International Journal of Natural and Engineering Sciences 5 (3): 27-30, 2011
ISSN: 1307-1149, E-ISSN: 2146-0086, www.nobel.gen.tr

Techno-Economic Performance of a Self-Propelled Rice Transplanter and Comparison with Hand Transplanting for Hybrid Rice Variety

Mohammad Reza ALIZADEH[1] Ali Reza YADOLLAHINIA[2] Fatemeh RAHIMI-AJDADI[1]

[1] Department of Agricultural Engineering, Rice Research Institute of Iran (RRII), Rasht, Guilan, IRAN

[2] Department of Agricultural Engineering, Deputy of Rice Research Institute of Iran, Amol, Mazandaran, IRAN

***Corresponding Author**
e-mail: alizadeh_mohammadreza@yahoo.com

Received: June 20, 2011
Accepted: June 29, 2011

Abstract

This study was conducted to evaluate the techno-economic performance of a self-propelled four rows walking-type rice transplanter and comparison with hand transplanting method in the paddy field. Mat type seedlings of a high-yielding rice variety namely *Hybrid* was used for transplanting. In order to evaluate the performance of the rice transplaner, observations on planting depth, number of seedlings per hill, hill spacing, number of missing, floating hills and costs of operation were recorded. The experiment was carried out in randomized complete block design with four treatments, *viz.* hand transplanting (T_1) and rice transplanter (machine transplanting) at three seeding rates of 60 g per tray (T_2) , 80 g per tray (T_3) and 100 g per tray (T_4) . The results indicated that the hill spacing in hand transplanting was measured to be 13.20 cm compared to the average of 12.67 cm in rice transplanter. The number of seedlings per hill in rice transplanter increased from 1.7 to 2.8 as the seeding rate increased from 60 to 100 g per tray. The missing hills decreased from 13.32 to 7.65 % with increasing seeding rate from 60 to 100 g per tray. The average labor input in rice transplanter was 30 man h ha^{-1} compared to 126 man h ha^{-1} in hand transplanting. The total cost of transplanting in the treatments of T_2, T_3 and T_4 was decreased by 19.20, 22.44 and 25.70%, respectively as compared to hand transplanting.

Key Words: Field performance. Hybrid rice variety, rice transplanter, single plant hill.

INTRODUCTION

Within the worldwide-cultivated cereals, rice (*Oryza sativa* L.) is one of the leading food crops in the world and is second only to wheat in terms of annual for food consumption. In Asia where 95% of the world's rice is produced and consumed, it contributes 40-80% of the calories of Asian diet. Rice is a major crop in Iran with a total paddy production of about 3.0 Mt on an area of 615000 ha [1, 4].

Increase in world population and limitation in agricultural land demand to efficiency and productivity in whole stages of rice production. On the basis, there is a significant trend to mechanization of rice production resulting in reducing the labor work and time consuming. Rice planting is one of the important stages in this viewpoint particularly in transplanting method. Manual paddy transplanting is the tedious, laborious and time consuming operations requiring about 250-300 man h ha^{-1} which is roughly 25% of total labor requirement of rice production [11]. It is reported that a delay in transplanting by one month reduces the yield by 25% and a delay of two month reduced the yield by 70% [13]. According to above and necessity of time saving and crop yield, in recent years, with introducing new models of rice transplanting machine, farmers were encourage to mechanized methods of rice transplanting. By reason of operational speed through transplanter machine, it can be reduced the disadvantages caused to delay in planting and increase in labor wages. In Iran rice transplanting is the most common method of rice establishment in the lowland if performed traditionally, faces to major challenge concerning time period and labor shortage.

Several researches were conducted to found, evaluate and optimize of the influence parameters on transplanter machine [3, 8, 12, 14, 16]. Mufti and Khan [11] found that the effect of seedling age and variety on number of seedling per hill were significant in Yanmar ARP-8 transplanter. Their results also showed that a 30% increase in yield and a reduction of about 70% in labor requirements in transplanting with machine compared to the manual transplanting. Farooq et al. [5] evaluated the diffusion possibilities of mechanical rice transplanters. Manjunatha et al. [9] studied on the self-propelled rice transplanter and reported that to breakeven with the cost of manual operation, the mechanical transplanter should be used at least in an area of 28 hectares per year. Their results indicated that the cost of mechanical transplanting per hectare was about 51% lower than manual transplanting. Goel et al. [6] studied on the effect of sedimentation period on performance of rice transplanter and concluded that 32 h of sedimentation period was suitable for operation of manual transplanter while the same was 56 h for Yanji transplanter. Behera et al. [2] surveyed the effect of puddling on puddled soil characteristics and performance of self-propelled transplanter in rice crop.

