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COMPARATIVE PERFORMANCE OF MECHANICAL TRANSPLANTING AND DIRECT SEEDING OF RICE

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Abstract: Rice is a major crop that is grown in more than 110 countries. The total area planted under rice in India is 44.0 million hectares which is largest in the world against a total area of 156.6 million hectares. The average yield of rice in India is 3.2 3.2 t·ha^{-1}. The reasons for low yield are limited area under irrigation, seasonal shortage of resources and delay in land preparation and transplanting. A study on economics and major constraints in rice cultivation in Kaithal district of Haryana was conducted during 2009-10. Total costs in rice production amounted to be Rs. 33778.68·ha^{-1}. Average yield was 4.99 t·ha^{-1}. Benefit-cost ratio worked out to be 1.27. Pests and disease incidence, lack of remunerative price and labour shortage were the major constraints in rice production.

Key words: *rice transplanter, farm economics, farm mechanization*

INTRODUCTION

The average yield of rice in India is 3.2 t·ha^{-1}. The reasons for low yield are limited area under irrigation, seasonal shortage of resources and delay in land preparation and transplanting. With the introduction of high yielding varieties of rice and increased emphasis on inputs like fertilizers, irrigation and pesticides, yields have increased considerably. But still there is a wide gap between potential and actual yield of rice in India. This gap can be further narrowed down with the adoption and prorogation of improved cultural practices and efficient input management. Various methods of sowing

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of rice are adopted in the county. These are direct seeding of dry seeds manually or with a seed drill, broadcasting or line sowing of dry seed/pre-germinated seed and transplanting of 3-4 weeks old seedlings in puddled fields. In India, manual transplanting of 3-4 weeks old nursery seedlings after puddling is the most commonly used conventional practice of rice cultivation. Manual transplanting is pre-dominant practice in almost all the rice growing areas but scarcity of labour, high cost of transplanting and less plant population are associated with this practice [2].

About 50 % of the total irrigated area is under rice cultivation in India, and 50 % of irrigation water is used for rice crop whose water requirement is 10^7 $l \cdot ha^{-1}$ [3]. Since, rice is the lowest productive crop per unit of water consumed amongst cereals; therefore, optimum water management and cultural practices need to be followed to ensure minimum losses of water. Approximately 75 % of water applied to rice crop is lost through deep percolation during submergence of field [4]. Hence, it is cultivated under puddled condition so as to minimize the percolation losses and to enhance the water and nutrient use efficiency of plant. Mostly, in India and other developing countries of Asia, rice is transplanted manually which is labour intensive and requires 250-350 man-hr ha^{-1} that is 25 % of the total labour requirement of the crop [5].

The mechanical transplanting of rice has been considered the most promising option, as it saves labour, ensures timely transplanting and attains optimum plant density that contributes to high productivity. Hence in the present study an eight row self-propelled rice transplanter (Model 2ZT-238-8) was evaluated for its performance on field scale.

The most common method of land preparation for wetland rice in south and Southeast Asia is puddling. This method primarily helps water saving by decreasing percolation and preventing leaching losses of plant nutrients. Puddling generally refers to breaking down soil aggregates at near saturation into ultimate soil particles. The degree of puddling also depends on tillage implement and intensity of puddling. During the puddling operation, the soil is rigorously manipulated, soil structure is thoroughly disturbed and air filled pore volume is drastically reduced. Land preparation for puddling starts in summer, whenever soil moisture conditions permit ploughing. After the onset of the monsoon when there is some standing water in the bunded rice fields, the puddling operation is performed. Farmers of Chhattisgarh do not drain the ponded water from their field as a precautionary measure to save the crop from intermittent dry spells. Due to the practice of keeping extra amount of standing water in the field, percolation losses increase several folds. Soil manipulation through puddling decreases permeability, increases water retention capacity, facilitates transplanting and eradicates weeds especially in heavy textured soil with high activity clay [6].

