Performance evaluation of a manually operated paddy drum seeder - a cost saving technology for paddy cultivation

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Abstract: A study was conducted at farmer field to evaluate performance of mechanized paddy cultivation (T_1), mechanized paddy cultivation with incorporation of Dhaincha before direct sowing of paddy seed (T_2) and the traditional farmer practice (T_3). Consecutive three years of data were obtained for analysis and different crop growth parameters were measured like panicle length, number of tillers, grain yield etc. for each treatment. It was found that the average grain yield for three years in different treatments T_1 and T_2 was enhanced by 10% and 14% respectively when compared with farmer practice. Average cost of cultivation was reduced by 25% in treatment T_2 where green manuring crop (Dhaincha) was grown and incorporated in soil with indigenous plough before paddy seeding. Study also revealed that due to mechanized cultivation practices, the crop was ready to harvest eight to ten days early than farmer's practices. The experiment well proved to raise the socio-economic status of the farmers by changing their strategy towards mechanized organic paddy cultivation.

Keywords: drum seeder, mechanization, green manuring crop, growth parameters

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1 Introduction

Rice (*Oryza Sativa*) is the most staple food crop in Visakhapatnam district of Andhra Pradesh in India covering about 100,000 ha area. To mitigate the growing population rate, rice production should rise to 120 million tonnes by 2020. India have diverse climatic and soil conditions throughout the country. Andhra Pradesh is endowed with variety of soil conditions ranging from less fertile coastal lands to highly productive fertile deltaic alluvia. Rice is more suited to high rainfall regions because it requires abundant moisture either through rainfall or irrigation to keep the soil under saturation throughout its life period. Water is the most critical input in order to assure the crop production. However, the cost of production for rice crop is drastically decreased because of enhanced rates of fertilizers and labour wages, due to more demand for labour at the time of transplantation. The global warming, water erosion and lack of water conservation structures cause seasonal monsoon conditions highly erratic and untimely. Under such conditions, the paddy nurseries are growing older and transplantation becomes delayed and limits the net income of the farmer and increases the crop duration. Nursery raising, transplanting, weeding and harvesting and its processing consume most of the labour requirement in rice cultivation and hence emphasis should be given for mechanizing these operations in order to reduce the labour requirement in rice cultivation. Paddy field mechanization is one of the most important necessity for higher yield in future. Mechanization in paddy can be possible at every stage of operation i.e. from land levelling to the harvesting of the crop and up to it's

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preparation of value-added products. The various equipment such as laser land leveller, puddler, paddy drum seeder, Chinese paddy transplanter, vertical conveyor reaper, paddy thresher etc. The paddy drum seeder and Chinese paddy transplanter play vital roles in bringing the real mechanization in paddy direct seeding and transplanting respectively in the world. Self-propelled rice transplanter fitted with 3 hp engine is able to transplant three to eight seedlings per hill (Sahay, 2008).

The performance of a seeder is mainly dependent on type of soil and field conditions, preparation of seed bed, speed of operation and power source (Kepner et al., 2000). A low-cost and manually operated seed drill was developed by using the cup feed metering mechanism and the performance was tested (Pradhan and Ghoshal, 2011). It was found that the actual field capacity of the drum seeder machine was 0.074 ha/h with field efficiency 77% and there was a net saving of US$ 30 per ha in comparison with the local traditional practices. The raising of nursery and manual transplanting are both labour-intensive and costly prepositions. The results of the study showed that the cost of operation for sowing paddy using drum seeder was 800 Indian rupee (INR) per ha as compared to INR 30000 per ha in conventional method. The cost of weeding and cost of irrigation in the field of drum seeded paddy and transplanted paddy were INR 700, 1500 and INR 5600, 4800 per ha respectively. Grain yield was 60 Q/ha for drum seeded paddy and 58 Q/ha for transplanted paddy, although not a wide difference but a measurable parameter. Gross return for drum seeded paddy was 90000 INR/ha leading to a net profit of 73900 INR/ha and benefit cost ratio of 4.59 whereas, gross return for transplanted paddy was 87000 INR/ha preceding a net profit of 69200 INR/ha and benefit cost (B: C) ratio of 3.89 (Singh and Hensel, 2012). The laboratory calibration was carried out with different combinations of drum fills, *viz.*, 90%, 75%, 50%, and travel speed *viz.*, 1 km/h, 1.2 km/h, and 1.5 km/h. From the laboratory calibration test the combination of 75% drum fill and 1 km/h speed was selected for field evaluation of drum seeder. The field efficiency of the seeder was found 55%. The cost of operation of drum seeder is INR 32.73per hour and INR 297per hectare (Chavan and Palkar, 2010). An experiment was conducted to improve the performance of the drum type seeder developed by the International Rice Research Institute for lowland paddy. The effective field capacity of machine seeding ranged in between 0.12 to 0.15 ha/hr and that of hand broadcasting was 0.22 ha/hr (Syedul Islam and Ahmad, 1999). The transplanting of rice seedlings which is a highly labour-intensive and expensive operation can be replaced by direct seeding that can reduce labour needs by more than 20% in terms of working hours required (Santhiet al., 1998). The raising of nursery and manual transplanting are both labour intensive and costly prepositions (Das, 2003). So, direct seeding is much helpful due to less labour and time requirement by skipping the operation of nursery raising and transplanting to the field manually. Considering the above aspects, the present study as an on-farm testing in paddy cultivation was undertaken by “Krishi Vigyan Kendra”. The research was conducted for direct sowing of sprouted paddy seeds through manually operated 8-row paddy seeder and other equipments like paddy thresher and cono weeder for minimizing the labour cost in order to compare cost of cultivation.