Despite these performance parameters of transplanter, in some varieties or conditions, the number of established transplant may be important. In *Hybrid* rice cultivation, it is important to transplant single plant hill for increasing yield and reducing seed cost. However, there was not any report on the field performance of rice transplanter for single plant hill transplanting. Therefore, the objective of this study was to evaluate the techno-economic performance of a self-propelled walking-type rice transplanter at three seeding rate of 60, 80 and 100 g per tray for transplanting of *Hybrid* rice variety and comparison with hand transplanting in the paddy field.

MATERIALS AND METHODS

This study was undertaken at the experimental farm of the Rice Research Institute of Iran (RRII), Guilan, Rasht to evaluate the field performance of a self-propelled four rows walking-type rice transplanter (Daedong DP480, Korea). It has a fixed row spacing of 30 cm and has provisions for adjustments of planting depth, number of seedlings per hill, floats pressure against soil, hill spacing and planting speed. The detailed technical features of the machine used in the test are given in Table 1.

The plastic trays were used to raise mat-type seedlings. For this, the sprouted paddy seeds of a high-yielding rice variety, namely Hybrid (Bahar1) were sown uniformly over the plastic trays in three seeding rates 60, 80 and 100 g per tray. The trays were covered with fine soils, stacked and covered with moist gunny cloth for germination of seeds for 48 h. Thereafter, the seedling trays were spread on the nursery bed in the main field and covered with polyethylene sheet for the greening and hardening stages. The mat seedlings were ready to transplant when they had 2-3 leaves and 20 days old with 15 cm height.

The field was prepared using common tillage practice, which is first plowing (primary tillage) once, followed puddling (secondary tillage) twice and leveling using two-wheel tractor under the flooding conditions. Before starting the tests, all the required adjustments as hill spacing, number of plant per hill, and planting depth were done based on the machine operator's manual and other agronomical aspects. The row and hill spacing for Hybrid rice cultivation was considered 30 and 13 cm, respectively. In order to measure the soil penetration resistance, the standard falling cone having 36 mm base diameter, 44 mm height and 115g weight was used to measure the penetrating depth. The cone was dropped from the height of 1m using measured stand [15].

To evaluate the performance of the rice transplanting machine, observations on planting depth, number of seedlings per hill, hill spacing, number of missing and floating hills were measured. In order to estimate transplanting cost, the data taken on working speed, total time and labor inputs by the transplanter and manual worker to complete the operation were recorded.

Table 1. Technical specifications of the rice transplanter used in the test

Description	Specification
Type of machine	Self-propelled walking type
Model	Daedong DP 480
Manufacturer	Daedong Co. Ltd., Korea
Power unit (hp)	2.6/1800 rpm
Overall dimensions (length, width and height in mm)	2385, 1530, 870
Weight (kg)	160
Number of rows	Four rows
Row spacing (cm)	30
Hill spacing (cm)	13, 15 and 17.5
Wheel diameter (mm)	612
Wheel width (mm)	90
Transmission level	Forward 2 levels Backward 1 level

The experiment was carried out in randomized complete block design (RCBD) with four treatments, *viz.* manual transplanting (T_1) and machine transplanting at three seeding rates of 60 g per tray (T_2) , 80 g per tray (T_3) and 100 g per tray (T_4) . Each treatment was replicated four times. Data were analyzed using the ANOVA and the means comparison was determined using Duncan's multiple range tests with the help of the computer package MSTAT-C.

RESULTS AND DISCUSSION

Analysis of variance (ANOVA) for the variables of treatments is shown in Table 2. The results indicated that there was a significant difference (P<0.01) among the treatments for the number of seedlings per hill and missing hills, however there was no significant difference between the means of falling cone penetration depth, planting depth, hill spacing and floating hills.

