



10. Mechanization and Energy Management

For achieving sustainable enhanced productivity and profitability in different farming systems, need-based and region-specific following engineering technologies related to agricultural mechanization and energy management have been developed. These include improved machinery for efficient farm operations, resource conservation; renewable energy technologies; gender-friendly tools for reducing drudgery of women farm-workers; efficient utilization of animal energy; and software for entrepreneurship development in custom-hiring of farm machinery.

Seed-cum-ferti drill for fertilizer application

For higher fertilizer-use efficiency, placement of fertilizers is recommended below the seed. Tractor-operated multi-row seed-cum-ferti drill places seeds at 50- mm depth and fertilizers at 50- to 150- mm depth. When fertilizer was applied at 150- mm depth to wheat with the drill, grain yield was maximum (5,565 kg/ha).

Five- row system weighing 180 kg requires 33-kW tractor for operation and covers 0.2-0.35 ha per hour.



Tractor-operated multi row seed-cum-ferti drill

Trench- planter for sugarcane

This tractor- operated planter is for planting cane in a trench of about 25–30 cm deep. Two rows of canes 30-cm apart are placed at the bottom of the trench. Fertilizers and insecticides are dispensed; cane setts are covered with soil, and sub-surface lateral for drip irrigation system is also laid; all these operations are carried out in a single pass. It can cover one hectare in 3–4 hours, depending upon the plot size. The cost of operation is one-third of the conventional planting.

Fertilizer-band placement cum earthing-up machine

This tractor (26- kW and above)- operated machine simultaneously places fertilizers, earths-up and cuts



weeds in maize, sugarcane and potato having more than 0.50-m row-to-row spacing. The field capacity and efficiency of the machine are 0.56 ha/h and 82.4%, respectively, and with this, there is considerable saving in fertilizers, time and labour over the traditional method.

Two-bed and eight-row carrot planter

This planter is for precise planting of carrot-seeds on the raised beds with a ridge height of 20 cm; and plants carrots in four rows on the each bed at row- to-row spacing of 7.5 cm. The average depth of seed placement is 2.25cm. The field capacity of the machine is 0.5 ha/h.

Manual onion-seeder

A two- row, manually -operated inclined plate- type onion-seeder covers 0.04 ha per hour effectively at an average speed of 1.24 km/h.



Manual drawn FYM applicator

The applicator fabricated consists of twenty-six rectangular openings, 3-cm apart at the bottom of the box to apply FYM in the field. An MS rod stand of 55 cm is also fitted at the centre of the arm to keep the unit in stationary position while filling-up FYM in the box. The storage capacity of the FYM applicator is 20-25 kg FYM with an application rate of 4.5-5.0 tonnes/ha.



Canopy-spraying system

Spray patterns of the selected nozzles of a modified intra-canopy spraying system were measured at 45 and 80 days after sowing (DAS) in soybean and at 90 and 120 DAS in pigeonpea. Six rows of pigeonpea were sprayed, covering a width of 3.6 to 7.2 m (row-to-row spacing varied from 0.6 to 1.2 m), and twelve rows of soybean were sprayed, covering a width of 4.2 to 5.4 m. The machine was also tested for spraying six rows of pigeonpea sown at 90 cm row-to-row spacing. The field capacity and efficiency of the machine were found 0.92 ha per hour and 77.4 %, respectively.

Air-assisted vertical boom sprayer

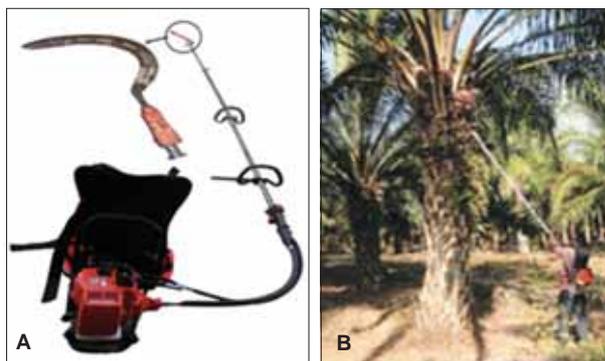
An air- assisted vertical boom sprayer for applying insecticides and other chemicals to fruit- crops operates at 540 rpm by tractor PTO; the nozzle discharge is 1.42 litres/min at 2,000 kPa pressure. Its field capacity and efficiency are 1.70 ha/h and 81%, respectively.

Solar powered knapsack sprayer

The knapsack sprayer developed for small and marginal farmers can be operated continuously for 6–8 hours. Its constant pressure system and quality spray result in effective control of pests.

