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Agricultural Mechanization and Energy Management

A brief description of machines developed for seeding and placement of fertilizer, planting, puddling, spraying, trash shredding, harvesting and weeding is presented here.

Animal-drawn zero till seed-cum-fertilizer drill: The zero till seed-cum-fertilizer drill (unit price of Rs 3,500) was used for direct seeding of wheat and placement of fertilizer without preparatory tillage under high soil moisture condition. By use of zero till drill the seeding was done timely for higher yield at reduced cost of cultivation. The direct savings in cost of operation for sowing wheat compared to the traditional practices of farmers (cost of operation, Rs/ha = 3,000 for 03 tillage and seeding behind country plough) was Rs 2,250/ha. Considering the command area of the drill of 03 ha, the total annual benefit was Rs 6,700/machine.

Animal-drawn improved puddler: Improved puddlers of different designs were developed for puddling of rice fields prior to transplanting. It was advantageous in terms of better puddling with reduced number of passes (2 nos.) compared to the traditional method of puddling by use of wooden comb harrow (4 passes) or mould board ploughing and planking. Due to rolling, the draft load on the animals was low (60 kg) compared to the traditional puddler and the work rate was higher due to increased size and requiring less number of passes to prepare the puddle bed. The unit price of the improved lug wheel puddler is Rs 5,000 and its field capacity is 0.08 ha/hr. Direct saving in cost of puddling operation compared to the traditional practice of farmers (Rs/ha = 2,600) is Rs 1,850/ha. Considering the command area of 03 ha, the total annual benefit to the farmers was Rs 5,550/machine.

Animal-drawn tool carrier with ridge maker for vegetable cultivation: Rider bottom as an attachment to the tool carrier was developed for making ridges for planting of vegetable seeds/ seedlings. Compared to the manual ridge making by spades (Rs 20/100 m length of ridge; size, mm; base width = 300, top width = 100 and height = 100) the animal-drawn rider with tool carrier could save Rs 15/100 m length of ridge, besides making the work faster for seasonal planting. The unit price of the ridge maker attachment is Rs 1,000. Its average field capacity is 1,000 m of ridge/hr. The unit may be more useful for ridge making in lighter soils for raised/broad bed cultivations.

Animal-drawn biasi rice cultivator

The 2-row improved biasi rice cultivator gave higher work rate and reduced plant mortality compared to the traditional practice. The unit price of the improved biasi cultivator is Rs 2,000 and its draft requirement is 50 kg. Compared to the traditional practice of farmers (cost of biasi operation, Rs/ha = 1,350) the improved 2-bottom biasi cultivator saved Rs 700/ha. Considering the command area of 04 ha the total annual benefits was estimated to be Rs 2,800/unit.

Rotary transmission system for electricity generation using draught animals: To increase the annual utilization of draught animals, rotary transmission system was developed for rotary mode application of draught animals, especially during off-seasons with gadgets for electricity generation and agro-processing. Gear transmission system is with speed step up of 01:125; further stepping the speed up by pulley-belt combination to the input shaft of the alternator. The generated electricity is stored in battery (17 plate, 12 volt) with back-up time of 04 hr at output load of 250 W. Processing gadgets: seed cleaner-cum-grader, maize sheller, chaff cutter and flour mill were evaluated for output of 300, 120, 40 and 8 kg/ha, respectively using one camel on the rotary system.

A camel power-based rotary complex for electricity generation and agro-processing was established at the NRCC, Bikaner for further testing and demonstration.

Package of matching equipment for donkeys: A package of improved equipment matching the power output of large white Kathiawad breed donkeys (body weight = 150 kg and pulling capacity = 30% of body weight) was developed for field operation and transport. The package includes harness, iron plough, blade harrow, 2-row seed drill, blade hoe, 2-wheel steel cart and agro-processing gadgets (chaff cutter, caster decorticator and winnower) for operation in rotary mode.

