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Performance evaluation of self-propelled rice transplanter

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Abstract
Direct seeding of rice and transplanting are the two common methods of rice establishment. Transplanting method is more popular among farmers due to higher yield and less weed growth as compared to direct seeded rice. Transplanting of paddy completely depends on manual labour in India. Rice transplanting is done manually and requires about 306 man-h/ha, which is roughly 42% of the total labour requirement of rice production. A study was conducted to evaluate the performance of eight row self-propelled rice transplanter at ICAR-National Rice Research Institute. The field capacity, field efficiency of self-propelled rice transplanter were 0.234 ha h^{-1}, 75.16% respectively. It was observed that, the percentages of missing, floating and buried hills were 9.5%, 3.0% and 2.0% when self-propelled rice transplanter working in the field. The depth of transplanting was 6 cm. At the time of operation depth of standing water was 2.5-3 cm. The number of seedlings per hill was 2-3.

Keywords: Self-propelled rice transplanter, field capacity and field efficiency

Introduction
Rice is one of the main food crops in the world, especially in Asia and Africa. India is the second largest country in the production of rice in world. The demand for rice is growing with ever-increasing population. The total area under rice crop during 2015-16 is 43.81 M ha. The production of rice increases from 93.35 MT to 104.40 MT during 2006-07 to 2015-16. Direct seeding of rice and transplanting are the two common methods of rice establishment. Transplanting method is more popular among farmers due to higher yield and less weed growth as compared to direct seeded rice. However, it requires high energy and also it is labour intensive. The land is ploughed thoroughly and puddled in 5-10 cm standing water. The rice seedlings were grown in nursery. The seedlings were uprooted manually and washed the root carefully to remove mud from roots. The uprooted seedlings were transplanted in main field manually. Transplanting of paddy completely depends on manual labour in India. Generally paddy transplanting is done manually and requires about 306 man-ha h^{-1}, which is roughly 42% of the total labour requirement of rice production (Sangeetha *et al.*, 2015) [4]. Manual transplanting also fails to meet the agronomical requirements like plant population per m^2, plant to plant and row to row spacing were not achieved and hence mechanical weeding is not possible. A delay in transplanting of one month reduced the yield by 25% and delay of two months reduced the yield by 70% (Rao *et al.*, 1973) [3]. Mechanical transplanting systems increased yield, improved labour efficiency, ensured timeliness in operation and faster transplanting. Farmers can transplant rice seedlings within very short and appropriate time by mechanical transplanter. 20-30 days seedlings were found most suitable for transplanting. The mat thickness for best results should be about 2 cm. Transplanting mat type seedling is becoming more popular due to its superior performance and reduced labour requirement (50 man-ha h^{-1}) (Dixit *et al.*, 2007) [1].

Materials and Methods
A eight row self-propelled paddy transplanter performance was evaluated at ICAR-National Rice Research Institute, Cuttack (Odisha) during 2017-18. It has eight rows with 238 mm row to row spacing. The machine was provided with three speed gear box for transporting, planting and reverse speed. It has separate crank shaft and connecting rod system with seedlings pusher. The machine has a provision to control the depth of planting automatically. The technical specifications of the transplanter are given in Table 1.

Table 1: Technical specification of transplanter

S. No	Particulars	Specification
1	Make / brand	VST Tiller Tractors Ltd.
2	Model	170F single cylinder air cooled diesel
3	Overall dimension (L×W×H), mm	2500 × 2131 × 1300
4	Weight, kg	305
5	Type of nursery required	Tray type
6	Engine power	2.94 kW (rated)
7	Fuel	Diesel
8	Cooling system	Air cooled
9	Walking mechanism	Single wheel driven- steel wheel in paddy fields or rubber tyre on land
10	Planting mechanism	Separate crank shaft and connecting rod system with seedlings pusher
11	Number of rows	8
12	Row spacing, mm	238
13	Distance between hills, mm	140-170 (standard), 100-120, 120-140, 170-200, 200-230
14	Planting depth, mm	0-60

Fig 1: Self-propelled rice transplanter

Nursery preparation

Self-propelled rice transplanter required tray type nursery for transplanting seedling into main field. Good fertile soil was selected for growing seedlings. The selected soil must be free from debris and foreign materials. The soil was sieved and placed as single layer in the tray. A good quality paddy seeds were taken for raising nursery and were soaked in water for one day. Initially, a layer of fine soil were placed, on which soaked paddy seeds were placed and finally covered with another layer of the soil. Tray type nursery was shown in Fig 2. The spread paddy seeds covered with another layer of fine sand. Regularly water was sprinkled on tray for good germination. The trays were watered regularly and maintained at atmospheric condition.

Fig 2: Raising of nursery

Field preparation

A plot contained clay type soil was selected for testing the transplanter. The field was prepared by using power tiller. The field was irrigated before initial puddling. During the initial puddling the depth of standing water was 5-10 cm. The field was left for 3-4 days after initial puddling with water for decomposing the previous crop straw and stubbles. The final puddling was done with the same power tiller. After final puddling the field was left for one day to settle the soil and regain the strength. This technique helps in good performance of the transplanter.

Performance Evaluation of Self-Propelled Rice Transplanter

Hill spacing

Hill to hill spacing was measured by using metric scale after transplanting. Ten randomly selected observations were taken and the mean was calculated to represent hill spacing.

Number of seedlings per hill

Number of seedlings per hill was measured by directly counting the number of seedlings picked by the planting finger and transplanted in the field per hill after transplanting. Ten randomly selected observations were taken and the mean was determined to represent number of seedlings per hill.

