

10. Mechanization and Energy Management

Mechanization of Indian farms not only increases production and productivity, but also reduces drudgery and increases labour productivity. This results in increased savings and higher income to the farmer. The quest for improved machines and equipment for farm operations has been driving the scientists to come out with many innovations and adaptations to existing machinery. In addition to individual ownership of farm machinery by the farmers, sophisticated and capital-intensive machines are being introduced for various farm operations, which can be adopted only through custom-hiring. The developments made in this field and important findings are presented.

Controller for variable seed rate and fertilizer application

A micro-processor-based controller and appropriate decision-support system was developed for varying seed and fertilizer rate independently at different forward speeds. The decision-support system can be trained to sow seeds of five different crops and five different varieties of each crop. Similarly, it is capable of applying five different types of fertilizers. A small screen-based selection board was provided, through which the farmer/operator can select crop, variety, row-to-row spacing, type of fertilizer and application rate of seed and fertilizer.



Variable seed-cum-fertilizer applicator

The system was tested with JS 9305 variety of soybean sown at 350 mm row-to-row spacing and fertilizer (diammonium phosphate) @ 80 and 100 kg/ha. The variation in seed rate over the set seed rate varied from 2.43 to 3.14%, while the observed variation in fertilizer rate was 1.61 to 4.85% against 10 to 20% variation being observed in conventional seed-cum-fertilizer drills. The field capacity of equipment was 0.28 ha/h at forward speed of 2.5 km/h.

Colour sensor-based site-specific herbicide applicator

A two-row tractor-mounted inter-row site-specific herbicide applicator was developed in which laser sensor



Colour sensor-based site-specific herbicide applicator

registers the presence of green weeds. This signal operates a solenoid actuated flow control valve which permits herbicide spray at the points where needed. To avoid crop to be sensed by laser sensor, guards were provided on both sides of each sensor and nozzle assembly. The row-to-row spacing can be adjusted from 150 to 450 mm for accommodating crops sown at different row-to-row spacing. It was tested at different operating speeds (1.28–3.30 km/h). Pot plants were kept at a distance of 1.5 m for testing purpose with average vertical plant height of 0.22 m (along with pot). The nozzles were operated at 294.2 kPa (3 kg/cm²) pressure. The missing percentage varied between 5 and 26, being lowest at operating speeds of 1.5–1.7 km/h.

Nursery bag filling machine

A media sieving, mixing and bag filling machine was designed and fabricated for nursery operations with the capacity of 1,000 bags (10 cm × 30 cm)/h. The machine consists of integrated system of mechanized sieving with a capacity of 2 tonnes/h.

Onion seed drill

A seed-cum-fertilizer-drill for sowing onion on raised beds was also developed and evaluated. It is a seven-row machine with a row spacing of 13 cm. The operational speed was 5 km with field capacity of 0.5 ha/h.

Cono weeder

Systematic studies on women workers while operating cono weeder were carried out which included cone apex angle, number of blades and height of blades on the cone to determine the minimum force required for ease of operation. The working width of the unit was 125 mm which weighed 5.4 kg, costing about ₹ 1,100. Ergonomical evaluation of the improved unit carried out

with 12 woman workers in comparison to IIRI cono weeder revealed its superiority in ergonomical parameters. Field capacity and weeding efficiency values for improved unit were 0.028 ha/h and 74% as against 0.022 ha/h and 72% for IIRI cono weeder.

Power weeder for cassava

The power weeder suited to cassava was developed by improvizing a commercial light weight mini roto-tiller which is light in weight (13 kg) and can be operated by a woman worker easily. Width of coverage is 350 mm and depth of operation extends up to 50 mm. The main rotor removes the weeds on the flat bed in between rows while the offset rotor removes the weeds spread over the mounds effectively. It has a field capacity of 0.2 ha/day with the field efficiency of 79% and weeding efficiency of about 90%.

Self-propelled hydraulically hoisted platform for orchard management

A hydraulically operated three-wheel self-propelled platform system was developed for harvesting mango, oranges, oil palm, etc. It is powered by a 8.2 kW petrol engine which can swivel by 360° and has hand-controls and steering on the working platform. The hydraulically hoisted platform is capable of keeping the operator at various heights ranging from 1.8 to 6 m. Fuel consumption of the unit during harvesting of mango was observed to be 2 litres/h.



