



10. Mechanization and Energy Management

For enhanced productivity and profitability of different farming systems, need-based and region-specific mechanization and energy management technologies have been developed. These include improved machinery for efficient farm operations, resource conservation; renewable energy technologies; gender-friendly and drudgery reducing tools for women farm-workers; and efficient utilization of animal energy for enhancing farmers' income. Some of these technologies developed in the last year are summarized in the following paragraphs.

General equipments

Sugarcane bud chipping equipment: The number of buds required to plant per hectare is 24,700 (at a spacing of 90 cm × 45 cm). Conventionally the chipping is done manually making it cumbersome and it takes about 205 h to chip buds required for 1 ha. Three models of sugarcane bud chipping equipments such as: pedal operated unit, pneumatically operated unit and a motorized unit have been developed. These units extract 700, 1,100 and 2,500 bud chips/h, respectively, saving in the cost of ₹ 26, 50 and 90, respectively.



Sugarcane bud chipping equipment

Rotary assisted raised bed former-cum-seeder: In view of the climate worthiness of the bed seeding system, a rotary assisted raised bed former-cum-seeder was developed. This unit is suitable for sowing soybean and wheat crops on raised beds. The provision for attaching a rotary tiller in front of the bed former-cum-seeder has been made. The rotary tiller can be detached while reshaping and sowing on permanent beds. The developed machine provides sufficient bed height with more intact and smooth bed compared with the sliding type bed shaper. Rolling type bed shaper also works as drive wheel for seed and fertilizer metering mechanism, which is a special feature of the machine. The width and height of bed formed by the machine is 1,200 and 200 mm, respectively. The field



Rotary assisted raised bed former-cum-seeder

capacity of the machine is 0.55 ha/h at a forward speed of 3 km/h. The seeder was commercialized.

Women friendly three-row rice transplanter: A three-row rice transplanter suitable for women workers has been designed and developed using anthropometric data and strength parameters of women workers. This transplanter uses mat type nursery with 18 to 20 days old seedlings. About 2 to 5 seedlings are planted per hill and the average missing hills are less than 5%. The row to row distance is 24 cm which can facilitate weeding by cono or *mandwa* weeder easily. The mean working heart rate of women workers was observed as 126 beats/min, showing that the equipment can comfortably be operated throughout the day with normal rest pauses. The average field capacity is 170 m²/h at a mean speed of 1.7 km/h.

Jute decorticator: A jute decorticator suitable for extraction of ribbon from jute stalk was developed. The machine is used to separate outer fibre (ribbon) and the inner soft cellulosic stem. The inner soft stem is broken into pieces and gets separated from the fibre without damaging the fibre. The machine runs on 5.6 kW three phase electric power supply. The material handling capacity is about 10,000 kg of whole crop/h and the



Jute decorticator



fibre output is 300 to 400 kg/h. Twenty units have been supplied to Jute Corporation of India (JCI), Kolkata for multi-location trials.

Pomegranate spraying system based on ultrasonic sensors: A universal tractor mounted ultrasonic sensor based pomegranate spraying system has been designed and developed. To make the pomegranate sprayer independent of operating speed, a ground wheel with proximity sensor was attached to the spraying unit. The effective field capacity and number of plants covered are 0.88 ha/h and 1,370 plants/h, respectively. The maximum application rate was 500 l/ha for turbo nozzles without sensor and the minimum rate was 200 l/ha for hollow cone nozzle with sensor. The maximum discharge rate was 440 l/h for turbo nozzles without sensor. The minimum discharge rate was 175 l/h for hollow cone nozzle with sensor. The percentage saving of liquid ranges from 25 to 30% and 45 to 50% with turbo nozzles and hollow cone nozzles, respectively.



Pomegranate spraying system based on ultrasonic sensors

Axial flow multi-crop thresher: An axial flow multi-crop thresher, capable of threshing cowpea, soybean, blackgram, paddy and wheat crops, has capacities ranging from 80 to 100 kg/h.

For cowpea, the best threshing performance was obtained at 15 mm concave clearance and 370 cylinder rpm (7.16 m/s) with a threshing efficiency of 98.9%, cleaning efficiency of 99.2%, visible grain damage of 2.2% and total losses of 2.8%. For wheat, the best performance was obtained at 15 mm concave clearance and 570 cylinder rpm (11.04 m/s) having threshing efficiency of 99.4%, cleaning efficiency of 99.1%, visible grain damage of 2.5% and a total loss of 2.4%.



