



## Agricultural Engineering and Technology

### Tractor-operated Machinery

**Inclined plate planter:** The 6-row tractor-mounted inclined plate planter was adopted for sowing intercrop on broad beds. A bed shaping/forming attachment was added as an integral part in the refined design of the planter. The planter was used for sowing of intercrop of soybean + pigeonpea on broad beds of 1,550 mm size (top width) at CIAE Farm. During field trials for sowing of three rows of soybean with two rows of pigeonpea at 300 mm row-to-row spacing, field capacity of planter was 0.42 ha/hr with an effective width of coverage of 1,850 mm. Field efficiency of planter was 64%.

**Check-row planter:** MPKV, Rahuri Centre of AICRP on FIM has developed a tractor-mounted check-row planter with row spacing of 1,000 mm. It consists of main frame of 230 mm length, three seed boxes with metering device, three furrow openers, power transmission unit and marker. The check row planter was evaluated at forward speed of operation of 2.87 km/hr. The working width was 2,700 mm. The depth of planting, row spacing and seed rate were 52 mm, 902 mm and 1.21 kg/ha, respectively. The field capacity, field efficiency and cost of operation were 0.613 ha/hr, 79.09% and Rs 250/ha, respectively. The number of hills and plant population were 7,572/ha and 11,995/ha, respectively.

**Three-row plug type vegetable transplanter:** TNAU, Coimbatore Centre of AICRP on FIM has developed a tractor-mounted semi-automatic three-row plug type vegetable transplanter for tomato, cauliflower, chillies and brinjal seedlings. The machine works on the principle of dropping-potted plants from a certain height to the ground. The impact of the seedling with soil block helps in its placement. The unit consists of main frame with hitching system, ground wheel, shoe type, furrow openers, compaction wheel, operators seat, plug type metering mechanism and two depth control wheels. The machine of 350 kg weight can be operated using 45 hp tractor. It employs press wheels inclined at an angle of 15° with the vertical as soil covering device.

The cost of the machine is Rs 22,000. The machine can be operated with 1.4 km/hr forward speed. It is economically viable in places where labour wages are more than Rs 60/day. The field capacity of the transplanter is 0.140 ha/hr and field efficiency 75% for transplanting chilli, brinjal and tomato with 450 mm row spacing.

- A light weight power tiller developed for use on small plots and terrace cultivation in hilly regions
- Tractor-mounted check-row planter developed with row spacing of 1,000 mm
- A semi-automatic tractor-mounted three-row plug type vegetable transplanter developed for tomato, cauliflower, chillies and brinjal and found economically viable in places where labour wages are more than Rs 60/day



MPKV check-row planter



TNAU three-row plug type vegetable transplanter



**Turmeric digger:** MPKV, Rahuri Centre of AICRP on FIM has developed a tractor-mounted turmeric digger suitable for harvesting turmeric sown on ridges at 600–750 mm row spacing. The unit consists of main frame, digging ridger and gathering unit. Two digging blades with shank were fixed on the frame spaced at a distance of 320 mm. A bar is attached with blades for separation of turmeric bulbs from the soil. The unit was evaluated for harvesting turmeric (Salem variety) at a forward speed of operation of 2.45 km/hr at soil moisture (db) of 18–25% in medium black soil. The field capacity and field efficiency were 0.175 ha/hr and 64.38%, respectively at working depth of 102 mm. The average damage of rhizomes was 6.94%. The average digging efficiency was 95%. The cost of operation was Rs 1,489/ha as compared to Rs 3,500/ha with conventional method of manual digging with fork.

**High capacity thresher:** AAU, Jorhat Centre of AICRP on FIM carried out feasibility testing of tractor-operated axial flow paddy thresher (Bharat) for total 50 hr. It gave output capacity of 5.6 t/hr. The fuel consumption was 4 l/t. The thresher saved 88% labour as compared to conventional practice.

**Rotary field shredder for sugarcane:** TNAU, Coimbatore Center of AICRP on FIM has developed a tractor-mounted rotary field shredder for shredding the sugarcane trash and crop residues



TNAU rotary field shredder for shredding sugarcane trash and crop residues

left in the field after harvesting sugarcane. For sugarcane grown in ridges and furrows, especially in ratoon crop, the unit can be operated with the tractor pto drive without damaging the ratoon crop. The unit consists of rotary member, gear box and transmission system. The field capacity of the unit was 0.37 ha/hr. It costs Rs 75,000.

**Banana stem shredder:** MPKV, Rahuri Centre of AICRP on FIM has developed a tractor-mounted banana stem shredder. It consists of main frame, shredding unit, feeding unit and power transmission unit. The power is transmitted from tractor pto to

shredding unit. The shredding unit was operated at 750 rpm.

**Paddy straw chopper-cum-spreader:** CCS HAU, Hisar Centre of AICRP on FIM conducted feasibility trials of tractor-operated paddy straw chopper-cum-spreader in 12.5 ha. The machine was tested with the combination of straw bailer/knotter. The field capacity was 0.8 ha/hr. The comparative cost of straw management with different combination was Rs 920, 800, 890 and 338/ha by using chopper + bailer, chopper + zero till, chopper + rotavator and chopper + burning of straw, respectively.

### Power-tiller-operated Machinery

**PAU light weight power tiller:** A light weight power tiller powered by 3.58 kW engine for use on small plots and terrace cultivation in hilly region was developed. It can also be used for wide spaced row crops (cotton, castor, pigeonpea and sugarcane) for interculture. The machine consists of power transmission system, two MS wheels, a frame and a rotary. The rotary blades can be used for weeding or seedbed preparation. The working width of the light weight power tiller was 450 mm (adjustable). The rotary equipment of light weight power tiller was evaluated for weeding in cotton and sugarcane crops. The field capacity was 0.09 ha/hr at forward speed of operation of 2.1 km/hr. The weeding index was 91.3% at 60 mm depth and 94.6% at 100 mm depth of operation.

**CIAE light weight power tiller:** The light weight power tiller is provided with petrol-start-kerosene-run engine of 3.75 kW. It was evaluated for puddling operation. Puddling operation was performed with the standing water of 60 mm depth in the field. The average bulk density of soil before and after puddling operation was 0.91 and 0.66 g/cc. The weed intensity before puddling operation was 45 g/m<sup>2</sup> (dry weight basis) with average height of 417.5 mm. No weeds were found after two operations of power tiller. The power tiller was operated at the forward speed of 2.42 km/hr. The effective field capacity was 0.096 and 0.11 ha/hr during first and second operations. Thus total time required to



CIAE light weight power tiller in puddling operation



complete two puddling operations was 19.51 hr/ha. The puddling index was 54.45% and cone index in depth zone of 0-200 mm of puddle bed was 0.55 MPa. The average depth of puddle land was 139 mm. The fuel consumption was 1.55 l/hr (kerosene). Cost of operation of power tiller was worked out to be Rs 68.59/hr and Rs 1,328/ha.

**Earthing-cum-fertilizer applicators** A power tiller-mounted unit suitable for earthing-up-cum-fertilizer application in wide row sugarcane crop has been developed by MPKV, Rahuri Centre of AICRP on FIM. The earthing-up unit consists of single ridger



Power tiller mounted earthing-cum-fertilizer applicator for wide row sugarcane crop is developed by MPKV

body (20 kg weight), an auxiliary bar of 500 mm height and 25 mm diameter provided for fixing it to fertilizer box. The fertilizer application unit consists of long trapezoidal shape fertilizer box of 460 mm × 40 mm with 25 kg fertilizer capacity. The unit employs cup-feed type metering mechanism having four cups (18 g capacity each) on fertilizer rotors. Provision of auxiliary chamber facilitates free fertilizer delivery. The unit was evaluated in sugarcane (CO 86032) at 1,200 mm row spacing and 105 mm depth of tilling operation. The working width was 600 mm. The average depth of fertilizer placement was 75 mm. The average weeding efficiency was 80.31%. At forward speed of operation of 1.169 km/hr, the machine gave field capacity of 0.50 ha/hr with field efficiency of 89.80%. The cost of operation was Rs 1,493/ha as compared to Rs 4,500/ha by conventional methods, i.e. *khurpi* for weeding and interculture and manual broadcasting of fertilizer. The equipment also saved Rs 1,257/ha as compared to weeding and earthing-up operations by bullock-drawn implements with manual broadcasting of fertilizer.

**Vertical conveyor reaper:** HPKV, Palampur centre of AICRP on FIM conducted feasibility testing of power tiller-mounted vertical conveyor reaper (NDUAT design) for wheat crop. The average plant height and grain moisture content at harvest were 680 mm and 9.8% (wb), respectively. The field capacity and field efficiency

were 0.13 ha/hr and 61.5% at forward speed of operation of 1.8 km/hr. The cost of harvesting was Rs 747/ha. The reaper saved 40% cost of operation as compared to sickle harvesting.

**Maize dehusker-cum-sheller:** HPKV, Palampur Centre of AICRP on FIM carried feasibility testing of power tiller-operated maize dehusker-cum-sheller for 25 hr. The average output capacity of sheller was 162 kg/hr with 1.2–1.5% grain breakage. The sheller was operated at 612 rpm. The costs of shelling and labour requirement were Rs 69/q and 1.2 man-hr/q, respectively. The cob moisture content, feed rate and fuel consumption were 15–17% (db), 205 kg/hr and 0.98 l/hr, respectively. The capacity was 12 times more than tubular hand maize sheller.

**Manure spreader:** TNAU, Coimbatore Centre of AICRP on FIM has developed power tiller-operated manure spreader. The unit consists of main frame, manure tub, conveying mechanism, spreading mechanism and adjustable rear aperture. For controlling the quantity of manure fed to spreader, adjustable door was provided in the rear end of the manure tub. The field capacity of the manure spreader was 0.62 ha/hr. The cost of spreading



TNAU power tiller operated manure spreader. It has the field capacity of 0.62 ha/hr

manure was Rs 91/ha. The savings in cost and time of operation were 85% and 94% as compared to manual method of manure spreading.

