Farm Mechanization in Rainfed Regions: Farm Implements Developed and Commercialized

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Foreword

Mechanization brings timeliness in field operations, precision in placement of inputs, reduced input cost, increasing productivity, removing drudgery in farm operations and imparts dignity to farm work, breaking inhibitions of educated youth in farm operations. Total power availability on Indian farms has increased at an average compound annual growth rate of 4.58 percent from 0.293 to 1.841 kW/ ha during the past 40 years. Combined share of human and draught animals in India has reduced from 60.8 % in 1971-72 to 10.1 % during 2012-2013.

As the human and draught animal power availability for agriculture is gradually diminishing, it is high time to adopt appropriate farm implements to reduce cost of cultivation and drudgery involved in farming operations. Particularly, farm mechanization in rainfed regions is a difficult task as the farmer's affordability is very much limited. Additionally, labour, and climate variability with weather aberrations is forcing farmers to ensure timeliness of critical agricultural operations. Dryland farmers cannot afford to fail in carrying out first sowing and face costly affair of re-sowing. Value addition at farm level is also an important factor to increase the profitability at farmers' level.

Since past 25 years, CRIDA has involved in design and development of various need based farm implements matching to power availability at farmer's level. Efforts in creating Institute and Industry linkage has given fruitful results in upscaling the successful technologies in very short time. This also has increased the adaptability of CRIDA implements by farmers for location specific needs.

I am happy that the authors have brought together all the successful and commercialized farm implements in one bulletin. This provides brief information about each implement and its utility apart from details on licensed manufacturing industry. I hope this bulletin will help the farmers, KVKs, policy makers and industry personnel to be aware of dryland mechanization progress and CRIDA's achievements in that direction. This further triggers the process of reaching unreached farmers. I congratulate all team members in bringing this bulletin in a brief and informative manner.

(Ch. Srinivasa Rao)

Preface

Farm mechanization in rainfed region faces challenges related to small holding farms coupled with location specific problems including variable soil conditions. Additionally, rainfed agriculture is challenged by vagaries of monsoon due to the climate variability. As the sowing window time is very narrow , it is difficult to complete sowing or to take chance for re-sowing if germination is effected by drastic variability in soil moisture availability. Often, weed management also causes major problem due to non availability of labour in peak seasons. Drudgery involved in all agricultural operations from sowing to threshing is discouraging rural youth and women to go for farming. In other words, present day rainfed agriculture is facing shortage of skilled labourers for completing important agricultural operations. Increased input cost of seed and fertilizer is driving many farmers to opt for precision based implements for mechanization of critical operations.

To solve these problems on client specific basis, CRIDA has initiated its mechanization research to design and develop the low cost farm implements to match the farmer's power availability. The first generation farm tool research was oriented towards bullock drawn equipment which performed well at field level. Encouraged by the success, the new initiatives in tractor drawn sowing and resource conservation equipment like six and nine row planters, Precision planter cum Herbicide applicator and Ridger cum Broad Bed and Furrow (BBF) planter were effectively transferred to the field level under Public Private Partnership mode through Industry Linkages. This has revolutionized farm mechanization research at CRIDA since many of the technologies have reached the unreached in a short time. Efforts in development of threshing and post harvest equipment resulted in outcome of Vegetable Preservator, Castor Sheller, Herbal Dryer and Dhal Mill which helped the farmers in primary processing and also resulted in value addition to farm products. A strong institute- industry linkage created by the CRIDA helped in refinement and upscaling the technologies at on-farm level.

This publication gives brief information regarding description and utility of successful farm implements which have been already commercialized along with approximate price and operational cost. Costs mentioned are subject to variation due to local factors like taxes and fluctuations in raw material cost. The list of the licensed industries for each implement is also given as a contact reference. We hope that this Bulletin helps in identifying suitable farm implements for the specific need of the farmers and related small scale industries towards their entrepreneurship. Finally the authors acknowledge the motivation, encouragement and help rendered by Director and staff members of CRIDA.

Authors

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Introduction

India's basic needs and economy is mainly dependent on agriculture. It contributes 14 per cent of the country's GDP, 11 % of its exports and 60 per cent of the employment potential. Rainfed agriculture occupies 55 percent net sown area, contributing 40 percent of food grain production and supporting 40 percent of the population. Resource poor farmers cannot afford to buy high cost equipment that are available in market. Additionally, varied cropping systems and soil conditions demand location specific and cost effective implements. The increased cost of cultivation during recent past coupled with reduction in draught animal power is forcing the rainfed farmers to go for suitable farm implements. Though total power availability on Indian farms has increased at 4.58 per cent from 0.293 to 1.841 k.W/ha during last 40 years, combined share of agricultural workers and draught animals has reduced from 60.3 percent in 1971-72 to 10.1 percent during 2012-2013 (Mehata et al, 2014).

Farm mechanization in dryland agriculture play a vital role in reducing cost of crop production and increase in cropping intensity. During 1975-76, cropping intensity was 120 % with power availability of 0.36 k.W/ha and it increased to 141% with the power availability of 0.36 k.W/ha. In the past four decades, CRIDA-AICRPDA (All India Coordinated Research Project on Dryland Agriculture) mechanization research helped in evolving new technologies with location specific recommendations that increased the cropping intensity apart from meeting the timeliness and precision in dryland agriculture. Since many years, farm machinery has become one of the important inputs that improve the efficiency in field operations at lower cost with high precision, ensuring comfort with reduced drudgery. It has been widely proved that the mechanization of various field operations increases the overall productivity by12 to 34 percent, facilitates enhancement of cropping intensity by 5 to 22 percent and more than all, increases gross income to farmers by 29 to 40 percent (Srivastava, 1993). Use of improved farm equipment has shown yield advantage of 15-20 percent over a base yield of 200-400 kg/ha (Singh 1995, Srinivas 2009). Deficit farm power is one of the impediment in timely completion of operations in drylands. Diminishing number of draught animal and diversion of agricultural labour to non-agricultural activities during peak operation season has created a farm power crisis in dryland farming. Hence, meeting farm power requirements with mechanical power sources like tractors and power tillers has become essential for sustenance of drylands. Although tractors are adapted in some dryland regions like Malwa (Madhya Pradesh), parts of Punjab, Uttar Pradesh and Haryana, Other dryland regions are still suffering from farm power deficit. After 1990, situation changed with the new policies that encouraged tractor use through financial assistance..

Off-late (2005-2010), innovations towards light weight and precision bullock drawn equipment like drill plough, plough planter, 2,3,4 row seed drills, 6,9-row tractor drawn seed plantess with inclined plate mechanism attracted the farmers and industrialists because of significant saving in seed (20 %) and fertilizer (30 %) apart from increase in crop yields (15-20 %) .

The NATP mission mode project on dryland mechanization (2001-2004) helped in developing the complete package of crop based machinery at different centres which included crop-region combinations like Castor-Hyderabad, Maize-Arjia, Sorghum-Solapur, Rice-Varanasi, Fingermillet-

Banglore, Soyabean-Indore, Pearlmillet-Hissar, Cotton-Akola and Grounnut-Anantapur. Products from these project like CRIDA 9-row multi crop planter, Castor sheller, Maize sheller, Groundnut digger, Cotton weeder, Ridger planter, Tractor drawn weeders, Orchard sprayer, Tree hole digger were upscaled through 14 Industries in 12 different States. It is observed that crop yields have increased by 12-35 % in addition to saving in crop production cost by 15-45 % in different cropping systems (Mayande, 2004). New model of workable farm machinery custom hiring centres backed by the local industries, met the crop specific machinery requirement of different cropping systems. This enabled easy availability of implements to the farmers at low rental cost. The same model was upscaled in the NICRA project in 100 KVKs in addition to 23 AICRPDA centres (Srinivasarao et al 2013).