Self-propelled hydraulically hoisted platform for orchard management

Harvesting tool for oranges in NEH region

A manual orange harvesting tool was developed which consists of 335 cm long bamboo pole having a cutter at the top. The cutter is operated by rope and clutch-type mechanism. A basket for collecting the oranges and a long cloth chute was provided to allow the oranges to reach ground level without damage and frequent unloading. It weighs 2 kg and costs ₹ 350. The unit was evaluated with ten workers and the output using this unit was 425 fruits/h. The mean working heart rate was 107 beats/min and the increase in heart rate over rest was 32 beats/min, which was within acceptable work load limit.

Safety attachment to Chemperi model palm climbing device

Commercially available Chemperi model climber was

modified to provide additional safety. A positive locking for Chemperi model was also provided to lock the device to the tree trunk to facilitate the climber to ascend/descend from the crown for cleaning and harvesting. The attachment provides full safety to the climber during these operations and also reduces the fear of height and risk of falling off.

Tractor-mounted pick positioner for fruit harvesting and pruning operations

A tractor-mounted pick positioner having a movable platform fitted on a tractor, with double acting hydraulic cylinder, was developed in which a person can reach to a height of 9.6 m for harvesting fruits and pruning trees.



Tractor-mounted pick positioner for fruit harvesting and pruning

The mechanism has provision for moving the platform in vertical plane only and horizontal movement of platform is achieved by positioning the tractor. Two persons are required for its operation, one on the platform and the other for driving the tractor, and the unit weighs 500 kg. It was evaluated on gooseberry (*aonla*) tree plantation and one person could harvest about 120 kg fruits per hour. Cost of this unit is ₹ 90,000 and can be fitted on tractors of 30 to 40 kW size.

Header unit of combine harvesters for harvesting of soybean

Reel speed (15, 20, 25, 30 rpm); reel configuration (bat type and finger pick up) and combining direction (along and across rows) were tested for various

combinations to reduce losses. Shattering losses were observed to be minimum (ranging between 2.4 and 5.2 g/m²) for reel speed of 25 rpm corresponding to reel index of 1.1. No apparent difference in header losses was observed while comparing combining direction, i.e. harvesting along and across the row. Stubble losses were observed to be lower for bat-type reel configuration in comparison to finger pickup-type reel. In all cases, loose plant losses were observed to be more in case of bat type reel than in finger pickup-type.

Pedal-operated ragi thresher-cum-pearler

Pedal-operated thresher-cum-pearler for finger millet or ragi has a capacity of 20 kg/h and pearling efficiency of 83% as against 3 kg/h and 70% in the traditional method of hand/foot pounding. The mean working heart rate and change in heart rate (Δ HR) values of the workers pedalling the machine were 126 and 46 beats/min which are within acceptable limit of workload.

Improved suspension system for tractor seat

An improved suspension system for the tractor operator's seat, for reduction in ride vibrations transmitted to tractor operator, was developed. This suspension unit is mounted below the seat and helps reduce ride vibrations by 15–30% under different operating conditions. Another method to attenuate vibrations being transmitted to the operator through tractor seat was developed using piezo-electric material blocks. Eight blocks sandwiched between two plates to act as the isolator unit are fitted beneath the tractor seat for reduction in vibrations. This piezo-electric material-based vibration isolator installed beneath the tractor seat was found to reduce the whole body vibration values by 27–55% in different operations. It was also observed that use of this isolator could reduce the body part discomfort score by 25–30%.

Vibration isolators for tractor steering wheel

Suitable vibration isolators at sub-assemblies of the tractor steering wheel were installed to isolate vibrations transmitted to tractor operators' hands. The steering wheel system was modified by inserting natural butadiene rubber (NBR) isolators at three points. The measured hand-arm vibrations transmitted from the tractor were evaluated as per ISO 5349 standard. The mounting of NBR isolators at steering wheel assembly reduces hand-arm vibrations transmitted to tractor operators by 20–40% under different operating conditions.

Agricultural Energy and Power

Briquettes of lantana biomass

Dried whole plant of *Lantana camara* were collected and further dried to moisture level of 20–25% in the open sun. It had a bulk density of 60 to 80 kg/m³. The dried biomass was shredded and transported to the briquetting unit. Dried and ground biomass was then converted to briquettes of 60 mm diameter, having a density of 1,060 kg/m³ for which energy consumption was 0.1 kWh/kg.

