms. More than six off-campus training programmes and field days were conducted in his field to show the effectiveness of the technology in the field condition. His systematic and well-maintained farming system was covered by DDK (two times) and AIR (two times), Port Blair.

Being an award-winning farmer, he serves as a profound source of inspiration and a prominent role model not only for those in his vicinity but also in the neighbouring villages. His dedication and remarkable success in farming have earned him recognition that extends from village to village and district to district. Notably, his concept of an integrated farming system in areas affected by brackish water inundation has resonated with other Tsunami-impacted farmers, who now follow his lead. By skilfully integrating the available resources and benefiting from the technical guidance provided by KVK, this farmer effectively mitigated the repercussions of the Tsunami. Today, he stands as a shining example and a guiding light for fellow farmers seeking to adopt similar practices and overcome challenges in their agricultural endeavours.

Production of certified paddy seed boost income of farmer (KVK, Dibrugarh)

Mr. Dulal Konwar, a hardworking and diligent progressive farmer belonging to Dibrugarh, owns 8.50

Off-campus training

ha of agricultural land. He attended training programs and undergone study tours outside the district sponsored by the Department of Agriculture. He adopted IFS which includes the components of paddy, rapeseed, vegetable crops such as okra, potato, and pumpkin, 3 cows, 40 ducks, and 22 poultry. He underwent training at KVK, Dibrugarh and ventured for paddy seed production under the technical guidance of KVK scientists. Initially, KVK provided Foundation seeds of Ranjit Sub-I and helped him in the certification process of paddy. In 2021–22, he sold 160 quintals of certified paddy seeds and earned ₹4,80,000 as against a net profit of ₹54,000 from double cropping of Rice followed by toria. He motivated 7 fellow farmers in the village for getting paddy seed certification of Ranjit Sub-1 since 2020.

A view of paddy seed production field

Integrated Farming System: An assured income for sustainable livelihood

Shri Kshetrimayum Jiten Singh, a marginal farmer with 0.25 ha of land, cultivated crops such as maize, cabbage, and brinjal. Despite his relentless efforts, he struggled to make substantial profits due to low yields resulting from a lack of knowledge and scientific techniques. His disappointment extended to his animal enterprises as well. Shri Jiten Singh participated in training programs organized by KVK, Thoubal and adopted improved cultivation techniques, emphasizing timely sowing, balanced fertilizer usage, and the proper application of plant protection chemicals. Additionally, KVK scientists provided guidance on scientific livestock rearing methods. Further, he gained valuable insights into the scientific management of livestock, including piggery through specialized training programs held at ICAR, Lamphel, and CAU, Imphal.

Due to technology adoption, he earned net profits from pumpkin and bottle gourd @ ₹9,600 and ₹12,500 with BCR 2.78 and 3.27, respectively. Additionally, implementing advanced cultivation technology for King chilli, coupled with effective pest and disease management, substantially reduced diseases like leaf curl and anthracnose. This led to increased yields and a net profit of ₹28,000, boosting an impressive benefit-cost (B:C) ratio of 6.00. Furthermore, the introduction of novel techniques in pig management, specifically the scientific management of piggery, transformed Shri Jiten's pig farming unit. This innovative approach resulted in a gross income of ₹1,27,600 and a net income of ₹1,02,800, with a remarkable B:C ratio of 5.15. The combined efforts across these enterprises led to a total profit of ₹1,52,900, showcasing the success of the IFS model facilitated by KVK scientists.

The successful implementation of IFS unit by Shri Jiten has a positive impact on fellow farmers in his village. His successful model has inspired other farmers in the village to adopt IFS as a reliable income assured system. Witnessing the prosperity and improved outcomes from his approach, other farmers have been encouraged to explore and implement integrated farming techniques, combining various agricultural activities like crop cultivation, animal husbandry, and agroforestry.

The cultivation of strawberries leads to prosperity for farmers (KVK, Pune-II)

In Maharashtra, Mahabaleshwar and some parts of Pune district are suitable for the production of strawberries. Khed, Ambegaon, and Junnar tahsils of the Pune district come under hilly areas. In the winter (*rabi*) season, tourists visit these places to taste red and orange strawberries. KVK Narayangaon conducted a demonstration and training on strawberry cultivation in the year 2018–19 for enhanced income of the farmers. KVK provided strawberry plantlets (tissue cultured) as critical input to farmers under OFT during the winter seasons of 2018–19 and 2019–20, in the Tribal region of Ambegaon Tehsil. The trial was conducted on 5 farmers' fields that had irrigated amenities. Each OFT was performed on a 1,000 m^2 region. The farmers used to cultivate paddy crops, but they did not receive any additional net income. To overcome this issue, they started cultivating strawberry harvests on raised beds

King chilli field

Bottle gourd field

Pumpkin field

Cultivation of strawberry

with drip watering and polythene mulching. The plant transplantation process was carried out in the first two weeks of September. The farmers were provided with recommendations for fertigation and plant protection measures.

The harvesting of strawberries began in November and continued until February of the following year. The farmers would start harvesting early in the morning and pack the strawberries into punnets with a capacity of 200 g. They adopted a strategy of roadside marketing, selling their produce to tourists visiting the Bhimashankar Temple. This helped them obtain premium prices of ₹200–250/kg, compared to the ₹150/kg they would get otherwise. The total yield obtained was 18000 kg/ha, resulting in net returns of ₹27,00,000 with BCR of 2.75. The beneficiary farmers found strawberry cultivation to be more profitable than paddy cultivation and adopted it in the next year. Ten farmers from surrounding villages also started cultivating strawberries. Farmers from the irrigated belt of the plain area of Khed, Ambegaon, and Junnar tehsil also adopted strawberry cultivation and started supplying collection centres of various agriculture malls like Tata, Birla, Reliance, Big Basket, amazon, etc. Presently, the area under strawberry cultivation in those 3 tehsils has increased to 24 ha. A commercial vegetable nursery has also started importing mother plants, and strawberry saplings are being made available to farmers at the tehsil level.

The area dedicated to growing strawberries has increased, and as a result, local farmers have started processing their produce into jam, jelly, and juice in a processing unit. This has ensured economic stability for their families. Some farmers brought their fruits to the KVK processing laboratory, where juice was prepared and bottled. This strawberry juice is now being sold in metropolitan towns. Some farmers are also keeping their strawberries in cold storage. As a result, the standard of living of farmers has increased considerably. The strawberry value chain has developed both forward and backward linkages, generating employment opportunities. Several farmers from surrounding areas and different districts come to see their plots and crops to follow these practices and collect saplings. Presently, farmers of the tehsil lead in the district in terms of strawberry production. Contribution of KVK scientists in this regard deserves appreciation.

The "Chinnor" rice variety proved to be profitable for farmers in Madhya Pradesh (KVK, Balaghat)

Balaghat is a predominately rice-grown area that covers approximately 2.60 lakh ha. In which Chinnor rice variety is a traditionally grown, very popular, ceremonial, and finely scented rice variety of the Balaghat district of Madhya Pradesh, has been bestowed with a Geographical Indication (GI) Tag. GI tags are typically granted to products that have specific qualities, characteristics, or reputations that are associated with their geographical origin. By receiving a GI Tag, Balaghat Chinnor rice can command a premium price in the market. This can result in higher income for local farmers who grow and sell this rice. Now a days, due to the GI Tag and promotions on various levels, the price of rice has risen from ₹70–150/kg. The average yield is now 20 q/ha, and it spreads over a 1500 ha area. Small and marginal farmer who cultivates about 0.4 ha area and produces around 4–5 quintals rice, receives ₹50,000 to 70,000 net profit. The production cost is also low (₹13,200/acre) as compared to other popular varieties (₹15,800/acre). The farmers received net return of ₹35,000–55,000, whereas the popular rice variety provides ₹20,000–25,000. The new area under Chinnor variety is increasing year after year, and expected to reach 10,000 ha by 2024. The demand for Chinnor rice is coming from other states as well as foreign countries. Three FPOs are registered for Chinnor cultivation, processing, and value addition, with a marketing budget of ₹60 lakhs/annum. It has helped in achieving livelihood security of small and marginal Chinnor growers in Balaghat District.

Thirumalapadi-A zero burning village of crop residue in Ariyalur district of Tamil Nadu (KVK, Ariyalur)

Thirumalapadi village in Thirumanur block is located in the Ariyalur district of Tamil Nadu, in the Cauvery delta area, known for its favourable conditions for the cultivation of paddy and sugarcane. In the Thirumalapadi

Performance of Chinnor rice variety in farmer's field

Packed Chinnor rice for marketing

village, sugarcane is cultivated over an area of 3100 ha. Farmers usually take 5–6 ratoons of sugarcane and burn the sugarcane crop stubbles after every harvest to make the field clean and add fertility to the soil. However, this practice eliminates flora and fauna in the soil ecosystem and leads to greenhouse gas emissions. To address this issue, the KVK, Ariyalur undertook a series of interventions like OFT, FLD, method demonstrations, and awareness programs on the harmful effects of burning and the use of microbial decomposers (waste decomposer of NCOF and TNAU bio-mineralizer) for *in situ* decomposition of sugarcane trash. The efforts of the KVK resulted in a total avoidance of burning in 1,650 ha of land. Moreover, there was an average increase of 15.50% in productivity due to the enhanced fertility of the soil where sugarcane trash was decomposed *in situ*. This technology is now spreading to neighboring villages, including Kulamanikum, Sembiyakudi, Pudukottai, Aranmanikuruchi, and Thirumanur, in an area of 875 ha.

Blending taste of coffee with the goodness of mushroom-A novel initiative in agriprenuership (KVK, Kollam)

Mr. Lalu Thomas, a 45-year-old chef an ex expatriate from UAE who lost his highly remunerative job due to the Covid crisis in 2019. The unexpected loss of job forced Mr. Lalu to return to his native village, Thalavoor in Kollam district. Finding a job according to his expertise was very difficult. He started searching for other avenues for supporting his family. He started cultivation and marketing of mushroom, he learnt many new lessons about the market demand, shelf-life of mushroom and demand harvesting. The bigger challenge was the shelf-life. Harvested mushrooms lost freshness within days chence this situation forced him to think new methods for enhancing shelf-life. In this regard, he approached KVK, Kollam for support

Spraying of waste decomposer on sugarcane trash

to solve the problem of shelf life of mushroom. Then he participated in training on value added products of mushroom organised by the KVK. Major topics covered were, Food safety standardization, nutritional quality, packing labelling, marketing, financial aid from related agencies, etc. This programme motivated him to develop Mushroom based products. He juggled in different products based on mushroom, viz. health drink, soup powder, dried items, snacks, chocolate, soap and so on. He started his production and research at his home with the guideline of KVK scientists. It was a great success. His products were launched during the 17th SAC meeting of KVK Kollam by the then Director of Extension. Initially he faced constraints of rejected mushroom due to rotting but now the scarcity of mushroom has become a problem. Then, he got training and started mushroom spawn production. He continued experimenting in mushroom cultivation and product formulation. From this experimentation came the idea of mushroom coffee-Labae mushroom coffee. KVK home scientist helped him to successfully prepare a unique blend of coffee with different mushrooms. Its nutrient value, shelf-life, organoleptic evaluation studies were carried out under the supervision of KVK home scientist. District Industry Centre, included Mr. Lalu in PMFME scheme and he was able to establish his new unit with an outlay ₹10 lakhs. Coffee bean for the product is being collected directly from farmers of Wayanad district.

Labae mushroom coffee is 70% mushroom and 30% powdered coffee bean. This mushroom coffee is a blend of 5 different mushrooms. Disinfected mushroom is solar dried using specially designed solar dryer and powdered using pulveriser. Roasted and powdered coffee bean is blended with the mushroom. About 3000 kg fresh mushroom is required to make 250 kg finished product. The product was launched by the Hon'ble Minister for Industries, Law and Coir in the Government of Kerala. The premium product of mushroom coffee is ₹450/100 g. The company received 250 kg order from Abu Dabi based marketing company and many other companies are also ready to place their order but raw material is a constraint. To address the problem, KVK with Krishi Bhavan has initiated a model group-based production at village level for mushroom production. Model mushroom village will open employment opportunities for more than 300 educated youth. The panchayat committee has decided to help this venture with the help of KVK and Department of Agriculture. ❑

18.
Research for Tribal and Hill Regions

NORTH WEST HIMALAYAS

Breeder seed production: During the period under report, 17.453 tonnes breeder seeds of 49 released varieties/inbreds of 15 crops were produced and 16.054 tonnes breeder seeds were supplied to different seed producing agencies for downstream multiplication to foundation and certified seed.

Quality seed production: Around 1,433 kg nucleus seed of 40 released varieties of 15 crops were also produced following standard methods of maintaining genetic purity. In addition to this, 401 kg Truthfully Labelled (TL) seed of 09 varieties of 07 crops were produced and 258 kg TL seeds were supplied to different stakeholders.

Crop varieties released and notified

Crop	Variety	Area of adoption	Salient features
Wheat	VL Cookies (VL 2041)	Northern Hills Zone comprising Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Manipur and Meghalaya	• Possesses an excellent biscuit quality (spread factor) value of 11.7 (the highest in the country) and a mean grain hardness index of 22.6. • Average grain yield of 29.6 q/ha in rainfed and 49.8 q/ha irrigated conditions.
Finger millet	VL Mandua 400 (CFMV 5)	Madhya Pradesh, Karnataka, Bihar, Chhattisgarh, Jharkhand, Gujarat and Andhra Pradesh	• Average grain yield 34.7 q/ha. • Possesses high protein (8.5%, total polyphenols (0.52 mg GAE/g) and high antioxidant activity (10.93 mM Trolox equivalent/g dw).
Soybean	VL Soya 99	North Hill Zone (Himachal Pradesh and Uttarakhand)	• Average grain yield 23.66 q/ha. 20.18% oil content in seed and 4.84 q/ha oil yield. • Highly resistant reaction against the frog eye leaf spot (FLS) under hot spot conditions of NW Himalayas.
Field pea	VL Uphar (VP 1429)	Zone I (Himachal Pradesh, Uttarakhand, Jammu, Kashmir and Ladhakh)	• Early maturing variety. High green pod yield (115.52 q/ha), high selling percentage (>50%) and 8–9 seeds per pod.
Field pea	VL Madhuri VPSP 906-1)	Zone IV (North Indian plains)	• First edible pod variety released at National level with average green tender pod yield is 126.59 q/ha. • Entire pods are edible and harvested at the tender stage of the pod.

VL Cookies (VL 2041)


VL Mandua 400

VL Soya 99


VL Uphar (VP 1429)


VL Madhuri (VPSP 906-1)

State varieties released and notified

Crop	Variety	Area of adoption	Salient features
Lentil	VL Masoor 150	Uttarakhand (Organic conditions)	• Maturity: 155–160 days. • Small seeded for timely sown rainfed organic condition of Uttarakhand hills; average yield 8.41 q/ha). • Moderately resistant against wilt, rust, pod damage and aphids.
Field pea	VL Matar 64	Uttarakhand (Organic conditions)	• Maturity: 155–160 days. • For timely sown rainfed organic condition of Uttarakhand hills; average yield 9.91 q/ha) • Moderately resistant against wilt and powdery mildew.

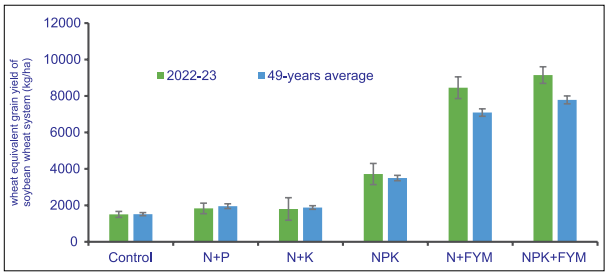
VL Matar 64

VL Masoor 150

CROP MANAGEMENT

Crop Production

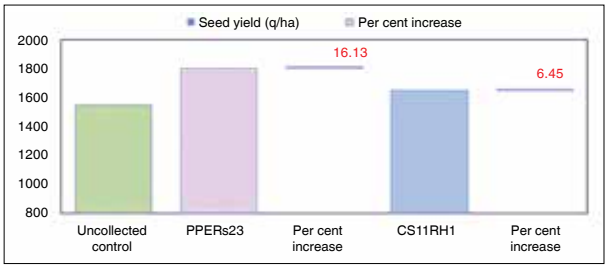
System yield of soybean-wheat cropping system influenced by long-term fertilization: A 49-years long-term experiment revealed that integrated use of farmyard manure (FYM) along with NPK or N alone improved the system yield of soybean-wheat cropping system (22.4 to 27.0%) under rainfed condition. However, long-term application of synthetic fertilizers alone reduces the yield (-20.3 to -117.4) of both crops compared to the first year of experimentation.



Wheat equivalent yield of Soybean-wheat system

Treatment	1973–74 (initial)	2022-23	% change
Control	33.0	15.2	-117.4
N+P	30.2	18.7	-60.9
N+K	36.0	19.5	-83.8
NPK	42.1	34.9	-20.3
N+FYM	51.2	70.9	27.8
NPK+FYM	60.4	77.9	22.4

Effect of Plant Growth Promoting (PGP) bacteria/ consortia on various crops: Treatment of finger millet (VL *Mandua* 379) seed with PGP bacteria/consortia [75% RDF (50% RDN + 25% N BY FYM) + *Pesudomonas*] recorded highest grain yield (18.99 q/ha) followed by [75% RDF (50% RDN + 25% N by FYM) + *Azotobacter* + *Pesudomonas*] (17.54 q/ha) over un-inoculated control (15.43 q/ha) with 75% RDF (50% RDN + 25% N by FYM). Treatment of wheat (VL *Gehun* 967) seed with PGP bacteria/consortia RDF (75% RDF + 25% N by FYM + *Azotobacter*) recorded highest grain yield (23.78 q/ha) over un-inoculated control (RDF) (18.28 q/ha).



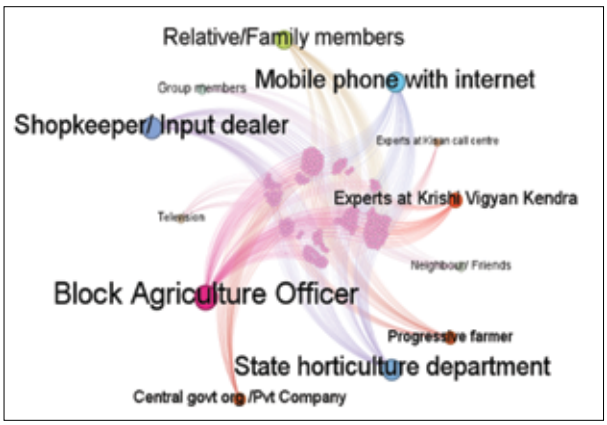
Under large field demonstrations, inoculation with PGP/PSB boinoculant *Pseudomonas* sp. PPERs23 and *Pseudomonas fragi* CS11RH1 enhanced seed yield of of VL *Sabji Matar* 15 by 16.1 and 6.5%, respectively over uninoculated control (15.50 q/ha).

Crop pollination through *Apis* and non-*Apis* bee pollinators in cucurbitaceous crops: The pollination efficiency and yield advantage studies were conducted in various cucurbitaceous crops. In snake gourd (*Trichosanthes tricuspidata*), the interaction between Indian bee (*Apis cerana indica)* and Bumble bee *(Bombus haemorrhodalis)* recorded 32.70% increase in seed yield and 43.60% increase in fruit yield. In round gourd (*Lagenaria siceraria*), the interaction between *Ceratina* sp. and *B. haemorrhodalis* recorded 54.69% and 48.50% increase in seed and fruit yield, respectively. Further in bitter gourd (*Momordica charantia*), *Ceratina* sp. and Indian bee in interaction recorded 106.70% and 73.55% increase in seed and fruit yield. Moreover, in ridge gourd (*Luffa acutangula*), *Apis cerana indica* and *B. haemorrhodalis* showed 39.74% and 66.75% increase in seed and fruit yield. However, in case of pumpkin (*Cucurbita moschata*), *B. haemorrhodalis* alone recorded 94.38% and 83.50% increase in seed and fruit yield respectively. It may be concluded that the wild insect pollinators play a significant role in yield enhancement in cucurbits along with their domesticated counterparts.

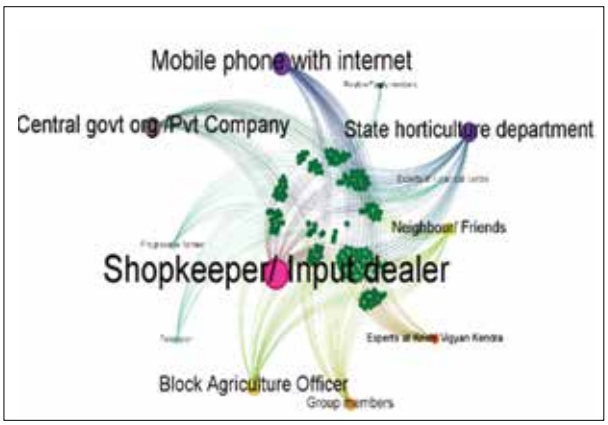
Agricultural information network usage among hill farmers of north eastern Himalayan regions: The study aimed to delineate and analyse the configuration of information networks of farmers with respect to the acquisition of information in north eastern hill regions covering 320 vegetable growers. Social network analysis was used to reveal the important sources as well as patterns of information access by farmers. For male farmers, Block Agriculture Officer/ATMA had the highest degree centrality, followed by shopkeeper/ input dealer and State horticulture department. For female farmers, shopkeeper/input dealer had the

List of superior pollinators in cucurbitaceous crops and their role in enhancement of seed and fruit yield

Crop	Superior pollinators	Seed yield increase over control	Fruit yield increase over control
Snake gourd	*Apis cerana indica* and Bumble bee	32.70%	43.60%
Round gourd	*Ceratina* sp. and Bumble bee	54.69%	48.50%
Bitter gourd	*A. c. indica* and *Ceratina* sp.	106.70%	73.55%
Ridge gourd	*A. c. indica* and Bumble bee	39.74%	66.75%
Pumpkin	Bumble bee	94.38%	83.50%



Social network structures among male farmers



Social network structures among female farmers

highest degree centrality. For males, Block Agriculture Officer/ATMA had the highest closeness centrality score and for females, shopkeeper/ input dealer had the highest scores. Factors determining agriculture network usage among female vegetable growers were landholding, farming experience, group membership and caste while age, education, landholding and hours dedicated to farming affected it among male vegetable growers.

Integrated Organic Farming System (IOFS) for livelihood, nutritional and economic security of small farm holders in Meghalaya: An IOFS model comprising of different enterprises, i.e. cereals, pulses, oilseeds, vegetable crops and climbing vegetables on protective structure all along the farm pond, fruits, dairy, fodder crops, central farm pond, duckery, farmyard manure (FYM) pit and vermicomposting unit was designed and tested on long term basis. The solid waste from dairy unit and farm was used for making FYM and compost. The model consists of a total area of 0.34 ha and a farm pond (0.046 ha) that can be put to use for aquaculture and duckery, and support crops with lifesaving irrigation. The model was demonstrated to 330 households in three villages, viz. Mynsain, Pynthor and Umden Umbathiang covering an area of about 300 ha. Results from beneficiaries who adopted the model showed that by merely investing an amount of ₹60,000 on IOFS, the farmers realized a net income of ₹65,000/ annum compared to rice mono-cropping or improved rice-vegetables cropping system. In this process, a total of 64.9 kg N, 19.8 kg P_2O_5 and 54.7 kg K_2O could be recycled showing that model has a potential to augment 98.03, 83.89 and 99.45% of N, P_2O_5 and K_2O hill based agro-ecosystems, respectively.

IOFS practiced in cluster approach in the adopted villages

Red cherry pepper (Dalle khursani): Remunerative organic crop of Sikkim: Red cherry pepper (*Capsicum annuum* var. cerasiforme) is one of the valuable cash crops of Sikkim. It is grown in almost every household in different cropping system, i.e. homestead cultivation, mono-cultivation and mixed cropping, etc. This chilli contains capsaicin which produces different pungency levels as well as carotenoids and phenolic compounds and is being used as natural pigment and antioxidant agents. However, the Scoville scale indicates that its pungency is very high and is in the range of 1,00,000–3,50,000. Fruit yield ranges from 80–150 q/ha with an average productivity of 120 q/ha. The average net return of ₹10,25,000/ha results in very high benefit:cost (B:C) ratio of 6.8. Production efficiency and economic efficiency of red cherry pepper are recorded as 63.15 kg/ha/day and ₹5,394.7/ha/day respectively. Red cherry pepper is selected as one district one crop for Gangtok district of Sikkim.

Micronutrient management in cauliflower and tomato in acidic soils in Meghalaya: Field experiments were conducted to investigate the influence of graded micronutrient doses, viz. zinc sulphate (zinc-21%), borax (boron-10.5%) and ammonium molybdate (52%) on the yield and quality of cauliflower (cv. Seminis Megha) and tomato (Arka Abhed) in Meghalaya condition. Results revealed that the cauliflower productivity increased substantially, i.e. up to 64% over control by the application of zinc sulphate (@15 kg/ha), borax (@15 kg/ha), and ammonium molybdate (@2.0 kg/ha) and two foliar applications of micronutrients, viz. zinc sulphate @0.25%, borax @0.10%, and ammonium molybdate @0.10% at 15–20 days-intervals beginning at 30 days after sowing (DAS).

In tomato, soil application of zinc sulphate and borax @5 kg/ha + ammonium molybdate @0.5 kg/ha along with 3 foliar applications (zinc sulphate and borax each @0.25% and ammonium molybdate @0.10%) at 15 days-interval starting from 30 days after transplanting (DAT) significantly increased the yield of tomato by 36.8% in Meghalaya condition. Foliar application of micronutrients increased the ascorbic acid content, whereas soil alone or soil + foliar application reduced its overall ascorbic acid content. Soil application along with 3 times foliar application of micronutrients found to be effective in increasing tomato productivity in the NEH region.

Tribal Sub Plan (TSP)

Technology Demonstrations

Maize FLDs in Kashmir: FLDs of maize hybrids VLQPMH 59 were conducted in Kashmir in 3 ha (72 nos.) in collaboration with Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir (SKUAST-K). FLDs were conducted in district Anantnag and Kupwara. The yield of VLQPMH 59 ranged from 50.0–62.0 q (average 55.0 q) and gain over the local cultivar ranged from 28.2–87.5% (average 56.0%). The yield of local cultivar ranged from 31.0–39.0 q (average 35.4 q).

For demonstration in the newly adopted tribal clusters, a total of 80.0 q seed of newly developed and popular wheat varieties from the institute i.e. VL *Gehun* 967, VL *Gehun* 953, VL *Gehun* 2014 and VL *Gehun* 907 was supplied to Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu (SKUAST-Jammu) for conducting demonstrations in tribal areas of district Rajouri, Kathua, Poonch, Udhampur, Kupwara and

Plastic mulch for Red cherry pepper

Red cherry pepper cultivation in farmers' field

Overview of experimental setup for cauliflower

Overview of experimental setup for tomato

SUCCESS STORY

Addressing the Nutritional Security through Improved Technologies

The challenge

Maize is India's third most important cereal crop next to rice and wheat. In spite of this fact, its production and productivity is relatively low, mainly due to the non-availability of quality seeds of improved varieties, less crop management and crop care by the farmers and poor post-harvest processing technologies. Moreover, normal maize is deficient in essential amino acids, particularly tryptophan and lysine; consequently, people consuming normal maize as a staple diet suffers from protein malnutrition. Quality Protein Maize (QPM), possessing opaque-2 (o2) allele in the homozygous recessive condition in the presence of endosperm modifiers, contains nearly twice the amount of tryptophan and lysine as compared to normal maize. The biological value of QPM's protein is, therefore, almost double (80%) of the normal maize (45%) and its quality is equivalent to 90% that of milk protein, i.e. casein.

The solution

To enhance the nutritional security in the hill region, institute has developed five QPM maize hybrids along with their package of practices. Among the five QPM hybrids, VLQPMH 59 is a recently developed hybrid recommended for cultivation in Uttarakhand hills. It is early in maturity (80–90 days), moderately resistant to turcicum and maydis leaf blight diseases and rich in nutritional quality (Tryptophan 0.77%, Lysine 3.33%). Post-harvest activities of maize are tedious and time-consuming, for which the Vivek Maize Sheller developed by the institute is the solution to replace manual shelling.

The application

Frontline demonstrations of bio-fortified (QPM) hybrid VLQPMH 59 were conducted in Dhanpau- Lakhwad tribal village cluster and Kwanu tribal village cluster, Dehradun, in about 30 acre area to enhance maize production, productivity and nutritional security of the tribal farmers. The yield of VLQPMH 59 was about 1.5 to 2 times that of their local cultivar. The yield data collected showed an increase ranging from 38.5 to 74.6% over the local cultivar. The farmers also reported that damage due to fall armyworm was relatively less in the hybrid variety than in the local cultivars. It was also less susceptible to diseases than the local cultivars. Due to its shorter stature and sturdy stem, it suffered less lodging damage. Bird damage was also relatively less due to tighter husk than the local cultivar. The maturity was also at par with that of the local cultivar and VLQPMH 59, therefore, fitted well in their existing cropping sequence.

