All India Coordinated Research Project
on
FARM IMPLEMENTS AND MACHINERY

At a Glance

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Fig.1. Locations and major activities of 25 cooperating centers of All India Coordinated Research Project on Farm Implements & Machinery.

AICRP on Farm Implements and Machinery

1.1 Historical Background of the Project

The Project started on May 21, 1975 during the V Five Year Plan Period with 6 centres with IARI, New Delhi as the Coordinating Centre and other Centres located at TNAU, Coimbatore; APAU, Hyderabad; PAU, Ludhiana; MPKV, Rahuri and ICAR Research Complex for NEH Region, Shillong. The Coordinating centre and the Coimbatore centre were given the status of Zonal Research Centres and the responsibility of establishing the prototype manufacturing workshop. The Coordinating Cell of the scheme was shifted from IARI, New Delhi to CIAE, Bhopal in September, 1977. During the VI Five Year Plan period, the project was strengthened by increasing centres from six to sixteen. The emphasis was also laid on the establishment of prototype manufacturing workshops and feasibility test centres. The major activities of the Project were research and development on farm implements and machinery, manufacturing of prototypes, feasibility testing of improved implements and training of village artisans. These four activities were assigned to six centres namely CIAE, Bhopal; TNAU, Coimbatore; PAU, Ludhiana; APAU, Hyderabad; MPKV, Rahuri and ICAR Research Complex for NEH Region, Shillong. Two centres located at Ranchi and Lucknow were given the activities of prototype manufacturing, feasibility testing and training of village artisans. The centres located at remaining eight places had only one activity of feasibility testing of equipment. These centres were HAU, Hisar, JNKVV, Jabalpur; CTAE, Udaipur; GBPUAT, Pantnagar; IIT, Kharagpur; KAU, Tavanur; IGFRI, Jhansi and GAU, Junagadh. The Junagadh centre was closed from 1st August, 1985 and therefore only 15 centres remained.

The Project continued during VII Five Year Plan period with financial outlay of Rs. 188.66 lakh as ICAR share and six new centres were started at NDUAT, Faizabad; AAI, Allahabad; AAU, Jorhat; Dr. PDKV, Akola; RAU, Pusa and UAS, Raichur. The Project continued during VIII and IX Five Year Plans with an outlay of Rs. 450 lakh and Rs.1140 lakh, respectively at 21 centres.

The AICRP on Power Tillers with seven centres was merged with the AICRP on FIM in April 2000. Of seven centres, five already had FIM centres and two centres i.e. OUAT, Bhubaneswar and HPKV, Palampur had only AICRP on Power Tillers. With addition of two Power Tiller centres with FIM, total centres of AICRP on Farm Implements & Machinery increased to 23.

One more centre was opened during XI Five Year Plan period and became operational at College of Agricultural Engineering and Post Harvest Technology (CAU), Ranipool, Gangtok (Sikkim) since April 1, 2009. The cooperating centre at GBPUAT, Pantnagar was upgraded to R&D centre during XI Five Year Plan since April 1, 2009. The centre located at CCSHAU, Hisar was upgraded to R & D centre during XII plan since April 1, 2015. The centre located at GBPUAT, Pantnagar; NDUAT, Faizabad and CSKHPKV, Palampur were closed and four new centres were opened at ANGRAU, Guntur; JAU, Junagadh; IGKV, Raipur and UAS, Bangalore since April 1, 2015. Therefore, there are now 25 centres working on two or more of the five distinct activities under the Project namely, research and development (R&D), prototype manufacturing (PMW), prototype feasibility testing (PFT), front line demonstration (FLD) and promotion of custom hiring. The locations of the centres with their details are given in Table 1.

1.2 Mandate

To identify the mechanization gaps and future needs of improved farm equipment and machinery for different agro-climatic regions, crops and operations, and to conduct research and development, prototype production, feasibility testing, frontline demonstration and promote custom hiring of farm equipment and machinery to bridge identified mechanization gaps.

1.3 Objectives

The objectives of the AICRP on Farm Implements and Machinery during the XII plan are as follows.

i. To identify the present mechanization gaps and future needs for improved farm equipment on the basis of objective analysis of prevailing agro-socio-economic factors for different crops, cropping patterns and agro-climatic regions.
ii. To design, develop and adopt farm implements and machines for rainfed and irrigated farming, hilly and plain regions suitable for animate, mechanical and electric power sources including power tiller, with a view to increase crop production and productivity of land and labour and to reduce drudgery.
iii. To test farm equipment in the laboratory and field for development of new machines and to conduct intensive and extensive trials on farmer's fields for evaluation and refinement for finalization of design of new as well as existing farm implements and machinery.
iv. To establish linkages with manufacturers by involving them in developmental process of farm machines and their production technology for the manufacture of improved farm implements.
v. To manufacture the required number of units in Prototype Manufacturing Workshop (PMW) of selected improved and proven designs of farm implements and machinery for their multi-location feasibility trials and promotional programmes.
vi. To conduct feasibility testing on farmer's fields of prototypes of proven designs of farm implements and machinery, selected from different regions for adoption under local conditions with a view to bridge the identified mechanization gaps.
vii. To train rural youth and entrepreneurs in custom hiring service of improved farm implements and machinery.
viii. To streamline testing procedure and training of engineers for standardisation and quality control in farm equipment manufacturing.

1.4 Activities under the project

The activities under AICRP on Farm Implements and Machinery include development/adaption of need based farm implements, their prototype manufacturing for multi-location trials, prototype feasibility testing to adapt new designs based on mechanization gaps and front line demonstration of proven designs to prove their efficacy, obtain feedback for design refinement and commercialization. The custom hiring activity was also taken up under the project since XI Five Year Plan.

1.4.1 Research and Development

This activity is on design, development, testing and design refinement of farm tools and implements for crops and cropping patterns of the respective regions where the

centres are located. It also includes study of prevailing agricultural systems to identify farm mechanization needs. This activity is being undertaken at ten centres.

1.4.2 Prototype Manufacturing

Eight Centres have Prototype Manufacturing Workshops (PMW). The basic functions of PMWs are multiplication of research prototypes and their supply to other centres for multi-location trials, development of manufacturing technology for new farm equipment and promotion of their manufacturing by involving local manufacturers. Besides, PMWs also cater to the needs of farmers for new farm equipment for the period during which manufacturers take up their designs for production.

1.4.3 Prototype Feasibility Testing

The activities on Prototype Feasibility Testing include:

a) Mechanization studies to identify crops and operations for which improved machines are required;
b) Identification of designs of farm implements and machinery which can be adopted to fill the identified mechanization gaps;
c) Procurement and feasibility testing of identified equipment on farmer's fields and their adaptation under local agro-climatic conditions;
d) Popularization of adapted farm implements and machinery among farmers and promoting their manufacturing by involving local manufacturers.

1.4.4 Front Line Demonstrations (FLD)

Under this activity, large scale demonstration of selected farm implements and machinery has been taken up by different centres on farmer's fields to:

a) Adapt new designs of farm equipment to bridge the identified mechanization gaps;
b) Test the efficacy of the identified equipment;
c) Popularize and commercialize the selected equipment; and
d) Obtain feedback from farmers for design refinement of the selected farm equipment.

1.4.5 Custom Hiring

This activity has been taken up in the project since 2011. It aims at establishment of custom hiring centres of farm equipment in different parts of the country:

a) To develop protocol and software for business model for entrepreneurship (custom hiring services) of improved farm implements and machinery.
b) To train rural unemployed youth in establishment of rural based service centres for distribution, repair and maintenance and custom hiring service of improved farm implements and machinery.

1.5 Centres under the Project and their Activities

There are 25 centres under the Project and their location and activities undertaken are shown in Fig.1.

a) Ten centres have R&D and eight centres have PMW activities.
b) All centres have PFT, FLD and custom hiring activities.

