Agricultural Engineering and Technology

FARM IMPLEMENTS AND MACHINERY

Tractor-operated Machinery

Lug-wheel puddler: A tractor-mounted, lug-wheel puddler of 1880-mm width has been developed for the shallow-tilled saturated soils. Its preliminary tests have indicated its average operation speed of 2.1 km/hr and depth of operation at 126 mm, and its effective field capacity is 0.32 ha/hr and field efficiency is 80%. It cost of operation has been Rs 192/hr, including that of tractor (Rs 185/hr).

- Developed a tractor-mounted, lug-wheel puddler for shallow-tilled saturated soils and a seven-row, tractor-operated till-plant machine.
- Transplanting tomatoes with 2-row vegetable transplanter costs Rs 2,050/ha for 300 hr of annual use; this through manual method costs Rs 2,400/ha.
- Multicrop planter designed and developed by incorporating salient features of the animal-drawn Jyoti multicrop planter.
- Developed and commercialized a flail-type mower-cum-chopper for fodder harvesting. This costs Rs 17,000.

Tractor-operated Machinery

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1. Tractor-operated lug-wheel puddler. This is for the shallow tilled saturated soils. Its effective field capacity is 0.32 ha/hr and its field efficiency is 80%.
2. Seven-row till-plant machine. This machine has showed better timeliness of sowing operation, reduced fuel consumption and reduced cost of operation and its performance is comparable to conventional crop establishment operations.
3. Pneumatic planter for vegetables. Tractor-operated this planter costs Rs 40,000 and cost of planting by this is Rs 265/hr.
4. Zero till seed-cum-fertilizer drill. This machine could give effective field capacity of 0.33 ha/hr at forward speed of 3.2 km/hr.
5. MPKV multicrop planter. This tractor-mounted, multicrop planter suitable for groundnut, sunflower, chickpea and wheat has been designed and developed by incorporating salient features of animal-drawn Jyoti multicrop planter. The initial cost of the machine is Rs 15,000.
6. Flail-type forage harvester-cum-chopper. This machine has been commercialized. In this, a single operation can harvest crop and load chopped fodders like maize, *bajra*, oats in the trailer attached behind the machine.
7. Baler. Its effective field capacity has been found 0.82 ha/hr at the field efficiency of 87.2%.

SUCCESS STORY

Tractor-mounted hydraulically-controlled wetland leveller

It consists of a frame to attach it to a 3-point linkage system of a 35-hp tractor. A swinging blade is fixed at the bottom of the frame. This blade is fixed with a hydraulic cylinder, which in turn is connected to auxiliary hydraulic system of the tractor. With this arrangement, tractor-driver from his seat itself can operate blade by moving the auxiliary hydraulic system control lever. The blade can be moved to any angle from 0° to 90° to horizontal angle. This arrangement facilitates to operate blade in a vertical position to move soil from the upper side to lower side. For smooth levelling of field, the blade is made nearly horizontal. During field operation, blade (3.2-m wide) covers entire width of tractor, including cage-wheels.

Levelling need to be done within 36 hours after last puddling. At puddling, 3-5 cm of water should be maintained in the field and blade should be kept nearly vertical in the first operation, moving soil from the higher level to lower level. During second operation blade should be kept nearly horizontal for getting smooth levelled surface.

The unit has been tested and found satisfactory for shallow puddling. The weight of the puddler is 220 kg and its cost is Rs 8,500.

Seven-row till-plant machine: A seven-row, tractor-operated till-plant machine has been developed and was field evaluated in *kharif* and *rabi* 2002-03 for sowing soybean and chickpea. Its performance has been compared with the conventional practice of crop establishment, i.e. tillage by tractor-operated, five-row duck-foot cultivator, followed by seeding by tractor-operated seed-cum-fertilizer drill. This new machine has showed better timeliness of sowing operation, with reduced fuel consumption and reduced cost of operation, and yields under 2 systems were comparable.

Pneumatic planter for vegetables: Tractor-operated pneumatic vegetable planter has been found with the field capacity 0.5ha/hr and field efficiency of 72.5% for peas (Arkil variety) in farmers' fields. About 90% of the seeds were within ±5 cm of the desired spacing of 20 cm. Seed rate of 50 kg/ha with this was 15-20% lower than the rate usually used by farmers. Its cost is Rs 40,000, and cost of planting by this is Rs 265/hr.

Two-row vegetable transplanter: A tractor-mounted, 2-row vegetable transplanter developed at the CIAE, Bhopal, has been tested for transplanting tomato, cabbage, cauliflower and brinjal seedlings in the farmers' fields in 3.15 hectares. Its field capacity has been found at 0.10 ha/hr with the field efficiency of 65-75 %. And cost of machine is estimated at Rs 26,500. With the manual method, 30 man-days per hectare are required for transplanting tomato at 60-cm row-to-row spacing and 45-cm plant-to-plant spacing. The operation cost of the transplanter for tomatoes comes to Rs 2,050 per hectare for 300 hr of annual use, and for manual method, it is 2,400/ha.

Zero-till seed-cum-fertilizer drill: Trials on tractor-mounted, zero-till seed-cum-fertilizer drill were conducted for sowing wheat, covering 20.5 hectares at 14 farmers' fields in Allahabad (Bastar, Kabara, Birpur and Panasa) and Pratapgarh districts. The machine gave an effective field capacity of 0.33 ha/hr at the forward speed of 3.2 km/hr. During trials, average soil moisture content (wb) was 23.9% and number of weeds were 10/sqm. The average depth of sowing and field efficiency were 580 mm and 63.4%.

MPKV multicrop planter: The tractor-mounted, multi-crop planter has been designed and developed by incorporating salient features of animal-drawn Jyoti multicrop planter. This is suitable for groundnut, sunflower, chickpea, soybean, *jowar* and wheat. A plate in vertical plane with cells on its periphery is used for metering seeds for each row. A fluted roller is used for metering granular fertilizers. Depending upon the crop, number of rows can be adjusted from 5 to 9. Furrow openers are spear-head type. Drive for metering mechanism is through a ground-wheel. The machine is mounted on a 3-point linkage system of the tractor of 35-hp or above. The initial cost of the machine is Rs 15,000.

UAS, Raichur centre, could carry out prototype feasibility testing of this for sowing mungbean. Its field capacity has been found 0.42 ha/hr with a field efficiency of 59%, and the germination percentage of the crop was 89%.

Strip till drill: Demonstrations on tractor-operated, strip till-drill for sowing wheat (PBW 343) were conducted in Semara, Birpur, Mugari and Ghoredeeh villages, covering a total of 7.7 hectares. At soil depth of 540-mm and soil-moisture content (wb) of 21.3 %, machine could give effective field capacity of 0.34 ha/hr, corresponding to the forward speed of 3.4 km/hr. In the delayed sowing, farmers could combine operations of tillage and sowing in a single pass by this machine.

Semiautomatic potato planter: It consists of a belt-cup-type of metering mechanism with 37 cups, spaced at 60 mm. The holes are provided on the frame for changing ridgers. Its hopper capacity is 140 kg. Machine's overall dimensions are 1.98 m × 1.83 m × 1.18 and its weight is 250 kg. With this, seed spacing can be changed by changing sprockets provided with the ground-wheel. Machine can be operated with 30-hp tractor. The CCSHAU Hisar centre had conducted trials on the planter, covering 6.2 hectares in Bhatala and Lalpura villages. The seed rate for potato (variety 222) was 3,000 kg/ha and no. of plants per 5-m length were 32.6.