Development of Precision Planter cum Herbicide Applicator that takes care work even in undulated lands has increased the precision in placement of seed and fertilizers (in reduced and zero tilled soils also). This intervention alone saved 30 percent of the energy requirement in crop production. Additionally, this will help in sowing operation in the field with standing residue without any problem.

New outcomes of resource conservation equipment like 3-row ridger Seeder, Paired row Planter and Broad bed furrow multi crop planters already created demand in farming community, due to considerable yield increase that were shown to them during on-farm demonstrations. Public-Private Partnership mode of new initiative in mechanization research is helping to upscale the successful implements among farming community in different states through industries. This bulletin provides details of improved implements developed by CRIDA under different projects that have been commercialized through the MoU (Memorandum of Understanding) signed industries.

Improved Implements and Devices for Different Agricultural Operations

I. Improved sowing equipment

Purpose

Timely seeding is essential in rainfed farming. Delayed sowing beyond normal window period prolong growing causing moisture stress on maturing crops. With the current seeding practices, farmers are unable to sow the crop at appropriate time because the conventional devices are slow in operation. In other hand, these devices require high labour input, thereby, increasing cost of production. Mostly unskilled farm hands drop the seed and fertilizer leading to gaps and bunching of plants in a row which results in non-uniform crop stand. The non-uniform crop stand create imbalance in utilization of nutrients and moisture reducing the crop productivity. To overcome these limitations and improve the productivity at reduced cost of production, improved designs of ferti-seed planters are needed. CRIDA developed user friendly models of seed-cum-ferti-drills and planters to meet the location-specific needs of the farmers. Field experiments were conducted and the models were upgraded and scaled up to cater the need of different categories of dryland farmers based on size of holding, draft power available and their purchasing power (Mayande et al., 2004).

These models are: (1) drill plough (2) plough planter (3) two-row planter (4) four-row planter (5) six-row planter (6) nine-row planter (7) Ridger planter and (8) Precision planter cum Herbicide applicator. These models are versatile with adjustability in depth and row spacing. Multi row units can be used to sow intercrops of different row ratios. Most of the dryland crops can be sown simply by changing the seed metering plates. Seed metering plates are designed to match the seed size and to obtain recommended seed spacing within the row. Fertilizer mechanism is suitable for drilling granular fertilizers only. The rate of application can be adjusted by adjusting the size of the orifice.

1. Drill Plough

Description: An inexpensive and efficient seed cum fertilizer placement device was developed at CRIDA for attachment to country plough. Seed and fertilizer are automatically metered by agitator and orifice mechanism and the furrow is covered by a floating blade attached to the unit. It required only a third of human labour and half of the bullock labour per hectare (ha) as compared to the traditional plough seeding technique (Fig.1).

Specifications of the drill plough

Length (mm)	: 430
Width (mm)	: 410
Height (mm)	: 420
Metering system for seedsand fertilizer	: Stationary metering plate with opening and a rubber agitator
Method of seed and changing fertilizer Quantity	: By changing metering plate
Field capacity	: 0.8-1.0 ha/day
Source of power	: One pair of bullocks

Fig.1 Drill plough

Advantages

- Compatible with country plough
- Simultaneous placement of seed and fertilizers
- Simultaneous seed covering
- Double area coverage
- Optimum crop stand
- Saving on labour
- Increased crop yield and profit because of timeliness and precision placement of seed and fertilizer

Suitability: All rainfed crops

Approximate cost: Rs. 2250/-

Cost of Operation: Rs. 2000/ha

2. Plough Planter

Description: The planter is similar to the drill-plough operation except that it has an inclined plate seed metering mechanism to obtain uniform intra-row spacing which is crucial to minimize competition for water and nutrient. This unit is supported by two wheels; pegged wheel at left, and plain wheel at right. The metering plates are rotated by the power transmitted by drive wheel through shaft and bevel gears. The cells in the metering plate are cast to match the seed size and shape. The number of seed cells per plate is designed to obtain desired seed spacing within a row (Fig 2.).

Specifications

Field coverage	: 0.8-1.0 ha / day
Source of power	: One pair of bullocks
Length (wheel to wheel)	: 520 mm
Length (only Box)	: 250 mm
Width	: 360 mm
Height	: 250 mm
Weight	: 16- 18Kgs
Ground wheel dia	: 390 mm

Fig 2. Plough planter

Advantages

- Optimum crop stand
- Suitability for all dry farming areas
- Compatible with country plough
- Precision seed metering and placement

- Uniform seed to seed distance
- Negligible maintenance cost
- Simultaneous application of seed and fertilizer

Suitability

For all rainfed crops where the plant to plant spacing is maintained

Approximate cost: Rs. 3000/-

Cost of operation: Rs. 2000/ ha

3. Two-row planter

Description: This is an upgraded model of plough planter with separate furrow openers for each row. It consists of a rectangular frame, hopper box, drive mechanism, guide wheels, two furrow openers, metering plates, seed tubes and other accessories. The inclined plate mechanism for seeding and agitator-orifice mechanism for fertilizing are used. The metering plates for groundnut, maize and other crops are designed to meet farmer's needs. The same metering plates can be used for single row, two row and four row planters. The gauge wheels with predetermined standard size are used for depth adjustment. The row spacing is balanceable with lateral shifting of furrow openers on the frame (Fig.3). It is recommended to the regions where the average bullock height and draft power is less. It can also be used in hilly regions.

Specifications

Field capacity	:	1.5-2.0 ha/ day
Source of power	:	one pair of bullocks
Length	:	740 mm
Length (only Box)	:	250 mm
Width	:	260 mm
Height	:	950 mm
Weight	:	74-80 Kgs
Ground wheel dia	:	340 mm
Length	:	430 mm
Width	:	380 mm
Height	:	260 mm
Beam Length	:	3000 mm

Fig.3.Two row planter

Advantages

- Two–row sowing and fertilizing at a time
- Row spacing and adjustable seed depth
- Uniform seed to seed distance
- Light weight

- Maintenance cost negligible
- Increased crop yield and profit

Suitability

It is suitable for all rainfed crops. Women friendly machine and is useful to the regions where the average bullock height is less.

Approximate cost: Rs. 16500/-

Cost of operation: Rs. 1500/ha.

4. Three Row /Four-Row Planter

Description: The upgraded frame of earlier planter is made to accommodate three row or four row Seed and Fertilizer box planter configuration. This planter (Fig.4) uses the inclined plate mechanism and is developed to meet the requirements of medium scale farmers. The depth of seeding is adjustable. The seed metering mechanism is based on inclined plate principle which is the same as for single or two row planters. It consists of a seed and fertilizer box which is mounted on a rectangular wheeled frame, guide wheels, drive mechanism, furrow openers, metering plates and seed tubes.