**Shredder-cum-in situ incorporator:** TNAU, Coimbatore Centre of AICRP on FIM has developed power tiller-operated roto shredder-cum-*in situ* incorporator. It consists of shredder assembly, power transmission system, hitch frame and rotary tiller attachment. The unit provided fine degree of pulverization enabling the rapid and homogeneous mixing of straw with soil. The field capacity and field efficiency were 0.08 ha/hr and 67.89%, respectively.

### Stationary Machinery

**Power weeder:** ANGRAU, Hyderabad Centre of AICRP on FIM conducted four feasibility trials of power weeder in sugarcane



Shredder-cum-in situ incorporator developed by TNAU has the field capacity of 0.08 ha/hr

sown at 60 cm row spacing. The field capacity, weeding efficiency and plant damage varied from 0.10 to 0.13 ha/hr, 65–75% and 2–3.5%, respectively. The average cost of weeding was Rs 600/ha. The speed of power weeder varied from 2.3 to 2.5 km/hr in different trials with effective working width of 55 cm.

UAS, Raichur Centre of AICRP on FIM conducted feasibility testing in red loam soil. The power weeder gave field capacity of 0.076–0.081 and weeding efficiency of 67–71% corresponding to soil moisture (db) of 17.89–18.11%. The working width, fuel consumption and working depth were 480 mm, 0.90–1.1 l/hr and 500–550 mm, respectively.

AAI, Allahabad Centre of AICRP on FIM conducted feasibility testing of power weeder in total 6.25 ha. The equipment was operated at a speed of 1.9 km/hr at soil moisture (db) of 18%. The field capacity and weeding efficiency were 0.053 ha/hr and 95%, respectively. The depth of tilling varied from 40 to 50 mm. The plant damage was 1.7%. The cost of operation was Rs 968/ha as compared to Rs 1,440/ha in conventional method of manual weeding with *khurpi*. The equipment saved 90.40% operating time and 32.78% in cost of weeding as compared to hand weeding by *khurpi*.

**Sunflower thresher:** MPKV, Rahuri centre of AICRP on FIM conducted feasibility testing of power-operated sunflower thresher (PAU design). The average grain straw ratio was 0.67%. The moisture content of sunflower seed was 14–16% (d.b.). The average threshing and cleaning efficiency were 99.12% and 86.74%, respectively. The average output capacity was 6.12 q/hr. The cost of operation was Rs 56/q. There was saving of 62.84% in threshing over commercial sunflower thresher. The PFT trials of thresher were conducted for total 116 hr.

**Flow through paddy thresher:** AAI, Allahabad Centre of AICRP on FIM conducted feasibility testing of flow through paddy thresher for total 77 hr. The thresher was operated at threshing

- Feasibility testing conducted for four different types of manually-operated paddy drum seeders
- Self-propelled mini combine adapted for efficient harvesting and threshing of safflower
- Self-propelled fodder harvester evaluated with crop gathering mechanism for berseem mixed with mustard



Flow through paddy thresher. The threshing efficiency and output capacity has been estimated at 99% and 1,300 kg/hr, respectively

drum speed of 955 rpm. The grain moisture (wb) was 12.59%. The threshing efficiency and output capacity were 99% and 1,300 kg/hr, respectively. The broken grain per cent varied from 0.6 to 1.1%. The cost of operation was Rs 18/q. It saved 72% in cost of operation as compared to manual threshing and time from 85 to 92% than conventional method.

**Groundnut pod stripper:** IIT, Kharagpur centre conducted testing of ANGRAU power-operated groundnut pod stripper. The centre incorporated feeding chute and screen to separate soil from groundnut. The stripper powered with 4.84 kW diesel engine was operated at 250 rpm. The output capacity, stripping efficiency, and cost of stripping were 90 kg/hr, 93%; and Rs 92/q, respectively. The fuel consumption and labour requirement were 0.75 l/hr and 3.33 man-hr/q, respectively. These modifications improved stripping efficiency (95%) and output capacity (120 kg/hr). The modified unit gave cost of stripping of Rs 50/q.

### Manually-operated Machinery

**Rice seeder:** AAU, Jorhat Centre of AICRP on FIM conducted feasibility testing of four different types of manually operated paddy drum seeders (24, 20, 12 and 8 kg wt). The mechanical drum seeders resulted in saving in time over manual line sowing conventional practice which varied from 78 to 95%. The most efficient operation (95% saving in time) was performed by plastic drum seeder. The operation speed of seeders varied from 1.88 to 2.61 km/hr. The field capacity varied from 0.139 to 0.283 ha/hr.



The grain yield with the use of different seeders varied from 2.94 to 3.28 t/ha.

**Machine for making bamboo sticks:** A prototype of simple manually-operated machine for making sticks of bamboo for use in manufacture of incense sticks (*agarbattis*), has been developed at CIAE, Bhopal. The capacity of the machine is about 5 kg of sticks per person-day (8 hr). The estimated cost of the prototype is about Rs 3,000. The machine is capable of providing gainful supplementary employment, with reduced drudgery and risk of injuries to the rural people living in areas contiguous to bamboo forests.

### Self-propelled Machinery

**Tree climber:** TNAU, Coimbatore Centre of AICRP on FIM has developed a tree climber free from any accident risk during its operation. The climber made of MS square pipe consists of two components. The components are connected by adjustable belts. The upper component is provided with a seating arrangement and lower component is having provision for holding the foot.

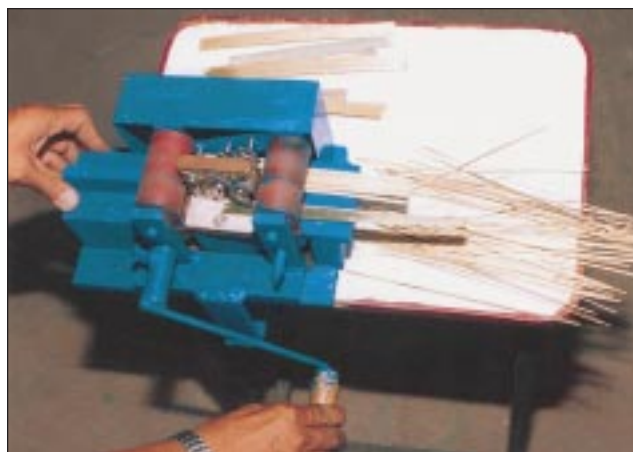


With tree climber the operator can safely climb a tree of 10 m height in 1.5 minutes

The rubber cushioning is provided at the portion of frames, which comes in contact with tree to avoid any damage to the tree. By standing on the lower component, the upper component can be moved up or down over the tree. The operator can safely climb a tree of 10 m height in 1.5 min. It costs Rs 2,000.

**Vertical conveyor reaper:** AAU, Jorhat Centre of AICRP on FIM conducted feasibility tests of self-propelled vertical conveyor reaper for harvesting rice. The machine gave effective field capacity of 0.176 ha/hr at forward speed of operation of 3.63 km/hr. It saved 94% in labour over conventional method of manual harvesting with sickle.

**Mini-combine for safflower:** For efficient harvesting and threshing of safflower crop, MPKV, Rahuri Centre of AICRP on



Bamboo stick making machine developed by CIAE has the capacity of 5 kg sticks/person-day (8 hr)

FIM has adapted a self-propelled mini combine after incorporating modifications in threshing and cleaning section. The mini combine is equipped with 4.4 kW engine. The unit is provided with a cutter bar of 1,000 mm length. It has been modified by introducing blower, straw outlet and sieve shaker. The cylinder concave was also replaced as per the suitability of safflower crop. The cylinder speed was increased to 14 m/sec. The provision of straw outlet was made at the other end of cylinder. A louvere was fitted to the side of cylinder where the material flowing through the concave was conveyed to the sieve. The seed and straw were separated using 7.8 mm hole size sieve and straw blower. The machine was evaluated for harvesting safflower and soybean crops. The average plant height and row spacing were 575 mm and 450 mm, respectively. It was operated at forward speed of operation of 1.53 km/hr for harvesting. The average stem diameter at cutting height was 6.95 mm for safflower at 140 mm height of cut. The cut crop was passed to the threshing section through conveyor. The working width was 900 mm. The actual field capacity and field efficiency were 0.11 ha/hr and 80.26%, respectively. The threshing and cleaning efficiencies were 100% and 90.73%, respectively. The total losses were 5.05%. The cost of operation was Rs 1,365/ha.

**Fodder harvester:** PAU, Ludhiana centre evaluated self-

- Tractor-mounted turmeric digger found suitable for harvesting turmeric sown on ridges as 600-750 mm row spacing
- Feasibility testing conducted for power-operated sunflower thresher
- Power tiller-operated manure spreader developed. The savings in cost and time of operation were 85% and 94% than manual method of manure spreading
- A manually-operated device for mechanizing the operation of stick making for incense sticks developed on request of Madhya Pradesh State Minor Forest Produce (T&D) Co-operation Federation Ltd



## SUCCESS STORY

### Self-propelled Rice Transplanter

KAU, Tavanur Centre carried out feasibility testing of 8-row riding type Yanji self-propelled rice transplanter. The transplanter has overall dimensions of  $2,400 \times 2,300 \times 1,200$  mm and its weight is 305 kg. It is equipped with 3.5 hp diesel engine which provides positive displacement of seedlings in the soil leaving minimum missing hills. Because of the float the transplanter did not face any problem of sinking in different soil conditions. During field trials the machine operator was accompanied with two labourers to check and regulate the mat seedlings. The Yanji transplanter has provision to regulate spacing between hills (120-140 mm) and adjustment for seedlings/hill (2-8 nos.). It costs Rs 1.30 lakh and field capacity was found 2,025 m<sup>2</sup>/hr. The seedlings/hill and missing hills were 2.25 and 7.30%, respectively. At planting depth of 60 mm and row spacing of 238 mm the hill spacing varied from 120 to 140 mm. It saved 40% time, 78% labour and 46% in cost of operation. It also saved 35% seed.