The impact

According to the farmers, the taste of rotis made from VLQPMH 59 flour, was good than that of their local cultivar. Though the grain of VLQPMH 59 was sold relatively at lower rate in the local mandi @ ₹20–22/kg, compared to their local cultivar @ ₹24-–25/kg, the overall gain was much higher due to its significantly higher yield than the local cultivar. The income from 1 acre of maize cultivation increased from ₹44,000 to ₹46,200 with a net benefit of ₹21,905 in the improved practice. The benefit-cost (B:C) ratio rose from 0.92 to 1.87 with the interventions. Overall, the farmers earned an additional benefit of ₹12,600 from additional yield and use of maize sheller compared to the conventional practice. The sheller saved considerable time and energy compared to manual shelling and significantly reduced the drudgery involved in manual shelling.

Anantnag in Jammu and Kashmir. The seed was shared with more than 300 tribal farmers in the Jammu and Kashmir regions. The improved wheat varieties showed an average yield advantage of 16–18% over the local cultivars of the tribal farmers.

Establishment of Farmer Participatory Seed Production System: *Rajmash* is the main cash crop of remote villages (Kailashpur, Malari, Gamshali, Niti etc.) of Niti Valley. The climatic conditions for taking seed crop of French bean are very congenial and hence as part of the institute's work plan to establish a farmer-participatory seed production system at local level. Seed production programme was undertaken at Kailashpur (near international border with China) in Chamoli district of Uttarakhand during rainy (*kharif*) season. A total of 7.17 q seed of French bean variety VL Bean 2 was procured from 7 Self Help Groups of the village. However, approx. 90% VL Bean 2 seed of last year produce was distributed among 500 tribal farmers of Niti-Mana valley. Farmers got 77.14% hike in yield as compared to their local rajmash with 175.55% income enhancement.

Frontline demonstrations of VLQPM Hybrid 59 in Kashmir during *kharif* 2022

SUCCESS STORY

Improved Wheat-Production Technology

The challenge

The availability of quality wheat seed is a major concern for the farmers of Uttarakhand hills. Moreover, there is a need to demonstrate the yield potential of newly released varieties to popularize it among the farmer's community. VL *Gehun* 967 is a newly released and notified wheat cultivar having excellent agronomic characteristics which need to be popularized among farmers.

The solution

In order to enhance the quality seed availability to the farmers and to demonstrate the yield superiority of the newly released wheat variety, VL *Gehun* 967 was included in the on-going farmer participatory seed production (FPSP)-cum-varietal demonstration programme of the institute in the Tharu tribal villages, Jhankat (N 28°949056°, E 79°791728°) and Nakulia (N 28°58.832', E 79°42.876') of Sitarganj (district Udham Singh Nagar, Uttarakhand). The farmers of these villages showed their keen willingness for the FPSP of VL *Gehun* 967 due to the associated monetary benefits and potential performance of the variety.

The application

The farmers involved in the participatory seed production were regularly given institutional support in the form of quality seed of the variety, regular monitoring of their fields by the scientific team for a range of seed production activities like weed management, insect and disease management, roughing activities and other on-field training-cum-demonstration activities. Besides, farmers were also trained at the institute to gain technical know-how regarding good agricultural practices as well as for quality seed production. In the process, the new variety is also being disseminated and popularized to the nearby region farmers.

Farmers' Participatory Seed Production (FPSP) of Wheat Variety VL *Gehun* 967

The impact

From the last 3 years, tribal farmers of the Sitarganj area have been cultivating the variety and producing truthfully labelled (TL) seeds of the wheat variety VL *Gehun* 967. The details of the seed procured from the farmers are as follows:

Year	Procurement (q)	Remittance to farmers (₹)
2019–20	41.38	91,036
2020–21	142.00	3,40,800
2021–22	134.57	3,22,968
Total	317.95	7,54,804

The income received by seed-producing farmers by direct procurement of seed by the institute was ₹7.54 lakhs. Apart from the monetary benefits, the technology was received by the farmers at an accelerated rate and the variety demonstrated a yield advantage of 5–7% over the local cultivars.

F_1 seed production of VMH 45 in Kashmir during *kharif* 2022

Wheat seed production demonstration-cum-farmer participatory seed production of wheat varieties VL *Gehun* 829 and VL *Gehun* 967 was organized in 1 acre each in Yamunakhadar (Vikasnagar, Dehradun) during winter (*rabi*) season of 2021–22. A total of 19.66 q seed (13.33 q VL *Gehun* 829 and 6.33 q VL *Gehun* 967) was produced. The procured seed was used for outreach programmes of the institute.

F_1 seed production of VLQPM Hybrid 45: Parental seed of VMH 45 was provided to SKUAST-K for taking up F_1 seed production during *kharif* 2022. F_1 seed production of VMH 45 was taken up SKUAST-K in farmer's field and 1,000 q seed of VMH 45 was produced. The seed was procured for use in outreach programmes of SKUAST-K.

Scheduled Caste Sub Plan (SCSP)

Polyhouses Distribution: 43 portable polyhouses with a surface area of 62.4 square meters each were

SUCCESS STORY

Adoption of Improved Varietal Technologies of Pulses and Oilseeds

The challenge

Pulses and oilseeds are one of the major *kharif* pulses in north western Himalayan hills particularly, in the state of Uttarakhand. These crops have an integral role in the sustainability of hill agriculture as well as in providing livelihood and food security to the millions of rural inhabitants. Lack of quality seeds of improved varieties, poor crop management, agricultural mechanization and post-harvest processing rendered farmers of the region devoid of reaping the potential benefits from its cultivation.

The solution

Improved high yielding cultivars of soybean (VL Soya 89 and VL *Bhat* 201) have appreciable yield potential of 23–24 q/ha and 15–16 q/ha, respectively along with resistance against frog eye leaf spot, bacterial pustules, pod blight and other diseases prevalent in hilly region of Uttarakhand. Improved variety of horse gram VL *Gahat* 19 was also introduced in farmer fields as demonstration. This variety has a yield potential of 8–10 q/ha as compared to local cultivars along with resistance against anthracnose and leaf spot. In addition to improved varieties, scientific crop management practices, farm mechanization implements and post-harvest processing methods offer an excellent solution for enhancing the profitability of farmers. High yielding varieties along with improved crop management practices were demonstrated in different villages of Almora district, where soybean, *Bhat* and horse gram were grown in large scale.

The application

In Jyoli village, Hawalbagh, Almora, frontline demonstrations (FLDs) of *kharif* legume crops were conducted. Thirty three farmers (26 female and 7 male) participated in the conduction of FLDs and enthusiastically introduced improved varieties of these crops in their fields. Frontline demonstrations of VL Soya 89 and VL Bhat 201 were conducted in 4 ha area whereas VL Gahat 19 covered 2 ha area in the farmer's fields. Improved small tools like VL Sickle, VL Kutla, VL Hand hoe, VL Garden rake and VL Line maker etc. were also introduced for ease in practicing the improved agricultural practices from sowing to harvesting of the produce. Awareness for the preparation of value added products like tofu and milk were also created among farmers for income generation.

The impact

As a result of adopting improved varietal technologies along with recommended package of practices under FLDs, appreciable yield enhancement and profitability was realized at farmers field. With full package of practices for soybean cultivation, the crop yield improved significantly in soybean by 20–25% than traditional varieties and cultivation practices followed in the region. However, this increase was more with black soybean varieties i.e. 35–40%. The income of farmers with the improved varieties was increased from ₹23,911 to 46,692 in soybean and ₹33,943 to 46,167 in black soybean from per hectare land. Using full package of practices for cultivation, crop yield improved remarkably from 30–35%.

provided to SC farmers in Bageshwar and Nainital districts. These polyhouses are intended to support year-round cultivation of vegetable crops.

Agriculture Input Distribution: Several inputs were distributed to SC farmers, including polytunnels, seeds of improved varieties (both cereals and vegetables), toolkits, solar dryers, and bee boxes. Additionally, live demonstrations were conducted on honeybee keeping and the use of power-operated knapsack sprayers during the Kisan Mela.

Training Program on Skill Development: A 10-day hands-on training programme was organized to develop skills in youth from adopted villages. This training aimed to enable them to repair and maintain machinery and equipment distributed in their villages. The training covered various aspects, such as measurement, metal cutting, welding, and machinery repair, creating self-employment opportunities for the trainees.

Training Program on Oyster Mushroom Cultivation: A two-day training program on oyster mushroom cultivation was conducted for farmers in the adopted village of Lakahni, Bageshwar. The training covered various aspects of mushroom cultivation, including substrate preparation, spawning, and disease and pest management, helping farmers diversify their agricultural practices.

SUCCESS STORY

Enhanced Income Through Protected Vegetable and Mushroom Production

The challenge

Mr. Madan Mohan is a young farmer of village Uderkhani of district Bageshwar. His primary occupation is agriculture; however, previously he was also engaged in copper smithy. He is having around 12 nali land, out of which only 03 nali is irrigated. He has been growing various crops for their family need. But enhancement of income has always been a challenge.

The solution

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora through its KVK, Kafligair, Bageshwar started working in this village under Schedule Cast Sub Plan (SCSP) scheme during 2020–21. In a farmers meeting of this programme Mr. Madan Mohan showed interest for vegetable production in polyhouse and mushroom production. But he was not having any experience or skill of this venture. Moreover, his economical condition also not allows investing for these enterprises. Therefore, through extending the benefits of SCSP project, one VL Portable Polyhouse was constructed in his field as well as 5 q pasteurized compost was also provided to him during 2022. Training as well as advice for both the enterprises was also provided to him by KVK (ICAR-VPKAS), Kafligair, Bageshwar.

The application

Mr. Madan Mohan took keen interest in protected vegetable and mushroom production. He remained in touch with ICAR-VPKAS and performed all the processes and followed the advice. The close monitoring, awareness, zeal to grow a new product of the area and sincerity led to produce a bumper crop of button mushroom and he produced 1 quintal saleable button mushroom. Likewise, he got 7.5 q vegetable production of tomato, capsicum, cabbage, cauliflower, French bean from VL Portable Polyhouse measuring 62.4 square meters. Most importantly, these produces were off-season when there was no glut available with the local retailers from Haldwani mandi.

The impact

With all these efforts from training, demonstration, adoption and marketing wrote a story of success and from these two enterprises he earned an income of ₹41,250.00 that was double than his previous usual farm income. Moreover, his interest and hard work and continuous learning habit let these both the enterprises highly profitable for him as well as became inspiration for the fellow farmers. His efforts were also recognized as felicitation in ICAR-VPKAS, Almora Kisan Mela.

Thus, these efforts and technologies are creating belief among the marginal schedule caste farmers and they are realizing that the suitable technologies are for them also that are bringing change in their life.

Frontline Demonstration of Improved Varieties of Finger Millet: Frontline demonstrations were conducted to showcase the benefits of two improved finger millet varieties (VL 376 and VL 352). These demonstrations highlighted the yield advantages of these varieties and promoted their adoption, along with management practices, to increase the profitability of finger millet production.

VL Sweet Corn Hybrid 2

Frontline Demonstration of VL Sweet Corn Hybrid 2: Frontline demonstrations were conducted in Dadim village, Nainital district, under the SCSP program. These demonstrations showcased the yield of VL Sweet Corn Hybrid 2, with green cob yields ranging from 157.1 to 174.8 q/ha. A Maize Field Day was also organized to further promote this hybrid corn variety.

Hands-on Training and Demonstration for Drip Irrigation Installation: A hands-on training and demonstration on the installation of drip irrigation

Drip irrigation installation

systems were organized for farmers. These systems were installed under polyhouses constructed at farmers' fields in various villages, including Darim in Nainital District, and Lakhani and Uderkhani in Bageshwar District. This initiative aimed to promote efficient water use, especially in hilly regions, by integrating drip irrigation with water harvesting.

Fabrication of VL Poly-tanks at farmer's fields: Polytank technology was demonstrated through farmer participatory approaches. Poly tanks were constructed in Darima village of Nainital district and Lakhani and Uderkhani villages of Bageshwar district, Uttarakhand. The hands-on training included tank construction, micro-irrigation system installation, and the use of poly sheets. Farmers were actively involved in this initiative, and they shared the cost of site preparation and tank construction.

Brick Lining of Polytanks: The use of brick lining for polytank technology was demonstrated at farmers' fields for rainwater harvesting and spring water storage for irrigation, especially during lean periods. This approach increased water productivity per unit of area, benefiting vegetable production in hilly terraced regions.

Kisan Diwas* (Farmers' Day) and *Jal Shakti Abhiyan: *Kisan Diwas* was organized in the SCSP village of Uderkhani village of Bageshwar district, Uttarakhand on 23 December, 2022, involving the participation of 75 farmers. The event aimed to create awareness about the challenges faced by hill farmers and promote sustainable agriculture. Officials provided information on innovative farming techniques, market trends, and government schemes. An awareness programme under *Jal Shakti Abhiyan* was also conducted in the village of Uderkhani on 18 August, 2022. This programme focused on water conservation, water resource management, and rainwater harvesting to ensure water security and sustainability in hilly regions.

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IP, Organization and Management

Department of Agricultural Research and Education

The Department of Agricultural Research and Education (DARE) was established in the Ministry of Agriculture, Government of India in December 1973 to coordinate and promote agricultural research and education in the country. DARE provides necessary government linkages for the Indian Council of Agricultural Research (ICAR), the premier research organization for coordinating, guiding and managing research in areas including crop science, horticulture science, natural resource management, agricultural engineering, animal science, fisheries science, agricultural education and agricultural extension in the entire country. With 113 ICAR institutions and 74 agricultural universities spread across the country, this is one of the largest national agricultural research systems in the world. Apart from ICAR the Department of Agricultural Research and Education has other autonomous bodies, viz. Agricultural Scientists Recruitment Board, the Central Agricultural Universities (CAUS) at Imphal (Manipur), Jhansi (Uttar Pradesh), and Pusa (Bihar); Agrlnnovate India Limited, New Delhi, under its administrative control. The Agrlnnovate India Limited (incorporated on 19 October 2011) aims to work on the strengths of DARE and ICAR and promotes, and spreads its research and development outcomes. The Agrlnnovate India Limited is an extended independent commercial outfit, which is expected to capitalize on the vast network of the ICAR institutes where the researchers are engaged in their mission to innovate and harness science to provide citizens access to food, nutrition, livelihood and income security.

Indian Council of Agricultural Research

The Indian Council of Agricultural Research is an autonomous organization under the Department of Agricultural Research and Education, Ministry of Agriculture and Farmers Welfare, Government of India. Formerly known as the Imperial Council of Agricultural Research, it was established on 16 July 1929 as a registered society under the Societies Registration Act, 1860 on the recommendations of the Royal Commission of Agriculture. It was reorganized in 1965 and again in 1973, with its Headquarters located in Krishi Bhawan, New Delhi, with support facilities in Krishi Anusandhan Bhawan 1 and 2 and NASC Complex, Pusa, New Delhi. The Union Minister of Agriculture and Farmers Welfare is the President of ICAR. The Principal Executive Officer of the ICAR is the Director General, who also functions as Secretary, Department of Agriculture Research and Education, Government of India. The General Body of the ICAR Society, headed by the Union Minister of Agriculture and Farmers Welfare is the supreme authority of the ICAR. Its members include; Ministers for Agriculture, Animal Husbandry and Fisheries, and the senior officers of the various state governments, Members of Parliament and the representatives from industry, research institutes, scientific organizations and farming community. The Governing Body headed by the community Director General, who is also the Secretary, DARE is the chief executive and decision making authority of the ICAR. The Governing Body consists of eminent agricultural scientists, educationist, public representatives and representatives of the farmers. It is assisted by the Accreditation Board, Regional Committees, Policy and Planning Committee, several Scientific Panels and Publications Committee. In scientific matters, the Director General is assisted by 8 Deputy Directors General, one each in (i) Crop Science, (ii) Horticulture Science, (iii) Natural Resource Management, (iv) Animal Science, (v) Agricultural Engineering, (vi) Fisheries Science, (vii) Agricultural Education, and (viii) Agricultural Extension, who are also assisted by Assistant Directors General, and are the Heads of their Subject Matter Division (SMDs) for the entire country. SMDs are responsible for extending all technical and financial guidance and support to the research Institutes, National Research Centres and the Project Directorates within their respective Divisions. In addition, Assistant Directors General of National Agricultural Science Fund (NASF), Coordination, Plan Implementation and Monitoring, Intellectual Property and Technology Management and Human Resource Management also assist the Director General in their respective job roles. The research set up of the ICAR include 113: 71 Research Institutes, 6 National Bureaux, 24 Project Directorates and Agricultural Technology Application Research Institutes, 12 National Research Centres, 82 All India Coordinated Research Projects + Network Research Projects. The Directorate of Knowledge Management in Agriculture (DKMA) functions as communication arm of the ICAR responsible for delivery of information/knowledge generated by the network of the ICAR and addresses mandate of ICAR through Publications, Information, Social Media and Public Relations Unit. The ICAR promotes research, education and frontline extension activities in 74 Agricultural Universities, which include 63 State Agricultural Universities, 4 Deemed Universities, 3 Central Agricultural Universities, and 4 Central Universities with agricultural faculty by giving financial assistance in different forms.

In the vibrant landscape of Indian agriculture, the Indian Council of Agricultural Research (ICAR) stands as a beacon of innovation and progress. As we mark the auspicious occasion of ICAR's 95th Foundation and Technology Day, it is only fitting to reflect on the profound impact the organization has had on shaping the future of agriculture in India. ICAR's commitment to agricultural diversity is evident in the development of 346 varieties of food grains and 99 varieties of horticulture crops, including 123 bio-fortified varieties. This multifaceted approach not only addresses the challenges of food security but also places a strong emphasis on nutritional well-being. The mapping of efficient cropping system zones represents a strategic leap towards optimizing agricultural production and resource management. ICAR's meticulous efforts in this regard promise to make agriculture not only more productive but also more sustainable, aligning with the global call for responsible farming practices. Fertigation schedules for 24 crops mark a paradigm shift in nutrient management, ushering in a new era of enhanced crop productivity. By focusing on the very foundations of plant health, ICAR ensures that farmers have the tools to cultivate healthier, more resilient crops. The development of 28 new equipment and machineries by ICAR is a testament to its commitment to mechanization and modernization in agriculture. These innovations promise to make farming more efficient, less labor-intensive, and in tune with the demands of a rapidly evolving agricultural landscape. ICAR's foray into vaccine development for both COVID-19 and livestock diseases, alongside cutting-edge diagnostics, underscores the organization's dedication to safeguarding the health of both animals and humans. This dual focus exemplifies ICAR's holistic approach to agriculture, where the well-being of livestock and farmers go hand in hand.

ICAR's foray into robotics research is a bold step that pushes the boundaries of agricultural science. By exploring new avenues in robotics, ICAR is not just embracing the future but actively shaping it, laying the groundwork for a more technologically advanced and sustainable agricultural sector. The revolution witnessed in the dairy and fisheries sector due to ICAR's efforts has far-reaching implications. Beyond economic growth, these developments contribute significantly to the food, nutrition, and livelihood security of the country. ICAR's research doesn't merely address immediate challenges but actively contributes to building a resilient and sustainable future.

In the grand tapestry of regional agriculture, ICAR's research emerges as a key player. Its role in feeding a growing population, providing a healthy diet, protecting the environment, and addressing the climate crisis cannot be overstated. As we celebrate ICAR's 95 years of excellence, we also look forward to a future where its research continues to be a driving force in shaping a sustainable and prosperous agricultural landscape in India and beyond.

ADMINISTRATION

Filling up of vacant posts

During the year, following posts were filled up under the promotion quota: 4 Director/CAO (Senior Grade), 2 Director (F)/Comptroller, 6 Deputy Secretary/CAO, 6 Deputy Director (Finance)/CFAO, 4 Under Secretary, 7 Senior Administrative Officer, 6 Senior Finance and Account Officer, 1 Law Officer, 2 Principal Private Secretary, 7 Administrative Officer, 7 Finance and Accounts Officer, 5 Section Officer (Hqrs), 16 Assistants (Hqrs) and 3 LDCs (Hqrs).

Financial up-gradation granted under MACP scheme

During the year, 21 eligible officers and staff of ICAR were granted the benefits of financial up-gradation under the Modified Assured Career Progression Scheme at ICAR Headquarters.

Finance: The Revised Estimates in respect of DARE/ICAR for 2022-23 were of ₹ 8,658.89 crores. An internal resources of ₹355.13 crores (including interest on Loans and Advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during the year 2022-23. The total allocation Budget Estimates for 2023-24 are of ₹ 9,504.00 crores.

INTELLECTUAL PROPERTY AND TECHNOLOGY MANAGEMENT

National Agriculture Innovation Fund (NAIF)

Intellectual property protection

Patents: During the period under report, 88 new Patent Applications were filed in different subject domain of agricultural sciences at Indian Patent Office (IPO). The cumulative figure of patent applications at ICAR has now risen to 1,543 applications. IPO had granted the 81 patents, which made ICAR's cumulative number of granted patents to 536. In this process 41 ICAR institutes were involved to protect their innovations, whereas IPO has also published 82 patent applications, out of these 12 applications were filed in the current reporting period.

Plant varieties: To protect the Plant Varieties, 23 varieties were filed at Plant Varieties and Farmers' Rights Authority (PPV&FRA). For applications filed earlier, 73 varieties were granted registration certificates

IP Portfolio

Council has submitted 307 applications through its 70 institutes to protect its intellectual assets at Copyright Office, IPO, and PPV&FRA.

during this period; which raised the cumulative figure of registered varieties to 1,454.

Copyrights: During the period under report 141 applications were filed by 32 ICAR institutes. A total of 601 filed copyrights have been thus recorded from different ICAR institutes.

Designs: Eighteen applications were filed by 9 ICAR institutes, which has risen the cumulative figure to 105.

Trademarks: Thirty seven trademark applications were filed by 18 ICAR institutes for different products and processes. Till date a total of 255 trademark applications have been filed.

Capacity building activities

To create awareness in the subject area of innovation management and technology transfer, different ICAR institutes have organized various capacity building programmes at institute/zonal/national level. In this process, 46 ICAR institutes were organized 277 awareness generation programs/interface/product-specific meets/workshops/seminars, wherein 20,000 plus scientists/researchers/business professionals/farmers/social workers were benefited. In order to expose the scientific and technical staff to specific nuances of intellectual property and technology management issues scientists were deputed to attend capacity building programmes organized by different public and private organization.

To create subject specific awareness on IPR issues among scientists of the council, 35 institutes were visited physically and organized different discussions, workshops and meetings where subject experts were invited from outside agencies viz. Law Faculties of Delhi University, Technology Information, Forecasting and Assessment Council (TIFAC), Indian Institute of Technology, Kharagpur; Law College, Pune etc.

Outreach activities

ICAR has celebrated World Intellectual Property Day on 26 April, 2023, as per World Intellectual Property Organization's (WIPO) theme of this Day in 2023 which was "Women and IP: Accelerating Innovation and Creativity". World IP Day was an opportunity to highlight the importance of IP rights, such as, patents, copyrights, designs, trademarks, and plant varieties for encouraging innovation and creativity among scientific fraternity of the Council.

Secretary, DARE and DG, ICAR gave a message on this occasion to all the ICAR institutes. In the spirit of above message, follow-up action was taken by IP and TM Unit. All the ICAR institutes celebrated this event and all the scientific, technical and other staff participated through online/offline mode. These sessions were addressed by women scientists/women IP experts from different public and private organizations who shared their knowledge and experience. The celebration of this event was published in different soft, print, and social media websites.

Start-up Master Class Series: A four-week long capsule of various sessions on start-up activities, was organized with the support of different domain specific experts/speakers/start-ups where all relevant topics to various facets of start-ups' trajectory were covered. This programme was attended by all ICAR's Agri-Business Incubation Centres (ABICs) based Start-ups, where 300 plus registrations were recorded ICAR-IARI, New Delhi, was the nodal centre.

***SAMAGRA*-Enabling the incubators:** A sensitization workshop to create an awareness as well as planning for future endeavours at ICAR's ABICs network, a residential programme was organized at ICAR-NASC Complex where different lectures were delivered by subject exerts, and also organized education visits to line departments, viz. start-up India. All the ABICs of ICAR network participated in this programme.

ICAR-industry/stakeholders meets: To showcase the ICAR's technology basket and to bridge the gap between industry and academia 11 institute specific industries/stakeholders meets were organized in the sectors of fruit and vegetable (ICAR-CISH, Lucknow; ICAR-CIAH, Bikaner; ICAR-CITH, Srinagar; and ICAR-IIHR, Bengaluru), seed planting material (ICAR-IIRR, Hyderabad), animal based products and process

Tech-Transfer

Institute Technology Management Units (ITMUs) at 81 ICAR Institutes signed 1047 licensing agreements with 675 public and private organizations/individuals for transferring their technologies/innovations/know-how.

Activities

were signed for Consultancy/Contract Research and Service with 251 public and private organizations. In this process 54 ICAR institutes were involved from different Subject Matter Divisions, by providing different professional services.

(ICAR-CSWRI, Avikanagar; ICAR-NRC on Mithun, Jharnapani; and ICAR-NMRI, Hyderabad), food processing (ICAR-CIPHET, Ludhiana), and natural resource management (ICAR RC for NEH, Barapani, and ICAR-IISWC, Dehradun).

Technology transfer/commercialization

This year, 691 licensing agreements were signed with 463 public and private organizations and farmers/ entrepreneurs. In this process 64 ICAR institutes were involved from different Subject Matter Divisions, and transferred 381 technologies in different disciplines which included Animal Production Technologies; Crop Production Technologies; Farm Machinery and Tools; Fish Farming and Processes; Food Processing Technologies; Plant Protection Technologies; Seed and Planting Material; Textile Process; and four technologies from allied sectors.

The highest number of technology licensing agreements were signed by the ICAR-IARI, New Delhi (150); followed by ICAR-IIHR, Bengaluru (83); ICAR-CPCRI, Kasaragod (58); ICAR-NRC Banana, Tiruchirappalli (30), ICAR-CARI, Izatnagar (28), which accounts 50% of total licensing.

Out of 691 licensing agreements, 265 were signed with IP protected technologies (i.e. protection under Design/Patents/Trademark/Copyright/PPV&FR registry) which secure 38.35% share of total licensing.

Professional service: This year, 356 agreements

Incubation Fund

To enhance the agri-business environment at Council 50 Agri-Business Incubation Centers (ABICs) have been supported at various institutes for facilitating the entrepreneurs/innovators/scholars/start-ups. During the reporting period, these centers had facilitated 559 such stakeholders for their business incubation activities. These efforts, motivated 192 entrepreneurs/startups to initiate their own business. To provide awareness and training on agri-business enterprises 171 Entrepreneur Development Programmes (EDPs) were organized by these centers, wherein 3,665 stakeholders were benefitted. To boost-up the partnerships with public and private organization 804 meetings/negotiations/ technology discussions were organized. These centers were also visited by different technology seekers/ inventors/business people/VIP/VVIP/ foreigners.

ICAR has several laboratories that are engaged in various types of services/testing, both for internal and external clients. It is important that any such testing is done in a standardized protocol and environment, which uses a mechanism that ensures that the laboratory produces valid test results.One such mechanism is accreditation of these laboratories using an international standard, i.e. ISO/IEC 17025:2017 “General requirement for the competence of testing and calibration laboratories”. Worldwide, this standard is used by Accreditation Bodies to accredit testing and calibration laboratories.

SUCCESS STORY

Mr. C. Arivumani is a sole proprietor of Imaya Marketing and having 20 years of experience in FMCG sector as a distributor in marketing. With the aim of starting his own production cum marketing value chain he approached the ICAR-National Research Center on Banana, Tiruchirappalli. The banana central core stem, once viewed as a mere byproduct, is emerging as a valuable resource in various sectors. Entrepreneurs who recognize its potential and are willing to explore innovative ways to use this often-overlooked part of the banana plant can find exciting opportunities for business growth and sustainability. He prepared juice from with the Banana central core stem along with pickles from banana flower. He was incubated at ABI and currently producing 2,000 liters of RTS/ month which is having the value of 1.5 lakhs/month. ICAR-NRCB extended its support for his trademark registration.

To prepare all ICAR laboratories ready for this accreditation with National Accreditation Board for Testing and Calibration Laboratories (NABL), which is a constituent board of Quality Council of India (QCI), Council has emphasized on capacity building of its lab-based scientists where they can register their laboratories under NABL and maintain its services. In the reported period Council had organized six NABL Assessor trainings at its different institutes, viz.ICAR-NAARM, Hyderabad (24); ICAR-NDRI, Karnal (19); ICAR-CIFRI, Barrackpore (19); ICAR-NIVEDI, Bengaluru (22); ICAR-CIFE, Mumbai (22); and ICAR-IVRI, Izatnagar(18) where 124 scientists were trained on these aspects. With all these efforts 15 ICAR labs got accredited in accordance with the Standard ISO/IEC 17025:2017, and many more are in process.