2. Farm Equipment Developed and Promoted Under the Scheme

2.1 Seedbed Preparation Equipment

Animal Drawn Patela Harrow

It is a secondary tillage equipment for clod crushing, stubble or trash collection, levelling and smoothening of land surface before seeding. It consists of a sal wood plank, trash collection hooks, cog wheel and lever for lifting. It is available in working width of 1.5 and 2.0 m. The frame carries a bar to which curved and pointed hooks are attached. The bar can be raised or lowered by means of the lever having a slotted sector to lock its position. It costs Rs. 6000/- and cost of operation is Rs. 560/ha. The effective field capacity of the equipment is 0.3 ha/h and labour requirement is 3-4 man-h/ha.

Power Tiller with Rotary Attachment

It is a single axle power unit to till the fields in dry condition and puddle the fields for rice crop. With other attachments, it can plough fields, make ridges and interculture in crops. It can renovate pastures, cut grasses, dig potatoes, spray insecticides, pump water and haul up to 1.5 t load. This implement is commercially available in the country and costs about Rs. 1,50,000/-. The cost of operation of rotary tiller is Rs. 1100/ha.

Tractor Mounted Pulverizing Roller Attachment to Tiller

Pulverizing roller is an attachment to commercially available cultivator. It pulverizes the soil and creates hardpan in the soil because of the impact of the blades on the soil. It consists of star wheels, central shaft, pulverizing members, mounting link and depth control tee. The pulverizing members are similar to lawn mower blades and are inserted in cast star wheels in such a way that it forms helical shape and progressively come in contact with soil. The roller is attached to the cultivator with the help of two mounting links. The savings in fuel and time with this machine are 20-35% and 20-30%, respectively. Additionally, it saves 20-30% water requirement for paddy fields due to better puddling. The cost of machine is Rs. 30,000/- and effective field capacity is 0.4 ha/h. There is a saving of Rs. 900/ha in cost of operation over traditional method.

Tractor Mounted Rotary Tiller

Tractor operated rotary tiller (also called Rotavator) is suitable for preparing seedbed in a single operation both in dry and wetland conditions. It is also suitable for incorporating straw and green manuring. It consists of a steel frame, a rotary shaft on which blades are mounted, power transmission system and gearbox. The blades are of L-type, made from medium

carbon steel or alloy steel, hardened and tempered to suitable hardness. The PTO of tractor drives the rotavator. The rotary motion of the PTO is transmitted to the shaft carrying the blades through gearbox and transmission system. Pulverizing of soil is more uniform and better because impact of revolving blades of rotavator shear the soil and make it fine. The use of a rotavator in paddy and wheat harvested fields saves fuel consumption of about 25-40% and 15-25%, respectively as compared to the conventional tillage implements. It saves about 40-60% of time and 20-30% of water during puddling. The cost of rotavator is Rs. 65,000 to 80,000 and its effective field capacity is 0.25 ha/h. There is a saving of Rs. 1000-1500/ha in cost of operation with rotary tiller as compared to traditional practice.

Tractor Operated Check Basin Former

A tractor operated check basin former has been developed at MPKV, Rahuri. The machine scrapes, collects and distributes the collected soil uniformly to form side bunds and cross bunds at regular interval of 6 m in a single pass. The size of check basin formed is 2 x 6 m. The effective field capacity of the machine is 0.15 ha/h and approx. cost of machine is Rs. 70,000/-. The cost of operation of the tractor operated check basin former is Rs. 3075/ha. It gives 96% saving in time and 32% in cost of operation as compared to conventional manual method.

2.2 Sowing, Planting and Trans-planting Equipment

Rotary Dibbler

It is a manually operated push type device for dibbling of medium and bold size seeds such as maize, soybean, sorghum, pigeon pea and bengal gram in well prepared seedbed. It consists of a rotating dibbling head with penetrating jaws, covering-cum-transport wheel, seed hopper with cell type wooden roller and a handle. Seed metering is cell type having six cells on periphery.The number of jaws varies from five to eight depending upon seed to seed distance. For its operation, the hopper is filled with seeds and transport-cum-covering wheel is drawn to rear side. The dibbler is then pushed forward in the direction of travel with covering cum transport wheel behind the dibbling head. The jaws penetrate into the soil and automatically drop the seeds. The seed to seed distance depends upon size of the polygon plate to which jaws are attached. This implement costs Rs 2300/- and its cost of operation is Rs 460/ha. It covers 0.6 to 1.0 ha/day and labour requirement is 27 man-h/ha.

Seeding Attachment to CIAE Animal Drawn Tool Frame

It is an attachment made for the bullock drawn CIAE multi-purpose tool frame and suitable for sowing wheat, gram, pea, soybean, sorghum and pigeon pea. It can apply granular fertilizers like urea and DAP. The hopper has compartments for fertilizer and seeds and the ground

wheel is a floating type thus enabling uniform seed placement even when the soil surface is not properly leveled. Seed metering device is of fluted rollers type and furrow openers are of shoe type. Separate side wheels allow accurate adjustment of the seed drill attachment and are also useful for transportation. The effective field capacity of the implement is 0.10-0.15 ha/h. This implement costs Rs 20,000/-. It saves 73% in labour and operating time and 55% in cost of operation as compared to conventional method of sowing behind country plough or seeding by broadcasting. It also results in 10 to 18% increase in yield as compared to sowing by conventional method.

Animal Drawn Three Row Seed cum Fertilizer Drill

It is an animal drawn simple, light weight and compact machine to sow crops like wheat, gram, sorghum, soybean, lentil, pea, sunflower, safflower etc and drill fertilizer in soil under rainfed condition. It consists of tubular steel section frame on which various components are mounted. The seed box is of mild steel and the metering mechanism uses aluminum-fluted rollers. The furrow openers are of shoe type and are made of medium carbon steel hardened and tempered for opening the furrow and placing the seeds at desired depth. The ground wheel provides the power needed for operating the seed metering mechanism and a pair of idler wheels on either side help in proper adjustment of depth of seed placement. A lever mechanism is also provided for raising and lowering the ground wheel on turns. A pair of bullocks can easily pull the implement. The working width of the machine is 225-700 mm. The weight of machine is 50 kg. The row spacing of the seed drill can be adjusted as per the requirement of the crop being sown. It costs Rs. 9000/- and cost of operation is Rs. 800/ha. The effective field capacity of equipment ranges 0.12 - 0.15 ha/h and labour requirement is 4-10 man-h/ha.

Bullock Drawn 4 Row Groundnut Planter

The groundnut farmers use the traditional practices of farm operations with the available bullock drawn implements which are labour intensive operations. The 4 row bullock drawn groundnut planter was developed at PJTSAU, Hyderabad and consists of seed hoper (8 kg capacity), trough feed type seed metering mechanism, ground wheel of 300 mm diameter and sprocket and chains for power transmission. The width of the planter is 1.2 m. The row to row and plant to plant spacing are 300 mm and 100 mm, respectively. The total weight of the machine is 55 kg and effective field capacity ranges 2.0-2.4 ha/day. The cost of equipment is Rs. 8000/- and cost of operation is Rs. 150/h.

Power Tiller Mounted Air Assisted Seed Drill

The germination percentage varies widely for small seeds such as sesame. A power tiller mounted an air assisted seed drill has been developed for drilling small seeds at the desired seed rate. The spacing between the rows can be adjusted from 300 mm for 4 rows to 600 mm for 2 rows. The effective field capacity of the machine is 0.25 ha/h. Lifting the tool bar can cut-off the power to seed metering shaft. The cost of operation with this machine is Rs. 750/ha as against Rs. 1200/ha for conventional method.

Power Tiller Operated Inclined Plate Planter

Power tiller operated 3 row inclined plate planter has been designed and developed at RCNEH, Barapani for sowing maize, soybean and pea crops in terraces and valley lands of NEH region. The power is transmitted from ground drive wheel to seed feed shaft through chain, sprockets and a set of bevel gears. The row to row spacing of the planter is adjustable (130-280 mm) by sliding the furrow openers on tool bar. Different crops can be sown by changing seed plates and by changing the transmission ratio. The effective field capacity of equipment is 0.12 ha/h in hilly region. The cost of inclined plate planter is Rs.12000/- and cost of operation is Rs. 1600/ha.