The Centre raised nursery using 50-55 kg/ha seed rate in 75 m<sup>2</sup> area. Seedlings of 16-22 days were used for self-propelled rice transplanter. Demonstration of raising mat seedlings without polythene sheets on the roof top of the terraced houses of farmers were successfully taken up at Kadavalloor Panchayat in Thrissur district. An area of 4.6 ha was transplanted with the use of such seedlings which reduced the requirement of separate nursery area and time gap between harvesting and transplanting. In Kole lands at Kattukambal in Thrissur district raising of mat type nursery and transplanting for 17 ha area was performed by trained woman workers. In Thuzhur Panchayat of Thrissur district village women accomplished mechanized transplanting operation efficiently.

The transplanter was also found suitable for low-lying clayey fields in Malappuram, Thrissur and Palakkad districts. At Puthsery and Anakara Panchayat, trainings were organized for 28 farm women and 4 unemployed youth in addition to on-farm training of mechanized rice transplanting.

At present 125 units are working in the state reducing the labour requirement to one-fourth and cost of cultivation to half.

## SUCCESS STORY

### Tractor-mounted Multipurpose Implement for Sugarcane

Tractor-mounted multipurpose equipment for sugarcane has been developed by IISR, Lucknow Centre of AICRP on FIM. There are two



Tractor-mounted multipurpose equipment under interculture mode (a), in seed drill mode (b) and in puddling operation (c)

versions of this equipment. The first model is a three-row sugarcane planter mode. The equipment can be used as (i) 9-tyne cultivator, (ii) for interculture operation, and (iii) earthing-up operations with minor adjustments. It can also be used as seed drill and paddy puddler. Attachments costing Rs 1,600 and Rs 4,000 are needed to use the equipment as seed-drill and puddler, respectively. The second model is basically a two-row sugarcane planter. For land preparation the equipment can be used as tractor-operated 9-tyne cultivator. For interculture it can be used for interculture operation in sugarcane field. The field capacity in interculture mode is 0.72 ha/hr. Three inter-row spaces are intercultured in a single pass. For earthing-up, three-rows of cane can be covered by this equipment with a field capacity of 0.66 ha/hr. For puddling, beater type sub-unit is mounted with the main frame of the equipment having field capacity of 0.35 ha/hr.

The tractor-drawn multipurpose equipment was tested in interculture mode for sugarcane (Copt 90223) spaced at 750 mm. The forward speed of operation, field capacity and cane damage were 4.20 km/hr, 0.72 ha/hr and 3.5%, respectively.

The earthing-up mode of tractor-drawn with row spacing of 750 mm. At tractor forward was 0.66 ha/hr. The working width of equipment This machine can perform six functions by fitting three-row sugarcane cutter planter, nine row equipment, earthing equipment, paddy-puddler Demonstrations were organized for farmers and conditions in 80 ha. The manufacturing of M/s Sunrise Industries, Barabanki who have



multipurpose equipment was tested for sugarcane speed of operation of 4 km/hr, the field capacity was 2,500 mm.

different attachments. It can work as two- or cultivator, interculture equipment, puddling and seed-drill.

manufacturers under different soil and crop multipurpose equipment has been taken up by already marketed 50 units.

propelled fodder harvester with crop gathering mechanism for berseem mixed with mustard. To eliminate problems in transmission system of crop gathering mechanism, two guiding shields were

employed on both sides behind the cutter bar to make a windrow of the cut fodder. The harvester was operated at forward speed of 1.5–2 km/hr. The effective cutting width was 1,250 mm. The



height of cut and fuel consumption varied from 35 to 50 mm and 0.5 to 0.6 l/hr, respectively. The field capacity varied from 0.12 to 0.15 ha/hr with field efficiency from 55 to 62%. The labour requirement varied from 34 to 40 man-hr/ha.

### **Mechanized Farming in Hill Region**

To mechanize rice sowing in hills, six-row manual mat type rice transplanter (PAU model) was evaluated by HPKV, Palampur Centre of AICRP on FIM at farmer's field for feasibility in villages namely lower and upper Lambagaon, Kothi Pahara, Barli, Kothi, Ghar, Bayara and Malan in 2.5 ha. The transplanter was operated at 20 cm row spacing and 10–15 cm plant spacing. The average field capacity and field efficiency was 0.033 ha/hr and 56%, respectively. The labour requirement was 61 man-hr/ha as compared to 250 man-h by conventional method. The cost of operation of equipment was Rs 488/ha as compared to Rs 2,000/ha with hand transplanting method. The field trials gave 3–4 plants/hill. There was saving of 68% in cost of transplanting including nursery raising compared to hand transplanting with root washed seedlings.

### ***Anthropometric and strength data of agricultural workers:***

AICRP on ESA started a programme on collection of anthropometric and strength data of agricultural workers through its co-operating centres as well as ad-hoc research schemes. Keeping into consideration the design requirements of agricultural hand tools and machinery, 79 body dimensions and 16 strength parameters have been identified for inclusion in the survey. At present, the data collection work is being carried out by 7 ESA centres and 7 ad-hoc schemes in 13 states. For measurement of body dimensions the equipment used is either the Harpenden Anthropometer or Siber Hegner Anthropometer or IIT, Kharagpur Anthropometer. For measurement of strength parameters, a strength measurement set-up developed at CIAE Bhopal is being used. Till date, data on 79 body dimensions for 8,241 agricultural workers from ten states and strength data on 16 parameters for 2,536 workers from three states have been collected. The mean stature and weight of agricultural workers on the basis of data collected so far worked out to be 163 cm and 53.8 kg, respectively for male workers and 151.2 cm and 45.9 kg, respectively for female workers.

***Status of adoption of safety measures on threshers:*** PAU Centre carried out a study to know the status of adoption of safety measures on threshers. The centre surveyed the threshers made by 30 manufacturers.

In all the spike tooth type threshers feeding chute was used and the chute dimensions were as per the BIS standard (IS 9020-2002). In Harambha type threshers only 36% manufacturers were providing safe centre-to-centre distance between conveyor rollers

- To mechanize rice sowing in hills, six-row manual mat-type rice transplanters evaluated at farmers' fields for feasibility
- Tractor-mounted multipurpose equipment for sugarcane developed with two versions
- For more cost-effective and energy-efficient rice-wheat system, the cultivation operation mechanized for timeliness of field operation and to reduce energy demand
- Study carried out to know the status of adoption of safety measures on threshers
- Double gear type pedal-operated paddy thresher developed and evaluated with 15 women workers

### **SUCCESS STORY**

#### **PAU Self-propelled Walk Behind Type Sprayer**

Crop spraying in most parts of Punjab is carried out with knapsack sprayers. Output from these sprayers is not uniform. Tractor-operated sprayers are not popular because of unsuitability of tyre width for the row spacing of 200 mm. To solve these problems, PAU, Ludhiana Centre developed light weight boom sprayer with narrow rubber wheels.



PAU self propelled walking type sprayer in operation

The sprayer was evaluated at Departmental research farm for spraying weedicide. After initial trials, machine was tested at 20 farmer's fields covering 70 ha for wheat crop, 10-15 days after first irrigation. The tank was filled with water and weedicide was added as per recommendation. The field capacity varies from 0.7 to 0.8 ha/hr at forward speed of operation from 2.5 to 3 km/hr. There is saving in labour requirement by up to 80% and cost of operation by 50% as compared to knapsack sprayer. The design has been taken up by a manufacturer for commercialization and ten units have been sold.

(> 1,200 mm) and about 44% of manufacturers were providing safe length of cover at feed inlet side ( $\geq 450$  mm). In 75% cases only the feed reversing system was provided. In 30% cases only full covering over transmission system was provided, whereas in remaining cases only partial covering was provided. About 69% of manufacturers were not aware of recommended measurements for the conveyor dimensions.



Only 40% of the manufacturers were providing operator's manual. Cautionary notice for proper working of machines was provided by 27% of the manufacturers. The centre also surveyed available threshers with 20 farmers and it was observed that only 20% of the threshers had ISI certified feeding chutes. In 15% of the threshers the transmission system was not covered at all, whereas it was partially covered in 35% and fully covered in the 50% of the threshers. It was also observed that in 20% cases the farmers have removed the covers provided by the manufacturers. None of the farmers were aware of the recommended dimensions of the safe feeding systems. About 60% of the farmers expressed the need of adjustable feeding platform and 85% of the farmers preferred to have automatic feeding provision.

#### **Status of adoption of safety features of chaff cutters:**

PAU Centre carried out a study to know the status of adoption of safety features on chaff cutters made by 29 manufacturers in Punjab. About 69% of the manufacturers did not provide gear reversal mechanism. Cutting mechanism was found to have no safety features namely flywheel locking device, front safety guard and covers on each blade and emergency stop control as specified in BIS standards (IS: 11459-1995, specification for power-operated



Vibration isolator attached under the seat of a tractor

chaff cutter and IS 7898-2001, manually-operated chaff cutter). 90% of the manufacturers did not provide belt cover/shields and pulley covers. Almost all the manufacturers were not providing instruction plate, caution notice and operator's manual. Only two manufacturers out of 29 were providing feeding chute of recommended size (900 mm). Gear cover was not available in 24% of the cases and flywheel cover was absent in 40% of the

## **SUCCESS STORY**

### **Mechanization of Rice-Wheat Cropping System**

To make the rice - wheat system more cost - effective and energy efficient the cultivation operations were mechanized for timeliness of field operations and to reduce energy demand, cost of production, production losses and drudgery of the tasks involved following conservation approach. Mechanized cultivation of transplanted rice compared to the farmers' practice (grain yield, t/

33.3% of irrigation water compared to conventional sown (grain yield, t/h = 4.46, benefit : cost ratio = 2.63 and water requirement, mm/ha = 600). Mechanized harvesting by combine harvester was cost effective for 35.7% over reaper thresher combination (cost of harvesting and threshing, Rs/ha = 2,311) and 67% over manual harvesting and threshing (Rs/ha = 4,500), besides ensuring



Mechanized transplanting of rice



Zero till drilling



Strip till drilling



Roto till drilling

ha=4.62 and benefit : cost ratio=1.78) showed 16.9% higher grain yield with 30.8% increased benefit : cost ratio. Zero and minimum tillage-seeding of wheat were time, fuel and cost effective for 62.4-71.8, 50.7-69.1 and 49.8 - 68.3% respectively than the conventional tillage (03-passes)-seeding (time, hr/ha = 12.35, fuel used, l/hr = 39.5 and cost of operation, Rs/ha 2,174). The conservation tillage wheat was advantageous in terms of higher net income and benefit : cost ratio for 11.53-16.02 and 15.4-21.9% respectively over the conventional practice (net income, Rs/ha =17,955 and benefit : cost ratio=2.63).

