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Agricultural Mechanization and Energy Management

A brief description of machines developed for land preparation, sowing/planting, spraying, harvesting and threshing, and energy for agriculture is presented here.

Light weight tool carrier for Asom: A lightweight tool carrier suitable for the local bullocks of Asom was developed. The unit weighs only 2 kg and can be easily carried by the farmer from the village to the field. It can also be used for carrying out various farm operations such as land preparation, interculture, ridge making and sowing.

Tractor-operated manure spreader: Farmyard manure spreader, developed earlier, was tested in the field using a 22 kW tractor. The manure application rate varied from 4.22 to 36.72 tonnes/ha at tractor forward speed from 0.41 to 1.12 m/s, respectively. The variation in the manure application rate over the swath of 2 m is less than 15%, which is the acceptable limit for spreading of granular fertilizers. It can be used for uniform application of farmyard manure in the field.

Tractor-operated cumin planter: A 5-row planter was designed with individual hopper and star wheel seed metering mechanism mounted on common frame. The height of hopper was kept as 40 cm to get accurate placement of seeds in shallow furrows. The machine was tested for cumin seed, besides fenugreek and coriander at National Research Centre on Seed Spices at Ajmer and on farmer's field. Seed rate of 10–12 kg/ha for cumin, 18–20 kg/ha for fenugreek an 10 kg/ha for coriander was obtained. Field capacity was 0.24 ha/hr

Plastic mulch machine for planting in plastic mulch conditions for groundnut and vegetables: Plastic mulch laying machine was modified to lay the mulch on two raised beds simultaneously. A tractor-operated 4-row punch planter consisting of modular planting units was developed to plant seeds on raised beds in plastic mulched condition. It was evaluated for groundnut and Frenchbean planting at the CIAE Farm and for Frenchbean alone at Indian Institute of Vegetable Research, Varanasi. The missing hills were found to be 8.5% and field capacity ranged from 0.12 to 0.16 ha/hr. It was evaluated with 22 kW (35 hp) narrow-wheel tractor having arrangement for tread width adjustment to accommodate the two raised beds. The benefit : cost ratio of 1.91 in case of groundnut and 2.12 in case of Frenchbean was recorded under plastic mulched condition apart from 30% saving of irrigation water.

Animal drawn manure spreader

Baler with reaping attachment: A tractor-operated baler with reaping attachment was developed in collaboration with indigenous baler manufacturer in Punjab. It was evaluated at CFMTTI, Budni in the paddy-harvested field. Effective working width of the machine was 1.55 m with the field capacity of 0.40 ha/hr. It could be operated at forward speed of 3.0 km/hr. Heights of stubbles before and after the operation of baler

were 267 and 125 mm, respectively. Average size of bales was 600 × 470 × 400 mm with the average weight of 10.5 kg/bale.

Whole crop maize thresher: A whole crop maize thresher was developed for shelling and conversion of stalk to chaff in a single operation. Field testing with whole crop of maize gave the output of 210 kg/hr. A tractor-operated multi-crop thresher was also modified with similar arrangement and tested on the farmer's field. The output of grain was observed to be 620 kg/hr with chaff size of 18 to 52 mm. This chaff was fed to the animals and 85% material present in the whole stalk was consumed. Moreover, significant saving in labour was found for detachment of cobs and transportation of crop from field to home in the range of Rs 2,000–2,100/ha. The threshing efficiency of electrically-operated and tractor-operated thresher was found to be 100% and cleaning efficiency was 98.6% and 96.2%, respectively.

Bio-mechanic studies of he-buffalo under controlled condition: A psychometric (controlled) chamber was designed and developed for bio-mechanic studies of animals. Experiments were carried out with he-buffaloes at different loads and speeds under different ambient conditions. It was found that he-buffaloes could be loaded up to draught of 14% body weight at 1.5 km/hr speed and up to 10% draught at 2.0 km/hr speed.

Animal-drawn manure spreader: A bullock-drawn manure spreader was developed to uniformly spread manure in fields by farmers owning bullocks. Power to auger and drum is given from ground wheel through chain and sprockets. Cost of the unit is Rs 25,000 with 0.66 tonnes/hr output capacity. The cost of operation is Rs 60/hr.

