RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 8 | Issue 1 | April, 2015 | 9–14
e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ DOI: 10.15740/HAS/IJAE/8.1/9-14

Development and performance evaluation of four row self propelled paddy transplanter

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Received : 20.08.2014; **Revised :** 03.02.2015; **Accepted :** 17.02.2015

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■ **ABSTRACT :** Rice is generally grown by transplanting seedlings in flooded field conditions or direct sowing depending upon the availability of water. Considering the need of Konkan region of Maharashtra, four row self propelled paddy transplanter was developed. The developed four row self propelled paddy transplanter consists of main frame, engine, gear box, transplanting mechanism, tray movement mechanism and drive system. The commercially available Honda-GK-200 petrol engine (3.5 hp) was selected as a prime mover. Laboratory test results showed that transplanting mechanism and feeding mechanism functions properly. During field trial the results reveal that hill spacing was 12 cm, the planting depth was observed to be 3 cm. The seedlings per hill and missing hills/m^2 were observed to be 3.66 and 4.33, respectively. The total number hills/m^2 area was obtained as 30. Fuel consumption for the newly developed transplanter was 1.9 l/h. The field efficiency of the transplanter was 80.47 per cent. The field capacity of the transplanter was 0.14 ha/h.

■ **KEY WORDS :** Paddy transplanter, Mat nursery, Puddled field, Field performance

■ **HOW TO CITE THIS PAPER :** Gaikwad, P.B., Shahare, P.U., Pathak, S.V. and Aware, V.V. (2015). Development and performance evaluation of four row self propelled paddy transplanter. *Internat. J. Agric. Engg.*, **8**(1) : 9-14.

Rice (*Oryza sativa* L.) is one of the leading food crops in the world within the world wide-cultivated cereals, and is second only to wheat in terms of annual food consumption (Alizadeh *et al*., 2011). The cultivation of rice is of immense importance to food security of Asia, where more than 90 per cent of the global rice is produced and consumed. Being the staple food for more than 62 per cent of people, our national food security hinges on the growth and stability of its production. The traditional rice farming system in India broadly includes wetland (lowland) and dry land (upland) system. Dry cultivation system is confined mainly to rain fed ecosystem with no supplementary irrigation facilities. Wet cultivation system is prevalent in areas, where adequate water supply is assured either through rainfall or irrigation or both. Rice is generally grown by transplanting seedling in flooded field conditions or direct sowing depending upon the availability of water. Konkan region is basically a narrow strip of 40 km wide running 750 km length from north to south and is a hilly terrain lying between Sahyadri ranges in the east and Arabian Sea in west. It receives an annual rainfall between 3000 to 4500 mm during June to October. In this region terrace farming is followed for paddy crop, the field is fragmented and wet land cultivation system is followed (Shahare and Bhat, 2011). The land is ploughed thoroughly and puddled in 3-5 cm standing water. In Konkan, the status of mechanization is very low. The transplanting operation is done manually. Increase in population and limitation in agricultural land demand to efficiency and productivity in whole stages of rice production in Konkan region. At transplanting time, there

is an acute shortage of labour. This results in increased labour wages and a delayed transplanting operation. Hence, there was an urgent need to have mechanization in rice production which will result in reducing the labour work and time consumption. Eight row Yanji-Shakti transplanter was tried in various parts of Konkan region but the limitations observed were smaller plot size and hilly terrain which reduces field capacity, difficulties in transportation. Also two row transplanter was developed at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli and limitations for this were low field capacity and hill to hill spacing was not uniform (Desai, 2012). Considering the limitations of eight row transplanter, two row transplanter and drum seeder, in order to enhance the field capacity, the work on high capacity transplanter of a four row was undertaken.

METHODOLOGY

Paddy transplanter is used to increase the speed of the transplanting operation and also proper placement of paddy seedlings in rows. The four row paddy transplanter was developed and tested in the laboratory and its functional trials were conducted in field. It was developed for rice (*Oryza sativa*) with view, to find the possible solution to the problems in paddy transplanting in the hilly terrain of Konkan region. The machine was developed considering various factors affecting the performance of the transplanter.

Size of farm :

Under the situation, commercially available eight row transplanter is difficult to turn in small plots. This reduces field efficiency also.

Undulating terrain :

Rice plots in Konkan are available on terraces resulting into difficulties in transportation of machine into fields. The machinery developed for this region must be light in weight which could be transported by two to three persons from one field to another.