Progressive Use of Hindi

Various useful programmes for public utility and farmers were organized by the institutions of the Council in Hindi and Regional Languages. All activities including agriculture extension related to KVKs located in Hindi speaking areas were also performed in Hindi and Regional Languages. Various publications on

SUCCESS STORY

Geetha's Home to Home, Thrissur, Kerala

A woman entrepreneur from Thrissur, Kerala, being disabled never stopped her from achieving her goals. She started Geetha's home to Home during the pandemic time of 2020. In her own brand developed a 'superfood supplement' *Curcumeal* using turmeric blended with other healthy ingredients. This product was the output of her two years research in turmeric value addition. During the course, she understood the value of high curcurmin turmeric varieties from ICAR-Indian Institute of Spice Research (IISR), Calicut and developed curcumeal using IISR Prathibha. Mrs. Geetha availed license for large scale cultivation of turmeric variety IISR Prathibha during July 2022. This has opened a new door to the turmeric value chain in front of Geetha's Home to Home and the firm started cultivation of IISR Prathibha in 10 acres comprising 47 farmers fields in Thrissur and Pathanamthitta. Other than cucumeal, Geetha launched two more products from turmeric 'First Drink' using turmeric and other spices such as black pepper and cinnamon and high curcumin Prathibha turmeric powder.

When Geetha thought of expanding the turmeric cultivation in farmers' fields, the major problem was the price instability of turmeric seeds. This was resolved by executing the MoU with the farmers by assuring a 100% buy back at a higher price than the market, benefiting both the farmers and the business. In 2023-24, the firm expanded the cultivation of IISR Prathibha into 54 acres including 315 farmers of 6 districts in Kerala, viz. Thrissur, Palakkad, Kollam, Idukki, Ernakulam and Pathanamthitta, with all scientific expertise from ICAR-IISR. Regular visits and instructions on good agricultural practices and quality agri inputs developed by ICAR–IISR yielded quality produce and quality value added products from this. Currently the firm is associated with 305 farmers including FPOs and 150 women farmers in 6 districts.

Geetha Home to Home organizes training and education to ensure the quality of turmeric with group of farmers direct/online. Within one year the products have reached the states of Kerala, Karnataka, Maharashtra, New Delhi, Jammu and Kashmir. The firm could employ 30 people in production and marketing sector. Mrs. Geetha Saleesh has participated in more than 35 expos to exhibit and introduce her products to the customers.

Mrs. Geetha Saleesh was selected for exhibiting the products during 95th ICAR foundation day cum technology day celebrated during 16-18 July 2023.

different subjects like Agricultural Science, Animal and Fishery Science and Horticultural Science were brought out in Hindi and Regional Languages by the Council and its institutes from time to time. With a view to provide Knowledge of various technologies on agriculture and wider publicity thereof, monthly Hindi magazine *Kheti* was published regularly. Rajbhasha Aalok, in-house Hindi magazine of ICAR Headquarters, was published regularly. This magazine includes articles on scientific subjects and government schemes in simple Hindi besides reports of various schemes and programmes being organized by the council and its institutes from time to time. Total number of notified subordinate offices of the Council under Rule 10(4) of Official Languages Rules, 1976 has increased up to 149.

During the period under report, 4 meetings of Official Language Implementation Committee were conducted on 21 December 2022; 24 March 2023; 30 June 2023; and 4 October 2023 respectively. In most of the ICAR Institutes/centers, Official Language Implementation Committees (OLIC) have been constituted and Meetings thereof were conducted regularly. The quarterly progress reports of ICAR-Headquarters are being sent on-line to the Delhi situated Regional Implementation Office, Department of Official Language, Government of India. The quarterly progress reports received from various Institutes are being reviewed and suggestions are given to them for effective implementation of OL policy. ICAR is participating in TOLIC's meetings regularly.

Four Hindi workshops were organized during this Period (i.e. 12 December 2022, 14 March 2023, 07 June 2023 and 10 August 2023).

As usual, during this year also, Rajbhasha week/fortnight/month was organized at Council's Headquarters and its institutes. At Council headquarters, various Rajbhasha Competitions were conducted during "Hindi Pakhwara". "Hindi Pakhwara" was organized at Council's Headquarters from 14 September 2023. On this occasion, the inspiring messages of Hon'ble Union Minister for Agriculture and Farmers Welfare were issued. The Director General, ICAR also issued an appeal thereby urging all officers/employees to do their maximum official work in Hindi.

Under the Cash Award Scheme of Official Language being implemented at the ICAR Headquarters, 10 personnel were given cash awards for doing their maximum work in Hindi during 2022-23.

In accordance with the instructions/orders of Department of Official Language, Ministry of Home Affairs, various Institutes were inspected for assessing the progress of Hindi during the period under report and suggestions were given to rectify the shortcomings observed during the inspection. This also includes inspection of Parliamentary Committee on Official Language. Besides, all materials to be presented in the Parliament, works related to Annual Plan, Demand for Grants, Governing Body, Standing finance committee, Parliamentary Committee of Ministry of Agriculture, Including Annual General Body meetings of ICAR Society, all proceedings of these meetings were prepared bilingually, i.e. Hindi and English. Hon'ble Agriculture Minister and other Senior Officers delivered their addresses in Hindi. Their speeches/messages were originally drafted in Hindi in the Council.

TECHNICAL COORDINATION

The mandates of Co-ordination (Technical) Section and Award Cell: Preparation of Monthly Cabinet Summary for Cabinet Secretary, Organizing meeting of 'Standing Committee' for grant of financial assistance to Scientific Societies and Academic Institutions for holding of National/International Conference/Seminars etc., and publication of Scientific Journals, Organizing Director's Conference, coordinatingand organizing the ICAR Regional Committee Meetings, Collaboration with Department of Science and Technology, Department of Biotechnology, Department of Scientific and Industrial Research, CSIR, ICMR, Bureau of Indian Standards etc., deal with the references received from Prime Minister's Office, President's Secretariat, Members of Parliament and VIPs etc., ICAR Annual Report and Audited Accounts laying in the Parliament, Parliament Questions of inter-divisional nature, Nodal point for e-samiksha portal for DARE/ICAR, Revision of guidelines for Awards from time to time, Releasing funds for Lal Bahadur Shastri (LBS) and Norman Borlaug Award projects, handle and promote the Swachhta Action Plan (SAP): releasing of funds, uploading of approved quarterly report on SAP portal. Organization of Swachhta Pakhwada/Swachhta Hi Sewa, Collecting and compiling the Swachhta Pakhwada Daily reports and uploading on the portal, handling the Swachh Bharat Mission: Organizing of Review Meetings of ICAR Institutes by Hon'ble Agriculture Minister/Hon'ble DG, ICAR to review the ICAR Institutes.

To collect, compile and provide the agenda to the Ministry of Home Affairs for Zonal Council Meetings, Arranging the Review Meetings of ICAR Institutes under the Chairmanship of Hon'ble AM, Various Campaigns from Government of India, Inter-ministerial assignments, Convergence of various Central Government Schemes and Organization of various important events viz. Foundation Day and Award Ceremony and all matter related to ICAR Awards including revision of guidelines for Awards.

ICAR Director's Conference and Annual Conference of Vice Chancellors was organized on March 4-5, 2023 at Bharat Ratna Dr. C Subramaniam Auditorium NASC Complex, Pusa, New Delhi.The conference was organized in physical mode and inaugurated by Secretary (DARE) and DG (ICAR) Shri J. N. Swain, Secretary, Department of Fisheries and Sh. Manoj Ahuja, Secretary, DA&FW and all the DDGs, ICAR participated as special guest. During the conference addressing the gathering, Himanshu Pathak, Secretary (DARE) & DG

(ICAR) highlighted the significant milestones achieved in the Green, White, Blue, Yellow, Golden, Silver, Brown, and Grey Revolutions. These revolutions have collectively transformed Indian agriculture, leading to a remarkable increase in production since 1970 within the same net sown area. The resilience of food production over the years was emphasized, showcasing the sector's ability to adapt and thrive. Dr. Pathak stressed the need for reorienting the National Agricultural Research and Extension System (NARES). Dr. Pathak emphasized the necessity of rightsizing ICAR to enhance efficiency. He proposed the "7Cs" approach, which includes Consortia research, Collaborative research, Contract research, Consultancy research, Commercialization, Costing Academics, and Constructing research facilities. Additionally, the potential of Public-Private Partnerships (PPP) was highlighted as a means of generating resources for the organization.

The Regional Committee Meetings held once every two years, provide an ideal platform for reviewing the status of agricultural research, education and extension in the mandated states and union territories. The Committee provides a forum for liaison and coordination among the institutes of the Indian Council of Agricultural Research (ICAR), State Agricultural Universities (SAUs) and State Departments of Agriculture, Horticulture, Animal Husbandry and Fisheries. Secretaries of State Departments, Members of ICAR Governing Body, Senior Officials from ICAR Headquarters and State Departments, Vice-Chancellors of SAUs, Directors and Scientists of ICAR Institutes in the region participate in the meeting, which is chaired by Secretary DARE & DG, ICAR. The problems being faced by the states in the areas of agriculture and related fields and the technology options/potential solutions available to be developed by the NARS system were discussed threadbare and actionable points were identified and assigned to the respective institutes/universities/KVKs to be resolved in a targeted time frame. The action taken on the issues raised in the previous Regional Committee Meetings were also reviewed. Meetings of ICAR Regional Committees No. IV, V, VII and VI were held on 07th November 2022, 27th April 2023, 18thAugust 2023 and 3rd November 2023 at ICAR-IIVR, Varanasi, NASC Complex, New Delhi, ICAR-CIAE, Bhopal and ICAR-CSWRI, Avikanagar,respectively through Physical/ Hybrid Mode. These meetings were inaugurated by Secretary (DARE) & DG, (ICAR). Hon'ble Agriculture Minister, Hon'ble Minister for Animal Husbandry, Dairying and Fisheries and Hon'ble Minister of State for Agriculture (ICAR) were also gave their valuable suggestions in the meetings by video conferencing.

During the fiscal year 2023-2024, the Council provided financial support to 35 societies for the publication of Scientific Journals. In addition, Societies/ associations/universities were supported for holding National Seminars/Symposia/Conferences (33 Nos) and International Seminars/Symposia/Conferences (19 Nos).

The Annual Report of ICAR for the year 2022-23 along with review statement was laid on the tables of Lok Sabha on 28-03-2023 and Rajya Sabha on 24-03-2023. The Annual Account & Audited Report of ICAR for the year 2021-2022 along with review statement was also laid on the table of Lok Sabha and Rajya Sabha on 13.12.22 and 09.12.2022 respectively (well before time). The Umbrella Memorandum of Understanding (UMoU) are being signed between the ICAR and host Institutions, i.e. Central/States Agricultural Universities and other Departments to co-operate in conducting research through All India Coordinated Research Projects (AICRPs) and any other such schemes funded/ sanctioned by the Council under various schemes to the Host Institution from time to time at specified location(s) under the specified Supervisor/Principal Investigator/ Leader of the Host Institution. Total 59 such UMoUs have been signed with the Central/State Agricultural Universities.

The 95th Foundation Day and Technology Day of ICAR: The Foundation & Technology Day of ICAR was Celebrated during 16 to 18 July 2023. During the occasion, certificates for 5 new technologies per SMD, along with the release of related products and books, were presented. The winners of the Hackathon were awarded, and three-day exhibition was organized. During the 95th Foundation and Technology Day Celebration of ICAR, around 500 farmers and 500 school children, in addition to senior officers of ICAR and other departments, visited the exhibition from 16-18 July, 2023. Sh. Narendra Singh Tomar, the Hon'ble Union Minister of Agriculture & Farmers Welfare and President of the ICAR Society, extended congratulations to ICAR and the dignitaries on this significant occasion.

Projects for five/three years' duration submitted by awardees of ICAR-Norman Borlaug Award and ICAR-Lal Bahadur Shastri Outstanding Young Scientist Award from about 14 Institutes across the country have been monitored and evaluated on yearly basis. Thereafter, grants have been released for the subsequent year in respect of such projects. The LBS projects will end in 2025–26 and the Norman Borlaug project will end in 2027–28 for which grants will be released on yearly basis after evaluation of the project progress report (s).

Review Meetings of ICAR Institutes: The working and future planning of ICAR Institutes were reviewed by the Hon'ble Union Minister of Agriculture & Farmers Welfare. Total 45 reviews were conducted and 12 Institutes of Crop Science, 20 Institutes of Horticulture Sciences, 4 Institutes of NRM, 5 Institutes of Engineering, 3 Institutes of Animal Sciences and 1meeting to review all the KVKs under Extension Division.

Under Swachh Bharat Mission, Swachhta Action Plan (SAP) activities, viz. (i) Microbial-based Agricultural Waste Management using vermicomposting at Krishi Vigyan Kendras adopted villages, (ii) Management and

Commercial Utilization of Fish Waste in 10 Fish Markets (in Urban locations) and (iii) Phytoremediation for cleaning sewerage water for agricultural application to be replaced at different locations have been undertaken by various units of ICAR. SAP activity-wise progress reports for three quarters have been compiled and uploaded on the SAP Portal. An amount of ₹ 350 lakhs have been given for undertaking the SAP activities during the financial year 2022-23 and the similar amount has also been earmarked for the current financial year 2023-24. Apart from this, date-wise Action Plan for Swachhta Pakhwada (From-16-31 December) was prepared and regularly uploaded on the designated Portal of the Ministry of Jalshakti, Department of Drinking Water and Sanitation. Besides this Special Campaign 3.0 disposal of pending matter from 2 October 2023 to 31 October 2023 was conducted successfully at the Council Headquarters as well as at all the Institutes of ICAR spread across India.

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20. Training and Capacity Building

The highlights of Training and Capacity Building programmes for ICAR employees of all categories undertaken during 2022-23 are enumerated below.

Executive Development Programmes for Newly Recruited Research Managers of ICAR: ICAR-NAARM, Hyderabad designed, developed and organized domestic component of Executive Development Programmes on 'Leadership Development' for Newly Recruited Research Managers in coordination with HRM Unit, ICAR HQs. In the programme, 33 RMPs (DDG, ADGs, Directors and Joint Directors) participated in 02 batches during 2022-23.

Training Programme on Advances in Simulation Modelling and Climate Change Research towards Knowledge Based Agriculture: ICAR-IARI, New Delhi organized a training programme on 'Advances in Simulation Modelling and Climate Change Research towards Knowledge Based Agriculture' for scientific staff of ICAR/Non-ICAR Institutes in coordination with HRM Unit, ICAR HQs during 17 November-07 December 2022, wherein 21scientists participated.

Online training programme on Management and Utilization of Plant Genetic Resources: ICAR-NBPGR, New Delhi organized an online training programme on 'Management and Utilization of Plant Genetic Resources' for scientific staff of ICAR/Non-ICAR Institutes in coordination with HRM Unit, ICAR HQs from1-21 February 2023. In the programme, 75 scientists participated.

Capacity Building Programme for Effective Implementation of Training Functions in ICAR by HRD Nodal Officers/Co-Nodal Officers: ICAR-NAARM, Hyderabad organized Capacity Building Programme for Effective Implementation of Training Functions in ICAR by HRD Nodal Officers/Co-Nodal Officers in coordination with HRM Unit, ICAR HQs during 27 February-01 March 2023. In which16 HRD Nodal Officers/Co-Nodal Officers of ICAR-Institutes participated, out of which 100% got first-time opportunity to participate in such type of programmes after taking over the charge of HRD Nodal Officers/Co-Nodal Officers.

Training Workshop for Vigilance Officers of ICAR Institutes: A training workshop for Vigilance Officers of ICAR Institutes was organized during 24-26 August 2022 by ICAR-NAARM, Hyderabad in which 20 Vigilance Officers participated, out of which 100% got the first-time opportunity to participate in such type of programme after taking over the charge of Vigilance Officer during 2022-23.

Training Programme for Regular Drivers of ICAR: A training programme on "Automobiles Maintenance, Road Safety and Behavioural Skills" for Regular Drivers of ICAR was organized in 03 batches during 2022-23 by ICAR-CIAE, Bhopal in coordination with HRM Unit, ICAR HQs in which 53 Regular Drivers participated, out of which 100% got first-time opportunity to participate in any kind of programme after joining service.

Training Porgramme for Administrative and Finance Staff dealing with Pension and Retirement Benefits: A specialised training programme on "Pension and Retirement Benefits"based on TNI for Administrative and Finance Staff dealing with Pension and Retirement Benefits in ICAR Institutes and HQs was organized by ICAR-NRRI, Cuttack in coordination with HRM Unit and Finance Division, ICAR HQs during 18-20 April 2022, in which 80 employees of such category participated, out of which 100% got first time opportunity to participate in such type of programme after joining service during 2022-23.

A specialized training programme on "National Pension Scheme" based on TNI for Administrative and Finance staff dealing with Pension and Retirement Benefits in ICAR Institutes and HQs was designed, developed and organized by ICAR-NRRI, Cuttack in coordination with HRM Unit and Finance Division, ICAR HQs during 16-18 June 2022, in which 53 employees of such category participated, out of which 100% got first-time opportunity to participate in such type of programme after joining service during 2022-23.

Capacity Building Programme for CJSC members of ICAR: ICAR-NAARM, Hyderabad organized a Capacity Building Programme for CJSC members of ICAR in which 42 members participated during 2022-23.

Training Programme for Technical Staff: ICAR-CRIDA, Hyderabad organized a training programme on 'Agrometeorological Data Collection, Analysis and Management' for technical staff in coordination with the HRM Unit, ICAR HQs from18-27 January 2023, in which 15 technical staff participated.

Training Programme at ICAR-CRIDA, Hyderabad

Training Porgramme for Farm Managers/ Technical Staff: ICAR-IIFSR, Modipuram organized a training programme on 'Farm Management' in coordination with HRM Unit, ICAR HQs in which 13 Farm Managers/ Technical staff associated with farm participated during 22-28 February 2023.

Training Programme at ICAR-IIFSR, Modipuram

Training Porgramme on 'Principles and Production Techniques of Hybrid Seed in Vegetables': ICAR-IIVR, Varanasi organized a training programme on 'Principles and Production Techniques of Hybrid Seed in Vegetables' in coordination with HRM Unit, ICAR HQs in which 12 officials working in different ICAR Institutes/ SAUs/ KVKs participated during 16-30 January 2023.

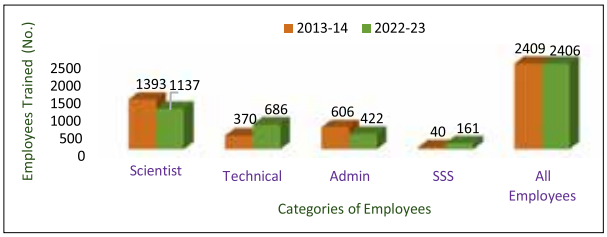
Nomination of employees in various Training Programmes: The Council nominated 548 employees of various categories in training and capacity-building programmes organized by ICRISAT, Hyderabad (10), ISTM, New Delhi (75), AJNIFM, Faridabad (49), ICAR-NRRI, Cuttack (100), ICAR-NAARM, Hyderabad (169), ICAR-CIAE, Bhopal (107), ICAR-IIFSR, Modipuram (30), GIMI, Israel (06) and Lal Bahadur Shastri National Academy of Administration, Mussoorie (02), out of which 369 had attended training programmes.

Impact Assessment of Training Programmes: Impact Assessment of Trainings attended by 2,171 employees of various categories of 90 ICAR-Institutes during 2020-21 was done as per proforma developed by DoPT**.** Based on the feedback of trainees received from different ICAR-Institutes, the overall impact of training was recorded to be Considerable-Great Extent with an average rating of 4.05/5.00. Similarly, based on the feedback of Reporting Officers of the Trainees received from different ICAR-Institutes, the overall impact of training on Trainees was also found as Considerable-Great Extent with an average rating of 3.96/5.00.

Employees Trained

Manpower Trained (In Terms of Number): During the reporting period, 2,406 employees underwent various types of training and capacity building programmes, out of which Scientists, Technical, Administrative including Finance, and Skilled Support Staff (SSS) were 1137, 686, 422 and 161, respectively. Compared to 2013-14, there was considerable improvement in the number of employees undergoing training where improvement was 85.4 and 302.5% in Technical and Skilled Support Staff, respectively during 2022-23.

During the reporting period, Crop Science Division deputed the highest number of all categories of employees, i.e. Scientists (347), Technical (236), Administrative including Finance staff (133) and Skilled Support Staff (64) for various capacity building programmes 1. Thus, overall, a maximum number of employees were trained in the Crop Science Division (780) followed by the Horticultural Science Division (409), out of 2,406 employees trained in the ICAR system.



Improvement in Capacity Building of ICAR Employees with theCreation of HRM Unit

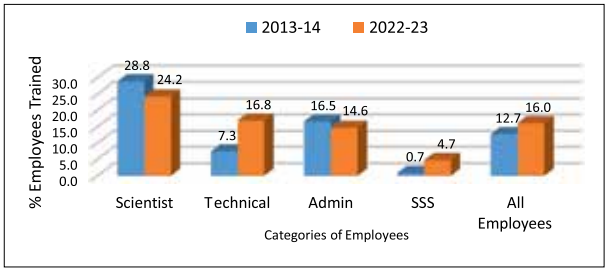
In terms of per cent employees trained under each category, Scientists (24.2%), Technical (16.8%), Administrative including Finance (14.6%) and Skilled Support Staff (4.7%) were trained in various aspects as per their training needs during 2022-23 with overall 16.0% employees across the categories got opportunity for capacity building. This is evident that 9.5 and 4.0% more number of Technical and Skilled Support Staff,

SMD-wise number of employees undergone training during 2022-23

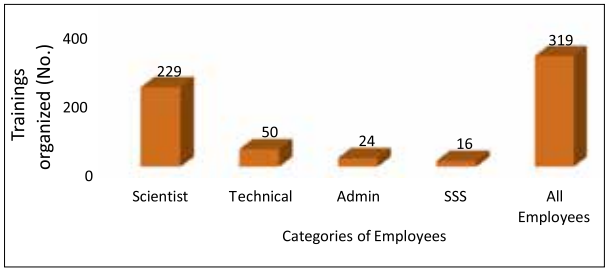
SMDs/HQs	No. of Employees Trained					Per Cent Employees Trained				
	Scientists	Tech.	Admin	SSS	Total	Scientists	Tech.	Admin	SSS	Total
Crop Sci.	347	236	133	64	780	22.0	18.8	17.2	5.2	16.2
Hort Sci.	226	109	69	5	409	33.4	18.7	19.8	1.2	20.4
NRM	158	113	51	0	322	21.3	13.5	13.9	0.0	13.7
Ag. Education	37	12	10	36	95	24.8	17.9	10.8	55.4	25.4
Ag. Engg.	49	58	27	16	150	25.9	26.4	23.7	22.5	25.3
Animal Sci.	165	121	31	6	323	23.6	19.4	7.1	0.6	12.0
Fisheries Sci.	139	34	85	34	292	25.2	8.0	31.6	12.5	19.2
Ag. Extn.	12	3	9	0	24	26.7	16.7	19.6	0.0	21.1
ICAR HQs	4	0	7	0	11	5.8	0.0	1.6	0.0	1.8
Total	1,137	686	422	161	2,406	24.2	16.8	14.6	4.7	16.0

Number of Training organized by various SMDs/ICAR HQs during 2022-23

SMDs/HQs	Scientists (No.)	Technical Staff (No.)	Administrative Staff (No.)	SSS (No.)	All Employees (No.)
Crop Science	42	8	8	3	61
Hort Science	19	8	3	6	36
NRM	31	14	4	0	49
Ag. Education	63	3	2	1	69
Ag. Engineering	29	6	3	1	39
Animal Science	18	3	1	4	26
Fisheries Science	16	7	3	1	27
Ag. Extension	11	1	0	0	12
Total	229	50	24	16	319



Per Cent Employees Undergone Training with the Creation of HRM Unit



Training Organized by Various ICAR-Institutes

respectively got training opportunities during 2022-23 as compared to 2013-14 with an overall improvement of 3.3% in capacity building of all the categories of employees.

The training programmes organised for scientists, technical, administrative finance, and skilled support staff were 229, 50, 24 and 16, respectively with 319 training programmes. Agricultural Education Division organised a maximum number of trainings for scientists (63), NRM Division for technical staff (14), Crop Science Division for administrative staff (08) and Horticultural Science Division for Skilled Support Staff (06), Moreover, maximum number of training programmes for all employees were organized by Agricultural Education Division (69) followed by Crop Science Division (61).

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21.
Publications, Social Media and Public Relations

The ICAR-Directorate of Knowledge Management in Agriculture (DKMA) is mandated to showcase ICAR's technologies, policies and other activities through latest information dissemination methods that cater to diversified stakeholders in the field of agriculture. In the fast changing knowledge intensive era, the DKMA is committed to promote ICT-driven technology and information dissemination system for quicker and more effective outreach. The ICAR-DKMA publishes periodicals, books, handbooks, Annual Reports, newsletters, bulletins, monographs, e-books, media columns, social media contents, advisories, etc. The knowledge banks are available in open access as well as in closed access models to the stakeholders in agriculture. ICAR-DKMA has already taken steps to disseminate knowledge by using up-to-date most popular ICT tools for benefitting the national as well as global agricultural world. The Directorate makes sincere efforts to spread information pertaining to agriculture through mass media for enhancing awareness of the people.

Knowledge and Information Products

With the advent of ICT the research journals were made available online (https://epubs.icar.org.in: Indian Agricultural Research Journals) and placed in open access. This platform was developed under NAIP and now hosts 53 journals belonging to ICAR funded societies. Its facilities include online article processing system, referee system and archives. The portal has archives of back volumes of research journals till 1994 pertaining to *The Indian Journal of Agricultural Sciences* (280 issues) and *The Indian Journal of Animal Sciences* (292 issues). Whereas popular journals namely *The Indian Farming* (106 issues) and *Indian Horticulture* (60 issues) are also hosted. About 37,000 articles are available online globally in open access.

The vision of the English Editorial Unit is to manage English Publications for enhancing knowledge base of all interested in agriculture. Its mission is to develop and disseminate useful agricultural knowledge in English, being generated through research, education and extension using print and e-knowledge resources up to the last mile across the globe for enhancing production and productivity. It has some objectives which are: To collate, compile, publish and disseminate useful agricultural knowledge in English. To plan and coordinate the dissemination of agricultural information in English at national and international levels. To manage e-platforms for bringing out open access research journals and semi technical journals. To bring out e-books and books on agriculture, animal husbandry, fisheries and allied sciences including home sciences using state-of-the-art information and communication technologies. To provide literature for strengthening and promoting research, education and extension.

