AGRICULTURAL MECHANIZATION

TILLAGE

Cone Penetrometer for Vertisols

A three point linkage mounted hydraulic operated cone penetrometer was designed and developed for measuring cone index up to 5000 kPa with operating depth up to 500 mm of soil profile. The system was driven by a 12V lead acid battery. A 'S' type load cell of 2000 N mounted between the cylinder and the cone penetrometer probe along with and a linear potentiometer of 550 mm stroke length for measuring cone index (Fig. 1). Two penetrometer probes, conforming to the ASABE standards and suitable for cone index of 2000 and 5000 kPa were used. Signals from the load cell and the linear potentiometer were acquired through the Campbell CR 3000 data logger and stored in text format in the computer memory disc. The text data were retrieved to the excel sheet to get the average cone index of the profile and the depth versus cone index plot as shown in (Fig. 2).

Package for Service Life Enhancement of Rotavator Blade through Surface Coating

The rotavator blades are subjected to extreme wear while working in highly abrasive situation. This requires replacement blades after 60-70 h of field operation. Enhancement of operating life and to reduce the abrasive wear requires surface improvement at macro level through powder coatings. To increase the life four treatments comprising of Nickle base 1060 powder along with different proportion of tungsten carbide (12.5, 25 & 50 %) were coated through thermal spraying technique using L & T make Super jet torch on rotavator blades (Fig. 3). The coated samples/ blades were analyzed in three layer test procedure i.e. dry sand rubber wheel abrasion tester as per...
ASTM G: 65: 1994, simulated accelerated soil bin and finally in the field. The results showed that the 1060 with 12.5% tungsten carbide have minimum mass wear followed by base 1060, 1060 with 25% WC and 1060 with 50% WC. It attributed to higher dissolution of WC in Nickle matrix at lower value of WC. The rotavator blades coated with 1060 and 12.5% WC showed 6.8 times higher service life compared to bulk hardened uncoated blades.

**SOWING AND PLANTING**

**Seed-cum-Ferti Drill with Varying Depth Fertilizer Application System**

Fertilizers directly placed in root zone to increase use efficiency. Therefore, a tractor operated multi row seed-cum-ferti drill was developed to apply fertilizer at differential depths (Fig. 4). Fluted roller metering mechanism and two different designs of shovel type furrow openers for seed and fertilizer placement were used for placement of fertilizer at different depth. The overall dimensions of the five rows varying depth seed-cum fertilizer drill was 2070×1445×1340 mm. It weighs about 180 kg, requires 45 hp tractor for operation in tilled soil. Its field capacity was 0.2-0.35 ha/h.

**Mechanization System for Effective Sett/Bud Treatment for Sugarcane**

A low pressure sett/bud treatment unit (Fig. 5) was developed to reduce the time needed for effective sett/bud treatment from the traditional practice of overnight soaking with fungicide/bio-control agents. The study was taken up with various treatments viz., Thiophante methyl (TM, 1000 ppm); Azole Strobin (AS,1000 ppm) and TM with AS (500 ppm each) for its efficiency at low pressure against red rot disease. Various bio-fertilizers viz., combination of azospirillium, glucanacetabacter and phoshobacterium is under evaluation for its efficiency at low pressure against red rot disease.