MATERIAL AND METHODS

The experimental study of "Comparative performance evaluations of mechanical transplanting and direct seeding of rice under puddle and unpuddle conditions" was conducted at the Research Farm of CCSHAU Rice Research Station, Kaul (Kaithal) during kharif season of 2009-10. Kaul is situated 30 km away from the holy city of Kurukshetra at latitude 290 51' N, longitude 760 41' E and altitude 241 metres above mean sea level. It is located in the heart of the rice growing region, called 'Rice Bowl of Haryana (State in India).

Self-propelled rice transplanter

The machine has of two detachable parts. The front portion has engine, gear box, lever for adjusting hill spacing, PTO shaft, toothed iron wheel for field operation, steering, driver's seat and two seats for two persons feeding seedlings or nursery cake. The rear portion has floating board, nursery platform, transplanting fingers with screws for adjusting plants/hill, depth setting lever, chain for height adjustment of float board and pedal for float-lifting. For movement one place to another, toothed iron wheel is replaced with motor bike wheel, and two small wheels are fitted below the floating board. Floating board serves as a base and also helps in movement of the machine over ponded water in the field. It also serves as a platform for placement of nursery during transplanting operation. On the lower side of the board, moulded rectangular plates with round and smooth edges have been attached (front to back) 23.8 cm apart for corrugation and smooth movement of machine. Corrugation helps in firm establishment of the transplanted plants and also in the faster movement of irrigation water. It also serves the purpose of light planking/smearing which reduces percolation losses.

Table 1. Technical Specification of the Self-propelled Rice Transplanter

Sr. No.	*Items*	*Specification*
1.	*Model*	*2ZT-238-8*
2.	*Dimension (L x W x H), cm*	*241X213.1X130*
3.	*Engine power, KW*	*2.4*
4.	*Fuel*	*Diesel*
5.	*Cooling system*	*Air cooled*
6.	*Weight, kg*	*320*
7.	*Number of rows*	*8*
8.	*Row to row spacing, cm*	*23.8*
9.	*Hill to hill spacing, cm*	*12 and 14*

It is powered by a 2.4 KW diesel engine with fuel consumption of 0.5 $l \cdot ha^{-1}$ in field operation (Fig. 1). It plants 8 rows in one pass at a spacing of 23.8 cm x 12 cm and 23.8 cm x 14 cm with 35 and 30 $hills \cdot m^{-2}$, respectively. The plant to plant spacing is adjustable with the help of a lever. Similarly, number of plants per hill may be varied (2-4 plants/hill) by adjusting the position of fingers through screws vis-a-vis nursery platform. Number of plants per hill can be increased by narrowing the spacing between fingers and the platform and vice-versa. To and fro movement of nursery platform is guided by the sliding mechanism provided below it. The machine cost around Rs 1.8 lakh per unit (USD 2800) and is currently being assembled by VST Tillers and tractor Ltd, Bangalore.

Figure 1. A view of transplanting by self propelled rice transplanter

Inclined plate type zero till seed-cum-ferti drill

Sowing of paddy seed was done using inclined plate zero till seed-cum-ferti drill. The machine was operated by 45 HP tractor. The machine was made of mild steel angle iron of size 60×60×8 mm with square cross-section (Fig. 2). Spacing between two furrow openers was 20 cm having 11 furrows. The seed and fertilizer box of zero-till ferti seed–drill was made by using mild steel sheet. The 'U' shaped seed box frame is fabricated from M.S. sheet and its front side was fitted with 11 inclined plates in separate boxs (Fig 3.4). The 'U' shaped seed box size was 18×25 cm and depth of seed in the box is 18 cm. Every inclined plate was having 24 'U' shape cell constructed around its periphery at uniform distance. The drive of the inclined cell plate was given by the main drive shaft through the bevel gear set. The trapezoidal shaped fertilizer boxes with cross section (Top width 21.5 cm, bottom width 11 cm, depth 19.5 cm and length of box 240 cm) are made from 20 gauge black sheet. The fertilizer metering mechanism force feed cum gravity type was fitted in the fertilizer box. Eleven numbers of holes were provided at the bottom of fertilizer box. The agitating gears are provided on shaft just at top of holes for feeding the fertilizer towards holes given at bottom of fertilizer box.