Motorized tool for bunch-harvesting of medium-tall oilpalm

Motorized bunch-harvesting back-pack mounted tool for medium-tall oilpalms operates by a 50 cc, 2-stroke petrol engine of 1.3-kW. It weighs 12 kg; has a light-weight engine, flexible shaft, light- weight telescopic pole and a cutter- head mechanism. The equipment tested in Andhra Pradesh, Tamil Nadu and Kerala could conveniently be used up to a height of 5-6 m. The average number of oilpalm-trees harvested were 15 per hour, depending on the efficiency of the operator, number of mature bunches per plant, orientation of bunches and land profile.



(A) Back pack model oilpalm harvesting equipment;
(B) Evaluation of motorized bunch harvesting tool

Tractor-operated groundnut-digger elevator

The tractor- operated digger elevator consists of a blade,an elevator-cum-pick-up reel, fenders, a gauge wheel, coulters and a power transmission system, and is operated with a tractor of 26- kW or more. The front end of the pick-up cum elevator reel is adjustable

Particle drift of air-assisted spraying systems

Three different types of spraying equipment – air- sleeve boom, boom sprayer and aero- blast sprayer were evaluated for particle drift in fields for varying wind speeds (1.5, 1.7 and 1.8 m/s), temperature (22° C, 28° C and 34° C) and relative humidity (54, 58 and 69%). The increase in variables from 22 °C,54 %, 1.5 m/s to 34° C, 69 , 1.8 m/s augmented drift from 30.6 to 52.3, 37 to 57.6 and 57 to 83 µg at 5-m distance and 18.3 to 25, 19.6 to 31.3 and 35 to 48.6 µg at 10-m distance for air-sleeve boom sprayer, boom sprayer and aero- blast sprayer, respectively.

The highest drift was with aero- blast sprayer, followed by boom sprayer and air- sleeve boom sprayer. Maximum drift was observed at 0.4 and 0.9 metre high zone area at 5 and 10 m distances, respectively, from sprayers in the laboratory and in the field experiments.

based on the depth of the working blade, and front end of the pick-up rod is adjusted so that spikes comb about 30- mm of the top soil to lift vines gently from loosened soil. The machine uproots and inverts 0.16- 0.21 ha of groundnut per hour.

Improved combine harvester

The two-row tractor-operated potato combine harvester has been improved for better separation (85%) and to reduce tuber bruising (<2%).



Large cardamom harvesting knife

An improved knife weighing 170 g, made of EN8 spring steel, reduces force required in operation and drudgery and thus minimizes chances of accident;400 improved knives were given to workers (270 males and 130 females).



Large cardamom harvesting knife used in the North-Eastern Hills



Tractor-mounted root crop harvester-cum-elevator

Digging onion and other root crops is a labour-intensive operation. A tractor-mounted machine for digging and elevating root crops has a field capacity of 0.28, 0.24, 0.21 and 0.21 ha/h for digging carrot, potato, garlic and onion, respectively, at a forward speed of 2.78, 2.41, 2.10 and 2.10 km/h. The damage was less than 1.0% for digging of carrot, potato, garlic and onion crops. Saving in labour for harvesting onion, carrot and garlic was 69.0, 59.2, 69.0 %, respectively, compared to manual harvesting.



Root crops harvesting system

Arecanut sheath shredder

Arecanut sheath is a good alternative as a fodder for cattle. Its sheath length and breadth ranges between 50-120 cm and 20-35 cm. A compact- and- energy-efficient arecanut shredder developed can be utilized for dry as well as moist arecanut sheaths. It consists of a drum that rotates at a speed of 800 rpm and has four blades, and a counter-shear to shear-cut in both directions. The shredder operates by a 2.2- kW electric



(A) Arecanut sheath shredder; (B) arecanut fodder

motor, and has a capacity of 100 kg/h, and shreds sheaths into particles of 5-8 mm.

Multi-millet thresher

Threshing of millets is a labour-intensive practice. Multi-millet thresher of 1,300mm × 1,300mm × 1,100 mm, weighing approximately 150 kg and operated by a 1.5- kW-electric motor, considerably reduces drudgery. The thresher capacity is 50 kg of *kutki*-grains per hour with more than 95% de-hulling efficiency; and this can be customized easily for all small millets by changing sieves and operating parameters. The thresher may even thresh millet crops of higher moisture content compared to traditional practices, thereby minimizing post-harvest losses.



Multi millet thresher

Seed extractor

For onion, a power-operated seed-extraction machine to extract seeds from sun-dried umbels was developed to enhance the capacity and to complete operation in time as compared to manual seed extraction. The machine performs well with extraction capacity of 28.9 kg/hour, extraction efficiency (99.7%), specific energy consumption of 0.051kWh/kg and minimum seed damage of 3%. The mechanically extracted seeds have good germination (96%) and vigour index (7,736).