Success story

Briquetting Plant for Agro-residues: Entrepreneurship

With technical guidance of the Central Institute of Agricultural Engineering, Bhopal, Shri Ajay Gandhi has successfully established a biomass briquetting plant (500 kg/h capacity) at Mandideep, Bhopal district. This plant produces 3,000 kg briquettes per day using agro-residues such as soybean straw, pigeonpea stalk, *Lantana camara* stalk and other woody weeds and sells them to local industries for utilization as fuel for thermal applications in boilers an agro-industries, brick kiln etc. The energy consumption in briquetting has been estimated to be 0.1 kWh/kg. Market price of biomass briquettes is ₹ 4/kg, whereas total expenditure for producing the briquettes works out to ₹ 3/kg. Thus it is possible to earn about ₹ 60,000/month by operating the plant for 6–7 h/day for 20–22 days/month. This activity permits farmers of nearby villages to gain additional income from biomass, which was otherwise being burnt in the field.



Briquetting plant for agro-residues

Pilot scale non-electric pyrolysis unit

A pilot scale non-electric pyrolysis unit of 2 kg capacity for conversion of biomass into charcoal, consisting of pyrolytic chamber, combustion chamber, air inlet provision, chimney, protruding cylinder and pyrolysis gas outlet, was developed. The maximum calorific value of charcoal was found to be 7,110 kcal/kg for beefwood (*Casuarina equisetifolia*) and 6,570 kcal/kg for *malai vembu* (*Melia dubia*). A larger pyrolysis unit with 100 kg capacity was also developed.

Pilot scale non-electric pyrolysis unit →



Cashew shell cake-based draft gasifier

A cashew shell cake-based draft gasifier suitable for applications needing thermal requirement of 10–12 kW was developed. Various parameters influencing gasification process were analyzed and average flame temperature of gas generated was found to be 487°C.



Cashew shell cake-based up draft gasifier

Packed bed solar heat-storage system for solar dryer

A packed bed heat-storage unit coupled with a solar dryer (100 kg/batch capacity) was developed to continue drying beyond sunshine hours. The heat-storage unit along with solar air heating system was connected to the existing low height solar tunnel dryer. The solar air heating collectors (9.2 m² collector area) are attached to the packed bed to add solar heat to the pebbles. The packed bed heat-storage box holds about 8.5 tonnes of pebbles of 50 mm size. The box is covered with double glass on the top to allow sun light to heat the pebbles in the box. A reflector on one side of the box has been provided to reflect and further add solar energy to the collector. The heat-storage box is insulated with glass wool (50 mm thick) to reduce heat loss. A centrifugal blower is provided to recirculate the hot air from solar air heater to the rock storage box as well as for drawing hot air for supply to solar dryer. The average ambient temperature and relative humidity were 30.5°C and 43%. Under hot air retrieval test from heat storage unit, the average temperature at the exit of the heat-storage box was 44°C (47–41°C) and at inlet point of the solar dryer was 42.5°C (45–40°C) during six hours of operation after sunset.

Irrigation and Drainage Engineering

Performance evaluation of sub-surface drainage system

Pigeonpea has limited tolerance for excess water compared to other crops and is classified as a sensitive crop. The performance of surface and sub-surface drainage (SSD) systems were evaluated through field experiments for pigeonpea (variety TJT 501). The crop was cultivated in drained fields using recommended dose of NPK and standard cultivation practices of tractorized farming. The yields obtained under various treatments were 0.73, 0.93, 1.08, 1.21, 1.34 and 1.37 tonnes/ha in pigeonpea under farmers field (control), surface drainage, SSD without envelope, SSD with envelope, SSD, chimney with envelope and surface + SSD with envelope respectively.

The SSD system also resulted in increase of yield in the subsequent crop (wheat variety HI 1544) by 14.5% over control (4.2 tonnes/ha) during *rabi* 2011–12. The benefit:cost ratio for pigeonpea cultivation in temporary waterlogged Vertisols was 1.27 to 1.79 for different drainage systems and 0.47 for control (lowlying Vertisols).

FRP demand fish feeders

The demand fish feeder was designed and fabricated with FRP material for pellet feed for outdoor culture systems. Its main components are 30-litre capacity feed hopper, activating mechanism and hopper holding stand.



Demand fish feeder is useful for outdoor culture systems

Angle of repose was set at 50° in demand of feed drops by gravitational force. Demand fish feeders were installed in three different farms of Odisha.

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