Bed planting of wheat: This machine for bed planting consists of a drive-wheel, fluted, roller-type seed mechanism and shoe-type furrow openers and furrowers for making bed. Its overall dimensions are 2,080 mm × 1,870 mm × 1,350 mm and can be operated with a 35-hp

tractor. The machine has cup-feed-type fertilizer metering mechanism. It weight is 270 kg. The unit cost of the machine is Rs 17,000.

Flail-type forage harvester-cum-chopper: A flail-type, mower-cum-chopper for fodder-crop harvesting has been developed and commercialized. This in a single operation can harvest, chop and load chopped fodders like maize, *bajra*, oats in the trailer attached behind the machine. The machine consists of a rotary shaft mounted with blades to harvest crop, an auger for conveying cut crop, and cutters for chopping and conveying chopped fodder through outlet on to trailer. The blades on the rotary shaft are staggered in 3 rows of 13 blades on each row on the horizontal axis, perpendicular to the direction of the motion. After the crop is cut by blades, it comes to auger which conveys it to chopper unit. The chopping mechanism having 3 blades, cuts crop into pieces, and chopped material is thrown out with high speed and is filled into hitched trailer.

Its field capacity, labour requirement and fuel consumption varied from 0.44 to 0.52 ha/hr, from 3.84 to 4.54 man-hr/ha and from 4 to 4.5 litres/hr. The cost of machine is Rs 70,000 and its cost of operation is Rs 1,113/ha.

Baler: Trials on tractor-operated baler (MK-55 Model) have been conducted. Its effective field capacity has been 0.82 ha/hr at the field efficiency of 87.2 %. Its bales (60 cm × 38 cm × 48 cm) output and average fuel consumption have been 1584 number/hr and 3.83 litres/ha.

Post-hole digger: Tractor-mounted post-hole digger has been field tested by the ANGRAU, Hyderabad centre, at Moinabad and Samshabad villages and at the University farm with 30-and-23 cm diameter augers for making holes for tree plantation. The field capacity with 30-cm auger varied from 12 to 15 pits/hr for digging 230 holes to the depth of 60 cm with the field efficiency of 80%. Its cost of operation is Rs 159/hr and Rs 19/pit in Red Chalka soil with 10% moisture (db).

Power-tiller-operated Machinery

Sweep cultivator: It is suitable for interculture operations in crops having row spacing of more than 300 mm. This machine of 40-kg weight has overall dimensions of 930 mm × 1580 mm × 1,370 mm. It gives field capacity of 0.18-0.25 ha/hr for different crops.

Trials on the power-tiller operated sweep cultivator were conducted in tobacco, covering total 1.3 hectares in Balua, Mirpur and Neemopur villages (Bihar). For average tobacco-plant of 220-mm, cross-interculture operations gave weeding efficiency of 72-80 %. Its fuel consumption and labour requirement were 0.7 litre/hr and 4.5 man-hr/ha.

Zero-till drill machine: This machine developed by the NDUAT, Faizabad, is suitable for 10-12-hp power-tiller. It can directly drill seeds and fertilizers without seed-bed preparation. It is suitable for wheat, barley, lentil, chickpea, pea, paddy etc. Machine size is 5 cm × 20 cm. Its cost is Rs 10,000, and its cost of operation is Rs 420/ha. It saves 68% in time, 85% in cost of operation compared to conventional practice, and increases yield by 6%.

- Zero-till drill machine is suitable for wheat, barley, lentil, chickpea, pea and paddy. It saves 68% in time and 85% on the cost of operation compared to the conventional practice.
- HPKV multicrop planter consists of a rotor-type metering mechanism with holes of different sizes on its periphery for different crops.
- Designed and developed a two-bottom, V-shaped blade digger for groundnut. Its effective field capacity is 0.052 ha/hr with field efficiency of 78%.
- Developed a power-tiller-operated chipper shredder for cotton-stalks and other agricultural waste materials like *neem* and *subabul* branches.

Power-tiller-operated zero-till drill. This NDUAT developed machine is suitable for 10-12-hp power-tiller. This saves 68% in time and 85% in cost of operation compared to conventional practice

Air-assisted seed-drill: Power-tiller-mounted, air-assisted seed-drill has been modified by providing stand for mounting blower assembly. One more furrow-opener with square-box holder has been fabricated and fitted on to the already fabricated tool-bar. For increasing seed-carrying capacity, seed entry place in the air pipes has been modified. Final adjustments have been made to get blower outlet speed of 0.5-4 metres/second.

HPKV multicrop planter: It consists of a rotor-type metering mechanism with holes of different sizes on its periphery for different crops. It can be used for two rows in maize and soybean and for three rows in wheat. It is operated at a speed of 2-2.5 km/hr in small terraces. Its feasibility test was conducted for wheat, covered in 1 hectare. Its effective field capacity and labour requirement have been found at 0.10 ha/hr and 19 man-hr/ha. Trials on it were also carried out covering a total of 2 hectares at Parei village of Kangra district; its effective field capacity and fuel consumption have been 0.10 ha/hr and 0.9 litre/hr. And the cost of the seeding with this planter has been 30-40 % lesser than *Kera* method.

Orchard sprayer: It consists of a horizontal triplex pump, working in an oil-bath. This pump gives discharge of 36 litres per minute and works at a pressure of 35 kg/sq cm. It has on the main-frame chassis, chemical tank, rubber wheels and operator's seat. This unit can also be conventionally used in pandal-type as well as Y-type of grape cultivation. For spraying in pomegranate and citrus, the booms, one each on the right and one on left side, are made up from GI pipe. Its field capacity is 0.80-0.90 ha/hr and gives droplets of 200-250 mm and their density is 20-35 nos./sq cm. The height of the sprayer is 6 m and its operating cost is Rs 52/hr.

Orchard sprayer. Its field capacity is 0.80-0.90 ha/hr and gives droplets of 200-250 mm, and their density is 20-35 nos/sq cm.

The orchard sprayer equipped with turbo-nozzles, developed at the MPKV, Rahuri centre, was used to conduct field tests in pomegranate and sweet orange. Its maximum number of droplets were in the range of 0-150 microns with droplet density of 6-54 droplets/cm^2. The values of number mean diameter and volume mean diameter varied from 51 to 73.31 and 51 to 217.94 microns.

OUAT groundnut digger: A two-bottom, V-shaped blade-digger for groundnut has been designed and developed with 200-mm width and 38° rake angle of each bottom. The blade spacing can be adjusted according to the row-to-row spacing of the crop. Two bottoms have been provided with shank and tyne for increasing or decreasing shank height by loosening clamps. Inclination angles of the tynes to the ground level could be increased or decreased by rotating pipe-frame inside another clamp attached to hitch bracket. The digger (120°C V blade) was tested at 2.1% soil moisture (db) at Paniora village in Khurda district in 1 hectare. Its effective field capacity has been 0.052 ha/hr with 78% field efficiency. Harvesting efficiency of the digger was 98%. Its cost of operation has been Rs 1,375/ha compared to Rs 2,500/ha in the conventional practice.

Chipper shredder: A power-tiller-operated chipper-shredder for cotton-stalks and other agricultural waste materials like *neem* and *subabul* branches and leaves has been developed. Its shredder, flywheel cutter has been transmitted power through main clutch pulley of the power-tiller. The observed speed of the cutter flywheel has been 3,000 rpm. It was also evaluated for shredding coconut and *chikoo* branches. Its output capacity was 180-200 kg/ha, and shredded material size was1-15 mm.

Self-propelled Machinery

Two-row cultivator for biasi operation: A self-propelled, 4.5-hp diesel-engine powered, 2-row cultivator for *biasi* operation for dry-seeded rice (broadcast/row seeded) has been developed. When this machine was tested, 35 days after rice sowing under standing water, its effective field capacity was 0.06 ha/hr with a field efficiency of 80%. This field capacity is twice as much as that of animal-drawn, 2-bottom *biasi* plough and 3 times that of farmer's practice of single-bottom wedge plough. Estimated cost of this cultivator is Rs 50,000.