Cultivation of wheat on permanent beds gave 7.9% higher grain yield and 26.5% higher benefit : cost ratio, besides saving

timeliness with reduced losses to late matured crop. Retrieval of wheat straw by straw combine (straw recovery = 55%) after grain combining was profitable for Rs 1,800/ha and by straw baler for rice (straw recovery = 45%). The profit margin was Rs 650/ha in place of burning of straw in the field by farmers.

Seven improved equipment and eight cultivation practices were developed based on feedback from farmers. The technology transfer activities included 38 on-farm trials with 42 adopted farmers, 344 FLDs covering 907 ha in 40 villages, 14 trainings for 267 beneficiaries and 20 fields. Five manufacturers have taken manufacturing of these equipment for rice-wheat cropping system and farmers have started adopting the improved equipment.



cases. None of the users had operator's manual for their chaff cutters.

**Anti-vibration devices for increased comfort:** For power tiller and tractor operators, anti-vibration devices for increasing comfort were developed.

**Power tiller operators.** The TNAU Centre of AICRP on ESA has developed vibration isolators for engine, handle bar and handle of the power tiller and tested their efficacy for attenuation of vibrations transmitted to the operator. The provision of isolators resulted in reduction of handle vibration by about 50% and the same was demonstrated to the power tiller manufacturers for adoption.

**Tractor operators.** The TNAU Centre of AICRP on ESA has developed vibration isolator for tractor seat and tested it for attenuation of vibrations transmitted to the operator. The provision of isolator below the seat helped in reducing the vertical vibrations transmitted to the operator by 30-80% in different operations at speeds ranging from 2.5 to 4.5 km/hr. The unit was demonstrated to tractor manufacturers for adoption.

### Ergonomical Evaluation of Tools and Equipment by Women Workers

The following equipment were ergonomically evaluated using women workers:

**Irrigation pedal pump:** The OUAT Centre evaluated a pedal pump for irrigation with 15 women workers. Its output was 3,290 l/hr at 3.4 m suction height. The mean working heart rate of the workers was 120 beats/min and the  $\Delta$ HR (increase in heart rate over resting) 50 beats/min. The mean oxygen consumption rate of the workers was observed to be 0.63 l/min.

**Pedal-operated paddy thresher:** The OUAT Centre of AICRP on ESA developed a double gear type pedal-operated paddy thresher. It was evaluated with 15 women workers. Mean heart rate during work was observed to be 127 beats/min and the mean change in heart rate values was 55 beats/min. The oxygen consumption rate was 0.86 l/min. The output of the thresher was 30 kg/hr. As the physiological workload is on higher side it is recommended to operate the thresher by two women workers in tandem so as to get comfort as well as output.



Ergonomic evaluation of irrigation pedal pump



Ergonomic evaluation of cotton stalk puller



Ergonomic evaluation of groundnut stripper

**Four-row paddy transplanter:** The CRRRI four-row paddy transplanter was evaluated with 15 women workers. The mean heart rate during work was 138 beats/min and the  $\Delta$ HR value was 68 beats/min. The oxygen consumption rate was observed to be 1.0 l/min. Output per hour with the four row unit was 0.017 ha/hr.

**Two-row paddy transplanter:** The CRRRI two-row paddy transplanter was evaluated with 15 women workers. The mean heart rate during work was 135 beats/min and the  $\Delta$ HR value was 65 beats/min. The oxygen consumption rate was observed to be 0.99 l/min. Output with the two-row unit was 0.008 ha/hr.

**Cotton stalk puller:** The TNAU Centre of AICRP on ESA refined the existing design of cotton stalk puller and evaluated it with 10 subjects. The mean heart rate during work was observed to be 125 beats/min and the  $\Delta$ HR values was 41 beats/min. The oxygen consumption rate was 0.535 l/min. Output with this equipment was 0.028 ha/hr. The performance of the refined equipment was better than the original unit and it can be recommended for adoption.

**Groundnut stripper:** The TNAU Centre of AICRP on ESA



refined the existing design of groundnut stripper available at TNAU. It was evaluated with ten women workers and the mean working heart rate was observed to be 93 beats/min and the  $\Delta$ HR as 15 beats/min. In a day one worker can strip about 88 kg of pods and four workers can work simultaneously with this equipment.

**Four-row paddy seeder:** The TNAU Centre evaluated four-row paddy seeder with ten women workers. The mean heart rate of the workers during operation was 139 beats/min and the  $\Delta$ HR being 48 beats/min. Two women are employed in cyclic system for operation of this equipment. After filling the seeds in the drum it takes about 25 minutes to get it emptied. Then the another worker fills the drum with seeds and operate the equipment for 25 minutes, whereas the first operator takes rest. This system helps to enhance comfort of the operator and also in maintaining efficiency of the implement. Output with this equipment was observed to be 0.06 ha/hr.

**Fruit harvester:** The KKV make fruit harvester was refined by TNAU Centre of AICRP on ESA and it was evaluated with ten women workers for sapota harvesting. Mean heart rate during work was 114 beats/min and the  $\Delta$ HR was 35 beats/min. The oxygen consumption rate was observed to be 0.460 l/min. The output with this unit was 420 fruits/hr.

**Sugarcane stripper:** The IISR design of sugarcane stripper was evaluated with 15 men and 15 women workers at OUAT, Bhubaneswar of AICRP on ESA. The mean heart rate during work with this equipment was observed to be 119 beats/min and 116 beats/min for men and women workers, respectively. The corresponding  $\Delta$ HR values were 42 beats/min and 47 beats/min whereas the oxygen consumption rates were 0.57 l/min and 0.51 l/min. The output values per hour were 49 kg/hr for men and 46 kg/hr for women workers.



Ergonomic evaluation of fruit harvester

### Effect of Pearling on Recovery of High Quality Low Fat Degermed Maize

CIAE model grain pearler was evaluated for pearling of maize grain, which facilitates the removal of germ from the kernel and preparation of maize flour and semolina for further development of extruded products. Cleaned and graded maize was initially

conditioned to 22% moisture content (wet basis) and then tempered for 8 hr. Then it is fed to grain pearler for pearling for different durations. The effect of pearling was seen on complete degermed maize recovery. The degermed maize recovery was obtained as 46.6, 74.7, 76.0 and 76.3% for 5, 10, 15 and 20 minutes pearling, respectively. Among the above duration of pearling, 10 minute pearling of maize having 22% moisture content is considered to be optimum duration of pearling giving degermed maize recovery to the tune of 75%. The fat content of degermed maize was found significantly lower, whereas protein content was comparable with whole maize kernel. Ash content of degermed maize kernel was also lower which is desired for the development of low fibre food products from the flour of degermed maize.

### Effect of Pre-milling Treatment on *dal* Recovery

Pigeonpea grains treated with cottonseed oil at different moisture contents (8–12%) were milled to see the effect of pre-milling treatment. 10% moisture content (wb), in the 0.2% cottonseed oil treatment and 12 seconds milling time was found optimum for milling of pigeonpea. Maximum gota recovery of 58% was observed at optimum condition. Milling efficiency at optimum condition was about 89%. A study was conducted to observe the effect of moisture content on per cent pitting of pigeonpea. Moisture content of the pigeonpea varied from 6 to 14%. Pitting of the

- Grain pearler evaluated for pearling of maize grain
- An integrated paddy dryer using biomass, solar and electricity developed
- Finger millet selected for effective combination with soy cereals for preparation of biscuits and extruded convenience ready-to-eat food products
- Vegetarian kabab prepared using soybean tofu, Bengalgram splits in different combinations
- Project profiles on processing of mustard, wheat soy, milk, pulses, spices, cattle feed, fruit and vegetables, and rural godowns drafted
- Arecanut dehusker designed and evaluated. The manual dehusker has been in great demand in Karnataka.

grain was done using CIAE, *dal* mill. The per cent pitting increased up to 10% moisture content and then decreased. Maximum pitting of 80.5% was observed at 10% moisture content (wb) and surface of about 50% grains was cracked during pitting.

### Technology for Processing of Wild Pomegranate for Quality Anardana

Keeping present day demand, technology has been developed at CIPHET, Abohar for processing of wild pomegranate to get anardana with desirable quality parameters. Cabinet cross flow drying at 55 for 7 hr produces the quality anardana with desirable



range of acidity (6.4%), vitamin C as ascorbic acid (15.5 mg/100 g) and red colour (41.71 as L value on hunter Lab colorimeter). The product when packed in 200 gauge LDPE has been found effective in retaining the quality parameters up to one year.

### **Integrated Paddy Dryer**

An integrated paddy dryer (1 tonne capacity) using biomass, solar (30 panels of 1.5 m × 0.9 m) and electricity (10 kW) as sources of heat was developed at CIPHET, Ludhiana. The energy required to dry paddy from 22% to 14% in 6 hr was calculated and collector area was determined. Iron fillings were provided in each panel to store thermal energy during peak hours and release slowly during off sunshine hours. The solar air heaters were evaluated for their performance at no load condition with varying flow rates. The maximum outlet air temperature was 83°C at a flow rate of 2.08 m<sup>3</sup>/min, whereas outlet air temperature was 40°C. The maximum air temperature was observed between 1 and 2 PM. The average flow rates were 1.15, 1.62 and 2.08 m<sup>3</sup>/min with one, two and three blowers running respectively. Drying of paddy from 22.5% to 13.9% moisture content took 6 hr. The fast drying is due to the high solar insulation.