The average falling cone penetration depth in the tested

Table 2. Analysis of variance (ANOVA) for the variables evaluated in hand and machine transplanting

	Mean square (M.S.)					
Source of variation (S.V.)	Degree of freedom (df)	penetration depth	Planting depth	Number of plants/ hill	Floated hills	Missing hills
Replication	3	3.568 ^{ns}	1.204 ^{ns}	0.064 ^{ns}	10.145 ^{ns}	23.823 *
Treatment	3	4.383 ^{ns}	0.280 ^{ns}	2.047 **	8.320 ^{ns}	136.529 **
Error	9	2.071	0.673	0.100	5.895	4.5000

ns: Non-significant   *: Significant at 5% level (P<0.05)   **: Significant at 1% level (P<0.01) field was measured to be 11.87 cm (Fig. 1). This parameter greatly affected by paddy field conditions and land preparation practices. Results of the study by showed that traffic ability of the tractor significantly decreased with increasing falling cone penetration depth.

The mean value for planting depth in hand transplanting was obtained 4.2 cm compared to 4.0 cm in machine transplanting (Fig. 1). In the present study, the planting depth was set at 3-4 cm; therefore, the desired planting depth was achieved under the test conditions. Higher planting depth under the soft soil condition was reported by Mori [10], Goel et al. [6] and Behera et al. [2].

The hill spacing in hand transplanting was measured to be 13.20 cm compared to the average of 12.67 cm in machine transplanting (Fig. 2). The average hill spacing in hand transplanting was closer to set point (13 cm) than that of rice transplanter. This might be due to excessive wheel sleep of the machine in soft paddy soil. Behera et al. [2] reported that the hill spacing not only depends on the puddling methods, but also influenced by sedimentation period (the period between the end of puddling and start of transplanting); higher sedimentation period more was hill spacing.

As shown in Fig. 3, the number of seedlings per hill in rice transplanter increased from 1.7 to 2.8 as the seeding rate increased from 60 to 100 g per tray. The average number of seedling per hill in rice transplanter was obtained to be 2.2 compared to 1.1 in hand transplanting. In Hybrid rice cultivation where one or two seedlings per hill are recommended, it is very important to adjust the adequate seeding rate per tray to achieve the desired agronomical requirement.

As shown in Fig. 4, there was no significant difference between the means floating hills under the tested treatments; however the average of floating hills in the treatments using rice transplanter (3.6%) was more than that of hand transplanting (0.8%). Higher percentage of floating hills might be due to poor anchorage of seedling in soft soil. Besides, high water level at low sedimentation period creates a wave action thereby washing away the seedlings which in turn might have increased the floating hills [2, 7].

There was a significant decreasing trend ($p<0.01$) in missing hills with increasing the seeding rate (Fig. 4). The missing hills decreased from 13.32 to 7.65 %, as the seeding rate increased from 60 to 100 g per tray. A lower missing hill in the higher seeding rate was due to the availability of more seedlings per unit area of the mat. There was no missing hill in the manual transplanting as the laborers carefully transplant the seedlings into puddled soil. Missing hill was found more than the allowable limit of 5% [10]. Similar observations were made by Behera et al. [2]. Goel et al. [6] in their study on effect of sedimentation period on performance of rice transplanter reported that the highest missing hills were observed at lowest sedimentation period in all the transplanters.

The comparison of transplanting costs in the experimental treatments is shown in Table 3. Among the treatments, the highest cost of 6185500 Rha^{-1} was associated with T_1 and the least one with 4595750 Rha^{-1} pertained toT_4. The average labor input in rice transplanter was 30 man h ha^{-1} compared to 126 man h ha^{-1} in hand transplanting. The cost increase of nursery in hand transplanting was 38.8% of total transplanting cost compared to 33.4% in rice transplanter. The total cost of transplanting in the treatments of T_2, T_3 and T_4 was decreased by 19.20, 22.44 and 25.70%, respectively as compared to hand transplanting.