Axial flow multi-crop thresher for hilly region

Hydraulically operated instrumented cone penetrometer: Measuring cone index manually beyond 1,000 kPa is a difficult task. To overcome the difficulty a three point linkage mounted, hydraulically operated cone penetrometer capable of measuring cone indices of up to 5,000 kPa and to a soil depth of 500 mm was developed. The main components such as battery, DC

power pack, hydraulic cylinder and the linear potentiometer are mounted on the three point linkage frame. The system is driven by a 12V lead acid battery. For measuring the cone index S type load cell of 200 kg capacity has been mounted between the cylinder and the cone penetrometer probe, and for depth of penetration linear potentiometer of 550 mm stroke length was used. Two penetrometer probes of different sizes, conforming to the American Society of Agricultural & Bio systems Engineers (ASABE) standards and suitable for cone index of 2,000 kPa and 5,000 kPa were used. Signals from the load cell and the linear potentiometer could be acquired through a data logger and stored in the computer for further analysis.

Improved ladder for apple harvesting: A light weight ladder made from locally available bamboos and weighing 12.5 kg was fabricated for apple harvesting. The ladder allows climbing up to a height of 2.40 m. This bamboo ladder helps the women workers to carry out the plucking of fruits comfortably and one worker can harvest about 100 kg of apples per hour. It can also be used for plucking other fruits like apricot, walnut, pomegranate and for other household chores also.



Improved ladder for apple harvesting in Himachal Pradesh

Coconut collector: Kalparasa, the device for collection of fresh hygienic coconut inflorescence sap was refined and the technology has been commercialized. Changes in mineral composition during natural fermentation of freshly collected coconut inflorescence sap were studied and a quality index to check the freshness of the sap has been developed.

Coconut milk expeller, processing gadget was improved with the provision for an in-built cooling mechanism and coconut flaking machine with a safe feeding mechanism.

Tractor power assisted equipments

Fertilizer dibbler for ratoon sugarcane: The field, after harvest of sugarcane, is covered by a mat of trash to a depth of 150 mm. Application of fertilizer through the crop residue requires dibbling by punching through the crop residues. A tractor operated fertilizer



Tractor operated fertilizer dibbler for ratoon sugarcane



dibbler for ratoon sugarcane was developed and this machine is suitable for placement of fertilizer without much soil disturbance and through the crop residue. The principal components of the implement are revolving spade, fertilizer metering device, fertilizer placement funnel, soil covering and pressing device. The field capacity of the unit is 0.2 ha/h.

Turmeric rhizome planter: A tractor rear mounted turmeric rhizome ridger planter was developed. The planting mechanism includes rhizome hopper, cup feed seed metering mechanism, rhizome metering shaft, shoe type furrow opener and spike tooth ground wheel with



Turmeric rhizome planter

chain sprocket drive for transmitting power from ground wheel to rhizome metering shaft. Three rows can be planted at a time at a required spacing. The row to row spacing of the planter is adjustable. The effective field capacity of the unit is 0.15 ha/h.

Pneumatic planter for okra and cotton: A tractor operated pneumatic planter suitable for planting okra and cotton seeds was developed. The effective field capacity of the machine is 0.29 ha/h at 85% field efficiency for planting okra. The operating cost is low



Tractor operated pneumatic planter for okra and cotton

and a saving of ₹ 4,826/ha is possible with this machine compared with the traditional method of okra planting. The effective field capacity of the machine is 0.30 ha/h at a field efficiency of 56% for cotton planting. The saving in operating cost is ₹ 4,597/ha compared with traditional method for cotton planting. When pneumatically assisted planting machine is used the seeds are saved tremendously and thinning will not be required, which further saves in seeds and labour for thinning.

Turmeric digger: A turmeric digger drawn by a tractor having 1.45 m width was developed. The penetration of blade of the digger into the soil was easy at a blade rake angle of 55°. An additional dead weight of 150 kg was required for deeper penetration. The implement can dig four rows at 300 to 350 mm depth in a single pass at a tractor speed of 2.5 km/h with a field capacity of 0.36 ha/h. The observed wheel slip is 12.5 to 15.0%. The developed turmeric digger works well for digging turmeric rhizomes deep into the soil with negligible damage.

Garlic harvester: Garlic harvesting, a very time consuming operation, requires labour of 30 man-days/ha. A tractor operated garlic harvester cum windrower was developed to harvest garlic. The power is given by tractor power take off (PTO) to gearbox with a ratio of 1 : 1. The field capacity of the harvester is 0.26



Tractor operated garlic harvester

ha/h at a forward speed of 2.4 km/h.