- Developed a self-propelled, 4.5-hp diesel-engine-powered, 2-row cultivator for *biasi* operation for dry-seeded rice and a self-propelled riding-type rice-seeder for sowing pregerminated rice.

Two-row cultivator for *biasi* operation. This self-propelled cultivator has been developed for dry-seeded rice (broadcast/row seeded). Its field capacity is twice as much as that of animal-drawn, 2-bottom *biasi* plough and three times that of farmer's practice of single-bottom wedge plough.

Riding-type (10-row) rice-seeder: Self-propelled, riding-type rice-seeder (10-row) has been developed for sowing pre-germinated rice. It consists of a main-frame of self-propelled (5-hp) unit of rice harvester mounted with rice-seeder (10-row). A wooden float has been attached to it and a seat has been provided to ride on the machine. The drive is taken from the ground wheel of the seeder to drop seeds.

Eight-row rice transplanter: It is a self-propelled, riding-type rice transplanter suitable for transplanting mat-type seedlings. It saves 65% in labour and operating time and 35-40% on the cost of operation, besides

Riding-*type rice-seeder.* This seeder has been developed for sowing pre-germinated rice.

PAU walking-type sprayer. This could save 70-80% hr of labour and 45-50% in cost of operation compared to knapsack sprayer.

increasing yield 5-10% of the conventional method of manual transplanting. It costs Rs 120,000 and its cost of operation is Rs 1,000/ha. It was used by farmers who could afford to purchase costly machine to do away with scarcity of manual labourers. Mat type of seedlings helped in growing more number of tillers per hill. Its feasibility testing was done with Pant 12 rice in 2.35 hectares. Its field capacity was 0.13 ha/hr and field efficiency was 68%; with this missing hills were 2.7% and floating hills were 0.6%. Number of seedling per hill were 3-5 at a 140-mm hill-to-hill spacing.

Power weeders: CIAE design: A self-propelled interculture equipment has been developed utilizing chassis of 1-m self-propelled, vertical-conveyor reaper by replacing the present diesel-engine with a light weight petrol-start kerosene-run 1.1 kW engine having rated engine speed of 1,500 rpm (at the cam shaft). This is a light machine and can operate with 3 sweeps of 150 mm for weeding operation in crops sown at 300-350 mm row-to-row spacing. If row spacing is 400 mm or more, only 2 sweeps of 150-200-mm size can be operated. A set of narrow wheels of 150-mm width has also been developed to facilitate operations of machine during weeding. Its feasibility trials have been conducted in groundnut and soybean.

ANGRAU model. This self-propelled rotary weeder is run with a 6.5-hp diesel-engine. Drive to rotary weeder is taken through two sets of V-belts and pulleys. A multiple-plate clutch is provided to cut-off drive to ground-wheel and weeder unit.The rotary weeding unit has two gangs of 300 mm each. Both gangs are mounted outside wheel tread of prime mover.

In its feasibility trials, machine was operated at 60-cm row spacing and 120-cm spacing between pairs. At 30-40% soil moisture (db) and 30-40-mm depth of tilling, its weeding efficiency was 76%. The machine speed was 2.5 km/hr.

TNAU model. It consists of a power unit equipped with 5.4-hp diesel-engine of 34-kg weight, power transmission gear-box, ground wheels, weeding unit handle and clutch. The width of coverage is 350 mm. The overall dimensions of 90 kg weeder are 2,100 mm × 640 mm × 1,170 mm. The machine can be used in maize, sugarcane, cotton, tapioca and grapes. The cost of equipment is Rs 55,000 and its cost of operation is Rs 770/ha. After one pass with rotary weeder, a ridger can be attached for earthing-up.

Balram II model. In cotton, with this, field capacity, field efficiency, weeding efficiency and cost of operation have been found as 0.23 ha/hr, 84 % and 53 % and Rs 45/hr. And for sugarcane, these have been 0.116ha/hr, 59%, 38% and Rs 47/hr respectively.

PAU walking-type sprayer. The self-propelled, light-weight boom sprayer fitted with 5-hp diesel-engine consists of a spraying unit at the back. The spraying unit has a boom with 12 nozzles, spray pump, tank for liquid and a pressure gauge. Ground clearance of the machine is 500 mm. The boom height can be adjusted from 600 mm

SUCCESS STORY

Manually-operated single-row garlic planter

A manually-operated, single-row garlic planter has been developed at the PAU, Ludhiana. This is simple in design and weighs only 12.0 kg. In this machine, planting mechanism is attached over existing design of the PAU wheel hand-hoe, which is used for interculture operation, and is already commercialized. The machine with a hopper capacity of about 3.0 kg is operated by 2 persons. One person pulls machine from front through a rope attached to hook on the machine and the other steers machine by holding it from the handle. Machine is also provided with markers for maintaining specific row-to-row distance. Plant-to-plant spacing can be varied by varying number of spoons on the periphery of the vertical plate. It can plant 0.3-0.4 ha/day with the help of 3 persons. The approximate cost of this machine is Rs 1,000 and this can be recovered from only 0.4 hectare. Labour requirement for sowing garlic with machine is only 83.0 man-hr/ha in comparison to 520 man-hr/hr by the traditional method. Also cost of sowing with machine is Rs 858/ha in comparison to Rs 5,200/ha with the traditional method.

- CIAE developed animal-drawn machinery planter is suitable for planting groundnut, maize, pigeonpea, sorghum and pulse crops. It saves 64% on operation cost compared to the conventional method.

to 1,300 mm. The unit controlled by the operator is provided with two narrow wheels and one supporting wheel at the back. The unit has provision to adjust track width from 900 mm to 10,50 mm. The swath-width of the sprayer is 6,300 mm. The capacity of tank, spacing between nozzles and pump speed are 1,00l, 1,000 mm and 630 mm.

Its feasibility trials were conducted on 26 hectares for wheat. The unit operated at operating pressure up to 400 psi.The machine sprayed weedicide which gave field capacity of 1 ha/hr at the forward speed of 3 km/hr. The fuel consumption varied from 0.4 to 0.6 litre/hr. It could save 70-80% hr of labour and 40-50 % in cost of operation compared to knapsack sprayer.

Vertical conveyor-reaper: This walking-type harvester for wheat, rice and safflower is suitable for cutting and windrowing crops. The engine power is transmitted to cutter-bar and conveyor belts through belt-pulleys. The prime mover of the machine is 5-6.5-hp diesel-engine. And the cost of the machine with prime mover is Rs 50,000.

Demonstrations were conducted with this for safflower-crop covering 6 hectares at 25 farmers' fields in Janwada and Markhal villages of Bidar district (Karnataka). Its effective field capacity was 0.2 ha/hr and labour requirement was 40 man-hr/ha.

Frontline demonstration of this for wheat covering 3 hectares at Keshavpur village, conducted at 2.7 km/hr forward speed, showed 0.22 ha/hr, 68% and 1.16 litres/hr effective field capacity, field efficiency and fuel consumption, respectively. The working width, height of the cut and the average moisture content of the crop-stem were 1,140 mm, 54 mm and 12.7% (wb). And the total losses during harvesting were 2.14%.

Animal-drawn Machinery

CIAE planter: It is suitable for planting groundnut, maize, pigeonpea, sorghum and other oilseed and pulse crops. It saves 64% on the operation cost compared to conventional method of sowing behind the country-plough with manual seed dropping. It costs Rs 6,500 and its cost of operation is Rs 390/ha. The trials at the UAS, Raichur, for sorghum, chickpea and sunflower showed its field capacity varying from 0.12 to 0.15 ha/hr.