The field performance of self-propelled rice transplanter and zero tillage seed-cum-ferti drill having inclined cell type seed metering mechanism were compared with manual method of rice transplanting. Field area of 0.014 ha for each treatment with adequate irrigation facilities was selected in RRS Kaul. Following treatments were used for the study.

Rice crop (CSR-30) was transplanted / sown in each plot at desired depth and recommended seed rate with both the machine. Recommended agronomic practices were followed in raising the crop. Field emergence in each plot was recorded after 7days, 14 days and 21 days of transplanting/sowing of the crop. Cost analysis based on labor requirement, cost of operation, breakeven point and payback period of both the machines was calculated for their economic feasibility.

Figure 2. A view of paddy sowing by inclined plate type zero till seed-cum-ferti drill

RESULTS AND DISCUSSION

Comparative field performance data of rice crop sown under different methods of establishment

Sowing of paddy seed was done using inclined plate zero till seed-cum-ferti drill. The machine was operated by 45 HP tractors. The machine was made of mild steel angle iron of size 60×60×8 mm with square cross-section. Spacing between two furrow openers was 20 cm having 11 furrows. The seed and fertilizer box of zero-till ferti seed–drill was made by using mild steel sheet. The 'U' shaped seed box frame is fabricated from M.S. sheet and its front side was fitted with 11 inclined plates in separate boxs (Fig 3.4). The 'U' shaped seed box size was 18×25 cm and depth of seed in the box is 18 cm. Every inclined plate was having 24 'U' shape cell constructed around its periphery at uniform distance. The drive of the inclined cell plate was given by the main drive shaft through the bevel gear set. The trapezoidal shaped fertilizer boxes with cross section (Top width 21.5 cm, bottom width 11 cm, depth 19.5 cm and length of box 240 cm) are made from 20 gauge black sheet. The fertilizer metering mechanism force feed cum gravity type was fitted in the fertilizer box. Eleven numbers of holes were provided at the bottom of fertilizer box. The agitating gears are provided on shaft just at top of holes for feeding the fertilizer towards holes given at bottom of fertilizer box.

The performance data of inclined plate type zero-till seed-cum-fertilizer drill is presented in Tab. 2. The machine was adjusted for a seed rate of 20 $kg \cdot ha^{-1}$. The average spacing between the seeds with inclined plate type zero-till seed-cum-fertilizer drill was 3-5 cm. Depth of sowing was recorded 4-6 cm. The average speed of operation of tractor for sowing of rice crop was 4.05 $km \cdot h^{-1}$. The effective field capacity of the drill was 0.55 $ha \cdot h^{-1}$ and field efficiency was 62.5 %. The average fuel consumption of tractor for direct sowing of rice crop was 3.2 $l \cdot h^{-1}$.

A VST rice transplanter Chinese make, model (2ZT 238-8) rice transplanter was used. The row to row spacing 23.8 cm and plant to plant spacing 12 cm. The machine was used under puddled and unpuddled conditions. The age of nursery (mat type) was used of 25 days. The puddle field was prepared with two 0peration of rotavator having 15 cm depth of water over the surface. The puddling index was 53%. The average speed of operation of self-propelled rice transplanter for sowing of rice crop was 1.28 km h^{-1}. The effective field capacity of the self-propelled rice transplanter was 0.16 $ha{\cdot}h^{-1}$ and corresponding field efficiency was 66.6%. The average fuel consumption of self-propelled rice transplanter was 0.46 $l{\cdot}h^{-1}$.

Number of seedling per hill: The number of seedling per hill varied from 2.3 to 2.8 under mechanical transplanting whereas in DSR method it was recorded 1.4 to 2 and in manual method it was found 2.1.