### **Rural Level Production of Potato Chips**

A pedal-operated potato peeler of 1.5 t/day capacity was developed and tested. All food contact parts of the machine have been made of stainless steel to avoid corrosion or any other infection to potato chips. The peeling efficiency of the peeler is above 90%. Estimated cost of the machine is approximately Rs 7,000.

### **Evaluation of Integral Extrusion-Expelling Unit**

As soybean is a low oil bearing material containing only 20% oil and also has a relatively hard seed grain, mechanical expression of oil from soybean requires many passes and pre-treatments. Extrusion-expelling overcomes this and recover almost 70% of oil in a single pass. However it has two separate units, one as extruder and another as expeller causing inconvenience in operation. An integral unit consisting of the feature of both has been developed and evaluated for its performance. The first section of the integral extrusion expelling unit works as extruder, whereas the later half of the unit works as an expeller. The unit is capable of expression of good quality soy oil in single pass without adversely affecting the cake quality. The unit was operated with a die having no restriction at the end as well as with restriction. The experiments were carried out using five levels of feed moisture, three levels of particle size and three levels of rpm. The maximum oil recovery of 72% was achieved using soy grit at 98 rpm in a single pass.

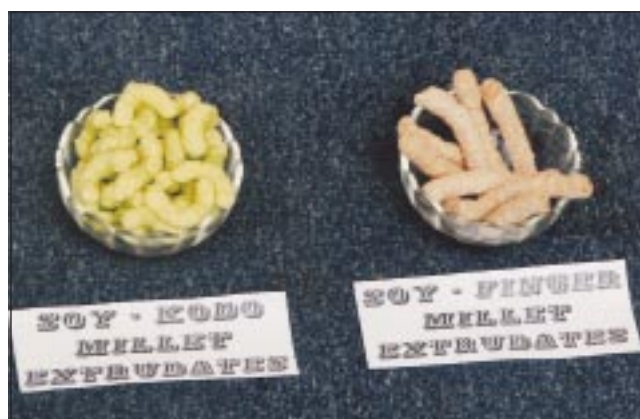
### **Soy-Finger millet Based Biscuit and Extruded Product**

Refined wheat flour, the major ingredients for biscuits was substituted with four levels of finger millet flour in standard SPU

recipe of soy-fortified biscuits. As level of finger millet flour incorporation increased, protein content of the biscuit decreased but the fat content and spread factor increased. Sensory panel assessments for appearance, colour and texture indicated that biscuits containing 80% flour of finger millet and 10% skim milk



Soy-finger millet based biscuits. The process and recipe have been standardized and is ready for commercial application



The extruded products have been prepared by substituting maize with finger millet



Vegetarian kabab has been prepared using soybean tofu and Bengalgram splits in different combinations



### SUCCESS STORY

#### Operational Research Project on Agro Processing Centres

Thirteen agro-processing centres have been established by Bangalore centre of AICRP on Post Harvest Engineering and Technology. In the APCs such as Aradeshahalli, Kuthinagere, Muthanallur and Babygrama, many ragi based food products like ragi malt, ragi roasted flour, ragi papad, ragi biscuit, etc. are being produced and marketed. Packaged ragi flour from APCs has penetrated into the nearby Bangalore city outlets and has been well received and becoming more and more popular. There were many enquiry's from various Self-Help Groups of the region to establish more APCs in their respective areas with PHT Scheme's technical support. PHT Centre of Bangalore has been identified as the nodal centre for conducting a short course on "Post harvest processing and agro-processing centers for value addition in rural areas

powder produced biscuits of acceptable quality and has nutritional value of 10.3% protein. Accordingly the process and recipe for soy-finger millet based biscuits were standardized and is ready for commercial application. The estimated cost of the product is Rs 47/kg product.

Extruded products were prepared by substituting maize with finger millet at three different levels incorporating soy flour at 10% levels in 90 : 10 maize : soy combination and studied the effect on sectional expansion index, longitudinal expansion index and volumetric expansion index, specific length and water-holding capacity decreased. Sectional expansion index decreased, whereas longitudinal expansion index and volumetric expansion index, specific length and water-holding capacity increased. As the level of millet fortification increased, the diameter, moisture content, specific length, water-holding capacity decreased. Incorporation of 10% soyflour and 25% finger millet flour produced extruded products of acceptable quality and had nutritional profile of 11.1% protein. The estimated cost of the product is Rs 35/kg.

#### Tofu-based Vegetarian Kabab

A vegetarian kabab has been prepared using soybean tofu, Bengalgram splits (*dal*) in different combinations, viz. 50 : 50, 60 : 40, 70 : 30 and 80 : 20 with spices. Sensory evaluation revealed that the product prepared with 60:40 (tofu : Bengalgram) ratio was adjudged as the best. Nutritional evaluation of the products indicated that the protein content decreased with increase in proportion of tofu, ranged between 8.87 and 11.19g/100g on fresh weight basis. Crude fat remained almost constant at about 10.2%. The quality of the product was also assured by microbiological evaluation with respect to total bacteria ( $2-4 \times 10^3$ ) yeast and moulds (12-14) per g. The product could be kept safe for 4 days

under refrigeration while at room temperature (about 29-32° and 80-85% RH) it could be kept for one day.

#### Post-harvest Technology for Rural/Micro Entrepreneurs

Project profiles on processing of mustard, wheat, soymilk, pulses, spices, cattle feed, fruit and vegetables and rural godowns have been drafted. The project profiles include information on the raw materials, processed products (mustard oil, wheat flour, ground spices, *dal*, soymilk, cattle feed, pickles, jams, jellies), production of raw material (state wise), market demand, process, quality standards, equipment required, list of equipment manufacturers etc. Financial analysis (total capital investment, annual profit, break even point, benefit : cost ratio, IRR and repayment schedule etc.) for each project has been carried out as per banker's methodology. Custom hiring was also considered while conducting financial analysis on milling of mustard, wheat and spices.

#### Development of Intermediate Moisture Coconut Chips

Modified atmosphere packaging technique for mature fresh coconut kernel has been developed in which the fresh kernel could be stored at 25°C for 6 months. Bottling of the kernel along with filling liquid medium would extend the shelf-life of fresh kernel to 3 months. Bottling of kernel cans could further enhance storage life of fresh kernel. Mature fresh coconut kernel paste with preservative could be bottled for the storage period of the paste to 3 months. The storage life of the fresh kernel paste could be further increased by actual canning of the paste. Vacuum packing in PVC film of thickness 0.0952 mm would extend the storage period of ball copra and cup copra to 4 months. A pilot scale fluidized bed dryer of capacity 200 coconuts per batch for drying fresh coconut kernel has been developed. The dryer mainly consists of a blower, heat distribution system and drying chamber. The agricultural waste furnace was used as heat source.

#### Machinery for Coconut Processing and Optimization of Drying Parameters

**Coconut modified splitting device:** The modified coconut splitting device performance was evaluated and the efficiency was found 514 nuts/hr. The coconut knife bevel angle was standardized as 25° for minimum splitting force of 0.155 N. The nut water drained into a collecting chamber from where it moved into a bucket through a pipe. After splitting the nuts, roll side ways and was collected automatically. The advantage of this device is that any unskilled person could operate with less strain and chances for hand injury are almost eliminated.

**Power-operated de-shelling machine:** The de-shelling machine was modified. The lip angle of the flight was fixed at 70°



## SUCCESS STORY

### Soy-based Cottage Level Enterprises

Simple and low cost technologies have been developed for cottage scale at Soybean Processing and Utilization Centre, CIAE Bhopal. The Centre has also started entrepreneurship development programme for upcoming entrepreneurs in 1995 for production of good quality acceptable soy-based products at cottage scale. The training is imparted on three major topics : soymilk and paneer production, production of fullfat soyflour and soy fortified bakery products, and soy based snack foods.

So far 659 participants have been trained in 64 batches on the above three topics and more than 163 soy- based cottage level enterprises have been set up based on these trainings in Punjab, Haryana, Maharashtra, Madhya Pradesh, Gujrat, Utter Pradesh, etc.

based on preliminary tests conducted, so that the nuts can fall freely from the flight uniformly in the de-shelling chamber. The de-shelling machine was tested for its performance evaluation with partially dried copra having moisture content of 66.4–25.7% db. The optimum average moisture content for de-shelling was 35% db. At 35% (db) moisture content the de-shelling efficiency was 82.5%. The effect of number of rotations on the de-shelling efficiency was explored at moisture content 35% db. Nuts (400 half cups) were loaded manually and the machine was operated.

At 30 rotations the efficiency of the machine was 85.64%, at 40 rotations the efficiency was 92.16% and this further increased to 93.5% by rotating 50 and 60 times. Hence, the optimum number of rotations was fixed as 40. The de-shelling time based on the speed of reduction gear output was four minutes. The relationship existing between moisture content and de-shelling efficiency was non-linear. The cost of de-shelling machine was Rs 27,100. The cost of de-shelling 1,000 nuts was Rs 53/1,000 nuts. The cost involved in de-shelling using human labour was Rs 36/1,000 nuts but the time taken is more than four times as compared to machine.

**Development of copra dryer:** Copra dryer was designed, developed and evaluated to dry coconut in 24 hr. The capacity of the dryer developed was 1,000 nuts per batch. The heating chamber was designed such that smoke does not come into contact with copra. Specially designed rolling in fuel trays were fabricated to hold coconut shell for burning. The burner designed generated heat for 5 hr without tending and the heat is retained for one more hour. The drying air temperature in the drying chamber was 80°C. The quality of copra obtained was light brown in colour. The oil content was 62.48–63.55%, indicate no loss of oil from copra dried at drying air temperature 80°C. The thermal efficiency of dryer at full load was 25.25–26.48% but decreased

when the load was reduced to half to 9.41%. The cost of the dryer was Rs 15,000. The cost of drying one kg copra in the dryer was Rs 5.33. The cost of drying one nut excluding the cost of nut works out to be Re 0.93.