Specifications

Weight	: 45-55 kg
Source of power	: One pair of bullocks
Field coverage	: 3.0-3.5 ha/day
Overall dimensions	: 1090X 260X 950 mm
Main frame	: 1090 X 260 mm
Seed box	: 630 X 45 X 15 mm
Shank	: 460 X 45 X 15 mm
Beam	: 3000 mm length
	dia. 60 mm

Fig. 4 Three row planter

Advantages

- Four- row sowing/fertilizing at a time
- Row spacing and adjustable
- Uniform seed to seed distance
- Adjustable seed depth
- Faster coverage
- Labour and seed saving
- Increased crop yield and profit

This planter was evaluated in the field by conducting various field studies and the data was given below in comparison to local method (Table-1)

Table 1: Comparative performance of four row planter over local drill (Groundnut crop).

Seeding device	Man (hrs/ha)	Bullock (hrs/ha)	Field coverage (ha/hr)	Plant stand/ ha (000)	Within row variation (CV %)	Yield (kg/ha)
CRIDA planter	2.4	2.4	0.4	300	58	1875
Local drill	7.2	4.8	0.21	270	83	1562

Suitability

It is suitable to all rainfed crops sowing and is recommended to the regions where the Bullock draft power is at medium level.

Approximate cost: Rs. 17500/- for 3- row bullock drawn planter and Rs. 18500 for 4- row bullock drawn planter

Cost of Operation: Rs. 700/ha for 4- row planter and Rs. 800/ ha for 3 row planter

5. Six-Row Planter

Description: There are many farmers in rainfed regions who own tractors. To suit their power availability six row planter (Fig. 5) was developed. The mechanism for seeding and fertilizing is similar to 4- row planter unit which was scaled up to match tractor powered tiller frame. The design consist of hopper box for seed and fertilizer, drive mechanism, mounting frame, seed tubes and metering plates. Row to row spacing can be maintained by adjusting the shanks on the frame as per the recommended spacing. A chain or wooden plank or a iron pipe can be fitted or hinged at the back to cover the furrows after seed and fertlizer placement if needed. The performance of six-row planter over traditional method is given in Table 2.

Specifications

Field coverage : 6-7 ha/ day
Source of power : Tractor
Overall dimensions : 1650 X 580 X 960 mm
(length Width X height)
Main frame : 1659 X 580
Seed box : 1630 X 430 X 300
Shank : 450 X 65 X 20
(length Xwidth X thick)
Weight : 235 to 240 kg

Fig. 5. Six row planter

Advantages

- Six-row sowing and fertilizing at a time
- Effective soil covering
- Uniform seed to seed distance
- Faster coverage
- Increased crop yield and profit
- Time saving by 80 % and labour saving
- 30 % saving in seed and fertilizer when compared to the conventional.

Table 2: Comparative Performance of CRIDA Planter over traditional method

Implement	Area (ha)	Field capacity (ha/hr)	Plant stand (per ha)	Germination(%)	Yield (kg/ha)	Cost of sowing (Rs/ha)
CRIDA castor planter	40	1.1	65000	88	430	600
Traditional method (behind country plough)	2	0.15	52000	79	350	2000

Suitability: For all types of soils and crops.

Approximate cost: Rs. 41000/-

Cost of operation: Rs. 600 - 800/ha based on the tractor hiring charges

6. Nine-Row Planter for closed space crops

Description: This planter (Fig. 6) is introduced to sow groundnut, soybean and other closely spaced crops with mechanical advantage and intercropping facility. The inclined plate seed metering mechanism will meet the precise seed to seed distance and maintain the recommended seed rate. The seed damage is negligible for the seeds like groundnut and other crops. The frame allows flexible row to row spacing because of which matching intercrops can be taken up.

Specifications

Field capacity : 7-8 ha/day
Source of power : 35 h.p.Tractor

Overall frame dimensions

Length : 2500 mm
Width : 580 mm
Height : 1100 mm

Box Dimensions

Length : 2500 mm
Width : 600 mm
Height : 380 mm
Weight : 295-310 Kgs

Fig. 6.Nine row planter

Advantages

- Nine-row sowing at a time
- Suitable for all intercropping systems.
- Faster coverage
- Labour and seed saving
- Uniform seed to seed distance

Suitability: It is suitable to medium to large size farms.

Approximate cost: Rs. 43500/-

Cost of operation: Rs. 500- 800/- ha as per the tractor hiring charges.

7. Precision planter cum Herbicide applicator

Purpose: Precision planter cum herbicide applicator was developed to meet the timeliness and precision for sowing operation in all types of ecosystems with a special focus for undulated lands which are most commonly seen in rainfed ecosystem. Apart from sowing operation, the pre emergence herbicide can also be sprayed during the sowing operation which controls the weeds effectively.

Description: The machine mainly consists of rigid frame attached with individual seed cum fertilizer boxes on the top and spring loaded swinging type tynes with slit type furrow openers at the bottom to open the soil very narrowly in which the seed and fertilizer are dropped at the recommended spacing and depth (Fig.7). The seed is dropped with the help of a well controlled inclined plate seed metering mechanism and the fertilizer is dropped with a spring auger. The herbicide is stored in a tank mounted on the rigid frame. A pump with 150 W capacity gets the power from an inverter which in turn gets the power from the battery (Korwar et al.,2012). The nozzles mounted on a pipe behind the planter sprays the adjusted dose of herbicide all along the width of the planter. Specifications are given below:

Specifications

Power source for hauling	Tractor (35 hp)
Number of rows	3 to 5
Row spacing	30-90 cm
Herbicide tank capacity	150 lits
Pump	0.2 hp,1200 lph
Nozzles	Flat fan nozzle
Power source for herbicide pump	Tractor battery (12 Volts) DC
Inverter (capacity)	DC to AC (650 VA)
Field coverage	0.4 ha/hour

Fig. 7.Precision planter cum herbicide applicator

Advantages

- High precision with considerable labour saving.
- It facilitates to apply the seed, fertilizer and pre-germination herbicide at a time.
- Reduce weed infestation.
- Faster field coverage enables completion of timely seeding.
- Precision placement of seed and fertilizer as their traveling distance is less
- It can do three operations at a time viz., seed sowing, fertilizer application and herbicide spraying.
- It can work well in two way sloppy lands because of individually operated spring loaded tines.
- Separate seed and fertilizer boxes are available for inter-cropping.
- Separate seed metering plates are available for different crops.

Suitability

It is highly suitable to undulated lands and for the fields where reduced tillage is recommended. This can also be effectively used for precision sowing in all the soils.

Approximate cost: Rs. 55000/-

Cost of operation : Rs. 1250/ ha

8. Three row Ridger planter /BBF planter

Purpose: The ridger planter is specifically designed to meet the requirements of rainfed agriculture in which the soil and water conservation plays a major role in crop production. This helps in in-situ rain water at on farm level during the season apart from sowing the seed and placing the fertilizer on the ridges at proper depth and placement. The broad furrows formed by the planter helps in conserving the rain water during the season and also works as drainage channels to drain out the excess water if heavy downpour occurs to save the crop during the initial drought and from excess flooding.

Description: It consists of a rigid frame with three point hitch mounting arrangement. Four ridgers were fixed on the frame with dimensions of 2500 x 750 mm. The ridger wings are adjustable to form a broad furrow of 35 cm to 65 cm wide according to crop geometry needs and the depth of conservation furrow can be made at 20-35 cm as per the soil conditions. The narrow headed furrow

Fig. 8. Three row ridger planter cum BBF planter

Fig. 9. Redgram sown with ridger planter

opener opens a small seed furrow on top of the ridge and the seed falls into the furrow at proper depth based on the tractor hydraulic depth control. The depth of seed furrow varies 25-60 mm. The fertilizer will be delivered into the furrow through spring auger mechanism (Srinivas et al., 2010). It forms three furrows during the tractor forward operation and the first ridger runs in the fourth furrow during its return to maintain the symmetry in formation of furrows and ridges based on the crop geometry requirement.