Animal feed block making machine : A suitable experimental model of continuous type animal feed block making machine was designed, developed and fabricated. The machine is driven by a 2 hp single phase, 1,440 rpm AC motor. A screw type metering mechanism has been designed to meter 23.0, 6.5, 18.5 and 25.5 g/revolution material with separate hoppers corresponding to clusterbean broken, *guar* gum powder, mineral mixture and common salt, respectively. All the metered raw materials are conveyed to mixing chamber to ensure proper mixing of the feed constituents with molasses. The gear pump is fitted with the machine to suck and spray precise quantity of molasses on to the mixture of feed constituents in the mixing chamber. The mixed material is fed to the block making device, which compacts it in the form of 50 mm × 150 mm strip that are cut into 250 mm long pieces. All three components of the machine like metering mechanism, mixing unit and block making unit were synchronized to work as composite unit called the animal feed block making machine. The machine makes 40 such feed blocks/hr at a cost of 50 paise/block against Rs 3 with manual method. The unit cost of the machine is about Rs 2.5 lakh.

Complete unit of animal feed block making machine

Controlled traffic rotary no-till slit drill/ planter: A reduction of 50 kg in the mass of the rotary no-till-slit-drill was achieved in Vertisols through modifications in the design. The modified unit was tested in combine/reaper harvested straw and non-straw fields, as compared to the conventional practice of 3 tillage operations and sowing. Wheat and chickpea responded well to the controlled traffic system in straw field as compared to both full plot and conventional sowing. The machine was also tried out under a collaborative activity on soybean-wheat cropping system with Indian Institute of Soil Science, Bhopal and similar results were obtained.

Tractor-mounted hill drop planter: A hill drop planter was developed with cup feed seed metering, constructional simplicity and suitability for various crops. Depth of seed placement can be adjusted between 25 and 60 mm as required for different crops. It follows the undulations on the field with hill-to-hill spacing adjusted by varying the number of pegs on the end wheel. Groundnut and maize were sown with the machine. The row spacing and hill spacing were found to be uniform. Thinning could also be carried out with ease. Average missed seeds ranged between 1 and 2%. Hills with more than 2 seeds were about 30% as a whole. Speed of operation should be less than 1.5 km/hr to avoid scattering of seeds by valve action.

Intra canopy pesticide application equipment for cotton and pigeonpea: A power tiller-operated

2-row canopy sprayer was developed. The average height of pigeonpea plants during testing was 1.89 m and the average height of lowest leaves was 0.81 m from the ground level. The diameter of the canopy at middle of the plant was 0.92 m. The row-to-row spacing of the crop was 140 cm. The system was operated at 3 kg/cm^2 pressure. The sprayer was evaluated for its performance by application of colour dye on pigeonpea plants. The power tiller was operated at the speed of 1.31 km/hr and the machine had a field capacity of 1.46 ha/hr.

Chipping sugarcane buds for nursery raising: Nursery raised from sugarcane bud chips and planting them in main field was found economical than traditional methods for seed multiplication. A-pedal operated sugarcane bud chipping equipment was developed at Industrial Extension Project Centre in collaboration with Sugarcane Breeding Institute, Coimbatore. More than 550 bud chips can be removed from the cane in one hour by one person.

Arecanut stripper: For minimizing drudgery of the workers with increased productivity and reduced expenditure, an impact type worker-friendly arecanut stripper with safety features was developed. The arecanuts are separated from bunches due to the impact force of pegs of rotating cylinder and the stripped areca nuts fall on the oscillating sieve. The oscillating motion of the sieve separates arecanut from the chaff and other impurities. A platform for the operator is provided at the height of 290 mm from ground level so that two workers can conveniently stand and hold the bunches. The entire unit is mounted on wheels for easy transportation within an arecanut plantation. The cost of the machine is Rs 15,000 (excluding engine or electric motor). It has many safety features and shields for the feeding chute. All the moving parts are provided with safety guards to prevent accidents.

RENEWABLE ENERGY

Operational research project on poultry litter-based biogas plant: A poultry litter-based biogas plant was constructed in village Hinotia (District Bhopal) by adopting the modified Janta (CCSHAU, Hisar) design incorporating hume pipe for inlet. The plant was initially charged with 100% cow dung and water in 1:1 ratio and after stabilization of biogas production, cowdung was replaced by poultry litter by 30% based on total solid content under solid state digestion conditions. The structural and operational evaluation of biogas plant was carried out for one-and-half years. The biogas produced fulfilled the fuel needs of a family of 6 members for day-to-day cooking. The use of poultry litter increased the yield of biogas generation by 17% (from 66 to 83%) compared to normal cowdung-based biogas plant.

