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Design, development and field evaluation of manually operated rice transplanter for system of rice intensification

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Abstract

A 2-row plug type rice transplanter with revolving magazine metering mechanism was developed and field evaluated for rice (*Oryza sativa*) crop. The seedlings of rice crop were grown in paper pot (80GSM). Plug technology was developed for the efficient production of high-quality seedlings for transplanting. Seedling parameters like root length, plant height, stem thickness and stem width and machine parameters like plant to plant spacing, planting depth, field capacity, field efficiency, total time of operation, speed of operation were recorded during field evaluation. The cost and time saved over manual transplanting without considering paddy seed cost was about 59.9 and 79.85 per cent. The cost of transplanting with considering seed cost was ₹ 3101 h^{-1}. The field efficiency and field capacity of the transplanter was observed to be 83.22 % and 0.014 ha h^{-1} respectively.

Highlights

- Plug type technology is used to develop manually operated rice transplanter.
- Manually operated rice transplanter field capacity and field efficiency is 0.014 ha h^{-1} 83.22% respectively.
- The cost and time saved over manual transplanting is 59.9 and 79.85% respectively.

Keywords: Transplanter, rice, SRI, Pot seedling, 2-row transplanter.

Rice, one of the three most important food crop in world forms the staple diet of 2.7 billion people. It is grown in all the continents except Antartica, with total production of 661.3 million tonnes. The paddy production in Asia is 600.4 million tonnes. Its cultivation is of immense to food security of Asia, where more than 90% of the global rice is produced and consumed. Being the staple food for more than 62% of people, our national food security hinges on the growth and stability of its production. India ranked first in area under paddy (41.66 million ha) and second in terms of production (85.31 million tonnes) and it stood next only to China in the world with respect to rice production. Rice is generally grown by transplanting seedling in flooded field conditions or direct sowing depending upon the availability of water. In Tamil Nadu region, wet land cultivation system is followed. The land is ploughed thoroughly and puddle in 3-5 cm standing water. The puddling is largely done by bullock drawn country plough and wooden planks in the region. In some of the pockets, tractor drawn rotavator and power tiller are used.

Transplanting is most labour consuming operation during paddy cultivation. The cost of puddling and transplanting shares 50% of total production. The man days required for transplanting ranges from 50-60 man-days/ha. Now a day's labour are very costly and scares. The delay in transplanting directly affects the yield. Hence, the transplanting operation needs to mechanize. In order to increase the productivity of rice seedlings a low cost plug type transplanter is proposed for system of rice intensification.

Materials and Methods

Two row plug type manually operated rice transplanter consists of ground wheel, revolving magazine, seedling tube, power transmission system, seedling tray and handle (Table 1).

Table 1. Specifications of prototype plug type rice transplanter

S.No	Type	Specification
1.	Over all dimension (L×B×H)mm	
	Length, mm	1200
	Breadth, mm	1050
	Height, mm	1250
2.	Weight, Kg	45
3.	Type of power source	Manually operated
4.	Number of rows	2
5.	Row spacing, mm	250
6.	Plant spacing, mm	250
7.	Type of seedling metering mechanism	Revolving magazine
8.	Number of revolving magazine	2
9.	Shape of seedling holder	Funnel
10.	Number of funnels in each revolving magazine	8
11.	Ground wheel	peg type
12.	Number of pegs on ground wheel	20
13.	Number of seedling tray	2
14.	Seedling tube	PVC

Constructional details

(a) Ground wheel

Mild steel peg type wheel is chosen because of its manoeuvrability. Diameter and thickness of the ground wheel is 600 and 50 mm respectively. Length and diameter of the peg is 35 and 6 mm.

