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Comparative analysis of commercially available rice transplanters to assess the suitability for system of rice intensification (SRI) method of cultivation

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Abstract
Rice is the staple food for over two thirds of the population of India. India has the largest area under rice cultivation, occupying an area of 42.3 M ha with an annual production of 140 Mt and a productivity of 3 t/ha. SRI method of planting requires planting the seedlings on the grid which is difficult for the workers who do not normally follow proper spacing in planting and maintain seedling population per hill. To overcome such difficulties, a suitable transplanter should be developed for SRI method of cultivation. There are several self-propelled rice transplanters available commercially, which will reduce labour requirement drastically thereby reducing the cost of cultivation. Evaluation was carried out with different transplanters, different seedling rates and different hill to hill spacings. Hill to hill spacing adjustment did not have any influence on number of seedling per hill for all the three transplanters. Minimum of 3 seedlings per hill in both Hi-Tech and Yanmar transplanter was obtained with minimum seedling rate adustment. Seedling rate and hill to hill spacing did not have any influence on depth of planting in all three transplanters. The number of missing hills per sq.m was inversely proportional to the seedling rate. Minimum 2% missing hills and minimum buried hills of 1.04% were observed in Hi-tech transplanter. The seedling rate and hill to hill spacing did not have significant influence on floating hills. Hi-tech transplanter was on par with yanmar transplanter. In addition, capital investment on Hi-tech transplanter was lesser to yanmar transplanter. Hence, Hi-tech transplanter was found suitable for modification to SRI.

Keywords: Transplanting, rice transplanter, SRI method, riding type transplanter, walk behind transplanter

1. Introduction

Rice is the staple food for over two thirds of the population in India. India has the largest area under rice cultivation, occupying an area of 43.39 M ha with an annual production of 104 Mt and a productivity of 2.4 t/ha (Kasula Sekhara and M. Devarajulu, 2019) [5]. In System of Rice Intensification (SRI) method, 15 days old seedlings are transplanted on well puddled field. Only one younger seedling is transplanted per hill with row to row and hill to hill spacing of 250 mm (Upholf, 2004) [7]. Marking is done on puddled soil before transplantation to ensure proper spacing. This method of planting requires careful planting on the grid which is difficult for the workers, who do not normally follow proper spacing in planting and do not maintain seedling population per hill (Berkelaar, 2001) [2]. Moser and Barett (2002) [6] reported that SRI is difficult for farmers to practice as it requires additional labour and intensive care during the crop production. The reason among the SRI adopters for the discontinuity was elicited through multiple response analysis and presented in the order of priority as perceived by the respondent's *viz.*, handling difficulty of the younger seedlings in transplanting, skilled labour shortage for mat nursery preparation and coverage of planting area (Alagesan and Budhar, 2009) [1]. To overcome such difficulties, a suitable transplanter should be developed for SRI. There are several self-propelled rice transplanters available commercially, which will reduce labour requirement thereby reducing the cost of cultivation. Dixit *et al.* (2007) [4] conducted a review on comparative performance of different rice transplanters developed in India and reported that 20 to 30 days seedlings were found most suitable for transplanting and the mat thickness for best result should be around 20 mm. They also concluded that the machine transplanting reduced the labour requirement to 59 man-h ha^{-1}. For SRI method of cultivation, single seedling per hill and hill to hill spacing play a crucial role in growth and yield (Chaudhary and Varshney, 2003) [3]. But, all the existing rice transplanters are not suitable for SRI method of transplanting, because the two important crucial factors for SRI are not met

Satisfactorily. So, there is need to develop or modify the existing model of rice transplanter to better suit SRI. Thus this comparative field performance evaluation of commercially available rice transplanters to select a transplanter suitable for modification for SRI is contemplated.

2. Materials and Methods

The important critical factors which affect the performance of rice transplanters suitable for SRI *viz.*, type of transplanters, seedling rate and hill to hill spacing were selected for the study. Three rice transplanters *viz.*, Hi-Tech walking type transplanter - 4 row (T_1), Yanmar riding type transplanter - 8 row (T_2) and Yanji riding type tranplnter -8 row (T_3) were selected. Number of seedlings per hill and seedling rate vary from machine to machine besides the seedling rate adjustment in particular transplanter. Hence, three levels of seedling rate *viz.*, minimum (P_1), minimum+1(P_2) and minimum +2 (P_3) were selected. Row to row spacing is fixed and hill to hill spacing is adjustable in all the machines. In Yanji rice transplanter, only two stages of hill to hill spacing adjustment is provided and the range of spacing adjustment is also low (150 mm and 170 mm). Hence, two levels of seedling rate *viz.*, minimum (H_1) and minimum+1(H_2) were selected.

Hill to hill spacing along the row, number of seedlings per hill, depth of planting, missing hills, floating hills, buried hills, damaged hills, standing angle and total number of seedlings per hill were measured in the field.

