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Impact of Field Preparation Methods on Performance of Mechanical Rice Transplanter: A case study of On-station of Directorate of Agricultural Research, Tarahara

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Abstract

Manual transplanting of rice is the most common rice establishment method in Nepal. Transplanting of paddy was solely dependent on traditional methods in Nepal. Nowadays, interventions for alternate and cost-efficient methods such as wet direct-seeded rice and machine transplantation through large plot demonstrations are done by different stakeholders in Nepal. Manual transplanting, which is our traditional method, consumes the biggest chunk of labor in the transplanting operation needed for rice production. A research was conducted in May 2022 inside the farm of Nepal Agricultural Research Council's Directorate of Agricultural Research, Koshi Province, Tarahara with the aim to evaluate the self-propelled riding type 8-row rice transplanter for two methods of field preparation viz. complete field preparation done using 18Hp power tiller-driven rotavator and 55 Hp tractor operated cultivator plus rotavator(i.e., Farmers' practice). Factors other than field preparation were kept constant or the same. The depth of the prepared field was measured in 10 different places of the two plots of about 0.2ha and was found to be 12cm in the case of the power tiller and 20cm in the case of the tractor. Actual field capacity was found to be (0.24ha/hr, 0.2ha/hr), field efficiency (78.18%, and 65.15%), and planting efficiency (84%, and 80%) for power tiller attached rotavator and tractor attached cultivator followed by tractor-driven rotavator(i.e. farmers' practice) fields. It is found that the missing hills, floating hills, and buried hills were also reduced by 0.25%, 0.87%, and 1.24% respectively in cases where a power tiller-driven rotavator was used to prepare the field completely. The rice seedlings were transplanted to a depth of 5.5-7 cm in both conditions. Standing water depth was maintained at 2-4 cm above the field. The seedling number per hill was 3-5. The age of the seedling was 18 days. Row-to-row spacing was 23.8cm and hill-to-hill spacing was 20 cm. The soil type of the farm is clay loam.

Keywords

Mechanical Rice Transplanter, power tiller, tractor, field capacity, field efficiency

1. Introduction

Rice (Oryza sativa) is the most important staple food crop and an important source of livelihood for Nepalese Farmers. It is reported that about 73% of rice is produced in the Terai, 24% in the hills, and 4% in the high hills [1]. Rice is cultivated in an area of about 1.49 million hectares and approx production is 5.61 million tons. The contribution of rice to total GDP is about 20%and AGDP is about 7%. Production of Rice involves a large number of laborers in different operations [2]. In manual(called traditional method in Nepal) paddy transplanting, the transplantation operation only requires about 306 man-ha h-1, which is roughly 42% of the total labor requirement of rice production. [3].

For conducting the research, rice seedlings were grown in trays of the transplanter by wet method following standard procedure. After 18 days, the seedlings were ready for mechanical transplantation. The grown seedlings were brought to a field where there were two fields of about 6katha(0.2ha) prepared by power tiller attached rotavator and tractor operated rotavator. Row-to-row spacing, hill-to-till spacing, number of plants per hectare can be maintained by using mechanical transplanting allowing subsequent mechanical weeding which manual methods fail to meet. Timely transplanting is crucial to rice production, one and two-month delays can cause a decline in yield of about 25% and 70% respectively. [4]. Mechanical transplanting systems can save time and cost of production by eliminating manual transplantation while keeping the yield up high as manual methods. Every 1% increase in the level of mechanization was found to significantly affect the yield positively for all crops(1.2125%), grain crops(1.5941%), and cash crops(0.4351%). [5]. In a study for mechanical transplanters, transplanting time was calculated to be 74.74% of the total time taken. The turning time loss was 10.10% and tray feeding was found to be 15.15% of the total time used for transplanting by a transplanter. [3]

2. Material and Methodology

An eight-row self-propelled riding-type rice transplanter performance was evaluated at the Directorate of Agricultural Research, Koshi Province, Tarahara in the main season rice of 2022 for two different field preparation methods. A 55Hp tractor with a cultivator for primary tillage and a rotavator for secondary tillage in one treatment and an 18Hp power tiller having a rotavator attached to it was used for both primary and secondary tillage for the second treatment. The technical specifications of the transplanter used in the study are given in Table 1.