Stationery Machinery

Indigenous seed counter: Bio-scientists in the country were using imported machines for counting seeds. At present, an indigenously built machine has been developed which can count seeds of several varieties of

CIAE planter. Animal-drawn this machinery saves 64% on the operation cost compared to conventional method of sowing behind the country-plough with manual seed-dropping.

soybean and wheat with 99% accuracy. Its cost is Rs 20,000.

CIAE solar-tracking device: Sun tracker developed for 450Wp SPV panel has been modified to be adopted for 900 Wp SPV panel to make it more reliable and user friendly. It consists of an electronic vibrator circuit to produce 38 electric pulses per minute, which activates an electromagnetic relay and ratchet and pawl to produce precise rotation of the shaft, mounted on the ball-bearings. The modified tracker has been extensively evaluated by tracking panel (from morning to evening) for 700 hr of operation and has been found to give satisfactory performance. The power output from the panel increased by about 30% under tracked condition (6000 Wh) as compared to non-tracked condition (4500 Wh) on the typical sunny day. The peak power output was observed to be 660 W (74% of peak installed capacity) during noon time on a typical sunny day in summer.

High-capacity pigeonpea thresher: A high-capacity pigeonpea thresher (10-hp capacity) has been designed and developed for the crop-length of more than 750 mm at the CIAE, Bhopal. It consists of an automatic chain-conveyor type feeding mechanism, a tapered spike tooth-type threshing cylinder, a woven wire-mesh concave, two aspirator blowers, a shaker assembly and transport wheels.

With this, stalks are broken into big pieces which can be easily used by farmers for domestic use. Threshing and cleaning efficiencies of this varied from 96.59 to 96.74% and 92 to 94.22%. The average broken grain, blown grain and sieve overflow were 1.21%, 0.31% and 0.13%.

High-capacity multicrop thresher: Frontline demonstration for this was organized for 21 hours at Siddanbhavi and Rampur villages of Raichur (Karnataka) for *jowar* (M 35-1). The threshing capacity varied between 2.13 and 2.41 tonnes/hr. Threshing and cleaning efficiencies were 99-99.5% with total losses of 1.98-2.35%. Fuel consumption and cost of operation were 3-3.25 litres/hr and Rs 165-310 per tonne.

And demonstrations for wheat (HD 2285) were

Modified solar tracking device. Sun tracker developed for 450 Wp SPV panel has been modified to adopt for 900 Wp SPV panel, to make it more reliable and user-friendly.The peak power output has been observed to be 660 W during noon time on a typical sunny day in summer.

organized at village Kareha for 20 hr. During trials threshing capacity, grain damage and straw size were 0.8-1.05 tonne/hr, 0.5-1% and 25-30 mm, respectively. Grain moisture and straw moisture (db) were 8-10% and 12-14%. The fuel consumption was 4-4.5 litres/hr.

Maize dehusker-cum-sheller: Modified peg-tooth thresher has been developed for maize-crop. For better shelling efficiency varying height pegs have been provided in staggered fashion. The pegs have been placed in 6 rows with 6 pegs in each row. In sheller sieves of 12.5 mm are used. The front and rear concave clearances are 50 and 25 mm, respectively.The concave grate has openings of 50 m × 50 m. The sieves of 12.5-mm size holes have been provided.

Test trials conducted for maize sheller have showed grain-straw ratio and moisture content of grain (wb) as 4.2 and 12.1%. At threshing cylinder speed of 678 rpm and feed rate of 1,440 kg/hr, threshing efficiency was 99.26% and cleaning efficiency was 99.96%. The output capacity and broken grains varied 0.63-0.67 tonne/ha and 2.6-3.02%, respectively.

ANGRAU sugarcane leaf stripper: The stripper equipped with 3-hp diesel-engine has been developed for

ANGRAU sugarcane leaf stripper. During trials at Hyderabad, its effective field capacity and fuel consumption were 1,300 kg/ha and 0.40-0.50 litre/hr.

- For counting seeds of crops, scientists were using imported machines. Now an indigenous seed-counting machine has been developed which costs Rs 20,000, and counts with 99% accuracy.
- Modified sun tracker to adopt 900 Wp SPV panel, instead of 450 Wp SPV, to make it user-friendly.
- High-capacity pigeonpea thresher designed and developed to break stalks into bigger pieces for domestic use.
- Modified peg-tooth thresher for maize.

estimated output capacity of 2 tonnes/hr. The equipment consists of 2 upper adjustable rollers and 2 lower fixed rollers. Rollers are covered with EPDM material on the circumference. Stripper is also provided with two brush carriers over which 4 nylon brushes are fixed at equal angles (90° each). The gap between two rollers is adjusted according to canes size; diameter of input rollers is kept lower than that of output rollers to enable canes to come out quickly after stripping leaves. The speed of the brush holder is 2,000 rpm and of feed roller input and feed roller shaft is 1,000 rpm and 375 rpm. Sugarcane is stripped by passing cane between 2-hand rubber rollers. Two brushes with hand-nylon strings are provided to strip cane-leaves. During trials at Hyderabad, effective field capacity and fuel consumption were 1,300 kg/hr and 0.40-0.50 litre/hr, respectively and the breakage of canes, efficiency of machine and labour engaged were 12.15%, 65% and 5.

Ergonomic Studies

Anthropometric and strength survey of agricultural workers: Seventy-nine body dimensions and 16 strength parameters useful for farm-equipment design have been identified. Till date anthropometric data have been collected for 293 (215 males and 78 females) agricultural workers in Madhya Prdesh, and collected anthropometric data for 1,587 (1,000 males and 587 females) workers and strength data for 421 (182 males and 239 females) agricultural workers in Tamil Nadu. The mean values for stature, weight, push strength and pull strength of male and female workers of Madhya Pradesh were 164.2 cm, 51.0 kg, 253 N, 231 N (Newton) and 151.4 cm, 45.0 kg, 177 N, 185 N,respectively. For Tamil Nadu, the values were 162.9 cm, 56.1 kg, 198 N, 241 N for male workers and 150.8 cm, 47.3 kg, 134N and 168 N for female workers.

Anti-vibration devices for comfort of power-tiller and tractor operators: Vibrations if transmitted to body parts not only cause discomfort to operator but also reduce efficiency of the operator. Vibration isolators for engine, handle-bar and handle of the power-tiller have been developed and tested for their efficacy for attenuation of vibrations transmitted to operator. The isolators resulted in reduction of handle vibration by 50%.

Besides these, vibration isolators have been developed

Strength measurement set-up

A strength measurement set-up for agricultural workers has been developed. As per the protocol of the strength data collection, it has been required for a worker to reach his peak strength within first 2 seconds and then maintain this peak strength for the next 3 seconds. It was difficult for the workers to maintain peak strength for the desired time without stimulation in the light or sound form. To take care of this, a timer alarm of 5 seconds has also been developed for guiding workers. Seventy-nine body dimensions and 16 strength parameters useful for agricultural equipment design have been identified and a document showing pictorial presentation and definitions has been prepared. Strength data of male as well as female agricultural workers have been collected to test working of the strength measuring set-up and to chalk-out protocol. The set-up has been found satisfactory for the data collection. The cost of the set-up is Rs 14,000 and cost of the timer alarm is Rs 2,000.

A strength measurement set-up for agricultural workers. Strength data of male as well as female agricultural workers have been collected to test working of the strength measuring set-up and to chalk-out protocol.

