Management of Energy Resources with Emphasis on Farm Implements and Machinery use in Dryland Agriculture

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Introduction

Agricultural mechanization helps in increasing production, productivity and profitability by ensuring timely farm operation, and increasing utilization efficiency of agricultural inputs. Besides it reduces drudgery and improves quality of rural life.

The average farm power density in India is 1 $kWha^{-1}$. Power availability during crucial period of operations causes limitation in timeliness. Required power density achieve timeliness of operations is estimated as 3.75 $kWha^{-1}$. Earlier, use of improved manual and animal operated agricultural machinery and small pump sets was prevailing. Later on, there has been a shift towards use of mechanical and electrical power increasing the size, and capacity. Now, about Rs. 50,000 crore annually (Rs. 30,000 crore for tractors, power tillers, combines, pump sets and different types of production machinery and Rs. 20,000 crore for post harvest machinery) is invested as against the annual investment of about Rs. 12,000 crore in fertilizers, Rs. 10,000 crore in HYV and Rs. 2,000 crores in plant protection chemicals.(Powar,2006)

Table1. Growth in population of selected farm power and crop production machinery during 1971-2001 (in thousand)

Name of machines	1971	1981	1991	2001
Tractors	176	594	1304	2760
Power tillers	13	15	34	93
Diesel engines	1546	3101	4659	6300
Electric motors	1629	4330	6910	9500
Power sprayers	45	124	470	700
Combine harvesters	0.20	0.30	8	10
Power threshers	205	1025	1379	2400
Tractor drawn seed drills/ planters	33	152	485	1000
Tractor drawn mould board/ disc ploughs	57	142	498	1000
Tractor trailers	81	315	1155	2500
Animal Operated Equipment				
Iron steel ploughs	5359	6688	9607	1100
Cultivators	NA	4262	5325	6400
Seed drills/ planters	NA	5616	7349	9500
Puddlers	1694	2823	2374	11000

Source: Srivastava, N.S.L. 2004. Small Farm Mechanization – Problems and Prospects. Small farm Mechanization. Choudhary Offset Pvt. Ltd., Udaipur. Pp 1-15

Growth in population of selected agricultural machinery is given in Table1 &2. To meet such demand and growth in farm mechanization, the National Bank for

Agriculture and Rural Development (NABARD) financed Rs. 330 crore in 1990-91, Rs. 685 crore in 1994-95. The total allocation for 1996-97 was Rs. 3100 crore, with around Rs. 600 crore of this was land marked for the farm mechanization. Around 120 percent of this is flowing forward farm mechanization.

Table 2. Growth of post harvest equipment (in thousand)

Sr. No.	Name of equipment	1991	2001
1	Cleaner and grader	110	290
2	Dryer	7	25
3	Maize Sheller	65	115
4	Flour mills	266	350
5	Rice mills	125	150
6	Dal mills	10	25
7	Oil expellers	225	450
8	Ground nut decorticators	150	380

Source: Srivastava, N.S.L. 2004. Small Farm Mechanization – Problems and Prospects. Small farm Mechanization. Choudhary Offset Pvt. Ltd., Udaipur. pp-15

2. FARM POWER IN DRYLAND AGRICULTURE

Farm power availability and utilisation in dryland agriculture is far less than that of irrigated agriculture be it in quality of field operation, in quantities of fertilisers applied and in overall crop management aspects. Accordingly, output levels are also far less than the irrigated crop yields. Yet, the output-input energy ratio is generally higher (3 to 8) in dryland crop production than that of irrigated crops (1 to 3). (How come, energy ratios considered here are more than one?) However, higher output-input energy ratios alone will not mean anything, without obtaining higher yields per unit area.

2.1 Human labour : About 222.5 million persons work as labour force in agriculture, mainly to carryout field operations like sowing, interculture, weeding, harvesting and threshing.They contribute about 11.1 million kw of power or about 0.08 kw/ha during 2001.

2.2 Draught animal: Indian agriculture has about 72.3 million draught animals.(2001) On an average one draught animal pair (DAP) is available for every 7 to 10 ha of cultivated area in drylands, while one pair is available for every 3-5 ha of land in irrigated agriculture. Desirable density is about one DAP for every 3-4 ha. For a crucial field operation like sowing, if the field capacity of sowing device is taken as 0.1 ha/hr, time required for completing sowing operation in a village would be atleast 7 to 8 days. Under receding moisture condition of dryland agriculture, sowing should preferably be completed in one day. This is a constraint, because some sowings would have been done in inadequate soil moisture conditions or would be waiting for next event of rainfall. In either of the cases delay in sowing operation takes place. This effects badly the crop performance and yields. One medium size bullock pair develops on an average 0.5 kw of power.This source contributed about 0.12 kw/ha of cultivated area.