Batch production of alcohol from agro-residues: Based on the optimized parameters for alcohol production from ground maize stalk and paddy straw (below 0.5 mm size), a laboratory-scale alcohol production plant (0.5 l/batch capacity) was designed, developed, fabricated and installed. The unit was evaluated for its capacity to produce ethanol. Operation of the plant was found to be satisfactory. The initial study indicated that alcohol production from the paddy straw was about 0.6 l/batch. The yield was about 290 ml alcohol/kg of paddy straw with alcohol content of 45%. In absolute term, the yield was 120 ml/kg of paddy straw. The yield of the alcohol from maize stalk was found to be 330 ml/kg of ground maize stalk with alcohol content of about 57%. In absolute terms, the yield was found to be about 188 ml/kg of maize stalk.

Improved briquetting machine: The existing briquetting machine was modified to reduce weight, space requirement, ease of replacing belts, feeding of the *char* and collection of briquettes. The output of the machine is 50 to 65 kg/hr depending on *char*. The average diameter of briquettes was 30 mm and length 35 to 80 mm. The weight of the machine has been reduced by 23 kg, besides ease of replacing belts, feeding of *char*, collection of briquettes, etc.

Briquetting of agro residues

Briquettes from soybean and pigeonpea stalks: The briquetting machine was tested for production of briquettes from soybean and pigeonpea stalks. The output of the machine for both stalks was found to be 350–370 kg/hr. The cost of production of briquettes was Rs 2.20/kg. A batch of 3,000 kg of stalk was converted into briquettes. The briquette size was 35 mm length and 60 mm diameter. The briquettes were tested using CIAE cook stove and local *sigri* to assess their suitability for domestic applications. These briquettes can

Large capacity low-cost fixed dome biogas plant

Technology for construction of low cost all brick masonry fixed dome type biogas plants in the capacity range of 10 to 90 m³ biogas/day was successfully developed, which cost up to 50% less than the floating drum type of plants. PAU, Ludhiana, converted floating drum plants to fixed dome masonry plants at 4 locations. All the 4 plants are since working satisfactorily and the *gurudwara* management has reported an annual saving of around 13 kl of diesel which was earlier used for cooking the *langar* (meals). Multi-location trials of the design have been successfully carried out at several locations in the country**.** So far, around 20 large capacity biogas plants (15 to 90 m³ capacity) have been set up at selected farmers' sites in Punjab, Karnataka, Goa and Madhya Pradesh.

be used for domestic application, in gasifier and commercial boilers.

Evaluation of 20 kW power plant: Biomass (wood chips)-based 20 kW power plant for electricity generation was commissioned at CIAE, Bhopal. The system has been initially tested on wood chips and electricity produced has been used to run the 11 kW electric motor of hammer mill of briquetting plant.

Natural convection solar dryer: A natural convection semi-continuous type solar farm dryer of modular design having separate air heater and drying chamber was developed. The aperture area of the solar air heater is 2.25 m². The drying chamber has been provided at the top of the solar air heater with opening for air outlet and an exhaust fan. The fan automatically switches on whenever air temperature at the inlet to drying chamber exceeds 60°C. Thirty kg of fresh fenugreek leaves was loaded in both the trays at the beginning and then on the upper tray at the start of 2nd and 3rd drying day. The efficiency during experiment on various drying days was 62%, 29%, 32% and 18%. The initial cost of the dryer is Rs 13,000 for 2.25 m^2 aperture area. Use of the fan is optional. The payback period of the system is 2 years. Field trials were conducted for drying of chilli at a farmer's place in Village Nathana, Distt. Bhatinda. In the solar dryer it took 5 to 8 days for drying of chillis for different trials. The drying time for chilli spread in the open sun varied from 15 to 20 days.

High rate bio-methanation plants for sago effluent: Based on the laboratory and small pilot plant study, a 50 m³/day capacity high rate biomethanation reactor was designed for treatment of 35,000 l/day of sago effluent. The diameter and height of the reactor are 2.55 m and 6.05 m, respectively. The volume of gas collection tank is 10 m^3. The high rate reactor was constructed and commissioned at a sago factory in Tamil Nadu. The total solids and volatile solids contents in the sago effluent were in the range of 2,000–4,250 mg/λ and 1,800–2,850 mg/λ respectively. The biological oxygen demand (BOD) was measured as 2,630–4,050 mg/λ. Around 75% of the BOD was destroyed during the treatment. The plant operation stabilized over a period of 40 days and 35–40 m^3 of biogas is generated every day. The system cost is Rs 2.50 lakh.

Solar photovoltaic system for electricity generation: Photovoltaic systems was installed and commissioned for 55 houses of a remote unelectrified village Dageria in district Dahod of Gujarat. Due to scattered nature of the houses, the power system was subdivided into 4 power pack units covering 43 families and the rest of the 12 families were provided with individual home lighting systems. The SPV panels, power supply poles and cables are intact even after 3 monsoon seasons and the power supply remained satisfactory.