**PLANT PROTECTION AND INTERCULTURE**

**Efficient Canopy Spraying System for Soybean and Pigeon Pea Crop**

The spray pattern of selected nozzles (HCN 80450 and HCN 80250) were analyzed for the spray deposition efficiency on soybean and pigeon pea crop and the soil at recommended nozzle pressure of 294.2 kPa with and without air sleeve arrangements at travel speeds of 1.5, 2.5 and 3.5
km/h. The spray deposition efficiency measured in soybean crop at 80 DAS showed significantly higher ratio of spray coverage area on plants to soil to the maximum 2.32:1 and on backside to front side of plant leaves to 0.43:1 at a forward speed of 3.5 km/h, when compared to non-air assisted spraying. Similarly for the pigeon pea crop, these ratios were found to be 2.36:1 and 0.84:1, respectively at a forward speed of 3.5 km/h, using HCN 80250 nozzle. It was also found that variation among these results was statistically non-significant at growth stage of 90 and 120 DAS for pigeon pea crop. Therefore, the system can be operated at a speed of 3.5 km/h with provision of air supply to reduce the spray losses to the soil surface and increase deposition on both sides of the leaves for soybean and pigeon pea crop. Based on these findings of optimized operating parameters, the design of spraying system was modified for use in soybean and pigeon pea crops, such that it could accommodate plant height of about 1.5 m (at 90-120 DAS) for pigeon pea and plant height of about 450 to 700 mm height (at 45-80 DAS) for soybean crop. A Modular intra-canopy sprayer system (Fig. 6) having 12 vertical air sleeves spaced 0.35m apart was designed for use in soybean crop. This design has provision for modification into a six row system with adjustable row spacing of 0.6 to 1.2 m for spraying in pigeon pea crop. For travel speed of 3.5 km/h the field capacity was calculated to be 1.47 ha/h in soybean and 1.26-2.52 ha/h in pigeon pea crop.

**HARVESTING**

**Evaluation of Self-Propelled Hydraulic Multi-Purpose Elevator**

The self-propelled hydraulic multipurpose elevator has been developed to carry out different orchard management operations. The self-propelled hydraulic multipurpose elevator has maximum vertical reach of 6 m, load carrying capacity of 200 kg and can be operated at maximum ground speeds of 3 km/h. This machine was developed with dimensions of $2.2 \times 6.3 \times 1.89$m with a platform to reach fruits on trees for easy picking. It is hydraulically powered with a 8.2 kW engine and has a low centre of gravity and ground clearance of 290 mm to maintain the stability during the field operation (Fig. 7). Lifting, lowering of the platform, forward and backward movement, and steering of the machine were controlled by the operator from the platform itself. The developed system can be operated safely
on plain field as well as hilly terrain having slope up to 5º lateral as well longitudinal slopes. The centre of gravity remained in the stable zone up to 200 kg load on platform at all the height. The operator was able to pick 700-1100 mangoes/h depending upon the fruit density of the trees. The fuel consumption during harvesting of mango was observed to be 2 l/h with 75% throttle. The cost of unit is Rs 7.5 lakh.

**Arecaanut Sheath Shredder**

In arecanut growing areas of Karnataka, dry arecanut sheath has been found to be a good alternative as cattle fodder. Considering the requirements a compact and energy efficient arecanut sheath shredder was developed (Fig. 8). The cutting characteristics of arecanut sheath were studied with texture analyzer. The maximum force for cutting of areca sheath was found to be 87.5 N/cm. A cutting mechanism was designed to achieve longitudinal and transverse cut of arecanut sheath in single pass of cutting blade. The machine has four high carbon steel straight blades mounted on rotating drum and a counter shear plate to provide longitudinal differential shear cutting of arecanut sheath into 8-12 mm size. The feeding mechanism was synchronised with the speed of cutting drum to get uniform size reduction of sheath into 8×5 mm chiplets. According the output capacity, the cutting drum dimensions, rotational speed and power requirement were optimized to 0.4 m diameter, 700 rpm and 3 hp, respectively. The machine was evaluated at Milk Co-operative Society, Panaje Arlapadavu (post), Puttur Taluk Dakshina Kannada District Karnataka. The capacity of the machine was found to be 130 kg/h.

![Fig. 8 View of a arecanut sheath, sheath cutter and fodder](image)

**Power Operated Ribbonner for Jute (Model- III)**

A new model of power operated jute ribbonner was developed to overcome shortcomings like wrapping of jute ribbon in the roller and improper functioning of spring loaded rollers for removal of peeled jute stick, observed in earlier developed Model-II of jute ribbonner. Based on the feedback of jute growing farmers, the frame of jute ribbonner was also modified to make the machine separable in two halves for easy

![Fig. 9 Power operated Jute Ribbonner](image)
transportability. Two units of new model of jute ribbonner were fabricated at CIAE and were demonstrated and tested at CRIJAF, Barrackpore and NIRJAF, Kolkota (Fig. 9). The capacity of the developed ribbonner ranged between 90-100 kg/h of ribbon with 85-90 % ribbonning efficiency. The performance of these prototypes was found to be satisfactory. The cost of the machine has been estimated to be Rs.50,000/- approximately, with 2 hp electric motor as power source.