2.3 Tractors: Tractor uses is gradually increasing in India and are available in 20 to 75 HP ranges. About 2.6 million tractors are in use in our country. Tractor density is high in Punjab, Haryana and Western UP and under irrigated areas in the rest of the country. About 2.5 lakh tractors are produced and sold annually. In the Punjab belt, tractor density is about one for every 5 to 7 ha, while in Telangana belt of AP it is one for every 50 to 100 ha. Desirable density is about one for every 15 ha.

2.4 Engines / Motors : Electric motors and diesel engines numbering around 9.52 and 6.47 million are used mostly to lift / pump water for irrigating the crops both from tube wells / open wells and canals. Engines are also used in plant protection and threshing equipment. Self propelled combine harvesters, winnowers are recent additions (since 20 years) to Indian agriculture.

Experience has shown that there is a definite and positive relationship between farm power availability and farm production levels. Farm power availability to individual farms varies from 0.1 to 6 kw/ha depending upon the economic status and need of the farmer. Farm power availability of 1 to 1.5 kw/ha seems to be comfortable in completing all field operations in time and hence would help in attaining good crop yields. Therefore, there appears to be good scope in India to substantially increase the crop yields even with incremental increase in the levels of power availability, provided such power sources are utilized to optimum levels with good energy management. Improved farm implements and machinery with higher capacities and improved cultivation practices can play a vital role in achieving this target. Low power availability can considerably delay a farm operation there by decreasing the yields. This could be overcome either by increasing the power availability, or by utilizing the existing power sources more efficiently. Field operations like tillage, sowing, fertilizer application, interculture, weeding, spraying and dusting (of plant protection chemicals), harvesting and threshing are very important and timeliness of these operations enhances and assures good crop yields. Delay in field operation has adverse effect on crop husbandry and results in reduction of yields from 10-80%. Availability of matching farm implements having high capacity is another factor. Timely availability of other inputs like seed, fertiliser, chemicals along with proper crop management are also equally important in crop production.

2.5 Farm power density and India and the world: Farm power available per hectare of land is one of the important indices of progress in production and productivity. India has 2.5 and 11.7 per cent of geographical and arable area of the world, respectively. In absolute terms they are 329 and 162 Mha. In area and arable area India occupies seventh and second position amongst the countries of the world. With 21.8 per cent of irrigated area of the world or 59 M ha of area irrigated, India occupies first rank amongst area under irrigation. Rainfed agriculture in India, extends over 97 Mha or nearly 67 per cent of the net cultivated area. India has 16 million population which is 17 per cent of the world population and is placed second in the world. With about

215, 181 and 383 million heads of bovine, sheep and goat and chicken it occupies first, third and seventh rank, respectively in the world. It produces 230 and 16 Mt of cereals and pulses, or about 11.1 and 27 per cent of the world production and occupies third and first rank respectively. It has 1.55 million of tractors or 6 per cent of the world's 26.3 million tractors and occupies third position in the world.

Average size of agricultural holdings in India is 1.6 ha and is very less as compared to the highest average holding of 3590 ha in Australia. Aargentina, Uruguay, Canada, New Zealand and USA has 470,285, 242, 216 and 197 ha of holdings. Japan, Korea, Nepal, Ethiopia and Tanjania are some of the countries having lesser average size of agricultural holdings i.e. 1.2, 1.1, 0.9, 0.8 and 0.2 ha respectively. In India, 60 per cent of economically active population is dependent on agriculture, as compared to world average of 45 per cent. In developed countries like UK, USA, Canada, Japan and Australia lesser persons i.e., 1.8, 2.2, 2.4, 4.3 and 4.7 per cent population is dependent on agriculture. Myanmar, China, Afghanistan and Sudan with 68, 67 and 62 per cent respectively are some of the countries having more population dependent on agriculture.

Tractors world wide registered a growth rate of 1200 per cent from 2.2 million to 26.3 million between 1980 and 1998. Growth rate of tractors and harvesters / threshers in India also is high to an extent of 404 per cent from 0.38 million to 1.55 million units during the some period.