Process optimization from production of cellulase and ethanol from cellulosic biomass: A rapid process for ethanol production from kinnow waste (peel + pulp) using galactose-adapted yeast cells was developed. Kinnow waste was treated with pressurised steam and vacuum filtered. The filtrate was fermented alone using *Saccharomyces cerevisiae* adapted to galactose medium produced 30% more ethanol and biomass in comparison to *S. cerevisiae* cells not adapted to galactose medium. Fermentation of the hydrolysate using *Candida tropicalis* yielded 5.94 g/l ethanol along with a xylitol concentration of about 5 g/l. Mixed culture solid state fermentation of soy hull supplemented with wheat bran using *Trichoderma reesei* and *Aspergillus oryzae* produced 1.07 FPU/ml and 1.21 IU/ml of cellobiase. Hydrolysis of the acid-treated rice straw using concentrated crude filterate extract hydrolyzed yielded 0.27 g glucose/g glucan.

IRRIGATION AND DRAINAGE ENGINEERING

Performance evaluation of drain envelope materials in Vertisols: The cost of the sub-surface drain envelope materials varies from 25 to 30% of the total cost of sub-surface drainage (SSD) systems depending upon the type of envelope materials. The SSD system with non-woven geo-textile fabric envelope resulted into 82% and 60% increase in sub-surface drain flow, respectively as compared to SSD without envelope. Sediment concentrations in sub-surface water drained through SSD without envelope was found to be 156.6 g/m^2 surface area of drain pipe. The maize crop

yield increased by 40% and 22.6% over the control (3.54 tonnes/ha) under SSD system with envelope and without envelope, respectively installed at 20 m drains spacing and 1.0 m drain depth. The SSD system with envelope resulted in 12% increase in yield of subsequent wheat crop over control. In heavy clay soils (Vertisols), the use of envelope materials is suggested for increasing the sub-surface flow through pipe drainage and effective drainage of temporary waterlogged areas. The hydraulic performance of coconut coir fibre and non-woven geo-textile fabric is at par. However, due to limited life of coconut fibre and long run higher cost as compared to geo-textile fabric (more than 25 years), the non-woven geo-textile fabric is suggested as envelope material for sub-surface drainage under Vertisols.

Autonmatic fertigation system for mango and guava: An automated drip fertigation system was adopted and installed in guava and mango orchards at CIAE farm. It has capability to operate on time basis and/or volumetric basis and/or sensor basis. The system has provision for independent valve and sequence programming for valves and backwash programming for sand filter. It has capacity to run independent fertilizer injector either on time basis or volumetric basis. The automated drip fertigation system performed with uniformity co-efficient, distribution uniformity and statistical uniformity more than 96%; co-efficient of variation of emitter discharge less than 0.05 and flow variation less than 20%. Techno-economic feasibility study indicated that adopted automatic fertigation system could be profitably used for 5–20 ha mango/guava orchard.

Growing processing quality potato using plastics mulch and drip irrigation: Plastics mulch with drip irrigation was evaluated against straw mulch to grow processing quality potatoes. Three drip irrigation levels of IW/CPE of 0.6, 0.8 and 1.0 and conventional check basin irrigation was applied. The mulches were applied after 55 days of sowing when the crop canopy was fully developed, which increased the minimum and maximum soil temperature by 2 to 3ºC and thus helped to maintain required soil moisture within the soil. The straw mulch did not affect soil temperature on a large extent. Both drip irrigation and mulch treatments affected the yield significantly with significant interaction effect. The highest average yield of 28.46 tonnes/ha was observed in the treatment under plastic mulch with drip irrigation, thus showing 32.1% increase, followed by organic and biodegradable mulches with an increase of 29.3% and 23.5% respectively over no mulch drip-irrigated crop.

Safety of lining from seepage water pressure: A technology to protect the polyethylene lining against the uplift pressure due to overland flow of water on sloppy terrains was developed, which was tested again with new water pond. Perforated plastic pipes of about 5 cm diameter were laid in trenches made in bottom of the pond. All the pipes (06 nos.) were made to converge to an outlet which led the water outside pond. Pipes were wrapped with coir rope to prevent choking of the perforations in the pipe. Then pipes were covered with sand. Above that plastic film was laid. Due to this arrangement seepage water was disposed out of pond safely and hydraulic pressure was released. Hence the damage to the lining was avoided.

