Journal of Dry Zone Agriculture, 2018, 4(2): 70 - 74
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ISSN 2012-8673

Growth and Yield Response of Mechanical Transplanted Rice at Different Plant Densities

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Abstract: Optimum plant spacing is among key agronomic parameters that influence on growth and yield in rice (*Oryza sativa* L.). A field experiment was conducted to evaluate the growth and yield response of mechanical transplanted rice at the Rice Research Station, Paranthan during *Maha* season, 2016/17. The machine transplanting method considered as practical option to minimize the labor usage with the timeliness cultivation of rice. Recent past, rice transplanter was introduced to paddy farmers of Kilinochchi district by the governmentof Sri Lanka. However, adaptation of this method is still low due to socio-economic background and lack of technical information. Four rows of man-propelled paddy KUBOTA (SPW 48c) transplanter was used in this study with 30cm row spacing (non-adjustable) and 5 within row spacing levels (12, 14, 16, 18 and 21 cm), replicated four times in each. The rice variety Co-10 was used with the plot size of 4m×6m. The plant height, number of tillers at different stages, percentage of canopy coverage and yield components such as panicle per hill, panicle length, grain yield and 1000 grains weight were recorded. Results revealed that the spacing of 30cm×16 cm produced significantly higher number of tillers and panicles than others. The spacing of 30cm×16 cm recorded the highest (p<0.05) percentage of canopy coverage (75 %), 1000 grain weight (24.9 g) and grain yield (7921.9 kg/ha). This study concluded that spacing of 30cm×16cm can be considered as optimum plant density for machine transplanted rice for the variety Co-10 compared to other tested spacing in this region.

Keywords: Canopy coverage, growth, mechanical transplanting, rice, spacing, yield

Introduction

Rice (*Oryza sativa* L.) is a staple cereal crop for more than half of the world's population. The ever-increasing population demands rapid increase in rice productivity to ensure global food security (Chauhan *et al*., 2011; Abid *et al*., 2015). Paddy occupies nearly 15 percent of arable lands (820,000 ha) in Sri Lanka. Direct seeding, which is the common method of rice establishment gives a lower

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yield compared to transplanting. Although conventional transplanting gives a uniform crop stand, it is quite expensive and requires more labor days besides involving lot of drudgery. Singh *et al*. (1985) reported that transplanting takes about 250-300 man hours/ha which is roughly 25 per cent of the total labor requirement of the crop. Further, along with rapid industrialization and migration to urban areas, the availability of labor became very scarce. As it hike the labor wages, manual transplanting found costly leading to reduced profits to farmers. In general, the cultivation time ranges from three to six months, depending upon the selected rice varieties and the seasons when crops are cultivated. Growth and yields of rice are sensitive much on variability of land preparation, climatic conditions, proper care, and water supplies. Thus, improper farming techniques may obviously lead to a waste of invested capital and low outcomes. Since rice cultivation requires a great deal of available labor, lack of man-power may lead to late farming or little care which signifies a pressing need for machine aid to boost crop production (ADB, 2014). Mechanical transplanting of rice has been considered as a promising technique to increase rice productivity through labor saving, timely transplanting, archiving optimum plant density in the field, and cutting down unnecessary labor use. A rice transplanter was introduced by the government recently to encourage farmers to adopt this technology. Therefore, this study was aimed to determine the suitable mechanical transplanting spacing promoting rice growth and increasing rice yield.

Materials and Methods

The experiment was carried out at Rice Research Station, Paranthan during *Maha* 2016/2017. The experimental site receives an average rainfall of 750 mm and average temperatures 28.4-34.5 °C (max) and 19.7-24 °C (min). The aim of this study was to find out the optimum plant density to the better performance of yield for mechanically transplanted rice. Five within row spacing levels such as30cm×12cm (T1), 30cm×14cm (T2), 30cm×16cm (T3), 30cm×18cm (T4) and 30cm×21cm (T5) were tested. The experiment was laid in a Randomized Complete Block Design with four replicates in each spacing level. The plot size was 6m×4m. Rice variety, Co-10 was selected as is it performed well in transplanted rice during the previous season. Seedlings were raised in a dapog nursery to use in mechanical transplanting. Pre-germinated seeds were spread uniformly in a tray filled using equal quantities of soil and farm yard manures. Seedlings of 2-3 leaf stage (15 days) were fed to transplanter. The man-propelled paddy KUBOTA (SPW 48c) transplanter with four rows was used for planting 3-4 seedlings per hill throughout the treatments on 8th December 2016. This machine has the adjustment for changing hill spacing (within row spacing-WRS) and row width (between rows) is 30 cm non-adjustable. All agronomic practices for rice were done according to guidelines given by Department of Agriculture (2013).

Data collection

The observations were recorded on plant height (cm), number of tillers, panicle length (cm), number of panicles per plant, percentage of canopy coverage, thousand (1000) grains weight (g), fertile tillers per plant, panicle length and grain yield per plot (kg). Percentage canopy coverage was measured by using Line Intercept Method (Canfield, 1941).

Percentage of canopy cover of rice=

$$\frac{\text{total distance of rice covered by rice canopy}\times 100}{\text{total distance of line}}$$

Data analysis

The collected data were subjected to ANOVA using software SAS (version 9.1). Significant means were separated using the Duncan's Multiple Range Test (DMRT) at $\alpha \leq 0.05$.