- Developed a strength measurement set-up for agricultural workers.
- Identified 79 body dimensions and 16 strength parameters useful for farm equipment design.
- Developed and tested vibration isolators for engine, handle-bar and handle of power-tiller for their efficacy for attenuation of vibrations transmitted to operators.

for seat and tractor-trailer hitch points and have been tested for their efficacy. The isolator below the seat helped in reducing vertical vibrations transmitted to operator by 30-80% in different operations at speeds ranging from 2.5 to 4.5 km/hr.

Optimum locations for tractor-control pedals for Indian operators: Right and left leg strength data for 20 subjects were collected at 5 horizontal (35, 40, 45, 50 and 55% stature) and 6 vertical (10, 13, 16, 19, 22 and 25% strature) locations of the foot-pedal from the seat reference point (SRP), keeping lateral distance from mid-line 200 mm for each pedal combination. It has been observed that a 5th percentile operator could reach vertically up to 370 mm below and 810 mm in front of the SRP. The maximum leg strength of 655 N for right leg and of 613 N for the left leg was observed when pedal was located at 55% stature in front and 10% stature below SRP. The optimum locations for brake and clutch pedals have been at the horizontal distance of 623 mm in front of the SRP, vertical distance of 296 mm below the SRP and 200-mm lateral from mid-line. It will be suitable for the 90% of the user population. The range of dimensions presented in IS: 12343 (1998) is very large and actuating force limits as given in IS:10703 (1992) are very high compared with leg-strength data of the Indian operators. Both these standards need to be revised in the light of the data generated to make the tractor work-place safe and comfortable for operators.

POST-HARVEST ENGINEERING AND TECHNOLOGY

Post-harvest management of oranges: An orange grader fabricated could grade fruits into 5 grades at a time on the basis of the size. This has been found effective for smaller grades. The theoretical capacity of the grader is 13.89 tonnes/day.

Cleaner for reduced dust emission in dal *mills:* A prototype of the cleaner equipped with suitable ducts, a forward curved centrifugal blower and a cyclone separator to arrest dust emission in *dal* mills has been developed. The diameter of the blower impeller is 300 mm with an inlet diameter of 150 mm. Its volumetric airflow rate is 22 m^3 /min and air velocity at winnowing section is 10 m/s. The blower housing has a diffuser angle of 5 degrees. Test results indicate that power requirement at load is 500 W and its input capacity is 900-1,000 kg/hr. The estimated cost of the cleaner with two prime movers (½ and 1 hp-electric motor) comes to about Rs 20,000. The screen effectiveness of the unit is 68-87%, and the purity of the cleaned grains is over 98 %.

Cleaner for reducing dust emission in *dal* mill. A prototype of the cleaner equipped with suitable ducts, a forward curved centrifugal blower and a cyclone separator to arrest dust emission in *dal* mills has been developed. This is 68-87% screen effective unit, and purity of cleared grains is over 98%.

Fermented banana beverage: A process for fermented banana beverage has been developed from banana pulp, water and sorghum flour in 1:4:0.83 ratio. A pre-grown, fresh-yeast culture suspension (*Saccharomyces cerevisiae*) was inoculated for fermentation. The average

- To arrest dust emission in *dal* mills, a prototype of the cleaner has been developed. The screen effectiveness of the unit is 68-87% and purity of the cleaned grains is over 98%.
- Developed process for making fermented banana beverage. The bottled product can be stored safely for 45 days at 30-35°C (room temperature).
- IISR designed improved cane-crusher gave maximum of 64% juice extraction.
- Developed juice filtration system

Rice storage losses in Punjab warehouses

The rice received at the 6 warehouses (Amritsar, Nabha, Moga, Fazilka, Pathankot, Ludhiana) in Punjab showed moisture content from 13.5 to 15.2 %. The final moisture content of stacks after 6 months of storage was 12.5 – 13.6%. And after 12 months, it was 13.2 to 14.2%. During first 6 months the rice lost on an average 1.0% in moisture and after 12 months loss was about 0.8%. Since losses are based on the initial moisture content and storage period, the losses on actual weighment basis and formula basis were compiled and analyzed for rice for less than or equal to 14% of the initial moisture and more than 14% of the initial moisture.

The data shows that for 6 months storage, the rice up to 14% moisture suffered storage losses of 0.62% and with more than 14% suffered 0.95% losses. Similarly, for 1 year storage rice with moisture less than 14% suffered 1.35% losses and that with more than 14% suffered 2.29% losses on weighment basis. It could be seen that losses on weighment basis were lower than on the formula basis for the first 6-7 months, and then the trend got reversed.

yield of the beverage has been 58% of the total mixture, which was equivalent to 65 bottles of 800 ml each. The final product contains 5-8% alcohol with *p*H of 3.5, which is suitable for beverages. The beverage has sour-sweet taste and beer-type flavour. The bottled beverage can be stored safely for 45 days at the room temperature (30-35°C).

Fermented banana beverage. A process has been developed for banana beverage from banana pulp, water and sorghum in 1:4: 0.83 ratio. The final product contains 5-8% alcohol with pH of 3.5. The bottled beverage can be stored safely for 45 days at room temperature.

Management of Jaggery and Khandsari

Improved IISR horizontal cane-crusher: The IISR designed, improved, horizontal power cane-crusher gave maximum of 64% juice extraction at 3.7-mm roller-gap at 3.3m/min. roller speed. At this roller setting, power requirenment for crushing 1 tonne of sugarcane was 7.9 kwh in 1,020 seconds.

Double stage filtration system for sugarcane juice: To obtain quality product, clean juice free from adulterants, dust and any other foreign materials, a filtration system for juice has been developed. In this, first-stage filter is made up of stainless steel 304 of 20 gauge sheet. It contains 3-mm round-hole sieve and has 29 holes/sq inch. Similarly second-stage filter is also made up of the same material with 0.5-mm sieve. For cleaning from very small particles, of insoluble impurities, third filter of 500 micron size has been provided on the top of the juice-tank.

Electronic thermometer for striking point in jaggery-making: Digital thermometer developed for judging striking point in jaggery-making has minimized risk of charring and of sub-optimal condition to remove concentrated mass from the pan. The instruments costs Rs 800 to Rs 5,000.

Ready-to-use vegetable clarificant for sugarcane juice: Optimum clarification of juice with deola seed powder was achieved at 0.1 to 0.5% concentrations. Apart from being good in physical appearance, jaggery obtained was hard crystalline and light-yellowish because of the instrinsic properties of the seed powder for enhancing efficiency of juice clarification. The clarificant could be effectively used for preparation of syrup and vinegar.

Improved 3-pan furnace for jaggery manufacture: This consists of a combustion chamber with an improved

SUCCESS STORY

Commercialization of vegetable-washing machine

A stainless-steel, 1-hp, electric-power-operated, vegetable-washing machine (drum water), which washes carrots, potatoes and spinach, has been tested and evaluated for washing, okra, turmeric and radish. The machine could wash effectively 0.2-0.25 tonne of okra and turmeric/ha and 0.15-0.2 tonne of radish/ha. The optimum performance parameters for washing for speed and time were 35 rpm for 4 min. for okra, 40 rpm for 5 min for turmeric and 50 rpm for radish. There was a significant microbial load reduction, and during washing microbiological washing efficiency ranged from 97.0 to 99.0%, which fulfills recommended international standards (80%), thus indicating adequacy of washing system. An improved model of the washing machine has been developed with increased capacity by 1.5 times, and with this washing has been improved by providing additional, pressurized sprays of water, through a central, perforated inner shaft. Five prototypes of this latest model of machine have been fabricated and tested.

grate design, a middle chamber for tapping heat from the flue-gases coming out of the combustion chamber and also to work as an air inlet chamber, and a flue-gases passage/channel rectangular in shape, 3 juice-boiling pans, a chimney made of masonary for taking out flue-gases, a bagasse feeding platform and an ash pit below the platform. The specially designed and fabricated juice-boiling pans were placed on the respective chambers. The first 2 pans are circular with convex bottom having 11/4" and 1" thicknesses and the third one is known as the gutter pan, it is rectangular with convex bottom (1/2" thick) along the length. The middle juice boiling pan has 11/2" × 11/2" hole/opening in its centre which connects with 2" and 35" long g.i. pipe from the bottom of the pan for draining-out juice. A gate valve has been provided at the end of the juice pipe. Also a protective cover of the thick m.s. sheet has been provided for this juice pipe. In additional to fuel-feed hole, the fresh air is supplied to combustion chamber enrouting middle chamber through two m.s. pipes (3") connected with two side openings of the chimney near its bottom and at the middle chamber. The chimney height is kept at approximately 12' with the base chamber of 5'3"×5'3"×2' and chimney of 2'9"×2'9"×12' with a hollow outlet opening of 1'3"×1'3".