Cropping intensity in India has increased from 111.1 to 136.1 per cent during 1950-51 to 1998-99, net irrigated and rainfed agriculture area was 57.03 and 8557 Mha. In about 18.52 and 29.5 M ha of irrigated and rainfed area, sowing was done more than ones and hence the gross areas were 75.55 and 115.07 Mha, respectively. Total gross cropped area was 190.62 Mha (Agricultural Research Data Book 2003). Average land holding was about 0.39, 1.43, 2.76, 5.9 and 17.33 ha respectively, under marginal small, semi-medium, medium and large farm categories**.** Diverse farm mechanisation scenario prevails in the country due to size at farm holdings (average farm holding size 1.6 ha) and socio-economic disparities. Gyanendra Singh (2002) reported that Indian agriculture continues to be dependent upon human agricultural workers (207 million in 1996-97) and drought aniaml pair (DAP) power (35 million pair). Present tractor population is about 2 million with an annual production 0.25 million. Tractor availability on an average is about 70 ha/tractor and drought animal is about 4 ha/pair. Farm power availability from all sources (animate and mechanical power) is shown in Table 1.**Tillage (15.6%), irrigation (80.5%), threshing (47.8%) and rice-milling (73%) operations by and large utilise mechanical power. (Percentages in parenthesis indicate extent of dominance of mechanical power).**

Today, India has one of the most dynamic farm machinery industry producing annually 2.5 lakh tractors. The largest in the world, 10,000 power tillers, 2.5 lakh seed drills, 4.0 lakhs power threshers. 45 lakhs sprayers and dusters, 7.0 lakh pumpsets, 850 combines besides a host of other farm equipment (Alam, 1999). The number of land holdings is increasing and holding size is steadily declining average holding size has declined from 203 ha in 1970-71 to 1.6 ha in 1990-91. Marginal and small farms (below 2 ha) numbering 78 per cent of the total holdings account for only 32 per cent of the area cultivated, whereas 20 per cent of medium farm (2-10 ha) account for 50 per cent as the cultivated area 1.7 per cent large farms (above 10 ha) account for 18 per cent of the cultivated area. Therefore its agricultural mechanisation, strategy there is need for a paradigm shift.

Table 3 Growth of animate and mechanical farm power sources in India

Power Source	1971	1981	1991	2001
Draught animal, million	82.6	70.7	70.0	72.3
Mkw	20.6	17.7	17.5	18.1
Kw/ha	0.13	0.1	0.1	0.12
Agril.workers, million	125.8	151.7	186.5	222.5
Mkw	6.3	7.6	9.3	11.1
Kw/ha	0.04	0.04	0.05	0.08
Tractors millions	0.15	0.52	1.32	2.60
Mkw	3.33	11.66	29.66	88.99
Kw/ha	0.02	0.07	0.16	0.48
Power tillers, million	0.02	0.08	0.10	0.12
Mkw	0.15	0.72	0.86	1.11
Kw/ha	0.001	0.004	0.004	0.006
Engines, million	1.55	3.10	4.66	6.47
Mkw	8.04	16.13	24.23	44.50
Kw/ha	0.05	0.09	0.13	0.24
Electric motors, million	1.63	4.33	8.91	9.52
Mkw	6.23	16.49	32.51	46.35
Kw/ha	0.04	0.10	0.17	0.25
Total farm power, Mkw	44.65	70.26	114.08	210.15
Gross crop area, Mha	165.8	172.6	185.9	185.4
Unit farm power, kw/ha	0.29	0.41	0.61	1.13

Source: Data Book on Mechanisation and Agro-Processing since Independence, 1997, CIAE, Bhopal.

But while on record average holdings may be reducing due to the lack of inheritance, operational holdings are emerging large amounts for mechanised farming as evidenced in Punjab and Haryana.

4.0 SHIFTS AND TRENDS IN FARM POWER SOURCES

Today's Indian agriculture draws 10 percent of its power requirements from animal sources, 27 percent from human sources and 62 percent from mechanical and 21 percent from electrical sources. Farm power availability to Indian agriculture is about 1.23 kw/ha.(Table 3) Developed countries like Japan, USA, France and Germany have 3.7, 1.1, 2.4 and 4.1 kw/ha while developing countries like Bangladesh, Pakistan and Egypt have 0.3, 0.3 and 0.6 kw/ha.