2 Material and methods

The following study for evaluating the performance of paddy drum seeder was undertaken at Garugubilli village in Visakhapatnam district of Andhra Pradesh. This KVK experiment was treated as On Farm Testing for three years as replications i.e. Kharif 2011, Kharif 2012 and Kharif 2013. Mostly the Visakhapatnam district receives comparatively good South-West monsoon rainfall and has soil texture i.e. red clay loam. A land of 1.2 hectare was selected for carrying out this experiment. Equipments such as paddy drum seeder, conoweeder and paddy thresher were used in order to have a complete mechanization in paddy crop cultivation. The study was carried out in three different plots with three treatments for consecutive three years. Three consecutive years were termed as replications, since the average annual rainfall and other climatic and soil situations were almost same. Following are the different

parameters considered to execute experiment.

Table 1 Basic information on experimental set-up

Sr. No.	Parameter	Observation or data
1	Paddy Variety	Srikakulam Sannalu (RGL-2537)
2	Soil Type	Clay loam soil
3	Average Annual Rainfall (mm) for three years	1100
4	Treatments	T_1 – Mechanization in paddy experimental plot with paddy drum seeder, Cono weeder, Paddy thresher. T_2 – Reclamation of soil by Dhaincha + Treatment No.1 T_3 – Traditional Farmer Practice
5	Replications	R1: Kharif 2011, R2: Kharif 2012, R3: Kharif 2013
6	Soil pH	7.9-8.4
7	Irrigation Source	Bore Wells
8	Area Required	1.2 hectare (3 acres)
9	N:P:K Status	150:16:40

2.1 Paddy drum seeder functional parts

The paddy drum seeder is used for sowing pre-germinated paddy seeds directly on well puddle and levelled fields. The seeder consists of a seed drum, baffles, main shaft, ground wheel, floats, and handle (Figure 1). Joining the smaller ends of frustum of cones makes the seed drum. The seed drum is hyperboloid shaped with 20 cm diameter. There are eight numbers of seeding metering holes of 9 mm diameter. Baffles in the drum maintain the uniformity in seed rate. Nine numbers of seed metering holes of 10 mm diameter are provided along the circumference of the drum at the both ends for a row to row spacing of 200 mm. Flat spikes of 12 mm wide and 25 mm long are joined on the plastic ground wheel parallel to its axis of rotation. The slope of the cone facilitates the free flow of seeds towards the metering holes. Two floats are provided on either side to prevent the shrinkage and to facilitate easy pulling of the seeder.

2.2 Cono Weeder

It is a small implement weighing 6 kg and can cover 15 cm operational width between two rows by push pull action (Figure 2a). Cono weeder has two cones which are plastic moulded with steel blades. There are six plain blades and six serrated blades. Cones will work in tandem to uproot and bury the weeds when the cones make a front and back movement. It also has the float assembly of 1 mm thickness which is at an accurate angle of 22 degrees to make the floating nature of the cono weeder. This manually operated machine helps to make weeding into an easy process.