The test results have indicated that per batch approximately 20-25 kg of bagasse could be saved. In addition, it reduced human labour, drudgery and inconveniences.

Packaging of jaggery in vacuum and nitrogen environment: Brix of jaggery obtained from sugarcane CoLk 8102 changed from 13.67 to 11.87, 12.3 and 12.0 when stored in the desiccator, nitrogen and vacuum respectively in 2 months. Similarly pol reading changed from 77.4 to 48.8, 72.3 and 70 g while reducing sugar increased from 5.7 to 8.5, 6.2 and 6.7% in desiccator, nitrogen and vacuum storage. Moisture content of jaggery changed from 7 to 16.5, 8.9 and 3.9% when it was stored in desiccator, nitrogen and vacuum. Jaggery solution *p*H changed from 6.5 to 5.5, 5.9 and 6.2 and colour reading changed from initial value of 190 to 275, 220 and 252 in desiccator, nitrogen and vacuum stored jaggery. This suggests that packaging of jaggery in nitrogen environment will be more suitable.

PLASTICS IN AGRICULTURE

Mulching of Strawberry

At the CSKHPKV, Palampur, and the CIPHET, Abohar, plastic mulch (black polyethylene sheet of 100 gauge) has recorded 30-40% higher yield of strawberry over straw and eupatorium mulch. Yield-attributing characters like berry weight, length and diameter were also significantly higher with plastic mulch. Runners planted at 15-cm row-spacing produced significantly higher yield (25 tonnes/ha)

- Turning-red tomatoes stored in perforated polybags with ethylene absorbent at room temperature had shelf-life of 10 days, it increased to 18 days if stored at 18°C.

Vegetable cultivation in polynet house

Polynet house was covered with UV-stabilized plastic sheet from November to February and thereafter was replaced with plastic net. Sweet-pepper yield in polynet house was 106 tonnes/ha, which was 25% higher than polyhouse (87 tonnes/ha) and 45% higher than net house (57 tonnes/ha).

Fish production in greenhouse covered ponds

After 20 days of rearing of carp it was observed that its mean growth in open and polyhouse covered ponds was 21.95 mm / 0.202 g and 19.7 mm / 0.139 g. The survival rate of the fry from spawn was 61.5 % in polyhouse pond and 40.2 % in open pond. The desirable plankton density was higher in polyhouse ponds compared to open pond. Average maximum and minimum air temperatures inside polyhouse ponds were found 10°C and 5°C higher than the open pond.

Perforated Polybags for Tomatoes

Turning-red tomatoes stored in the perforated polybags with ethylene absorbent at room temperature had shelf-life of 10 days, and it increased to 18 days when tomatoes were stored at 18°C at the PAU, Ludhiana. Mature green tomatoes with ethylene scavenger could be stored for 16 days at room temperature and 19 days at 18°C. The lycopene content and TSS have been found significantly higher for tomatoes packed in polybags without perforations. Tomatoes harvested at mature green or turning-red stage have better shelf-life.

COTTON TECHNOLOGY

Light weight cotton-gin: The CIRCOT has developed a light weight gin. The weight is reduced by about 60%, keeping output at 5 kg seed-cotton per hour. This gin can be operated with a remote control as well.

Heap-making machine for cotton: The CIRCOT has designed and developed a mechanical heap-maker that is able to throw cotton into well-formed heaps at the rate of 3,000 kg/hr. Efforts are on to increase heaping rate and bulk density of heap.

- Developed a light-weight cotton-gin, which can be operated with a remote control as well.
- CIRCOT designed and developed a mechanical heap-maker for cotton.

SUCCESS STORY

Variable speed double-roller gin

The two most important machine parameters that influence productivity of lint in double-roller gins are the speed of the roller and the oscillation frequency of the beater. Almost all commercial double-roller gins employ a fixed roller speed of 90-100 rpm while beater itself oscillates with a frequency of 900-1000 rpm; the ratio of these speeds is 1:10.

The operational efficiency of the gins depends on the adjustment of the speeds based on the staple length of the cotton, requiring relatively higher roller speeds for cottons of longer staple lengths. The existing arrangement in gins does not permit alteration in speed ratio as any increase in the roller speed correspondingly affects frequency of the oscillation of the beater, affecting quality and quantity of the lint delivered during ginning.

Speciality of VS gin

- Has flexibility for adjusting speed of roller and beater independently according to the staple length of the cotton.
- Faster ginning.
- Higher lint out-turn with uniform lap.
- Easy way to change speeds by use of step pulley and V-belt.
- All important fibre parameters are preserved, and there is no deterioration in lint quality.

To overcome this problem the CIRCOT has come up with a *Variable Speed Double Roller Gin* that leaves ample room for adjusting roller and beater motions to desired speed ratio appropriate for cotton staple under the process. This has helped to increase in the productivity of gin to 60-80%, without affecting lint quality. The production of lint per inch of the roller is between 1.5 and 2 kg/hr compared to the existing rate of less than 1kg/hr.

To obtain higher out-turn of longer staple cottons higher roller speeds up to 140-150 rpm are used and for medium staple cottons up to125 rpm; keeping the beater frequency steady at 1,000 rpm. The short staple cottons are best processed with beater frequency of 750 rpm, keeping roller speed as 100 rpm. The VS Gin technology of the CIRCOT has been patented and sealed having serial No. 189878.

A comparative trial of VS Gin and that of the conventional gin was conducted at the factory level at M/s Uday Cotton Industries, Khadi, Mehsana District, Gujarat. Extensive factory trials gave 72 kg lint output/hr as against 52 kg lint/hr from conventional gin.

The CIRCOT has transferred this technology to M/s U. D. Patel and Company, Mumbai, for commercial exploitation in ginning Industry.

Yarn count predicted accurately using neural network: Highest Standard Count (HSC) is a single integrated index that provides an easy way to express quality of cotton and is considered a unique mean of expressing the maximum spinning potential of the given cotton. The CIRCOT has developed an Artificial Neural Network model (ANN) using fibre properties such as 2.5% span length, uniformity ratio, micronaire value, bundle strength and percentage of mature fibres as input to predict highest standard count (HSC) value. This model is able to predict HSC within an error of ± 4.23 counts. Since the spinning industry is very familiar with the concept of count, understanding and using HSC as an index for characterizing spinnability would not pose any problem and would be more favoured than the current Fibre Quality Index, which is used to indirectly assess spinnability of cotton.

CIRCOT's improved microspinning system

Miniature spinning assembly of the CIRCOT consists of carding, drawframe, sliver to yarn ring-frame and roving to yarn computerized ring-frame. These machines are gearless and run smoothly and are designed incorporating the most modern technology like electronic drive system. The main machine parameters like draft, speed and twist can be set easily from the machine panelbox. These machines have better design features and are available approximately at one-fourth the cost of the imported ones.