Table 4 Percentage contribution of different power sources to total power availability in India

Share of total power	1972	1982	1992	2002	2006
Agricultural worker	15.11	10.92	8.62	6.49	5.77
Draught Animal	45.26	27.23	16.55	9.89	8.02
Tractor	7.49	19.95	30.21	41.96	46.70
Power Tiller	0.26	0.33	0.40	0.54	0.60
Diesel engine	18.11	23.79	23.32	19.86	18.17
Electric motor	13.77	17.78	20.90	21.26	20.73
Total power kw/ha	0.295	0.471	0.759	1.231	1.502

Source: Power availability in Indian Agriculture, 2000 CIAE, Bhopal.

4. PROGRESS OF MECHANISATION IN DRYLAND AGRICULTURE

In spite of rapid growth of agricultural machinery during the past two decades, the level of mechanization in the country as a whole is still considered to be low.

Table 5: Level of mechanization in India (1996)

Operation	Level of mechanization
Tillage	40
Sowing	29
Plant protection	34
Harvesting	1
Threshing	52

Source: Report on the sub-group on agricultural implements and machinery for 9th Five Year Plan.

4.1 Tillage: The ultimate aim of tillage is to change a soil from a known initial condition to a different desired condition by mechanical means. For crop production, this aim would be to provide a soil environment for improved plant growth and production and would be applicable where appropriate land-use measures are employed and where tillage is considered to be a means for controlling land degradation. Tillage operations for seed-bed preparation are often classified as primary and secondary.

Primary tillage: It is an initial major soil working operation and normally designed to reduce soil strength, cover plant materials and rearrange aggregates. It cuts and shatters soil and may bury trash by inversion, mix it into the tilled layer or leave it basically undisturbed. Primary tillage layer is more aggressive, relatively deeper operation and usually leaves the surface rough. Country plough, MB plough, disc plough, chisel plough are used for this purpose.and sub-soilers.

Secondary tillage: It creates refined soil conditions after primary tillage. It refers to stirring the soil at comparatively shallow depth and many times is proceeded by primary tillage operation. Objectives of secondary tillage are: (i) to improve seed bed by greater pulverisation of the soil, (ii) to conserve moisture by summer-fallow operation to kill weeds and reduce evaporation, (iii) to cut-up and mix vegetative matter in soil and (iv) to break clods, firm the top soil and put it in better tilth for seeding and germination of seeds. Implements normally used for secondary tillage operations are blade harrow, cultivator, disc harrow and tyne harrow etc.

Conservation tillage: In contrast to clean tillage systems for which the emphasis is on covering residues, the emphasis in conservation tillage is on reducing soil and water losses, often by maintaining residues on the surface by non-inversion tillage. Types of conservation tillage are stubble mulch tillage, minimum or reduced tillage and no tillage.

Stubble mulch tillage: Stubble mulch tillage system is generally not suited to hand or animal drawn methods, but was developed for and is widely used in tractor powered system. Stubble mulch tillage is based on sub-surface tillage with sweeps or blades which undercut the surface, thus severing plant roots and retaining crop residues on the surface. Sweep sizes normally range from 0.75–1.5m wide, whereas blades may be upto2.4m wide. Stubble mulch machines may have several sweeps or blades so that wide strips of land can be tilled with each pass through the field. Where large amounts of residue are present, a one-way disk plough or tandem disk can be used for initial tillage to incorporate some residues with soil.

Minimum or reduced tillage: Minimum or reduced tillage systems are those in which the number of field operations is reduced or in which some operations are combined. Primary or secondary tillage operations may be eliminated or combined. Much of crop production in Africa and Asia is through a form of minimum or reduced tillage because it saves labour, especially where facilities and equipment are limited.

No-tillage: No-tillage system is based on the use of herbicides to control weeds and on planting the crop without any prior seedbed preparation. Consequently, a herbicide applicator, a fertilizer applicator, a seeding unit and a power source are needed for a no-tillage system.

4.1.1 Tillage and Crop Productivity in Drylands; Tillage in dryland agriculture is an energy intensive operation. Studies reveal that it is possible to take good crops with reduced tillage, minimum tillage or even no tillage if desired population is established, nutrients applied and weeds are controlled. Energy consumption for seed bed preparation varied from 420 to 940 MJ ha^{-1} for wheat, sorghum, pulses and oilseeds to about 1680 – 1790 MJ ha^{-1} for paddy crop (Thyagaraj et al., 1992). Under farmers' field conditions tillage consumed about 220 and 350 MJ ha^{-1} under animal and tractor power, which was about 13 to 21% of total energy to complete field completions (AICRP on Energy Requirements in Agricultural Sector, 1996).