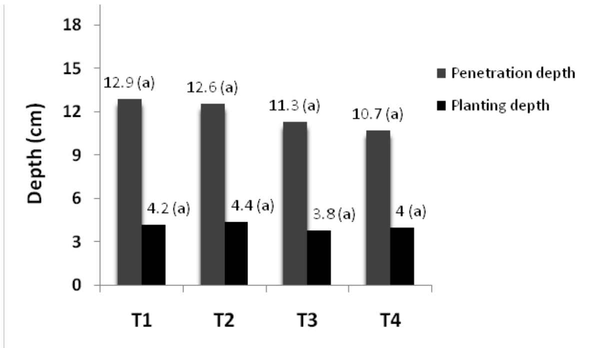

Fig. 1. Falling cone penetration and planting depth in the treatments
T1: Hand transplanting, T2: Rice transplanter (60 g per tray), T3: Rice transplanter (80 g per tray), T4: Rice transplanter (100 g per tray)

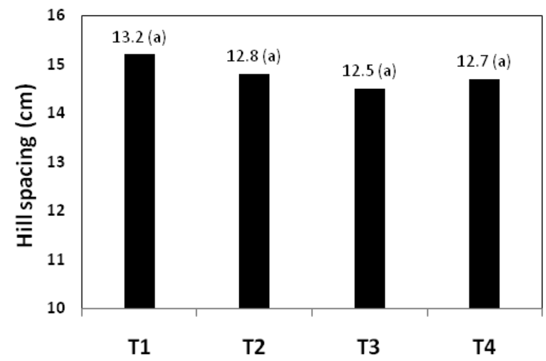

Fig. 2. Hill spacing of the different transplanting methods
T1: Hand transplanting, T2: Rice transplanter (60 g per tray), T3: Rice transplanter (80 g per tray), T4: Rice transplanter (100 g per tray)

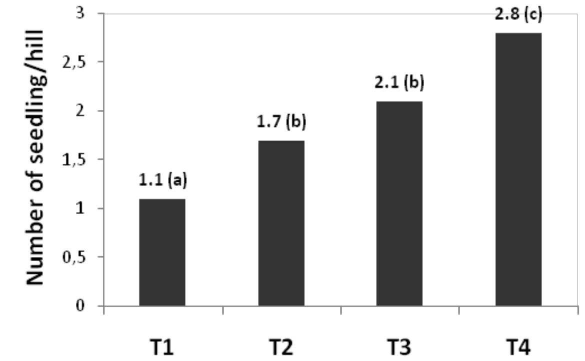

Fig. 3. Number of planting per hill in the experimental treatments
T1: Hand transplanting, T2: Rice transplanter (60 g per tray), T3: Rice transplanter (80 g per tray), T4: Rice transplanter (100 g per tray)

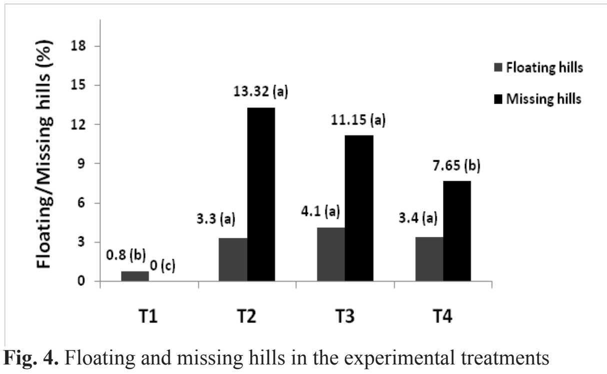

Fig. 4. Floating and missing hills in the experimental treatments
T1: Hand transplanting, T2: Rice transplanter (60 g per tray), T3: Rice transplanter (80 g per tray), T4: Rice transplanter (100 g per tray)

Table 3. Cost analysis of the different rice transplanting methods

Operation	T1		T2		T3		T4	
	Quantity	Cost (Rh^{-1})	Quantity	Cost (Rh^{-1})	Quantity	Cost (Rh^{-1})	Quantity	Cost (Rh^{-1})
Nursery raising:					-	-	-	-
Seed (kg)	30	292500	15	146250	20	195000	25	243750
Soil preparation (MH)	-	-	10	250000	10	250000	10	250000
Plastic sheet (kg)	20	600000	10	300000	10	300000	10	300000
Seedling tray	-	-	220	396000	220	396000	220	396000
Seedbed preparation (MH)	30	900000	15	450000	15	450000	15	450000
Fertilizer (kg)	3	12000	1.5	6000	1.5	6000	1.5	6000
Nursery protection (MH)	30	600000	20	400000	20	400000	20	400000
Subtotal- I	**-**	**2405500**	**-**	**1552250**	**-**	**1601000**	**-**	**1649000**
Transplanting:	-	-	-	1948250	-	1997000	-	2045750
Nursery uprooting (MH)	20	600000	-	-	-	-	-	-
Nursery transport (MH)	10	300000	10	300000	10	300000	10	300000
Transplanting (MH)	96	2880000	*	2000000	*	2000000	*	2000000
Missing plantations (MH)	-	-	30	7500000	20	500000	10	250000
Subtotal-II	**-**	**3780000**	**-**	**3050000**	**-**	**2800000**	**-**	**2550000**
Grand total		**6185500**	**-**	**4998250**	**-**	**4797000**	**-**	**4595750**