Self-propelled Rice Transplanter

It is suitable for transplanting paddy seedlings in puddled soils. It is a single wheel driven, riding type machine and fitted with diesel engine. It transplants seedlings from mat type nursery in eight rows in a single pass. The drive wheel receives power from the engine through V-belt, cone clutch and gearbox. A propeller shaft from the gearbox provides power to the transplanting mechanism mounted over the float. The float facilitates the transplanter to slide over the puddled surface. The tray containing mat type nursery for 8 rows is moved sideways by a scroll shaft mechanism, which converts rotary motion received from the engine through belt-pulley, gear and universal joint shaft into linear motion of a rod connected to the seedling tray having provision to reverse the direction of movement of tray after it reaches the extreme position at one end. Fixed fork with knock out lever type planting fingers (cranking type) are moved by a four bar linkage to give the designed locus to the tip of the planting finger. The cost of the equipment is approximately Rs. 2.25 lakh. It can transplant 1.2-1.5 ha/day with the help of 5 persons by working at a speed of 1.1-1.5 km/h. The cost of operation with the transplanter is Rs. 3,000/ha as compared to Rs. 5000/ha by traditional method. It saves about 65% labour and 40% cost of operation as compared to manual transplanting. Four row self-propelled walking type and six/eight row four wheels driven riding type self-propelled transplanter are also commercially available.

Tractor Operated Zero Till Seed cum Fertilizer Drill

It has been developed to sow wheat directly in rice harvested fields without preparing the seedbed. It is a 9/11/13-row unit consisting of fluted rollers for seed metering and agitators over adjustable openings for fertilizer metering. It is operated by 26 kW tractor and consists of tubular steel section frame, seed and fertilizer boxes, fluted roller metering mechanism for seeds, two depth control wheels for controlling sowing depth, inverted 'T' type furrow openers made of medium carbon steel with high speed steel tip in the front for opening narrow slits in untilled soil, ground drive wheel having lugs on its circumference and acts as a power source to drive the metering mechanism of the drill and power transmission system. The zero-till drill is operated in the field when the soil moisture is about 24-27% and the stubble height of previous harvested crop is not more than 150-200 mm. The effective field capacity of the machine is 0.3-0.4 ha/h with about 75% field efficiency. Use of zero-till drill for direct sowing of wheat after rice was found advantageous in terms of 50-60% saving in time and 40-50% saving in cost of sowing as compared to the conventional practice of seedbed preparation and sowing with seed-cum-fertilizer drill. The cost of machine is Rs. 45,000/-. The machine saves about Rs. 1000-1500/ha.

Tractor Mounted Bed Former cum Seeder

A bed-former-cum-seeder has been developed at PAU, Ludhiana for sowing wheat. The bed planter consists of a frame, planting hoppers, fertilizer box, furrow openers, bed shaper and power transmitting wheel. The frame is made of mild steel sections. The furrow openers are ridger type and have mouldboard and share point. The wing span of the mould board can be adjusted. The share is made of medium carbon steel or alloy steel, hardened and tempered to suitable hardness. The machine makes two beds. It can sow two or three rows of wheat on each bed. It has seed metering unit of vertical disc type. The draft requirement of the machine is reduced due to roller type bed shaper. A planting attachment has also been made with the machine for sowing maize, groundnut, cotton etc on the beds. The effective field capacity of machine is 0.26 ha/h. The approximate cost of equipment is Rs. 50,000/-. The cost of operation is about Rs. 4500/ha as compared to Rs. 3400/ha in conventional method. It saves about 20-30% water and 20% seeds.

Tractor Operated Inclined Plate Planter

Tractor operated 6-row inclined plate planter is a multi-crop planter for planting of bold and small seeds and developed at CIAE, Bhopal and PAU, Ludhiana. The planter consists of a frame with tool bar, modular seed boxes, furrow openers and ground drive wheel system. It has six modular design seed boxes with independent inclined plate type seed metering mechanism. Seed plates for sowing different seeds can be selected and changed easily. The plate thickness, number

and size of cells on seed plate vary according to seed size and desired plant-to-plant spacing. For operation, the seed is filled in the hopper, seeds are picked up by the cells of inclined plate and delivered in the opening connected to furrow opener through seed tubes. Shoe type furrow openers ensure deep seed placement in moist zone for sowing under dryland condition. Modular seed box furrow opener units are adjustable for sowing seeds at different row-to-row spacing. The plant to plant spacing can be varied by changing the transmission ratio. The drive to seed metering mechanism is transmitted from ground drive wheel through chain and sprockets. It can be adopted for sowing inter-crop on broad beds. The effective field capacity of the equipment is 0.42 ha/h with an effective width of coverage of 1.85 m. The approximate cost of the equipment is Rs. 40,000/-. The cost of operation is Rs. 2300/ha as compared to Rs. 3500/ha by conventional method.

Tractor Operated Small Seed Planter

A tractor (26.11 kW) operated six row planter has been designed and developed at PAU, Ludhiana for planting small seeds like onion. It consists of inclined plate type metering mechanism, seed hopper for each row, shovel type furrow openers and three point hitch system. The capacity of the seed hopper is about 1.5 kg and metering plate of 130 mm diameter is made of plastic. The power to the metering mechanism is provided from the lugged ground wheel. The row to row spacing of the machine is 150 mm whereas plant to plant spacing can be changed either by changing the plate with different number of notches or by changing the sprockets. The effective field capacity and cost of operation of the machine are 0.16 ha/h and Rs. 5090/ha, respectively at forward speed of 2.0 km/h for onion seeding. The sowing is done on beds having top width of 1.0 m to suit vegetable digger for digging the crop. There is saving of about 50% in cost of operation and 81% in labour requirement as compared to traditional method of onion sowing.

Tractor Operated Garlic Planter

A tractor operated six row garlic planter has been developed at PAU, Ludhiana with actuating spoon (23 mm diameter and 2.5 mm depth size) type metering mechanism for planting of garlic at 150 mm row spacing. It consists of seed metering plate, seed hopper, agitator and seed covering device. The power to the metering mechanism is provided from the ground wheel with the help of chain and sprockets. The garlic planter is evaluated for sowing garlic (Punjab Garlic 1 variety) on 1.0 m wide beds. The effective field capacity of the machine is 0.18-0.21 ha/h at a forward speed of 2.00 to 2.25 km/h. An average percentage of missing and multiples are 9.13 and 26.70%, respectively with the garlic planter. There is a saving of 82% in labour requirement and 57% in cost of operation as compared to manual planting. The approximate cost of the machine is Rs. 150,000 and cost of operation is Rs. 6200/ha.

Tractor Drawn Turmeric Rhizome Planter

A tractor drawn turmeric rhizome ridger planter has been designed and developed at TNAU, Coimbatore. The overall dimensions of machine are 2.00 x 2.06 x 1.03 m. It consists of 3 ridger bottoms and planting mechanism for planting on one side of the ridges in one pass. The planting mechanism includes rhizome hopper, cup feed seed metering mechanism, rhizome metering shaft, shoe type furrow opener and spike tooth ground wheel with chain sprocket drive for transmitting power from ground wheel to rhizome metering shaft. Three rows can be planted at a time at the required spacing. The effective field capacity of the implement is 0.15 ha/h and it costs Rs. 70,000/-. There are savings of 51%, 88% and 50% in cost of operation, labour and rhizome quantity, respectively as compared to traditional method of planting.