Summer tillage with either animal drawn blade harrow or tractor drawn cultivator have benefited the dryland crop production in terms of (i) greater moisture retention in the soil, (ii) lesser weed infestation and (iii) greater output-input energy ratio as compared to not carrying out the summer tillage. Moisture content at 15 cm depth increased from 7.3 to 8.7% under blade harrowing and from 7.8 to 9.2% under cultivator operation. Weed intensity (at 25 days after sowing, DAS) decreased from 6.4 to 3.8 q ha^{-1} by summer ploughing. Additional input energy of about 320 MJ ha^{-1} by summer ploughing increased the output-input energy ratio from 18 to 20 (AICRP on Energy Requirements in Agricultural Sector, 1996). Summer tillage prior to seeding showed increase in sorghum yield when compared to plough seed technique (Yadava et al., 1984).

4.1.2. Effect of Tillage on Moisture Conservation: Studies on broadbed and furrow configuration where traffic zone was clearly separated from the cropping zone was carried out at ICRISAT. Four tillage treatments were evaluated viz. (i) split-strip ploughing, (ii) strip ploughing (using left and right hand MB Plough), (iii) Chiseling to 120 cm depth where crop rows were to follow and (iv) shallow cultivation by duck-foot sweeps (Bansal et al., 1987). Table 6 shows the trend of soil moisture depletion in the 20 cm layer during the early growth of sorghum crop. Split-strip tillage holds marginally more of water, but moisture depletion during stress is faster. Consequently, at the end of dryspells, moisture in intensive tillage was less than in shallow tillage treatments. Hypothesis to explain this differences in soil moisture in tillage plots is that (i) the intensive tillage provided better environment for crop growth and root development resulting in higher transpiration rate that led to faster depletion of moisture, or (ii) in shallow tillage, soil is stratified in two layers : a top tilled layer and sub-surface untilled layer. The stratification causes increased resistance to moisture movement. Tillage before onset of rainy season (with pre-monsoon showers) is essential for increasing infiltration and for effective weed control. Effect of ploughing before onset of monsoon at Bangalore and Hyderabad is given in Tables 11 and 12. Deep tillage using MB plough and chisel plough is beneficial for rain water conservation (Table 3).

4.2. Seeding and fertilizer application: Timely seeding is essential in rainfed farming. Delayed sowing beyond normal length of growing season can cause low moisture stress on maturing crops. Location specific improved seeding devices have been developed by different research centres all over India to suit local seeding requirements. Included in them are FESPO Plough, Drill Plough, Plough Planter, Two-Row, Three-Row, Four-Row, Animal Drawn Seed Cum Fertilizer Drills and Multi tractor drawn seed cum fertilizer drills. Malaviya drills, Rayala gorru, Jyoti planter are only some of them to mention. These improved devices with their higher capacity, versatility and lower sowing costs are helping farmers in achieving timeliness of operation as well increasing the productivity.