Cassava harvester: Harvesting of cassava is done manually by loosening the soil with crowbar, if the soil is compact. The plant is pulled up gently without dragging the roots. This process is tedious and requires about 40 man days/ha. A tractor operated cassava harvester works well with two rows in sandy soil and with single row in heavy soil. The field capacity is 0.08 ha/h for single row and 0.17 ha/h for two rows. The undug tuber is 2.5% and damage to tubers was less than 1%. It saves 40% cost compared with manual harvesting.



Tractor operated cassava harvester

Animal power operated equipments

Garlic planter cum fertilizer applicator: Manual garlic planting involves drudgery and requires huge time for planting. An animal drawn three-row garlic planter with cup type metering mechanism and fertilizer drilling attachment was developed. The seed fall height is kept low to avoid bouncing of the seeds and to maintain uniformity. The sowing depth can be varied from 25 to 40 mm. The average draught requirement and field capacity of the implement are 450 N and



Animal drawn three-row garlic planter-cum-fertilizer applicator

0.08 ha/h, respectively. The height of hopper can be adjusted with the help of lifting rod handle to regulate quantity of cloves in metering section. Seed spacing, miss index and multiple index were 10.87 ± 4.01 cm, 10.23 and 7.45, respectively, in field conditions. The seed damages were as low as 4% and the labour requirement is only 13 man-h/ha.

Garlic digger: Manual garlic digging with spades and shovels, is very cumbersome and time consuming. An animal drawn garlic digger was developed. The field capacity of the machine is 0.1 ha/h, which is almost 25 times more than manual digging. The digging



Animal drawn garlic digger

efficiency is 86%. The average draught for operation of the digger is 683.5 N and the damage to garlic was in the range of 5 to 8%.

Renewable Energy Equipment

Micro-processor based single axis sun tracker for SPV panel: A single axis sun tracker for SPV panel (2.4 kWp capacity) was developed. The sun tracker consists of the SPV panel mounting frame, worm drive slewing ring, gear box stepper motor and micro-controller. The controller is programmed to rotate the solar panel at every 7.5 min by 1.875° leading to the required rotation of $15^\circ/\text{h}$ for 9 h during the day. The power output from the tracked SPV panel is 21% higher compared with non-tracked panel in the month of November.

Entrained gasifier for different crop residues: An entrained gasifier of 10 kW capacity for gasification

of different crop residues was developed. Thermocouples are fitted in the reactor at different zones to assess the temperature profile. Biomass feeding unit has a screw conveyor to feed powdered biomass and is mounted at the top portion of the gasifier reactor. Performance of the gasifier was evaluated using powdered biomass. The average temperature achieved in the reactor is 900°C at the feeds rates ranging from 8 to 10 kg/h.

Generation of bio-char from crop residues: A horizontal axis bio-reactor was developed and evaluated to generate char from the crop residues. Slow pyrolysis was conducted in the electrically heated horizontal reactor to generate char from the pigeon-pea stalk. The char recovery varies from 33 to 60% depending on pyrolysis conditions. The total carbon in the raw material is $45 \pm 0.5\%$ which could be increased to 78% by charring. The pH of the char was shifted towards basic nature ($\text{pH} > 7$) from the acidic nature of the raw material. The char generated from the unconfined system had a superior activation energy profile in comparison to that from confined system. The char generated under unconfined chambers could be adopted as bio-char for improving the soil quality.



Entrained gasifier for different crop residues

Mini harvester for maize and sorghum: CRIDA mini tractor drawn harvester consists of two harvesting rows with a rotary cutting disc in each row which can cut the stalks as they enter into the cutting zone. The guiders fixed at the front pulls the stalks into the cutting zone. A horizontally placed rotary cutting disc cuts the stalk with prescribed impact and shearing force. The crop stalks are held tight with two pairs of V-belts fixed on horizontal pulleys arranged in each row. The 3-tier conveying system pushes the stalks to the rear of the harvester. The initial trials revealed that it can cover 1 ha in 8 h.

Solar groundwater pumping model for eastern region of India: A solar groundwater pumping system was developed and tested at Patna. In this model a 3,000 Wp solar array energizes a 3 HP submersible ac pump which lifts groundwater from a depth of 20 m into a grounded tank and a dc surface pump, energised by 1,500 Wp solar array, delivers water out of tank to the fields for irrigation. On every bright sunshine day the net drafted groundwater ranged from $104\text{--}125 \text{ m}^3$ during November to January, whereas, from February to October it was $150\text{--}174 \text{ m}^3/\text{day}$. This amount of water was enough to irrigate $2,000\text{--}3,000 \text{ m}^2$ cropped area every day by surface method of irrigation. This pump is also able to operate drip system as well as low pressure sprinkler under direct coupling with pipe network.