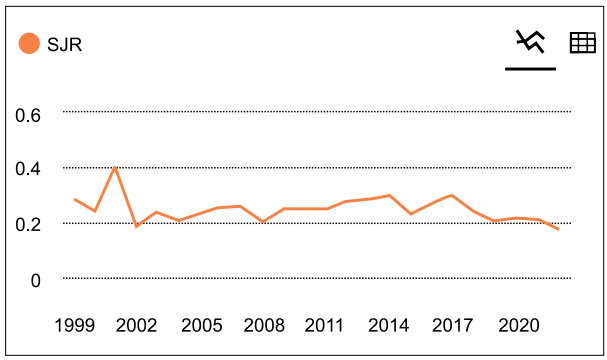
A new OJS version 3.4.0-4 (https://epubs.icar.org.in) was developed and implemented for the journals. *The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences*, the flagship research journals of ICAR having international fame have a wide clientele. During the reporting period, a total of 3,697 submissions in the Indian Journal of Agricultural Sciences and 1,547 submissions in the Indian Journal of Animal Sciences were received. Out of these submissions, 285 articles in *The Indian Journal of Agricultural Sciences* and 280 articles in *The Indian Journal of Animal Sciences* were published. The user base of the journals is expanding and has reached to 41,410 users *The Indian Journal of Agricultural Sciences* and 22,610 users *The Indian Journal of Animal Sciences*. The journal website was visited nearly 45,000 times by the audience belonging to 143 countries. The journals have considerable metrics,

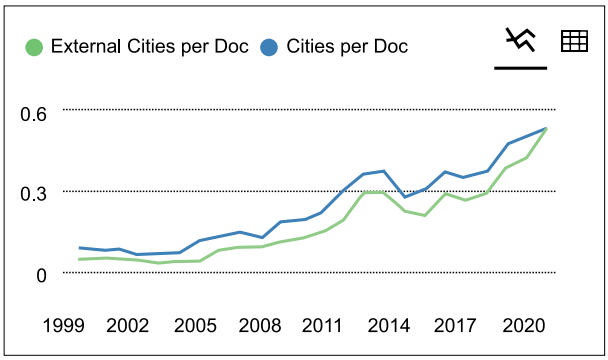
The Indian Journal of Agricultural Sciences

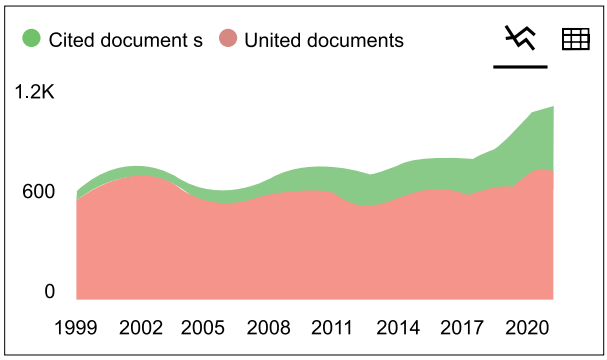
Issues published 12
Articles published 285
Total submissions 3,697
Registered users 41,410

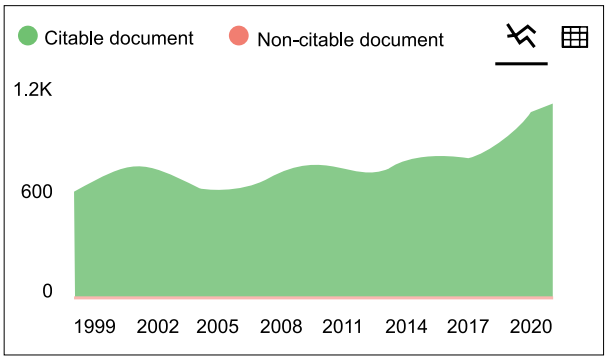
The Indian Journal of Animal Sciences

Issues published 12
Articles published 280
Total submissions 1,547
Registered users 22,610

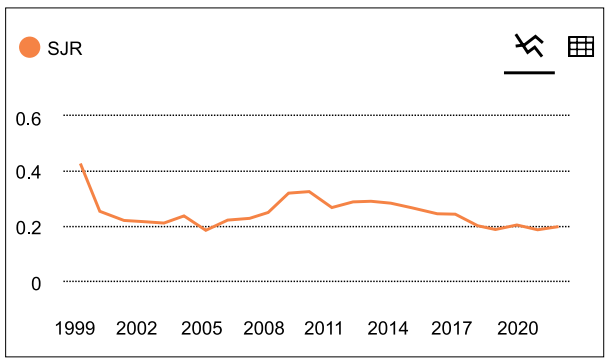


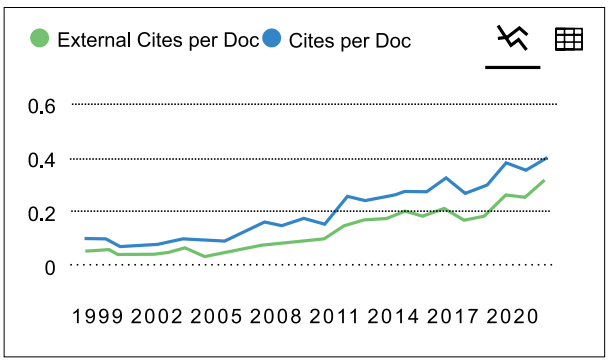


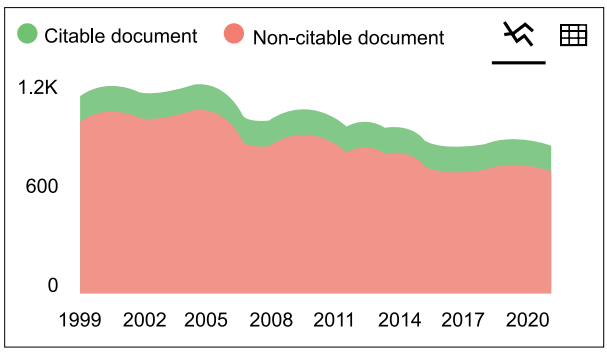


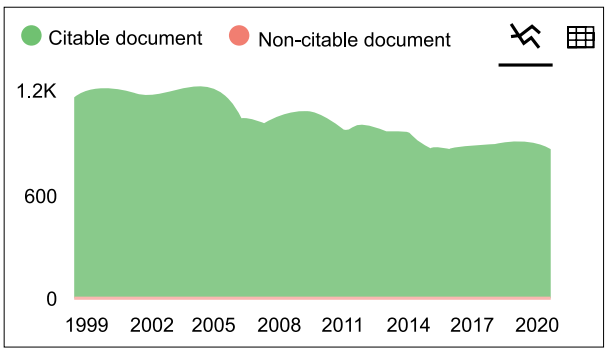


Metrics for *The Indian Journal of Agricultural Sciences*









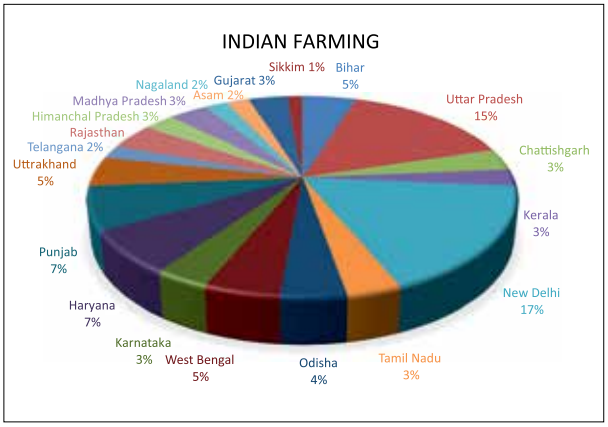
Metrics for *The Indian Journal of Animal Sciences*

viz. impact factor and H index are 0.4 and 30 for *The Indian Journal of Agricultural Sciences* and 0.4 and 25 for *The Indian Journal of Animal Sciences* despite the fact these are multi-disciplinary in nature.

Popular periodicals like *Indian Farming* (monthly) and *Indian Horticulture* (bimonthly) were brought out for outreach to the masses. The total submissions in the *Indian Farming* and *Indian Horticulture* were 380 and 148, respectively. The registered users were 5,610 in the *Indian Farming,* whereas 3,710 in *Indian Horticulture.* A total of 180 articles were published in the *Indian Farming* and 76 in *Indian Horticulture.* Special issues of the *Indian Farming* were brought out on the theme Rich in Heritage, Full of Potential on the occasion of International Year of Millets 2023 and on the occasion of G20 Meeting of Agricultural Chief Scientists. Special issues of the *Indian Horticulture,* on themes such as Vegetable Crops (March-April 2023), Medicinal and Aromatic Plants (September-October 2023) and Horticulture in North-East Region

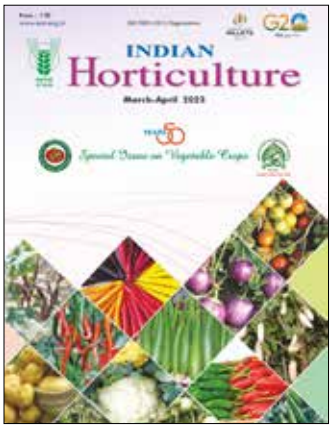
Indian Farming

Issues published 12
Articles published 180
Total submissions 380
Registered users 5,610

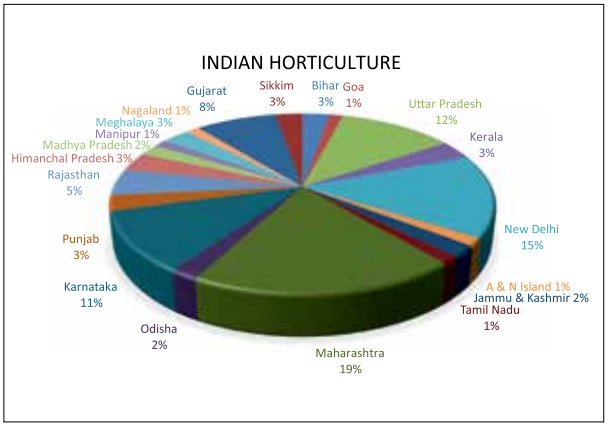


State-wise distribution of published articles

Indian Horticulture



Issues published 6
Articles published 76
Total submissions 148
Registered users 3,710



State-wise distribution of published articles

(November-December 2023) were brought out.

During the year, Digital Object Identifier (DOI) number allotment to articles for both the research journals was continued for benefit of the authors as well as journals immensely. To provide authentic knowledge to readers of the research journals plagiarism checker software iThenticate was subscribed. For facilitating publication of the books, e-book platform was developed.

Under the books publication programme of the English Editorial Unit, seven new titles were published namely: Textbook of Watershed Hydrology, Textbook on Cheese Technology, Importance of Millets and Improved Production Technologies, Fundamentals of Soil Science, Fundamentals of Soil and Water Conservation Engineering, Textbook of Entomology and Textbook on Veterinary Extension.

The in-house publication like *ICAR Reporter* and *ICAR News* are also available on ICAR website for wider global outreach. These were viewed in about 140 countries world over.

Technical work (editing and proofreading)

Author guidelines were developed for bringing out Research Journals; Popular magazines; and books. These guidelines are available online (Research journals and popular journals: https://epubs.icar.org.in and for books on https://ebook.icar.org.in/). These guidelines put ICAR in-house style at par with International Research Publications. Editorial Unit ensure that all international publishing reforms are adopted in ICAR. International nomenclature is followed in technical names using www.sp2000.org. International unit system is ensured in the ICAR content. Plagiarism is checked by plagiarism checking software. The system has adopted a Plagiarism Policy to keep ICAR brand intact. Revision of important textbooks, technical books, handbooks is initiated by Editorial units after feedback from Business Unit. Special issues of popular journals on topical issues are conceptualized, planned and finalized by editorial units. Editing and proofreading of all periodicals, and Annual Report is done in-house by the respective units. The aim is meeting the quality and the deadline. Finalization of all books is done in-house, which includes index making, checking of preliminary pages (Contents, Preface, Foreword, About the Author, About the Book), and all text from printing point of view. Article certificates and Copyright certificates (books) are maintained in EEU.

Editorials; 'About the Author' and 'About the Book' for books; 'Overview' and 'Foreword' pertaining to ICAR Annual Report; Preface for handbooks; Index in all Handbooks, books and Annual Report, Subject-wise index, Author index and List of reviewers in both the research journals were prepared.

The ICAR flagship Hindi monthly journal *Kheti* and

Global visibility of ICAR research

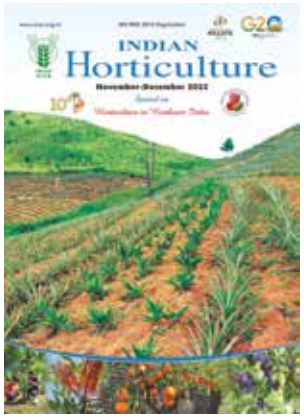
The Directorate is showcasing ICAR technologies, policies and other activities through print, electronic and web mode. The editorial units help in development of content in value added information products in print, electronic and web mode. The ICAR periodicals are hosted on http://epubs.icar.org.in. This site is connected to Google analytics that provides reports on user flow on this portal.

bi-monthly horticulture journal *Phalphul* published 18 issues. During the reported period 4 special issues of *Kheti* were published namely *'Pashu Aahar Visheshank'* and *'Dalhan par Vishesh Samagri'*, *'Matsyiki Visheshank'* and *'Sasya Vigyan Congress Visheshank'*. Similarly three special issues of *Phalphul* namely *'Phal Sabji Prasanskaran'*, *'Paudh Nursery'* and *'Videshi Evam Alpdohit Bagwani Fasal Visheshank'* were published. The purpose of these special issues is to compile and make available latest information about a particular subject in a very comprehensive manner for the benefit of readers.

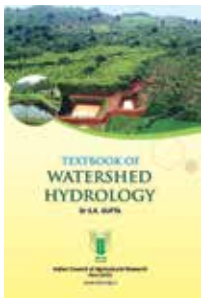
Apart from journals a booklet *Ullekhniya Uplabdhian (2014-2023): Amritkal mein Viksit Bharat ki Akanchha ke Saath Badhte Kadam* was also published.

Production Unit

Production Unit, DKMA is solely responsible for the designing, print-production of the Council's Scientific Research Journals, Semi-technical periodicals, Magazines, Newsletters, Books, Monographs, Handbooks, Technical Bulletins, Textbooks, Annual Reports, Research Highlights, Proceedings and other print materials using modern and latest print-production technology.



During this period, a number of important publications: ICAR Significant Achievements 2014-2023, 9 Saal Seva Sushasan aur Garib Kalyan, Cheese Technology, Watershed Hydrology, etc. along with Council's Scientific Research Journals (24 issues), Semi-technical periodicals (12 issues), Magazines (26 issues), Newsletters (4 issues) were also produced. A number of knowledge products in the form of e-books and online publications in English and Hindi are produced for the use of students, scientists, researchers, policy planners, farmers, extension personnel and general public.



Business Unit

The Business Unit is responsible for sales, marketing, promotion and timely distribution of Council's important publications and periodicals.

Business Unit successfully organized/participated and facilitated the following exhibitions for showcasing ICAR technologies and publications during the reported period: (i) G20 Meeting, BHU, Varanasi, Uttar Pradesh from 17 to 22 April 2023; (ii) Meeting of Agriculture

Chief Scientists G20 19 April 2023, NASC, New Delhi; (iii) Exhibition of ICAR Publications at PJTSAU, Hyderabad from 15-16 June 2023; (iv) ICAR Foundation Day 16-18 July 2023, NASC, New Delhi; (v) International Horticulture Expo, 21-23 July 2023, Pragati Maidan, New Delhi; (vi) XVI Agricultural Science Congress, 10-13 October 2023, Kochi, Kerala; and (vii). Agri and Horti Expo 2023, 3-5 November 2023, Dilli Haat, Pitampura, New Delhi.

The Unit achieved the revenue of approximately ₹ 43.00 lakhs till October 2023 from sale of publications and advertisements.

Social Media

To disseminate information in real-time, the ICAR website is updated on a regular basis, and in total 4,613 pages were updated. A total of 41,89,432 page views from more than 200 countries were recorded. Knowledge seekers across the globe visited the Website. The top five countries visiting the Website include India, United States of America, United Kingdom, United Arab Emirates and Nepal.

A newly designed and more user-friendly ICAR website was developed and hosted with more than 19,000 pages. The New Website has a Publication Cart through which the stakeholders can purchase ICAR Publications online.

During the reporting period DARE website (dare.gov.in) was certified with GIGW certification from STQC.

On ICAR Facebook, a total of 519 Posts were published during the year and it has 2, 29,171 Followers. ICAR Twitter Handle has more than 2,28,458 Followers. On an average, 3 Tweets are posted every day and a total of 1,114 Tweets were posted during the year and Tweets earned 2,161.29K impressions. The YouTube Channel of ICAR has Video Films, Animations, Lectures/Interviews by dignitaries and Eminent Scientists, Proceedings of National and International Events, etc. It has 72,700 Subscribers.

Publicity, Public Relations and Media

It is responsible for publicity of achievements of the ICAR in the country and abroad. It provides a single platform for publicity and other related activities and highlights the research findings at national and international levels. It organizes press conferences/ briefings addressed by the Union Agriculture Minister, Minister of State for Agriculture & Farmers Welfare, Secretary (DARE) and DG (ICAR), Deputy Director-Generals, and Directors of various research institutes; and projects materials of immediate value to various newspapers, agricultural and current affairs magazines and electronic media.

Millets in every plate, promoted through ICAR tableau: ICAR-DKMA participated in Republic Day Celebrations third time on 26 January 2023 with a tableau on the theme of International Millets Year declared by UN. ICAR showcased millets in Republic Day tableau as the UN celebrates India's superfoods. The tractor in front of the tableau was decorated with a rangoli of millets - ivory-coloured jowar, grey-brown pearls of bajra and deep red ragi grains -- showcasing a combination of traditional farming and modernity.

ICAR tableau dedicated to International year of Millets

The tableau of ICAR showcased the flourishing crops of jowar, bajra, ragi, kutki and sanwa, besides new nutritional millet products.

The 8 events organised by the Council were widely covered by national print media as well as electronic media, especially by DD Kisan, All India Radio, PIB, PTI, Univarta, ANI etc. along with numerous national and local newspapers and electronic media.

Participation in exhibitions at regional, national and international level: The Unit organized exhibitions and displayed important items relating to agricultural development in an interesting manner to spread awareness of new ideas, varieties, technologies, etc. and also advised the institutes on exhibition-related issues.

The Council participated in and organised exhibitions and displayed important items relating to agricultural development in an interesting manner to spread awareness of new ideas, varieties, technologies, etc and also advised the institutes on exhibitions-related issues. The Council participated and coordinated in 51 National and International level exhibitions annually like the Exhibition during ICAR foundation day, Indian Science Congress at Nagpur, Vision Rajasthan at Sirohi, 19thAgro organic world expo etc.

Single window for Advertisement: The Unit provided the insertion of various advertisement facilities to the divisions and sections of the Council on a regular basis throughout the year. Several advertisements for appointments, tenders, etc. were published in newspapers through BOC (DAVP). The advertisements were published in 600 newspapers in Hindi, English and vernacular languages covering all the states of India.

Publicity through publication and literature: The publication titled '9 Saal Sewa, Sushasan aur Garib Kalyan' on achievements during 2014-2023 related to the Ministry of Agriculture and Farmers Welfare was compiled and presented by this Unit. Similarly, two other publications titled "DARE-ICAR Significant Achievements 2021-22" and 'Significant Achievements (2014-23): Aspiring for a developed India in the Amrit Kaal' highlighting the achievements of the Council and its institutes were also compiled for publication.

Documentary films and visuals: Five documentary films were made during the last financial year on various subjects like 'Technical Marvel of ICAR', 'Salient achievements of ICAR', Film on Dr C. Subramaniam Convention Centre is best known as the architect of India's modern agricultur, Biofortified varieties developed and released by ICAR and so on.

Coordination with NARS: The public relations and Media unit of ICAR coordinates with National Agricultural Research System which consists of mainly 113 ICAR Institutes, 5 CAU and 63 SAUs. Guiding on exhibition-related issues. A number of 40 meetings were organized to discuss ICAR participation in various exhibitions organized across the country, improvement quality of docu-film as well as coverage of events etc. Most of the meetings were organised in virtual mode.

Apart from the mandated job, the Unit also provides the logistic facilities for the meetings at CR and other committee halls of the council. There was a total of 164 meetings were held in the CR1 and DG committee room where all the logistic facilities were provided by the Unit.

❑

APPENDIX 1

ACTIVITY PROGRAMME CLASSIFICATION

Budget Estimates (BE) and Revised Estimates (RE) for the year 2022-23 and BE 2023-24 in r/o DARE Secretariat, Contribution, CAUs and NAAS and IAUA are given in Table 1.

Table 1. Budget Estimates and Revised Estimates of DARE

(Rupees in Lakh)

Items		Budget Estimates	Revised Estimates	Budget Estimates
		2022-23	2022-23	2023-24
		Unified Budget	Unified Budget	Unified Budget
Major Head	**'3451'**			
090	Secretariat-Economic Services	790.00	764.80	817.60
091	Agricultural Scientists' Recruitment Board	2475.00	2972.00	1769.00
Major Head	**'2415'**			
80	**General**			
80.120	Assistance to other institutions			
01	**Grant-in-Aid Central Agricultural University Imphal**			
010031	Grants in Aid General	-	-	-
010035	Grants for creation of Capital Assets	-	-	-
010036	Grants in Aid Salaries	-	-	-
02	**Grant-in-Aid Central Agricultural University Bundelkhand**			
020031	Grants in Aid General	550.00	850.00	1300.00
020035	Grants for creation of Capital Assets	10495.00	10195.00	9000.00
020036	Grants in Aid Salaries	1600.00	1600.00	1700.00
03	**Grant-in-Aid Central Agricultural University Bihar**			
030031	Grants in Aid General	1500.00	1567.00	1700.00
030035	Grants for creation of Capital Assets	4500.00	4790.00	5367.00
030036	Grants in Aid Salaries	14500.00	15100.00	17744.00
05	**Grants-in-Aid to National Academy of Agricultural Sciences and Indian Agricultural Universities Association**			
050031	Grants in Aid General	160.00	118.20	76.40
050035	Grants for creation of Capital Assets	-	-	-
050036	Grants in Aid Salaries	-	-	-
06	**Agricultural Scientists' Recruitment Board**			
060031	Grants in Aid General	-	-	-
060035	Grants for creation of Capital Assets	-	-	-
060036	Grants in Aid Salaries	-	-	-
80.798	**International Co-operation (Minor Head)**			
01	**India's Membership Contribution to Commonwealth Agricultural Bureau**			
010032	Contribution	60.00	60.00	60.00
02	**India's Membership Contribution to Consultative Group on International Agricultural Research**			
020032	Contribution	580.00	620.00	620.00
04	**Asia Pacific Association of Agricultural Research Institutions**			
040032	Contribution	10.00	10.00	10.00
05	**N.A.C.A.**			
050032	Contribution	48.00	48.00	48.00
07	**International Seed Testing Association, Zurich, Switzerland**			
070032	Contribution	5.00	5.00	5.00
08	International Society for Horticulture Science, Belgium			
080032	Contribution	-	-	-
Major Head '2552' North Eastern Areas				
259	**General (Agri. Res. & Edn. Schemes) (Minor Head)**			
01	**Grants-in-Aid-General to Central Agricultural University, Imphal**			
010031	Grants in Aid General	2500.00	2700.00	2900.00

(Concluded)

Items		Budget Estimates	Revised Estimates	Budget Estimates
		2022-23	2022-23	2023-24
		Unified Budget	Unified Budget	Unified Budget
010035	Grants for creation of Capital Assets	5500.00	5500.00	6442.00
010036	Grants in Aid Salaries	18800.00	18800.00	19000.00
5475	**Capital Outlay on other General Economic Services**			
00.001	Direct and Administration (Minor head)			
01	**Secretariat**			
06	**DARE**			
06.52	Machine and Equipment			4.00
06.71	Information Computers Telecommunication Equipment			5.00
06.74	Furniture and Fixtures			3.00
02	ASRB (Detailed head)			
02.51	Motor Vehicles			-
02.52	Machinery & Equipment			20.00
02.71	Information Computers Telecommunication Equipment			80.00
02.72	Building and Structures			800.00
02.74	Furniture and Fixtures			119.00
02.77	Other Fixed Assets			10.00
	Total-ASRB (Sub-Head)			**1041.00**
	TOTAL	**64073.00**	**65700.00**	**69600.00**

Notes on Demands For Grants, 2023-2024

MINISTRY OF AGRICULTURE AND FARMERS WELFARE

DEMAND NO. 2

Department of Agricultural Research and Education

A. The Budget allocations, net of recoveries, are given below: (Rupees in crore)

Schemes		Actual 2021-2022			Budget 2022-2023			Revised 2022-2023			Budget 2023-2024		
		Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
	Gross	8439.94	...	8439.94	8513.62	...	8513.62	8658.89	...	8658.89	9493.59	10.41	9504.00
	Recoveries	-71.93	...	-71.93	...	...	...	...	...	...	...	...	...
	Receipts	...	...	...	...	...	...	...	...	...	...	...	...
	Net	8368.01	...	8368.01	8513.62	...	8513.62	8658.89	...	8658.89	9493.59	10.41	9504.00
CENTRE'S EXPENDITURE													
I Establishment Expenditure of the Centre													
1. Secretariat	2415	6.64	...	6.64	7.03	...	7.03	7.43	...	7.43	7.43	...	7.43
	3451	5.98	...	5.98	32.65	...	32.65	37.37	...	37.37	25.87	...	25.87
Total –Secretariat	5475	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**10.41**	10.41
		12.62	**...**	**12.62**	**39.68**	**...**	**39.68**	**44.80**	**...**	**44.80**	**33.30**	10.41	43.71
II Central Sector Schemes/Projects													
2. Agricultural Extension	2415	283.71	...	283.71	209.61	...	209.61	209.61	...	209.61	285.58	...	285.58
	2552	...	...	...	34.11	...	34.11	34.11	...	34.11	41.42	...	41.42
Total -Agricultural Extension		**283.71**	**...**	**283.71**	**243.72**	**...**	**243.72**	**243.72**	**...**	**243.72**	**327.00**	**...**	**327.00**
3. Agricultural Engineering	2415	54.90	...	54.90	46.07	...	46.07	46.07	...	46.07	61.79	...	61.79
	2552	...	...	...	2.23	...	2.23	2.23	...	2.23	3.21	...	3.21
Total -Agricultural Engineering		**54.90**	**...**	**54.90**	**48.30**	**...**	**48.30**	**48.30**	**...**	**48.30**	**65.00**	**...**	**65.00**
Management of Natural Resources													
4. Natural Resource Management Institutes including Agro Forestry Research	2415	167.56	...	167.56	112.95	...	112.95	112.95	...	112.95	196.24	...	196.24
	2552	...	...	...	31.95	...	31.95	31.95	...	31.95	43.76	...	43.76
Total -Natural Resource Management Institutes including Agro Forestry Research		**167.56**	**...**	**167.56**	**144.90**	**...**	**144.90**	**144.90**	**...**	**144.90**	**240.00**	**...**	**240.00**
5. Climate Resilient Agriculture Initiative	2415	47.00	...	47.00	36.78	...	36.78	36.78	...	36.78	...	...	...
	2552	...	...	...	4.09	...	4.09	4.09	...	4.09	...	...	...
Total -Climate Resilient Agriculture Initiative		47.00	...	47.00	40.87	...	40.87	40.87	...	40.87	...	...	...
6. Crop Science	2415	603.28	...	603.28	476.15	...	476.15	476.11	...	476.11	649.92	...	649.92
	2552	...	...	...	49.93	...	49.93	49.93	...	49.93	64.49	...	64.49
Total -Crop Science		**603.28**	**...**	**603.28**	**526.08**	**...**	**526.08**	**526.04**	**...**	**526.04**	**714.41**	**...**	**714.41**

Contd..

(Concluded)

Schemes		Actual 2021-2022			Budget 2022-2023			Revised 2022-2023			Budget 2023-2024		
		Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
7. Horticultural Science	2415	181.46	...	181.46	133.76	...	133.76	133.76	...	133.76	187.00	...	187.00
	2552	...	...	...	23.77	...	23.77	23.77	...	23.77	25.00	...	25.00
Total -Horticultural Science		**181.46**	**...**	**181.46**	**157.53**	**...**	**157.53**	**157.53**	**...**	**157.53**	**212.00**	**...**	**212.00**
8. National Agricultural Science Fund	2415	42.00	...	42.00	35.67	...	35.67	35.67	...	35.67	...	...	...
9. Animal Science		257.59	...	257.59	199.89	...	199.89	199.89	...	199.89	270.23	...	270.23
	2552	...	...	...	24.52	...	24.52	24.52	...	24.52	29.77	...	29.77
Total -Animal Science		**257.59**	**...**	**257.59**	**224.41**	**...**	**224.41**	**224.41**	**...**	**224.41**	**300.00**	**...**	**300.00**
10. Fisheries Science	2415	137.99	...	137.99	115.92	...	115.92	115.92	...	115.92	146.39	...	146.39
	2552	...	...	...	2.97	...	2.97	2.97	...	2.97	3.61	...	3.61
Total -Fisheries Science		**137.99**	**...**	**137.99**	**118.89**	**...**	**118.89**	**118.89**	**...**	**118.89**	**150.00**	**...**	**150.00**
Agricultural Education													
11. Agricultural Universities and Institutions	2415	299.94	...	299.94	237.76	...	237.76	237.76	...	237.76	291.63	...	291.63
	2552	...	...	...	26.01	...	26.01	26.01	...	26.01	31.11	...	31.11
Total -Agricultural Universities and Institutions		**299.94**	**...**	**299.94**	**263.77**	**...**	**263.77**	**263.77**	**...**	**263.77**	**322.74**	**...**	**322.74**
12. Economic Statistics and Management	2415	27.65	...	27.65	24.51	...	24.51	24.51	...	24.51	...	...	...
13. National Agricultural Higher Education Project (EAP)		224.63	...	224.63	167.18	...	167.18	167.00	...	167.00	92.26	...	92.26
Total -Central Sector Schemes/ Projects		**2327.71**	**...**	**2327.71**	**1995.83**	**...**	**1995.83**	**1995.61**	**...**	**1995.61**	**2423.41**	**...**	**2423.41**
III Other Central Sector Expenditure													
a Autonomous Bodies													
14. ICAR Headquarters		5551.90	...	5551.90	5877.06	...	5877.06	6006.28	...	6006.28	6384.59	...	6384.59
	2552	...	...	...	...	...	...	...	...	...	...	...	...
		5551.90	...	5551.90	5877.06	...	5877.06	6006.28	...	6006.28	6384.59	...	6384.59
15. Central Agricultural Universities	2415	520.79	...	520.79	331.45	...	331.45	341.02	...	341.02	368.11	...	368.11
	2552	...	...	...	268.00	...	268.00	270.00	...	270.00	283.42	...	283.42
		520.79	...	520.79	599.45	...	599.45	611.02	...	611.02	651.53	...	651.53
16. National Academy of Agricultural Sciences	2415	1.29	...	1.29	1.60	...	1.60	1.18	...	1.18	0.76	...	0.76
17. Agricultural Scientists Recruitment Board		25.63	...	25.63	...	...	...	...	...	...	...	...	...
Total -Autonomous Bodies		**6099.61**	**...**	**6099.61**	**6478.11**	**...**	**6478.11**	**6618.48**	**...**	**6618.48**	**7036.88**	**...**	**7036.88**
b Others													
18. Actual Recoveries		-71.91	...	-71.91	...	...	...	...	...	...	...	...	...