SOWING- LOCAL METHOD

Field Capacity : 0.40 ha/day
Cost of Operation : Rs. 280/ha

SOWING- DRILL-PLOUGH

Field Capacity : 0.80 ha/day
Cost of operation : Rs.125/ha
Price: Rs.650/-

TWO-ROW PLANTER

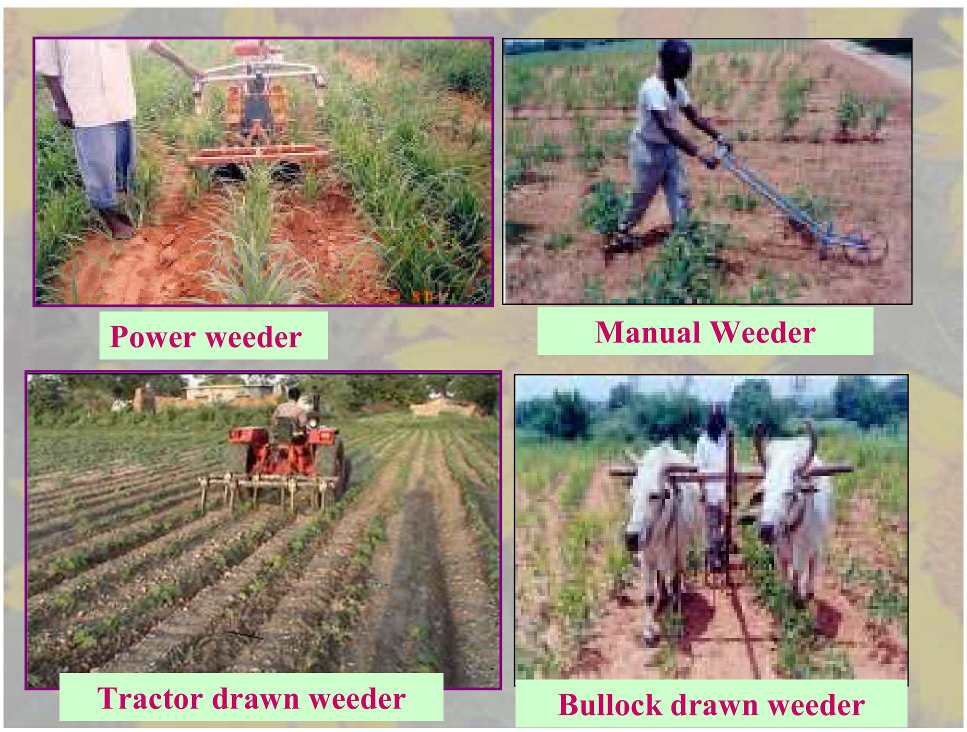
Field Capacity : 1.50 ha/day
Cost of operation : Rs.70/ha
Seed saving : 15-20%
Price: Rs.7,500/-

FOUR-ROW PLANTER

Field Capacity : 3.0 ha/day
Cost of operation : Rs.35/ha
Seed saving : 15-20%
Price: Rs.15,500/-

4.3. Interculture and weeding equipment: Weed infestation in dryland crops is always severe. The interculture operation in dryland crops aim at not only to remove the weeds but also to create soil mulch that would conserve soil moisture. The commonly used hand hoe (khurpi) requires 35-60 labour-days/ha. Many types of weeding tools/ weeders were developed at different institutions. The most popular type is the CIAE wheel-hoe having different sizes of sweeps and blades suited to crop row width and available power.

Thyagaraj et al, (1995) developed a tractor operated two-row interculture implement that removed 56 percent of weeds and retained 15.5 percent of moisture in the soil layers. Bullock drawn blade harrow has about 63 percent weed removal efficiency and caused to retain 13.6 percent moisture in the soils. Manual wheel hoe removes 69 percent weeds and causes to retain 11.5 percent of moisture in the soils under similar situation. In terms of field capacity, moisture retention and crop production tractor operated inter-culture was superior than the other two while cost economics favored the bullock drawn implements.



4.3.1.Power weeders: At CIAE, Bhopal, power weeders (Little master, Balram-3 and Dinesh) are manufactured for intercultural operations.

A new power weeder was made by upgrading the engine to 3 HP petrol start Kerosene run engine. It can be used for crops with 90 cm row-to-row spacing. The mean values of effective field capacity, forward speed and weeding efficiency were 0.14 ha/ hour, 2.10 km/ hour and 80.7 %, respectively without plant damage.

CIAE Twin Wheel Hoe Weeder

Citrus pruner

Weeding is largely carried by women labours. To reduce the drudgery and to increase the efficiency a twin wheel hoe weeder is manufactured. This is very handy and effective. CRIDA, Hyderabad, manufactured an efficient tractor drawn, 3-row weeder for dry land areas.

4.4. Plant Protection Equipment: The commercial and high value crops like cotton and pigeonpea grown in dry lands consume about 65 percent of pesticides sprayed. These crops are often over sprayed to mitigate the risk. There is no specific equipment to meet the precise need of these crops. A total loss of cotton crop in Andhra Pradesh and pigeonpea in north Karnataka leading to suicides by farmers during 1997-98 season emphasizes the need to look into the design of crop specific spraying equipment for precision and targeted spray to achieve chemical saving and reduce spraying cost. It is needed to strengthen the research efforts in the area of plant protection equipment for dryland crops.