**Commercialization of arecanut dehusser:** The AICRP on PHT, Bangalore Centre has designed and evaluated arecanut dehusser. The equipment was demonstrated through KVK, Hiriyyur to many Swashakthi groups of women. Based on feedback, the outlet of the dehusser was modified for operational convenience.

### Use of Plastics in Paddy Thresher

At VPKAS, Almora polycarbonate sheet were utilized in development of pedal-operated paddy thresher-cum-pearler. The machine was basically designed and developed for hilly region where the weight of the machine is the major concern. The GI sheet replaced by polycarbonate sheet of 1 mm thickness, reduced the total weight of the machine to 40 kg. The total weight reduction was 10% and provided better look. The machine appears to be less noise producing during operation as compared to the metal body. Also it reduced the probability of injury hazards during operation. The plastic body has another advantage of being rust proof. The frame of the machine is made of angle iron and MS pipe. The machine is manually operated by single man/woman. The output capacity of the machine is 80–100 kg/hr and its efficiency was found to be 98%. Its approximate cost is Rs 3,500.

### Plastic Mulch Laying Machine

The trials of machine were conducted at CIAE Farm and at IIVR, Varanasi on 0.3 ha using white colour plastic sheet of 25 micron thickness. Plastic sheets from 5 to 30 micron thickness and up to 1,500 mm width could be used on the machine. CIAE,



Plastic mulch laying machine. Plastic sheets from 5 to 30 micron thickness and up to 1,500 mm width can be used on the machine



Bhopal Centre of AICRP on FIM conducted feasibility testing of plastic mulch laying machine in 0.2 ha for groundnut crop with 1,100 mm mulch width. The machine was set for 800 mm plastic mulch bed. Sowing on the plastic mulch beds was performed manually at 200 mm row and plant spacing. The field capacity and field efficiency of the machine were 0.16 ha/hr and 58.7%, respectively. The labour requirement was 12.5 man-hr/ha with the use of machine as compared to 278 man-hr/ha in manual mulching practice. The cost of operation was Rs 1,544/ha in comparison to Rs 3,336/ha in conventional practice.

### **Live Fish Transportation System**

A cycle rickshaw based system developed at CIPHET, Ludhiana was used for live fish transportation. An insulated box having outer size of length 135 mm, height 860 mm and width 840 mm was fabricated with double wall mild steel iron sheet. Thermo-coal insulation was provided between the iron walls. This box is mounted on the standard cycle rickshaw. The box can hold 8 numbers of plastic crates of size 540 × 360 × 295 mm in two layers of four crates each. The total capacity of icebox is 150 kg of fish with 80% filling of each plastic crate and 1:1 ratio of ice and fish. This was evaluated with the freshwater fish (Catla). The ice and fish is arranged in alternate layer. The top and bottom layer is filled by ice.

### **Drying of Onion and Chilli in Greenhouse**

A study on application of greenhouse for drying onion slices has been conducted at CIPHET, Abohar. The overall acceptability was found better in the samples pretreated with 0.3% KMS, followed by 0.5% NaCl and control. The slices dried in forced ventilated polyhouse gave better acceptability with better rehydration ratio, followed by slices dried in low cost polyhouse with chimney and open sun-drying.

Drying of chilli in polyhouse was studied at PAU, Ludhiana and it was found that the total drying time for the drying of chillies in green house and open air drying was 8–9 days and 9–11 days, respectively which was 1–2 days less than the open air drying to attain the moisture content equal to the moisture content of the green house dried chillies. Moreover the dust and other impurities had to be sieved in open air drying before use which took extra time and labour. The relative humidity and the temperature followed the exponential trend. The capsaicin content of the green house dried chillies was higher by 10% than the open air-dried chillies.

### **Packaging Fruits and Vegetables**

Studies on packaging of selected fruits and vegetables was conducted at CIPHET, Abohar and it was found that: Shrink

wrapping of kinnow fruit drastically reduced the weight loss as compared to unwrapped fruits. Acidity and ascorbic acid decreased while total soluble solids increased during storage. Changes in biochemical composition were almost inconsistent for different plastic films. However, plastic film (LDPE) with least thickness (20 and 25  $\mu$ m) was found to be worthwhile proposition for individual shrink wrapping of kinnow fruit due to their delaying effect on fruit deterioration. The results indicated that shrink wrapped fruit stored at low temperature could be kept up to ten weeks as against four weeks at ambient condition.

### **Fish Feeders**

At CIFA, Bhubaneswar, three demand fish feeders, each of capacity 30 l (13 kg feed) were installed in three different silos with 3, 6 and 9 m<sup>3</sup> water volumes and 0.8, 1.6 and 2.4 m water depths, respectively during December 2004. In other three similar silos the fish feeding was done by feeding trays and they were treated as controls. The efficiency of demand feeders was found better in comparison to control in different silos irrespective of depth.

### **Soil Solarization for Weed Control**

An experiment on soil solarization for weed control in brinjal nursery was carried out at PAU, Ludhiana and it was found that maximal soil temperature at a depth of 5 cm reached nearly 60°C under polyethylene covered plots, whereas it was only 51°C in the uncovered plots. There was large increase in temperature in the upper soil layer (5 cm) under polyethylene with increase of 8–10°C in maximal soil temperature compared with unmulched soil. The maximal temperature lasted for 2–3 hr. The number of days when the maximum soil temperature equalled or exceeded 50, 55 or 60°C under different treatments was also observed. Solarization reduced total dry matter accumulation and density of weeds at 15, 30 and 45 days after the PE films had been removed. Weed dry matter accumulation was reduced from 241.1 g/m<sup>2</sup> in control plots to 10.4 g/m<sup>2</sup> in solarized soil for 45 days.

***Performance evaluation of modified double roller gin:*** The improved double roller gin developed is sturdy and operator friendly. It consumes 30% less energy than conventional machine.

***Evaluation trials on stick machine and saw band cleaner:*** A stick machine and saw cylinder cleaner designed and developed at CIRCOT, Mumbai were evaluated for their performance with four mechanically picked cotton varieties, viz. CNH 120 MB, GSH 2, CNH 123 and PKV 081. It was noted that the cleaning system could effectively improve the grade of the lint and there was no deleterious effect on fibre attributes.



**Burning behaviour of cotton bales:** Studies on burning behaviour of cotton bales were carried out for M/s. New India Assurance Co. Ltd. The study revealed that a single bale when set on fire took only 27 hr to turn to ashes completely. The hoops remained more or less intact. Addition of inflammable material like diesel initially to sustain the fire did not reduce the time of gutting. Attempts to partially quench the fire decreased the time of gutting substantially. The fire propagates very fast in loose cotton mass along the edges of the bale.

**Effect of different mordants on dyeing of polyester-cotton blended fabrics with natural dyes:** In a small-scale trial, about 7 m of mercerized heatset polyester:cotton blended fabric was mordanted with alum and dyed with manjishtha. For mordanting, a winch was used and dyeing was carried out on jet-dyeing machine. The dyebath exhaustion from this dyeing was 50%. The exhausted dyebath was reused to dye cotton fabric. Final exhaustion value of dyebath was 56%. The dyed fabric retained the colour even after 15 washing.

**Commercial testing:** During this year approximately 6,500 cotton fibre sample were tested for quality evaluation and an amount of Rs 21,37,162 alone was received as test fees.

**Electronic fibre bundle strength tester:** Manually-operated jute fibre bundle strength testing instrument, designed and developed by NIRJAFT has been in use for more than three decades. The instrument results in about 5% error in addition to the human errors involved in operation. The current electronic instrument is a newly developed precision instrument for automatic operation and recording of data digitally which will completely remove the human error. Moreover, as the instrument is totally portable, it can be used in fields as well. The results can be stored automatically in built-in memory of the instrument which can be downloaded in laboratory with PC interface. This instrument is



Electronic fibre bundle strength tester is a manually-operated device developed by NIRJAFT

useful to jute mills, research and testing organizations, educational institutions and jute promoting agencies.

This instrument is available in four models having different features in the price range of Rs 20,000–65,000.

**Particle board from date-palm leaves – a viable substitute of wood/plywood products:** Date-palm leaves are suitable for making particle boards having physico-mechanical properties, viz. impact strength, tensile strength, flexural rigidity etc. and swelling properties in water at par or even better when compared with jute stick particle boards. Incorporation of filter in the form of mill waste and agricultural byproducts with thermosetting resin further improves the interfacial bond leading to better mechanical properties of the boards. Moisture content of date-palm leaf (DPL) is low and no additional chemical reagents are required to block the hydroxyl and other oxygen containing groups that attract moisture. The dimensional stability of the boards are well maintained in a wide range of atmospheric conditions. These boards can well be used in making door/window panels, book shelf, false ceiling, table top, tea-table and packaging boxes for packing fruits tea etc. Cost of DPL board will be about 50% less compared to wood/plywood products available in the market.

**Molecular characterization of lac insect lines:** DNA isolation protocol has been standardized for single mature female lac insect. PCR conditions for screening of primers and RAPD studies were optimized. Preliminary screening of 20 lac insect lines using 8 random primers yielding positive amplicons showed that this technique would be useful for molecular characterization of lac insects at both intra- and inter-specific levels.



Hand-operated lac grader



Hand-operated lac winnower for village level processing



**Melting profiles of waxes from seedlac of different lac producing countries:** The melting profiles of waxes isolated from seedlac of Indian, Thai and Chinese origin were studied by differential scanning calorimetry. The Thai lac wax contained a major fraction with high melting temperature (98°C) as compared to others. The waxes extracted from seedlac of all the three countries contained two common wax fractions with similar melting temperatures (around 49 and 72°C).

**Biological control of lepidopterous lac insect predators:** Two lepidopterous predators namely, *Eublemma amabilis* and *Pseudohypatopa pulvereana* cause considerable damage (30–40%) to lac crop. *Bacillus thuringiensis* (0.05%) was found at par with endosulfan (conventional insecticide) for control of the lepidopterous predators (60–70%) of lac insect.