Tractor Operated Sett Cutter Planter for Sugarcane

The whole stick sugarcane cutter planter has been developed at ICAR-IISR, Lucknow and consists of ridger body attached to frame to create furrows, sett cutting unit, fertilizer application unit, chemical application unit, sett covering unit and seed box. The planter is PTO driven and mounted at three point linkage system of a tractor. The cutting of the cane of 350 mm length is done automatically in the machine and setts are treated with insecticides at the cutting point. The setts are placed in the furrow created by ridger bodies with overlapping up to 30%. The pesticide is also sprayed at the ends of sett in the furrows. The sett placed in the furrow is covered immediately after the treatment, the furrow is closed and rows are leveled by the leveler provided in the machine. The effective field capacity of the machine is 0.20 ha/h. The approximate cost of equipment is Rs. 50,000/-. The cost of operation of equipment is Rs. 2800/ha as compared to Rs. 4300/ha by traditional method.

Tractor Operated Sugarcane Seedling Transplanter

The tractor operated semi-automatic sugarcane transplanter has been developed at MPKV, Rahuri for transplanting sugarcane seedlings. It consists of main frame, two rotary drums, power transmission system, seedling tray, furrow openers, ground wheel, press wheels, seats for workers and depth control mechanism. The plant to plant and row to row spacing of the machine are 600 and 1500 mm, respectively. The working width and depth of the machine are 1500 and 148-150 mm, respectively. The average effective field capacity and field efficiency are 0.30 ha/h and 80.78%, respectively at forward speed of 2.56 km/h. The machine results in net saving of Rs. 2055/ha as compared to conventional method.

Tractor Operated Multi-crop Planter for Seed Spices

The sowing of seed spices is mainly done by broadcasting method or drilled in small plots at a spacing of 250-300 mm and depth of 10-15 mm. A 7 row multi-crop planter with individual hopper boxes and fertilizer drilling attachment has been developed at MPUAT, Udaipur. The seed metering mechanism of the planter is mounted on a common frame. The seed metering mechanism of star wheel (plastic) is made of circular rotor of 90 mm diameter with 10 cells of 20 mm length. The height of seed dropping from hopper is kept at 400 mm to get the placement of seeds at a depth of 10-15 mm. The inverted T type furrow opener of smaller size is fitted in the drill. The machine has been tested for sowing of cumin, coriander and fenugreek at NRC on Seed Spices, Ajmer and farmer's fields. The seed rate of 6.5-7.5, 12-15 and 9-10 kg/ha is recorded for cumin, fenugreek and coriander, respectively. The effective field capacity of machine is 0.28-0.30 ha/h with depth of seed placement of 12-15 mm.

Tractor Operated Pneumatic Planter

Tractor operated pneumatic planter has been developed at MPKV, Rahuri and is suitable for precision planting of single seed of crops like cotton, okra etc. at pre-determined spacing. It consists of main frame, aspirator blower, disc with holes, metering plate, individual hopper, furrow openers and ground wheel. Seed coming in contact with rotating disc gets stuck to the holes on the plate through suction and falls when suction is cut-off at the lowest position near the ground. The effective field capacity of the machine for planting okra is 0.29 ha/h with 85.22% field efficiency. There is saving in operating cost of Rs. 4826/ha as against traditional method for planting okra. The effective field capacity of the machine for cotton planting is 0.30 ha/h with 55.55% field efficiency. The saving in operating cost is Rs. 4600/-ha as against traditional method for cotton planting. There is a saving of costly seeds and labour requirement as compared to traditional method as thinning operation is eliminated.

Tractor Operated Vegetable Transplanter (Picker Wheel Type)

One of the major problems in vegetable cultivation is transplanting of seedlings. This requires lot of labour, which is very costly. A two row semi-automatic planter having picker wheel type metering mechanism has been developed at PAU, Ludhiana to transplant root wash type seedlings on the beds as well as on flat fields. Two persons (one for each row) are required to place the seedlings in the flappers when these open at the top position. After the seedling is dropped in the furrow, the soil is compacted around it with the help of two moving inclined wheels. The effective field capacity of machine is about 0.10 ha/h at forward speed of 1.0 km/h. The cost of operation with the machine is Rs. 2200/ha as compared to Rs. 2800/ha with manual transplanting.

Tractor Drawn Planter cum Boom Sprayer for Groundnut

A planter with four nozzles herbicide spraying attachment has been designed and developed at PJTSAU, Hyderabad for groundnut crop.The planter cum herbicide sprayer is suitable for simultaneous sowing and spraying of herbicide in groundnut crop. It consists of piston type pump, flat pattern nozzle on the boom, two drums of 220 l capacity each, seed box of 40 kg capacity and inclined plate metering mechanism for planting of seeds. The piston type pump receives the power from PTO shaft of tractor to pump the chemical from tank into nozzles through inlet and outlet pipes. The spraying attachment is fitted at the back of the planter which sprays the chemical uniformly after the furrow is closed by the covering blade. The effective working width of spraying is 2.40 m and the pump operating pressure ranges 200-500 kPa. The application rate of spraying unit is 492-612 l/ha. The effective field capacity of 8 row implement is 0.62 ha/h at forward speed of 2.5 km/h.

2.3 Interculture and Fertilizer Application Equipment

Wheel Hoe

It is a manually operated long handle push-pull type tool and widely used for weeding and interculture in row crops. The number of wheels varies from one to two and the diameter depends upon the design. The frame has got a provision to accommodate different types of soil working tools such as straight blades, reversible blades, sweeps, V-blade, tine cultivator, miniature furrower, spike harrow (rake) etc. The handle assembly has a provision to adjust the height of the handle to suit the operator. For operation, the working depth of the tool and handle height are adjusted. It covers 0.10 ha/day. It costs Rs. 800/- and cost of operation is Rs. 2000/ha.

Cono Weeder

The cono weeder is used to remove weeds between rows of paddy crop. The weeder consists of two rotors, float, frame and handle. The rotors are cone frustum in shape, smooth and serrated strips are welded on the surface along its length. The rotors are mounted in tandem with opposite orientation. The orientation of rotors creates a back and forth movement in the top 30 mm of soil. The float, rotors and handle are joined to the frame. The float controls working depth and does not allow rotor assembly to sink in the puddle. The push-pull operation of cono weeder in between rows makes weeding effective. It costs Rs. 1900/- and field capacity is 0.18 ha/day.

Self-propelled Power Weeder

The machine is useful in row crops and horticultural crops for weeding and seedbed preparation. It consists of a 4.1 kW diesel engine mounted on the power tiller chassis, power transmission system, two MS wheels, a frame and a rotary tiller. The power from the engine is transmitted to the rotary with the help of belt and chain and through gear train to the ground wheels. The rotary tiller has been provided with 16 blades fitted on high-pressure pipe of 37.5 mm diameter with the help of nuts and bolts to the flanges. For depth adjustment, two skids made of flat are provided on both sides of power tiller. A power cut-off device is provided to engage or disengage the power to the rotary system. The wheels with lugs are provided for traction. The speed of power weeder ranges 2.3-2.5 km/h with an effective working width of 550 mm giving effective field capacity of 0.10 to 0.13 ha/h. The cost of self-propelled power weeder is about Rs. 40,000 and average cost of weeding is Rs. 1000/ha. The equipment saves 90% operating time and 30% in cost of weeding as compared to hand weeding by khurpi.

Power Weeder for Low Land Rice

A two row power weeder has been developed at TNAU, Coimbatore in collaboration with M/s Premier Power Equipment & Product Pvt. Ltd., Coimbatore. It is suitable for doing timely weeding operation under all soil conditions in line sown and SRI paddy. It is a self-propelled, compact and light weight power weeder. It weighs 17 kg and consists of 1.30 kW engine, float and rotary cutting blades. There are four high speed rotating blades (300 rpm) on either side, which weed two rows at a time. The weeding width is 150 mm. Due to compactness and less weight, it is easily maneuverable between the crop rows at speed. The row spacing is 236 mm and hill spacing is 168 mm. The effective field capacity of the power weeder is 0.70 ha/day and is about 4 times higher than cono weeder. The average fuel consumption is 0.4 l/h. The commercial model of the weeder is being manufactured under the brand name Garuda.