**Motorized Bunch Harvesting Tool for Medium Tall Oil Palm**

A back pack mounted motorized bunch harvesting tool for medium tall oil palms was developed at IEP-CIAE, Coimbatore Centre in collaboration with Directorate of Oil Palm Research, Pedavegi, Andhra Pradesh (Fig.10). The equipment has a light weight engine, flexible shaft, light weight telescopic pole and cutter head mechanism. A 50 cc 2 stroke petrol engine of 1.75 hp, weighing 2 kg was used as source of power and tested for its suitability for back pack mounting. A flexible shaft of 8 mm diameter was attached from the engine to the cutter head through telescopic pole to transmit the power. The length of 30 mm diameter light weight telescopic pole made of aluminum alloy was varied from 0.9 m to 3 m by telescopic arrangement. Handles were provided on the telescopic aluminum pole, so that operator can hold the equipment easily. The reciprocating cutter knife was mounted on the light weight telescopic aluminum pole which could be operated up to a height of 6-7m. The total weight of the back pack model of harvesting equipment was 12 kg. The modified oil palm harvesting equipment was evaluated at different oil palm plantations at Andhra Pradesh, Tamil Nadu, and Kerala. The back pack model of oil palm harvesting equipment was also evaluated using the high raised platform developed by DOPR and was found suitable to reach a height of 9 m. The cost economics study revealed that the breakeven point of backpack model of oil palm harvesting equipment was 5500 oil palms/annum or 62 days/annum.

(a) Back pack model oil palm harvesting equipment; (b) Evaluation of the motorized bunch harvesting tool; (c) Evaluation of trolley mounted model of oil palm harvesting equipment in combination with raised platform

Fig. 10 View of different bunch harvesting tool for medium tall oil palm
Refinement and Adoption of Header Unit of Combine Harvesters to Reduce Header Losses in Soybean

Field trial with combine harvester having finger pick-up reel and bat type reel were conducted to study the header losses during the harvesting of soybean crop (Fig. 11). Data on different losses viz. shattering, stubble and loose plant losses were measured for both types of reel. A quick-release, foldable type flexible canvas bat was developed and fabricated. These were mounted on fingers of finger type pick-up reel of the combine to act as bat type reel. With experimental combine (CLAAS-CropTiger-30) at Institute farm, shattering losses were observed to be lower with bat type reel in comparison to finger pick-up reel. The combine harvester was operated with a reel index of 1.2 to 1.3 (i.e. reel speed 20-30% higher than ground speed) at forward operational speed of 3.5 - 4.5 km/h, to control the header losses.

Development of Animal Drawn Garlic Digger

An animal drawn groundnut digger was modified and adopted for garlic digging (Fig.12). Field trials were carried out at farmer's field in Islamnagar village, Bhopal. The digger consists of frame, two standards, beam, handle, ground wheel depth adjustment mechanism and V-shaped blade of 650 mm size with 170° sweep angle. A pair of bullocks developed 600 N draft to cut and loose the soil beneath the garlic bulb during the field operation of implement. The lifter rods attached behind the blade facilitate separation of soil clods and plant material while operating the implement. After digging, the garlic plants were exposed to the ground surface. The field capacity of implement was 0.13 ha/h with digging efficiency of 90%.

Makhana Harvesting

Harvesting/collection of scattered makhana seeds from the bottom surface of pond is very tedious and painful activity. This involves a lot of drudgery in the traditional practice (by holding breath for 1.5-2 min (driver has to go deep into water and work in awkward postures). Therefore, a mini diving kit (Suit with cap, mask, back pack harness, 10 lit air cylinder, guage alongwith 1st & 2nd stage pressure regulator) as shown in Fig. 13, was demonstrated for harvesting of makhana at Keothi village near Regional Centre for Makhana, Darbhanga for its suitability. This kit was
found very useful for *makhana* harvesting. It helped the diver to remain under water for more than 45 min with 10 lit capacity air cylinder.