Hi-Tech (4 row) Yanmar (8 row) Yanji (8 row)

Fig 1: Operational views of selected rice transplanter for the study

Hill to hill spacing was measured by a steel scale of 0.30 m length after transplanting. Twenty randomly selected observations were taken for each replication and the mean was determined in each case. Number of seedlings per hill was measured by directly counting the number of seedlings picked by planting finger and transplanted in the field per hill after transplanting. Depth of planting is the distance between the points on the seedling just outside the soil surface to the tip of the root. The seedlings were uprooted immediately after transplanting holding them close to the soil surface. The distance from that point to the tip of the root was measured as the depth of transplanting. The standing angle was measured using the protractor. The vertical line is taken as the reference and the inclination towards the direction of travel is taken as positive value and the inclination against the direction of travel is taken as negative value.

Missing hills were counted in a square m area after transplanting. Percentage missing hill was calculated by using the following relationship.

$$\text{Missing hills} = \frac{\text{No. of missing hills per sq. m}}{\text{Total no. of hills per sq. m}} * 100$$

Floating hills were counted in a m^2 area after transplanting. Percentage of floating hills was calculated using the following relationship.

$$\text{Floating hills} = \frac{\text{No. of floating hills per sq. m}}{\text{Total no. of hills per sq. m}} * 100$$

Buried hills were counted in a m^2 area after transplanting. Percentage of buried hills is calculated using the following relationship.

$$\text{Buried hills} = \frac{\text{No. of buried hills per sq. m}}{\text{Total no. of hills per sq. m}} * 100$$

Damaged hills were counted in m^2 area after transplanting. The percentage of damaged hills was calculated using the following relationship

$$\text{Damaged hills} = \frac{\text{No. of damaged hils per sq. m}}{\text{Total no. of hills per sq. m}} * 100$$

The field allotted for the machine transplanting was divided into six equal sub plots with the interval of 1.0 m spacing between the sub-plots. Transplanting was carried out with the selected levels of the type of transplanter, seedling rate and hill to hill spacing (Fig. 1).

3. Results and Discussion

Hill to hill spacing did not have any influence on number of seedling per hill for all the three transplanters. Minimum of three seedlings per hill with minimum seedling rate (P_1) in Hi-Tech (T_1) and Yanmar Transplanters (T_2) were observed, whereas the minimum + 2 seedling rate (P3) of Yanji Transplanter (T_3) registered the maximum of 9 number of seedlings per hill (Fig. 2). The seedling rate did not have any influence on hill to hill spacing. Hill to hill spacing was directly proportional to the hill to hill spacing for all the three Trans planters. Mean hill to hill spacing of 140 mm and 180 mm were observed in Hi-Tech Trans planter respectively for minimum (H_1) and minimum + 1 (H_2) hill to hill spacing adjustment.

Hill to hill spacing of 160 mm and 190 mm were observed in Yanmar Tran's planter respectively for minimum (H_1) and minimum + 1 (H_2) hill to hill spacing adjustment. Hill to hill spacing of 150 mm and 170 mm were observed in Yanji Tran's planter respectively for minimum (H_1) and minimum + 1 (H_2) hill to hill spacing adjustment.