Large size portable PV dryer-cum-winnower: A module of portable solar PV dryer having provision to load five drying trays, each of size (0.9 m \times 0.6 m)





was designed and fabricated with alternative materials such as slotted iron angle, fibre glass sheet etc., eliminating the need of welding required otherwise in making the frame and the related problems of carrying heavy structure to field. After initial testing, an up-scaled portable PV dryer having 6 such modules, detachable pre-air heating tunnel with fan and compatible PV module (75 Wp) with storage battery backup (40 Ah) was installed at Krishi Vigyan Kendra, Pali to dehydrate 100–150 kg fruit/vegetables. With the use of the pre-heating tunnel (3.7 m length), the inside thermal gradient of the drying chamber reduced from 5–6°C to 2–2.5°C leading to uniform solar drying. The battery backup (40 Ah) helped facilitate drying even under cloudy conditions. Experiments revealed better regulation of the drying temperature due to constant speed of the fan leading to uniform drying in different trays. The device was tested for dehydrating fenugreek, mint leaves and *Prosopis cineraria* pods. Retention of colour and aroma was observed in the dried product with more acceptability. In addition to drying, the device can also be used for winnowing and lighting during night. The portability and multi-functionality of the device make it more useful for rural areas.

Photovoltaics PV clad controlled environment enclosure: A PV clad enclosure (ground area 15.3 m²) was developed with fiber sheets, two interconnected PV arrays of amorphous silicon solar cells (60 Wp each) provided at the top on the slots of inclined green corrugated fibre glass sheet roof and earth embedded pipes with provisions to suck air by PV operated fan through pipe network to create controlled environment. The data from different seasons indicated reduction in air temperature at the exit of the fan to a range of 6–10°C in summer and 2–4°C rise in winter—close to the values predicted by a mathematical model. Performance of the PV clad enclosure with forced circulation of air through earth embedded pipes and PV mister indicated reduction in the inside temperature by 4–6°C below the ambient temperature during extreme weather conditions in summer. Tomato plants were grown successfully inside the PV clad structure which revealed regulation of the inside temperature to desirable levels. The developed PV clad enclosure can be used for nursery raising and allied agricultural applications.

Portable poly tent fish drier: Portable poly tent fish drier of dimensions 2.4 m × 2.4 m × 1.8 m was designed. The drier on an average maintains an inside temperature of 43°–45°C for a period of four to five hours on sunny days when outside temperature ranges from 30°C to 49.4°C. Maximum capacity of the drier to hold material (fish, feed, etc.) for drying is about 200 kg. For drying about 200 kg



of fish silage, from moisture content of 75% up to a level of 30%, it takes 3 days.

Personal protective equipments

Makhana harvesting in ponds: The manual harvesting of Makhana involves lot of drudgery. During collection of makhana seeds from the ponds, mud enters into the worker's ears, eyes, nose and mouth. The worker also gets affected from skin diseases due to this problem. To alleviate the drudgery involved in harvesting of makhana seeds from ponds, a protocol



Personal protective equipment for makhana harvesting in ponds

has been tested utilizing appropriate diving gear. The diving gear permits the diver to remain under water for sufficiently long time, without any drudgery and health risk. Since, the worker is safe and comfortable; the output in this system is better compared with the traditional system. Also, there are no injuries and skin related problems as the operator is protected from mud, thorns/prickles and insects while working inside the pond. The output of the worker with the developed system is 11.3 kg/h compared with 3.8 kg/h in the traditional system.

Cashew nut processing operations: The cashew nut shell liquid during cashew nut shelling and scooping operations, reacts badly on fingers/hands/skin, and causes skin irritation and injuries. The pure latex (non-slip grip) glove resulted in high capacity shelling (a capacity of 12.6 kg/h) with no sweating and no decrease in sensation to hands as compared with shelling without gloves (which resulted in a shelling capacity of 3.2 kg/h). In scooping operation the mean output of a worker was 8.37 kg/h when gloves were used compared with 2.15 kg/h without gloves. Thus, the workers can get higher output using these gloves, the chances of injuries are minimized, and the hands are also protected from cashew nut shell liquid.

For women workers in fish processing units: During fish processing the hands of workers come in frequent contact with ice and ice cold water, causing headache, body ache, and skin related problems in about 90% of workers, blanching of hands in 74%, back pain in 71%, frequent hand injuries in 57%, and respiratory irritation in 53% (sneezing/coughing). A study was carried out to identify a suitable hand



protection device for use in fish dressing activity. Combination of medical examination gloves (inside) and cotton gloves (outside) provide good grip to handle fish easily for dressing and the hands were protected from cold. The average capacity of dressing of fish without gloves was 36.6 kg/h as against 42.4 kg/h while using the developed gloves.