A set of donkey-drawn implements with modified harness (modified Balram plough blade harrow, blade hoe, 2-row seed drill, seckon type harness with yoke, breast-cum-shoulder harness and single donkey steel cart) was supplied to NRC on Equines, Hisar for further testing and demonstration for use by farmers in light soils.

Rotary nozzles for tractor-operated sprayer for mango orchard: Rotary nozzles for mango orchard was developed. These nozzles were tested in the lab as well as in fields. The nozzles provide effective spraying, reduce loss of pesticide, cover large area of plant canopy and found effective in proper and even placement of pesticides. Field testing of tractor-operated Tycoon sprayer equipped with rotary nozzles was conducted for spraying operation in mango orchards.

Chopper type tynes for power tiller rotavator for sugarcane trash shredding: Handling of sugarcane trash and its incorporation in the soil is a big problem. Hence, chopper type tynes were developed for power tiller rotavator for sugarcane trash shredding. When L-shaped tynes are used for sugarcane trash shredding, entanglement of trash around the rotavator shaft is observed. The normal angle for L-shaped tynes is 118° +/-2° which was changed to 160° – 180° to make it chopper type tynes. Field trials of power tiller rotavator equipped with chopper type tynes were conducted as per BIS/RNAM test code on an area of above 2 ha. Effective field capacity of power tiller rotavator equipped with chopper type tynes was observed to be 0.065 – 0.085 ha/hr with 66.60 – 82.27% field efficiency. Operating cost was observed to be in the range of Rs 977 – 1,314/ha. Significant reduction in sugarcane trash size was observed in both field trials.

Self-propelled lucerne harvester: A walking type self-propelled lucerne harvester was developed. It consists of a gearbox and cutter bar. Cutter bar is bi-directional reciprocating type made from high carbon steel. Length of stroke for cutter bar is 25 mm and effective width of cutter bar is 860 mm. A man can walk behind the machine with an average speed of 2 km/hr. The recommended speed ratio of the average cutter bar speed to the forward speed of machine is 1.3 : 1.4. Two wheels are used for transportation purpose. The ground wheels drive the reel of the harvester. Ground drive provides the desirable feature of maintaining a constant speed ratio between peripheral speed and forward speed. The effective field capacity was found to be 0.113 ha/hr and field efficiency was noted as 70–75%. The average cost of operation was found to be Rs 850/ha as against Rs 1,770/ha by conventional method, giving a net saving of 52% in cost and 90% in time.

Tractor-operated vegetable transplanter for brinjal, cauliflower and tomato: A 2-row tractor-operated vegetable transplanter with picker wheel type metering mechanism was developed for transplanting seedlings of brinjal, cauliflower and tomato etc. It was modified to 3 rows to increase the capacity of the machine. The plant-to-plant spacing and row spacing in the modified machine can be adjusted to suit for transplanting requirements of different types of vegetables/crops. The plant-to-plant spacing in both the machines can be varied as 30, 45 and 60 cm by changing sprockets or number of fingers. Trials in chilli, cabbage, cauliflower, gobi sarson and brinjal indicated that the plant missing was about 2 – 3.5% at a speed of about 0.8–1.0 km/hr depending upon the plant-to-plant spacing and skill of operator. The yield was at par with the traditional methods. The machine saves about 80–84% labour in comparison to manual planting depending on crop spacing. The approximate price of the machine is Rs 70,000.