Figure 1 Manually operated paddy drum seeder in working condition at experiment field

Figure 2a Cono weeder

Figure 2b Paddy thresher

2.3 Paddy thresher

Field Marshel engine operated paddy thresher was also introduced for separating the grains from the ear heads of paddy plants. The power transmission unit consisted of belt and pulley system which was rolled on

10 hp engine. On upper side the feeding hopper was provided for uniform feeding of the harvested plant, but the moisture content of the plant should be maintained properly. Concave and cylinder assembly through the grains were separated and through the sieve provided on back side of the thresher, fine quality of paddy at main outlet can be obtained. Blower was provided for straw and light weight particle separation. The experiment was carried out with the help of following treatments and replication (Figure 2b).

2.4 Traditional method of nursery raising and transplanting the seedlings at field

1) Land levelling is done by the traditional land levelling equipments which are normally drawn and which consume much time for proper churning and levelling of soil.

2) After proper land levelling, the water level of 5 to 10 cm was maintained on the field.

3) When the soil will be at its field capacity, the puddler which consists of two full kg wheels having lugs mounted on it made to revolve on the soil and continued until the proper mud and churning of soil takes place.

4) The water level is maintained at the experimental field for a week.

5) The raised seedlings were pulled out manually from the nursery with the help of labour.

7) The seedlings in line were combed in the soil for the cultivation and yield.

2.5 Operations required for direct sowing of paddy seed through drum seeder technique Land Preparation

1) Direct seeding avoids the nursery raising, pulling up the seedlings and transplanting at the field. Levelling of the land and proper drainage facility are the most important things in this method of operation.

2) Land levelling can be done by laser leveller, tractor drawn cutting blade. For proper seed bed preparation rotavator having rotary tines can be used for mixing the organic matter remained at the field after the harvesting of the previous crop.

3) Puddling was carried out with the help of tractor drawn puddler or rotavator in 5 to 10 cm water level and thus to achieve the land levelled one, mud field should be levelled properly. The puddle field was made hard pan so as to reduce the leaching of water before 24 h of sowing the seeds.

2.6 Paddy seed treatment:

4) The seed is wetted in 0.1 % carbendaizim solution about 24 h. A gunny bag in which the required quantity of seed was soaked for 24 h and bag was kept for 16 h in wet conditions for incubation process. For rapid sprouting, the slight hot water over wet gunny bags was sprinkled after every 3 to 4 h.

5) Dry the seeds for 20 min in the open air for removing the water and maintaining proper moisture in the pre-germinated paddy seeds before filling in the drums of seeder (Figure 5).

6) For the dry paddy seed treatment, the hand operated seed mixture drums are also available for uniform mixing of the chemical over the seed as coating so as to reduce weed infestation.

2.7 Operational procedures of paddy drum seeder

7) Care was taken that thin film of water i.e. 1 cm over the field was maintained at the time of sowing operation because more quantity of water makes the seeds to be float on the water and not in the soil (Figure 1).

8) The sprouted paddy seeds were filled in all drums upto 2/3rd of its capacity at a time.

9) The ground wheels make the impression to serve as a marker for next pass and helps for good movement of seeder due to lugs provided on the periphery of the wheels.

10) After turning the drum seeder for second pass,care should taken that the first wheel should go through the same line of previous pass in order to maintain the row to row distance of 20 cm (Figure 3).

Figure 3 Germination stage of paddy after line sowing with drum seeder in treatment T_2

11) Continuous watch should be taken at the holes and cover of the drum because of blockage of the seed due to high speed of operation which can be result in low germination percentage.

12) Refill the drums with seed when it reaches to the 1/4th of its capacity and continue the operation. Minimum two labours are required for completing the sowing operation i.e. one labour is for pulling the seeder and the other is for checking the flow of seeds from holes and filling the pre-germinated seeds in the drum and in helping at turning point of drum seeder.

2.8 After direct sowing operation

13) Thin layer of water was maintained at the field up to proper germination of the seed. Water should be flooded at the field after every three days of germination up to 12 days (Figure 4). But, covering the seeds under more water is also not a good option because of anaerobic condition and results in less germination percentage.