ARECANUT DEHUSKERS

Women- friendly rotary arecanut dehusker

Hand-operated arecanut dehusker suitable for women-workers consists of a hopper, a conveying screw, cutting tips and a handle. Graded nuts are fed into the conveying screw through the hopper. The capacity of the unit is 5 kg per hour and it costs ₹ 3,000.

Pedal-operated arecanut dehusker

Dehusking efficiency, kernel breakage and dehusking capacity of this arecanut dehusker is 97 %, 6.7 % and 15 kg per hour, respectively. The unit is mounted on wheels, weighs 110 kg, and costs ₹ 25,000. The mean heart rate of male-workers operating the unit was 127 beats per min.; indicates that it can be operated continuously and comfortably.



Hybrid *ber* grader

A hybrid *ber* grader of capacity 500 kg/hour was developed for grading mixed lot of *ber* into three sizes, i.e. >35 mm, 25-35 mm and <25 mm to enable farmers to get higher price on premium-size fruits.

Dehusker for kodo millet and *kutki*

An eco-friendly and an energy-efficient millet mill is being utilized for de-husking foxtail millet, little millet, kodo millet, proso millet and barnyard millet. It has a capacity of 100-110 kg of millet- grains per hour (at 10-12 % moisture content) with 95 % de-husking efficiency.



Software for custom-hiring of farm machinery

This software facilitates selection of an appropriate farm machinery for a given cropping system and a set of agroclimatic conditions. With the software, finalization of operating parameters of the selected machinery can be done for maximizing benefits, and it has been demonstrated to stakeholders from different states.

Gravity-based ropeway system

The ropeway system, consisting of two trolleys, rolling over two separate steel- wire ropes (track ropes), suspended from two towers, transports materials from road to fields in the hilly terrain. The trolleys are connected to a single looped wire rope of smaller diameter (hauling rope) in between two track ropes, at two extreme levels by means of cable ties. When the laden trolley rolls down by its own weight along the one-track rope from the upper station, another trolley with the lighter weight at the bottom station hauls up along the next rope. A flywheel brake is fitted at the lower station to regulate speed of moving



Gravity-based ropeway for hills

trolleys. The ropeway has a slope of 30 degrees, and weight ratio of downward and upward moving load is at 3:1. Cost of 150-m ropeway unit is ` 2 lakh.

Fishing vessel for managing natural marine resources

The CMFRI procured a 19.75 m OAL fisheries research vessel F.V. Silver Pompano for carrying out fisheries related research in the territorial waters under NICRA. The vessel shall be used for trawl fishing both bottom and mid-water trawling using Issac-Kid Midwater Trawl system and collection of oceanographic parameters and marine biotic and abiotic samples from the sea. The vessel is equipped with underwater CTD sampler, Doppler current meter, instruments for chlorophyll measurement, zooplankton, TSS and sediment sampling. The vessel has a laboratory for preliminary analysis and to fix samples for further analysis. An automatic weather station is available to collect atmospheric parameters rainfall and humidity.



New Fishing Vessel for managing natural marine resources

Mobile fish vending unit

A prototype mobile fish vending unit was developed at CIFA. The major features of the system include a cycle rickshaw, 170 L chilled box (requires ice 42.5 kg); 66 L tray; cutting and processing area, 0.42 m²; capacity of storage water, 10 L; waste disposal volume, 8.0 L; scales and fins disposal volume, 8.0 L; insentient disposal volume, 8.0 L; capacity of semi- process products, 50 kg; capacity of whole fish process products, 120 kg. The unit cost is estimated to be ` 52,780. It provides best possible market quality, a proper form of semi-processed or final product, health safety of





products, and applies the most rational raw processing method. Unit is suitable in urban/municipality areas with proper waste disposal.

Fish meal plant

CIFT, Kochi designed and developed a 10 kg capacity fish-meal plant out of SS 302. The equipment consists of a chopper to input fish/fish waste, which is followed by a fish cooker. Fish cooker is screw type with variable speed using VFD technology, which gives the flexibility of using different fishes having different cooking time. The cooker is fitted with pressure gauge, dial thermometer and safety valve for standardizing the system with different variety of fishes. The machine also contains a hydraulic type oil extractor to extract fish oil after cooking, which will be collected outside the machine. An electrical fish dryer is also incorporated to dry the slurry of the extractor, which is used as fish meal.