Specifications

Field capacity	:	7-8 ha/day
Source of power	:	45 h.p.Tractor

Overall frame dimensions

Length	:	2500 mm
Width	:	580 mm
Height	:	1100 mm

Box Dimensions

Length	:	2500 mm
Width	:	600 mm
Height	:	380 mm
Weight	:	350Kgs
No. of ridgers	:	4
Ridger operating width	:	45-65 cm
Ridger operating depth	:	20-35 cm

Advantages

1. It is used for in-situ water conservation.

2. Precision seed and fertilizer placement on ridges along with conservation furrows.

3. It saves labour and energy by 80 % over conventional a method.

Suitability

The ridger planter was successfully used for sowing the castor, groundnut, maize, sorghum and cotton. It can also be used as BBF planter wherever required with minor adjustment.

Approximate cost: Rs. 60000/-

Cost of operation: Rs. 800/ha

II. Weeding and Interculture Equipment

Weeding is considered as most critical operation in rainfed agriculture. As the resources are limited, they compete with the main crop if not removed and effects the crop yields drastically. Apart from this, the limited moisture availability during the season reduces the number of optimum weeding days. To overcome this, CRIDA has developed improved manual, bullock drawn and tractor drawn weeders to match the different power sources and needs of farmers (Mayande et al., 2004). These tools create soil mulch apart from removal of weeds. These also proved in improving the efficiency of available power and make best use of available moisture while reducing the cost of operation.

1. Manual weeder

Description: This is manually pushed wheeled device followed by vertically adjustable sweep or blade mounted on a tool frame (Fig. 10). A long handle with wooden grip provides most comfort to men or women operating the tool. It is simple, low cost and easily adoptable equipment. It consists of 3 blades which can fixes as per the width of operation (Fig.11).

Fig. 10. Close up view of Manual weeder

Fig. 11. Weeding in vegetable crop

Specifications

Components	Size (mm)
Field capacity	0.14-0.16 ha/day
Wheel dia.	1540
Adjustable flat (Length X width X thickness)	430X20X3
Tyne frame (Length X width X thickness	590X20X5
Tyne(Length X width X thickness	165X10X10
Intercultural blade Length X width X thickness	165X20X5

Advantages

- Low cost
- Compatible with operator
- Saving in time (72%)
- Saving in labour

Suitability

Weeding in closely spaced crops and vegetable garden, It is a women friendly tool.

Approximate cost: Rs. 1100/-

Cost of operation: Rs. 1000/ha

2. Spike tooth type Manual Weeder

Description: The first model (Fig. 12) of manual weeder consists of a spoked wheel (30cm diameter) made of either 16mm diameter rod or 24X3mm size mild steel flat. Two bent metal pipes of 18mm one ends are fixed to the wheel bushing using a small shaft on either side to function as a frame of the implement. Behind and close to the wheel, vertically adjustable shank of the weeding blade is fitted using bolt and nut to the frame**.** The other ends of the metal pipes are joined to a straight or crescent shape bent pipe to function as handle to the implement.

Fig. 12. Spiked double ring weeder

Specifications

Support wheel : Spiked double ring, 30 cm diameter

Blade shape : Flat / crescent / V - shape

Advantages

- These models are simple in design and could be easily replicated by rural artisans at low cost.
- Adoptable to wide range of vegetables as well as rainfed crops by replacing the soil working component i.e. blades.
- Suitable to both for women and men farmers alike in operation due to adjustable height in few inches to suite to stature of agricultural workers.
- Highly suitable to carry contract weeding job by agriculture based landless poor and small farmers during weeding season.

Suitability

To remove weeds in line sown various vegetable crops and rainfed crops such as sorghum, maize, red gram, castor, groundnut, cotton, soyabean etc.

Approximate cost: Rs. 1100/-

Cost of operation: Rs. 1000/ha

3. Bullock Drawn Weeder

A metal tool frame on which a single narrow shovel with shank is mounted at front center of the frame and at rear a blade matching to crop row spacing is mounted (Fig. 13). A pipe beam is attached to the frame, which is hitched by a pair of bullocks. The blades are either straight or V – shaped depending upon the field condition and weed intensity. Since all components are made of metal, it is long lasting with negligible maintenance. The tools, not only effective in removing the weeds but also creating a concave structure between the rows for capturing the rain water and also supporting the plants with soil mass. This requires one pair of bullock and one person.

Fig. 13. Bullock drawn weeder

Specifications

Field coverage : 0.8-0.9 ha/ day

Source of power : one pair of bullocks

Operation blade width: 300-450 cm

Length of the beam : 3000 mm

Advantages

- Light weight
- Low cost
- Controls weeds effectively and cover the area much faster than conventional tool and does the earthing up operation.

Suitability

It is suitable to the broad row spaced crops where bullocks can easily enter.

Approximate cost: Rs. 2250/-

Cost of operation: Rs. 1500/ha

4. Tractor Drawn Weeder

Tractor drawn cultivator frame is used to mount different sizes of straight and V- blades depending on crop row spacing (Fig. 14). This can cover 3-5 rows at a time. This is most suitable in the field sown by tractor drawn planter. If the row to row spacing of crops is less, we can recommend to use the appropriate weeder along with tractor mounted with narrow width tyres (around 25 cm width) so that the plant damage can be avoided. Normally one to two weedings with this tool will create the weed free environment and the yields will also be improved.

Fig. 14. Tractor drawn weeder

Specifications

Field coverage : 6-7 ha/ day

Source of power: Tractor

Operating width : 30-45 cm

Advantages

- Faster coverage
- Efficient weed control
- Creating soil mulch
- Low cost of operation
- Effective earthing up with good crop anchoring with adjacent soil

Suitability

It is suitable to the broad row spaced crops in which tractor wheels can easily go.

Approximate cost: Rs. 1500- (3 blades set cost)

Cost of operation: Rs. 1200//ha

III. Spraying Equipment

Orchard Sprayer

Purpose: Orchard crops suffer from heavy attack of pest and diseases which cause about 20 to 40 per cent yield losses. This can be prevented by timely spraying of pesticides using orchard sprayer. Conventionally farmers used hydraulic sprayers in which liquid discharged from the spray nozzle does not reached the remote location in tree canopy. Identifying the problem, a air carrier sprayer is designed and developed to achieve the target spray for effective control of pest and diseases.

Description: It is a air carrier sprayer consist of the components like, blower assembly, pump, nozzle, nozzle adopter, spray liquid tank, power transmission system and mounting frame (Fig. 15). The blower assembly consist of blower unit, inlet bell, outlet bell, diffuser and air outlets. Blower outlet can be adjusted according to the tree height. Axial flow blower is a turbo machine which transfer energy from rotating impeller to air. Sprayer produces fine drop lets (150 $x10^{-3}$ mm) of pesticide/insecticide to the target area so that it easily penetrates inside of stomata of leaves and hence increases pesticide use efficiency (Mayande et al., 2004) .