(b) Power transmission system

Power is transmitted by means of sprockets, chain, driving shaft, driven shaft and bevel gears. The shaft which connects the two ground wheel is called driving shaft and the shaft which drives the two revolving magazine is called driven shaft. Both the ends of driven shaft were fitted with bevel gears. Power is transmitted by means of bevel gears to rotate the revolving magazine. Number of teeth and bore diameter of the bevel gear were 18 and 16 mm respectively. A by-cycle sprocket of 34 teeth is mounted on the driving shaft and connected with another sprocket of same 34 teeth mounted on driven shaft by means of mild steel chain. The centre to centre distance between the sprockets is 670 mm (Figure 1). Revolving magazine rotates for each rotation of ground wheel in the ratio of 1:1 (Figure 2).

(c) Revolving magazine

The machine consists of two revolving magazine. A revolving magazine contains two circular plates of each 16 gauge thick, connected by means of 150 mm long mild steel shaft. Bottom circular plate of 600 mm diameter is fixed with stand and to circular plate is revolving about the vertical axis. A clearance of 40 mm is maintained between the top and bottom circular plate.

The top circular plate contains eight holes of 40 mm diameter. Funnels made u of mild steel were welded with the holes on the top circular plate. Top diameter of the funnel is 80 mm and the bottom diameter is 40 mm on the side. Bottom of the holes are welded with mild steel hollow pipe of 38 mm long and 40 mm diameter is welded.

Fig. 1. Power Transmission

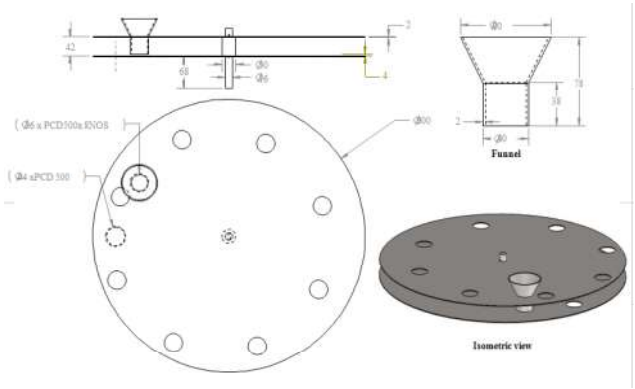

Fig. 2. Revolving Magazine

A hole of 40 mm diameter is made on the bottom circular plate. The hole is welded with 100 mm long mild steel pipe of 50 mm diameter is provided at the bottom of the bottom circular plate. The steel pipe is attached with seedling tube.

(d) Seedling tube

The machine contains two seedling tubes at the bottom of each revolving magazine. Seedling tube is used to drop seedlings to the ground from revolving magazine. The steel pipe attached with the bottom circular plate of the revolving magazine is connected with 700mm long PVC pipe of 50 mm diameter.

(e) Seedling tray

The seedling trays made u of mild steel with the dimension of 500×250×20mm were made and attached with main frame each at the top of the revolving magazine by means of 'L' angle of size 16×15×2mm. One seedling tray can accommodate 92 seedlings with paper pot.

(f) Handle

A mild steel hollow square bar of 25mm size used to make handle. 600mm length of square bar is welded at both the bottom of the main frame in slanting position and 400mm length of bar is welded at both the end of slanting bar. A pipe of 25 mm diameter is welded at both ends to connect the square bar in order to facilitate easy handling.

Raising the Nursery

(a) Paper Pot

The machine been designed to transplant young seedlings grown on paper pots in portray. Size and shape of the paper pot plays an important role in the quality of nursery seedlings. To raise, nursery, it was decided to use portable and degradable paper pot. Cylindrical and conical paper pots are attempted. It was observed that roots of seedlings in the cylindrical pots were detached by seedling metering mechanism and lodging of seedlings during transplanting was also observed. Hence, it was decided to use conical paper pots (Figure 3) for nursery preparation. Cone made up of 80 GSM white paper in single layer filled with soil medium (Figure 4). As the commercial portray dimensions are 40mm high and 37mm diameter, height and diameter of the cone was made to 54mm and 32mm respectively.