![Makhana harvesting mini diving kit and product](image)

**Fig. 13  Makhana harvesting mini diving kit and product**

### THRESHING

**Multi Millet Thresher**

In order to reduce drudgery involved in millet threshing, a research activity was undertaken to develop a multi-millet thresher. Based on the engineering properties of the millets, diameter of threshing drum, length of concave, diameter of main shaft, length and width of aspirator; and length of cleaning and grading sieve were optimized to 430, 260, 45, 747, 182 and 7000 mm, respectively. The developed thresher was tested for threshing of small millets (Fig. 14). The threshing capacity and efficiency of machine were 100 kg/h and 98%, respectively. The machine was also tested for dehusking of small millet (*kutki*) grain. It was capable to dehusk 50 kg kernel/h of small millet (*kutki*) with more than 95% dehulling efficiency. For increasing the cleaning efficiency of multi millet thresher one additional blower was fitted in the thresher. The cleaning assembly was also modified by applying two additional sieves of size 3, 5 mm that resulted increase in cleaning efficiency from 80 to 90%.

### CONSERVATION AGRICULTURE

**Package of Improved Implements for Bed Cultivation**

Package of equipment for bed forming cum seeding/planting, bed shaping, intercultural operation, chemical application and harvesting was identified and modified to match the track width (1500 mm) of a 35 hp tractor and bed size: bottom width 1500 mm, top width 1200 mm, and
bed height 100 mm. Equipment were evaluated for cultivation of soybean – wheat and maize –
gram crops on raised bed during *kharif* and *rabi* seasons, respectively. The specifications and
field capacities of equipment are given in Table 1. The slippage of tractor with machines ranged
6-8% during different field operations. The fuel (high speed diesel) consumptions were 56.9 and
44.9 l/ha for bed cultivation and 108.7 and 90.4 l/ha for conventional cultivation of soybean–wheat and maize-gram cropping systems, respectively. Permanent bed cultivation of soybean-wheat and maize-gram cropping systems has resulted in savings of 48% and 46.35% in
CO₂ emission compared to conventional flat cultivation system.

### Table 1 Package of equipment for cultivation of soybean-wheat and maize-gram crops on bed

<table>
<thead>
<tr>
<th>Operation</th>
<th>Name of the equipment</th>
<th>Specifications</th>
<th>Field capacity ha/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raised bed forming cum seeding/planting</td>
<td>Tractor mounted bed former cum seeder/planter</td>
<td>Bed size : top width 1200 mm, bottom width 1500 mm, row spacing adjustment from 100 – 500 mm.</td>
<td>0.35</td>
</tr>
<tr>
<td>Interculture operation</td>
<td>Tractor mounted sweep cultivator</td>
<td>Sweep size 5 × 150 mm, for soybean crop and 4 × 150 mm for maize crop,</td>
<td>0.15</td>
</tr>
<tr>
<td>Chemical application</td>
<td>Tractor mounted hydraulic sprayer</td>
<td>Tank capacity: 150 l, nos. of nozzles:14, type of the nozzle: hallow cone, adjustable distance between nozzle: 300 –600, Swath: 40 - 60 m.</td>
<td>0.6</td>
</tr>
<tr>
<td>Harvesting</td>
<td>Self-propelled vertical conveyor</td>
<td>Reciprocating cutter bar size:1000 mm, length of stroke:75 mm, stroke /min: 740, power: 6 hp diesel engine.</td>
<td>0.21</td>
</tr>
<tr>
<td>Bed shaping cum seeding planting</td>
<td>Tractor mounted bed shaper cum no till seeder/planter</td>
<td>Bed shaper for bed size: top width 1200 mm, bottom width 1500 mm, bed height 100 mm and no till seed cum fertilizer drill for planting of soybean-wheat and maize-gram on beds.</td>
<td>0.4</td>
</tr>
</tbody>
</table>