Tractor Mounted 3-Row Rotary Weeder

A tractor mounted rotary weeder has been designed and developed at PAU, Ludhiana. It consists of a main frame, gearbox, three rotary weeding blade assemblies, a 40 mm square shaft for transmission of power from gearbox to rotary assemblies and a set of sprockets and chains. A standard 3-point hitch arrangement has been provided to mount the frame to tractor. Power from tractor PTO is transmitted to main square shaft through gearbox mounted on main frame and a set of sprockets and chain. It facilitates adjustment of row-to-row spacing from 675 to 1165 mm. The effective field capacity of machine is 0.24 ha/h with weeding efficiency of 83-87%. The approximate cost of this machine is Rs. 60,000/-. The cost of operation with the machine is Rs. 1700/ha for single weeding as compared to Rs. 3600/ha by manual weeding. The machine saves 54% labour and 74% cost of operation as compared to traditional method.

Fertilizer Band Placement cum Earthing up Machine

The tractor operated (26 kW and above) fertilizer band placement cum earthing up machine has been designed and developed at GBPUAT, Pantnagar. The machine is suitable for simultaneous placement of fertilizer, earthing up and cutting of weeds in crops such as maize, sugarcane, potato etc having more than 0.50 m row to row spacing. The urea fertilizer application rate ranges from 60 to 250 kg/ha. It helps in top dressing of fertilizer at 50 to 100 mm from the plant. The effective field capacity of machine is 0.56 ha/h with 82.4% field efficiency. The approximate cost of the machine is Rs. 50,000. There is considerable saving in fertilizer, time and labour over traditional method.

Tractor Operated Fertilizer Dibbler for Ratoon Sugarcane

The field after harvest of sugarcane is covered by a mat of trash up to a depth of 150 mm and punch application enables placement of fertilizer through crop residue. A tractor operated fertilizer dibbler for ratoon sugarcane has been designed and developed at TNAU, Coimbatore for placement of fertilizer without much soil disturbance and through crop residue. The principal components of the implement are revolving spade, fertilizer metering device, fertilizer placement funnel, soil covering and pressing device. The cost of the unit is Rs. 45,000/- and effective field capacity is 0.2 ha/h. The cost of operation is Rs. 1550/ha and results in saving of 60% as compared to the conventional method.

GPS Based Variable Rate Granular Fertilizer Applicator

A GPS based variable rate granular fertilizers (NPK) applicator has been developed at IIT Kharagpur and CIAE Bhopal to ensure ideal application of fertilizers as basal dose. It consists of a differential global positioning system (DGPS), micro-processor, micro-controller, DC motor actuator, power supply, threaded screw arrangement and fluted roller fitted metering mechanism. The fertilizer application rate is changed according to the prescribed application rate at the identified grid with coefficient of variation (CV) of 11.7-15.0%. The RMSE and relative differences (RD) at different levels of application rates range from 1.3 to 4.6 and from 1.75 to 6.56, respectively. The fertilizer application accuracy ranges from 89.3% to 98.1% at various discharge rates. It was observed that the developed variable rate fertilizer applicator (VRFA) was effective and accurate to respond to the target application rates with small delay of time. It was concluded that the developed VRFA system closely met the target fertilizer application rate at the selected grid.

2.4 Plant Protection Equipment

Multi Orchard Sprayer

It is suitable for spraying chemicals in orchards like grapes, citrus, pomegranate etc. It consists of an HTP (horizontal triplex piston) pump, trailed type main chassis with transport wheels, chemical tank with hydraulic agitation system, cut-off device and boom equipped with turbo nozzles. It is fitted with turbo nozzles operating at a pressure of 883-1766 kPa and generates droplets of 100-150 micron in size. The orientation of booms can be adjusted depending upon the plant size and their row spacing. The spray booms are mounted behind the operator. The boom covers half of the tree canopy on either side of the sprayer. It costs Rs. 60,000/- and can cover 0.40-0.70 ha/h at forward speed of 1.20-1.50 km/h.

Tractor Mounted Boom Sprayer

The sprayer essentially consists of a tank made of fibre glass or plastic, pump assembly, suction pipe with strainer, pressure gauges, pressure regulators, air chamber, delivery pipe and spray boom fitted with nozzles. The sprayer is mounted on 3-point linkages of the tractor and utilizes PTO power of the tractor to operate the pump of the sprayer. It uses high pressure and high discharge pump as the number of nozzles may be up to 20 depending upon the crop and make of the sprayer. Basically the spray boom can be arranged in two ways viz ground spray boom and overhead spray boom. For ground spray boom, the planting has to be done in rows keeping in view of track width of the tractor. The overhead spray boom is designed for tall field crops and planting is done in such a way that it leaves an unplanted strip of about 2.5 m width for operation of the tractor. Therefore, a planted strip may be 18-20 m wide and a fallow strip has to be left for tractor operation after every planted strip. There is a provision of raising the height of boom with increase in crop height.

Tractor Operated Aero Blast Sprayer

The machine consists of a tank of 400 litre capacity, pump, fan, control valve, filling unit, spout adjustable handle and spraying nozzles. The nozzles release the pesticide solution into stream of air blast produced by the centrifugal blower. The air blast distributes chemical in the form of very fine particles throughout its swath on one side of tractor. The major portion of swath is covered by the main blast through the main spout and auxiliary nozzles cover the swath area near the tractor. The sprayer is mounted on the tractor 3-point linkage and operated by tractor PTO. The orientation of air outlet can be adjusted for its direction and width of coverage. The machine can cover about 1.7 ha/h at a speed of 1.5 km/h. The application rate of sprayer can be varied from 100 to 400 l/ha depending upon different valve settings. The

effective width of sprayer is about 13.0 m. The unit price of aeroblast sprayer is Rs. 1.00 lakh. The cost of operation of this machine is Rs. 500/ha as against Rs. 700/ha by conventional method.

Ultrasonic Sensor Based Pomegranate Spraying System

A sensor based tractor mounted automatic spraying system has been developed at IIT Kharagpur for detection of plant canopy and spraying of liquid chemical over the detected plant canopy. The developed sprayer consists of ultrasonic sensors, micro-controller board, solenoid valves, one way valves, spray pump, pressure gauge, relief valve, nozzle and 12 V battery. The sensor, programmer and non-return valve are attached to commercial ASPEE air assisted spraying system for evaluating at MPKV Rahuri pomegranate research farm. In order to make the pomegranate sprayer independent of operating speed, a ground wheel with proximity sensor is attached to the spraying unit. The spraying system is tested with and without sensor with attachment of turbo and hollow cone nozzles. The effective field capacity and number of plants covered are 0.88 ha/h and 1370 plants/h, respectively. The application rate is found maximum (500 l/ha) for turbo nozzles without sensor and minimum (200 l/ha) for hollow cone nozzle with sensor. The percentage saving of liquid with the sprayer is 25-30% and 45-50% with turbo nozzles and hollow cone nozzles, respectively.

2.5 Harvesting and Threshing Equipment

Naveen Sickle

It is a serrated blade sickle suitable for harvesting wheat, rice and grasses. The wooden handle has a bend at the rear for better grip and to avoid hand injury during operation. It costs Rs. 60/- and cost of operation is Rs. 2000/ha. The effective field capacity of sickle is 0.018 ha/h and labour requirement is 80 man-h/ha.

Power Tiller Operated Vertical Conveyor Reaper

It is a power tiller front mounted, walk behind type reaper windrower suitable for harvesting and windrowing of erect rice crop. The reaping attachment consists of cutter bar, two crop conveyor belts, crop row dividers and star wheels. The cutter bar and conveyor belts are driven by engine through belt-pulley and safety clutch. The effective field capacity is 0.16-0.20 ha/h.The unit price is Rs. 40,000/ and its cost of operation is Rs. 1400/ha.