Coir-cotton composite yarns for conveyor-belting

For the first time, coir-cotton composite yarns have been developed through friction spinning technology for the industrial end-uses. From coir-cotton composite yarns, conveyor belt material has been fabricated. As a cheaper fibre, replacement of cotton-fabrics with coir will help in bringing down the cost of conveyor-belting.

Production of xylanase from Penicillium funiculosum: Xylanase is an enzyme that can biodegrade lignocellulosic substrates to useful end-products. Fungus *Penicillium funiculosum* could secrete xylanase simultaneously when cultivated for cellulase production using cellulose as the carbon-source. The maximum yield of xylanase could be obtained 72 hr after incubation when substrate on which organism was cultivated had 1.0% cellulose and 0.25% peptone. The enzyme thus produced had maximum activity equivalent to 33.3 units/ml at a *p*H of 6.0 and temperature 50°C that is considered optimum for use in textile finishing applications.

Angora rabbit hair blends with cotton: Angora rabbit hair with cottons like Suvin and DCH 32 have been blended. Since Angora fibres are shorter compared to

wool, they cannot be effectively utilized through long-staple woollen and worsted spinning systems for manufacturing consumer acceptable textiles. This novel blending in cotton system is beneficial way of utilizing rabbit hair. Knitted fabrics produced from blended yarns are found to possess adequate bursting strength, whiteness, softness and bulkiness. Several innovative end-products like low-shrink knitted fabrics, single jersey and light weight soft feel women's wear have been prepared.

LAC TECHNOLOGY

Habitat management in lac eco-system: Vegetables growing as an intercrop in the plantation of *Flemingia semialata* has showed significant improvement on the growth attributes of the lac-host plants such as height, basal girth, canopy spread and shoot length, and this will help to meet diversified needs of lac growers.

Flemingia semialata propagation through stem-cutting

Vegetative propagation technique for *Flemingia semialata*, a recently identified quick-growing, potential brushy lac-host, through planting of stem-cuttings in trenches under high humid conditions, has been successfully attempted. This technique shall now be used in raising plantation of true-to-the type, high-yielding plants in a large scale for intensive lac culture.

Water-thinnable coating compositions for cementitous surfaces

Water-thinnable coating compositions from lac have been developed for cementitous surfaces. They possess most of the desired properties as per the BIS specifications. They can be diluted to desired consistency and can produce hard, smooth and matt-finish on application by brush. The air-dried films have showed good adhesion on metal, tin, plate, glass, wood, concrete, masonry and limited surfaces with good resistance for water as no effect could be observed even after dipping for four months in water.

Identified and collected rare variants of palas (Butea monosperma): Three rare variants of palas (*Butea monosperma*), with unifoliate flowers, yellow flowers and white flowers have been identified, collected and planted in the institute plantation for conservation of plant biodiversity.

Synthesis of some bio-active compounds from aleuritic acid: Aleurityl hydrazide was synthesized from methyl aleuritate by treating it with hydrazine hydrate in methanol. The compound showed antifungal activity. A sex pheromone of *Helicovoerpa armigera* (cotton bollworm), (Z)-9-Hexadecenal, was synthesized in quantity from aleuritic acid, the major component acid of the lac, with an overall yield of 20%.

New cyclic thioureide has been synthesized from aleuritic acid adopting simple reaction sequences.

Shellac-based can-lacquer formulations for packaging. Various can-lacquer formulations developed have been applied on the aluminium foil by spray, with/without suitable pigments, for possible use in packaging of sweets and confectioneries. The results obtained are quite satisfactory with regard to flexibility, attractive appearance and adhesion

JUTE TECHNOLOGY

Minimal water for extraction of jute fibres: Because of acute shortage of retting water, farmers are compelled

Value-addition of safflower petals

Natural dyes from petals

Safflower petals yield a water-soluble, yellow dye and an alcohol-soluble red dye. An appropriate technology has been developed for extraction and application of yellow dye on the cotton goods. It is possible to create a spectrum of shades ranging from yellow to olive-green by using right proportions of appropriate ecofriendly mordants. The dyed fabrics possess an acceptable level of washfastness (3-4) with a very good colour uniformity and reproducibility. It is estimated that around 0.5 lakh tonnes of yellow colourant valued around Rs 5,000 million can be generated annually in the country.

Herbal tea from petals

A recipe has been successfully formulated for herbal tea preparation from safflower-petals. The proportion of various ingredients has been optimized and subjected to an extensive organoleptic evaluation trials.

Petals as food additive and colourant

A technology has been developed to incorporate safflower-petals in powdered form in various popular food items like *barfis, pedas, jalebis,* shrikand, and in a number of bakery and dairy products. The acceptability of the petal-incorporated food items has been demonstrated through extensive organoleptic trials. The non-toxic safflower petals on account of the presence of the polyphenolic and other molecules transform food items into herbal health-care products.

to ret jute-plants for fibre extraction in roadside ditches, ponds and canals. As a result, quality of the extracted fibres is reduced and farmers fail to get the remunerative price from their produce. With the NIRJAFT technology, retting is effected in just water-soaked conditions by the application of a specific fungus belonging to *Sclerotium* group, thus reducing substantially water requirement. Bench-scale trials have found that with this retting could complete in a shorter time than traditional retting.

Blending jute and allied fibres: The NIRJAFT has worked on blending of coir and jute successfully in jute-spinning system in 20:80 ratio. Better results could be obtained when coir fibre prior to blending was steamed under 15 psi pressure. The blended products are much better in productivity, strength and extension properties than 100% coir products.

Blending ramie with tasar waste: Tasar waste has been blended with varying proportions of ramie ranging from 100 to 25%. Spinnability and regularity of the blended yarns (51-104 tex) improved due to higher fineness of tasar, which provides higher number of fibres in the same cross-section of yarn. The blended yarns have been found suitable for manufacturing garments, apparels and decorative fabrics.

Jute blended with sisal: About 20% sisal could be blended with 80% jute. Strength and durability of these blended yarns increased significantly. And these yarns can be used for making scrubber, matting and floor covering.

ENERGY IN AGRICULTURE

Crop residue conversion to liquid fuel. Pretreatment of paddy-straw (400 micron) with 2% NaOH for 1 hour at 15 psi pressure in autoclave could result in 88% delignification and 100% increase in cellulose content. Hydrolysis of alkali-treated paddy-straw with 75% (w/v) sulphuric acid resulted in release of 30% (w/w) sugars. And hydrolysis with crude culture filtrate of *Trichoderma reesei* (5FPU/g) and commercial cellulase (1.5% v/v) resulted in 48 and 81% saccharification of cellulose. Fermentation of hydrolysates of alkali-treated paddy-straw obtained after treatment with acid, crude culture filtrate and commercial enzyme and supplementation with 1.24% yeast nitrogen-base using *Saccharamyces cerevisiae* (1% w/v) could produce 78, 139 and 224 ml ethanol/kg paddy-straw.

- Fermentation of hydrolysates of alkali-treated paddy-straw obtained after treatment with acid, crude culture filtrate and commercial enzyme and supplementation with 1.24% yeast nitrogen-base using *Saccharamyces cerevisiae* (1% w/v) could produce 78, 139, 224 ml ethanol/kg paddy-straw.
- Developed an improved CIAE stove for biomass charred briquettes.
- An unglazed solar air-heater has been developed which works as the roof of the building.
- Designed and developed solar refrigerator.

Bagasse-based gasifier. Developed an open-core gasifier of 700-mm internal diameter. This system has been installed at the site of the sugarcane-farmer for jaggery preparation. Its burner efficiency is 52% compared to 16% of the conventional system.