Fig. 3. Cone shaped paper pot

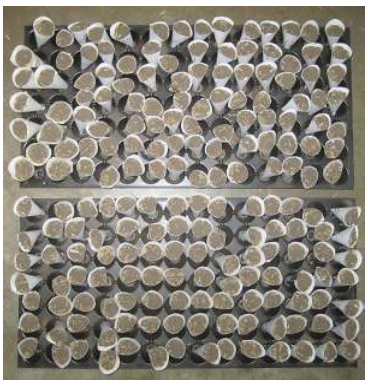

Fig. 4. Paper pot filled soil medium

(b) Seed Preparation

Seed were soaked for 12 hours and water was drained off completely. Drained seeds were kept in a wet gunny bag for 24 hours for sprouting. By this time white root called radical breaks open the outer coat and starts emerging out of the seed**.** At this stage the sprouted seed is ready for sowing.

Paper cones were filled with soil, vermicompost and coirpith according to the treatment schedule and sprouted seeds were sown manually. Watering was done twice a day till transplanting was carried out. The trays were kept outside the shade jnet for 3 days and after germination, the trays were kept inside the shade net. The plant biometric parameters such as height of plant without root, length of root, thickness and width of shoot were measured at the time of transplanting.

Field Preparation

Fill the water in the field upto a depth of about 7 to 10cm. Then puddle the field uniformly and properly upto a maximum depth of 10 cm. After the puddling plank the field and leave it for one or two days depending upon the type of soil, so that the soil settles down completely. Now the field is ready for transplanting and water level in the field at the time of transplanting should not be more than 5cm. If the depth of puddling is more, the soil become too loose and the transplanter will sink in the field and it also spouts the transplanter rows.

If the water in the field is more at the time of transplanting, the seedlings are not fixed properly in the soil and they start floating, whereas, if the water is too less, the soil sticks with the ground wheels and planting becomes difficult. It also leaves the field uneven and ruts are not filled properly.

Working Principle

The rice transplanter is driven by ground wheel. It consists of ground wheel, two circular plate and power transmission system. Funnels in the top circular plate were filled with seedlings with paper cones. Top circular plate was rotated by means of pulling the transplanter. While rotating the top circular plate funnel coincides with the hole of bottom circular plate resulting in dropping of paper cone placed on the respective funnel of top circular plate due to gravity through the seedling tube.

Results and Discussion

An experimental set up was developed and tested at wet land, Tamil Nadu Agricultural University to find out time for subsequent feeding of seedlings in the funnel**.** So the operator was allowed to pull the transplanter at different forward speed of 0.5, 0.4 and 0.3 Km h^{-1}. Based on the simulation study it was observed that at 0.3 Km h^{-1} the rice seedlings can be fed into the funnel. So the operator was trained to pull the plug type rice transplanter at a speed of 0.3 Km h^{-1}. Different forward speed for rice seedlings on missing, multiple and quality of feed index were studied at different combinations to standardize the desired spacing of mechanized rice transplanting. The results obtained are discussed in the following sections.

Miss Index

Miss index is the percentage of spacing greater than 1.5 times the theoretical spacing. Miss index was varied from row to row, and in row2 the highest missing index (30%) was recorded (Figure 5).

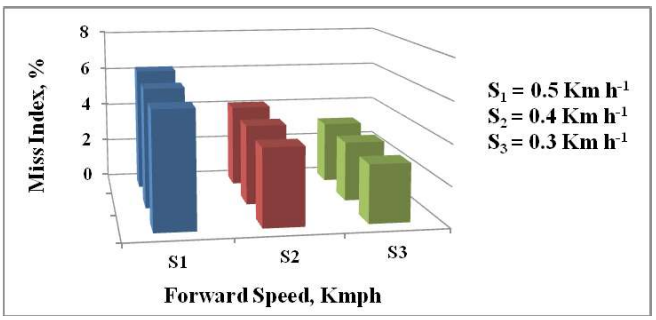

Fig. 5. Influence of forward speed on miss index, %

Multiple Index

Plant to plant spacing was measured in both row1 and row2. Multiple indexes were calculated from the spacing of 0.5 times less or equal to theoretical spacing. Multiple index was varied from row to row and row2 the highest multiple index (20%) was recorded (Figure 6).