Figure 4 Tillering stage of rice crop in experiment treatment T_2

2.9 Weed management

Weed growth was checked during the first four weeks after sowing. In case of transplanting, immediately after sowing within one or two days oxadiargyl at 35 g/acre by mixing in 500 mL of water mixed with 25 kg of sand was applied. Even after pre-emergence application of herbicides, weed growth was found; so post emergence spraying of herbicide bispyribac sodium (Nomnigold) at 80 mL/acre was recommended to the farmer. In case of farmer practice i.e. manually transplanted rice, two-hand weeding at 20 and 40 days after transplanting was done with the help of labour. Whereas, cono weeder was used twice at regular interval of 12-15 days after sowing (DAS) for weeding purpose in drum seeder technique.

2.10 Fertilizer Management

The NPK dose was recommended to the farmer for all treatments at the dose of 32, 24 and 20 kg/acre respectively (Figure 4). Nitrogen was applied in three splits as basal, at the time of tillering and at panicle initiation stage. Further, total quantity of phosphorus was applied as basal whereas K was applied in two equal splits, i.e. at basal and at panicle initiation stages, so Spray $ZnSo_4$ i.e. 2 g/lit for correction of Zinc deficiency.

2.11 Plant Protection aspects

To reduce the insects and pests build-up, some cultural practices like summer ploughing, growing pest resistance varieties, use of recommended dose of fertilizer, alternate wetting and drying were adopted. It was noticed that some insects and pests were above threshold level, so recommended spray of profenphos i.e. 2 mL/L of water against leaf folder and panicle mite was applied. At the time of harvest cut worms were also noticed, so to control damage dichlorovas 1 mL/L of water plus chloropyryphas (2.5 mL/L of water) during evening hours was sprayed. Among rice diseases, leaf blast and neck blast was noticed. For control of the diseases under favourable conditions, recommended thicyzole 75 cups at the rate of 0.65 mL/L water was sprayed.

2.12 Field capacity and field efficiency

The theoretical field capacity is the rate of field coverage that would be obtained if the seed drill was operating continuously without interruptions like turning at the ends and filling of hopper. The effective field capacity is the actual average rate of coverage including the time lost in filling hopper and turning at the end of rows.

$$\text{Theoretical field capacity} = \frac{W \times S}{10}, \text{ ha/h}$$

where, W is the width of coverage, m; S is the speed of operation, kmph;

Effective field capacity (ha/h) = Area of plot (m^2) × 0.36/Actual time taken (s)

$$\text{Field efficiency} = \frac{\text{Actual field capacity}}{\text{Theoretical field capacity}}$$

2.13 Determination of germination count and cutting experiment

One square meter area of crop was randomly selected

to calculate per cent of germination and yield (Figure 5). The germination count and harvesting count were calculated after 11 and 18 days of sowing (DAS) from one square meter sown area and at harvesting stage. These test locations were earmarked for further study.

Figure 5 Crop cutting experiment at harvesting stage for calculating grain yield T_2

3 Results and discussion

The experimental data collected from the field while comparing the drum seeder with the traditional practices in cultivation of paddy crop is presented and discussed in terms of the following heads:

1) Survey in traditional paddy cultivation areas in three villages

2) Comparison of paddy drum seeder with the farmer practices

3) Economics or cost of cultivation involved using the drum seeder techniques

3.1 Survey in traditional paddy cultivation areas

A survey from three different villages (Sureddypalem, Garugubilli, and Chuchukonda) was conducted to understand the problems in paddy cultivation and analyse those problems. Ten traditional paddy growers from each three villages were selected. The profarma which consists of 10 important possible questions or constrains in paddy cultivation under same soil and climatic situations were provided in local language and asked to give the marks in between 1-10 against 1 to 10 questions. The average of marks of 10 farmers have calculated for each village and put according to problems vs. village name. The following summary from the farmer was received to analyse the data (Table 2).