Bagasse-based gasifier: An open-core gasifier of 700-mm internal diameter and 1,860-mm height has been developed. This has been fitted with a continuous ash removal mechanism. Outer surface of the reactor has been provided with glasswool insulation to minimize heat loss. The gasifier has been tested with bagasse briquettes of 30-mm diameter and with an air-flow rate of 200 m^3/hr, which could generate producer gas at the rate of 257 m^3/hr. The flame temperature of 657°C could be obtained. The system has been installed at the site of the sugarcane-farmer for jaggery preparation. Burner efficiency has been 52% as compared to 16% for the conventional system. The system could save 40% of fuel and 45% in time compared to conventional system for jaggery-making.

Roof integrated unglazed solar-air heater: An unglazed solar air-heater has been developed, which also

Roof integrated unglazed solar-air heater. This costs around Rs 1,000/m^2. Its single module evaluation recorded a temperature rise of 15°C.

works as the roof of the building. This heater has been made using hollow black colour PVC section in one mm wall thickness. One module of the heater has 1.75 m^2 surface area (2,730 mm × 300 mm × 25 mm). Single module of the heater was evaluated and a temperature

rise of about 15°C was recorded. Thereafter, a large system measuring 21m^2 surface area, which formed roof of the small shade, was erected and its performance was evaluated during summer and winter. The increase in air temperature varied between 18.9° and 13.2°C during summer (solar insolation 917 to 1069 W/m^2) and 16.6 to 10.2°C during winter (solar insolation 750-930 W/m^2), and air-flow rate varied between 441 and 1,075 m^3/hr. The heater did not shown any discolourization or wear and tear during 18 months of its exposure to outdoors. It costs around Rs 1,000 per m^2.

Solar refrigerator designed: A SPV system for operation of a top-opening, 73-litre capacity DC refrigator has been developed. This refrigerator system was used to store animal vaccines and other medicines in the village veterinary clinic. Performance of the system has been found satisfactory over 9 months. Keeping in view the requirement of the rural industry, a 80-litre capacity, top-opening refrigerator mainly to store single products has been designed and developed. This refrigerator is equipped with Danfoss make DC compressor of 12 V/24V. And thermostat with seven settings enables user to obtain a wide range of temperature varying between –4.6 and 1.5°C. Its daily energy consumption varies between 450 and 875 Wh.

Solar refrigerator. This refrigerator has been used to store animal vaccines and other medicines in a village veterinary clinic.

Natural draft gasifier for thermal application: The cylindrical gasifer (700-mm diameter and 1,260-mm height) has been provided with 4 air-tiers located above the grate at the intervals of 90° at the periphery. Gas outlet of diameter of 300 mm (located 800 mm above grate) is fitted at an angle of 30° on the periphery of the gasifier with chimney at the height of 126 mm from the grate. An ash removal system has been provided for agitating fuel-bed and removal of ash from the grate. The gasifier also has a light-weight, fire-brick inner insulation of 50 mm.

The gasifier has performed satisfactorily with a thermal output of 106.7-121.3 kW. Its biomass consumption rates ranged between 35 and 40 kg/hr for wood-chip and 24-37 kg/hr for soybean-straw. The respective grate temperature was 1258-1380°C for wood-chips and 1154-1234°C for soybean straw. The provision of insulation could increase the grate temperature by 1.6 to 3.9%. The outer surface temperature of the gasifier near the grate remains 65-98°C, with surface temperature decreasing with the height to around 50°C at 300 mm from the gasifier-top.

Animal Energy

Animal-operated zero-till drill: The single-row, zero-till drill developed requires a draught of 35 kgf and its field capacity has been found at 0.03 ha/hr. The two-row,

Improved cookstove for low pollution

A CIAE improved stove has been developed for biomass charred briquettes. It has provisions for supplying adequate air for burning and reducing heat losses due to radiation and convection. It consists of two concentric mild steel grates with small holes which are supported on a mild steel grill. About 0.5-kg briquettes can be fed at a time in the stove that lasts around 1 hour. The stove is ideal for cooking requirement of a family of 4-5 members.

CO emission level in typical rural kitchen of Madhya Pradesh with single mouthed traditional *chulha* and CIAE Improve stove

Kitchen type	Type of *chulha*/stove	Average CO level (ppm) in breathing zone (0.3 m to 0.6 m radius around the *chulha*/stove)	
		Sitting zone (0.5-m height)	Standing zone (1.5-m height)
Conventional thatched roof: type (18-20 m^3 volume)	Single-mouth traditional chulha	12	15
-do-	CIAE improved stove with briquettes	2	3

CIAE improved stove has been developed for biomass charred briquettes. About 0.5-kg brigquettes can be fed at a time and that lasts around 1 hr.

zero-till drill has a field capacity of 0.05-0.06 ha/hr and its draught requirement has been 45+10kg for light soils and 75+10kgf for heavy clay soils. Zero-till drill had resulted in 5% increase in yield as compared to conventional method.

Modified adjustable collar harnesses: Pantnagar-adjustable collar harness and Allahabad harness have been modified to increase yoke-contact area for providing comfort to animals during work. The increased output has been utilized for operation of 100-150-mm plough with a single animal harness using buffaloes with a work-rest schedule of 4 hours work and 7 hours rest for the field preparation during *rabi*. The animals could operate plough without showing any additional fatigue symptoms. The collar harness intervention has resulted in 20-25% more power output. The contact area could increase to 17% in modified harness. The improved implements matching draught capacity of animals under farmer's field could increase command area from a pair of buffaloes by 22-40% in various crop rotations, when buffaloes were used as a power source in *tarai* region.

Bullock-operated generator: The device consists of an improved design of bull-gear coupled to generator for electricity generation. The bull-gear consists of spur and helical gears and all gears are arranged vertically. The gear and shaft and key are made of EN 19 and EN 8 steel for its mechanical strength, longer life and also for amenability to surface hardening. The magnification ratio of a bull-gear has been 310-08. The bull gear coupled to 1 KVA alternator operating at 750 rev./min could give the power output ranging from 500 to 750 watts.

TECHNOLOGY TRANSFER

- The success rate of starting soy-processing technology has been found 70% and 100% in Haryana and Punjab.
- A manufacturing package for serrated sickle that has edge over plain sickle consisting of dies and punches for blade, blade-holder, holder bending die, and a compact-serration making system using milling process to produce 0.8-mm deep, 10-mm wide serration over 180-mm sickle-blade length, has been developed for small manufacturers. The complete system costs Rs 60,000 with Rs 9.40 lakh of total investment. A total of 72,000 sickles per annum as production capacity can earn about 7.20 lakh per year at Rs 10 per sickle. The break-even point has been calculated as 35% with the adoption of this package.
- A low-cost design of natural convection, flat-plate type solar water-heater has been developed. This consists of 2-flat plate collectors, each of 1 m^2 aperture area. A plate-type simple heat exchanger has been provided in water-store tank to avoid scaling of collector pipes. Heat losses from storage tank have been reduced by using 20-cm thick composit insulation of glass-wool and thermocole. The heater heats 100 litres of water up to 55-60°C on sunny days in winter at Ludhiana. Overnight drop in temperature of hot water has been less than 5°C. It is now commercially available at a cost of Rs 13,600 from M/s Vishiv Karma Solar Energy Corporation, Phillaur.
- A simple to use electronic temperature controller, for using with natural convection solar dryers, has been developed. The controller is now available at Rs 2,500.

Flat-plate type solar-water heater. This heats 100 litres of water up to 55-60° on sunny days in winter at Ludhiana. Overnight drop in temperature of water was less than 5°C.

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- Pantnagar adjustable collar harness and Allahabad harness have been modified to increase yoke contact area for providing comfort to animals.