Fig. 15. Orchard Sprayer

Performance of CRIDA Orchard Sprayer

The performance of air-carrier orchard sprayer was evaluated on 10 ha commercial mango orchard. The size and density of droplet is within the most desirable range for effective control of pests and diseases. The spray droplet distribution was uniform across the tree canopy locations. The spraying operation was done at a tractor speed of 2.39 km/hr. Spray application rate was 80l/ha. There is a saving of about 50 per cent in spray chemicals as the spray droplets are reaching target uniformly without much wastage. This covers area an 12-14 ha/day. The cost of operation per ha about 5 times low in air assisted sprayer. The comparative cost evaluation of conventional spraying and spraying with CRIDA orchard sprayer is given below. It indicates that the cost of spraying with CRIDA air assisted sprayer is about 20% of cost of conventional spraying.

Specifications

Parameter	Values
Crops	Mango and other orchards
Spray application rate	70-80l/ha
Width of coverage	10m
Forward travel speed	2.4km/hr
Tank capacity	150litrs
Power requirement	12kW
Pump	HTPsingle piston
Overall dimensions (I×W×H)	1.5×0.65×1.2
weight	70 kg

Suitability

CRIDA Orchard sprayer is suitable for spraying of all dryland horticultural crops.

Approximate cost: Rs. 70000/-

Cost of operation: Rs. 1000/ha (excluding the chemical)

IV. Post Harvest Equipment

1. Castor Sheller

Purpose: Castor is an important cash crop predominantly grown in Telangana and Gujarat states. This is very hardy and drought resistant crop, making it most suitable to grow in dryland conditions. Castor shelling is one of the important operations, which requires large number of human labour. The present practice is manually beating the dried castor shells, which is drudgerious, and time-consuming operation. In conventional method, one person can give output of about 60 kg/hr. The shelling cost is about Rs.100 per quintal. During the peak shelling season, there is acute shortage of human work force for this operation, thereby, the delay in processing and marketing of the grains. Considering these constraints and demand registered by farmers in the region, the power-operated castor-shelling machine was designed at CRIDA.

Description: Castor shelling machine (Fig. 16) consists of a threshing drum, concave, feeding tray, set of sieves and blower unit. The machine requires 3 hp, 3- phase electric motor. Castor kernerls are fed manually through a feeder tray, which enters the threshing unit (Srinivas et al., 2004). The castor kernerls are crushed between threshing drum and concave, which causes the breakage of shells without damaging the seeds. The threshed material then falls on inclined screen where the air jet from blower fixed opposite to screen blows away the broken shells, which are lighter in weight. The grains are heavier and slide down the screen and move to grading sieve. The graded grains are separately collected from the outlets. It requires 2 persons for operation. The unit is mounted on the rubberized wheels, because of which it can be easily transported from one place to other place. The castor sheller gave 97% shelling efficiency and 95% cleaning efficiency with output of 700 kg/hr. The shelling cost was significantly reduced to Rs. 5 per quintal .

Fig. 16. Castor Pod Sheller

Specifications

Dimensions: (Length X Width X Height) : 2400 X 770 X 1580 mm

Weight : 175 Kgs

Threshing cylinder : 350 mm dia, 495 mm length

Blower : 320 mm dia, 620 mm length

Power source : 3 h.;p, 3 phase

Advantages

- It reduces the drudgery
- It saves 90 % of labour compared to the traditional method
- Higher shelling and cleaning efficiency provides quality seed
- It can be used on hiring basis at village level
- Cost of operation is much cheaper than other threshers

Suitability: For shelling and cleaning the castor of small and bold varieties

Approximate cost: Rs. 70000/-

Cost of operation: Rs. 20/quintal

2. Groundnut stripper

Purpose: Groundnut is a major oil seed crop grown in India, however, most of the cultivation operations are done by conventional devices which requires higher cost of operation. Among all operations, groundnut pod stripping is predominantly a manual operation. Presently, ground nut pods are stripped manually immediately after harvesting or left the field for 4-5 days for sun drying and then stripped manually (Fig 17). The cost of manual stripping of groundnut ranges from 3000-4000 per hectare, which comes to 18-20% of total production cost. Deficit of human labour during peak harvesting season is one of the major constraints in recent past, which is leading to shifting groundnut area to other crops. Therefore, development of mechanical groundnut stripping machine becomes inevitable intervention to minimize the operation cost and sustain the area under groundnut in some region. Keeping this point in view groundnut stripper is developed and commercialized

Description: This is a hand-held type of ground stripping machine works on principles of impact and shearing force applied to gyrate of pods by series of angular loops fixed on a rotating drum. it consists of a threshing drum with special type of pegs and rotates on a rigid frame (Adake et al., 2004). The stripped pods fall on to the sieve. It is operated by 1 h.p. electric motor (Fig. 18) The detailed design specifications are below..

Specifications

Particulars	Specifications
Mainframe	800 x 780 x 602 mm
Stripping Cylinder	Loop type
Diameter of cylinder	290 mm
Length of cylinder	680 mm
Shape of loops	‘U’ (□ 6 mm)
Number of loops on cylinder	84
Spacing between loops	55 mm
Length of loops	75 mm
Concave clearance	45 mm

Feeding platform	770 mm x 210 mm
Perforated screen	720 mm x 450 mm
Oscillating mechanism	Cam
Weight of groundnut stripper	130 kg
Power transmission	Belt and Pulley
Power source	1 hp electric motor

Performance: The performance details off CRIDA groundnut stripper is presented in Table 3. The higher stripping efficiency of 98% and cleaning efficiency of 95% was obtained at 400 rpm of cylinder speed. Breakage of pods was negligible, about 80% parts of the plant can be utilized as fodder due to removal of soiled roots. The output of machine varies between 140-150 kg/hr depending on condition of plants. Stripping cost per hectare reduced by 78% as compared to manual stripping leading to increased net profit, initial investment on a machine can be recovered with stripping of about 30-40 quintal produce in one season. Farmers also have a opinion to use 1.5 hp petrol-start kerosene engine replacing electric motor in case of irregular electric supply problem

Table 3: Performance of groundnut stripper

Particular	Performance
Optimum cylinder speed	400 rpm
Stripping efficiency	98%
Cleaning efficiency	95%
breakage	Nil
Fodder utility	80%
Output capacity (wet pods)	150 kg/h

Fig. 17. Manual groundnut pod stripping method

Fig.18. Groundnut stripper in farmer's field

Advantages

- Eight times increase in stripping output of four persons
- About 83% saving in operation time
- 79% saving in operation cost

- About 38% higher fodder availability
- Early market gain
- Higher profitability

Suitability to Crops

CRIDA groundnut stripper is suitable for all bunch type groundnut varieties. It is specifically designed for stripping of wet pods from the harvested plants

Approximate cost: Rs. 17500/-

Cost of operation: Rs. 30/quintal

3. Vegetable Preservator

Purpose: Preservation of fruits and vegetables at the producer level has been a major problem in India. Many cold storage units were developed in public and private sectors, however, these units were restricted to bulk produce and high value products at trading agent level rather than the producers. Though, some mini-cold storage units are available in the market, they are seldom used by the farmers because of their high initial cost. Severe shortage of electricity at rural level also became a major constraint in adopting the electric power based preservators for fruits and vegetables. Considerable amount of fruits and vegetables produced in India are lost due to improper post harvest, handling and storage. As a result, there is a considerable gap between the gross production and net availability. In addition to that, there is no proper primary and secondary storage facilities.