**Integration of horticulture with lac culture for higher income:** Continuous cropping of okra, garlic and bitter gourd was done during *kharif*, *rabi* and *zaid* seasons in the inter row spaces of *Flemingia semialata* planted at single paired rows. Significantly higher lac yields were obtained under this system as compared to *F. semialata* without integration. The yield of broodlac and sticklac were 40.7 and 12.2 q/ha, respectively, which were higher by 84.4 and 87.7%, respectively, as compared to control (without vegetable crops).

**Changes in industrial parameters of lac on storage:** During conversion of seedlac (semi-refined lac) to shellac (refined lac), oxalic acid is sometimes added by the lac industry to improve the gloss. This results in marked decrease in the flow values (fluidity) of shellac with storage. It reduces to zero within 30 months of storage due to polymerization rendering it unsuitable for industrial use. Both seedlac and shellac absorb moisture from the environment under high humid condition. Treatment with suitable antioxidant has been found to reduce this phenomenon. Storage in polybag can also be employed to minimize moisture absorption.

**Gender friendly motor-operated lac grader and lac winnower for village level processing:** Primary processing of lac involves five major operations namely, crushing, washing, drying, winnowing and grading. Motor-operated lac grader and lac winnower have been developed for value-addition to lac at village level. The capacity of the lac grader and the lac winnower are 60 kg/hr and 500 kg/hr. The machines designed are gender friendly and will be useful in reducing drudgery and improve the efficiency.

## Animal Energy

**Portable electronic weighing machine for animals:** The portable platform type electronic weighing machine of 1,800



Portable electronic weighing machine for animals has the capacity of 1,500 kg (least count 1%)

mm × 1,200 mm platform pan has the capacity of 1,500 kg (least count 1%) and has provision of 12V battery and inverter for operation of scale in absence of AC power. Side and front railing have been provided on the system for control of movement of animal on the machine. Weighing system is very compact and could be dismantled and transported easily on a jeep trailer. The system is ready for field use/commercialization.

**Animal rotary mode set up:** To increase utilization of animals, the chaff cutter, winnower, castor/groundnut decorticator, dal mill, rice thresher were installed in villages and operated by



Animal rotary mode set up in operation

animals in rotary mode of operation. Six units of rotary mode set up were installed in villages to run the agricultural equipment. With rotary mode of operations, the animals could be used for 28.6% more than the average annual use of 800 hr. It also resulted in saving in fuel and electricity.

## Renewable Sources of Energy

**Dewatering machine for digested slurry from biogas plants:** Palampur Centre of AICRP on RES has developed a



perforated rotating drum type slurry dewatering machine which suits 85 m<sup>3</sup> capacity biogas plants. The machine comprises slurry handling and power transmission assemblies. The filtered water is collected and drained on one side of the machine through a channel. The dewatered slurry moves downward inside the cylinder and is discharged at the lower end. The performance was found best for 4.0° inclination and 108 rpm of the cylinder and around 4,800 litres/hr slurry flow rate. The average initial total solids concentration (TSC) in the input slurry was 6.5%. The TSC of the dewatered slurry was 10.5–11% and that of the filtered water 2.4–2.5%. The dewatered slurry may be sun-dried for about a week and transported to fields for use as manure. The filtered water may be used for preparing fresh cattle dung slurry for feeding into the biogas plant. Normally around 4,000 litres of the digested slurry is discharged everyday from a 85 m<sup>3</sup> capacity biogas plant. As such the machine may suit a battery of 4–6 biogas plants of 85 m<sup>3</sup> capacity each.

**Pilot plant for anaerobic digestion of rice straw:** SPRERI, Vallabh Vidyannagar Centre of AICRP on RES has developed and evaluated a pilot plant for anaerobic digestion of paddy straw in thermophilic temperature range. The pilot plant consists of six batch type insulated and externally heated reactors, a gas storage unit, a water heating system and necessary pump, piping, etc. The technology offers a promising alternative to large-scale burning of paddy straw in northern, western and central India and will have advantages of converting paddy straw to convenient source of energy and valuable organic matter for use as manure and avoiding serious air pollution.

**Durable biomass cook stoves for hilly terrains:** MPUAT, Udaipur Centre of the AICRP on RES Scheme modified the designs of single pot “Chetak” and double pot “Udairaj” cook stoves on the basis of initial multilocation trials. Costs of construction for the Chetak and Udairaj stoves have been estimated to be Rs 190 and 250, respectively. The two stoves have been evaluated and average thermal efficiencies for 1 kg/hr fuel wood burning rate have been reported as 22% for the single pot Chetak stove and 26% for the double pot Udairaj stove.

**High rate anaerobic treatment system for sago industry effluent:** A 10 m<sup>3</sup> capacity high rate biomethanation system for treatment of effluent was installed in a sago factory located in Erode district of Tamil Nadu. The system has been commissioned and is under operation with 1 day hydraulic retention period. The reactor operated for 130 days during the peak season, i.e. March–July, 2005 and for 30 days during off season i.e. July–August, 2005. Around 7,000 litres/day of effluent having COD in the range of 4,900–5,300 mg/litre was treated in the reactor and average biogas yield of 9.2 m<sup>3</sup>/day was obtained. Methane content of the biogas was 74.5%. The average reductions in total solids, volatile

solids, BOD and COD have been reported to be 80.2%, 71.6%, 89.4% and 84.6%, respectively. The sago factories in the region normally produce around 25,000 litres of effluent everyday. A full capacity high rate reactor may produce 35–40 m<sup>3</sup> of biogas everyday which may replace around 50% of the fuelwood requirements of the factory. The fuelwood is used for drying of sago granules.

**Use of ethanol as diesel engine fuel:** Emulsifications of ethanol-diesel fuel blend using 1-butanol as surfactant carried out by GBPUAT, Pantnagar Centre of AICRP on RES have shown profound stability even at lower ambient temperature. The micro-emulsions of diesel fuel with anhydrous (200° proof) and aqueous (195°, 190°, 185°, 180° and 170° proof) ethanol using 1-butanol as surfactant were prepared by splash blending the constituents in different proportions at room temperature (29–34°C). All emulsified fuels, except those prepared with 170° proof ethanol, were found clear and transparent with no sign of phase separation under wide temperature regime of 0–45°C. Various micro-emulsions were found stable during 3 months long duration stability test with respect to temperature, change in viscosity, sedimentation, phase separation, foaming and pH value. A 3.73 kW Kirloskar make stationary constant speed single cylinder compression ignition engine having standard injection timing was tested as per IS : 1000 [P:8] : 1980 using high speed diesel fuel and various micro-emulsion fuels. Of all the fuels tested, diesel – 180° proof ethanol – 1 butanol emulsified in 100 : 11 : 35 parts by volume was found the best with the possibility of substituting about 31% diesel with alcohols.

**Fixed dome modified biogas plant suitable for black cotton soil region:** The design of conventional fixed dome Janta biogas plant 2 m<sup>3</sup> was modified for adoptability in black cotton soil areas by structural improvement through use of 5 piles (20 cm diameter) up to soil depth of 3 m to form pile cap to bear the load on soil of biogas plant. The gap between the plant wall and earth were filled with stone dust to minimize the effect of soil shrinkage/swelling on the plant structure. After evaluation at CIAE Bhopal, 5 units were installed in villages at users’ site on cost sharing mode. After stabilization, the plants were charged with fresh cow dung without addition of water for influent preparation. On an average, a saving of 10–20 litres of water/day/m<sup>3</sup> of plant has been possible. Use of biogas for cooking has resulted into average saving of 1,000 kg of fuelwood/year/family.

**Family size fixed dome type biogas plants for solid-state feeding of cattle dung:** These were installed at 25 more selected rural houses located in Tamil Nadu, Karnataka, Madhya Pradesh, Assam, Punjab and Maharashtra. Compared to the common design, these plants require 80–100% less water for operation, produce up to 30% more gas, cost almost the same and



make feeding and handling of the digested slurry far more easier. The space required for drying of the digested slurry is also reduced by one-fourth.

**Walk-in type solar tunnel dryer:** It was developed by MPUAT, Udaipur Centre and has recently been adopted for drying goose berry pulp and hand made paper sheets. A 3.75 m × 21.00 m size solar tunnel dryer has been installed on a goose berry farm



Walk-in type solar tunnel dryer installed in a farm for drying goose berry pulp

in Banswara district of Rajasthan at a total cost of Rs 60,000. One ton of goose berry pulp (obtained from 1.5 tonnes of fresh fruits) loaded in the tunnel dryer at a moisture content of around 89% got dried to a moisture content of around 9% in 1–2 days depending upon ambient conditions. The cost of drying goose berry pulp in the solar tunnel dryer was lower by more than 50% as compared to electrically heated drying system.

**Open core down draught gasifier:** For thermal applications, developed by SPRERI, Vallabh Vidyanagar Centre of the project, with a fuel burning capacity of up to 100 kg/hr has been installed in an industry in Khaira district of Gujarat to replace conventional



Open core biomass gasifier installed in an industry for chicory roasting

wood fired system for chicory roasting. The average biomass consumption of the gasifier was found 60 kg/hr and conversion efficiency was 68%. The working space in the conventional wood fired system had higher levels of carbon monoxide and nitrogen oxides as compared to producer gas based roasting system. The quality of end product (roasted chicory) in the gasifier system was found far superior to the wood fired system primarily because of uniform heating and better temperature control. The payback period for the gasifier system is estimated to be 22 months.

### Micro Irrigation System

A low cost equipment for nutrient management through micro irrigation system was developed at PAU, Ludhiana. Four different thicknesses of orifice meter were developed for fertigation in drip irrigation system. Orifice meters are working on the Bernolouii's principle. The different thicknesses of orifice meters were 1, 0.75, 0.50 and 0.25 inch having orifice diameter 3.175 mm (1/8 inch) with fertilizer inlet of 1.588 mm (1/16 inch). The suction rates of all the orifice meter were measured with normal irrigation water under a range of operating pressures. The suction rate of water soluble fertilizer varied from 40 lph to 7.5 lph.