Contd..

(Concluded)

Schemes		Actual 2021-2022			Budget 2022-2023			Revised 2022-2023			Budget 2023-2024		
		Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
	3451	-0.02	...	-0.02	...	...	...	...	...	...	...	...	...
		-71.93	...	-71.93	...	...	...	...	...	...	...	...	...
Grand Total –		8368.01	...	8368.01	8513.62	...	8513.62	8658.89	...	8658.89	9504.00	10.41	9504.00
B. Developmental Heads													
Economic Services													
Agricultural Research and Education		8362.05	...	8362.05	8013.39	...	8013.39	8151.94	...	8151.94	8941.93	...	8941.93
Secretariat-Economic Services		5.96	...	5.96	32.65	...	32.65	37.37	...	...	25.87	...	25.87
Capital Outlay on Other General Economics Services		...	...	...	...	...	...	...	...	...	...	10.41	10.41
Total -Economic Services		8368.01	...	8368.01	8046.04	...	8046.04	8189.31	...	8189.31	8967.80	10.41	8978.21
Others													
3. North Eastern Areas		...	...	...	467.58	...	467.58	469.58	...	469.58	525.79	...	525.79
Total -Others		**...**	**...**	**...**	**467.58**	**...**	**467.58**	**469.58**	**...**	**469.58**	**525.79**	**...**	**525.79**
Total -		**8368.01**	**...**	**8368.01**	**8513.62**	**...**	**8513.62**	**8658.89**	**...**	**8658.89**	**9493.59**	**10.41**	**9504.00**
C. Investment in Public Enterprise													
01 Agrinnovate India Limited		...	2.37	2.37	...	5.00	5.00	...	2.87	2.87	...	2.87	2.87

1. The provision is for the expenditure on salary and establishment expenditure of Department and Agricultural Scientists Recruitment Board (ASRB). ASRB is an attached office of DARE.
2. The provision is for the activities to reach out to the farmers at grass root level through Krishi Vigyan Kendras to disseminate and refine frontline agricultural technologies. It includes training of farmers and extension personnel on local technologies, distribution of seed, planting materials, testing of soil and water samples.
3. The provision is for research, development and refinement of farm equipment, process and value addition protocols.
4. The provision is for research to address low farm productivity and profitability, land degradation, low water productivity, soil health deterioration and low nutrient use efficiency, deterioration in ecosystem services, abiotic stresses, etc. It is necessary to encounter deteriorating natural resource base for long term sustainability.
5. The provision is to conduct strategic research and technology demonstration to enhance resilience of Indian agriculture to climate change and climate vulnerability. The research on adaptation and mitigation covers crops, livestock, fisheries and natural resource management. This scheme will be merged with Natural Resource Management Institutes including Agro Forestry Research scheme with effect from financial year 2023-24.
6. Research provision is to develop trait- specific high yielding field crop varieties/hybrids having tolerance to pest and diseases, besides various abiotic stresses. The quality attributes are also given due importance with no yield penalty. The All India Coordinated Research Project (AICRPs)/Network Research Projects with active collaboration with State Agricultural Universities (SAUs) are engaged in the development of improved crop varieties/ hybrids, cost-effective production and environment-friendly protection technologies in different agro-climatic regions.
7. The provision is to address thrust areas of enrichment of horticultural genetic resources, development of new cultivation with resistance mechanism to biotic and abiotic stresses, appropriate production technology and health management system of horticultural and vegetable crops.
8. Supports basic and strategic research in agriculture to address the prioritized research problems. This scheme will be merged under non scheme budget with effect from 2023-24.
9. The provision is to develop new technologies to support production enhancement, profitability, competitiveness and sustainability of livestock and poultry sector for food and nutritional security. It will facilitate need based priority research in livestock and poultry sector in on-going and new emerging areas to support productivity increase, thereby reducing the gap between potential and actual yield.
10. The provision is to implement research and academic programmes in fisheries and aquaculture. It also provides technical, training, analytical, advisory support and consultancy

services in the field of resources assessment and management, standardization of aquaculture hatchery and grow-out culture technologies, responsible fishing system and species diversification and utilization of inland saline soils for aquaculture, fish health monitoring, etc.

11. The provision will provide financial support to all the agricultural universities in the country comprising State Agricultural Universities (SAUs), Deemed Universities (DUs), and Central Universities (CUs) with Agriculture Faculty. The scheme is also responsible for maintainance and improvement of standard of agricultural education through:(i) accreditation of educational institutions, (ii) providing International/national fellowships both at post and undergraduate levels, (iii) organization of training and capacity building programmes for the scientists/faculty of National Agricultural Research System in cutting-edge areas.
12. The provision is for conducting research in the areas of agricultural economics and agricultural statistics to address the policy, management and database issues and accordingly provide need-based support to other schemes and agricultural stakeholders. This scheme will be merged with Agricultural Universities and Institutions scheme with effect from financial year 2023-24.
13. It is an externally aided project funded by World Bank and the Government. The provision is for the externally aided component of the National Agricultural Higher Education Project (NAHEP) which aims to develop resources and mechanism for supporting infrastructure, faculty and student advancement, providing means for better governance and management of agricultural universities, so that a holistic model can be developed to raise the standard of current agricultural education system that provides more jobs and is entrepreneurship oriented on par with global agricultural standards.
14. Provision is primarily for the salaries, pensions, expenses on administrative and logistic support to different schemes under ICAR in order to implement them efficiently.
15. The provision is to strengthen the regional education, research and extension capabilities based on local agro-climatic situation.
16. The provision is to provide a forum to Agricultural Scientists to deliberate on important issues of agricultural research, education, extension and present views of the scientific community as policy inputs to planners, decision/opinion makers at various levels.
17. The provisions are for the creation of an separate autonomous body which would be responsible for the recruitment to posts in the Agricultural Research Service (ARS) of the ICAR and other group A posts in ICAR.

APPENDIX 2

DEPARTMENTAL ACCOUNTING ORGANIZATION
Accounting Organization of Department of Agricultural Research and Education

The Secretary as Chief Accounting Authority in the Department of Agricultural Research and Education discharges his functions with the assistance of Financial Adviser and Chief controller of Accounts.

2. As per Rule 70 of GFR 2017, the Secretary of a Ministry/ Department as Chief Accounting Authority of the Ministry/Department shall:

i. Be responsible and accountable for financial management of his Ministry or Department;

ii. Ensure that the public funds appropriated to the Ministry or Department are used for the purpose for which they were meant;

iii. Be responsible for the effective, efficient, economical and transparent use of the resources of the Ministry or Department in achieving the stated project objectives of that Ministry or Department, whilst complying with performance standards;

iv. Appear before the committee on Public Accounts and any other Parliamentary Committee for examination;

v. Review and monitor regularly the performance of the programmes and projects assigned to his Ministry to determine whether stated objectives are achieved;

vi. Be responsible for preparation of expenditure and statements relating to his Ministry or Department as required by regulations, guidelines or directives issued by Ministry of Finance;

vii. Ensure that his Ministry or Department maintains full and proper records of financial transaction and adopts systems and procedures that shall at all time afford internal controls;

viii. Ensure that his Ministry or Department follows the Government procurement procedure for execution of works, as well as for procurement of services and supplies and implements it in a fair, equitable, transparent, competitive and cost-effective manner;

ix. Take effective and appropriate steps to ensure his Ministry or Department:-

(a) Collects all money due to the Government and

(b) Avoid unauthorized, irregular and wasteful expenditure.

3. As per Para 1.3 of Civil Accounts Manual, the Chief Controller of Accounts and on behalf of the Chief Accounting Authority is responsible for:

(a) Arranging all payment/Principal Accounts Officer Except where the Drawing and Disbursing Officers are authorized to make certain types of Payments.

(b) Compilation and consolidation of account of the Ministry/Department and their submission in the form prescribed, to the Controller General of Accounts; preparation for the Demands for Grant of his Ministry/ Department, getting them duly audit and submitting them to the CGA, duly signed by the Chief Accounting Authority.

(c) Arranging internal inspection of payment and accounts records maintained by the various subordinate formations and pay and accounts Offices of the Department and inspection of records pertaining to transaction of Government Ministries/Departments, maintained in Public Sector Banks.

4. The Chief Controller of Accounts, Ministry of Agriculture and Farmers Welfare performs his duties with the assistance of Controller/Dy. Controller of Accounts, Pr. Accounts Office at HQ and 09 Pay and Accounts Offices, Four Pay and Accounts Offices are located in Delhi/NCR, One each in Mumbai, Chennai, Cochin, Kolkata and Nagpur. All payments pertaining to the Department/Ministry are made through PAOs/ CDDOs attached with respective PAOs. DDOs present their claims/bills to the designated PAOs/CDDOs, who issue cheques/releases e-payment after exercising the necessary scrutiny as per provisions contained in Civil Accounts Manual, Receipt and Payment Rules and other order issued by Government from time to time.

5. As per Para 1.2.3 or Civil Accounts Manual, Principal Accounts Office at HQ functions under a Principal Accounts Officer who is responsible for:

(a) Consolidation of the accounts of the Ministry/ Department in the manner prescribed by CGA;

Preparation of Annual Appropriation Accounts of the Demands for Grants controlled by Ministry/ Department, submission of Statement of Central Transactions and material for the Finance Account of the Union Government (Civil) to the Controller General of Accounts:

(b) Payment of loans and grants to State Government through Reserve Bank of India and wherever this office has a drawing account, payment therefrom to Union Territory Government/Administrations:

(c) Preparation of manuals keeping in view the objective of management accounting system if any, and for rendition of technical advice to Pay and Accounts Offices, maintaining necessary liaison with CGA's Office and to effect overall coordination and control in accounting matters:

(d) Maintaining Appropriation Audit Registers for the Ministry/Department as a whole to watch the progress of expenditure under the various Grants operated on by the Ministry/Department;

(e) Principal Accounts Office/Officer also performs all administrative and coordinating function or the accounting organization and renders necessary financial, technical, accounting advice to department as well as to local Pay & Accounts offices and Out Station Pay & Accounts offices.

6. As per provisions contained in Civil Accounts Manual, Pay & Accounts offices make payments pertaining to

respective Ministries/Departments and in certain cases payments will be made by the departmental Drawing and Disbursing Officers (DDOs) authorized to draw funds, by means of cheques drawn on the offices/branches of accredited bank for handling the receipts and payments of the Ministry/Department. These payments will be accounted for in separate scrolls to be rendered to the Pay and Accounts Offices of Ministry/Department concerned. Each Pay and Accounts Office or Drawing and Disbursing Officer authorized to make payments by cheques/e-payments. Will draw only on the particular branch/branches of the accredited bank with which the Pay and Accounts Office or the Drawing and Disbursing Officer as the case may be, is placed in account. All receipts of the Ministry/Department are also be finally accounted for in the books of the Pay and Accounts Office. The Pay and· Accounts office is the basic Unit of Departmentalized Accounting Organization. Its main functions include:

(a) Pre-check and payment of all bills. Including those of loans and grants-in-aid, submitted by Non-Cheque Drawing DDOs.

(b) Accurate and timely payments in conformity with prescribed rules and regulations.

(c) Timely realization of receipts.

(d) Issue of quarterly letter of credit to Cheque Drawing DDOs and post check of their Vouchers/bills.

(e) Compilation of monthly accounts of receipts and expenditures made by them incorporating there with the accounts of the cheque Drawing DDOs.

(f) Maintenance of GPF accounts other than merged DDO and authorization of retirement benefits.

(g) Maintenance of all DDR Heads.

(h) Efficient service delivery to the Ministry/Department through banking arrangement by way of e-payment.

(i) Adherence to the prescribed Accounting Standards, rules and principles.

(ii) Timely, accurate, comprehensive, relevant and useful financial reporting.

7. The overall responsibilities or Departmental Accounting Organization in respect of Ministry of Agriculture and Farmers Welfare are:

(a) Consolidation of monthly accounts of Ministry and its submission to the CGA.

(b) Annual Appropriation Accounts.

(c) Statement of Central Transactions.

(d) Preparation of "Accounts at a Glance".

(e) Union Finance accounts which are submitted to the CGA, Ministry of Finance and Principal Director of Audit.

(f) Payments of grants-in-aid to Grantee Institutions/ Autonomous Bodies etc.

(g) Rendering technical advice to all PAOs and Ministry; if necessary in consultation with other organizations like DoPT. Ministry of Finance and CGA etc.

(h) Preparation of Receipt Budget.

(i) Preparation of Pension Budget.

(j) Procuring and supplying of cheque books for and on behalf of PAOs/Cheque Drawing DDOs.

(k) To maintain necessary liaison with Controller General of Accounts office and to effect overall co-ordination and control in accounting matters and accredited Bank.

(l) To verify and reconcile all receipts and payments made on behalf of Ministry of Agriculture and Farmers Welfare through the accredited Bank, i.e. State Bank of India.

(m) To maintain accounts with Reserve Bank of India relating to Ministry of Agriculture and Farmers Welfare and to reconcile the cash balances.

(n) To ensure prompt payments.

(o) Speedy settlement of Pension/Provident fund and other retirement benefits.

(p) Internal Audit of the Ministry, subordinate and attached offices under Ministry of Agriculture and Farmers Welfare and its Grantee institutions, Autonomous Bodies etc.

(q) To make available accounting information to all concerned Authorities/ Divisions.

(r) Budget co-ordination works of Ministry of Agriculture and Farmers Welfare.

(s) Monitoring of New Pension Scheme and revision of pension cases from time to time.

(t) Computerization of Accounts and e-payment.

(u) Administrative and co-ordination function of the accounting organization.

(v) Roll out of PFMS under Central Sector Schemes in Grantee Institutions/Autonomous Bodies.

(w) Non-Tax Receipt Portal (NTRP) in Ministry of Agriculture and Farmers Welfare.

8. Accounting information and data are also provided to the Financial Advisor and Chief Accounting Authority to facilitate effective budgetary and financial control. Monthly and progressive expenditure figures under various sub-heads/object-heads of the grant of the Ministry of Agriculture and Farmers Welfare are furnished to Budget Section of the Ministry including Senior officers. Progress of expenditure against budget provisions are also submitted weekly to the Secretary and Addl. Secretary & Financial Adviser as well as Heads of Divisions of the Ministry, controlling the grant for purposes of better monitoring of expenditure in last quarter of the financial year.

9. The Accounting organization also maintains accounts of long-term advances such as House Building Advance, Motor Car Advance and GPF accounts of employees of the Ministry.

10. The verification and authorization of pensionary entitlement of officers and staff members is done by the Pay & Accounts Offices on the basis of service particulars and pension papers furnished by Heads of Offices. All retirement benefits and payments like gratuity, cash equivalent to leave salary as well as payments under Central Government Employees Group Insurance Scheme: General Provident Fund etc. are released by Pay & Accounts Offices on receipt of relevant information/ bills from DDOs.

Internal Audit Wing

(a) The Internal Audit Wing carries out audit of accounts of various offices of the Ministry to ensure that rules, regulations and procedures prescribed by the government are adhered to by these offices in their day to day functioning. Internal Auditing is an independent, objective assurance and consulting activity designed to add value and improve an organization's operations .It basically aims at helping the organization to accomplish its objectives by bringing a systematic, disciplined approach to evaluate and improve the effectiveness of risk management. Control and governance processes. It is also an effective tool for providing objective assurance and advice that adds values, influence change that enhances governance, assist risk management, control processes and improve accountability for results. It also provides valuable information to rectify the procedural mistakes/deficiencies and thus, acts as an aid to the management. The periodicity of audit of a unit is regulated by its nature, volume of work and quantum of funds.

(b) The Internal Audit Wing working under the overall guidance of Chief Accounting Authority and Financial Advisor has focused on strengthening governance structures, capacity building and leveraging technology in appropriate manner to ensure an efficient and effective Internal Audit practice.

(c) In pursuance of O/o Controller General of Accounts, Department or Expenditure, Ministry of Finance, OM no.G.25014/33/20 I 5-16/Mf .CGA/IAD/306-53 dated 15.05.17 and as per provisions contained in Generic Internal Audit Manual (Version 1.0) issued by O/o CGA, Audit Committee has been constituted in this Department under the Chairmanship of Secretary (DARE) and DG (ICAR) with the approval of Secretary (DARE) and DG (ICAR) and terms of reference of Internal Audit Committee has been defined in O/o CCA OM No. Agri/IAW/Audit Committee (DARE)/2022-23 (Computer File No. 197946)/523-532 dated15.09.2022.

(d) During the financial year 2023-24, the focus of Audit was to detect errors in fixation of Pay paid in excess as well as in short.

Status of Outstanding Internal Audit paras in the Department of Agricultural Research and Education (DARE) as on 30.09.2023 are given below:

Banking Arrangements

State Bank of India is the accredited bank for PAOs and its field offices in the Ministry of Agriculture & Farmers Welfare. The e-payments processed by the PAOs/CDDOs are settled through CMP, SBI, Hyderabad in favor of the bank account of vendors/beneficiaries. In some cases, Cheques issued by the PAOs/CDDOs are presented to the nominated branch of the accredited bank for payment. The receipts are also remitted to the accredited banks by the respective PAOs/CDDOs apart from Non-Tax-Receipt Portal (NTRP). Any change in accredited bank requires specific approval of Controller General or Accounts, Department of Expenditure, Ministry of Finance.

Principal Accounts Office has 09 (Nine) Pay & Accounts Offices. Four PAOs are located in Delhi/NCR. One each in Mumbai, Chennai, Cochin, Kolkata and Nagpur. All payments pertaining to the Department/Ministry arc made through PAOs/CDDOs attached with respective PAOs. Drawing and Disbursing Officer present their claims/bills to the designated PAOs/CDDOs, who issue and releases e payment after exercising the necessary scrutiny as per provisions contained in Civil Accounts Manual, Receipt and Payment Rules and other orders issued by Government from time to time.

Initiatives on e-payment

Thee-payment system in all Pay & Accounts Offices of Ministry of Agriculture & Farmers Welfare had been successfully implemented from 2011 onwards.

e-Payment System

Since, the IT Act, 2000 recognizes the digitally signed documents or electronic records digitally authenticated by means of an electronic method or procedure in accordance with the provisions of section 3 of the Act, the Controller General of Accounts had developed a facility in COMPACT for electronic payment (e-payment) through digitally signed electronic advices. This had replaced the existing system of payment through cheque while leveraging the COMPACT application running in all Pay & Accounts Offices in all Ministries/Departments of Central Government.

Thee-payment system developed was a fully secured web based system of electronic payment services which introduces transparency in government payment system. Payment of dues from the government under this system were made by credit of money directly into the bank account of payee through a digitally signed e-advices generated from COMPACT through the 'Government e-payment Gateway (GePG)' on a secured communication channel. Necessary functional and security certification were obtained from STQC Directorate for its roll out. The system was implemented in all Central Government Civil Ministries/Departments in a phased manner.

GePG has further been upgraded to PFMS system, which is an Integrated Financial Management System of Controller General of Accounts, for sanction preparation. Bill processing, payment, receipt management. Direct Benefit Transfer, fund flow management and financial reporting

Department	Outstanding paras Up to 31.03.2023	Paras raised from 01.04.2023 to 30.06.2023	Paras dropped from 01.04.2023 to 30.06.2023	Total outstanding Paras as on 30.06.2023
DARE	11	NIL	0	11
ICAR	33	NIL	21	12
Units Total	41	NIL	0	41
Department	Outstanding paras upto 30.06.2023	Paras raised from 01.07.2023 to 30.09.2023	Paras dropped from 01.07.2023 to 30.09.2023	Total outstanding Parasason 30.09.2023
DARE	11	NIL	NIL	11
ICAR Units	12	NIL	4	8
Total	41	NIL	13	28

Public Financial Management System

Public Financial Management System (PFMS) initially started as a Plan Scheme named CPSMS of the erstwhile Planning Commission in 2008-09 as a pilot in four states of Madhya Pradesh. Bihar, Punjab and Mizoram for four Flagship schemes, e.g MGNREGS, NRHM, SSA and PMGSY. After the initials phase of establishing a network across Ministries/Departments. It has been decided to undertake National roll-out of CPSMS (PFMS) to link the financial networks of Central, State Governments and the agencies of State Governments.The scheme was included in 12th Plan initiatives of erstwhile Planning Commission and Ministry of Finance. Presently PFMS is the scheme of Department of Expenditure, Ministry of Finance and being implemented by O/o Controller General of Accounts across the country.

(1) As per MoF, DoE. OM No.66 (29) PF-11/2016 dated 15/07/2016, Hon'ble Prime Minister has emphasized the need for improved financial management in implementation of Central Plan Schemes so as to facilitate Just-in-Time releases and monitor the usage of funds including information on its ultimate utilization. The Public Financial Management System is administered by the O/o controller General of Accounts in the Department of Expenditure which is an end-to-end solution for processing payments, tracking, monitoring, accounting, reconciliation and reporting. It provides the scheme managers a unified platform for tracking releases and monitoring their last mile utilization.

(2) In order to abide by the directions to implement Just-in-time releases and monitor the end usage of funds, it has been decided by Ministry of Finance to universalise the use of PFMS to cover all transactions/payments under the Central Sector Schemes. The complete monitoring of these schemes require mandatory registration of all Implementing Agencies (IAs) on PFMS and mandatory use of Expenditure, Advances & Transfer (EAT) module of the PFMS by all IAs. The Implementation Plan covers the complete universe of Central Sector Schemes, which inter-alia requires the following steps to be taken by each Ministry/Department:-

(i) All central schemes have to be mapped/configured and brought on the PFMS platform.

(ii) All Implementing Agencies (IAs) recieving and utilizing funds needs to be mandatorily registered on PFMS.

(iii) Usage of PFMS modules has to be made mandatory for all registered agencies for making payments, advances and transfers.

(iv) All Departmental Agencies incurring expenditure in respect of Central Sector Schemes must register and compulsorily use the PFMS Modules.

(v) All Grantee Institutions have to adopt PFMS modules for making Payments/Transfers /Advance from Grants received from the Central Government. This will enable generation of on-line Utilization Certificates for claiming funds from the Central Government.

(vi) Ministry has to take an action for integrating their respective systems/applications with the PFMS.

Modules to implement the Mandate

Modules developed/under developed by PFMS for stakeholders as per the Union Cabinet approval and mandate are as under:

I. Fund Flow Monitoring (EAT Modules)

(a) Agency registration

(b) Expenditure management and fund utilization through PFMSEAT module

(c) Accounting Module for registered agencies

(d) Treasury Interface

(e) PFMS-PRI fund flow and utilization interface

(f) Mechanism for State Governments towards fund tracking for State schemes

(g) Monitoring of Externally Aided Projects (EAP)

II. Direct Benefit Transfer (DBT) modules

(a) PAO to beneficiaries

(b) Agency to beneficiaries

(c) State treasuries to beneficiaries

III. Interfaces for Banking

(a) CBS (Core Banking Solutions)

(b) India Post

(c) RBI (Reserve Bank of India)

(d) NABARD & Cooperative Banks

Modules to Implement Enhanced mandate

(1) PAO Computerization-Online e-payments, receipts and accounting of Government of India

(a) Programme Division module

(b) DDO module

(c) PAO module

(d) Pension module

(e) GPF & HR module

(f) Receipts including GSTN

(g) Annual Financial Statements

(h) Cash Flow Management

(i) Interface with non-civil ministries

(2) Non-Tax Receipt Portal.

Other Departmental Initiatives

To leverage the capabilities or PFMS. several other departments have approached PFMS for developing utilities for their departmental need as follows:

(i) CBDTPAN Validation

(ii) GSTN bank account validation

Implementation Strategy

An Action Plan has been prepared and approved by Ministry of Finance for phased implementation of Public Financial Management System.

Improved Financial Management through

Justin Time (JIT) release of funds

Monitoring of use of funds including ultimate utilization

Strategy

Universal roll-out of PFMS which inter alia includes

- Mandatory registration of all Implementing Agencies (IA) on PFMS and
- Mandatory use of Expenditure Advance & Transfer (EAT) Module of PFMS by all IAs.

I. Implementation Strategy for Central Sector (CS) schemes/ transaction

- Activities to be completed
- Mandatory registration and use of EAT module by IAs
- Mapping of all relevant information of Schemes
- Uploading of budget of each scheme on PFMS
- Identify implementation hierarchy of each scheme
- Integration of System Interface of specific schemes with PFMS, e.g. NREGA Soft, Awas Soft
- Deployment and training of trainers

II. Implementation Strategy for Centrally Sponsored Schemes

Activities to be under taken by states

- State Treasury Integration with PFMS
- Registration of all SIAs on PFMS (1st level and below)
- Mapping of stale schemes with corresponding central schemes
- Configuration of State schemes on PFMS
- Configuring State Schemes components
- Identify and configure hierarchy of each state scheme
- Integration of PFMS with schemes specific software application
- Deployment and training of trainers Continuous support for implementation

At present, all nine (09) Pay & Accounts Offices of M/o Agriculture Farmers Welfare, four (4) PAOs arc located in Delhi/NCR. One each in Mumbai, Chennai, Cochin, Kolkata and Nagpur arc functioning successfully on PFMS. All payments are routed through PFMS and e-payments being directly credited into the beneficiary's bank account.

I. ***Employees Information System (EIS) Module of PFMS:*** This Module has been implemented in all Drawing & Disbursing Offices of Ministry of Agriculture & Farmers Welfare.

II. ***CDDO Module of PFMS:*** CDDO module of PFMS has been rolled out in all Cheque Drawing and Disbursing Offices of Ministry of Agriculture & Farmers Welfare.

III. **Online Portal (Bharatkosh) for collection of Non-Tax Revenue in the Ministry:**

- The objective of Non-Tax Receipt Portal (NTRP) is to provide a one-stop window to Citizens/Corporate/Other users for making online payment of Non-Tax Revenue payable to Government of India (Gol).
- Non-Tax Revenue of Government of India comprise of a large bouquet of receipts, collected by individual departments/ministries. Primarily these receipts come from Dividends, Interest receipts, Spectrum charges, RTI application fee, purchase of forms/magazines by students and many other such payments by citizens/ corporate/other users.
- The online electronic payment in a completely secured IT environment, helps common users/citizen from the hassle of going to banks for making drafts and then to Government offices to deposit the instrument for availing the services. It also helps avoidable delays in the remittance of these instruments into Government account as well as eliminates undesirable practices in the delayed deposit of these instruments into bank accounts.
- NTRP facilitates instant payment in a transparent environment using online payment technologies such as Internet Banking, Credit/Debit Cards.
- NTR Portal has been functional in new Ministry of Agriculture & Farmers Welfare since inception in FY 2019-20.
- Expenditure, Advance and Transfer (EAT) Module of PFMS: All eight **(08)** Autonomous Bodies of Ministry of Agriculture & Farmers Welfare have beenon-boarded on Expenditure Advance Transfer (EAT) module of PFMS.

Treasury Single Account (TSA)

The Expenditure Management Commission (EMC) vide Para 125 of its September, 2015 report has recommended that in order to minimize the cost of Government borrowings and to enhance efficiency in fund flows to Autonomous Bodies, Government should gradually bring all Autonomous Bodies (ABs) under the Treasury Single Account (TSA) System. Under Department of Agricultural Research & Education, the TSA is implemented in the following:

- Indian Council of Agricultural Research (ICAR)
- Central Agriculture University, Imphal
- Central Agriculture University, Bundelkhand
- Central Agriculture University, Samastipur (Bihar)
- National Academy of Agricultural Sciences

The details of the Budgetary Provision & Expenditure their against is reflected below:

- Ministry of Finance, Department of Expenditure Vide Office Memorandum F.No. 26(118)/EMC Cell/2016

TSA Figures as on 31-10-2023

(₹/ In Crore)

Name of ABs	Budget Estimate	Releases	% of Releases
Central Agriculture University, Imphal	283.42	212.57	75%
Central Agriculture University, Bundelkhand	120.00	90.00	75%
Central Agriculture University, Samastipur (Bihar)	248.11	186.08	75%
National Academy of Agricultural Sciences	0.76	0.38	50%
ICAR Headquarters	6384.59	4803.04	75.23%

dated 24.02.2022 has issued "Revised instructions on bringing Autonomous Bodies (ABs) under the Treasury Single Account (TSA) System".