### Effect of Conservation Tillage on Energy Requirement and Cost of Production of Wheat under Vertisol

As a part of the collaborative study with Indian Institute of Soil Science, Bhopal on long term effect of no-tillage (rotary no till slit seed cum fertilizer drill), reduced tillage (one pass rotavator and seed cum fertilizer drill) were evaluated for wheat production and energy requirement under vertisol. The field capacity, fuel consumption, energy requirement and cost of production of wheat under different tillage systems are given in Table 2. A 35 hp tractor was used to carry out the field operations with different equipment. It was observed that cost of production and energy requirement in conventional tillage (two operations of duck foot cultivator and seed cum fertilizer drill) were 40.62%, 4.68% and 21.12%, 2.32% higher as compared to reduced and no tillage systems, respectively. There were net saving of Rs. 7800/- and Rs. 4750 per ha year for reduced and no tillage systems over conventional system of wheat crop cultivation under vertisol condition.
### Table 2 Effect of conservation tillage on energy requirement and cost of production

<table>
<thead>
<tr>
<th>S No.</th>
<th>Particulars</th>
<th>No Tillage</th>
<th>Reduced Tillage</th>
<th>Conventional tillage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Energy equivalent for tillage and sowing Man, machine and fuel energy (MJ/ha),</td>
<td>578.81</td>
<td>1162.00</td>
<td>2714.15</td>
</tr>
<tr>
<td>2.</td>
<td>Energy equivalent for FYM + labour (MJ/ha)</td>
<td>919.20</td>
<td>919.20</td>
<td>-</td>
</tr>
<tr>
<td>3.</td>
<td>Energy for herbicide (2–4 D), + labour (MJ/ha)</td>
<td>249.60</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4.</td>
<td>Energy equivalent for fertilizers: 100:60:30, kg/ha N, P, K + labour (MJ/ha),</td>
<td>6946.20</td>
<td>6946.20</td>
<td>6946.20</td>
</tr>
<tr>
<td>5.</td>
<td>Energy equivalent for irrigation – 2 Nos. Man, machine and electricity, (MJ/ha),</td>
<td>2335.46</td>
<td>2594.92</td>
<td>2594.92</td>
</tr>
<tr>
<td>6.</td>
<td>Energy equivalent for harvesting and threshing Man, machine and fuel energy, (MJ/ha),</td>
<td>1202.26</td>
<td>1202.26</td>
<td>1202.26</td>
</tr>
<tr>
<td>7.</td>
<td>Total energy, MJ/ha</td>
<td>12231.5</td>
<td>13324.6</td>
<td>13456.8</td>
</tr>
<tr>
<td>8.</td>
<td>Energy required, (MJ/tonne of grain)</td>
<td>2168.7</td>
<td>2537.2</td>
<td>3010.6</td>
</tr>
<tr>
<td>9.</td>
<td>Cost of production, Rs/ha</td>
<td>19200.0</td>
<td>22250.0</td>
<td>27000.0</td>
</tr>
</tbody>
</table>

**PRECISION AGRICULTURE**

**Evaluation of Microcontroller Based Five-row Seed cum Fertilizer Drill**

The five row microcontroller based seed cum fertilizer drill was developed and calibrated at increasing levels of forward speed, seed and fertilizer rates (Fig.15). The soybean seed rate was observed to vary between 1.61 to 4.85% (mean 1.75±1.53%) for a fixed seed rate setting and different forward speeds. However no definite correlation was observed between the forward speed and the measured variation in seed rate. On testing for sowing of wheat in field at the seed rate of 120 kg/ha, the variation in seed rate was observed 2.16 ±0.71% as compared to 10-20% in the conventional seed cum fertilizer drills utilizing ground wheel to drive its metering mechanism. It was observed that under laboratory conditions the variation in seed/fertilizer delivery from the set values were less than 3%. However under field conditions the variation in seed delivery from set values was about 3% while variation in fertilizer delivery was about 20%. Design changes are being attempted to lower the variation below 3%. New microcontroller based approach using ground speed sensing and stepper motor actuators for driving the metering shafts showed promising result for development of fixed rate precision seed-cum-fertilizer applicator.