### Development of Screen Filter

At CIPHET, Abohar the screen filter was designed for a low capacity and is sufficient for micro irrigation system in greenhouse. The 75 mm and 50 mm PVC pipe were used for fabricating the filter. The 50 mm PVC pipe was used as an inlet pipe and 75 mm PVC pipe was used as a casing for the filter. The 50 mm PVC pipe of 40 cm length was used as a filtering house for the filter. The circular holes were made at equal spacing on 50 mm PVC pipe and it covered with the nylon net of 80 mesh. After preliminary testing, the filter was modified with arrangement of back wash assembly system and fabricating it with 90 mm and 50 mm PVC pipe. The 90 mm PVC pipe acts as a casing and 50 mm PVC pipe acts as a filtering house of the filter. The back wash assembly helps in cleaning of the filter without detaching the filter unit from main line. It also removes the particles deposited in the filter unit time to time and thus improves the filtration efficiency. The filter was tested in the field for effect of sand silt concentrations on removal efficiency and effect of pressures on removal efficiency of the filter. The filter unit was also tested.

### Drainage Technology to Enhance Productivity of Soybean and Sequential Crop of Chickpea in Vertisols

Field experiments were conducted at CIAE, Bhopal consecutively for the last four years in Vertisols to study the effect of drainage on soybean variety (JS 335). Recommended doses of NPK @ 20,



50 and 20 kg/ha and standard recommended cultivation practices of mechanized farming were used. Surface drains having bottom width of 30 cm, depth 45 cm and top width 90–120 cm with 0.20–0.35% bed gradient and side slope of 1: 1 were laid out using tractor-drawn ditcher. Sub-surface drainage(SSD) system was laid on one ha area with 72/80 mm corrugated and perforated PVC pipes at 20 m spacing at 1m depth. Crop condition before and after installation of SSD clearly indicated advantages of drainage system.

Surface drainage system and sub-surface drainage resulted in 35–40% and 50–54% increase in yield of soybean crop, respectively over control. Yield of subsequent crop of chickpea (JG 315) was also increased by 15% over control. Cost of forming surface drainage with tractor-drawn ditcher is Rs 450–500/ha and for sub-surface drainage with PVC pipe is Rs 35,000/ha. The pay back period for surface drainage is less than one year and that for sub-surface drainage is six years. The benefit : cost ratio of cultivating soybean with surface drainage system was 1.77. The B/C ratio of soybean cultivation with and without SSD systems in low-lying vertisols was found to be 1.36 and 0.42, respectively. Surface drains at 15–20 m spacing with 0.45 m depth and sub-surface drains at 20 m spacing with 1.0 m depth are found to be effective for draining excess water in soybean crop.

### Feasibility of Mole Drainage in Vertisols

Mole drains are unlined cylindrical channels formed in sub-soil, which function like clay or plastic drain pipes. A tractor-drawn mole plough was designed and evaluated at CIAE, Bhopal. Mole drains were formed at a depth of 60 cm with 60 m lateral length with 75 hp tractor using mole plough in an experimental area of 0.3 ha, at three spacings (2, 4 and 6 m) and 4 replications leaving 6 m buffer strip and control plot of 0.5 ha. After installation, short lengths (1.0 m) of perforated PVC pipe of 110 mm diameter was inserted in each mole channel outlet to prevent the collapse of outlet. The mole drain outlet was then



A low-cost screen filter, sufficient for micro-irrigation system in greenhouse

connected with a PVC sub-main in each spacing and the sub-main in turn was connected to a sump to monitor the drain performance. To enhance the productivity of soybean in Vertisols the mole drainage technology is inexpensive, effective, technically feasible and economically viable.

### Technology for Water Harvesting and Recycling for Sustainable Agriculture

For sustainable agriculture water harvesting ponds and recycling of water in *kharif* and in *rabi* is necessary. The blackish clayed soils of CIAE Farm being hard rock area, availability of underground water is very less. Considering topography three dugout ponds of 2.5, 5.5 and 14 ha-m capacities were constructed on 1.3, 2.0, and 6.0 ha area, respectively with total capacity of 2.2 lakh cubic metre to irrigate 45 ha command area including 10 ha under drip irrigation. All water resources; openwells, tubewells and ponds were connected through underground HDPE pipeline grid with hydrants at 66 m to facilitate irrigation and ground water recharge. Studies revealed that water-harvesting pond can be constructed in 10–12 of watershed area with 3 m depth. The minimum run-off received is about 300 mm to fill up the pond every year. About 60–70% of stored water can be utilized for irrigating crops. Entire *kharif* and 50% of *rabi* crop can be irrigated twice with two-fold increase in yield. Excess run-off water during rainy season may be utilized for ground water recharging, 0.2–0.65 ha-m/ha excess over 0.3 ha-m/ha is available in 4 or 5 years. Water harvesting and recycling of stored water is technically feasible and economically viable (benefit : cost 1.3–2.0).

### Low Friction Foot Valve for Water Pumping Systems

Commercially available foot valve used in water pumping systems was improved upon through material substitution and modifications in the strainer. While the material of construction was changed to polypropylene, the strainer opening area was increased to three times that of the cross-section of suction pipe. The ratio of flap opening area to the cross-section of suction pipe was 1.3 and the flat of the strainer bottom changed to an S shaped curve. In the process of these modifications the mass of the foot valve was reduced to 1.6 kg. The performance of this improved low friction foot valve (LFFV) was evaluated along with the commercially available one as per IS : 10805-1986 on the computerized test set-up. The friction co-efficient of the LFFV was found to be 0.76. While the functional head loss went down, there was an increase in the discharge rate. Energy efficiency of LFFV is estimated to be twice that of commercial one and it has a potential to increase the pumping system efficiency by 2.3%. Economic analysis, based on mass manufacture of LFFV, indicates a payback period of about three years.

### CIAE Technologies Demonstrated in Sikkim

CIAE in collaboration with ICAR Complex for NEH Region, Gangtok and Directorate of Food Security and Agriculture of



### Trainings

- Cotton quality evaluation and specialized training in HVI and AFIS at CIRCOT, Mumbai
- Training on ginning at GTC, Nagpur.
- Trainings on gasket shellac cement compound and lac processing and scientific methods of lac production at ILRI, Ranchi.
- Small equipment and technology for production and value-addition of horticultural and other crops of hill region and entrepreneurship development.
- Krishi Vigyan Kendra of CIAE, Bhopal, organized 54 vocational training programmes for improving cultural practices, vocational skill and standard of rural people. The Centre also organized 45 sponsored training programmes (sponsored by NATP, IFFCO, Department of Agriculture, Government of Madhya Pradesh).
- Agricultural graduates from Madhya Pradesh were trained for establishing agri-clinic or agri-business for self-employment opportunities. After the training the graduates are eligible to get individual loan of up to Rs 10 lakh or up to Rs 50 lakh as a group for setting up of agri-clinic or agri-business through NABARD. The third batch of the training programme organized during 22 November 2004 – 20 January 2005 was participated by 32 agricultural graduates.
- A training programme on processing of agro produce including soybean processing and utilization, from village Amajhir (Dist. Sehore) in collaboration with SEWA, Sehore.

Sikkim organized a two-day interaction meeting-cum-demonstration of improved agricultural implements/processing equipment at Gangtok during June 2–3, 2005. CIAE product catalogue, leaflets and other extension literature were distributed among the farmers and delegates during the demonstrations.

### Frontline Demonstration

Frontline demonstration of improved agricultural machinery was taken up under four centrally sponsored (DAC) programmes. FLD of improved agricultural machinery for major oilseed crops was operated through 37 centres (KVKs) for training and demonstration of improved agricultural machinery. Under the programme, 14 manual, animal- and tractor-operated improved agricultural equipments were taken up for demonstration at each centre. These equipments contributed 10–70% saving in time and 20–90% saving in labour apart from contributing towards higher crop productivity.

Frontline demonstration for major pulse crops was operated through 38 centres (KVKs and centres of AICRP on FIM) for

training and demonstration of improved agricultural machinery. Under the programme, 15 manual, animal- and tractor-drawn equipment were taken up for demonstration at each centre. These equipment contributed 12–60% saving in time and 15–65% saving in labour apart from contributing towards higher crop productivity.

Frontline demonstration of zero till seed-cum-fertilizer drill, strip till seed-cum-fertilizer drill and raised bed planter was taken up in 24 centres in Assam, Bihar, Chhattisgarh, Haryana, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Punjab, Rajasthan, Uttar Pradesh, Uttaranchal and West Bengal. A total of 245 zero till drills with target area of 2,000 ha and 30 nos of raised bed planters with target area of 300 ha were provided to the participating centres.

Frontline demonstration of improved rice wheat equipment with 15 centres in Andhra Pradesh, Assam, Chhattisgarh, Haryana, Jharkhand, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Tamil Nadu, Uttaranchal, Uttar Pradesh, Bihar and West Bengal was taken up.

### E-Directory of Farm Machinery Manufacturers

A Directory of Agricultural Machinery and Manufacturers, containing information on machinery for various production and post-production operations in agriculture was published. The E-Directory contains all relevant information regarding the availability of various implements and post-harvest equipment in a computer readable format. It also covers many of the renewable energy technologies available in the country for the use of average farmer/farming community. Information on each item contains a brief description, broad specifications, its uses and power source requirement. At the end of each item, the source of availability in the form of postal address of the manufacturer has been provided.

### Commercialization of Manually-operated Paddy Seeder

A light weight paddy seeder was developed and evaluated for its mechanical and ergonomical performance and was found very useful. As there was a lot of demand for this equipment in southern states, commercial launching of this equipment was done in the name of “TNAU-Maharasi direct paddy seeder” in Tamil Nadu and “Raidco-Aiswarya” in Kerala. M/s. KSNM Marketing, Coimbatore is authorized by the university for manufacture and sale of the unit in Tamil Nadu. The Regional Agro Industrial Development Co-operative of Kerala (RAIDCO) is marketing this seeder in Kerala. More than 1,000 units of this seeder have been sold by these manufacturers to the farmers.