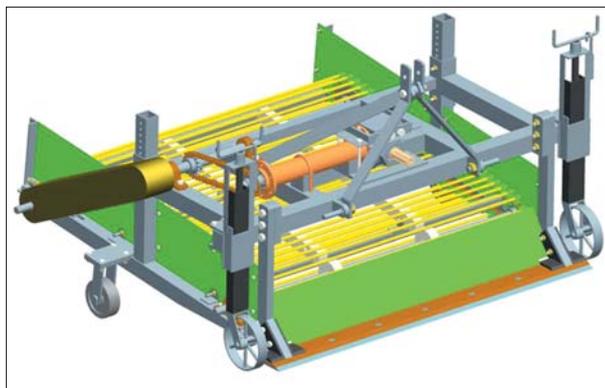


11. Mechanization and Energy Management

Farm mechanization has played a critical role in improving agricultural production as well as productivity through timeliness of field operations and by enabling proper and efficient use of inputs. A number of successful farm machineries have been developed and commercialized during the past two decades through the sustained efforts of R&D institutions and industry. However, individual ownership of farm machinery by small and marginal farmers, which constitute the core of Indian agriculture, often proves to be uneconomical, especially in operations like land preparation and harvesting. With continued shrinkage in average farm size, custom hiring of farm machinery is being increasingly practised.

Agricultural mechanization aims to expose the world to the technological and mechanical aspects of farming equipment, power sources and improved farm tools machinery. Agriculture has been vastly improved in the past few centuries owing to inventions made in this field. It implies the use of various improved farm tools and equipment to reduce the drudgery involved in the work and to enhance the overall productivity and production with the lowest cost of production.

Precision planter-cum-herbicide applicator: A precision planter-cum-herbicide applicator was designed and developed for conservation agricultural operations like sowing under zero and reduced-tilled lands. The planter consists of spring-loaded flexible shanks apart from individual seed and fertilizer metering boxes to meet the precision in undulated two-way slopping lands. The herbicide is sprayed in the rows through the nozzles arranged behind the planter. An electric pump draws the power from an alternator kept below the herbicide tank which is mounted on the frame to build-up the pressure in the nozzles for controlled spray. The alternator is run with tractor battery power. The cost of total assembly is ₹ 55,000. This helps in timely application of herbicide at right place and saving on labour wages of ₹ 1,000/h.



Bullock-drawn groundnut planter: A four-row bullock-drawn groundnut planter was designed for row-to-row and plant-to-plant spacing of 300 mm and 100 mm respectively. The planter, weighing 55 kg, has an average field capacity of 2.2 ha/day and cost of operation of ₹ 150/h.

Seed-cum-fertilizer drill for hilly regions: A one-row seed-cum-fertilizer drill was adopted for sowing of wheat and mustard on narrow terraces in hilly regions of Sikkim. Farmers in the area sow wheat by broadcasting. The weight of the drill was 22 kg and the field capacity for sowing of wheat under conventional tillage was 0.028–0.03 ha/h. The one-row seed-cum-fertilizer drill was also evaluated for zero till sowing of wheat after harvest of rice. For this purpose, the furrow openers were replaced with inverted ‘T’ openers. The field capacity of the drill was 0.028 ha/h. A saving of 44% in cost of operation was observed as compared to conventional method of sowing by broadcasting after tillage.

Tractor-operated rear-mounted onion harvester: Considering the importance of timely harvest of onion crop, a harvester was developed. The field capacity of the prototype was observed to be 0.18 ha/h. The harvester saved 50% of harvesting cost as compared to manual method, besides accruing higher economic returns as a result of timely harvest.



CAD model of tractor-operated rear-mounted onion harvester (left) and onion harvester under evaluation (right)

Animal-drawn farmyard manure spreader: Considering the requirement of small and marginal farmers, the tractor-drawn farmyard manure spreader, developed earlier, was modified for operation by a pair of bullocks. The power requirement of the manure spreader, having 500 kg capacity, was observed to be 0.46 kW which is well within the draft capability of a pair of bullocks. The field capacity of the machine was 0.19 ha/h at operational speed of 2.4 km/h. The developed unit reduced the cost of manure spreading by 26% as compared to conventional practice of manual manure spreading.