Table 2 Survey of identification of problems or constrains in growing the paddy crop

Problems	Name of the village				
	Surya Redypalem (Avg. Score of 10 Farmers)	Gurgaballi (Avg. Score of 10 Farmers)	Chuchukonda (Avg. Score of 10 Farmers)	Total Marks (Out of 30)	Rank (In the range 1-10)
1. Erratic climatic situations	6	7	5	18	4
2. High seed and fertilizer requirement and its unavailability	8	6	9	23	2
3. High labour requirement	6	6	7	19	3
4. Weeding Problem	6	7	4	17	5
5. High Investment in nursery raising and transplanting and lack of mechanization awareness	8	9	9	26	1
6. Soil for paddy cultivation	8	5	5	18	4
7.Lack of Knowledge among paddy cultivation	5	4	4	13	7
8.Land development	4	7	5	16	6
9. High Pesticide use	6	7	5	18	4
10. Low Interest in paddy cultivation	4	5	3	12	8

After analysing the table summary, it was observed that immediate actions need to be taken on solving highest ranked problem in order to gear up the paddy cultivation.

a. High investment in nursery raising and transplanting because of lack of mechanization awareness.

b. High seed and fertilizer requirement.

c. High labour requirement.

Considering these data, KVK introduced new techniques in paddy cultivation and it was found that 8-row manually operated paddy drum seeder for direct sowing of sprouted paddy seeds, cono weeder for intercultural operations and paddy thresher for threshing

were the most suitable equipments in order to tackle above problems. Out of three villages, KVK selected Gurgaballi village to conduct the experiment for consecutive three years in Kharif 2011, Kharif 2012 and Kharif 2013. Parametric data were taken for all those three years to analyse the grain yield.

Table 3 Machine performance parameters of 8-row paddy drum seeder

1	Parameter	Observation
2	Row to row Distance	20 cm
3	Average Depth of operation	1to 2 cm
4	Speed of the operation	1.2 km/h
5	Theoretical Field Capacity	0.21 ha/h
6	Actual Field Capacity	0.14 ha/h
7	Field Efficiency	70.97%

3.2 Comparison of paddy drum seeder with the farmer practices

The paddy drum seeder which mainly consists of seed drums and main shaft was tested at the field with 1.2 km/h speed in clay loam soil. The data for analysis was taken with three replications and with the three treatments. Table 4 shows the highest yield was obtained in T_2 treatment due to reclamation of soil. Reduction of salinity level in the soil and enhanced N status of soil because of plantation of Dhaincha crop before paddy cultivation resulted in maximum yield at treatment T_2 among all the treatments, i.e., 14% increase in the yield (Figure 6). In the Kharif 2012, the paddy crop was affected by the flood situation in the district and hence the yield and plant growth parametric data was poor in Table 3. The average enhancement in yield for both treatments (T_1, T_2) and for three years 2011, 2012, 2013 was 12% when it is compared with the farmer's practices. The main reason behind crop yield deficiency is water logging due to high intensity rainfall and poor drainage facility which causes a serious issue in taking the oxygen at root zone depth. Due to more rainy days the required sunshine hours were also reduced which was also a considerable factor in reducing the plant growth parameters in the Kharif 2012. In case of Kharif 2013, it was observed that significant reduction in yield compared to Kharif 2011 data which is due to light and late rainfall at the peak demand from monsoon season (Figure 6).

Table 4 Comparison of plant growth parameters for each replication for three treatments

Sr. No	Parameter	Treatment (T_1)			Treatment (T_2)			Treatment (T_3)		
		TR_{11} (Kharif 2011)	TR_{12} (Kharif 2012)	TR_{13} (Kharif 2013)	TR_{21} (Kharif 2011)	TR_{22} (Kharif 2012)	TR_{23} (Kharif 2013)	TR_{31} (Kharif 2011)	TR_{32} (Kharif 2012)	TR_{33} (Kharif 2013)
1	Plant height/cm	126	120	122	128	120	122	116	110	113
2	No. of tillers/m^2	646	635	640	650	560	555	510	495	505
3	Panicle length/cm	26	24	22	27	24	23	20	19	21
4	No. of Filled grains per Panicle (No.)	124	121	118	129	120	118	110	102	105
5	Grain Yield/kg ha^{-1}	5625	5480	4900	5890	5750	5250	5090	4620	4750

Table 5 Average grain parametric data for three years

Sr. No	Parameter	Treatment (T_1) Average data for three years i.e. Kharif 2011, 2012, 2013)	Treatment (T_2) Average data for three years i.e. Kharif 2011, 2012, 2013)	Treatment (T_3) Average data for three years i.e. Kharif 2011, 2012, 2013)
1	Plant height/cm	122.66	123.33	115.66
2	No. of tillers/m^2	640	593	528
3	Panicle length/cm	24	24.66	21.33
4	No. of Filled grains per Panicle (No.)	121	122	111
5	Grain Yield/kg ha^{-1}	5270	5562	4762

Note, T_1 is the mechanization in paddy experimental plot with paddy drumseeder, cono weeder, paddy thresher; T_2 is the reclamation of soil by Dhaincha + Treatment No.1; T_3 is the traditional farmer practices.