4.5. Harvesting equipment for dryland crops: Harvesting of dryland crops largely depend on human labour and the most commonly used tool is sickle. It consumes considerable human time. There are a number of conventional sickle designs. These designs were improved to minimize the drudgery and to get higher work output. Serrated sickles increased harvesting efficiency by 15-20%. Efforts have been made to develop mechanical harvestors for dryland crops. Ramaiah and Gowda (1996) of UAS, Bangalore modified a self-propelled vertical conveyor paddy reaper for harvesting finger millet crop. The field-test on small plots showed that the reaper could harvest finger millet at the rate of 0.24 ha/h and cut at a stubble height of an average 7.3 cm under dryland conditions. Guruswamy (1997) of Raichur centre (Karnataka) modified the self-propelled vertical conveyor reaper of 1 m width for harvesting safflower. The test results show that the modified unit can be used successfully for harvesting safflower. The unit harvests 0.15 ha/h as compared to 0.01 ha/hr by manual harvesting.

4.5.1 Castor Sheller: Castor shelling done manually causes broken seed losses of 8 to 10 percent. Shelling operation often constitutes 20-30 percent of cultivation cost. In addition to APAU and TNAU models, CRIDA developed two castor shellers with 1 and 2 hp range as power source. The smaller unit has 1.7 q/h capacity. The 2hp model ensured higher shelling efficiency in addition to higher capacity. The cost of operation was Rs. 5 per quintal of seed.

4.5.2 Vegetable Preservator: For preserving vegetables, zero energy preservator, using the principle of cooling by evaporation of water was developed at CRIDA. This fibre reinforced plastic (FRP) preservator, stores 5 to 20 kg of vegetables at 8 to 10^0C below the ambient temperature (18 to 25^0C) and at higher humidity (80-85percent) and increases the shelf life by 7 to 12 days (Srinivas, 2004).

CRIDA
ZERO ENERGY PORTABLE VEGETABLE PRESERVATOR

- ★ **Estimated 40-50% loss of fruits and vegetables in storage, handling and transport**
- ★ **Preservator is made of FRP has two compartments, water tank and lid. Dripping water wets the pine grass in FRP compartments**
- ★ **Inside chamber temperature reduce by 8-10^0C compared to outside temperature**
- ★ **Shelf life of fruits and vegetables increased by 7-12 days**
- ★ **Available in 4 sizes : 5,15, 30 & 50 kg: Cost Rs. 1000-2200/-**
- ★ **Design licensed to industry**
- ★ **About 1000 units manufactured. Sale : 400 units**

4.5.3 Herbal/ Vegetable dryer: For drying herbal, aromatic and cosmetic leaves like curry leaves and henna leaves, Srinivas (2004) developed a Herbal/Vegetable Dryer, having, 8 cubic metre drying space of for drying colour-sensitive leaves under controlled humidity and temperature.

The processing of dryland crops has not received adequate attention of dryland research. The value addition of crops should be an essential component of dryland farming systems to make farming economically viable.

4.5.4 Low cost technology for storage of pulses: Pulses stored in gunny bags and traditional mud bins causes 12-15 percent losses mainly due to high moisture, improper storage conditions and attack by pulse-beetles. Use of improved metallic bin coupled with treatment of grains with 4% $NaHCO_3$ reduces the storage losses to 1.5 percent. Pigeonpea could be safely stored upto 180 days with $NaHCO_3$ treatment in metallic bins as compared to 120 days in traditional bins. Use of Probe cum Pitfall Trap developed by CIAE, Bhopal and TNAU Coimbatore was found to be more effective in trapping pulse-beetles.

4.5.5 Ventilating type drier for improving sorghum grain quality: In a network project in six districts of AP (Mahaboobnagar), Maharashtra (Parbhani, Akola), Karnataka (Dharwad), M.P (Indore) and Tamil Nadu (Coimbatore) the technology of artificial drying of grain after harvesting at physiological maturity was tried to increase the quality and market acceptability of kharif sorghum. Results during 2001-02 indicated the superiority of grain subjected to this technology and fetched 30 per more market price. The drier costs Rs. 1,50,000 and can be owned by Panchayats or farmers club at village level. Its fixed and variability cost (18 tonnes capacity) were Rs. 10,000 and Rs. 3, 875 per year (15 year life span) and about 131 q of sorghum grain has to be dried per year to recover the fixed cost of the drier. About 2 t of sorghum grain could be dried to 16 percent (from 28 percent) in 24 hours and operational cost was 35 paise per kg of grain. (Venkateshwarlu, 2004)

5.0. CONCLUSION: Use of farm machinery and implements in dryland agriculture and horticulture will continue to play pivotal role in ensuring timeliness, precision and reduction in human drudgery. Much more implements will have to be brought into usage in order to increase productivity and reduce the cost of cultivation.

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