Tractor-operated rotary weeder: A rotary weeder was developed, consisting of a main frame, gearbox, 3 rotary weeding blade assemblies, a square shaft for transmission of power from

Tractor-mounted onion harvester-cum-elevator

Onion harvester-cum-elevator was developed for digging onion and other root crops. It consists of a digger blade made from high carbon wear-resistant steel. The width and thickness of the blade is 1,144 mm and 16 mm. The field capacity of the machine is 0.28, 0.24, and 0.21ha/hr when operated at speed of 2.78, 2.41 and 2.10 km/hr, respectively, whereas the damage is 1.98, 1.92 and less than 1.0%, respectively. The saving in labour ranged from 62 to 71%. Saving in cost of operation and labour for harvesting onion, carrot and garlic was 52.28, 46.71, 52.28% and 69.05, 59.29 and 69.05%, respectively as compared to manual harvesting. The approximate price of the machine is Rs 40,000.

gearbox to rotary assemblies and sets of sprockets and chains. A standard 3-point hitch arrangement has been provided to mount the frame to the tractor. Power from tractor PTO is transmitted to main square shaft through gearbox mounted on mainframe and set of sprockets and chain. The speed reduction from PTO to gearbox is 5:9. The machine was operated in more than 8.0 ha area on farmers' fields. It saves 54% labour and 74% cost of operation as compared to traditional method. The cost of the machine is about Rs 60,000.

Farmyard manure spreader: A 2-tonne capacity tractor-operated farmyard manure spreader was developed. It consists of manure spreading unit, feeding auger and slanting platform to convey the farmyard manure to the spreading unit. The field capacity and field efficiency of the machine were 0.34, 0.35, 0.36 ha/hr and 75, 76 and 74% at forward speeds of 2.25, 2.32 and 2.4 km/hr, respectively. Average width of application was 2.0 m. Manure application rate and uniformity of manure spreading increased with increase in flow/delivery rate of manure from the opening.

Controlled traffic rotary no-till slit drill: A 7-row (30 cm row spacing) controlled traffic rotary no-till slit drill for sowing of soybean under crop residue of wheat crop was developed. A modular seed box with furrow opener was directly mounted on rear frame of seed drill. The modular unit consists of primary and secondary seed hoppers and vertical rotor type seed metering system. The 180 mm diameter rotor picks the seed from secondary seed box and drops it in the seed delivery pipe. The flow of seeds from primary to secondary hopper is controlled through an adjustable seed delivery chute. Press wheels are provided in front for sowing under crop residue of wheat and rice.

Manually-operated tool for de-suckering for hill banana: A manually-operated banana de-suckering tool was developed. The tool consists of a handle for pushing the scoop and a pipe to which a de-suckering scoop is attached at the end. A small footrest is provided on the pipe for applying additional force for penetration in the sucker zone. The tool is effective in removal of the unwanted suckers in hill banana.

Desuckering and clump removal equipment for hill banana: The prototype of banana clump removal equipment, developed earlier, was attached to the light weight power tiller and tested at farmers' field at Gobichettipalayam, Erode district, Tamil Nadu. The average time taken to remove the big clump in dry condition was 5 min. and only 30 sec. for small clump in wet conditions. Serrated blade is provided at the cutting edges of the screw for easy cutting of clump material.

Raised bed maker-cum-planter-cum-cultivator: A customized raised bed maker-cum-planter-cum-cultivator for field trials was developed. The machine consists of 3 toolbars; the ridgers are mounted on the front, cultivators on middle and planting units on the rear toolbar. The rear toolbar on which planting units are mounted can be detached for interculture operations. For planting operation, the spacing between ridgers can be adjusted according to tractor tread. The working width of the machine is 1,500

Desucking and clump removal equipment takes 5 min to remove big clump in dry condition and only 30 sec for small clump in wet condition

Mole plough for Vertisols

A mole plough was designed and evaluated for its performance at CIAE farm. The dimension of the mole plough includes a leg with 1,000 × 250 × 25 mm and a foot of 100 mm with 110 mm bullet diameter. The total weight of the plough was 85 kg. Since the mole drain formation depends on the soil physical properties, soil samples were collected in 3-day interval to form mole drains during optimum moisture content (22–26%), using liquid limit apparatus. The liquid limit of soils in the experimental plot was worked out as 47.81% and plastic limit was found to be 22.7%. Unit cost of mole plough is Rs 8,000.