- Ministry of Finance, Department of Expenditure Vide Office Memorandum F.No.26(118)/EMC Cell/2016 dated20.10.2022 has issued "Amendment in revised guidelines for implementing Treasury Single Account (TSA) System in Autonomous Bodies (Abs)", which states that "these guidelines shall be applicable to Autonomous Bodies (ABs) including Statutory Bodies and Central Public Sector Enterprises (CPSEs) receiving more than Rs. 100.00 crores in a F.Y. as Grants-in-Aid".

New Developments in the Ministry

I. Enforcement of enhanced security layers in online payment process in Public Financial Management System (PFMS)

In order to ensure safety measures on PFMS platform, the following features are being enforced for treasury operations:

(a) Verification of each payment request with physical bill without fail before putting the digital signature by Pay & Accounts Offices (PAOs).

(b) Use of NIC/GOV domain e-mail IDs for user registration by the officials dealing with PAO and DDO module of PFMS.

(c) Immediate deactivation of user(s) found to be no longer active

(d) Deactivation of user ID/Digital key of PAO/ AAO user type at the time permanent transfer/ superannuation).

(e) Use of NIC/GOV domain e-mail IDs for user registration by the officials dealing with PAO and DDO module of PFMS.

(f) Implementation of OTP based log in system on PFMS in phased manner.

II. Implementation of electronic Bill (e-Bill) System of Public Financial Management System (PFMS)

In pursuance of the Digital India Initiative of Hon'ble Prime Minister, it was decided to develop a system to enable end to end digital processing of bills and claims from vendors, suppliers, contractors and all other types of payees of Government. The system was developed in the PFMS for the use in all Civil Ministries and Departments. With the initiative of e-bill, the complete payment system has become paperless.

- End-to-End electronic processing of claim and bill through PMFS on pilot-roll out of electronic Bill (e-Bill) system has been introduced in Department of Agricultural Research and Education w.e.f. 01.06.2022.
- The expenditure up to 31.10.2023 in respect of DARE with reference to BE 2023-24 is annexed at Annexure - "A"

ANNEXURE-A

Grant No. 02
Department of Agricultural Research and Education Monitoring of Expenditure over BE
Transaction Date: 01.04.2023 to 31.10.2023

(₹/ in Crores)

S. No.	Name of Scheme/Description	BE 2023-24	Progressive Exp. up to 31.10.2023 (Provisional)	% age of expenditure over BE
	1	2	3	4
1.	Establishment Expenditure of the Centre			
1.1	Secretariat	8.30	4.47	53.86%
1.2	Agricultural Scientist Recruitment Board	27.98	8.32	29.74%
1.3	International Cooperation – Other Programmes	7.43	0.08	1.08%
	Total – Establishment Expenditure of the Centre	43.71	12.87	29.44%
2.	Central Sector Schemes/Projects			
2.1	Agriculture Extension	327.00	245.25	75.00%
2.2	Agriculture Engineering	65.00	48.75	75.00%
2.3	Natural Resource Management Institute Including Agro Forestry Research	240.00	180.00	75.00%
2.4	Crop Sciences	714.00	535.81	75.00%
2.5	Horticultural Science	212.00	159.00	75.00%
2.6	Animal Science	300.00	225.00	75.00%
2.7	Fisheries Science	150.00	112.50	75.00%
2.8	Agricultural Universities and Institutions	322.74	242.06	75.00%
2.9	National Agricultural Higher Education Project (EAP)	92.26	54.60	59.18%
	Total - Central Sector Schemes/Projects	2,423.41	1,802.97	74.40%
3.	Other Central Sector Expenditure			
3.1	Autonomous Bodies			
(i)	ICAR Headquarters	6,384.59	4,803.04	75.23%
(ii)	Central Agricultural Universities			
	CAU-Imphal	283.42	212.57	75.00%
	CAU- Bundelkhand	120.00	90.00	75.00%
	CAU – Samastipur (Bihar)	248.11	186.08	75.00%
	TOTAL - Central Agricultural Universities	7,036.88	5,292.07	75.02%
	Total – Other Central Sector Expenditure	7,036.88	5,292.07	75.02%
	Total (Grant No. 02)	9,504.00	7,107.91	74.79%

APPENDIX 3

LIST OF THE MEMBERS OF THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

4(i) Minister-in-charge of the portfolio of Agriculture & Farmers Welfare in the Union Cabinet- President of the Society.

President

1. Shri Arjun Munda — Ex-officio
Minister of Agriculture & Farmers Welfare, Government of India, Krishi Bhavan, New Delhi-110 001

4(ii) Minister of State in the Union Ministry of Agriculture & Farmers Welfare dealing with ICAR- Vice President of the Society

Vice President

2. Shri Kailash Choudhary — Ex-officio
Minister of State for Agriculture & Farmers Welfare, Government of India, Krishi Bhavan, New Delhi-110 001

4(iii) Union Ministers holding charge of Finance, Planning, Science & Technology, Education and Commerce (in case the Prime Minister is holding any of these portfolios, the Minister of State in the Ministry/Department concerned).

3. Smt. Nirmala Sitharaman — Ex-officio
Minister of Finance and Corporate Affairs, Government of India, North Block, New Delhi-110 001

4. Shri Rao Inderjit Singh — Ex-officio
Minister of State (IC) for Planning, Statistics & Programme Implementation and MoS of Corporate Affairs, Government of India, Room No. 132, NITI Aayog, New Delhi 110 001

5. Dr. Jitendra Singh — Ex-officio
Minister of State (IC) for Science & Technology and Earth Sciences, Government of India, CSIR Building, 2 Rafi Marg, New Delhi-110 001

6. Shri Dharmendra Pradhan — Ex-officio
Minister of Education, Skill Development and Entrepreneurship, Government of India, Shastri Bhavan, New Delhi-110 001

7. Shri Piyush Goyal — Ex-officio
Minister of Commerce & Industry Government of India, Udyog Bhavan, New Delhi-110 001

4(iv) Other Ministers in the Union Ministry of Agriculture & Farmers Welfare.

8. Sushri Shobha Karandlaje — Ex-officio
Minister of State for Agriculture & Farmers Welfare, Government of India, Krishi Bhavan, New Delhi-110 001

4(v) Union Minister and Minister of State(s) in the Union Ministry of Fisheries, Animal Husbandry & Dairying, Union Minister of Fisheries, Animal Husbandry & Dairying will be the Senior Vice-President.

Senior. Vice-President

9. Shri Parshottam Rupala — Ex-officio
Minister of Fisheries, Animal Husbandry and Dairying, Government of India, Krishi Bhavan, New Delhi-110 001

10. Shri Sanjeev Kumar Balyan — Ex-officio
Minister of State for Fisheries, Animal Husbandry and Dairying, Government of India, Krishi Bhavan, New Delhi-110 001

11. Dr. L. Murugan — Ex-officio
Minister of State for Fisheries, Animal Husbandry and Dairying, Government of India, Krishi Bhavan, New Delhi-110 001

4(vi) Ministers in the States in-charge of Agriculture/Horticulture/ Animal Husbandry/Fisheries.

ANDHRA PRADESH

12. Shri Kakani Govardhana Reddy — Ex-officio
Minister for Agriculture and Cooperation, Government of Andhra Pradesh, A.P. Secretariat, Valagapudi, Hyderabad, Andhra Pradesh-500 022

13. Dr. Seediri Appalaraju — Ex-officio
Minister for Animal Husbandry &Fisheries, Government of Andhra Pradesh, A.P. Secretariat, Valagapudi, Hyderabad, Andhra Pradesh-500 022

ARUNACHAL PRADESH

14. Shri Er. Tage Taki — Ex-officio
Minister for Agriculture, Animal Husbandry, Horticulture & Fisheries, Government of Arunachal Pradesh Room No-308, Block-II, Civil Secretariat, Itanagar, Arunachal Pradesh-791 111

ASSAM

15. Shri Atul Bora — Ex-officio
Minister for Agriculture & Horticulture & Animal Husbandry Government of Assam, Assam (Civil) Secretariat, Dispur, Guwahati, Assam-781 006

16. Shri Parimal Suklabaiya — Ex-officio
Minister of Fisheries, Government of Assam, Assam (Civil) Secretariat, Dispur, Guwahati, Assam-781 006

BIHAR

17. Sh. Kumar Sarvjeet — Ex-officio
Minister for Agriculture & Horticulture, Government of Bihar, Vikas Bhavan, New Secretariat, Bailey Road, Patna, Bihar-800 015

18. Md. Afaque Alam — Ex-officio
Minister of Animal Husbandry & Fisheries, Government of Bihar, Vikas Bhavan, New Secretariat, Bailey Road, Patna, Bihar-800 015

CHHATTISGARH

19. Shri Ravindra Choubey — Ex-officio
Minister of Agriculture, Animal Husbandry & Fisheries, Government of Chhattisgarh, Mahanadi Bhawan, Mantralaya Naya Raipur-492 002

DELHI

20. Shri Gopal Rai — Ex-officio
Minister for Development, Delhi Secretariat, I.P. Estate, New Delhi-110 002

GOA

21. Shri Ravi Naik — Ex-officio
Minister of Agriculture and Horticulture, Government of Goa, Secretariat, Porvorim, Goa-403 521

22. Sh. Nilkanth Halarnkar — Ex-officio
Minister of Animal Husbandry & Fisheries, Government of Goa, Secretariat, Porvorim, Goa-403 521

GUJARAT

23. Shri Raghavjibhai Hansrajbhai Patel — Ex-officio
Minister for Agriculture, Animal Husbandry & Fisheries, Government of Gujarat, Swarnim Sankul-1, 2nd Floor Sachivalaya, Sector-10, Gandhinagar, Gujarat-382 010

HARYANA

24. Shri Jai Prakash Dalal — Ex-officio
Minister for Agriculture and Farmer Welfare, Horticulture, Animal Husbandry and Fisheries, Government of Haryana, Haryana Civil Secretariat, Chandigarh, Haryana-160 001

HIMACHAL PRADESH

25. Shri Chander Kumar — Ex-officio
Minister for Agriculture & Animal Husbandry, Government of Himachal Pradesh, H.P. Secretariat, Shimla, Himachal Pradesh-171 002

26. Shri Jagat Singh Negi — Ex-officio
Minister for Horticulture, Government of Himachal Pradesh, H.P. Secretariat, Shimla, Himachal Pradesh-171 002

JHARKHAND

27. Shri Badal Patralekh — Ex-officio
Minister of Agriculture, Animal Husbandry, Government of Jharkhand, Project Building HEC, Dhurva, Ranchi, Jharkhand-834 004

KARNATAKA

28. Shri N. Chaluvarayaswamy — Ex-officio
Minister for Agriculture, Government of Karnataka, Vidhan Soudha, Bengaluru, Karnataka-560 001

29. Shri S.S. Mallikarjun — Ex-officio
Minister for Horticulture, Government of Karnataka, Vidhan Soudha, Bengaluru, Karnataka-560 001

30. Shri K.Venkatesh — Ex-officio
Minister of Animal Husbandry Government of Karnataka, Vikasa Soudha, Bengaluru, Karnataka-560 001

31. Shri Mankal Vaidya — Ex-officio
Minister of Fisheries, Government of Karnataka, Vikasa Soudha, Bengaluru, Karnataka-560 001

KERALA

32. Shri Sri P. Prasad — Ex-officio
Minister for Agriculture, Government of Kerala, Government Secretariat Annexe, Thiruvananthapuram, Kerala-695 001

33. Smt. J. Chinchu Rani — Ex-officio
Minister for Animal Husbandry, Government of Kerala Government Secretariat Annexe, Thiruvananthapuram, Kerala-695 001

34. Shri. Saji Cherian — Ex-officio
Minister for Fisheries, Government of Kerala, Government Secretariat Annexe, Thiruvananthapuram, Kerala-695 001

MADHYA PRADESH

35. Shri Kamal Patel — Ex-officio
Minister of Agriculture Development, Government of Madhya Pradesh, Vallabh Bhavan, Bhopal, Madhya Pradesh-423 006

36. Sh. Prem Singh Patel — Ex-officio
Minister of Animal Husbandry, Government of Madhya Pradesh, Vallabh Bhavan, Bhopal, Madhya Pradesh -423 006

37. Shri Tulsi Silawat — Ex-officio
Minister of Fisheries Welfare and Fisheries Development, Government of Madhya Pradesh, Vallabh Bhavan, Bhopal, Madhya Pradesh-423 006

38. Shri Bharat Singh Kushwaha — Ex-officio
(MoS independent charge)
Minister of State for Horticulture, Government of Madhya Pradesh, Vallabh Bhavan, Bhopal, Madhya Pradesh -423 006

MAHARASHTRA

39. Shri Dhananjay Munde
Minister for Agriculture, Government of Maharashtra, Mantralaya, Mumbai, Maharashtra-400 032

40. Sh. Sandipanrao Bhumare — Ex-officio
Minister for Horticulture, Government of Maharashtra, Mantralaya, Mumbai, Maharashtra-400 032

41. Sh. Radhakrishna Vikhe Patil — Ex-officio
Minister for Animal Husbandry, Government of Maharashtra, Mantralaya, Mumbai, Maharashtra-400 032

42. Shri Sudhir Mungantiwar — Ex-officio
Minister for Fisheries, Government of Maharashtra, Mantralaya, Mumbai, Maharashtra-400 032

MANIPUR

43. Shri Olnam Lukho Singh — Ex-officio
Minister for Agriculture, Vet. & Animal Husbandry, Government of Manipur, Manipur Secretariat, Imphal, Manipur-795 001

44. Sh. Letpao Haokip — Ex-officio
Minister for Horticulture, Room No. 214, South Block, Government of Manipur, Manipur Secretariat, Imphal, Manipur-795 001

45. Shri Shorokhaibam Rajen — Ex-officio
Minister for Fisheries, Room No. 316-318, South Block, Government of Manipur, Manipur Secretariat, Imphal, Manipur-795 001

MEGHALAYA

46. Dr. Mazel Ampareen Lyngooh — Ex-officio
Ministry of Agriculture & Farmer's Welfare, Government of Meghalaya, Meghalaya Secretariat, Main Building Shillong, Meghalaya-793 001

47. Sh. Alexander Laloo Hek — Ex-officio
Minister for Animal Husbandry & Fisheries, Government of Meghalaya, Meghalaya Secretariat, Main Building Shillong, Meghalaya-793 001

MIZORAM

48. Shri Zoramthanga — Ex-officio
Hon'ble Chief Minister and holding the charge of Ministry of Horticulture Department, Government of Mizoram, Aizawl, Mizoram-796 001

49. Shri Er Lalrinawma — Ex-officio
Ministry, Animal Husbandry, Government of Mizoram, Aizawl, Mizoram-796 001

50. Shri C. Lalrinsanga — Ex-officio
Ministry of State (IC) for Agriculture, Government of Mizoram, Aizwal, Mizoram-796 001

51. Shri K. Lalrinliana — Ex-officio
Ministry of State (IC) for Fisheries, Government of Mizoram, Aizwal, Mizoram-796 001

NAGALAND

52. Shri Mhathung Yanthan — Ex-officio
Minister, Ministry of Agriculture, Government of Nagaland

53. Shri A. Pangjung Jamir — Ex-officio
Minister, Ministry of Fisheries & Aquatic Resources, Government of Nagaland

54. Shri Kazheto — Ex-officio
Minister, Ministry of Animal Husbandry, Government of Nagaland

55. Smt. Salhoutuonuo Kruse — Ex-officio
Minister, Ministry of Human Resource Development & Horticulture Government of Nagaland

ODISHA

56. Shri Ranendra Pratap Swain — Ex-officio
Minister for Agriculture, Fisheries & Animal Resource Development, Government of Odisha, Odisha Secretariat, Bhubaneswar, Odisha-751 001

PUNJAB

57. Shri Chetan Singh Jauramajra — Ex-officio
Minister of Horticulture, Government of Punjab, Punjab Civil Secretariat, Chandigarh, Punjab

58. Shri Gurmeet Singh Khudian — Ex-officio
Minister for Agriculture & Farmers Welfare, Government of Punjab, Punjab Civil Secretariat, Chandigarh, Punjab

59. Shri S. Gurmeet Singh Khudian — Ex-officio
Minister for Animal husbandry & Fisheries, Government of Punjab, Punjab Civil Secretariat, Chandigarh, Punjab

PUDUCHERRY

60. Shri. C. Djeacoumar — Ex-officio
Minister of Agriculture & Animal Husbandry, Government of Puducherry, Puducherry-605 001

61. Shri. K. Lakshminarayanan — Ex-officio
Minister for Fisheries, Government of Puducherry, Puducherry-605 001

RAJASTHAN

62. Shri Lal Chand Kataria — Ex-officio
Minister for Agriculture, Animal Husbandry & Fisheries, Government of Rajasthan, Rajasthan Secretariat, Mantralaya Bhawan, Jaipur, Rajasthan-302 005

SIKKIM

63. Shri Lok Nath Sharma — Ex-officio
Minister for Agriculture Development & Horticulture, Animal Husbandry, Government of Sikkim, New Secretariat, Development Area, Gangtok, Sikkim-737 101

TAMIL NADU

64. Shri Thiru M.R.K. Panneerselvam — Ex-officio
Minister for Agriculture & Horticulture, Government of Tamil Nadu, Chennai, Tamil Nadu-600 009

65. Shri Thiru Anitha R. Radhakrishnan — Ex-officio
Minister for Fisheries & Animal Husbandry, Government of Tamil Nadu, Chennai, Tamil Nadu-600 009

TELANGANA

66. Shri Singireddy Niranjan Reddy — Ex-officio
Minister of Agriculture, Government of Telangana, Haka Bhawan, 2nd Floor, Nampally, Telangana Secretariat Hyderabad, Telangana-500 004

67. Shri Talasani Srinivas Yadav — Ex-officio
Minister of Animal husbandry & Fisheries, Government of Telangana, Room No.261, D-Block, Telangana Secretariat, Hyderabad, Telangana-500 004

TRIPURA

68. Shri Ratan Lal Nath — Ex-officio
Minister for Agriculture & Farmers Welfare, Government of Tripura, Civil Secretariat, Agartala, Tripura-799 001

69. Sh. Sudhangshu Das — Ex-officio
Minister for Animal Resource Development and Fisheries, Government of Tripura, Civil Secretariat, Agartala, Tripura-799 001

UTTARAKHAND

70. Shri Ganesh Joshi — Ex-officio
Minister for Agriculture & Horticulture, Government of Uttarakhand, Uttarakhand Vidhan Sabha Bhawan, Dehradun, Uttarakhand

71. Sh. Saurabh Bahuguna — Ex-officio
Minister for Animal Husbandry & Fisheries, Government of Uttarakhand, Uttarakhand Vidhan Sabha Bhawan, Dehradun, Uttarakhand

UTTAR PRADESH

72. Shri Surya Pratap Shahi — Ex-officio
Minister of Agriculture, Government of Uttar Pradesh, UP Civil Secretariat, Lucknow, Uttar Pradesh

73. Shri Dharampal Singh — Ex-officio
Minister of Animal Husbandry, Government of Uttar Pradesh, UP Civil Secretariat, Lucknow, Uttar Pradesh

74. Shri Sanjay Kumar Nishad — Ex-officio
Minister of Fisheries, Government of Uttar Pradesh, Room No. 89 Vidhan Sabha Main Building, UP Civil Secretariat, Lucknow, Uttar Pradesh

WEST BENGAL

75. Shri Sobhandeb Chattopadhyay — Ex-officio
Minister for Agriculture, Government of West Bengal, Nabanna, 3rd Floor, 325, Sarat Chatterjee Road, Mandirtala, Shibpur, Howrah, Kolkata, West Bengal-711 102

76. Shri Swapan Debnath — Ex-officio
Minister of Animal Resources Development, Government of West Bengal, Prani Sampad Bhavan, LB-2, Sector-III, Salt Lake, Kolkata, West Bengal-711 102

77. Shri Biplab Roy Chowdhury — Ex-officio
Minister of State (IC) for Fisheries, Government of West Bengal, Benfish Tower, 8th Floor, 31 GN Block, Salt Lake, Sector-V, Kolkata, West Bengal-711 102

78. Shri Arup Roy — Ex-officio
Minister of Horticulture, Government of West Bengal, Benfish Tower, 4th Floor, GN Block, Sector V, Salt Lake City, Kolkata, West Bengal-711 102

4(vii) Member, NITI Ayog, In-charge of Agriculture.

79. Prof. Ramesh Chand — Ex-officio
Member (Agriculture) NITI Ayog, Niti Bhawan, New Delhi-110 001

4(viii) Six members of Parliament—four elected by Lok Sabha and two elected by Rajya Sabha.

81. VACANT — (due to office of profit)

82. VACANT — -do-

83. VACANT — -do-

84. VACANT — -do-

85. VACANT — -do-

86. VACANT — -do-

4(ix) Director-General, Indian Council of Agricultural Research.

87. Dr. Himanshu Pathak — Ex-officio
Secretary, DARE & DG, ICAR, Krishi Bhavan, New Delhi-110 001

4(x) All Secretaries in the Ministry of Agriculture & Farmers Welfare.

88. Shri Manoj Ahuja — Ex-officio
Secretary, Deptt. of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Krishi Bhavan, New Delhi-110 001

4(xi) All Secretaries in the Ministry of Fisheries, Animal Husbandry & Dairying.

89. Dr. Abhilaksh Likhi, — Ex-officio
Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, Government of India, Krishi Bhavan, New Delhi-110 001

90. Ms. Alka Upadhyaya — Ex-officio
Secretary,
Department of Animal Husbandry and Dairying, Ministery of Fisheries, Animal Husbandry and Dairying, Government of India, Krishi Bhavan, New Delhi-110 001

4(xii) CEO, NITI Ayog

91. Shri B.V.R. Subrahmanyam — Ex-officio
CEO, Niti Aayog, Yojana Bhavan, Sansad Marg, New Delhi-110 001

4(xiii) Secretary, Department of Bio-Technology.

92. Dr. Rajesh S. Gokhale — Ex-officio
Secretary,
Department of Biotechnology, Block 2, 7th Floor, CGO Complex, Lodhi Road, New Delhi-110 003

4(xiv) Director-General, Council of Scientific and Industrial Research.

93. Dr. (Mrs.) N Kalai Selvi — Ex-officio
Director General, Council of Scientific and Industrial Research, Anusandhan Bhavan, 2-Rafi Ahmed Kidwai Marg, New Delhi-110 001

4(xv) Chairman, University Grants Commission.

94. Prof. M. Jagadesh Kumar — Ex-officio
Chairman, University Grants Commission, Bahadur Shah Zafar Marg, New Delhi-110 002

4(xvi) Chairman, Atomic Energy Commission (or Director, Bhabha Atomic Research Centre, if nominated by the Chairman, Atomic Energy Commission)

95. Dr. Ajit Kumar Mohanty — Ex-officio
Chairman, Atomic Energy Commission, Department of Atomic Energy, Anushakti Bhavan, Chhatrapati Shivaji Maharaj Marg, Mumbai, Maharashtra-400 001

4(xvii) Member, Finance (Secretary/ Additional Secretary) in the Ministry of Finance, Government of India.

Alternative member for Ministry of Finance - AS & FA (DARE/ICAR)

96. Dr. T. V. Somanathan — Ex-officio
Secretary (Expenditure), Department of Expenditure, Ministry of Finance, North Block New Delhi-110 001

Alternative member for Ministry of Finance - AS & FA (DARE/ICAR)
Ms. Alka Nangia Arora — Ex-officio
Aditional Secretary & FA (DARE/ICAR), Krishi Bhawan, New Delhi-110 001

4(xviii) Five Vice-Chancellors of Agricultural Universities, nominated by the President.

97. Dr. Anupam Mishra — 29.12.2023
Vice Chancellor, Central Agricultural University, Imphal, P. O. Box No. 23, Imphal, Manipur-795 004

98. Dr. Rajeshwar Singh Chandel — 05.06.2025
Vice Chancellor, Dr. Y. S. Parmar University of Horticulture & Forestry, Solan, Nauni, Himachal Pradesh-173 230

99. Dr. P.S Pandey — 29.9.2025
Vice Chancellor, Dr. Rajendra Prasad Central Agricultural University, Smastipur, Bihar-848 125

100. Dr. S. P. Tiwari — 13-03-2026
Vice-Chancellor, Nanaji Deshmukh Veterinary Science University, Jabalpur, Madhya Pradesh-482 004

101. Prof Balraj Singh — 13-03-2026
Vice-Chancellor, Sri Karan Narendra Agriculture University, Jobner-303 329

4(xix) Five technical representatives, namely Agricultural Commissioner, Horticultural Commissioner, Animal Husbandry Commissioner and Fisheries Development Commissioner from Union Ministries of Agriculture & Farmers Welfare/Fisheries, Animal Husbandry & Dairying and Inspector-General of Forests, Government of India.

102. Dr. Praveen Kumar Singh — Ex-officio
Agriculture Commissioner, Dept. of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Krishi Bhavan, New Delhi-110 001

103. Dr. Prabhat Kumar — Ex-officio
Horticulture Commissioner, Dept. of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Krishi Bhavan, New Delhi-110 001

104. Dr. Abhijit Mitra — Ex-officio
Animal Husbandry Commissioner, Department of Animal Husbandry & Dairying, Ministry of Fisheries, Animal Husbandry & Dairying, Chander Lok Building, Janpath, New Delhi-110 001

105. Dr. A. Antony Xavier — Ex-officio
Fisheries Development Commissioner, Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, Krishi Bhavan, New Delhi-110 001

106. Sh. Ramesh Kumar Pandey — Ex-officio
Inspector General of Forests (NAEB), Ministry of Environment & Forests, Paryavaran Bhawan, B-Block CGO Complex, Lodi Road, New Delhi-110 003

4(xx) Fifteen scientists from within and outside the Council including one representative from the Indian Council of Medical Research, nominated by the President.

107. Dr. G. Kumaraswamy — 11.11.2024
H. No. 7-42/25, Saraswathi Colony, Street no. 4A, Bapuji Nagar, Nacharam, Hyderabad, Telangana-500 076

108. Dr. A. Veerabhadra Rao — 11.11.2024
12-13-483/39/1, Tarnaka, Street No 14,Lane 6, Hyderabad, Telangana-500 017

109. Dr. Bagwan Naimoddin — 11.11.2024
98-H, Sanjari Park-2 & 3, Nr. GEB Colony, Pethapur, Gandhinagar, Gujarat-382 610

110. Dr. Swadhinta Krishna — 11.11.2024
V-5 Osho Universe, Vinayak Puram, Sector -12, Vikas Nagar, Lucknow, Uttar Pradesh-226 022

111. Dr. Rajendra Prasad — 11.11.2024
Professor, Department of Horticulture, Kulbhaskar Ashram P.G.College, 4/4 C Muir Road, Near Anand Hospital, Prayagraj-211 002

112. Dr. Nitai Charan Das — 11.11.2024
Prof., Department of Soil and Water Conservation, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal-741 252

113. Sh. Dinesh Patil — 11.11.2024
Parth–Granth, Ward no. 42, Subhash Nagar, Durg, Chhattisgarh-491 001

114. Dr. Yogesh A. Murkute — 11.11.2024
PG Department of Geology, RTM Nagpur University, Law College Square, Nagpur, Maharashtra-440 001

115. Dr. Koushik Majumdar — 11.11.2024
Centre for Bamboo Cultivation and Resources Utilization (BCRU), Department of Botany, Tripura University, West Tripura, Suryamaninagar, Tripura-799 022

116. Dr. Arun Kumar Das — 11.10.2025
Retd. Professor & Head, OUAT, Flat No. 4102, Terra Block, Dnoxy Park, Dumduma, PO Khandagiri, Bhubaneshwar, Khurda-Odisha-751 019

117. Dr. Purushottam Ramniwas Zanwar — 11.10.2025
Associate Professor (Agricultural Entomology), Department of Agricultural Entomology, College of Agriculture, VNMKV, Parbhani, Maharashtra-431402

118. Dr. Vinod Singh — 11.10.2025
Department of Genetics and Plant Breeding, A.N.D. University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh-224 229

119. Dr. Rajendra Singh Rajput — 11.10.2025
B-17/4, Vasant Vihar, Ujjain, Madhya Pradesh

120. Dr. Maganti Sheshu Madhav — 11.10.2025
FRSB, FABAP, FTAS, FRA, FBOYSCAST, Associate-NAAS Director, ICAR-Central Tobacco Research Institute (CTRI), Bhaskar Nagar, Rajahmundry, Andra Pradesh-533 105

Representative from the Indian Council of Medical Research

121. Dr. Bharati Kulkarni — 01.11.2025
Scientist G & Head, Division of Reproductive Biology, Maternal & Child Health & Nutrition, Indian Council of Medical Research, V. Ramalingaswami Bhawan, Ansari Nagar, New Delhi-110029

4(xxi) Three representatives of commerce and industry, nominated by the President.