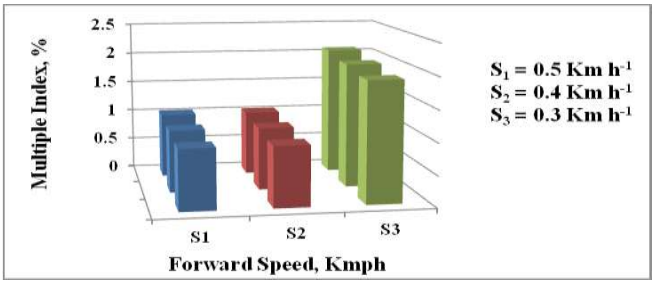

Fig. 6. Influence of forward speed on multiple index, %

Quality of Feed index

The quality of feed index is the measure of how often the spacing was close to the theoretical spacing. Quality of feed index was varied from row to row. It was calculated from multiple and miss index. Highest quality of feed index was recorded in row1 70% (Figure 7).

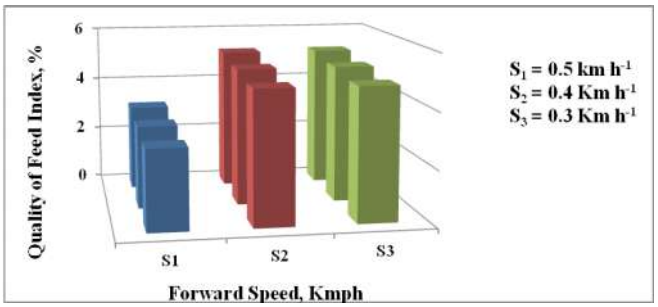

Fig. 7. Influence of forward speed on quality of feed index, %

The data related to different soil medium of seedling characteristics such as plant height, root length, stem thickness and width are presented in Table 2 and Performance evaluation of two row plug type rice transplanter are shown in Table 3.

Table 2. Seedling biometric observations

S. No	Root Medium	Plant height, cm	Root length, cm	Stem thick-ness, cm	Stem width, cm
1.	Soil	15	10.2	1.06	1.93
2.	Soil+ coir pith (3:1)	12.5	8.2	0.98	1.75
3.	Soil + vermicompost (3:1)	14.3	9.5	1.05	1.91
4.	Soil+ Farm Yard Manure (3:1)	17.5	7.7	1.10	1.65
5.	Soil + Vermicompost + Coir pith (3:2:1)	17.8	11.4	1.15	2.06

Field Performance and Evaluation

Table 3. Performance evaluation of two row plug type rice transplanter

S. No	Parameter	Row1	Row2
1.	Missing index, %	20	30
2.	Multiple index, %	10	20
3.	Quality of feed index, %	70	50
4.	Plants in lying down position, %	30	40
5.	Planting angle, °	80	75
6.	Depth of planting, cm	4.5	4.3
7.	Average spacing, cm	24	27

The two row plug type rice transplanter was field evaluated (Figure 8) for CO^{-45} variety and compared with manual transplanting of bare root seedlings. The plant missing, doubling, quality of feeding and depth of planting were noted. Transplanting of rice plug seedling was done in June, 2012.

Fig. 8. Field evaluation of plug type rice transplanter

A field of 10×20 m size was prepared for the experiment. The transplanter could transplant rice seedlings upto 0.096 ha/day with the help of three persons. However, labour requirement for seedling transplant could be considerably reduced by proper management. Also, transplanting time could be reduced by proper training the operators and by gaining experience.

The plant population obtained from the machine was low against the required plant population of 16 seedlings/m^2 area. The machine resulted into high weight of 45 Kg which was responsible for seedling spacing. Hence it is needed to modify the machine for required row spacing (25×25cm).