An increase of above 50% soybean yield was observed in 2, 4 and 6 m mole drain spacings, over control. The drains are functional for the last 3 monsoon seasons. Output capacity was 0.28 ha/hr at 4 m drain spacing.

One labour was required for monitoring the pump used for draining out the collected water. Cost of operation of the mole plough at 2, 4 and 6 m drain spacings was Rs 3,182, 1,811 and 1,169/ha, respectively. The drains performed well continuously for the 3 seasons. The returns on the investment can be obtained in the first year of installation due to enhanced soybean yield. Increase in yield of soybean due to mole drainage is @ 3 q/ha. The increase in income was worked out Rs 3,000/ha/year.

ORP trials of the technology were successfully carried out at farmers' fields in the villages of Raisen and Bhopal districts.

mm. During planting operation, the ridgers make a raised bed on which seeds are placed by the modular planting units. The spacing between the rows can be adjusted and minimum spacing of 225 mm can be achieved. The machine can also be used for intercrop sowing. Each of the functional components is modular and can be adjusted as per the requirements. Two units of the machine have been supplied to ICRISAT for sowing of soybean in Raisen and Sagar districts.

Energy saving control strategy for polyhouse environment under warm-humid climates: To save energy, a strategy with combination of different systems, i.e. natural ventilation system, fan and pad evaporative cooling, fogging and shading was worked out. The study was conducted with a pipe framed polyhouse (16□× 40□) equipped with various cooling and controlling devices and operating systems like mechanized natural ventilation, exhaust fan, excelsior cooling pad, wind pump water delivery and micro tube irrigation system, microprocessor-based greenhouse controlling system, foggers cooling and different pumping units.

In January, ventilators may be kept closed during night time to take advantage of CO_2 enrichment. In February, ventilators may be kept open during 9AM–5PM and closed during off sunshine hours, however, suitable shading may also be used during peak sunshine hours, i.e. between 12 noon and 3 PM. In first fortnight of March, use of evaporative cooling and shading may help to reduce 1 – 2 hr evaporative cooling period. During second fortnight, use of shading with forced evaporative cooling methods bring down inside air temperature below optimum range (25±5°C). Natural ventilation is enough during night hours. In April, suitable night cooling is also needed in addition to shading with forced cooling during day hours. During May–June, forced cooling with shading is needed in the greenhouse to bring down the temperature within the good production range.

Drainage technologies for crops sensitive to waterlogging in Vertisols: Surface and sub-surface drainage (SSD) systems for maize and pigeonpea crops were designed using meteorological data of 20 years. The different kinds of SSD systems (SSD with filter, SSD - chimney with filter, combination of surface and SSD with filter and SSD without filter) were installed at 20 m drain spacing and 1.0 m depth with drainage sump-wells fitted with automatic water pumping and measuring devices on 3.0 ha land. Field experiments were carried out during *kharif* seasons of 2005–07. The surface drainage at 20-drain spacing increased the yield of maize and pigeonpea by 20 – 40% over the control. The SSD lowered the temporary water-table by 0.40 m within a day. The maize and pigeonpea yields increased by 34 – 59.5% and 39 – 64.2% over the control, respectively under different SSD systems. The yield of subsequent *rabi* season chickpea and wheat crops (cultivated in SSD fields) increased by 14% and 12% over control, respectively due to sub-surface drainage. The benefit-cost (B/C) ratios for maize and pigeonpea cultivation in temporary waterlogged Vertisols were found to be 1.35 – 1.53 for surface drainage and 1.36 – 1.79 for SSD systems. The pay-back period for SSD systems for crops sensitive to waterlogging is 6–7 years. Under high water-table condition, when natural outlet is available near the field, the combination of surface and SSD is recommended for draining Vertisols effectively. For cultivation of the water-sensitive crops under temporarily waterlogged Vertisols surface drainage and SSD technologies are techno-economical feasible.