Self-propelled Vertical Conveyor Reaper

It is an engine operated, walk behind type harvester suitable for harvesting and windrowing cereals like wheat and paddy and oilseed crops. The reaper consists of engine, power transmission box, lugged wheels, cutter bar, crop row dividers, conveyor belts with lugs, star wheels, operator's controls and a sturdy frame. The engine power is transmitted to cutter bar

and conveyor belts through belt-pulleys. During forward motion of the reaper, crop row dividers divide the crop, which come in contact with cutter bar, where shearing of crop stems takes place. The cut crop is conveyed to one side of the machine by the conveyor belt fitted with lugs. The crop is bundled manually and transported to threshing yard. The effective field capacity of the machine is 0.15 - 0.17 ha/h. The cost of the machine is about Rs. 80,000. The cost of operation is Rs. 1150/ha with this machine as compared to Rs. 3200/ha by traditional method. There is a saving of 90-95% in labour and time and 63% in cost of operation as compared to conventional method.

Self-propelled Fodder Harvester (Cutter bar Type)

The self-propelled cutter bar type (CBT) forage harvesters are in extensive use for forage harvesting. The cutter bar is operated by a suitable engine (7.6 kW, air cooled). The cutter bar is fitted as an attachment to the reaper-binder machine. The machine is used for harvesting fodder crops like berseem and lucerne. The width of cut is 1.2 m and height of cut is 50-100 mm for berseem crop. The effective field capacity of the harvester is 0.4 ha/h at forward speed of 4.00 km/h.

Self-propelled Platform Type Fruits Harvesting System

Orchard management operations like harvesting, pruning, spraying and other canopy management practices in fruit trees such as mango, citrus and sapota are difficult and labour intensive. Hand picking continues to be the only method of fruit harvesting in India. Therefore, a self-propelled hydraulic multi-purpose system has been designed and developed at ICAR-CIAE, Bhopal for medium height fruit trees to increase harvesting/pruning efficiency in orchards. It has a maximum vertical reach of 6 m, load carrying capacity of 200 kg and can be operated at maximum ground speed of 3 km/h. This machine is designed with dimensions of 2.20 × 6.32 × 1.89 m and can be used as a platform to reach fruits on trees for easy picking. This machine is hydraulically powered by 8.7 kW petrol engine. Lifting and lowering of the platform, forward and backward movement, and steering of the machine are controlled by an operator from the platform. The machine is easy to operate and requires low maintenance. It can be operated safely on flat field as well as on hilly terrain having lateral as well longitudinal slope up to 5°. The operator is able to pick up 700-1100 mangoes/h depending upon the fruit density on the tree. The approximate cost of the machine is Rs. 7.50 lakh. The fuel consumption during harvesting of mango is 2 l/h.

Tractor Front Mounted Vertical Conveyor Reaper

The machine is used for harvesting cereal crops like wheat and paddy. It consists of a 76 mm pitch reciprocating cutter bar assembly, seven crop row dividers, and two vertical conveyor belts fitted with lugs, pressure springs, pulleys and gearbox for the power transmission system. The crop row dividers are fitted in front of the cutter bar assembly and the star wheels are mounted over the crop row dividers. The machine is mounted in front of the tractor and the power to the machine is given from tractor PTO. The height of the machine above ground is controlled by tractor hydraulic system with the help of pulleys and steel ropes. After the crop is cut by the cutter bar, it is held in a vertical position and delivered to one side of the machine by lugged belt conveyors and fall on the ground perpendicular to the direction of movement of machine in the form of a windrow. The effective field capacity of the machine is 0.4 ha/h at 2.5-3.5 km/h forward speed. The cost of operation is about Rs. 1600/- as against Rs. 3200/ha by traditional method.

Tractor Mounted Fodder Harvester

A tractor (41 kW) operated flail type harvester cum chopper cum loader has been designed to facilitate harvesting, chopping and loading operations simultaneously. The crops viz. bajra, sorghum, maize, barseem and oats with height 1.00 to 2.50 m and stalk density 20-80 plants/m² can be harvested successfully. The machine consists of a rotary shaft mounted with blades (flails) to harvest the crop, auger for conveying the cut crop, cutters for chopping and conveying chopped fodder through outlet into the trailer. The blades on the rotary shaft are staggered in three rows of 13 blades each on a horizontal axis perpendicular to the direction of motion. The blades cut the crop and auger conveys it to the chopper unit. The chopping mechanism having 4 blades cuts crops into pieces and the chopped material is thrown out at high speed and is filled into the hitched trailer to the machine. It also harvests lodged and over matured crop without any difficulty. The effective field capacity of the machine is 0.20 ha/h at a forward speed of 2.5-4.0 km/h. The cost of operation of the machine is Rs. 1500/ha against Rs. 3200/ha by conventional method.

Tractor Mounted Root Crop Harvester cum Elevator

A root crop harvester cum elevator has been developed at PAU, Ludhiana for digging onion and other root crops. The effective field capacity of the machine is 0.28, 0.24, 0.21 and 0.21 ha/h for digging of carrot, potato, garlic and onion crops, respectively at a forward speed of 2.78, 2.41, 2.10 and 2.10 km/h. The damage to tubers is 1.98, 1.92 1.22 and less than 1.0% for digging of carrot, potato, garlic and onion crops, respectively. The approximate cost of the machine is Rs. 60,000/-. The saving in cost of operation and labour for

harvesting onion, carrot and garlic is 52.28, 46.71, 52.28%, and 69.05, 59.29 and 69.05%, respectively as compared to manual harvesting.

Tractor Operated Groundnut Digger Elevator

A tractor operated (26 kW and above) groundnut digger elevator has been developed at PAU, Ludhiana. It consists of a digging blade of 1200 mm width, elevator cum pick up reel, fenders, gauge wheel, coulters and power transmission system. The front end of the pick-up cum elevator reel is adjustable based on depth of working of blade. The front end of the pick-up rod is adjusted such that the spikes comb about 30 mm of the top soil to lift vines gently from the loose soil. It digs the groundnut vines below the pod zone and elevates them by an elevator-picker reel (conveyor) for dropping on the ground. The soil attached to the vines is shaken off in the process and a windrow is formed with the help of deflector rods. The vines are dropped in such a manner that pods get exposed to the sun for speedy drying. The machine can uproot and invert 0.16-0.21 ha/h. The unit cost of the machine is Rs. 50,000/ and its cost of operation is Rs 3,200/ha.The machine saves 65% in labour and 32% in cost of operation.

Tractor Operated Garlic Harvester cum Windrower

Garlic harvesting is very time consuming and requires labour of about 30 man-days/ha. Farmers go for single pass of duck foot cultivator for loosening of garlic bulbs from soil and bulbs are collected manually. A tractor operated garlic harvester cum windrower has been developed at MPUAT, Udaipur for harvesting of garlic. The machine consists of a blade with triangular point knives mounted over a MS flat for its use in heavy soil for smaller size soil clods and less draft requirement. The machine has chain type separating mechanism made of MS bars of 12 mm at spacing of 38 mm along with horizontal vibrating forks of 250 mm length at spacing of 200 mm for good separation of soil from clods. The windrower unit is made of MS bars at spacing of 25 mm and mounted at 90 degree to conveyor direction in two unequal halves. The power is given by tractor pto to gearbox with a ratio of 1:1. The oscillating vibrating fork is also given power from gearbox with crank pinion arrangement. The effective field capacity of machine is 0.26 ha/h. The digging losses range 2-3 bulbs/m². The unit price of machine is Rs. 35,000/ and its cost of operation is Rs. 3,885/ha.