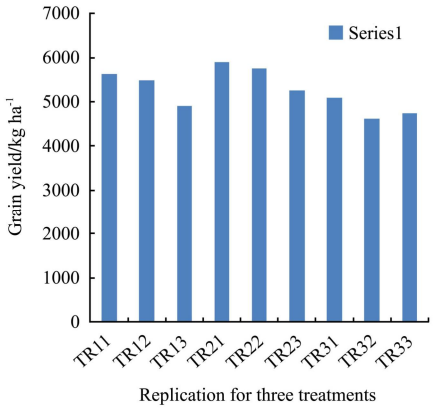

Figure 6 Grain yield of each replication in all treatments for three years

3.3 Cost of cultivation involved in mechanized paddy cultivation and traditional practices

Cost of cultivation includes expenditure on various inputs (seed, fertilizer, herbicides, labour etc.) from the period of sowing to harvesting the crop. The cost of cultivation was highest in farmer's practices whereas it was lower in treatment three comparatively other two treatments (Table 6). The cost of cultivation was highest in T_3 due to high seed requirement and huge labour cost for nursery raising, pulling and transplanting. The highest benefit ratio was found in T_2 compared to other two treatments. Farmers were satisfied and accepted this technology for future use in paddy cultivation. In both T_1 and T_2, crop was ready to harvest earlier by 7 to10 days than the farmer practice. Also the highest B: C ratio i.e. 1: 3.12 was found in treatment T_2 compared to remaining other two treatments.

Table 6 Cost of cultivation (per acre basis) with farmer practices

Sr. No	Particular	Treatment (T_1) (Same for three years)	Treatment (T_2) (Same for three years)	Treatment (T_3) (Same for three years)
1	Labour cost of nursery raising and transplanting or direct seeding	2 Semi-skilled labour = INR 300	3 Semi- skilled labour =INR 450	15 Labour = INR1500
2	Seed Required -(Seed Procurement Cost)	Paddy seed-12kg (INR 300)	Paddy seed-12kg (INR.300) and Dhaincha12kg (INR300) Total Cost= INR 600	Paddy seed -30kg (INR750)
3	Labour cost in weeding	Use of 2 conoweeder (2 labour) = INR600	Use of 2 conoweeder (2 labour) = INR. 600	Two times weeding with 20 labour =INR 2000
4	In case use of machinery on custom hiring Basis (Per day)	Drum seeder – INR 100 Conoweeder- INR100 Paddy Thresher- INR 400 Total= INR 600	Drum seeder – INR 100 Conoweeder- INR100 Paddy Thresher- INR 400 Total= INR 600	No use of Machinery = INR 0
5	Total cost of cultivation (Sr. No.1+2+3+4+other inputs required like fertilizer, herbicide and pesticides)	INR8400	INR8650	INR 11500
6	Average yield recovered from Kharif 2011, 2012 and 2013 (kg/acre)	2134	2252	1928
7	Gross returns at Rs. 900/bag of 75 kg	INR 25608	INR 27024	INR 23136
8	Net returns from per acre	INR17208	INR18374	INR11636
9	Benefit- Cost Ratio	1:3.04	1:3.12	1:2.01

4 Conclusions

1) Survey among the farmers shows that huge amount of labour were required in growing nursery, transplanting and harvesting operations and which was a time consuming process too.

2) Drum seeder proved one of most important cost saving technology in the district by reducing required quantity of seed to minimum and the man power required for cultivating paddy crop.

3) The cost of cultivation was reduced by 26% because of mechanized paddy cultivation and net returned per acre was also increased by 34%.

4) The average increase in yield for the both treatments i.e. T_1 and T_2 (Kharif 2011, 2012 and 2013) was 10% and 14% respectively when compared with farmers practices.

5) The crop duration was also reduced by 7-10 days by using paddy drum seeder technology and line sowing help in proper weed management by conoweeder.

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