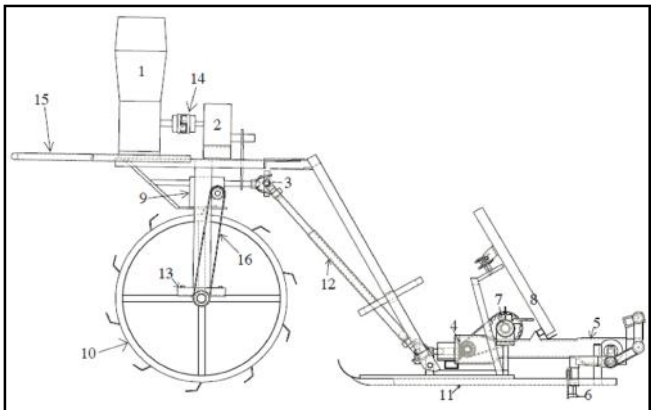
Operating conditions :

The machine was developed for transplanting of seedlings under properly puddled soil and its settlement.

Development procedure :

The power requirement for the transplanter was calculated and it was found to be 3.2 hp accordingly the commercially available higher size hp engine used for the transplanter having 3.5 hp power and 3600 rpm rated engine speed. For transplanting seedlings the commercially available transplanting mechanism was selected which has the knock out mechanism at the needle end. Commercially available gear box was used having gear ratio 12.5:1 so that at the transplanting mechanism get 288 rpm speed. Also one more gear box was selected having gear ratio 12:1 so that the speed from transplanting mechanism gets reduced to 24 rpm which was used for forward motion of transplanter. Considering this gear ratio and planting distance of 12 cm the drive wheel with luggs was designed having 50 cm effective diameter with 10 luggs of height 6 cm and width 7 cm on its peripheri. For seedling, tray was designed with four sections having its overall dimensions of 40 × 96 cm. For getting new piece of nursery during every stroke of transplanting arm the tray movement mechanism was designed. Lead srew was used for tray movement. In lead screw due to lead and threaded grove on shaft, the revolutions of shaft slides tray horizontaly. One stroke of transplanting arm slides tray 1.5 cm. The speed was reduced in the ratio 3:1 from transplanting mechanism to the tray movement mechanism using chain and sprocket. Float was designed for the transplanter which slides on the mud. The overall dimensions of the float are 1100 × 750 × 8 mm.

The schematic view of developed four row transplanter is shown in Fig. A and developed transplanter is shown in Fig. B.



(1) Engine, (2) Gear box (GR 12.5:1, (3) Universal joint, (4) Bevel gear, (5) Transplanting arm, (6) Needle operating mechanism, (7) Tray operating mechanism, (8) Tray, (9) Gear box, (GR 12:1), (10) Drive wheel with lugs, (11) Float, (12) Propeller shaft, (13) Pedestal bearing, (14) Coupler,(15) Handle,(16) Chain and sprocket mechanism

Fig. A : Schematic representation of developed paddy transplanter

Fig. B : Developed four row self propelled paddy transplanter

Performance evaluation of newly developed four row self propelled paddy transplanter :

The performance testing of four row self propelled paddy transplanter was carried out as per test code and procedure provided by RNAM (1995) at Agronomy farm of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The newly developed four row paddy transplanter was tested for its performance. Before testing the machine in the field, the laboratory test of the transplanter was carried out. The machine was operated in laboratory for observing its forward movement and working of transplanting mechanism using newly developed driving mechanism.

Laboratory testing of newly developed four row paddy transplanter was done and different parameters were measured. The transplanter was jacked first; arrangement was made properly to test the transplanter in laboratory. Observations of engine speed, drive wheel speed, speed of transplanting mechanism was taken. The number of seedlings per hill was measured.

After satisfactory working of the machine under laboratory condition, the performance of developed machine in the field was studied. The field of 10 m ×10 m size was prepared using power tiller. The depth of tilling was kept as 12 cm. Puddling of the field was carried out with the help of power tiller. The soil was allowed to settle for 48 hours. After settlement, depth of water was maintained in the field to 2-4 cm. Before field testing, sufficient practice was given to operator for operating the machine in the puddled soil without load (running in idle without operating transplanting mechanism). The crop of 21 days old of 12-15 cm height with 3-4 leaves grown in mat type nursery was cut into small pieces and placed on the tray and field test of the developed transplanter was carried out. The trial was replicated three times. The developed machine operating in the field is shown in Fig. C. The various parameters recorded during field testing are plant to plant spacing, planting depth, number of plants per hill, number of hills per m^2 area, missing hills, total time required for operation, time loss for turning, speed of operation, field efficiency, puddling index, field capacity and fuel consumption.

Fig. C : Field testing of newly developed four row self propelled paddy transplanter

■ RESULTS AND DISCUSSION

The four row self propelled paddy transplanter was developed and fabricated in workshop of Department of Farm Machinery and Power, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The specifications of machine are as given in Table 1.

The transplanter was tested in laboratory as well as on the field. Laboratory test results showed that transplanting mechanism and feeding mechanism functions properly. Constant row spacing of 23.8 cm was maintained. No break downs were observed during laboratory test. Laboratory tests results of the machine are mentioned below in Table 2.