122. Shri Lokendra Singh — 13-07-2026
Salwa, Tehsil Badnagar, Ujjain, Madhya Pradesh-456 313

123. Shri Arun Mandal — 13-07-2026
S/O-Dinesh Ch. Mandal,
Vill-Sahadargachh, PO-Bidhannagar, PS-Phansidewa, Dist-Darjeeling, West Bengal-734 426

124. Dr. Kernel Singh Risam — 13-07-2026
171/7 Nanak Nagar, Jammu

4(xxii) One farmer from each region of the country as mentioned in Rule 60(a) and four representatives of rural interests, nominated by the President.

125. **(Representative of Region- I)**
VACANT

126. **(Representative of Region- II)** — 13.07.2026
Dr. Bhaskar Naik Karamsi
Door No. 11-2-380, Naik Nagar, Beside Marremma Temple, Ananthapuramu, Andhra Pradesh-515 001

127. **(Representative of Region- III)** — 13.07.2026
Prof. (Dr.) Kishore Kumar Baruah
Sai Sai Villa, Kanaklata Road, Narayan Nagar, Kumarpara, PO Bharalumukh, Guwahati, Assam-781 009

128. **(Representative of Region- IV)** — 7.9. 2026
Sh. Venugopal Badaravada,
Shri Yama Aditya Temple, Manikarnika Kshetra, Sankatha Ghat, Varanasi, Uttar Pradesh-221 001

129. **(Representative of Region- V)** — 13.07.2026
Shri R. K. Sangwan
Address: H. No. 108B, South City-2, Gurugram, Haryana-122 018

130. **(Representative of Region- VI)**
VACANT

131. **(Representative of Region- VII)** — 13.07.2026
Shri Rahul Manikrao Shinde
C-603, Sapphire Park, Nr Wisdom World School Park Street, Wakad, Pune, Maharashtra-411 057

132. **(Representative of Region- VIII)**
VACANT

Four Representatives of Rural Interests, nominated by the President.

133. Sh. Umendra Dutt — 21.11.2024
Kheti Virasat Mission, R. V. Shanti Nagar, Jaitu, Distt - Faridkot, Punjab-151 202

134. Sh. Manoj Bhai Purushottam Solanki 21.11.2024
Near Thakar Temple, Junavas Gram Panchayat Road, Madhapar (Tal. Bhuj), Kachchh, Gujarat-370 020

135. Sh. Ashok Kumar Tekam 21.11.2024
Doctor's Residence, Opposite District Copp. Bank, Girls College Road, Bhagat Singh Ward, Seoni, Madhya Pradesh-480 661

136. Sh. Badri Narayan 21.11.2024
49- Gayatri Nagar-1, Tonk Road Sanganer, Jaipur, Rajasthan-302 018

4(xxiii) Four Directors of the Indian Council of Agricultural Research Institutes, nominated by the President.

137. Dr. Amresh Chandra 18.9.2025
Director, Indian Grassland & Fodder Research Institute (IGFRI), Jhansi, Uttar Pradesh-284 003

138. Dr. Arun Kumar Tomar 07.12.2023/Term- 07.10.2025
Director, Central Sheep and Wool Research Institute (CSWRI), Avikanagar, Rajasthan-304 501

139. Dr. Triveni Dutt 16.03.2025/Term- 30.09.2026
Director, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly Uttar Pradesh-243 122

140. Dr. R.A. Marathe 16.03.2025/Term- 27.04.2026
Director, National Research Center on Pomegranate, Solapur, NH-65, Solapur-Pune Highway, Kegaon, Solapur Maharashtra-413 255

4(xxiv) Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR

141. Shri Deependra Kumar Choudhari 23.07.2026
IAS, Secretary, Department of Agriculture & Horticulture Government of Uttarakhand, Secretariat, 4-Subhash Road, Dehradun, Uttarakhand

142. Dr. Ashish Kumar Bhutani 23.07.2026
IAS, Additional Chief Secretary, Agriculture Department Government of Assam, D-Block, 3rd Floor Janata Bhawan, Dispur, Guwahati, Assam-781 006

143. Shri Sudhir Rajpal, IAS, 23.07.2026
ACS Agriculture & Horticulture, Department of Agriculture & Farmer Welfare Government of Haryana, Krishi Bhawan, Sector 21, Budhanpur, Panchkula, Haryana-134 117

144. Smt. Veera Rana 23.07.2026
Agricultural Production Commissioner, Directorate of Farmer Welfare & Agriculture Development, 2nd Floor, C - Wing, Vindhyachal Bhawan, Arera Hills, Bhopal, Madhya Pradesh-462 004

4(xxv) One representative of Agro and Agro-Processing Industries, nominated by President

145. Sh. Kanwal Singh Chauhan 13.09.2025
Shimla Farm, Village-Aterna, Distt. Sonipat, Haryana-131 023

4(xxvi) One representative from a distinguished Non - Governmental Organization dealing with Agriculture/ Extension, nominated by President

146. Ms. Sushma Singh 10-07-2026
Flat 1602, Tower No.1, Sunworld Vanallika, Sector 107, Noida, Uttar Pradesh

4(xxvii) Secretary, Indian Council of Agricultural Research-Member Secretary

147. Shri Sanjay Garg Ex-Officio
Addl. Secy. (DARE) & Secy. (ICAR), Krishi Bhavan, New Delhi-110 001

APPENDIX 4

LIST OF THE MEMBERS OF THE GOVERNING BODY OF THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

Rule 35(i)
Chairman

1. Dr. Himanshu Pathak — Ex-Officio
   Director-General,
   Indian Council of Agricultural Research, Krishi Bhawan,
   New Delhi - 110001

Ex-Officio Members
Rule 35(ii)
Member, Finance, Alternate member-Financial Adviser (DARE/ICAR)

2. Dr. T. V. Somanathan — Ex-Officio
   Secretary (Expenditure) Department of Expenditure, 129-A, North Block,
   Ministry of Finance,
   North Block, New Delhi - 110 001

Alternate member-Financial Adviser (DARE/ICAR)

Ms. Alka Nangia Arora, — Ex-Officio
Addl. Secretary & Financial Advisor (DARE/ICAR), Krishi Bhavan, New Delhi - 110 001.

Rule 35(iii)
Chief Executive Officer, National Institution for Transforming India (NITI Aayog) or representative (not lower than the rank of Joint Secretary)

3. Shri B.V.R. Subrahmanyam — Ex-Officio
   CEO, NITI Aayog Yojana Bhavan, Sansad Marg,
   New Delhi - 110 001

Rule 35(iv)
Secretary, Department of Agriculture Cooperation & Farmers Welfare

4. Shri Manoj Ahuja — Ex-Officio
   Secretary (Department of Agriculture & Farmers Welfare), Ministry of Agriculture, Krishi Bhavan,
   New Delhi - 110 001

Rule 35(v)
Secretary, Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying

5. Ms. Alka Upadhyaya — Ex-Officio
   Secretary, Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying,
   Krishi Bhavan, New Delhi - 110 001

Rule 35(vi)
Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying

6. Dr. Abhilaksh Likhi Secretary — Ex-Officio
   Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Krishi Bhavan,
   New Delhi - 110 001

Rule35(vii)
Three Scientists and one management expert from outside ICAR nominated by the President

7. Dr. Bagwan Naimoddin — 11.11.2024
   98-H, Sanjari Park-2&3, Nr. GEB Colony, Pethapur-382610, Gandhinagar, Gujarat

8. Dr. Rajendra Prasad — 11.11.2024
   Professor
   Department of Horticulture, Kulbhaskar Ashram P.G. College, 4/4 C Muir Road, Near Anand Hospital,
   Prayagraj - 211 002, Uttar Pradesh

9. Dr. Arun Kumar Das — 11.10.2025
   Retd. Prof. & Head
   Flat No.-4102, Terra Block, DNOXY PARK, Dumduma. P.O- Khandagiri, Bhubaneswar -751019,
   Dist. Khurda, Odisha

Rule 35 (viii)
Five Vice-Chancellors of Agricultural Universities-nominated by the President)

10. Dr. Anupam Mishra — 29.12.2023
    Vice Chancellor,
    Central Agricultural University, Imphal
    P. O. Box No. 23, Imphal - 795 004, Manipur

11. Dr S. P. Tiwari — 13-03-2026
    Vice-Chancellor
    Nanaji Deshmukh Veterinary Science University, Jabalpur - 482 004, Madhya Pradesh

12. Dr Rajeshwar Singh Chandel — 05.06.2025
    Vice Chancellor
    Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh

13. Prof Balraj Singh — 13-03-2026
    Vice-Chancellor
    Sri Karan Narendra Agriculture University, Jobner-303 329, Rajasthan

14. Dr. Punyavrat S. Pandey — 29.09.2025
    Vice Chancellor,
    Dr. Rajendra Prasad Central Agricultural University, Samastipur-848 125, Bihar

Rule 35(ix)
Three Members of Parliament nominated by the President- (Two from Lok Sabha and one from Rajya Sabha)

15. Vacant -
16. Vacant -
17. Vacant -

Rule 35(x)
Four Farmers/Representatives of Rural Areas nominated by the President

18. Shri R. K. Sangwan — 13.07.2026
    H. No. 108B, South City-2 Gurugram- 122 018, Haryana

19. Sh. Venugopal Badaravada, — 7.9.2026
    Shri Yama Aditya Temple, Manikarnika Kshetra, Sankatha Ghat, Varanasi-221 001, Uttar Pradesh

20. Shri Manoj Bhai Purushottam Solanki — 21.11.2024
    Near Thakar Temple, Junawas Gram Panchayat Road, Madhapar (T. Bhuj), Kutch – 370 020, Gujarat

21. Shri Badri Narayan 21.11.2024
49- Gyatri Nagar-1, Tonk Road Sanganer, Jaipur, Rajasthan - 302 018

Rule 35(xi)
Three Directors of Research Institutes of the Council nominated by the President

22. Dr Arun K. Tomar 07.12.2023
Director, ICAR-Central Sheep and Wool Research Institute (CSWRI) Avikanagar (Malpura), 304 501, Distt.-Tonk (Rajasthan)

23. Dr. Triveni Dutt 15.3.2025
Director,
ICAR-Indian Veterinary Research Institute, Bareilly - 243 122, Uttar Pradesh

24. Dr. Amresh Chandra 18.09.2025
Director, Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh - 284 003

Rule 35(xii)
Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR

25. Shri Deependra Kumar Choudhari 23.07.2026
IAS, Secretary,
Department of Agriculture & Horticulture
Government of Uttarkhand
Secretariat, 4-Subhash Road,
Dehradun, Uttarkhand

26. Dr. Ashish Kumar Bhutani 23.07.2026
IAS, Additional Chief Secretary,
Agriculture Department, Government of Assam
D-Block, 3rd Floor, Janata Bhawan, Dispur, Guwahati – 781 006, Assam

27. Shri Sudhir Rajpal, 23.07.2026
IAS, ACS Agriculture & Horticulture
Department of Agriculture & Farmer Welfare
Government of Haryana,
Krishi Bhawan, Sector 21, Budhanpur, Panchkula, Haryana -134 117

28. Smt. Veera Rana 23.07.2026
Agricultural Production Commissioner
Directorate of Farmer Welfare & Agriculture Development
2nd Floor, C- Wing, Vindhyachal Bhawan,
Arera Hills, Bhopal – 462 004,
Madhya Pradesh

Rule 35(xiii)
One representative of Agro and Agro-Processing Industries to be nominated by President

29. Sh. Kanwal Singh Chauhan, 13.09.2025
r/o Shimla Farm,
Vill. Aterna, District- Sonipat, Haryana-131 023

Rule 35(xiv)
One representative from a distinguished Non-Governmental Organization dealing with Agriculture/ Extension nominated by President

30. Ms. Sushma Singh, 10.07.2026
MSA Flat No. 103,
Tower-1, Butler palace,
Lucknow – 226001
Uttar Pradesh
Flat 1602, Tower No.1, Sunworld Vanallika, Sector 107, Noida

Rule 35(xv)
Secretary, ICAR- Member Secretary

31. Sh. Sanjay Garg, Ex-Officio
Additional Secretary, DARE & Secretary, ICAR,
Krishi Bhawan,
New Delhi- 110 001

APPENDIX 5

SENIOR OFFICERS AT THE HEADQUARTERS OF THE ICAR

1. **Dr. Himanshu Pathak**
   Director General, ICAR and
   Secretary to the Government of India, Department of Agricultural Research and Education

2. **Shri Sanjay Garg**
   Secretary, ICAR and Additional Secretary to Government of India,
   Department of Agricultural Research and Education

3. **Ms Alka Nangia Arora**
   Financial Adviser, ICAR and Additional Secretary to Government of India,
   Department of Agricultural Research and Education

Deputy Directors General
1. Dr. Joykrushna Jena
   (Fisheries Science)
2. Dr. Tilak Raj Sharma
   (Crop Science, Horticulture Science-Additional Charge)
3. Dr. Suresh Kumar Chaudhari
   (Natural Resource Management)
4. Dr. Joykrushna Jena
   (Fisheries Science, Animal Science-Additional Charge)
5. Dr. Rakesh Chandra Agarwal
   (Agricultural Education & National Director, NAHEP)
6. Dr. Shyam Narayan Jha
   (Agricultural Engineering)
7. Dr. Udham Singh Gautam
   (Agricultural Extension)

Assistant Directors General
Crop Science
1. Dr. D. K. Yadava (CC and Seed)
2. Dr. Sanjeev Gupta (OP)
3. Dr. S.C. Dubey (PP&B)
4. Dr. Sharat Kumar Pradhan (FFC)

Horticultural Science
1. Dr. Vishaw Bandhu Patel (FPCHS-I)
2. Dr. Sudhakar Pandey (FVS&MP) (HS-II)

Natural Resource Management
1. Dr. Rajbir Singh (AAF&CC)
2. Dr. A. Velmurugan (S&WM)

Agricultural Engineering
1. Dr. Kairam Narsaiah (PE)
2. Dr. Krishna Pratap Singh (FE)

Animal Science
1. Dr. Amrish Kumar Tyagi (AN&P)
2. Dr. Ashok Kumar (AH)
3. Dr. Gyanendra Kumar Gaur (APB)

Fisheries Science
1. Dr. Bimal Prasanna Mohanty (IF)
2. Dr. Shubhadeep Ghosh (MF)

Agricultural Extension
1. Dr. Rajarshi Roy Burman (AE)
2. Dr. Ranjay Kumar Singh (AE)

Agricultural Education
1. Dr. (Mrs.) Seema Jaggi, (HRD)
2. Dr. Shanti Kumar Sharma (HRM)
3. Dr. Ajit Singh Yadav (EQAR)
4. Dr. Bimlesh Mann (EP&HS)

Other Units
1. Dr. Neeru Bhooshan (IPTM&PME)
2. Dr. Atmakuri Ramakrishna Rao (PIM)
3. Dr. Bikash Mandal (IR)
4. Dr. Anil Rai (ICT)
5. Dr. Anil Kumar (TC)

National Agricultural Science Fund (NASF)
1. Dr. Jitendra Kumar (NASF)

Directorate of Knowledge Management in Agriculture
1. Dr. Suresh Kumar Malhotra, Project Director

Principal Scientists
Crop Science
1. Dr. S.K. Jha
2. Dr. P. R. Chaudhary
3. Dr. Renu
4. Dr. Ishwar Singh
5. Dr. Pawan Kumar Sharma

Horticultural Science
1. Dr. Vikramaditya Pandey
2. Dr. Anup Kumar Bhattacharjee
3. Dr. Prakash Chandra Tripathi

Natural Resource Management
1. Dr. Adlul Islam
2. Dr. B. P. Bhatt
3. Dr. Ram Swaroop Yadav
4. Dr. Rakesh Kumar

Agricultural Education
1. Dr. (Mrs.) Vanita Jain
2. Dr. Kanhiya Prasad Tripathi
3. Dr. (Ms) Smita Sirohi
4. Dr. Sita Ram Sharma
5. Dr. Dinesh Chand
6. Dr. Navin Kumar Jain

Fisheries Science
1. Dr. (Mrs.) Yasmeen Basade
2. Dr. Prem Kumar

Agricultural Engineering
1. Dr. Devinder Dhingra
2. Dr. Abhay Kumar Thakur
3. Dr. Panna Lal Singh

Animal Sciences
1. Dr. Harvinder Kumar Narula
2. Dr. Rajneesh Rana
3. Dr. Keshab Barman

Agricultural Extension
1. Dr. Ved Parkash Chahal
2. Dr. Keshava
3. Dr. Sujeet Kumar Jha
4. Dr. Arvind Kumar

Other Units
1. Dr. A. P. Ruhil (ICT)
2. Dr. Himanshu (ICT)
3. Dr. Krishan Pal Singh (ICT)
4. Dr. Manoj Kumar Tripathi (PIM)
5. Dr. Basant Kumar Kandpal (PIM)
6. Dr. Anjani Kumar Jha (DKMA)

7. Dr. Manoj Kumar (PIM)
8. Dr. A.S. Mishra (Tech. Cdn.)
9. Dr. Sanjeev Panwar (Tech. Cdn.)
10. Dr. Shiv Datt (IPTM)
11. Dr. Vikram Singh (IPTM)
12. Dr. (Mrs.) Manju Gerard (NASF)
13. Dr. Ashok Kumar (NASF)
14. Dr. A.K. Mishra (IR)
15. Dr. Pramod Kumar Rout (DG Office)
16. Dr. Praveen Malik (DG Office/Agrinnovate)
17. Dr. Suryanarayan Bhaskar (DoAFW)

National Agricultural Higher Education Project (NAHEP)

1. Dr. (Mrs) Hema Tripathi, PS & NC
2. Dr. Anuradha Agrawal, PS & NC
3. Dr. Sanjay Singh Rathore (On the rolls of IARI, New Delhi), PS & NC

APPENDIX 6

ICAR INSTITUTES AND THEIR DIRECTORS

1. Dr. Ashok Kumar Singh
   Indian Agricultural Research Institute,
   New Delhi – 110 012
2. Dr. Triveni Dutt
   Indian Veterinary Research Institute,
   Izatnagar – 243 122, Uttar Pradesh
3. Dr. Dheer Singh
   National Dairy Research Institute,
   Karnal – 132 001, Haryana
4. Dr. Ravishankar Chandragiri Nagarajarao
   Central Institute of Fisheries Education, Jaiprakash Road,
   Seven Bungalow (Versova),
   Mumbai – 400 061, Maharashtra
5. Dr. Ch. Srinivasa Rao
   National Academy of Agricultural Research Management,
   Rajendranagar,
   Hyderabad – 500030, Andhra Pradesh
6. Dr. Kotha Sammi Reddy
   National Institute of Abiotic Stress Management,
   Malegaon, Baramati,
   Pune - 413 115, Maharashtra
7. Dr. Sujay Rakshit
   Indian Institute of Agricultural Biotechnology,
   Ranchi - 834 010, Jharkhand
8. Dr. Probir Kumar Ghosh
   National Institute of Biotic Stress Management, Baronda,
   Raipur – 493 225, Chhattisgarh
9. Dr.Eaknath B. Chakurkar
   Central Island Agricultural Research Institute, Post Box No. 181, Port Blair – 744 101
   Andaman & Nicobar Islands
10. Dr. O.P. Yadav
    Central Arid Zone Research Institute,
    Jodhpur – 342 003 Rajasthan
11. Dr. Champat Raj Mehta
    Central Institute of Agricultural Engineering, Nabi Bagh
    Berasia Road, Bhopal – 462 038, Madhya Pradesh
12. Dr. Jagadish Sadanand Rane
    Central Institute of Arid Horticulture,
    Bikaner - 334 006, Rajasthan
13. Dr. Y. G. Prasad
    Central Institute for Cotton Research
    Post Bag No. 2, Shankar Nagar P.O.
    Nagpur - 440 010, Maharashtra
14. Dr. Damodaran Thukkaram
    Central Institute for Sub-tropical Horticulture,
    Rehmankhera, PO Kakori,
    Lucknow – 227 107, Uttar Pradesh
15. Dr. Mahendra Kumar Verma
    Central Institute of Temperate Horticulture,
    Old Air Field, Rangreth – 190 007
    Jammu & Kashmir
16. Dr. Nachiket Kotwaliwale
    Central Institute of Post-Harvest Engineering and Technology,
    P.O. PAU Campus,
    Ludhiana - 141 004, Punjab
17. Dr. Sujeet Kumar Shukla
    Central Institute for Research on Cotton Technology,
    Adenwala Road, Matunga,
    Mumbai – 400 019, Maharashtra
18. Dr. K. Balachandra Hebbar
    Central Plantation Crops Research Institute,
    Kasaragod – 671 124, Kerala
19. Dr. Brajesh Singh
    Central Potato Research Institute
    Shimla – 171 001,
    Himachal Pradesh
20. Dr. Vinod Kumar Singh
    Central Research Institute for Dryland Agriculture,
    Santoshnagar, Saidabad P.O.,
    Hyderabad – 500 059, Telangana
21. Dr. Dinesh Babu Shakyawar
    National Institute of Natural Fibre Engineering and Technology, 12, Regent Park, Kolkata – 700 040, West Bengal
22. Dr. Amresh Kumar Nayak
    National Rice Research Institute,
    Cuttack – 753 006, Odisha.
23. Dr. Rajender Kumar Yadav
    Central Soil Salinity Research Institute, Zarifa Farm,
    Kachhwa Road, Karnal – 132 001, Haryana
24. Dr. M. Madhu
    Indian Institute of Soil and Water Conservation,
    218, Kaulagarh Road,
    Dehradun – 248 195, Uttar Pradesh
25. Dr. Maganti Sheshu Madhav
    Central Tobacco Research Institute,
    Rajahmundry – 533 105, Andhra Pradesh
26. Dr. G. Byju
    Central Tuber Crops Research Institute,Sreekariyam,
    Thiruvananthapuram - 695 017, Kerala
27. Dr. Parveen Kumar
    Central Coastal Agricultural Research Institute, Ela, Old Goa,
    North Goa – 403 402, Goa
28. Dr. Anup Das
    ICAR Research Complex for Eastern Region, ICAR Parisar, P.O. Bihar Veterinary College,
    Patna – 800 014, Bihar
29. Dr. Vinay Kumar Mishra
    ICAR Research Complex for NEH Region,
    Umroi Road, Umiam, Ri-Bhoi,
    Meghalaya – 793 103
30. Dr. Rajendra Parsad
    Indian Agricultural Statistics Research Institute,
    Library Avenue, Pusa Campus,
    New Delhi – 1100 012
31. Dr. Amaresh Chandra
    Indian Grassland and Fodder Research Institute,
    Pahuj Dam, Gwalior Road,
    Jhansi – 284 003, Uttar Pradesh
32. Dr. Sanjay Kumar Singh
    Indian Institute of Horticultural Research
    Hessaraghatta Lake Post,
    Bengaluru – 560 089, Karnataka
33. Dr. Girish Prasad Dixit
    Indian Institute of Pulses Research,
    Kanpur – 208 024, Uttar Pradesh
34. Dr. Siba Prasad Datta
    Indian Institute of Soil Sciences,
    Nabi Bagh, Berasia Road,
    Bhopal – 462 038, Madhya Pradesh
35. Dr. Dinesh
    Indian Institute of Spices Research, Marikunnu P.O.,
    Kozhikode - 673 012, Kerala
36. Dr. Rasappa Viswanathan
    Indian Institute of Sugarcane Research,
    Rai Bareilly Road, P.O. Dilkusha,
    Lucknow – 226 002, Uttar Pradesh

37. Dr. Abhijit Kar
National Institute of Secondary Agricultural
Namkum, Ranchi – 834 010, Jharkhand
38. Dr. Tusar Kanti Behera
Indian Institute of Vegetable Research, PB No. 01,
PO Jakhini, Shahanshapur
Varanasi – 221 005, Uttar Pradesh
39. Dr. G Hema Prabha
Sugarcane Breeding Institute,
Coimbatore – 641 007, Tamil Nadu
40. Dr. Lakshmi Kant
Vivekanand Parvatiya Krishi Anusandhan Sansthan,
Almora – 263 601, Uttrakhand
41. Dr. Gouranga Kar
Central Research Institute for Jute and Allied Fibres, Barrackpore, Kolkata - 700120, West Bengal
42. Dr. Sunil Kumar
Indian Institute of Farming System Research,
Modipuram, Meerut – 250 110,
Uttar Pradesh
43. Dr. Kancherla Suresh
Indian Institute of Oil Palm Research,
Pedavegi– 534 450, West Godavari, Andhra Pradesh
44. Dr. Ravi Kumar Mathur
Indian Institute of Oilseeds Research, Rajendranagar,
Hyderabad – 500 030, Telangana
45. Dr. Raman Meenakshi Sundaram
Indian Institute of Rice Research,
Rajendranagar, Hyderabad - 500 030, Telangana
46. Dr. Gyanendra Pratap
Indian Institute for Wheat and Barley Research
P. Box No. 158, Agrasain Marg,
Karnal – 132 001, Haryana
47. Dr. Arjamadutta Sarangi
Indian Institute of Water Management, Opposite Rail Vihar,
Chandersekharpur
Bhubaneshwar – 751 023, Odisha
48. Dr. Mridula Devi
Central Institute for Women in Agriculture,
Plot No.50, Mauza-Jokalandi,
P.O. Baramunda,
Bhubaneswar-751 003, Odisha
49. Dr. Ayyandar Arunachalam
Central Agro-Forestry Research Institute,
Near Pahuj Dam,
Jhansi – 284 003, Uttar Pradesh
50. Dr. Dilip Kumar Ghosh
Central Citrus Research Institute,
P.B. No. 464, Shankar Nagar P.O.,
Amravati Road,
Nagpur – 440 010, Maharashtra
51. Dr. Pratap Singh Birthal
National Institute of Agricultural Economics & Policy Research,
P.B. No. 11305, DPS Marg,
Pusa, New Delhi – 110 012
52. Dr. Sanjay Kumar
Indian Institute of Seed Science
P.B. No. 11, Kusmaur, P.O. Kaithauli,
Mau Nath Bhanjan – 275 101, Uttar Pradesh
53. Dr. (Mrs.) Tara Satyavathi Chellapilla
Indian Institute of Millets Research,
Rajendranagar,
Hyderabad – 500 030, Telangana
54. Dr. Kunwar Harendra Singh
Indian Institute of Soyabean Research, Khandwa Road,
Indore – 452 017, Madhya Pradesh
55. Dr. Ramcharan Bhattacharya
ICAR-NIPB (earlier NRCPB)
LBS Centre, Pusa Campus,
New Delhi - 110012
56. Dr. Subhash Chander
National Research Centre for
Integrated Pest Management,
LBS Building, New Delhi - 110012
57. Dr. Krishna Gopal Mandal
Mahatma Gandhi Integrated Farming Research Institute,
Piprakothi, Motihari,
East Champaran, Bihar – 845 429
58. Dr. Ashok Kumar Tiwari
Central Avian Research Institute
Izatnagar, Bareilly – 243 122, Uttar Pradesh
59. Dr. Tirtha Kumar Datta
Central Institute for Research on Buffaloes, Sirsa Road,
Hissar – 125 001, Haryana
60. Dr. Manish Kumar Chatli
Central Institute of Research on Goats, Makhdoom,
Mathura - 281122, Uttar Pradesh
61. Dr. Basant Kumar Das
Central Inland Fisheries Research Institute,
Barrackpore – 700120, West Bengal
62. Dr. Kuldeep Kumar Lal
Central Institute of Brackishwater Aquaculture,
75, Santhome High Road, Raja Annamalai Puram,
Chennai – 600 028, Tamil Nadu
63. Dr. George Ninan
Central Institute of Fisheries Technology,
Willingdon Island, Matsyapuri P.O.,
Kochi– 682 029, Kerala
64. Dr. Pramoda Kumar Sahoo
Central Institute of Freshwater Aquaculture,
Kausalyaganga, Bhubaneshwar,
Khurda – 751 002, Odisha
65. Dr. A. Gopalakrishnan
Central Marine Fisheries Research Institute,
P.B. No. 1603,
Ernakulam North P.O.,
Kochi – 682 018, Kerala
66. Dr. Arun Kumar
Central Sheep and Wool Research Institute,
Avikanagar – 304 501, Distt. Tonk, Rajasthan
67. Dr. Raghevendra Bhatta
National Institute of Animal Nutrition and Physiology,
Adugodi,
Bengaluru – 560 030, Karnataka
68. Dr. Aniket Sanyal
National Institute of High Security Animal Diseases,
Anand Nagar, Bhopal-462021
69. Dr. Ashok Kumar Mohanty
Central Institute for Research on Cattle, P.B. No. 17, Grass Farm Road, Meerut Cantt. – 250 001, Uttar Pradesh
70. Dr. Hanuman Sahay Jat
Indian Institute of Maize Research,
PAU Campus, Ludhiana - 141 004, Punjab
71. Dr. Baldev Raj Gulati
National Institute of Veterinary Epidemiology and Disease Informatics,
H.A. Farm Post, Hebbal,
Bengaluru-560 024, Karnataka