Tractor Operated Cassava Harvester

In India, cassava is presently harvested manually by loosening the soil with crowbar if the soil is compact. The plant is pulled up gently without dragging the roots. Dragging can cause bruises and cuts to roots which may lead to early deterioration. This operation requires about 40 man days/ha. A tractor operated cassava harvester has been developed at TNAU, Coimbatore to eliminate this laborious process. It consists of main frame, shanks, digging blade, hitching frame and depth adjustment wheels. It is

designed for both two rows and single row operation. The shank is designed as a bent leg plough with an angle of 150° to accommodate the dug cassava tubers. The blade angle of 5° is provided for easy penetration into the soil. The row spacing can be altered by moving the shanks in the main frame. The depth wheels are provided to adjust the depth of operation. The harvester is tested in association with M/s SPAC Tapioca Products Limited, Anthiyur and works well with two rows in sandy soils and with single row in heavy soils at optimum moisture content. The effective field capacity is 0.08 ha/h for single row and 0.17 ha/h for two rows machine. The undug tuber is 2.5% and damage to tubers is less than 1%. The unit price of the machine is Rs. 30,000/. The cost of operation of cassava harvester is Rs. 2,380/ha and saves 40% in cost as compared to manual harvesting.

Tractor Drawn Turmeric Digger

A 33.6 kW tractor drawn turmeric digger of 1.45 m width has been developed at PJTSAU, Hyderabad. The penetration of blade of the digger into the soil is easy at blade rake angle of 55° and an additional dead weight of 150 kg is required for deeper penetration. The implement can dug four rows at 300-350 mm depth in single pass at 2.5 km/h tractor speed with an effective field capacity of 0.36 ha/h. The developed turmeric digger works well for digging the turmeric rhizome lying 200-250 mm deep into soil, with negligible damage. The cost of the implement is Rs. 22,000-25,000/-. The cost of digging of turmeric with the implement is Rs. 4,830/ha.

Tubular Maize Sheller

It is a manually operated sheller suitable for shelling maize from dehusked cobs. Shelling is done by holding the sheller in left hand and gradually inserting the cob into the sheller by right hand with little forward and backward twist. The capacity of sheller is 15-20 kg/h. It costs Rs. 60/- and cost of operation is Rs. 75/kg.

Pedal Operated Thresher

It is suitable for threshing rice. It consists of wire-loop type threshing cylinder operated by foot pedal or motor. It saves 20% labour and 40% operating time as compared to conventional method of hand beating on a wooden platform. It costs Rs. 5,500/- and its cost of operation is Rs. 28/q.

Groundnut cum Castor Decorticator

It is a manually operated oscillating type device having cast iron shoes with triangular projections for decortication of groundnut and castor pods to separate kernels. Separate concaves are provided for decorticating groundnut and castor. It is not provided with cleaning device. It costs Rs. 2400/- and its cost of operation is Rs. 0.56/kg. It saves 98% in labour and operating time and 89% in cost of operation as compared to conventional method of hand shelling.

Power Operated Axial Flow Sunflower Thresher

An axial flow thresher is operated by 5.6 kW motor or tractor and is suitable for threshing sunflower. It consists of a feed hopper, bar type cylinder, thrower, two sieves, concave and a blower. The cylinder of length 1500 mm has two portions, the first one of 1300 mm is for threshing and the second one of 200 mm for straw throwing. The threshing portion has raised spikes. The cylinder concave clearance is 40 mm and is uniform throughout its length. The cylinder is hexagonal in shape and is fitted with seven louvers at a spacing of 180 mm. The cleaning system consists of a centrifugal blower and three sieves inclined at an angle of 7-15°. The axial flow thresher has a capacity of 8.0 q/h clean grains. The threshing efficiency of the thresher is more than 99%. The unit price is Rs. 80,000/. The cost of operation of this machine is Rs. 450/t as compared to Rs. 1000/t with conventional method. There is a saving of 85% in labour, 75% in time and 30% in cost of operation.

Power Operated Maize Dehusker cum Sheller

The machine has a threshing cylinder of 495 x 1460 mm size with peg type drum. It uses centrifugal type blower. There are three round sieves with 12.5 mm size holes in upper sieve, 7 mm in middle sieve and 3 mm in lower sieve. Concave clearance is kept about 50 mm and opening size of concave is 5.1 x 5.1 mm. Cylinder speed is kept at 13.7 m/s. The output of machine varies from 1.7 to 2.1 t/h at moisture content of 11.8 to 24.8%. The cleaning and threshing efficiency range 94-99% and 96-98%, respectively. The overall grain losses are from 0.65 to 1.42%. The percent recovery of grain with the machine is 97% as compared to 78.4% in manual threshing. The unit price of equipment is about Rs. 40,000. The cost of operation of this machine is Rs. 500/t against Rs. 1500/t by traditional method. There is a saving of about 60-70% in cost of operation and about 90% in labour as compared to traditional method of dehusking and threshing.

Whole Crop Maize Thresher

A whole crop maize thresher has been developed for shelling of maize cob and simultaneously converting stalk to chaff. The thresher is designed for 5.5 kW power with spike tooth cylinder having 6-7 bolts per row on periphery. Concave is prepared by placing 8 mm square bars at a spacing of 18 mm. Threshing speed is kept at 620 rpm. The output capacity of whole crop maize thresher is 210 kg/h. The output of grain is observed as 640 kg/h with chaff size of 18 to 52 mm. This chaff is fed to animals and 85% material is consumed in comparison to the whole stalk. The unit price of the machine is Rs. 70,000/-. Moreover, significant saving of Rs. 2000-2100/ha in labour was for detachment of cobs and transportation of crop from field to home.

Tractor or Electric Motor Operated Multi-crop Thresher for Seed Spices

The traditional practice of threshing of seed spices is either by beating on drums or on wooden logs or treading under tractor wheels on mud floors. It requires lots of labour and lot of dust and stone come in during the threshing process and are to be removed manually by hand sieves or cleaning machine in factories reducing the quality of seed spices. Therefore, a tractor/electric motor operated thresher has been developed at MPUAT, Udaipur in collaboration with M/s Make well Industries, Unjha (Gujarat) and evaluated for threshing of cumin and coriander crops. The drive to power transmission is given by telescoping shaft connected to PTO of tractor. An electric motor of 5.6 kW is mounted on frame so wherever electricity is available, thresher can be used with electric power. The output capacity of thresher is 240-260 kg/h. The unit price of thresher is Rs. 70,000.

High Capacity Multi crop Thresher

It is suitable for threshing wheat, maize, sorghum, rice, gram, pigeon pea, soybean, mustard, sunflower, safflower and linseed crops. It consists of spike tooth cylinder, aspirator type blower and sieve shaker. Two top covers, three concaves, three sieves and variable cylinder speeds (7-21 m/s) are provided for threshing different crops. Reciprocating sieve system consists of replaceable set of sieves and screens mounted on oscillating frame. The upper sieve separates chaff bigger than grain while lower screen let the dust and smaller particles than grain pass through thus help in delivering clean grain at main outlet. The grain output capacity is 16-20 q/h for wheat, 8-10 q/h for raya, 6-8 q/h for gram, 4-5 q/h for green gram, 4.0 q/h for moong and 5.0 q/h for guar crops. The machine is operated at the lowest cylinder speed of 300 rpm for moong to minimize the breakage while it is operated at 500 rpm for guar crop. Threshing efficiency, un-threshed grain and visible damage are 98-99%, 1.5-2.0% and 1.0%, respectively. Threshing efficiency and cleaning efficiency are observed to be within the recommended limit. An average total losses are about 5%. The cost of machine is Rs. 70,000/- to Rs. 80,000/ and operating cost is Rs. 250-300/h. The thresher is provided with four wheels made of cast iron for transportation and motor stand to fit the motor on it. It also has provision for attaching universal shaft for operating the thresher by tractor PTO.

Multi-crop Plot Thresher

It is suitable for precision threshing samples of wheat, gram, sorghum, soybean, safflower, pigeon pea and pearl millet of field experiments. It consists of a spike tooth cylinder, concave, aspirator blower and sieve shaker. The capacity of this equipment is 3-4 times higher over manual method of threshing crop samples. It has a grain recovery of over 99.5%. It costs Rs. 28,000/- with motor and cost of operation is Rs. 800-1300/t.