The newly developed four row self propelled transplanter also operated in field for filler trial. The result reveals that the hill spacing for newly developed transplanter was 13.16 cm. The planting depth of the transplanting was observed to be 3 cm. The seedlings per hill and missing of hill were observed to be 3.66 and

Table 1 : Detailed specification of transplanter

Sr. No.	Particulars	Details/specifications
1.	Overall dimensions (mm)	Length : 1350 mm; Width :1150 mm; Height : 1100 mm
2.	Weight (kg)	110 Kilograms
3.	Planting rows	Number : four
		Spacing : 238 mm
4.	Engine	Model: GK-200 (Honda Make);
		Power (kW): 2.8 kW/3.5hp; Speed (rpm): 3600 rpm; Fuel : Petrol
5.	Wheel	Type : Lugged, 60×60 mm, No. of lugs=10
		Diameter: 500 mm; Speed = 24 rpm
6.	Float	Shape: Rectangular
		Size : 1100 mm× 750 mm, made up with G.I. sheet (22 gauge), covered with
		PVC sheet of size 1100 × 450 × 8 mm
7.	Planting mechanism	Mechanism of planting fork: knock out mechanism. No. of fork = 4, spacing =
		238 mm, Shaft speed 288 rpm
		Locus of planting : Elliptical
8.	Number of workers required for operating the machine	2 No.; One for operating and other for feeding nursery

Table 2 : Laboratory test results of transplanter

Sr. No.	Observations	Test 1	Test 2	Test 3
1.	Engine speed, rpm	3600	3125	2875
2.	Speed at gearbox (output), rpm	288	250	230
3.	Speed of drive wheel, rpm	24	21	20
4.	Speed of transplanting arm, strokes /min	285	247	225
5.	Row to row spacing, cm	23.8	23.8	23.8
6.	Number of seedlings per stroke	4-5	3-5	4-6
7.	Hill spacing (calculated)	12	12	12

Table 3 : Performance parameters of developed four row transplanter under different tests

Sr. No.	Items	Transplanting			
		T_1	T_2	T_3	Average
1.	Planting distance,(cm)	12.5	13	14	13.16
2.	Row spacing, (cm)	23.8	23.8	23.8	23.8
3.	Planting depth, (cm)	2.5	3.5	3	3
4.	No. of seedlings/ hill	3	4	4	3.66
5.	No. of hills/m^2	30	32	29	30
6.	Travel speed (km/hr)	1.56	1.42	1.46	1.48
7.	Missing hills/ m^2	6	4	3	4.33
8.	Sinkage (cm)	3.5	3.1	2.7	3.1
9.	Fuel consumption (l/h)	1.9	1.93	1.89	1.90
10.	Field efficiency, (%)	83.33	79.04	79.06	80.47
11.	No. of persons required for operating machine	1	1	1	1
12.	No. of persons required for mat feeding	1	1	1	1

4.33, respectively. The plant population was obtained to be 105.47/ m^2 area. The total numbers of hill/m^2 area were obtained as 30. Fuel consumption for the newly developed transplanter was 1.9 l/h. The operating speed of the transplanter was observed to be 1.48 km/h. The field efficiency of the transplanter was 80.47 per cent. Total time of operation for one hectare field was obtained to be 7.19 hr.

Time required for transplanting, turning, feeding the nursery were found to be 4.76, 0.71, 1.72 h/ha, respectively. The field capacity of the transplanter was 0.14 ha/h. The performance parameters in details are given in Table 3.

The operating cost of newly developed transplanter was calculated Rs. 359/h and Rs. 2580/ha. In general, the newly developed transplanter worked satisfactorily in the field.

Conclusion :

- The performance of developed four row self propelled paddy transplanter was satisfactory.
- Considering engine speed 3600 rpm and reducing it to 288 rpm at gearbox output, designing tray movement mechanism, driving mechanism, the achieved hill to hill spacing of 13.16 cm at forward speed of machine 1.48 km/hr and row spacing 23.8 cm, picking 3-5 seedlings by the arm in a stroke indicated the developed transplanter works satisfactory to achieve desired plant population of 105.47/m^2 against 100 m^2 of the theoretical plant population.
- The field capacity and field efficiency of newly developed transplanter was found to be 0.14 ha/h and 80.47 per cent, respectively.
- The labour requirement for transplanting operation was reduced to two.
- As compared to manual transplanting the newly developed transplanter remarked saving in cost of transplanting operation by Rs. 2420/ha (48.40 %) which is quite substantial amount.

Looking into the light weight, higher field capacity as compared to two row transplanter, hill and row spacing and optimum plant population with newly developed transplanter, it can be concluded that this machine can be a solution for mechanized transplanting in the fragmented hilly region of Konkan.

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