Number of plants/hills per square meter: The number of plants per square meter under DSR techniques was observed in the range of 120 to 150 whereas number of hills per square meter varied from 27 to 32 under mechanical transplanting and in manual it was observed 33. Transplanting was done with manual method as per recommended row to row and plant to plant spacing (20×15 cm)

Number of missing hills per square meter: Results recorded revealed that the number of missing hills per square meter varied from 1 to 2 whereas no such observations was recorded as neither required under DSR and manual method.

Number of floating hills per square meter: The number of floating hills per square meter varied from 1 to 5 when the crop was transplanted with self-propelled rice transplanter.

Missing index: The missing index varied from 3.1 to 7.4% when the crop was transplanted with self-propelled rice transplanter.

The grain yield was similar among all the treatments when compared with manual PTR, except Zero-till mechanical transplanting having lower grain yield than all other methods. Maximum grain yield was recorded under zero-till DSR with residue and puddled manual transplanting. These results are in line with the findings of Thakur (1993) [7].

Yield and yield attributes under different methods of rice establishment

Plant height of crop was similar under all the establishment methods. However, Puddled mechanical transplanting and Puddled manual transplanting had larger plant height. Days of crop maturity were similar in all establishment methods.

Maximum effective tillers were recorded under manual transplanted rice under puddle conditions and also in unpuddled mechanical transplanting but these were non-significant in all other establishments' method.

Panicle length in all the treatments was found to be non-significant. Among the treatments the panicle length was shorter in T_4 treatment than other treatments. Numbers of grains per panicle non-significantly differ in all the crop establishment method (Tab. 2). 1000-grains weight was influenced by enhanced growth during grain development period. There was no-significant difference in 1000-grain weight among all the treatments.

Table 2. Comparative field performance data of rice crop shown different methods

S.No.	Parameters	T_1	T_2	T_3	T_4	T_5	T_6	Manual (T_7)
1.	Area covered (m^2)	140.2	140.2	140.2	140.2	140.2	140.2	140.2
2.	Speed of operation($km \cdot h^{-1}$)	4.05	4.05	4.05	1.3	1.28	1.28	-
3.	Row to row spacing (cm)	20	20	20	23.8	23.8	23.8	20
4.	Hill to hill distance (cm)	3.3	3.5	4.4	12	12	12	15
5.	No. of seedling/ hill	1.4	2	1.5	2.3	2.5	2.8	2.1
6.	No. of plants m^{-2}	150	142	120	27	32	32	33
7.	No. of missing hills m^{-2}	-	-	-	2	1	1	-
8.	No. of floating hills m^{-2}	-	-	-	5	1	1	-
9.	Missing index (%)	-	-	-	7.4	3.1	3.1	-
10.	Fuel consumption ($l \cdot h^{-1}$)	3.21	3.21	3.21	0.46	0.46	0.46	-
11.	Actual field capacity ($ha \cdot h^{-1}$)	0.55	0.55	0.55	0.18	0.16	0.16	-
12.	Field efficiency (%)	62.5	62.5	62.5	75	66.66	66.66	-
13.	Puddling index (%)	-	-	-	-	-	52.3	52.7

Economic analysis

The lowest yield of (29.75 $q \cdot ha^{-1}$) was obtained in T_4 and the maximum yield (32.67 $q \cdot ha^{-1}$) was obtained in T_5. Economic of rice cultivation under different crop establishment techniques is presented in the Tab. 3.