Results and Discussion

Plant height

Plant height (cm) measured at three growth stages (Table 1) varied significantly (p<0.05) with different densities. Maximum plant height (95.04 cm) recorded in the treatment 5 (30cm×21cm) could be due to less competiveness among plants for absorbing water and nutrition.

Similar results shown that the widest spacing might be attributed to maximum utilization of light, water and other inputs to produce and then translocate photo-assimilates into sink (Khaliq *et al*., 2011). Minimum plant height (88.04 cm) was recorded in the treatment 4 (30cm×18cm). At vegetative stage, plant heights were not significantly differed among densities. Similar results found in mechanically transplanted rice to increase their leaf biomass during the vegetative period irrespective to within row space (Illangkoon *et al*., 2017).

Number of tillers per hill and panicle number per hill

The number of tillers produced per hill under the different spacing adopted is presented in Table 2. The number of tillers per hill produced significantly (p<0.05) differed among densities. A positive correlation was observed between densities and tillers per hill. However, the number of tillers produced per m^2 decreased with increased densities (T5). The maximum number of tillers per hill and panicle numbers per hill were recorded from the treatment 3 (30 cm ×16 cm spacing). Illangkoon *et al*. (2017) reported that a negative correlation between within raw space and tillers/m^2. Lowest number of productive tillers and panicle numbers per hill were observed in the plant spacing 30cm×18cm (T4).

Figure 1: Taking measurement of canopy coverage

Table 1: Plant height (cm) at different growth stages

Treatment	Vegetative stage	Reproductive stage	Harvesting stage
T1 (30cm ×12cm)	44.46^{a}	70.13^{c}	90.08^{b}
T2(30cm × 14cm)	42.79^{a}	77.46^{ab}	90.25^{b}
T3(30cm × 16cm)	44.63^{a}	75.71^{b}	92.75^{ab}
T4(30cm × 18cm)	43.13^{a}	80.33^{a}	88.04^{b}
T5(30cm × 21cm)	45.71^{a}	80.83^{a}	95.04^{a}

The numbers not sharing a letter in common in the same column, differed significantly at $p< 0.05$

Percentage of canopy coverage

The maximum plant canopy coverage (75 %) was recorded in treatment 3 (30cm×16cm spacing) and it was significantly higher than others. In addition, visual observation showed a less weed population in the same (T3) treatment and it could be due to high canopy coverage.

Panicle Length (cm)

Data on panicle length (Table 2) revealed that treatment 5 (30cm×21cm) had significantly higher panicle length (22.46 cm) compared to the rest. Similar results showed that the increased plant spacing, the effects on panicle density and grain yield were significantly high (p<0.01) (Baloch *et al*., 2002). The treatment 2 (30cm×14cm) showed the lowest (20.83 cm) panicle length.

Thousand-grain weight (g)

Thousand-grain weight, an important yield-determining component, is a genetic character least influenced by environment (Ashraf *et al*., 1999). The plant density showed significant (p<0.05) effect on 1000 grains weight. Higher 1000 grains weight (24.90 g) was recorded in treatment 3 and lower grain weight (22.70 g) recorded in treatment 1.

Grain yield

The effect of spacing on grain yield is presented in Table 2. Grain yield was significantly influenced by the plant density. Grain yield was high in treatment 3 (16cm×30cm) followed by treatment 1. Highest performance in grain yield could be due to an optimum

Table 2: Analysis of variance under different levels of spacing

Treatment	Tiller Numbers per hill	Percentage of Canopy Cover	Panicle Number per hill	Panicle length (cm)	Yield (kg/ plot)	Yield (kg/ha)	1000 seeds weight(g)
T1	14.00^{b}	70.63^{ab}	13.21^{b}	20.92^{b}	17.34^{ab}	7224.0^{ab}	22.70^{c}
T2	12.13^{c}	68.75^{ab}	11.25^{c}	20.83^{b}	13.89 ^{b}	5786.5^{b}	24.53^{ab}
T3	17.42^{a}	75.31^{a}	16.54^{a}	20.88^{b}	19.01^{a}	7921.9^{a}	24.90^{a}
T4	11.83^{c}	59.06^{b}	10.54^{c}	21.67^{ab}	12.88^{b}	5364.6^{b}	23.43^{bc}
T5	14.96^{b}	72.06^{b}	12.92^{b}	22.46^{a}	14.28^{b}	5947.9^{b}	24.05^{abc}

The numbers not sharing a letter in common in the same column, differ significantly at $p< 0.05$

condition for light reception, less competition for nutrient consumption and thereby the high accumulation of photosynthates in grains. The lowest yield (5364.6 kg/ha) was recorded inT4.

Conclusion

This study concluded that planting space can play a vital role to increased rice yield under mechanical transplanting system. The spacing of 30cm×16cm produced 8.7% higher yield than the yield at 30 cm ×12 cm spacing. Highest canopy coverage was also recorded at 30cm×16cm spacing showing the visible increase in weed suppression capacity. The results on this single season experiment revealed that 30cm×16cm row-hill spacing can be successfully used for high yielding Co-10 red pericarp rice under mechanical transplanting system. However, this research needs further validation.

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