RENEWABLE ENERGY

Optimization of parameters for utilization of paddy straw, kinnow pulp and pea pods for production of cellulases, ethanol and feed supplements: Primary hydrolysis using sulphuric acid treatment resulted in about 25% hydrolysis of rice straw and the secondary hydrolysis resulted in further hydrolysis of about 13%, thus about 38%

Industrial application of solar tunnel dryer

A walk-in type solar tunnel dryer of 3.75 m × 17 m size floor area was installed in the premises of M/s Cotton Products India, Ayed, Udaipur for drying 600 kg treated cotton per batch from initial moisture content of 40% to a final moisture content of around 5% on a sunny day. The system is working satisfactorily for more than a year. Fully convinced with the technology, another firm M/s Raj Surgical, village Lakkadvas, Udaipur has installed 3 units of the walk-in type solar tunnel dryer at its factory each having a loading capacity of 600 kg of wet surgical cotton. Around 1,800 kg of treated cotton at mc of around 40% is spread on continuous trays of 2.75 m width in thin layers of approximately 5 cm thickness. The average temperature inside the dryer was found 15–18°C higher than the ambient temperature. The mc of the cotton reduced to around 5% in 1 sunny day. Cost of materials including labour for the 3 dryers was estimated to be Rs 4.1 lakh. Average cost of drying one batch of approximately 600 kg of wet cotton was estimated to be around Rs 560 as compared to Rs 1,240 in the existing diesel-fired dryers, primarily because of very high costs of electricity and petro-fuel consumption. The pay-back period has been estimated to be around 10 months. The system is under regular operation in the factory.

sugars were produced from the 2-stage hydrolysis of paddy straw.The furfural, furan and phenolic compound concentration was relatively much less even at 4% oxalic acid (w/v) concentration as compared to the production of furfural, furan and phenolic compound even at lower concentrations of strong acids such as HCl and H_2SO_4. Supplementing kinnow pulp with wheat bran in 3:2 in simple distilled water resulted in FPase and ß- glucosidase activity of 13.2 and 12.8 IU/gds and a ratio of nearly 1:1 which is considered to be most appropriate for achieving ideal saccharification efficiency of pretreated lignocellulosic material. Employing co-cultures of *Trichoderma reesei* RC 30 and *Aspergillus niger* BC 1 in the ratio 1:1 on paddy straw and wheat bran combination of 3:2 resulted in FPase, CMCase and ß- glucosidase activity of 28 IU/gds, 46 IU/gds and 25 IU/gds, respectively.Acid hydrolysate of kinnow waste using mild HCl without any detoxification treatment resulted in an ethanol concentration of 12g/l from total sugar concentration of 44g/l obtained by acid hydrolysis process with a fermentation efficiency of about 58%.

Solar dryer for silk cocoon drying: The solar dryer was evaluated for drying 50 kg of raw silk cocoons during March–May 2008. The cocoons were uniformly loaded in 30 trays (4.0 kg/m^2). The moisture content of raw silk cocoons reduced from 60.7% to 11.8% (wb) during 18 sun-shine hours in March. The solar intensity during drying was 600–900 W/m^2 and air flow rate was about 480 m^3/hr. The recommended moisture content for the dried cocoon is below 12%. Similarly, the moisture content of raw silk cocoons reduced from 60.2% to 11.5% (wb) during 16 sun-shine hours in May 2008. The solar intensity during drying process was 650–1,000 W/m^2 and airflow rate was 480 m^3/hr. The average rendita of the dried silk cocoons in the solar drier was 7.75 as compared to 7.78 in the electrical-dried cocoons. The reelability of the solar-dried cocoons were found to be at par with the electrical-dried cocoons. The average tenacity (load to break the thread) of the silk thread of 22 denier obtained from solar-dried and electrical-dried cocoons were 0.77 N and 0.75 N, respectively. The strength of the solar-dried cocoon thread and electrical-dried cocoon thread were 323.3 N/mm^2 and 314.6 N/mm^2, respectively. There was no significant difference in strength of thread between the solar and electrically-dried cocoon threads.