Standardization of method for pond lining

Two water harvesting pond lined with LDPE sheet (250 micron) were constructed: first in research farm (480 m^3), and second in the farmers' field (1,000 m^3). The pond was dug as per the design, and bed and sides were made weed and stone free. Steps at 50 cm vertical interval were made on sides of the pond to hold the agrifilm at its place. On top sides, continuous trench of 30 cm × 30 cm was dug for the purpose of anchoring the agrifilm to prevent it from sliding down. Pre-emergence weedicide was also sprayed on sides and bed to arrest the weed growth. After the sides and bed were dressed properly, 10 cm thick layer of sieved sand was spread uniformly on bed and sides to provide cushion to the agrifilm. After that agrifim (250 µ) was laid properly in the pond. For joining, bitumen of 85/25 and 80/100 grade in the ratio of 2:1 was used. While laying too much stretching or tightness of the agrifilm was avoided, particularly on sides. Over agrifilm, soil cover of 15 cm was provided. Stone pitching on sides was done in the research field pond to safeguard the sides of the pond against erosion and any other external forces.

LDPE-lined ponds: Low-density polyethylene lined small ponds were found quite effective in providing supplemental irrigation to horticultural/vegetable production in hilly areas. Water resources of 2,417 m^3 capacity were developed at the farmers' field in Uttarakhand with funding under NHM in two clusters, i.e. in village Bhagartola in Almora and village Darim in Nainital and a total of 26 and 52 tanks were constructed in the two villages, respectively. The capacity of the tanks ranged from 10 to 289 m^3. The source of water for these tanks was runoff and low discharge natural springs. The farmer born the cost of earthwork, while the institute contributed for polyethylene and covering material (coal tar felt). Farmer shared 37% cost for tanks of 10–15 m^3 range, while it increased to 84% for tanks of 280–300 m^3 capacity. The cost/m^3 was also found to reduce from Rs 271 for 10–15 m^3 capacity to Rs 120 for tanks of 280–300 m^3 capacity. A total of 20 tanks out of

78 tanks constructed at the farmers' field, were evaluated for irrigation in different vegetable production catchments. It was observed the supplemental irrigation (in form of check basin) from such developed tanks helped in 14.7 to 27.8% increase in the productivity of different vegetables.

Gravity fed micro-irrigation system: Micro-irrigation in conjunction with LDPE-lined pond constructed on higher elevated terrace and operated by gravity was evaluated in participatory mode in the field of Mr Inder Singh, village Darim, district Nainital and funded by Horticultural Technology Mission project on micro-irrigation system. The system was hydraulically evaluated. To deliver 3 and 5 mm of water per irrigation, 0.75 L and 1.25 L was required to be deliverd from one emitter during winter (vegetablepea) and summer (Frenchbean), respectively. The overall emitter flow rate variation was 26.54% which is slightly higher than the acceptable limit of 20% (ASAE, 1985). The Christiansen uniformity co-efficient (CUC) was 86.29% which is within the permissible limit of 85% (ASAE, 1985). The overall distribution uniformity (Du) was found as 87.46%. The gardenpea and Frenchbean were grown using the micro-irrigation system. Garden pea had yield 6.3% higher in micro-irrigation as compared to check basin, but Frenchbean had comparable yields in both the methods. Though the vegetable yield was not increased significantly, the system helps in increasing the area under irrigation. The net present value (NPV) of net returns was calculated as Rs 160,523 and 65,223 for micro-irrigation and check basin irrigation, respectively at the current market price of Rs 7/ kg each for vegetablepea and Frenchbean. The micro-irrigation system had B:C ratio of 1.78 and IRR of 12.2 which is higher than check basin irrigation (B:C ratio 1.38; IRR 6.4%).

Mechanized system for production of *malai lachha*: A prototype of a mechanized system for production of *malai lachha* was developed. Trials were conducted with variable parameters such as lip-slot openings, concentration of milk and steam pressures. A combination of variable parameters, concentration of milk as 30% TMS, 3 layers of concentrated milk, 1 mm opening of the variable lip-slot die and 0.3 kg/cm^2 steam pressure with 60 min. of heating time was optimum for the production of best quality of *malai lachha.*

The advantages are: reduction in labour, hygienic design, reduction in operational time, uniform product quality, and capacity (1 kg/hr)

Resource-specific purse seine net: A tuna-purse seine net of 1,100 m length, 125 m depth, weighing approximately 10 tonnes and having mesh size of 120 mm was designed for big size fishery. Experimental-cum-pre-commercial fishing operations landed good catches of large yellow fin tunas, skipjack tunas, carangids and seer fishes, which evinced keen interest among the fishermen of Kochi. ❑