Depth of transplanting

The depth of transplanting was determined by uprooting the seedlings immediately after transplanting. The seedlings were hold close to the puddle soil surface for uprooting. The distance from that point to the tip of the root was measured by scale to find the depth of transplanting. Ten randomly selected observations were taken for depth of transplanting.

Missing hills

The number of missing hills were counted along with total number of hills in m^2. Five observations were taken randomly and the mean was represented as percentage of missing hills. Percentage of missing hills was calculated using the following relationship.

$$\text{Missing hills, \%} = \frac{\text{Number of missing hills per m}^2}{\text{Total number of hills per m}^2} \times 100$$

Floating hills

Floating hills are the hills where all the seedlings in a hill are either floating on the surface or just placed on the surface of the mud. Floating hills were counted in m^2 area after transplanting. Five observations were taken and the mean was calculated as percentage of floating hills. Percentage of floating hills was calculated by the following formula.

$$\text{Floating hill, \%} = \frac{\text{Number of floating hills per m}^2}{\text{Total number of hills per m}^2} \times 100$$

Burried hills

Hills which are completely buried under soil after transplanting are called buried hills. Buried hills were counted in a square meter area after transplanting. Five observations were taken and the mean was represented as percentage of missing hills. Percentage buried hills was calculated by the following formula:

$$\text{Burried hills, \%} = \frac{\text{Number of burried hills per m}^2}{\text{Total number of hills per m}^2} \times 100$$

Damaged hills

These can be divided into two categories. Damage is caused by cutting or bending of the seedlings, or internal damage of the growing point of the seedling due to crushing by planting fork. Damaged hills were counted in a square meter area after transplanting. Five observations were taken and the mean was represented as percentage of burried hills. Percentage of damaged hills was calculated by the following formula:

$$\text{Damaged hills, \%} = \frac{\text{Number of damaged hills per m}^2}{\text{Total number of hills per m}^2} \times 100$$

Standing angle of planted seedling

The angle at which seedling is transplanted with vertical is called the standing angle of planted seedling. Ten randomly selected observations were taken for self-propelled rice transplanter with and without urea briquette applicator attachment and the mean was determined to represent standing angle of planted seedling.

Effective field capacity

It is the actual rate of coverage of area by a machine. Effective field capacity was determined using the following relationship:

$$\text{Effective field capacity,} \frac{\text{ha}}{\text{h}} = \frac{\text{Total area covered,(ha)}}{\text{Total time taken,(h)}} \times 100$$

The total time taken in above relationship includes time losses in turning, loading of trays and machine adjustment required during the operation.

Field efficiency

Field efficiency is the ratio effective field capacity and theoretical field capacity. It was determined by the formula given below:

$$\text{Field efficiency} = \frac{\text{Effective field capacity}}{\text{Theoritical field capacity}} \times 100$$

The theoretical field capacity was determined by following relationship:

$$\text{TFC} = \frac{\text{W} \times \text{S}}{10}$$

Where,

TFC = Theoretical field capacity, ha h^{-1}

W = Width of machine, m

S = Speed of operation, km h^{-1}

Results and Discussion

The performance evaluation of eight row self-propelled rice transplanter was studied at ICAR-NRRI, Cuttack during 2017-18. The performance of the transplanter under puddled field condition was evaluated in terms of field parameters and transplanting parameters.

Performance evaluation of eight row self-propelled rice transplanter

The field was puddled well and levelled with power tiller and leveled. The puddled field was allowed sedimentation period of 24 h to gain strength. The eight row self-propelled rice transplanter worked well in the field condition. No breakdowns were observed during the operation. The fingers and fork performed well without clogging during the operation. The self-propelled rice transplanter evaluated in terms of operating speed, hill spacing, number of plants per hill, depth of transplanting, missing hills, floating hills, buried hills, damaged hills, field capacity, field efficiency, machine index, angle of planted seedling and fuel consumption.

At the time of operation, depth of standing water was observed as 2.5-3 cm. The average spacing of hill to hill and row to row were 15.2 cm and 23.8 cm respectively. The number of seedlings per hill was 2-3. The average standing angle of transplanted hill observed as 83˚. The field capacity of the self-propelled transplanter was 0.234 ha h^{-1} with field efficiency of 75.16%. The operating speed of self-propelled transplanter was found as 1.84 km h^{-1}. The working time includes the productive time (transplanting) and non-productive (time lost in field) times. Non-productive time includes the turning losses, supply the seedling mats, cleaning and adjustments. The field machine index of self-propelled transplanter was 88.09%. The percentage of transplanting time was calculated as 74.74%. The loss for turning time loss and rate for tray feeding were 10.10% and 15.15% respectively. The fuel consumption of self-propelled transplanter was 1.66 l h^{-1} or 6.94 l ha^{-1}.

The average percentage of missing hills, floating hills, buried hills were 9.5%, 3% and 2% respectively shown in Fig 3. Least plant damage was observed. The mean depth of planting was observed 5.7 cm.

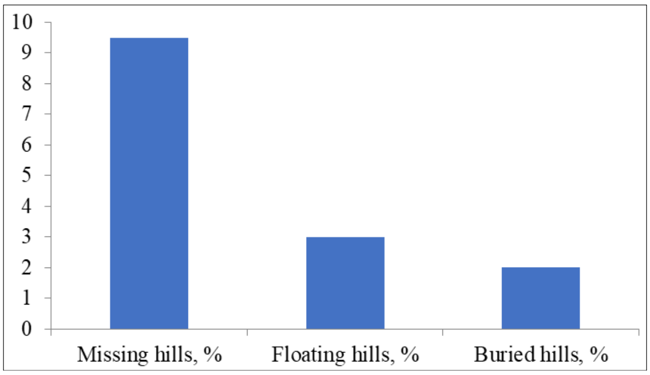

Fig 3: Planting performance of transplanter

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