Table 3. Yield and yield attributes under different methods of rice establishment

Treatments	Days to crop maturity	Panicle length [cm]	No. of effective Tillers/m^2 at harvest	No. of grains/panicle	Test weight [g]	Grain yield [$kg \cdot ha^{-1}$]
T_1	144	23.26	220	76.66	23.43	31780
T_2	144	23.26	220	73.52	23.40	31290
T_3	144	23.77	221	78.33	24.04	32.19
T_4	145	22.56	218	73.30	23.11	29750
T_5	145	23.55	220	76.61	23.85	31940
T_6	145	23.98	220	78.77	24.06	32670
T_7	145	24.34	221	79.55	23.69	32020
SEm	0.39	0.62	0.63	4.75	0.65	0.75
CD 5%	NS	NS	NS	NS	NS	NS

The rental value of the land is assumed to remain the same offset the price fluctuation. The gross returns of T_4 and T_2 were found less as compared to other treatments. The lowest and highest net returns were found to be Rs.5314 (T_7) and Rs.16090 (T_3) per hectare, respectively.

The highest benefit cost ratio was obtained as 1.27 and 1.30 for T_2 and T_3, respectively. The lowest benefit cost ratio was obtained as 1.08 and 1.16 for T_7 and T_4, respectively.

CONCLUSIONS

1. The break-even point of the inclined plate type zero-till seed cum ferti-drill in terms of annual area of coverage was determined as 19.53 ha. Payback period of the inclined plate type zero-till seed-cum-ferti-drill decreased with the increase in annual area covered and found to be 0.09 year.
2. The field capacity, field efficiency and fuel consumption of transplanter were found as 0.18 $ha \cdot h^{-1}$, 65.33% and 0.46 $l \cdot h^{-1}$ respectively. Nursery feeding to the transplanter consumed approximately 18.75% total time of operation.
3. The field capacity and field efficiency of tractor operated inclined plate type zero-till seed cum ferti-drill were found as 0.55 $ha \cdot h^{-1}$ and 62.5%, respectively.
4. The cost of transplanting by self-propelled rice transplanter was estimated to be Rs 1372 per ha (if 250 hours run) as compared to Rs 2500 per ha with custom hiring cost of transplanting.
5. The cost of sowing by tractor operated inclined plate type zero-till seed cum ferti drill was Rs. 629 per ha (if 300 hours run) as compared to Rs 1250 per ha with custom hiring cost of sowing . The labour requirement with tractor operated inclined plate type zero-till seed cum ferti drill was 4 $man\text{-}h \cdot ha^{-1}$.
6. Alternate methods of rice establishment like zero-till DSR with or without residue, zero-till MTR, unpuddle MTR and puddle MTR produced grain yields similar to conventional PTR.
7. The break-even point of the self-propelled rice transplanter in terms of annual area of coverage was determined as 45 ha. Payback period of the transplanter decreased with the increase in annual area covered and found to be 0.98 years.

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UPOREDNE KARAKTERISTIKE MEHANIČKOG PRESAĐIVANJA I DIREKTNE SETVE PIRINČA

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Sažetak: Pirinač je osnovna kultura koja se gaji u više od 110 zemalja. Ukupna površina posejana pirinčem u Indiji je 44 miliona hektara, što je najviše u svetu, u poređenju sa ukupnom površinom od 156.6 miliona hektara. Prosečan prinos pirinča u Indiji iznosi samo 3.2 $t \cdot ha^{-1}$. Razlog za ovako nizak prinos su ograničene oblasti koje se navodnjavaju, sezonski nedostatk resursa i kašnjenje sa pripremom zemljišta i presađivanjem. Proučavanje ekonomskih parametara i najznačajnijih ograničenja u uzgoju pirinča u oblasti Kaithal u Haryana izvedeno je tokom 2009-10. Ukupni troškovi u proizvodnji pirinča iznosili su Rs. 33778.68$\cdot ha^{-1}$. Prosečni prinos bio je 4.99 $t \cdot ha^{-1}$. Odnos prihoda i troškova iznosio je 1.27. Pojava štetočina i bolesti, slaba cena i nedostatak radne snage predstavljali su glavna ograničenja u proizvodnji pirinča.

Ključne reči*: presađivač pirinča, poljoprivredna ekonomija, poljoprivredna mehanizacija*

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