For spraying safety: The operator needs to wear personal protective equipments (PPE) during pesticide sprays. An efficient spraying safety kit was developed which consists of a face mask, a pair of gloves, eye protector, and an apron. The face mask is fitted with a filter of double layered water repellent poly propylene.

For chloropyriphos pesticide, the filtering efficiency of this face mask is 84.2%. The mask is comfortable to wear as the temperature rise inside the mask is only 1.6°C and the breathing resistance is a meagre 0.68 m bar. The PVC gloves identified have a good wearing as well as gripping comfort. The selected eye



Spraying safety kit

protector is made up of plastic frame with fibre glass ocular with good wearing and visual comfort. The lens area and the weight of the eye protector is 105 cm² and 70 g, respectively. An apron made using water proof polyester allows only 1.5% of pesticide penetration and 6% rise in temperature during spraying trials.

Electro-adsorption based effluent treatment system: An electro-adsorption based water filtration unit for treatment of contaminated water was designed using electrically charged column with physically entrapped adsorbents. Flow rate of the unit is 20 litre/min. Initial trials exhibited 40 to 60% removal of ammonia and 40% removal of arsenic from water containing about 5 ppm of ammonia and arsenic, respectively.

Fisheries Equipment

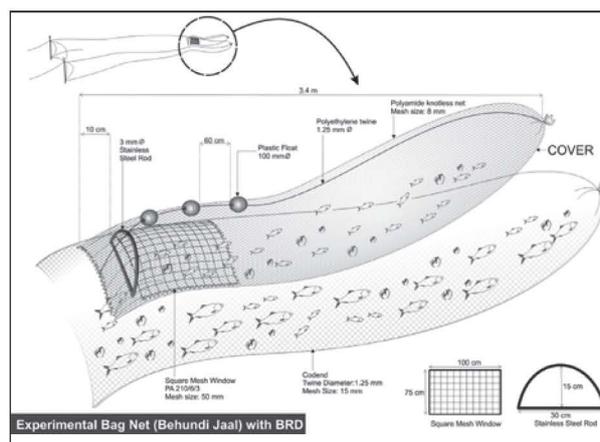
Sunboat-the solar boat: A solar powered boat, sunboat, was developed. The boat can achieve a speed of about 4 knots/h in calm waters and can run for about two to three hours on complete charging. Its twin hull construction gives high stability during fishing activities and the deck area is wider compared with conventional boats of similar size. Propellers are made of plastic composite and do not corrode. Height of propellers is adjustable



Sunboat — solar powered boat

as per requirement and one of the propellers is steerable which helps in manoeuvring the boat. Navigational lights are also run by solar power facilitating safe fishing in early morning, late evening or night hours. Specifications of the boat are overall length 3.63 m, breadth 1.75 m and depth 0.60 m, power 500 W, propulsion 2 × 0.60 kW and battery 12 V. The carrying capacity is four persons and can be used for aquaculture activities, gill netting, line fishing, transportation, aqua-tourism, etc.

By-catch reduction devices: By-catch reduction device (BRD), designed to reduce capture of hilsa juveniles in stationary bag nets, consists of a square mesh window of size 1 m × 0.75 m made of 50 mm



mesh, introduced near the cod end. These bag nets are under operation in rivers Hooghly in West Bengal and Narmada in Gujarat. Through BRD, 41 species could escape and mean escapement of juveniles of hilsa was 11.60% of the total catch excluded from BRD. Use of BRD excluded juveniles from being caught in commercial bag net fishing along major hilsa migrating grounds, thereby protecting the diminishing fish stocks.

Dairy Equipment

Improvised butter melter: Butter is usually kept in cold storage at -18°C to -20°C in 20 or 25 kg blocks. It is melted in a butter melter before being further processed for reconstitution or into production of ghee. The improvised butter melter system was designed at NDRI. The fabricated model (scale down ratio 4 : 1) consists of a network of heated pipes with longitudinal plate fins. Dimensions of the tubes of the network and their spacing were kept at par with the original equipment. The performance evaluation aspects of the equipment, viz. butter block cutting time, cutting capacity, heat utilization efficiency, percentage molten butter, volumetric reduction ratio, U-value, average temperature gradient and free fatty acid content were studied. The optimum specifications were: combination of a network with fins, steam as the heating medium and an applied weight of 16 kg. This combination improves the equipment capacity by three times and Heat Utilization Efficiency (HUE) upto 12% compared to conventional system having HUE of 2.9%.

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