Table 1: Technical specifications of the transplanter

Particulars	Specifications
Width, mm	1300
Weight, kg	305
Length, mm	2500
Height, mm	2131
Rated Power,KW	2.94
Engine	Single Cylinder Air Cooled
Rated Speed,rpm	2600
Row Number	8
Row Spacing,mm	238

Figure 1: Nursery for Transplanter

Figure 2: Float type mechanical rice transplanter in operation

2.1 Nursery preparation

For the research purpose nursery was prepared in trays. Dry fertile soil was taken from the field and was sieved to eliminate debris and pebbles. The soil and finely decayed organic manure was mixed in the ratio of 4:1 and was mixed properly before placing to the trays. The good quality seeds previously soaked for 24hrs and kept in jute bags in damp place for about 36 hrs i.e., sprouted seeds were uniformly sprayed in the trays and then covered by a thin layer of fine sieved soil. The seedlings were then closely monitored and taken care of with proper irrigation using a sprayer and taking them in proper sunlight and shed as per needs of the plants. After 18 days the nursery was ready to be planted using a mechanical transplanter as above mentioned in both plots.

2.2 Field preparation

Two plots of about 6katha (0.2 ha) were selected. The fields were prepared using two different implements, one completely done by power tiller and another completely by a tractor. Initial plowing was done 12 days prior to final field preparation. The second field was plowed initially using a spring tine cultivator and left for about 12 days to decay the weeds and straw of wheat. The final puddling was done using a power tiller rotavator and the second field using a tractor rotavator keeping standing water height about 8-15 cm. The field was then left for 48 hours so that the soft weeds decay and the soil gets settled and regains strength keeping in mind that the technique helps in good performance of the transplanter.

2.3 Parameters under consideration for performance evaluation of transplanter

2.3.1 Hill-to-hill spacing

After transplanting the previously prepared field using two different methods, hill-to-hill spacing was measured by using a measuring tape. Ten observations(called replications) were randomly selected for calculating the average hill-to-hill spacing in both cases.

2.3.2 Seedlings per hill

The number of seedlings per hill was obtained by direct counting the number of seedlings that the machinery fingers picked and placed in the field on each hill. For calculating the value of average seedlings per hill, ten different hills were fairly selected and averaged.

2.3.3 Transplanting depth

The transplanted seedlings were uprooted holding at the puddled soil surface just after the transplanting and the distance from the holding point to the tip of the root was measured by measuring scale. For getting a representative averaged value, here also the process was repeated ten times.

2.3.4 Missing-hills, (MH%)

The number of hills that are not transplanted was counted to get the missing hills. And total number of hills was also counted in an area covered by the machine in one-meter length. This process was repeated in random places five times and observations were taken and the mean was represented as a percentage of missing hills. To calculate the percentage of missing hills, the following relationship was applied.

$$MH\% = \frac{\text{Number of missing hills per m}^2}{\text{Total number of hills per m}^2} * 100 \tag{1}$$

2.3.5 Floated-hills, (FH%)

Floated hills are hills that are either floating on the mud or kept on the surface of the mud by the pickers of the transplanter. This data was calculated after taking measurements in an area of the one-meter square and replicated in five different places after finishing transplanting. Then this data was represented as the percentage of the total number of hills in the sampled area using a relation as given below.

$$FH\% = \frac{\text{Number of floating hills per m}^2}{\text{Total number of hills per m}^2} \times 100 \quad (2)$$

2.3.6 Buried-Hills, (BH%)

Those hills which are completely buried inside the mud during the transplanting are called buried hills. An area of one meter square was taken randomly in five places and such hills were counted manually. Thus achieved hill number was changed to the percentage of total hills using relationship given below:

$$BH\% = \frac{\text{Number of buried hills per m}^2}{\text{Total number of hills per m}^2} \times 100 \quad (3)$$

2.3.7 Actual Field Capacity (AFC%)

Actual Field Capacity is defined as the total area that a transplanter transplants divided by the total time(time lost in machine turning, loading of seed trays, and machine setting). Actual field capacity was calculated using the following expression:

$$AFC\% = \frac{\text{Total area covered, ha}}{\text{Total time taken, hr}} \times 100 \quad (4)$$

2.3.8 Theoretical Field Capacity (TFC)

It is calculated using the measurements of the width of the machine, and speed of operation and was determined by the following relationship:

$$TFC = \frac{W \times S}{10} \times 100 \quad (5)$$

Where
TFC = Theoretical Field Capacity, ha/h
W = Width of Transplanter, m
S = Speed of operation, km/h

2.3.9 Field Efficiency, (FE%)

Field efficiency is defined as the ratio of effective field capacity to theoretical field capacity. It was determined using the given expression:

$$FE\% = \frac{\text{Actual Field capacity}}{\text{Theoretical Field Capacity}} \times 100 \quad (6)$$

2.3.10 Planting Efficiency, (PE%)

Planting efficiency is the representation of the actual plants that are properly planted in the field by using a mechanical transplanter. It is calculated using the following relationship:

$$PE\% = \left(1 - \frac{(MH+FH+BH)}{TNH}\right) \times 100 \quad (7)$$

Where, TNH = Total no. of hills in sampled area

3. Result and Discussion

The performance evaluation of eight rows of self-propelled riding-type rice transplanters was done at NARC-DoAR Koshi Province in 2022 for main season rice. The performance of the mechanical float-type transplanter under puddled field conditions using two different field preparation methods was evaluated in terms of transplanting performance parameters keeping other associated things the same.

