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Effect of Different Crop Establishment Methods on Growth and Yield Response of Lowland Irrigated Rice in the Northern Region of Sri Lanka

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Abstract: Inappropriate method of crop establishment is one of the reasons for low yields in rice (*Oryza sativa* L.) cultivation. A field experiment was conducted to evaluate the effect of crop establishment methods such as, manual transplanting at 30 cm row spacing, broadcasting (check), dry seeder method, mechanized transplanting, random transplanting by hand and parachute method on growth and yield of 3½ month age group rice. The experiment was laid out in randomized complete block design with 3 replicates in each treatment. Data on number of plant/m^2, plant height, number of tillers/m^2, panicles/plant and paddy yield were recorded. Economics and cost-benefit ratio of each planting method were also calculated. The results indicated that paddy yield and cost-benefit ratio were significantly high in mechanized transplanting (5.57 and 1.58 t ha^{-1}, respectively) and parachute method with the values of 4.84 and 1.94 t ha^{-1}, respectively for the same parameters. Broadcasting method revealed a lower yield and cost-benefit ratio (4.11 and 1.22 t ha^{-1}, respectively) compared with mechanized transplanting and parachute method. However, broadcasting showed a higher yield due to presence of high number of plant per area than the transplanting by hand. It was further revealed that plant height, tiller density and panicles per plant were significantly high in mechanized transplanting method and par with parachute method. Therefore, both mechanized transplanting and parachute method can be considered as economical methods of crop establishment to increase the crop productivity in rice.

Keywords: Cost-benefit ratio, parachute, planting method, rice, transplanting

Introduction

Rice is the single most important crop occupying 15.6 % of the total cultivated area in Sri Lanka. On average 1,868 117 acres (756,005 ha) were sown during 2016 and the average yield was about 4,349 kg/ha. About 1.8 million families are engaged in paddy cultivation island-wide. Sri Lanka

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currently produces 2.9 million tons of paddy and satisfies around 95% of the domestic requirement (Department of Census and Statistics, 2015/2016 *Maha* Season). The per capita consumption of rice fluctuates around 116 kg per year depending on the price of rice, bread and wheat flour, it is projected that the demand for rice will increase at 1.1% per year and to meet the rice production should grow at the rate of 2.9% per year (Department of Agriculture, 2016). Increasing the cropping intensity and national average yield are the options available to achieve this production targets. The current cost of production of rough rice is Rs. 8.57 per kg. The cost of labor, farm power and tradable inputs constitutes 55, 23 and 23 % respectively (RRDI, Bathalagoda). The labour cost has risen at a higher rate than other costs over the last few years. This situation will place our country under increase pressure to produce low cost and high quality rice in the future.

In Sri Lanka, rice is commonly grown by broadcasting and it requires less number of labour units. Transplanting is widely practiced in most of the Asian countries (Mabbayad and Obordo, 1971). Direct seeding is not feasible due to decreasing water availability for crop cultivation. Both methods have their own advantages and disadvantages. However, an efficient weed management in transplanted rice gave higher economic yields than direct seeding method (Hossain *et al*., 2002).

"Parachute Method" of rice transplanting technique was recently introduced and being practiced to some extent, which overcomes some of the problems prevailing in these two traditional methods. It requires less labour, less time and can be more efficient. Other advantages are healthy and quick stand establishment, high productive tillering capability and can lead to higher grain yield. However, parachute method of rice transplanting requires more skilled labours for nursery raising and transplanting in the field. Therefore, the present study was designed to compare different rice planting methods to choose the most economical and farmer friendly one.

Materials and Methods

This experiment was carried out at Rice Research Station, Paranthan, during the November 2016/2017 Maha season. Six treatments such as manual transplanting at 30 cm row spacing (T1), broadcasting (T2); (check), dry seeder at 30 cm row spacing (T3), mechanized transplanting at 30 cm row spacing (T4), random transplanting by manual means (T5) and parachute method (T6) were arranged in randomized complete block design (RCBD) with three replicates in each treatment.

Seeds were sown in nurseries for T1, T4, and T5 on 8th of November 2016. On the same day, field establishments for broadcasting and dry seeder sowing were practiced. Twenty five days old seedlings were used for transplanting in T1, T4 and T5 methods. For parachute method, seedlings were raised in plastic trays. These trays contained 430 plugs. Seeds were dropped in each plug. After that, seedlings at the age of 12-15 days

were transplanted by throwing in a projectile manner into the puddle soil. Fertilizers were applied based on the recommendation of Department of Agriculture (2013). All other agronomic practices were kept uniform for all the treatments.

Data Recording

Fifteen plants were selected randomly for measuring plant height of each plot. The numbers of panicle bearing tillers were recorded at harvest by using a quadrat of 1 m^2 and calculated the average number of tillers/m^2.