APPENDIX 7

NATIONAL BUREAUX AND THEIR DIRECTORS

1. Dr. Satya Nand Sushil
   National Bureau of Agricultural Insect Resources,
   P.B. No. 2491, H.A. Farm Post,
   Bengaluru – 560 024, Karnataka

2. Dr. Alok Kumar Srivastava (Acting)
   National Bureau of Agriculturally-Important Micro-organisms, P.B. No. 6, Kusmaur,
   Maunath Bhanjan – 275 101, Uttar Pradesh

3. Dr. Gyanendra Pratap Singh
   National Bureau of Plant Genetic Resources,
   Pusa Campus, New Delhi-110 012

4. Dr. Nitin Gorakh Patil
   National Bureau of Soil Survey and Land Use Planning,
   Shankar Nagar, P.O. Amravati Road,
   Nagpur – 440 010, Maharashtra

5. Dr. Bishnu Prasad Mishra
   National Bureau of Animal Genetic Resources,
   P.B. No. 129, G.T. Road Bye Pass,
   Karnal – 132 001, Haryana

6. Dr. Uttam Kumar Sarkar
   National Bureau of Fish Genetic Resources,
   Canal Ring Road, P.O. Dilkusha,
   Lucknow – 226 002, Uttar Pradesh

APPENDIX 8

DIRECTORATES, PROJECT DIRECTORATES, AGRICULTURAL TECHNOLOGY APPLICATION RESEARCH INSTITUTES AND THEIR DIRECTORS

1. Dr. Sandip Kumar Bera
   Directorate of Groundnut Research,
   Post Box No. 5, Ivnagar Road,
   Junagadh – 362 001, Gujarat

2. Dr. Pramod Kumar Rai
   Directorate of Rapeseed - Mustard Research, Sewar,
   Bharatpur – 321 303, Rajasthan

3. Dr. Janki Sharan Mishra
   Directorate of Weed Research,
   Maharajpur, Adhartal,
   Jabalpur – 482 004, Madhya Pradesh

4. Dr. Jamboor Dinakara Adiga
   Directorate of Cashew Research,
   Darbe, P.O. Puttur – 574 202,
   Dakshina Kannada, Karnataka

5. Dr. K. V. Prasad
   Directorate of Floriculture Research
   Pune, Maharashtra

6. Dr. Manish Das
   Directorate of Medicinal & Aromatic Plants Research,
   Boriavi, Anand – 387 310, Gujarat

7. Dr. Ved Prakash Sharma
   Directorate of Mushroom Research, Chambaghat,
   Solan – 173 213, Himachal Pradesh

8. Dr. Vijay Mahajan
   Directorate on Onion & Garlic Research,
   Rajgurunagar, Pune– 410 505,
   Maharashtra

9. Dr. Rabindra Prasad Singh
   Directorate of Foot and Mouth Disease, IVRI Campus,
   Mukteshwar -263138, Uttarakhand

10. Dr. Rudra Nath Chatterjee
    Directorate of Poultry Research,
    Rajendranagar, Hyderabad - 500 030, Andhra Pradesh

11. Dr. Pramod Kumar Pandey
    Directorate of Coldwater Fisheries Research, Anusandhan Bhawan, Industrial Area, Bhimtal – 263 136, Uttarakhand

12. Dr. Suresh Kumar Malhotra
    Directorale of Knowledge Management in Agriculture,
    Krish Anusandhan Bhawan-I, Pusa, New Delhi - 110 012

13. Dr. Pothula Srinivash Brahmanand
    Water Technology Centere, IARI Campus, Pusa New Delhi - 110 012

Agricultural Technology Application Research Institutes

14. Dr. Parvender
    Agricultural Technology Application Research Institute,
    Zone-I, PAU Campus, Ludhiana-141004, Punjab

15. Dr. Subrata Kumar Roy
    ICAR-Agricultural Technology Application Research Institute (ATARI), Zone VIII, Pune, Maharashtra

16. Dr. Amulya Kumar Mohanty
    Agricultural Technology Application Research Institute,
    Zone-III, TOP, Umroi Road, Barapani - 793103,
    Meghalaya

17. Dr. Shantanu Kumar Dubey
    Agricultural Technology Application Research Institute,
    Zone-IV, G.T. Road, Rawatpura, Near Vikas Bhawan,
    Kanpur-208002, Uttar Pradesh

18. Dr. Nagulameera Shaik
    Agricultural Technology Application Research Institute,
    Zone-V, CRIDA Complex, Santoshnagar, Hyderabad – 500 059, Andhra Pradesh

19. Dr. Jai Prakash Mishra
    Agricultural Technology Application Research Institute,
    Zone-VI, CAZRI Campus,
    Jodhpur - 342003, Rajasthan

20. Dr. Shyam Ranjan Kumar Singh
    Agricultural Technology Application Research Institute,
    Zone-VII, JNKVV Campus, Jabalpur-484002
    Madhya Pradesh

21. Dr. V. Venkatasubramanian
    Agricultural Technology Application Research Institute,
    Zone-VIII, ICAR Transfer of Technology Project,
    MRS HA Farm Post, Hebbal,
    Bengaluru - 560030, Karnataka

22. Dr. Anjani Kumar
    Agricultural Technology Application Research Institute,
    CPRS Campus P.O,
    Sahay Nagar, Patna,
    Bihar - 801506

23 Dr. Pradip Dey
   ICAR-Agricultural Technology Application Research Institute Kolkata, Zone V, Bhumi Vihar Complex, Block GB,
   Sector II,
   Salt Lake City, Kolkata-700 097, West Bengal

24. Dr. Kadirvel Govindasamy
    Agricultural Technology Application Research Institute,
    Banphool Nagar, Basisthpur, Guwahati,
    Assam - 781006

APPENDIX 9

NATIONAL RESEARCH CENTRES AND THEIR DIRECTORS

1. Dr. Selvarajan
   National Research Centre for Banana,
   Thogamalai Road, Thayanur Post,
   Thiruchirapalli – 620 102, Tamil Nadu

2. Dr. Kaushik Banerjee
   National Research Centre for Grapes,
   P.B. No. 3, Manjri Farm Post,
   Solapur Road, Pune - 412 307, Maharashtra

3. Dr. Bikas Das
   National Research Centre for Litchi
   Mushahari Farm, Mushahari,
   Muzaffarpur – 842 002, Bihar

4. Dr. Sankar Prasad Das
   National Research Centre for Orchids, Pakyong,
   Gangtok – 737 106, Sikkim

5. Dr. Rajiv Arvind Marathe
   National Research Centre on Pomegranate,
   NH-9, Byepass Road, Shelgi
   Sholapur – 413006, Maharashtra

6. Dr. S N Saxena (Acting)
   National Research Centre on Seed Spices,
   Tabiji 305 206, Ajmer, Rajasthan

7. Dr. Artabandhu Sahoo
   National Research Centre on Camel
   Jorbeer, P.B. No. 07
   Bikaner – 334 001, Rajasthan

8. Dr. Tarun Kumar Bhattacharya
   National Research Centre for Equines,
   Hissar – 125 001, Haryana

9. Dr. Sukhadeo Baliram Barbuddhe
   National Research Centre on Meat,
   Chengicherla, P.B. No. 19, Uppal PO,
   Hyderabad – 500 039, Andhra Pradesh

10. Dr. Girish Patil S
    National Research Centre for Mithun, Jharnapani, P.O.
    Medziphema– 797 106, Nagaland

11. Dr. Vivek Kumar Gupta
    National Research Centre on Pig,
    Rani, Guwahati – 781 131,
    Assam

12. Dr. Mihir Sarkar
    National Research Centre on Yak,
    Dirang, West Kameng– 790 101 Arunachal Pradesh

APPENDIX 10

ALL INDIA CO-ORDINATED RESEARCH PROJECTS AND NETWORK PROGRAMMES

AICRPs

1. AICRP on Micro and Secondary Nutrients & Pollutant Elements in Soils and Plants, Bhopal
2. AICRP on Soil Test Crop Response, Bhopal
3. AICRP on Long Term Fertilizer Experiments, Bhopal
4. AICRP on Salt Affected Soils and Use of Saline Water, Karnal
5. AICRP on Irrigation Water Management, Bhubaneshwar
6. AICRP Dryland Agriculture, Hyderabad
7. AICRP on Agrometeorology, Hyderabad
8. AICRP on Integrated Farming System, Modipuram
9. AICRP on Agroforestry, Jhansi
10. AICRP on Weed Management, Jabalpur
11. AICRP on Farm Implements and Machinery, Bhopal
12. AICRP on Ergonomics and Safety in Agriculture, Bhopal (ESA)
13. AICRP on Energy in Agriculture and Agro based Industries, Bhopal (EAAI)
14. AICRP on Animal Energy System, Bhopal (earlier UAE)
15. AICRP on Plasticulture Engineering and Technology, Ludhiana
16. AICRP on Post Harvest Engineering and Technology, Ludhiana
17. AICRP on Rice, Hyderabad
18. AICRP on Wheat and Barley, Karnal
19. AICRP on Maize, Ludhiana
20. AICRP Sorghum, Hyderabad
21. AICRP on Pearl Millets, Jodhpur
22. AICRP on Small Millets, Bangaluru
23. AICRP on Forage Crops and Utilization, Jhansi
24. AICRP on Chickpea, Kanpur
25. AICRP on MULLaRP, Kanpur
26. AICRP on Pigeon Pea, Kanpur
27. AICRP NSP (Crops), Mau
28. AICRP on Oilseed, Hyderabad
29. AICRP on Linseed, Kanpur
30. AICRP on Sesame and Niger, Jabalpur
31. AICRP on Groundnut, Junagarh
32. AICRP on Soybean, Indore
33. AICRP on Rapeseed and Mustard, Bharatpur
34. AICRP on Sugarcane, Lucknow
35. AICRP on Cotton, Coimbatore
36. AICRP on Nematodes in Cropping System, New Delhi
37. AICRP on Biocontrol of Crop Pests, Bengaluru
38. AICRP-Honeybees and Pollinators, New Delhi
39. AICRP Fruits (Tropical and Sub Tropical), Bengaluru
40. AICRP Potato, Shimla
41. AICRP Floriculture, Pune
42. AICRP Mushroom, Solan
43. AICRP Vegetables, Varanasi
44. AICRP Tuber Crops, Thiruvananthapuram
45. AICRP Palms, Kasaragod
46. AICRP on Cashew, Puttur
47. AICRP Arid Zone Fruits, Bikaner
48. AICRP Spices, Calicut
49. AICRP on Medicinal & Aromatic Plants, Anand
50. AICRP on Cattle, Meerut
51. AICRP on Goat Improvement, Makhdoom
52. AICRP on Nutritional and Physiological Intervention for Enhancing Reproductive Performance in Animal
53. AICRP on ADMAS, Bengaluru
54. AICRP on Foot and Mouth Disease, Mukteshwar
55. AICRP on Poultry, Hyderabad
56. AICRP on Pig, Guwahati
57. AICRP Home Science

NETWORK PROJECTS

1. AINP on Soil Biodiversity - Biofertilizer, Bhopal
2. Network Programme on Organic Farming, Modipuram
3. Network project on Engineering Intervention in Micro irrigation system for Improving Water Productivity
4. Network project on Processing and Value Addition of Natural Resins and Gums, Ranchi
5. Network Project on Conservation of Lac Insect Genetic Resources, Ranchi
6. All India Network Project (AINP) on Potential Crops, New Delhi
7. Application of Micro-organisms in Agriculture and Allied Sectors (AMAAS)
8. Network Project on Functional Genomics and Genetic Modification in Crops, NIPB, New Delhi
9. AINP on Arid Legumes, Kanpur
10 AINP on Tobacco, Rajamundry
11. AINP on Jute and Allied Fibres, Barrackpore
12. AINP on Soil Arthropod Pests, Durgapura, Rajasthan
13. AINP on Agricultural Acarology, NCIPM, New Delhi
14. AINP on Pesticides Residues, New Delhi
15. AINP on Vertebrate Pest Management, Jodhpur
16. Network O&G
17. Network Project on Buffalo Improvement, Hisar
18. Network on Sheep Improvement, Avikanagar
19. Network on Gastro Intestinal Parasitism, Izatnagar
20. Network Programme on Blue Tongue Disease, Izatnagar
21. All India Network Program on Neonatal Mortality in Farm Animals, Izatnagar
22. All India Network Program on Diagnostic Imaging and Management of Surgical Condition in Animals, Izatnagar
23. Network Project on Animal Genetic Resources, Karnal
24. AINP Mericulture
25. AINP on Fish health

APPENDIX 11

AGRICULTURAL UNIVERSITIES

State Agricultural Universities

1. Acharya NG Ranga Agricultural University, Guntur, Andhra Pradesh
2. Dr YSR Horticultural University, Venkataramannagudem, Andhra Pradesh
3. Sri Venkateswara Veterinary University, Tirupati, Andhra Pradesh
4. Assam Agricultural University, Jorhat, Assam
5. Bihar Agricultural University, Sabour, Bhagalpur, Bihar
6. Bihar Animal Sciences University, Patna, Bihar
7. Indira Gandhi Krishi Vishwavidhyalaya, Raipur, Chhattisgarh
8. DAU Shri Vasudev Chandrakar Kamdhenu Vishwavidyalaya, Anjora, Durg, Chhattisgarh
9. Sardar Krushinagar Dantiwada Agricultural University, Dantiwada, Gujarat
10. Anand Agricultural University, Anand, Gujarat
11. Navsari Agricultural University, Navsari, Gujarat
12. Junagarh Agricultural University, Junagarh, Gujarat
13. Kamdhenu University, Amreli, Gujarat
14. Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana
15. Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana
16. Maharana Pratap University of Horticulture, Anjanthali, Karnal, Haryana
17. Ch. Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya, Palampur, Himachal Pradesh
18. Dr. Yaswant Singh Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh
19. Birsa Agricultural University, Ranchi, Jharkhand
20. Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, Jammu & Kashmir
21. Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, Jammu & Kashmir
22. University of Agricultural Sciences, Bengaluru, Karnataka
23. Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, Karnataka
24. University of Agricultural Sciences, Raichur, Karnataka
25. University of Agricultural Sciences, Dharwad, Karnataka
26. University of Horticulture Science, Bagalkot, Karnataka
27. Keladi Shivappa Nayaka University of Agriculture and Horticulture Sciences, Shivamogga, Karnataka
28. Kerala Agricultural University, Thrissur, Kerala
29. Kerala University of Fisheries and Ocean Studies, Panangad, Kochi, Kerala
30. Kerala Veterinary and Animal Sciences University, Pookode, Wayanand, Kerala
31. Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior, Madhya Pradesh
32. Nanaji Deshmukh Pashu Chikitsa Vishwavidyalaya, Jabalpur, Madhya Pradesh
33. Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh
34. Dr. Balasaheb Sawant Kokan Krishi Vidyapeeth, Dapoli, Maharashtra
35. Maharashtra Animal and Fisheries Sciences University, Nagpur, Maharashtra
36. Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra
37. Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra
38. Dr. Punjabrao Deshmukh Krishi Vishwa Vidyapeeth, Akola, Maharashtra
39. Odisha University of Agricultural & Technology, Bhubaneswar, Odisha
40. Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab
41. Punjab Agricultural University, Ludhiana, Punjab
42. Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan
43. Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan
44. Rajasthan University of Veterinary and Animal Sciences, Bikaner, Rajasthan
45. Sri Karan Narendra Agriculture University, Jobner, Rajasthan
46. Agriculture University, Kota, Rajasthan
47. Agriculture University, Jodhpur, Rajasthan
48. Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu
49. Tamil Nadu Veterinary and Animal Sciences University, Chennai, Tamil Nadu
50. Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam, Tamil Nadu
51. Sri Konda Laxman Telangana State Horticultural University, Hyderabad, Telangana
52. Sri PV Narsimha Rao Telangana Veterinary University, Hyderabad, Telangana
53. Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana
54. Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand
55. VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Uttarakhand
56. Chandra Shekhar Azad University of Agricultural and Technology, Kanpur, Uttar Pradesh
57. Acharya Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh
58. Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh
59. U.P. Pt. Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidhyalaya Evem Go Anusandhan Sansthan, Mathura, Uttar Pradesh
60. Banda University of Agricultural and Technology, Banda, Uttar Pradesh
61. Bidhan Chandra Krishi Vishwavidhyalaya, Mohanpur, West Bengal

62. West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal
63. Uttar Banga Krishi Vishwavidhyalaya, Cooch Behar, West Bengal

Central Agricultural Universities

64. Central Agricultural University, Imphal, Manipur
65. Rani Laxami Bai Central Agricultural University, Jhansi, Uttar Pradesh
66. Dr. R. P. Central Agricultural University, Pusa, Samstipur, Bihar

Deemed Universities

67. Indian Agricultural Research Institute, New Delhi
68. Central Institute of Fisheries Education, Mumbai, Maharashtra
69. Indian Veterinary Research Institute, Bareilly, Uttar Pradesh
70. National Dairy Research Institute, Karnal, Haryana

Central Universities with Agricultural Faculty

71. Aligarh Muslim University, Aligarh, Uttar Pradesh
72. Nagaland University, Medziphema, Nagaland
73. Banaras Hindu University, Varanasi, Uttar Pradesh
74. Visva Bharti (Pali Siksha Bhavana) P.O. Santiniketan, Bolpur, West Bengal

APPENDIX 12

Total number of employees in the ICAR and its research institutes, and number of employees of scheduled castes, scheduled tribes and other backward classes, and PwD employees

S. No.	Class of Posts	Total Posts sancti-oned	Total employees in position No.	SC Employees		ST Employees		OBC Employees		PwD Employees		EWS Employees	
				No.	% to total employees	No.	% to total employees	No.	% to total employees	No.	% to total employees	No.	% to total employees
1.	**Scientific Posts**												
a.	DR- Scientist	4451	3646	547	15	231	6.33	1106	30.33	28	0.7	31	0.85
b.	DR- Senior Scientist	1295	738	53	7.18	13	1.76	97	13.14	0	0	0	0
c.	DR- Principal Scientist (HoDs/HoRS/PCs)	665	378	24	6.34	6	1.58	44	11.64	1	0.26	0	0
d.	RMP Positions (DDGs/ADGs/PD DKMA/ Director/ Joint Director)	175	165	5	3.03	0	0	11	6.66	0	0	0	0
Total		**6586**	**4927**	**629**	**12.76**	**250**	**5.07**	**25.53**	**25.53**	**29**	**0.58**	**0**	**0.62**
2.	**Technical Posts**												
a.	Category-I	3622	2161	390	8.05	218	10.09	408	18.88	25	1.16	0	0.00
b.	Category-II	2427	1294	205	15.84	105	8.11	305	23.57	12	0.93	0	0.00
c.	Category-III	327	125	10	8.00	11	8.80	25	20.00	12	1.60	4	3.20
Total		**6376**	**3580**	**605**	**16.90**	**334**	**9.33**	**738**	**20.61**	**39**	**1.09**	**4**	**0.11**
3.	**Administrative posts**												
a.	Group-'A'	587	388	51	13.14	44	11.34	53	13.66	10	2.58	0	0
b.	Group-'B'	3045	1565	259	16.55	127	8.12	249	15.91	40	2.56	0	0
c.	Group-'C'	1236	780	157	20.13	71	9.10	192	24.62	9	1.15	0	0
Total		**4868**	**2733**	**467**	**17.09**	**242**	**8.85**	**494**	**18.08**	**59**	**2.16**	**0**	**0**
4.	**Supporting Skilled staff**												
Total		**4889**	**3174**	**775**	**24.42**	**256**	**8.07**	**575**	**18.12**	**24**	**0.76**	**2**	**0.06**

Acronyms

ABI : Agri-business Incubation
ACR : Agro climatic region
AER : Agro ecological Region
AgIn : Agri-Innovate India Limited
AICRP : All India Coordinated Research Project
AIs : Artificial inseminations
ALS : Alternaria leaf spot
ALV : Avian leucosis virus
ANN : Artificial neural network
APIS : Application Programming Interfaces
APR : Adult plant resistance
ARYA : Attracting and Retaining Youth in Agriculture
ASF : African Swine Fever
ASIS : Abiotic Stress Information System
ATICs : Agricultural Technology Information Centres
AWC : Available water capacity
BEP : Break-even point
BMC : Bulk Milk Chiller
BPH : Brown plant-hopper
CA : Conservation Agriculture
CAAST : Centres for Advanced Agricultural Sciences and Technology
CABYV : Cucurbit aphid borne yellow virus
CAFT : Centre for Advanced Faculty Training
CAM : Crassulacean Acid Metabolism
CAUs : Central Agricultural Universities
CCARI : Central Coastal Agricultural Research Institute
CFLDs : Cluster Frontline Demonstrations
CIWA : Central Institute for Women in Agriculture
CSAT : Climate Smart Agriculture Technologies
CSISA : Cereal Systems Initiatives for South Asia
DARE : Department of Agricultural Research and Education
DBT : Direct Benefit Transfer
DSp : Diagnostic specificity
DST : Drought and Salt Tolerance
DUs : Deemed-to-be-Universities
FAW : Fall armyworm
FLDs : Frontline Demonstrations
FMD : Foot and mouth disease
FPOs : Farmer Producer Organizations
GBS : Genotyping by Sequencing
GM : Grey mildew
GWAS : Genome-Wide association study
GWP : Global Warming Potential
ICDK : Immunochromatography dared chicken detection kit
ICT : Information and Communication Technology
IDA : International Depository Authority
IDP : Institutional Development Plan
IEC : Information Education and Communication
ICBR : Incremental cost benefit ratio
IFS : Integrated Farming System
IG : Innovation Grants
IGP : Indo-Gangetic Plain
IMTA : Integrated multi-trophic aquaculture
INSA : Indian National Soil Archive
IOFS : Integrated organic farming system
IPO : Indian Patent Office
IISS : Indian Institure of Soil Science
KSHAMTA : Knowledge Systems and Homestead Agriculture Management in Tribal Areas
KVKs : Krishi Vigyan Kendras
LABYV : Luffa Aphid-borne Yellow Virus
LAMP : Loop-mediated Isothermal Amplification
M&AP : Medicinal and Aromatic Plants
MAS : Market assisted selection
MVK : Mevalonate Kinase
MGMG : Mera Gaon Mera Gaurav
MLIFS : Multilayer integrated farming system
MoA : Memorandum of Agreement
MOET : Multiple Ovulation and Embryo transfer Technology
MSSP : Mega Sheep Seed Project
MYMV : Mungbeam Yellow Mosaic Virus
NAARM : National Academy of Agricultural Research Management
NAE : Niche Area of Excellence

NAHEP : National Agricultural Higher Education Project
NAIMCC : National Agriculturally Important Microbial Culture Collection
NARES : National Agricultural Research and Education System
NARI : Nutri-sensitive Agricultural Resources and Innovations
NARS : National Agricultural Research System
NASF : National Agricultural Science Fund
NBAIM : National Bureau of Agriculturally Important Microorganisms
NBAIR : National Bureau of Agricultural Insect Resources
NBFGR : National Bureau of Fish Genetic Resources
NBSS & LUP : National Bureau of Soil Survey and Land Use Planning
NCBI : National Centre for Biotechnology Information
NEH : North Eastern Hill
NEP : New Education Policy
NGRR : National Genomic Resource Repository
NHCP : National Herbarium of Cultivated Plants
NIAP : National Institute of Agricultural Economics and Policy Research
NICRA : National Innovations in Climate Resilient Agriculture
NINFET : National Institute of Natural Fibre Engineering and Technology
NUE : Nitrogen Use Officiency
OPU-IVEP : Ovum pick up and *in-vitro* embryo Production
QTL : Quantitative trait loci
RDF : Recommended dose of fertilizer
RILs : Recombinant inbred lines
RPA : Recombinase polymerase amplification
RSM : Response surface methodology
SARATHI : System of Agri-information Resources Auto-transmission and Technology Hub Interface
SARS-CoV-2 : Severe acute respiratory syndrome coronavirus 2
SAUs : State Agricultural Universities
SDGs : Sustainable Development Goals
SMDs : Subject Matter Division
SPARROW : Smart Performance Appraisal Report Recording Window
SSDF : Sub-surface Drip Fertigation
SSS : Skilled Support Staff
SOC : Soil Organic Carbon
TL : Truthfully labelled
TLB : Turcicum leaf blight
TMIS : Training Management Information System
TPS : True Potato Seed
TSP : Tribal Sub-Plan
UAV : Unmanned aerial vehicle
VOCs : Volatile Organic Compounds
WUE : Water Use Efficiency
ZT : Zero tillage

❑

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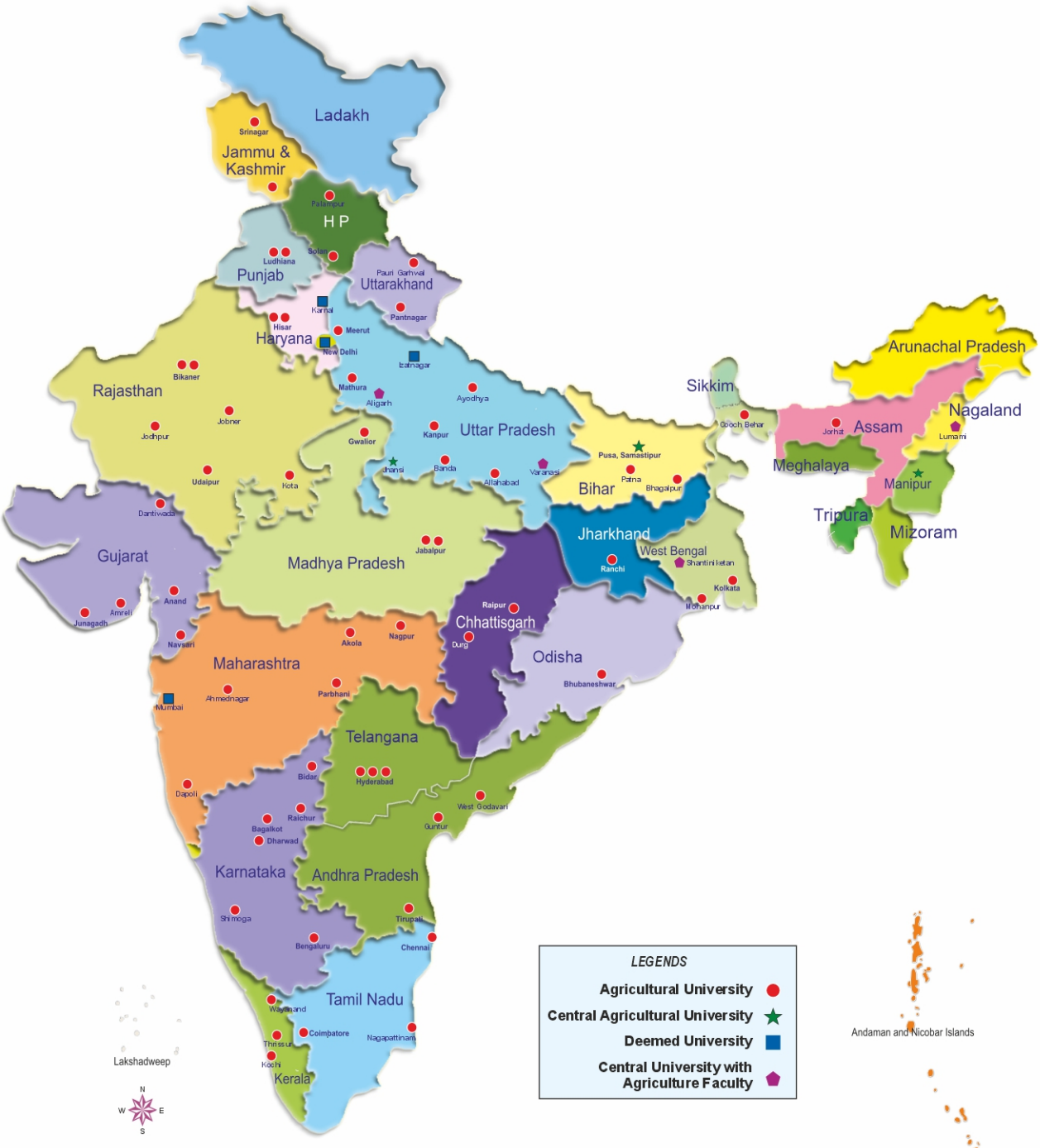
INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Agricultural Universities



*Map not to scale

- 63 State Agricultural Universities (SAUs)
- 3 Central Agricultural Universities
- 4 Deemed Universities
- 4 Central Universities having Faculty of Agriculture

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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