Description: It is made up of fibre reinforced plastic (FRP) for its longer durability. It consists of two cylindrical baskets with circular holes all around their periphery (Fig. 19). Smaller basket is inserted in larger one with one-inch gap between them (Srinivas et al., 2004). Pine grass mats are placed all around in the gap between baskets. A tubular water tank is placed on top. Low discharge drippers are fixed at a bottom surface of tank so that the water is continuously dipped on to the mats. The mats absorb the water and are continuously wetted. Excess water drains out through circular path at bottom of outer basket and outlet tube. The drained water is collected in a bottle. The whole structure is placed on a steel tripod stand to enable the drain water collection. The button type low discharge irrigation drippers commonly available in the market were selected and fixed to bottom surface of circular tank. Tank design is wider on top and tapered towards bottom to enable free movement of water into drip inlet. Inlet of dripper is embedded to tank bottom surface during molding. The dripper outlet is threaded to inlet by rotating in clockwise direction. The dripper discharge can be controlled within some limit by rotating dripper outlet clockwise or anticlockwise. Discharge is minimum when dripper is fully tightened position. The water in the tank enters into inlet of dripper and moves through a designed micro size path to outlet. Since this path is very small it allows a controlled water drops out on pine grass chamber. About 4-6 drippers depend on size and tank are sufficient to keep pine grass wet. However, if water in the tank contains a suspended particles or dissolved salts, the dripper path may get clogged and water stops dripping out. Therefore, it is desirable to use clear water. In case of clogging of drippers, the water drops will stop. All drippers are visible and can be accessed through rectangular aperture from inside basket chamber. Clogged drippers outlets can be unscrewed and

taken out from cleaning inside disc path for salt accumulation or clogging by suspended particles and refitted after cleaning. It is advisable to observe all drippers daily once while filling the water tank in the morning. The water can be filled in the tank through opening kept on top of tank. The opening can be closed with lid similar to water bottle.

Water tank has a capacity of 4.5-7 litres depend on size of preservator. The filling of water tank daily morning is advantageous, as during day time there will be higher evapotransmission losses from pine grass compare to night time. The full tank in the morning provides a higher gravitational pressure for normal discharge of water through dripper. As the water level goes down lowering gravity pressure also affect the dripper discharge. Therefore, low evapotranspiration in the night also synchronizes the low water level in tank and low dripper discharge without affecting the wetting of pine grass. The grass mats generally will last for one year depending on quality used, hence should be replaced once in a year or earlier as per grass condition and quality.

The lid with holder at centre and circular holes for aeration is placed on top of the cooling chamber resting on inside surface of the water tank. The outer basket is also provided with two holders in opposite direction for lifting and moving the preservator units. Inside the cooling chamber, fruits or vegetables of different types can be staked in plastic removable trays to avoid mechanical damage, friction and to enhance aeration inside the cool chamber (Fig. 20).

Fig. 19. Vegetable preservator (5 kg capacit)

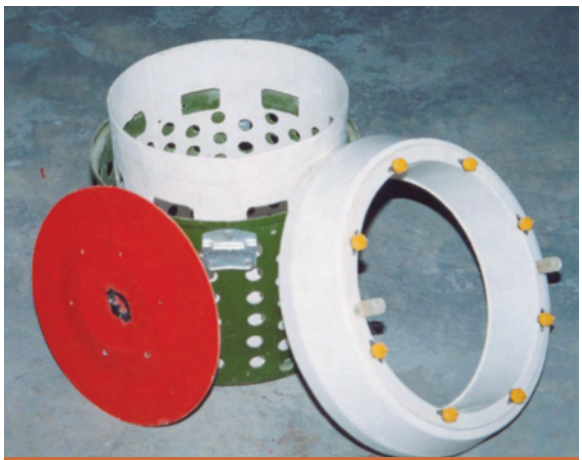

Fig 20. Components of the Preservator
1. Outer body 2. Inner body 3. Water tank
4. Lid 5. Dripper 6. Aeration holes

Performance

The performance of a preservator device was evaluated to study the enhancement of shelf life of different type of vegetables/fruits, to study the impact of storage tank levels on discharge of drippers, correlation between ambient temperature and inside temperature during different seasons.

Shelf life of vegetables and fruits

The perishable products like tomatoes, brinjal, ladies finger, leafy vegetables, mangoes, grapes, guava, custard apple was studied under normal room temperature (Table 4).

Table 4: Shelf life of selected vegetables and fruits.

Vegetables/fruits	Shelf life (days)	
	Normal conditions	CRIDA Preservator
Tomato	4	10
Brinjal	4	9
Ladies finger	3	8
Leafy vegetables	2	7
Mango	4	10
Grapes	4	8
Guava	4	10
Custard apple	2	8

Leafy vegetables can be stored for about 7 days while tomatoes and some fruits can be stored safely for 10 days after harvest as compared to storage under normal room conditions. Thus, this device has opened a new vistas for small scale vegetable and fruit growers. The losses during handling, storage and transport can be saved to large extent and higher returns are imminent by enhancing marketability of product for longer period of time. However, it should be kept in mind that the product remains in good condition as long as it is inside the preservator for above period of time. It may start fast deteriorating once taken out from chamber after storage. Therefore, it is advisable that the product stored in preservator for few days should be immediately used or consumed after taking out from chamber.

Specifications

It is available in three models based on the vegetable storage capacity of the container.

Model 1: 5 kg capacity

Model 2: 15 kg. capacity

Model 3 : 50 kg capacity

	50 kg Model	15 kg Model	5 kg model
Inner Dia	520 mm	370 mm	310 mm
Outer Dia	600 mm	440 mm	75 mm
Height	480 mm	460 mm	355 mm
Weight	8-9.5 kg	7-8 kgs	5-5.5 kg

Advantages

- CRIDA Preservator keeps the storage chamber temperature at 18-25^{0}C, which is 8-10^{0}C less than the room temperature.
- The higher humidity (around 80-85%) with good aeration inside the chamber helps in increasing the shelf life of the produce.
- Shelf life of the produce can be extended to 7 to 10 days based on the product.
- The unit is portable which helps in easy transportation of fruits/vegetables.
- This structure reduces the handling and transportation damages.
- Allows the bio-respiration of the fresh fruits and vegetables and helps in enriching nutritional quality and enzymes development.
- Prevents the distress sale by the farmers.
- Prevents the nutrient loss.

Suitability

It is suitable to preserve all kinds of fruits and vegetable which are in semi ripened stage.

Approximate cost: The approximate cost for different models ares given below:

5 kg capacity: Rs. 1800/-

15 kg capacity: Rs.2750/-

50 kg capacity : Rs.3600/-

Cost of operation: Nil

4. CRIDA Herbal dryer

Purpose: Drying is considered as secondary processing and value addition operation at producer's level. Many of the agricultural products needs to be preserved at optimum moisture content for longer storability. Apart from this, some of the high value crops products needs to be dehydrated by removing the moisture up to 60 %. The conventional method of sundrying or shade drying spoils the product. Hence, a Herbal dryer is designed and developed to suit the small and marginal farmer's need for on-farm value addition.