**Evaluation of Pre-Emergence Herbicide Strip Applicator**

A pre-emergence 6-row herbicide strip-applicator an attachment to inclined-plate planter was developed to apply herbicide at the time of sowing in widely spaced crops such as soybean, pigeon pea (Fig 16). The machine was tested for soybean (variety JS 9560, row spacing - 0.45 m) and pigeon pea (variety UPAS 120, row spacing - 0.90 m) crops during kharif season of 2012-13.
The treatments were included no pre-emergence herbicide application (control), blanket application and strip application of pre-emergence herbicide. The pre-emergence herbicide (ORAM-32, 30% Pendamethylene Al) was applied on a 0.2 m strip width per nozzle (0.1 m on either side of row) at the rate of 1 kg/ha active ingredient. The inter-row and intra-row weed intensities observed at 21 days after sowing in different treatments, are given in Table 3. From field experiments it was observed that about 40-50% herbicide can be saved with the use of pre-emergence herbicide applicator. The operating cost of the pre-emergence herbicide applicator with inclined plate planter was worked out as 1350/- per ha for field capacity of 0.4 ha/h. The same machine was found suitable for use as post-emergence herbicide/pesticide applicator after the removal of furrow openers and increasing the height of nozzles from the ground.

Table 3 Inter-row and intra-row weed intensities in different treatments

<table>
<thead>
<tr>
<th>Crop</th>
<th>Treatments</th>
<th>Weed Intensity, weeds/m²</th>
<th>Inter-row</th>
<th>Intra-row</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean</td>
<td>Strip application</td>
<td>226</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blanket application</td>
<td>35</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>271</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>Strip application</td>
<td>243</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blanket application</td>
<td>40</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>252</td>
<td>175</td>
<td></td>
</tr>
</tbody>
</table>

On-the-Go Soil Electrical Conductivity and pH Measurement Device

An electronic device was developed for on-the-go assessment and quantification of variability of soil attributes for site specific crop management. Investigations were conducted in a soil bin at different EC levels of soil (Fig. 17). Three sets of four electrode Wenner array comprising of disc electrodes of 15 cm, 20 cm and 35 cm diameter were designed and fabricated to conduct experiments on soil EC. Two outer electrodes served as current injecting electrodes and resulting voltage drop due to current travelling through soil was measured across two inner electrodes. It was observed that 35cm disc electrodes were best suited for measurement of soil EC, as voltage output across these electrodes was stable and least affected by external electromagnetic interference. An automatic soil sampler consisting of a small cup for holding the 50-100 g of soil samples for pH measurement during travel in field has also been designed. The vertical movement of the small cup for measurement was controlled by a digitally operated solenoid coil.
Decision Support System (DSS) for Custom-Hiring Strategies on Agricultural Machinery

A DSS was developed for custom-hiring strategies of agricultural machinery (Fig. 18). The DSS was capable of determining number of equipment required for custom-hiring centre, custom rate, and suitable location of the custom hiring centre in a particular taluk. It was also applicable for making decision on hiring or owning particular equipment. The DSS was specially developed for southern states of the country by collecting data on taluk-wise/mandal-wise in a selected taluk/mandal in each agro climatic zones of Tamil Nadu, Andhra Pradesh, Karnataka, and Kerala on cropping pattern, size of land holding, area of cultivation, suitability of equipment, number of existing equipment, labour cost, custom rate, and transport cost. The mathematical model was developed for decision making by deriving important parameters viz, type of equipment required for custom-hiring centre at particular taluk, number of equipment required, cost of machine, cost of operation, cost of hiring, and locating the centre in the taluk. Validation of the software developed is under progress.

![Custom Hiring Business Model](image1)
![Main Options Custom Hiring](image2)

Fig.18 DSS for custom-hiring strategies on agricultural machinery