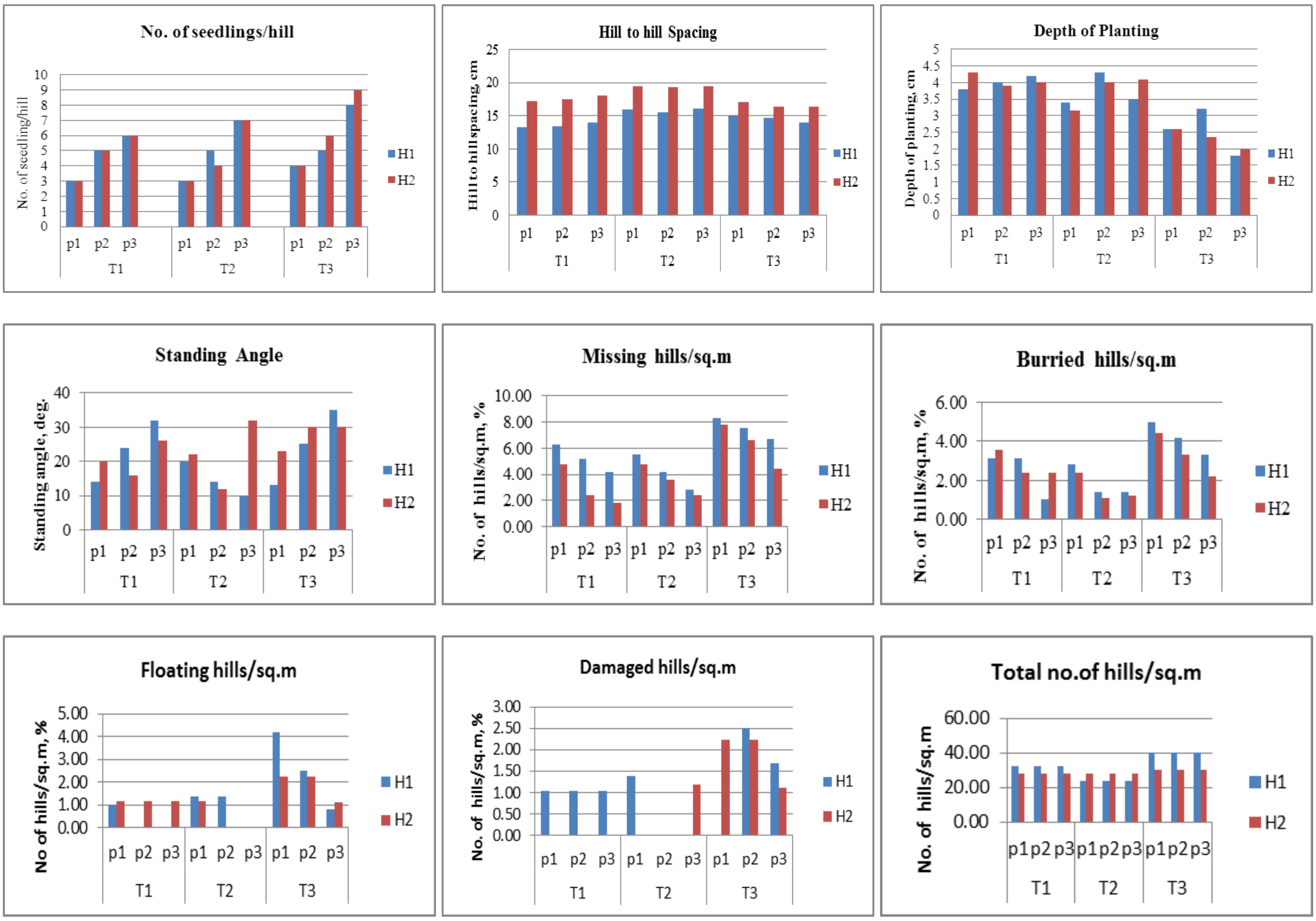

Fig 2. Effect of selected transplanting parameters on dependent variable

Seedling rate adjustment and hill to hill spacing adjustment did not have any influence on depth of planting for all the three Trans planters. The depth of planting was on par for Hi-Tech and Yanmar Tran planters. The average depth planting of 40.3 mm was observed for Hi-Tech transplanter, whereas that was 37.4 mm for Yanmar Tran planter and 24 mm for Yanji Tran planter. The standing angle of seedlings increased as the number of seedling or seedling rate increased for Hi-Tech and Yanji Tran planter. An average of 22^{o} standing angle was observed for Hi-Tech Trans planter whereas 18.3^{o} and 26^{o} for Yanmar and Yanji Tran planters were observed respectively.

The number of missing hills per sqm was inversely proportional to the seedling rate adjustment. This might be due to the fact that the probability of number of missing hills was reduced as the number of seedling per hill increased. Hill to hill spacing adjustment was found to affect the number of missing hills per m^2 inversely. The number of missing hills was higher for Yanji Tran planters followed by Hi-tech and Yanmar transplanted. Minimum 2 per cent of missing hills per m^2 was observed for Hi-tech transplanted with minimum +2 seedling rate and minimum +1 hill to hill spacing combination (P_3H_2). An average of 3.74 per cent missing hills was observed for Yanmar trans planter, whereas 4.14 and 6.75 per cent of missing hills were observed for Hi-Tech and Yanji transplanters respectively. Trend similar to that of missing hills was exhibited for the buried hills. The minimum number of buried hills of 1.04 per cent was observed for Hi-tech transplanter with minimum +2 seedling rate and minimum hill to hill spacing combination (P_3H_1). The seedling rate adjustment and hill to hill spacing adjustment did not have any significant influence on number of floating hills for all the transplanters studied.

Higher percentage (Average of 3 per cent) of floating hills was observed for all the treatments of Yanji transplanter. Minimum floating hills was observed with minimum +1 seedling rate and minimum +1 hill to hill spacing combination (P_2H_1) and minimum +2 seedling rate and minimum hill to hill spacing combination (P_3H_1) of Hi-tech and with all the combinations of seedling rate and hill to hill spacing of Yanmar transplanter, whereas maximum of 4.1 per cent floating hills was noticed with minimum seedling rate and minimum hill to hill spacing combination (P_1H_1) of Yanji transplanter. Trend similar to that of floating hills was exhibited for damage hills for all the transplanters.

4. Conclusion

The results of the comparative field performance evaluation of the three transplanters revealed that Hi-tech transplanter was on par with Yanmar transplanter in terms of most of the parameters under study. In addition, capital investment on Hi-tech transplanter was lower to the Yanmar transplanter. The average depth planting of 40.3 mm was noticed for Hi-Tech transplanter. The standing angle increased as the number of seedling or seedling rate increased. Combination of minimum seedling rate and minimum + 1 hill to hill spacing (P_1H_2) gave minimum number of seedlings per hill of 3-4 with less average number of missing hills/m^2 of 6-7% for both Hi-Tech and Yanmar trans planters. Hence, Hi-tech transplanter with minimum seedling rate (3-4 seedlings/hill) and maximum hill to hill spacing (210 mm) was optimized for modification for SRI.

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