Description: Keeping in view the constraints in sun drying and shade drying, CRIDA has developed a Herbal Dryer which uses the Liquid Petroleum Gas as fuel. It mainly consists of a drying chamber with eight cubic meters volume made of 16 gauge mild steel (Fig. 21). The drying chamber is made in two layers with 1" gap in between in which glass wool is filled for thermal insulation. A removable stand was kept inside the chamber to arrange the trays for keeping the product, which is to be dried. More than 40 trays (40 cm x 40 cm) can be arranged in a zigzag way so that the hot air moves in a S-shape path. A separate furnace is used to heat the atmospheric air, which is then blown in to the drying chamber with the help of 0.5 h.p. blower. A 6mm copper plate is used as a heating

element in the furnace. Two burners fuelled with LPG are placed beneath the copper plate and using a thermostat based electronic relay system the gas flow is controlled in to the burner. Always, the threshold level of gas flow is maintained, to keep the burners lighting even when the relay is in off position. The temperature and humidity inside the drying chamber is measured with the help of the sensors attached to the thermostat-relay control system. A control panel is placed outside the dryer to read and set the temperature. The set temperature is maintained accordingly by controlling the gas flow into the burners. If the drying chamber temperature exceeds the temperature, the relay will cut off the excess flow of gas into the burners. If the temperature reduces inside the drying chamber, the relay will open the gas valve for excess flow in to the burners. The humidity inside the drying chamber is also displayed on the control panel. Opening and closing of ventilators arranged at the bottom and top of the drying chamber. control the humidity. Biogas can also be used in place of LPG, if available.

Fig. 21. Herbal Dryer

Fig. 22. Dehydrated henna in comparison with sun drying

Specifications

Blower	:	0. 5 h.p. single phase
Fuel system	:	LPG or Biomass if biomass stove is used
Drying chamber size	:	220X180X160 cm (lbh)
No of trays	:	42
Drying capacity	:	50 -70 kg of wet product (may vary according to the product)

Advantages of the Herbal dryer over conventional methods

- Accuracy in maintaining the set or required temperatures.
- Uniform flow of the hot air into the drying chamber to maintain the required temperature unlike to the normal ovens used for dehydration of the products where the airflow is cut off to
- maintain the temperatures. Hence the herbal dryer product is superior to other methods of drying.
- The LPG/Biogas provides quick energy flow of gas to regain the set temperature in short time so that there will be no variation in drying product ambient conditions.

- The drying cost is reduced as the energy use is optimized since it is automated system.
- It reduces the labour cost.
- No contamination, no impurities in the dried product.
- Precision control provides a better quality product at cheaper rate.

Suitability

Experiments carried out at CRIDA and at farmers fields indicated that the dryer can be successfully used for drying of medicinal and aromatic, plants like Henna and Senna, Amla vegetables like Tamotoe, ladies finger and other green leaf vegetables like coriander, curryleaf etc (Pratibha et al, 2006).

Approximate cost of the Herbal dryer: Rs. 65000/ (42 tray capacity)

Cost of operation: The average drying cost of operation would be around Rs. 5-6/ kg of dried product. However, it may vary from product to product.

5. Mini Dhal Mill

Purpose : In Indian diet, pulses occupy an important place, as they are main source of protein. Pulses contain about 18 -25% protein by weight and contribute 15 – 30% of overall daily protein requirement in different parts of India. About 80% of the pulses produced in the country are consumed in the farm of dhal or besan after dehulling, followed by splitting of cotyledons. Removal of the hulls or husk reduces roughage, improves storability and palatability on consumption in various forms. Nearly 30 – 40% of the pulses being processed in the country are milled at cottage scale level by the farmers in rural areas following traditional practices. However, the rural processing systems are inferior in product quality and also low in dhal recovery. The commercially available dhal milling units are larger in capacity and require higher capacity power sources. Development of appropriate small scale pulse processing machinery suitable to rural areas will further increases pulses processing at on-farm level besides farmer gets remunerative price to their produce in addition to the reduction in wastage of product in handling and transportation.

Description: The design of CRIDA mini dhal milling machine (Fig. 23) consisted of three main parts viz., a metal stand, abrasive roller with concentric mesh drum and aspirator with an electric motor. The stand to which other parts fitted is 95X64X100 cm in size made of L angle. An abrasive conical roller, 30 to 25 cm diameter and 60cm in length is fitted on the stand with a concentric mesh encircling the roller leaving 3cm annular space all around with two end plates to impart required action on the grain. At the upper end plate a provision was made to input the grain through a hopper and at the lower end an outlet to collect the milled output. The concentric mesh shell is fabricated into two halves for easy repair and maintenance. To separate the husk and other finer materials from the milled products an aspirator is fixed at out let portion of machine. The required rotational speeds to roller and aspirator blower are provided through pulleys and V-belt arrangements. The machine is powered by a 3 hp electric motor**.** The machine is useful both for imparting pretreatment to raw grain and milling the treated grain. In order to obtain quality products using the dhal mill, grain pretreatment processes also optimized for red gram, bengal gram and black gram (Sanjeev Reddy and Maruthi, 2008).

Work performance: To impart pretreatment, the cleaned grain is passed through the machine with lighter force, which causes a mild abrasion/scratches to husk to absorb water or oil as for requirement of the grain to be processed. For this pretreatment mode of operation, the capacity of machine varies from 400 to 300kg per hour and one farm labor is required. If, the unit is combined with grain pre-treater for value added application two labourers are essential. In dhal processing application the milling unit capacity ranges from 150 – 200kg per hour (B.S. Reddy et al., 2003). It gives 10 percent improvement in dhal recover when compared with conventional processing practices and on far in performance when compared with commercial dhal processing units with recovery ranging 72 – 78% (Fig. 24). The processing cost worked out will be Rs.5/- per kg, of which 60% can be met through sale of bi-products.

Fig. 23. Mini dhall mill

Fig. 24. Processed dhal

Specifications

Frame : 95x64x100 cm, L - angle made

Roller : Conical - 30 to 25cm diameter, 60cm length

Mesh drum : Hardened galvanized Iron, 2mm perforations

Power source : 3hp mill unit / 5hp mill and sieve set

Advantages

- Reduces drudgery in pre-treatment and milling of various pulse grains.
- Using the machine both soaked and dried (conventional process) and oil pretreated (commercial process) grain can be milled suiting to both on-farm and value addition applications.
- If properly adopted to on farm conditions create off - season employment for the farm families besides reducing valuable produce loss in handling and transportation.
- The economics of pulses processing technology using mini dhal mill is very favorable on village scale, if all bi-products are well utilized.

Suitability

To use for pulse processing such as red gram, Bengal gram and black gram

Approximate cost: Rs. 70000/- for 3 h.p. capacity and Rs. 80000/- for 5 h.p. capacity.

Cost of operation: Rs. 5/- kg.