Moving platform type wood cutter: A moving platform type wood cutter using 30 cm diameter carbide tipped circular saw blade and powered with a 3-hp electric motor was developed for preparing the feed for a gasifier. The cutter was extensively tested on dry and freshly harvested *Prosopis juliflora* and mixed wood logs of 25 – 50 mm diameter. Three different types of blades having 40, 60 and 80 teeth were tried for their performance and the blade with 80 teeth gave the best performance. The output of the machine with 40 mm length size cuts was in the range of 225 – 250 kg/hr as against the presently used machine which gives output between 60 and 90 kg/hr. The moisture content of the freshly harvested wood logs was 39%. The energy required in cutting was 4 – 6 kWh/tonne and cost of sizing wood (when the length of cut was 4 cm) was between Rs 120 and 125/tonne of wood.

Technology for ethyl easter of jatropha oil: A simple process for ethyl estrification of jatropha oil was standardized to achieve maximum recovery of ester having low kinematic viscosity. Raw jatropha oil at 6:1 molar ratio may be reacted with 170° proof ethanol (moisture content 15%) at 70 – 75°C reaction temperature for 90 min. in presence of 3% KOH and then allowed to settle for 24 hr to get maximum ester recovery of around 83% with lowest kinematic viscosity of 5.39 cS. The relative fatty ester content of jatropha oil ethyl ester had 47.2% oleic acid ester, followed by 30.9% linoleic acid ester, 13.6% palmitic acid ester and 6.2% stearic acid ester.

Paddy straw-based biomethanation system: Based on the results of laboratory and pilot plant study a field scale 50 kg/day mesophilic plant to

Industrial application of packed bed solar air heater

M/s Vishwa Karma Solar Energy Corporation, Phillaur under the technical guidance of PAU centre of AICRP on RES, installed a solar drying system equipped with 30 packed bed type SAH panels, each of 1.5 m × 0.9 m size in the premises of CIPHET, Ludhiana during 2004 – 05. Recently, the firm has installed a SAH system to supplement the heat requirement for drying of bleached wool at factory site of M/s Raghav Woolen Mills at Ludhiana. The factory is drying bleached wool using diesel-fired air heating system. Seventy two packed bed type SAH panels, each of 1.25 m^2 area were installed at the roof of the factory to produce hot air for use in the factory. Temperature of the hot air varies in the range of 50–55°C and average thermal efficiency of the system is around 35%. The annual diesel consumption before installation of the solar air heating system was around 21.8 k litres. The diesel consumption after installation of solar air heating system has reduced to 15.6 k litres, resulting in a saving of diesel by around 28%. The total investment of Rs 5.5 lakh for the system will be paid back over a period of 2.7 years. The expected life of the system is 15–20 years. The system has recently been sanctioned a subsidy of Rs 1.58 lakh by MNRE, GOI. The pay-back period with subsidy has been computed as 1.95 years.

produce biogas from rice straw was commissioned. The plant after evaluation of its performance was proposed to be shifted to an identified farmer's/ user's place for carrying out long duration testing and evaluation of the system and its management. The system consists of 6 M S reactors, each having capacity to take load of 250 kg rice straw, an MS platform, ladder and piping. Since the reactors are insulated and the process is exothermic, it is being operated without giving external heat for maintaining reactor temperature. The feeding of first batch reactor was initiated in September 2007 using 680 kg prepared rice straw at 25% TS supplemented with 30 kg castor cake and 32 g of $FeCl_3$ and 826 kg of inoculum. All the 6 reactors were gradually filled at an interval of 5 days. Quantity of biogas produced in each reactor is being recorded daily. The biogas production of 191 l/kg TS was recorded after 25 days of incubation period and methane content in biogas was 56±2%.