Data analysis

Economic analysis was done by calculating the gross income considering the prevailing price of paddy. The cost of each establishing methods were calculated separately for each treatment. Net income was calculated using formula as a difference of gross income and variable cost. Benefit Cost Ratio (BCR) was calculated by dividing gross income by total cost of production. The data were analyzed statistically by Analysis of variance (ANOVA) and mean comparison was performed within treatments using Duncan Multiple Range Test (DMRT) at 5% significant level.

Results and Discussion

Plant density

Number of plant/m^2 under different establishment methods was significantly differed (p<0.05) and observed to be in the order of T3 > T2 > T4 > T6 > T5 > T1 (Table 1). It was in par with the study that the higher number of seedlings or plants was found in direct seeded methods than the transplanted methods (Luzes, 1991; Sharma *et al.*, 2005).

Plants Height

Plant height also differed significantly (p<0.05) between the different establishment methods. Maximum plant height was recorded in T6 (86.67 cm) (Table 1) followed by T4 and T5 (81.62 and 78.16 cm, respectively). Minimum plant height was recorded in T3 (67.83 cm). The results were in conformity to those of Tsai *et al*. (1986) and Singh *et al*. (2004) who reported that plant height was significantly greater where rice was established by transplanting as compared when it was directly seeded.

Table 1: Effect of different rice establishing methods on paddy yield and yield contributing parameters of rice crop

Planting methods	Plant density	Plant height (cm)	No. of active tillers (m^2)	No. of panicles/ m^2	Paddy yield (kg/ha)
T1	15.7^{d}	77.83^{bc}	349.54^{ab}	317.13^{ab}	4044^{c}
T2	59.4^{ab}	71.62^{dc}	217.59^{bc}	212.24^{bc}	4111^{c}
T3	70.2^{a}	67.83^{d}	263.89^{b}	236.11^{b}	4244^{bc}
T4	37.6^{b}	81.62^{ab}	421.30^{a}	412.04^{a}	5566^{a}
T5	22.4^{c}	78.12^{bc}	312.50^{ab}	307.87^{ab}	3966^{c}
T6	28.2^{c}	86.66^{a}	432.87^{a}	403.61^{a}	4844^{b}

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

Table 2: Cost of production, cost-benefit ratio and net income of different rice establishment methods

Planting methods	Cost of production (Rs. ha^{-1})	Income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	Cost- benefit ratio
T1	114,092	123,620	9,528	1:1.08
T2	104,511	128,011	23,500	1:1.22
T3	112,015	124,615	12,600	1:1.11
T4	107,152	169,725	62,573	1:1.58
T5	119,366	112,957	3,591	1:1.03
T6	117,195	152,532	35,337	1:1.30

Number of Tillers/m^2

The maximum number of tillers were found in T6, followed by T4 (432.87 and 421.3 tillers m^{-2}, respectively) and these were statistically at par with each other (Table 1). There was no significant different between T1 and T5. The lower number of tillers was recorded in T2, followed by T3 (217.59 and 263.89 tillers m^{-2}, respectively). The higher number of tillers in parachute and mechanized transplanting compared to the other methods might be attributed to the deep placement of seedling and better establishment of roots (Craigimiles *et al*., 1968; Ramamoorthy *et al*., 1974).

Number of Panicles/m^2

Number of panicle bearing tillers were influenced significantly (p<0.05) by various sowing methods (Table 1). Mechanized transplanting produced higher number of active tillers (412.04 m^{-2}) while broadcasting produced minimum active tillers (212.24 m^{-2}). Moreover, roots of plant could not penetrate deep enough to exploit the soil resources fully, giving a fair chance to the weeds to compete with the crop plant. Similar results were reported by Naklange *et al*. (1996).

Paddy yield (Kg/ ha)

Paddy yield was significantly (p<0.05) differed among planting methods (Table 1). The highest yield was obtained inT4 (5566 kg/ha), followed by T6 (4844 kg/ha). Mechanized transplanting and parachute method gave 35.3 % and 18.01 % greater yield in paddy over the broadcasting method (check).

Economic analysis

Economic analysis (Table 2) revealed that the highest net benefit (Rs. 62,573 ha^{-1}) was observed in T4 followed by T6 (Rs. 35,337 ha^{-1}). Cost-benefit ratio was also high in these two methods with values of 1.58 and 1.30, respectively. The lowest net return and minimum benefit cost ratio were recorded in T5 (Rs. 3,591 ha^{-1} and 1.03, respectively). Broadcasting method (check), which is the common practice among farmers, gave a comparatively lower net benefit and cost-benefit ratio (Rs.

23,500 ha^{-1} and 1.22, respectively) than that of mechanized transplanting and parachute method. In contrast, it gave higher net benefit than manual transplanting.

Conclusions

From this study, it can be concluded that mechanized transplanting is better than the other methods. Parachute method also gave better a yield and overcomes some of the issues in traditional planting method. Parachute method required less labour, less time and found more efficient. However, its net return was low due to high initial cost for plastic trays and skilled labours. Broadcasting method (check) required higher seed rate and its efficiency is very low compared with the mechanized transplanting and parachute methods.

Suggestions and Recommendations

This study can be conducted for different age groups of new improved varieties to determine the yield variations.

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