The average speed of operation of transplanter was 0.3 Km/hr. The field efficiency was 83.22%. Draft requirement was observed to be 40 Kgf. Number of operators required for various operations were observed to be three. Details of time requirement of transplanter for transplanting, nursery feeding, repair and adjustments are presented in Table 4. The time required for transplanting was observed to be 66.6 hr/ha. The time loss in turning and feeding was 7.5 hr/ha and 4.166 hr/ha respectively. The time loss on repair and adjustment was 2.08 hr/ha. Total time of operation of the transplanter was observed to be 80.41 hr/ha. The field capacity of the transplanting machine was found to be 0.0149 ha/hr.

The machine is pulled type and it is required by three operators in the field. This increased the labour requirement. This is also drudgeries for three operators. It could not maintain the required plant populations per hill. This emphasise the need for modification of machine for required row spacing and making it self-propelled.

Table 4. Field evaluation results

S. No	Description	Value
1.	Effective width, m	0.5
2.	Operating speed, ms^{-1}	0.0833
3.	Size of field, m × m	10 × 20
4.	Actual time taken to cover field, min	80
5.	Time lost for turning, min	9
6.	Time lost for filling seedling	5
7.	Adjustments, repairs, min	2.5
8.	Total time of operation, min	96.5

Conclusion

The field capacity of the rice transplanter was 0.014 ha h^{-1} and the cost of transplanting without considering paddy seed cost was ₹ 3005 ha^{-1}. The cost and time saved over manual transplanting without considering paddy seed cost was about 59.9 and 79.85%. The cost of transplanting with considering seed cost was ₹ 3101 h^{-1}. The cost saved over manual transplanting with considering seed was about 61.7%. The cost of plug type rice transplanter was ₹ 5000.

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References

Anonymous. 2006. SRI Method of paddy cultivation. Watershed Support Services and Activities Network. Secunderabad.1-20.

Anonymous 2009. District social and economical report of ratnagiri district. Directorate of financial and statistics, planning departmrnt M.S.p-35.

Dananchezhian, P. 2012. Development of a machine

transplanting system suitable for system of rice intensification technique. Ph.D. Thesis. Tamil Nadu Agricultural University.

Garg, I.K., Sharma, V.K. and Mahal, J.S. 1997. Development and Field Evaluation of Manually Operated, Six Row Paddy Transplanter. *Agricultural Mechanization in Asia, Africa and Latin America,* **28**(4): 21-24.

Ginigaddara, G.A. and Ranamukhaarachchi, S.L. 2011. Study of age of Seedlings at Transplanting on Growth Dynamics and Yield of Rice under alternating flooding and Suspension of Irrigation of Water Management. *Recent Research in Science and Technology* **3**(3): 76-88.

Janarthanan, P. and Ramasamy, S. 2008. Impact of number of seedlings and spacing in modified SRI method of rice cultivation. 3rd National symposium on SRI at Tamil Nadu Agricultural University, Coimbatore, 131-132.

Kavitha, R. 2005. Mechanical transplanting of vegetable crops as influenced by soil, crop and operational parameters. Tamil Nadu Agricultural University. Ph.D., Thesis.

Mohanty, D.K. and Barik, K.C. 2010. Comparative Performance of Eight Row Self-propelled Rice Transplanter and Manual transplanting at Farmer's Field. *College of Agricultural Engineering and Technology,* OUAT, Bhubaneswar. **34**(4): 15-17.

Shahare, P.U. and Bhat, M.R. 2011. Performance evaluation of semi automatic two row rice transplanter. *International Journal of Agricultural Engineering* **4**(1): 103-105.

Srivastava, A.K., Goering, C.E. and Rochrbach, R.P. 1994. Engineering principles of Agricultural Machines. ASAE textbook No 6. American society of Agricultural Engineers. p601.