T1: Hand transplanting, T2: Rice transplanter (60 g per tray), T3: Rice transplanter (80 g per tray), T4: Rice transplanter (100 g per tray)
MH: Man-hour * Transplant hiring rate

Acknowledgements

The authors would like to thank the Rice Research Institute of Iran (RRII) for providing the laboratory facilities and financial support of this research.

REFERENCES

[1] Alizadeh MR, Minaei S, Tavakoli T, Khoshtaghaza MH. 2006. Effect of de-awning on physical properties of paddy. Pak. J. Biol. Sci. 9: 1726-1731.

[2] Behera, BK, Varshney BP, Goel AK. 2009. Effect of puddling on puddled soil characteristics and performance of self-propelled transplanter in rice crop. The CIGR Ejournal, Vol. X. Manuscript PM 08020.

[3] Eam-o-pas K, Munthumkarn V, Ounkong N, Goto Y, Yamauchi T. 1988. Performance of a self-propelled riding type rice transplanter. Kasetsart J. (Nat. Sci. Suppl.). 22: 79-87.

[4] Farahmandfar R, Farahmandfar E, Ramezani A. 2009. Physical properties of rough rice. Int. J. F. Eng. 5(5): 1-10.

[5] Farooq U, Sheikh AD, Iqbal M, Bashir A, Anwar Z. 2001. Diffusion possibilities of mechanical rice transplanters. Int. J. Agri. Biol. 3(1): 17-20.

[6] Goel AK, Behera D, Swain S. 2007. Effect of sedimentation period on performance of a rice transplanter. The CIGR Ejournal, Manuscript PM 07034, Vol. X. 1-14.

[7] Kanoksak EOP, Munthumkarn V, Ounkong N, Goto Y, Yamachi T. 1988. Performance of a self-propelled riding type rice transplanter. Kasetsart J. 22: 79-87.

[8] Kim SS, Kim BK, Choi MG, Back NH. 1999. Effects of seedling age on growth and yield of Machine Transplanted rice in Southern plain region. Korean J. Crop Sci. 44(2): 122-128.

[9] Manjunatha MV, Masthana Reddy BG, Shashidhar SD, Joshi VR. 2009. Studies on the performance of self-propelled rice transplaner and its effect on crop yield. Karnataka J. Agric. Sci. 22(2): 385-387.

[10] Mori Y. 1975. Performance evaluation of rice transplanters evaluated by national test. JARQ. 9(3): 152-155.

[11] Mufti AI, Khan AS. 1995. Performance evaluation of Yanmar paddy transplanter in Pakistan. Agricultural mechanization in Asia, Africa and Latin America. 26 (1): 31-36.

[12] Rani TS, Jayakiran K. 2010. Evaluation of different planting techniques for economic feasibility in rice. Electronic Journal of Environmental, Agricultural and Food Chemistry. 9(1): 150-153.

[13] Rao MV, Pradhan SN. 1973. Cultivation practices. Rice Production Manual, ICAR; 71-95.

[14] Sajita T, Jayakiran K. 2010. Evaluation of different planting techniques for economic feasibility in rice. Electronic Journal of Environmental, Agricultural and Food Chemistry. 9(1): 150-153.

[15] Salokhe VM, Ramalingam N. 2001. Effects of direction of rotation of a rotary tiller on properties of Bangkok clay soil. Soil & Tillage Research. 63: 65-74.

[16] Singh G, Sharma TR, Bockhop CW. 1985. Field performance evaluation of a manual transplanter. J. Agric. Eng. Res. 32: 259-268.