Tractor Operated Straw Combine

Straw reaper is pulled by a tractor of 34 kW with an attached trolley. Two persons are required for its operation. A straw reaper essentially consists of four main units viz. stubble cutting and collecting unit, feeding unit, straw bruising unit and '*bhusa*' blowing unit. Two different types of straw bruising mechanisms are commonly used in the existing models of straw combines. These include a spike tooth cylinder and serrated saw type mechanisms. Serrated saw type cylinders are mostly used in the straw combines for bruising. As soon as the attached trolley is completely filled with straw, it is unloaded near the dumping site normally located centrally or in the corner of the field and another trolley is attached. The effective field capacity of the machine varies from 0.4 to 0.6 ha/h at forward speed from 2.5 to 3.0 km/h. The average width of cut of the machine is 1.90 m. The straw recovery is about 55-60% and depends upon the stubbles height remaining in the field after harvesting by combine. Straw recovery rate varies from 25 to 35 q/ha. The grain collected in pan ranges from 50 to 100 kg/ha with recovery of 40 to 60%. The approximate cost of the machine is Rs. 1.50 to 2.00 lakh. The cost of operation is Rs. 1200/ha.

Tree Climber

In order to harvest coconut and arecanut at faster rate with proper safety, a tree climber has been developed at TNAU, Coimbatore. The climber made of M.S. square pipe consists of two components connected by adjustable belts. The upper component is provided with a seating arrangement and lower component is having provision for holding the foot. The rubber cushioning is provided at the portion of frames, which comes in contact with tree to avoid any damage to 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. The cost of operation with tree climber is Rs. 3500/ha as compared to Rs. 5000/ha with conventional system.

Tractor Operated Banana Clump Remover

Banana crop is maintained for two years to get the benefit of two harvests. The crop needs removal of clumps (plants along with root portion) after two years. During the process of removal of the clump, the mother plant along with the rhyzome and side suckers as a whole mass has to be removed so as to prepare the land for the next crop. Manual labourers do this operation using crowbars and spades. A tractor operated banana clump remover has been developed by adopting frame of nine tyne cultivator. Two sub-soiler shanks (100 x 15 x 1000 mm) with shares of size 190 x 40 x 5 mm are fitted to nine tyne cultivator frame at 225 mm spacing. These two sub-soilers work as a fork for removing the banana clump. A deflector is provided to push the soil sideways. The equipment is attached to the 3-point linkage of a 26 kW tractor. The effective field capacity of machine is 0.5 ha/h. The unit price of clump remover is Rs. 20,000/. The cost

of operation with the equipment is Rs 700/ha as compared to Rs. 2000-2500/ha during manual digging of clumps. Thus, there is a saving of Rs. 1300-1800/ha.

Power Operated Sugarcane Sett Cutter

Power operated (0.75 kW, 1440 rpm, single phase electric motor) sugarcane sett cutter has been developed at MPKV, Rahuri. It has four numbers of cutting blades to cut sugarcane setts. The capacity of the developed cutter is 6500 setts/h. The time required to cut setts for one hectare by the developed machine is 2.13 h. The cost of machine, cost of operation and time saving over manual operation are Rs. 75000, Rs. 300/ha and 93%, respectively.

Power Operated Onion Detopper cum Grader

Presently, detopping and grading of onion in our country are done manually which are very time consuming and labour intensive operations. A power operated onion detopper cum grader has been developed at MPKV, Rahuri. The machine consists of feeding mechanism, detopping mechanism and grading mechanism. Onions after detopping are graded in five grades of < 35 mm, 35-50 mm, 50-60 mm, 60-85 mm and > 85 mm. The average feeding rate, detopping capacity and efficiency are 277 kg/h, 238 kg/h and 86%, respectively. The average power requirement at load is 0.9 kW. The average onion leaf neck length before and after detopping are 315 mm and 23 mm, respectively. It is observed that 1.88, 44.73, 33.08, 20.29 and 0% onions are graded in grades of < 35, 35-50, 50-60, 60-85, > 85 mm, respectively. The approximate cost of power operated onion detopper cum grader is Rs. 85,000/-. Average cost of operation of onion detopper cum grader is Rs. 256/t as compared to Rs. 813/t during manual onion detopping and grading.

Power Operated Garlic Stem and Root Cutter

Power (0.75 kW electric motor) operated garlic stem and root cutter has been developed at MPUAT, Udaipur. It consists of main frame, feeding unit, clamping unit, cutting unit, power transmission unit and garlic bulb dropping chute. The feeding unit consists of two feeder boxes on opposite side of the machine to feed the garlic for cutting stem and root. The clamping unit is provided inside the feeder box to hold the garlic bulb and stem. The cutting unit consists of four pair of counter rotating root and stem cutters below each of the feeder box. The garlic bulb dropping chute is provided just below the cutting unit in such a way that garlic bulbs after cutting of root and stem collect in a tray. The mean output capacity with plain and serrated type cutters for one side of the feeder box is 33.89 kg/h and 33.15 kg/h, respectively. The mean cutting efficiency is 99.23, 99.14 and 98.90% for small, medium and large size garlic bulbs, respectively. The power requirement for cutting stem and root is 1.2 kWh.

At a Glance

Major technologies developed, promoted and commercialised under AICRP on FIM

Sl. No.	Name of Equipment	Power Source	Centre
1	Tractor drawn pulverizing roller attachment	Tractor 26.11 kW	PAU
2	Tractor drawn spiked clod crusher	Tractor 26.11 kW	GBPUAT
3	Tractor mounted rotavator	Tractor 26.11 kW	Comm.
4	Manually operated garlic planter	Two-three persons	PAU
5	Manually operated low land rice seeder	Two persons	TNAU
6	CIAE animal drawn planter	Bullock pair	CIAE
7	Self-propelled rice transplanter	Diesel engine 2.61 kW	KAU
8	Tractor mounted zero till drill	Tractor 26.11 kW	GBPUAT
9	Multi-crop seed drill cum planter	Tractor 26.11 kW	PAU
10	Pneumatic planter	Tractor 26.11 kW	CIAE
11	Tractor drawn inclined plate planter	Tractor 26.11 kW	CIAE
12	Tractor mounted raised bed planter	Tractor 26.11 kW or above	PAU
13	Automatic potato planter	Tractor 26.11 kW or above	PAU
14	Tractor operated sett cutter planter	Tractor 26.11 kW	IISR
15	Tractor mounted strip till drill	Tractor 26.11 kW	GBPUAT
16	PAU wheel hand hoe	One person	PAU
17	Self-propelled weeder	Diesel engine 2.61 kW	TNAU/ CIAE
18	Power weeder for low land rice	Petrol engine 1.30 kW	TNAU
19	Light weight power tiller/ weeder	Diesel engine 6.19 kW	TNAU
20	Self-propelled high clearance sprayer	Diesel engine 15 kW	PAU
21	Aeroblast sprayer	Tractor 26.11 kW	PAU
22	Self-propelled vertical conveyor reaper	Diesel engine 3.73 kW	CIAE

Sl. No.	Name of Equipment	Power Source	Centre
23	Tractor mounted vertical conveyor reaper	Tractor 26.11 kW	PAU
24	Tractor mounted fodder harvester	Tractor 26.11 kW or above	PAU
25	PAU Axial flow sunflower thresher	Electric motor 5.59 kW	PAU
26	Maize dehusker cum sheller	Electric motor 3.73 kW	PAU
27	Groundnut harvester	Tractor 26.11 kW	TNAU
28	Pedal operated thresher	Two persons	IIT
29	High capacity multi-crop thresher	Tractor 26.11 kW	CIAE
30	Straw combine	Tractor 26.11 kW	PAU
31	Tractor mounted root crop harvester	Tractor 26.11 kW	PAU

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Table 1. Cooperating Centres of All India Coordinated Research Project on Farm Implements & Machinery and Major Activities

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				R&D	PMW	PFT/ FLD
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AICRP on Farm Implements and Machinery

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				R&D	PMW	PFT/ FLD
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R&D - Research & Development
PMW - Prototype Manufacturing Workshop
PFT - Prototype Feasibility Testing
FLD - Front Line Demonstrations

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