Power-operated ribbonner for jute: A power-operated jute ribbonning machine was developed for output of 100–125 kg/h of jute ribbon. The cost of operation was found to be ₹ 8–9/kg of jute fibre. Ribbonning efficiency was observed to vary from 95 to 98%.

Power tiller-operated bench terracer-cum-leveller for hilly region: The width of the bench terraces in the hills ranges from 2 to 5 m depending on the slope of the land. A narrower width is recommended for shallow soils so that digging and earth moving will



Power tiller-operated bench terracer-cum-leveller

not be too deep. All these jobs are presently done by manual labour which increases the cost of operation and drudgery. To mechanize the bench terracing work, a mechanical device known as power tiller-operated bench terracer-cum-leveller was developed. The maximum field capacity and volumetric soil capacity of the terracer were found to be 0.12 ha/h and 0.6 m³ respectively.

Tractor-operated multi-crop planter for seed spices: The sowing of seed spices is mainly done by broadcasting method or drilled in small plots at a row spacing of 25–30 cm and depth of 1–1.5 cm. Keeping in view the need of farmers and export potential of seed spices, a 5-row planter with individual hopper boxes was further modified to 7-row multi-crop planter. The machine, having fertilizer drilling attachment and variable row-to-row spacing arrangement, was successfully tested for sowing of cumin, coriander and fenugreek at the NRC on Seed Spices, Ajmer and farmers' field in Jalore district of Rajasthan. The field capacity of machine was 0.28–0.3 ha/h with depth of

seed placement as 12–15 mm. For small farmers, a two-row hand-operated multi-crop seed spices planter was also developed and tested for sowing of fenugreek crop.

Needle type tray seeder for vegetable nursery production: An automated pro-tray sowing machine was developed to mechanize the placement of seeds in the pro-tray cells. The machine costing ₹ 30,000 can sow about 80 trays of cells each in an hour. The savings in cost and labour was found to be about 54% and 60% respectively.



Needle type tray seeder for vegetable nursery production

Vegetable transplanter: The labour requirement in manual transplanting of vegetable seedlings is as high as 250 man-h/ha for tomato and chilli, and 184 man-h/ha for brinjal. A revolving magazine-type transplanting mechanism for 2-row vegetable transplanter was developed and evaluated in the laboratory and in the field. The transplanter was evaluated in the field for brinjal and tomato plug seedlings and compared with the manual transplanting of bare root seedlings. The cost of transplanting/ha for brinjal with the machine and by manual labour was found to be ₹ 3,536 and ₹ 4,600 respectively. Costs of transplanting/ha for tomato with the machine and by manual labour were found to be ₹ 3,302 and ₹ 5,080 respectively. The average field capacity of the machine is 0.11 ha/h with 80% field efficiency.

Power weeder for SRI cultivation: A twin-row engine-operated weeder having float and rotary cutting blades was developed. This weeder, weighing 17 kg, was found to perform well under all soil conditions. Weeding was performed with the help of rotary cutting blades. The commercial model is now being manufactured under the brand name *Garuda*. The weeder has been approved for supply under subsidy schemes of Tamil Nadu, Andhra Pradesh, Odisha, Bihar and Chhattisgarh. The machine can cover 0.70 ha/day.

Air-sleeve boom sprayer: Air-assisted spraying system was found more efficient for application of pesticides to control insects and pests as compared to knapsack, aero-blast and boom sprayers. A study on bio-efficacy was conducted to evaluate spray efficacy

of pesticide application for selected three sprayers against sucking pests on *Bt* cotton in which the effect of volume deposition, distribution and techniques of spraying of insecticide on insect-pests of cotton was measured. The bio-efficacy of Monocrotophos was measured for aphids, jassids, mealybugs, thrips and whitefly. The reduction in infestation of pest was observed between 75.14% and 82.33% for air-sleeve boom sprayer over 68.56%–75.78 % for boom sprayer, 62.84% and 70.81% for aero-blast sprayer and 11.33% and 17.89% for knapsack sprayer. The yield of cotton was recorded as 2,856 kg/ha for air-sleeve boom sprayer, which was found significantly higher than other three sprayers, i.e. 2,515 kg/ha for boom sprayer, 2,248 kg/ha for aero-blast sprayer and 1,802 kg/ha for knapsack sprayer.