AGRICULTURAL ENERGY AND POWER

Biogas-storage system

A biogas-storage system consists of a moisture-absorption unit, a compressor and a storage cylinder. Moisture from the gas is removed by passing through moisture-absorption unit filled with 3A molecular sieves (alkali metal alumino silicate) prior to compression. Moisture-free gas is compressed into a cylinder at 9-bar pressure. Time required for compressing 1 kg gas is 20 min. The compressed gas is filled into CNG cylinder, and gas stored for 2 months under ambient conditions showed no change in its composition. Methane content was 80 % prior to storage and remained same even after two months storage.

Biomass-based decentralized power plant for agro-enterprises

A 100- kW biomass- based power generation system integrated with biomass-briquetting plant (500 kg/h) was installed and commissioned at Silari, Udaipura in Raisen district in a decentralized mode. It consists of an open-core gasifier, a gas cleaning-and-cooling unit, a Cummins engine gen-set and an electrical control panel. Briquettes of soybean-straw and pigeonpea- stalk (60 -mm diameter) were used as a fuel to operate the



100 -kW biomass-based power plant

gasifier. Electricity generated from the gen-set is supplied to operate a *dal* mill (65-kW) and a briquetting plant (30–35-kW). The biomass consumption of the plant varies from 95 to 100 kg/h.

Electronic Control Module for automatic supplementation of LPG to producer-gas

An electronic control module (ECM), consisting of a speed sensor (rev/min), a programmable logic controller (PLC) and a relay-and-power supply unit, supplements liquid petroleum-gas (LPG) automatically to a biomass-based power plant to avoid sudden fluctuations in load. The complete system (ECM + LPG) evaluated with producer- gas- based electricity generation system of 20- kW required recovery time of 5–7 seconds to govern speed change at different load variations while running gen-set with producer-gas alone, as compared to 7–9 seconds with manually controlled LPG supplemented system. The transient speed change was within acceptable limits; with no permanent speed change when load on the system varied, and ECM was used to supplement LPG- blended producer- gas at the time of changing of load.

Torrefaction unit for processing biomass

A torrefaction unit for thermal treatment of biomass (soybean and pigeonpea) reduces energy consumption and increases calorific value for efficient gasification. The system was evaluated for treating biomass at temperatures ranging between 200 and 250°C. The torrefied biomass formed uniform-sized particles during grinding, and energy consumption was reduced by 20% as compared to the untreated biomass. The recovery of biomass after torrefaction varied from 65 to 80%, and calorific value of the biomass increased from 17 MJ/kg to 20 MJ/kg.

Kitchen-waste-based Prefab balloon digester

Prefab balloon digester was commissioned at Sainik School, Chittorgarh, to handle about 200 to 250 kg of kitchen-waste per day. About 12 m³ gas/day was generated and was used for cooking meals; saving at least 15 LPG cylinders in a month. The capital cost of the plant was ₹ 2.50 lakh, and its operating cost was about ₹ 100 per day. The payback period is approximately 2.90 years.



Biomass combustor for bulk drying of farm produce

A prototype of biomass combustor to generate hot air up to 120°C for various thermal applications has highest thermal efficiency of 64.6% with mixed fuel- wood and 62.3% with biomass briquettes for air- flow rate of 800 m³/h and fuel- feeding rate of 4 kg/h.



ANIMAL ENERGY UTILIZATION

Dung-collection machine

Two models of dung collectors have been developed to facilitate cleanliness and sanitation in animal/dairy to farms. One model operates by 750- W electric motor and the other by 1.0- kW petrol- engine. Capacity of dung collection was 225 kg at a speed of 1.99 m/s by the former model and was 105 kg at the speed of 0.84 m/s by the latter model.



(A) Petrol-engine-operated dung collector; and
(B) Electric-motor-operated dung collector

Animal-drawn drum seeder

An animal-drawn onion drum seeder with adjustable row-row spacing in seed chambers mounted on a rotating shaft driven by ground wheel for seed sowing on flat beds was developed. The operating width of machine is 1.7m with a field capacity of 3 ha/day and seed rate of 7.5 kg/ha.

Bullock- drawn wedge- and wing- plough for narrow hill terraces

A bullock- drawn wedge- plough, weighing 13 kg, for tillage and puddling on narrow terraces of hilly region of Sikkim, has a field capacity of 0.25 ha/h for tillage at 150- mm depth and of 0.02 ha/h for puddling at 190- mm depth.



A wing- plough for shallow tillage and puddling up to 100-120- mm depth, weighing 8 kg, has a field capacity 0.025 ha/h for puddling and of 0.03 ha/h for tillage at speed of 2.2 and 2.4 km/h; ` 300/ha were saved by these implements compared to the traditional wooden- plough.

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