The two fields were puddled well and leveled separately with a power tiller-attached rotavator and tractor-attached cultivator plus rotavator. The prepared fields were both allowed to settle down for about a period of 48 hours to attain strength. The eight-row self-propelled riding-type rice transplanter worked properly in fields. No malfunctioning of the different parts was seen during the operation. No fingers were clogged during the operation and the seed mat which was grown in the trays was in excellent condition. The self-propelled rice transplanter was evaluated in terms of operating speed, the number of plants per hill, transplanting depth, hill-to-hill spacing, missing hills, floated hills, buried hills, field capacity, fuel consumption, and field efficiency. When the machine was operated after 48hrs of field preparation, the depth of standing water over the surface was measured as 2-4 cm. The average spacing of the hills and rows was recorded to be 20 cm and 23.8 cm respectively. The number of seedlings in the hills was 3-5. The field capacity of the self-propelled riding type transplanter was 0.24 ha/h and 0.2 ha/hr with field efficiency of 78.18% and 65.15%, planting efficiency of 84% and 80% respectively for power tiller rotavator prepared field and tractor cultivator plus tractor rotavator prepared field as shown in figure1. The transplanter was operated at speed of 1.67 km/h. The total time includes productive time (transplanting) and nonproductive (time lost in

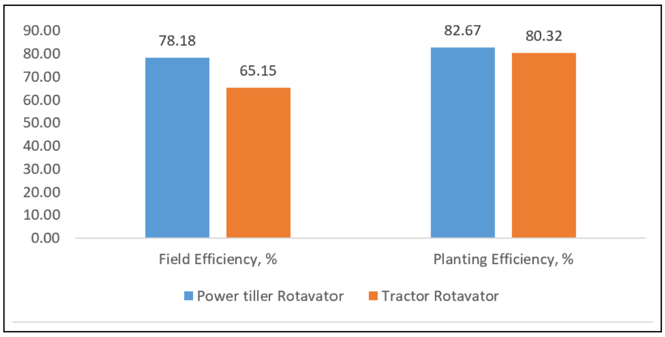

Figure 3: Efficiency of transplanter with varying field preparation

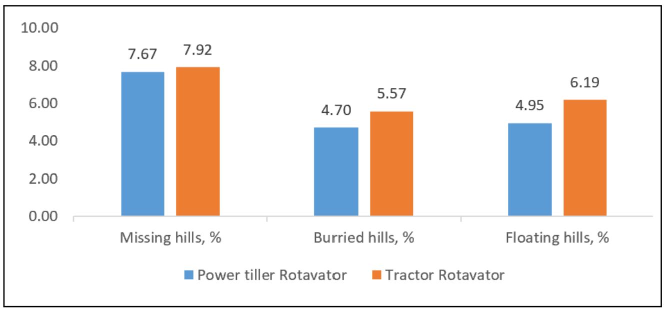

Figure 4: Plantinig performance of Transplanter under varying field preparation implements

the field) time. Non-productive time includes turning losses, supplying the seedling mats, cleaning, and adjustments. The fuel consumption of the transplanter was recorded to be 1.25 ltr/h. The percentage reduction of missing, floating, and buried hills were found to be 0.25%, 0.87%, and 1.24% respectively on shifting from field preparation using tractor operated cultivator plus rotavator to power tiller-operated rotavator which is shown in the figure 2 as well. The depth of transplanting was 5.5-7 cm. A negligible amount of Plant damage was observed.

4. Conclusion and Recommendation

The performance of mechanical rice transplanter depends critically on the field preparation methods. In previous operations in the same location, the rice transplanter was not performing satisfactorily. Studying the field preparation method adopted on-station previously it was found that the only field preparation method was tractor attachments and hence deep plowing. This study is an attempt to change plowing depth using a lighter implement i.e., a power tiller attached rotavator keeping in mind that the smaller depth of plowing means the smaller quantity of mud bed created, and hence the float of the transplanter under study(affordable as compared to other recent transplanters) would carry lesser amount of mud and hence floating, buried and missing hills can be reduced increasing the planting efficiency that would create positive perspective for better acceptance of the technology among farmers. The field preparation using a power tiller is also important because of the small land parcels available in the context of Nepal. This result can be useful to other float-type transplanters as well. So, it is recommended to prepare the fields to shallow depths of about 10-15cm.

5. Further Research Direction

Further research can be done on the field preparation methods for other transplanters such as walking behind type, 4-wheel transplanters, etc. Also, the level of field compaction caused due to the field preparation methods and their impact on infiltration rate, long term yield variation trends can be studied.

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