Pedal-operated maize dehusker sheller: To reduce the time required and the drudgery involved in traditional dehusking and shelling operations, a pedal-operated maize dehusker sheller was developed for maize cobs taking anthropometric and other ergonomical parameters of workers in consideration. This machine performed both the operations simultaneously. The capacity of the machine was 130 kg/h with grain damage less than 1%. The dehusking and shelling efficiencies of the machine were 97 and 95% respectively. Ergonomical performance of the sheller showed that the mean working heart rate of male workers for dehusking and shelling operation was 143 beats/min. The machine is operated by two persons, one for pedaling and the other for feeding the unhusked cobs. This machine is suitable for small and medium farmers as well as for farmers in tribal areas.

Power tiller-operated zero-till drill for hilly region: A power tiller-operated zero-till drill was designed for hilly regions. The field performance of



Power tiller-operated zero-till drill

zero-till drill was carried out at Palampur University farm in *rabi* 2009 and at farmers' fields. The effective field capacity was observed to be 0.09–0.10 ha/h at a forward speed of 2.1–2.2 km/h with field efficiency of 56–62%. The cost of operation with zero-till drill was 60% lower as compared to traditional method.

Self-propelled paddy transplanter

Impact assessment of mat-type seedling transplanting technology developed in 2009 was done. This machine can transplant mat-type seedlings in 2 ha/day with four persons. Labour requirement with the self-propelled paddy transplanter is 16–20 man-h/ha, and it is 200–220 man-h/ha by the manual method. Data for impact assessment were collected from a representative sample of growers who were using self-propelled paddy transplanter and manual transplanting of paddy in different villages of Thrishur, Palakkad and Malappuram districts during 2009–10.

The cost of mat-type nursery growing was found in the range of ₹ 3,500–4,000/ha while it was ₹ 2,300–2,400/ha in the traditional nursery with self-propelled paddy transplanter technology with seed saving of 15–20 kg/ha and labour saving of 200 man-h/ha. In traditional method, average yield realised was 4.83 tonnes/ha, and it was 5.70 tonnes/ha in the self-propelled paddy transplanting method. Saving in operation cost with mechanical transplanter was about 30% over conventional manual transplanting.

Palmyra tree climber: The palmyra trees have a wide variation in diameter along the trunk unlike coconut trees and, therefore, the coconut tree climber developed earlier cannot be used for these trees. Hence, a palmyra tree climber was developed. The unit having two frames connected by straps is provided with adjustable seating arrangement and side supports for comfortable and safe operation. Adjustments were provided in the unit for changing the size of tree-holding section so as to have firm grip. The dimensions of tree climber was decided based on relevant anthropometric data of workers. The centre of gravity of the worker's body lies within the tree climber system and therefore the unit is stable and safe. As compared to the conventional tree climbing method, the unit reduces the drudgery of workers by 65% as reflected from overall discomfort rating score.

Hand-operated rotary arecanut peeler: The hand-operated arecanut peeler consists of a hopper, inner drum with pricks and conveying arrangement, perforated outer drum and a handle. The outer drum is kept stationary and the inner drum is rotated by the operator using handle provided on the machine. The pricks fitted on the periphery of internal drum peels the outer shell of the arecanut superficially without damaging the nuts. The machine, costing ₹ 7,500 gave an output of 490 nuts/h at the operating cost of ₹ 1/kg peeled arecanuts.

Test rig for tractor roll-over protective structures: A test rig for static testing of tractor roll-over protective structure (ROPS) as per IS: 11821 (part 2)-1992 was developed. The rig included test bed, reaction frame, hydraulic actuators, control panel, crushing beam and instruments for measurement of force and deflection with data acquisition system. A mounting fixture attached with axle housing was developed which can accommodate different cross sections of ROPS. This

mounting fixture can also be used to retrofit ROPS on tractors.