IV. Commercialization of CRIDA Technologies

The implements developed at CRIDA were initially tested at farm and farmer fields successfully and the designs were transferred to various industries through an agreement signed by both the parties. The list of the industries which have signed MOU (Memorandum of Understanding) for license to manufacture and sale of different products is given below:

	Name of the Implement	MOU's signed with
1	Plough planter	1. M/S Karshak Industries, # 18-3-14, Chetrinaka, Lal Darwaza, Hyderabad-500053. 2. M/S Paru Engineers Pvt. Ltd., Plot No 161/B, IDA, PH II, Cherlapally, Hyderabad-500051. 3. Sree datta Engineering works, B.No. 8-222/4, Old Airport Road, Goutham Nagar, Ferozguda, Secunderabad-500011.
2	Two row Bullock drawn planter	1. M/S Karshak Industries, # 18-3-14, Chetrinaka, Lal Darwaza, Hyderabad-500053. 2. M/S Paru Engineers Pvt. Ltd., Plot No 161/B, IDA, PH II, Cherlapally, Hyderabad-500051. 3. M/S Vishvakarma Agro Engg. Works, Arjia Chowrasta, Ajmer Road, Bhilwara (RAJ) 311001.
3	Three row Bullock drawn planter	1. The Maharashtra Agro- Industries Development Corrporation, Rajan House, 3rd Floor, Prabhadevi, MUMBAI- 400025. 2. M/S Kale Industries, Plot No. E-64/1, Opp. Kirti Gold oil Mill, MIDC, Latur-413531.
4	Four row Bullock drawn planter	1. The Maharashtra Agro- Industries Development Corrporation, Rajan House, 3rd Floor, Prabhadevi, MUMBAI- 400025. 2. M/S Karshak Industries, # 18-3-14, Chetrinaka, Lal Darwaza, Hyderabad-500053. 3. M/S Rohit Steel Works, Sector No.18, plot No. 92, Krishna Nagar, PCNTDA, Chinchwad, Pune-411019. 4. M/S Hindustan Agro Industries, Opp Jaswant theartre, GT Road, Malout -152107 (Panjab). 5. M/S LCT Feeder's Pvt Ltd. , 6-158, SLNS Colony, Balapur X Road, Hyderabad- 79.

5	Six row Tractor drawn planter	1. The Maharashtra Agro- Industries Development Corporation, Rajan House, 3rd Floor, Prabhadevi, MUMBAI- 400025. 2. M/S Viajyashekara Agro Service Centre, sarjapura, Anekal Taluk, Banglore rural. 3. M/S Nirmala Industries, Plot No 61, IIrd Phase, autonagar, Guntur-522001. 4. M/S LCT Feeder's Pvt Ltd. , 6-158, SLNS Colony, Balapur X Road, Hyderabad- 79. 5. M/S Rohit Steel Works, Sector No.18, plot No. 92, Krishna Nagar, PCNTDA, Chinchwad, Pune-411019.
6	Nine row Tractor drawn planter	1. M/S Karshak Industries, # 18-3-14, Chetrinaka, Lal Darwaza, Hyderabad-500053. 2. M/S Rohi Steel Works, Sector No.18, plot No. 92, Krishna Nagar, PCNTDA, Chinchwad, Pune-411019. 3. M/S Paru Engineers Pvt. Ltd., Plot No 161/B, IDA, PH II, Cherlapally, Hyderabad-500051. 4. M/s Sri Lakshmi Narasimha Swamy Industires, Korrapadu Village, Tadipatri road, BK samudram mandal, Anantpur 515001. 5. M/S Vishvakarma Agro Engg. Works, Arjia Chowrasta, Ajmer Road, Bhilwara (RAJ) 311001. 6. M/S Nirmala Industries, Plot No 61, IIrd Phase, autonagar, Guntur-522001. 7. M/S Hindustan Agro Industries, Opp Jaswant theartre, GT Road, Malout -152107 (Panjab). 13.M/S Veepee Engineers, 123-A,Ravindrapuri, Varanasi-221005. 8. M/S Rohit Steel Works, Sector No.18, plot No. 92, Krishna Nagar, PCNTDA, Chinchwad, Pune-411019.
7	CRIDA Orchard sprayer	1. M/S Paru Engineers Pvt. Ltd., Plot No 161/B, IDA, PH II, Cherlapally, Hyderabad-500051.
8	Caster Sheller with 3 H.P. motor	1. M/S Karshak Industries, # 18-3-14, Chetrinaka, Lal Darwaza, Hyderabad-500053. 2. M/s. Slessers and Tom Electronics Private Limited 205, Ganga Vihar, Chaitanyapuri, Dilsukhnagar, Hyderabad. 3. M/s. Aruna Industries, Plot no. 119-B, IDA, Khatedhan, Hyderabad-77.

9	Groundnut stripper 1 h.p. motor	1. M/S Rohit Steel Works, Sector No.18, plot No. 92, Krishna Nagar, PCNTDA, Chinchwad, Pune-411019. 2. M/s Rajlaxmi Engineering Corporation 32, Immambada Chowk, Great Nag Road, Nagpur, 440 003. 3. M/s Viswakarma Industry Ltd, Arjia Chowrasta, Ajmer Road, Bhilwara 311 001, Rajasthan.
10	CRIDA 3-row ridger planer (can be used as paired row planter)	1. M/S Mahindra & Mahindra Ltd, APPLITRac, FES,Mahindra & Mahindra Ltd.,5th floor, EPU Building,Gate no.4, Akurli Road, Kandivli (E), Mumbai - 400101.
11	Ridger planter/BBF planter	1. M/S Rohit Steel Works, Sector No.18, plot No. 92, Krishna Nagar, PCNTDA, Chinchwad, Pune-411019.
12	Precision planter cum Herbicide applicator	1.Khedut Agro Engineering Pvt Ltd. Plot No.6, SurveyNo.191, Shantidham Society Road,Near Orke Farm, 8-B, National Hig way, Veraval (Shapar). Ta. Kotada Sangani, Dist. Rajkot. (Gujarat).
13	Vegetable preservator	1. M/S Paru Engineers Pvt. Ltd., Plot No 161/B, IDA, Ph-II, Cherlapally, Hyderabad-500051
14	CRIDA Herbal Dryer	1. M/S Lakshmi Engg. Works, Plot no 6, Opp: Auto Nagar, sainagar, Phasel, vansthalipuram, hydaerbad- 70.

Conclusions

CRIDA's effort in farm mechanization has gained the momentum since last two decades with the acceptance of small and marginal farmers who are the major stake holders of rainfed agriculture. Usage of bullock drawn equipment reduces the human drudgery involved in critical operations. Many of the CRIDA implements are women friendly as they need not walk behind the plough during sowing which is a cumbersome operation. Apart from this, the other appropriate manual weeding tools increases the human energy efficiency and reduces the cost of operation. Tractor drawn six row & 9-row planters, Precision planter cum herbicide applicators and ridger planters meet the timeliness and precision of sowing operations increases the yield and saves around 30 % of seed and fertilizers. Caster Sheller, Groundnut stripper, Vegetable preservator, Herbal drier and Dhal mill helps in primary processing at farmer's level at reduced cost and increases the value addition. CRIDA's effort in working with Industries in PPP mode (Public Private Partnership) paved the way for reaching the unreached during the last two decades and created a positive impact in farmer's field.

Lessons learnt and Way forward

Small holdings of rainfed agricultural which is typical scenario limited the scope of design and development of precision based implements. The resource poor farmers were not ready to buy the improved models of bullock drawn equipment during the initial stage of mechanization. However, better policy interventions during the recent past in addition to the increased awareness on reducing the cost of cultivation attracted the small farmers for these implements. The institute- industry-farmer

interactive meets during the early period helped in refinement of need based machinery. Collaborative effort of designer and manufacturer (Institute-Industry) which was an outcome of NATP Mission mode project on dryland mechanization revolutionized the CRIDA mechanization programme and resulted in reaching the rainfed farmers through our technological backstop.

The changed scenario in recent past is posing many challenges for design and development of high precision equipment for input and resource conservation. Design and development of appropriate machinery for conservation agriculture is under our institute priorities to mitigate the effect of climate change in rainfed regions. Our new initiatives in technical backstopping of Custom hiring centres with the improved machinery will be much helpful to the new generation farmers.

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