Solar-assisted heat pump dryer for high-value crops: A solar-assisted heat pump dryer (20 kg/batch capacity) was fabricated and operationalized. The dryer consisted of a drying chamber, dehumidifier, solar collector panel and heating back up. The heat pump dryer was evaluated by drying *amla* fruit (blanched, deseeded and cut into 5–6 pieces). The drying times of *amla* in the heat pump dryer were 50 h and 18 h at 35°C and 50°C, respectively, as compared to 8–10 days in the open sun-drying. The ascorbic acid (vitamin C) contents of the *amla* dried at 35°C and 50°C were about 490 mg/100 g and 320 mg/100 g as compared to 260 mg/100 g dry *amla* in case of the open sun-drying. The overall (heating and cooling) coefficient of performance (COP) of the heat pump was 4.8. Augmentation of the pump with solar heating system improved the COP to 6.6. Thermal efficiency of the solar-assisted heat pump dryer was 24–30%.

Biogas plants for cold climate: An insulated floating drum type biogas plant was designed to minimize the adverse effect of low temperature on the performance of the biogas plants during winters. It had diameter to depth ratio of digester as 1:1, 100 mm thick expanded styro foam insulation was provided around the digester as well as steel gas holder. An increase of 35% in cumulative biogas production was noted as compared to an un-insulated plant of the same capacity.



Insulated biogas plant

A 2 m³/d capacity RCC biogas plant having diameter to depth ratio of 1:1 suitable for hilly areas was also developed. Mild steel sheet mould in pieces was fabricated both for the casting of digester as well as casting of concrete dome. The whole plant can be cast within two to three days. One such plant on cost sharing basis was installed at a farmer's home in Almora district of Uttarakhand at an altitude of 1,500 m (above mean sea-level).

Bio-methanation plant: A bio-methanation plant for digestion of fruit and vegetable processing residues for energy generation was designed and installed at Fruit and Vegetable Unit of Mother Dairy Foods

Processing Ltd, Mangolpuri, New Delhi. A new concept of biogas generation from such residues was incorporated in this system. Majority of volatiles are being extracted from fresh waste and the leachate is fed to the methane reactor for biogas generation. At present, leachate of around 3 tonnes residues is mixed with treated Treatment Plant water in the ratio of 1:8 and is being fed to the reactor, and biogas production is being recorded. Around 50 m³ of biogas is produced everyday. The loading rate will be gradually increased to bring it up to design load of 10 tonnes residue everyday.

High solid biogas plant: A 35 m³ high solid biogas plant was installed at the Central Farm of the TNAU, Coimbatore campus and coupled with a 7.5 kVA generator. A gas conversion kit was used to change the existing dual fuel diesel engine to 100% biogas-run engine. The biogas plant was commissioned with cattle dung by adding equal quantity of water with daily loading of 875 kg of cow dung at about 15% TSC. The average daily biogas production obtained from the plant was 31.4 m³/d. The biogas produced was used for running the generator for three to four h/day with the gas consumption of 4.5 m³/h. The system, costing ₹ 3.5 lakh, has payback period of 18 months.

Crop residue briquettes gasification-based power generation system: Power generation system of 100 kW capacity, based on briquetted crop residues, was developed and operationalized. The system consists of an open top, throatless, downdraft gasifier to generate the producer gas. The raw producer gas after cooling and cleaning is fed to a producer gas-based engine to run the generator set. The system has been evaluated for more than 500 h using briquettes prepared from groundnut shell, sugarcane bagasse, pigeonpea stalk, soybean stalk and cotton stalk.

Inverted downdraft biomass gasifier cook stove: The inverted downdraft biomass gasifier cook stove used small wood pieces. Under laboratory conditions, the thermal efficiency of the stove using small wood pieces as fuel was found varying between 35 and 39%, which was more than 10% higher than the minimum value recommended by the Ministry of New and Renewable Energy (MNRE) for biomass cook stoves. However, its surface temperature was very high, up to 180°C.



Biomass gasifier cook stove

The outer surface of the stove has been covered with GI mesh as safety guard. The emissions and surface temperature of the cook stove of the revised design are within the permissible limits set by the MNRE.