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Effects of Seedling Raising Methods on the Economic Performance of Manually Operated Paddy Transplanter

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ABSTRAK

Satu kajian telah dijalankan untuk mengenalpasti kaedah percambahan benih keatas prestasi ekonomi sebuah jentera penanam padi. Kos percambahan benih padi menerusi kerangka kayu, buluh, plastik, tali nylon dan dulang plastik bagi satu hektar kawasan masing masing adalah US$ 27.21, US$27.77, US$27.20, US$27.04 dan US$44.89. Walaubagaimanapun bagi percambahan jenis semaian basah kosnya hanya US$19.32. Faedah bersih penanaman berjentera dengan menggunakan semaian menerusi kerangka kayu, buluh dan plastik masing masing adalah US$13.48, US$19.46 dan US$16.05 per hektar berbanding penanaman secara manual dengan semaian basah. Diantara kaedah percambahan yang diuji, percambahan menggunakan kerangka plastik didapati lebih sesuai dimana keluasan pulangan setahun adalah 1.9 ha. Dengan teknik ini seorang petani dapat menjimatkan US$16.00 per ha berbanding kaedah penanaman secara manual.

ABSTRACT

A study was conducted to identify the effects of different seedling raising media on the economic performance of a manually operated transplanter. The costs of seedling production in wooden frame, bamboo frame, plastic frame, nylon rope and plastic tray nurseries for transplanting one hectare of land were US$27.21, US$27.77, US$27.20, US$27.04 and US$44.89 respectively. However, for wet bed nursery, it was only US$19.32. The net benefit from machine transplanting with wooden, bamboo and plastic frame seedlings were US$ 13.48, US$ 19.46 and US$ 16.05 per ha respectively compared to hand transplanting with wet bed seedlings. Among the five seedling raising media, plastic frame was considered the most appropriate one, where the break-even area per year is only 1.9 ha. Using this technique, a farmer can save about US$ 16.0 per ha compared to hand transplanting method.

Key words: paddy, seedling, transplanter, Dapog nursery, wet bed nursery, wooden frame, bamboo frame, plastic frame, plastic tray, nylon rope, pre-germinated seed, break-even analysis, partial budget analysis

INTRODUCTION

Rice has been accepted as a staple food for half of the world population and about 90% of them live in Asia. Rice crop may be established by direct seeding or transplanting. Until 1965, people used to produce rice by direct seeding with

traditional varieties. However, with the introduction of high yielding varieties (HYV), the production practice shifted from direct seeding to transplanting. There were some specific studies which confirmed that transplanting rice produced 10 to 20% more yield than broadcasted rice (Ramiah and Hanumontha 1936; Bautista 1938; and Ghose *et al.* 1960). Devasundrarajah (1971) reported that there are two clear advantages in transplanting method of rice production. Transplanted paddy occupies field with lesser time compared to direct seeded paddy and it facilitates the control of weeds. Rice transplanting is a highly labour intensive farming operation which consumes about 30% of the labour needed for rice production. According to Islam (1993), about 400-450 man-hr/ha were necessary for hand transplanting in rows, but in the case of random transplanting, the labour requirement was 300-350 man-hr/ha.

A manually operated rice transplanting machine was developed at International Rice Research Institute (IRRI) in the late seventies and later modified in Bangladesh for adaptation to the farmers. The transplanter needed soil-bearing type seedling and capable of transplanting 5-6 times faster than the hand transplanting method. The field performance and economic feasibility of the transplanter are dependent on the seedling raising methods.

Some studies were conducted at IRRI on the seedling raising media, namely using gunny bag, banana leaves and bracts, concrete floor and plastic sheets (Salazar et al. 1985). But their economic comparisons were not reported. Therefore, this study was undertaken:

(a) to compare the costs of different seedling raising methods for manually operated transplanter with a view to reduce production cost.
(b) to identify an appropriate method which can help promoting machine transplanting among the farmers.

MATERIALS AND METHODS

The costs of seedling production in Dapog and tray nurseries for transplanting one hectare of land by machine were calculated. The cost of seedling production for hand transplanting was calculated based on the wet bed method. The Dapog nurseries were provided with wooden, bamboo and plastic frames; however, the nylon ropes were provided only along the boundaries. The tray nursery was made of plastic material. The size of the tray was 40 cm × 20 cm × 3 cm. The seedlings produced in Dapog nursery with different frames were transplanted by BRRI transplanter. However, seedlings produced in wet bed nursery were transplanted by hand in rows. The transplanting costs by machine and hand were calculated separately. The transplanting costs were added to the seedling production costs. The cost of materials and labour were calculated on the basis of Dhaka market as the study was conducted in Bangladesh which is a typical rice growing country in South East Asia. For Dapog and wed bed nurseries, the seedlings were produced in the beds of 10 m^2 and 20 m^2 areas respectively; however, the seedling production costs were expressed in US$/ha. The sizes of the individual plot for machine and hand transplanting were

2.4 m × 20 m each and the transplanting costs were expressed in US$/ha. The treatments were as follows:

T_1 = Cost of machine transplanting with wooden frame nursery seedling
T_2 = Cost of machine transplanting with bamboo frame nursery seedling
T_3 = Cost of machine transplanting with plastic frame nursery seedling
T_4 = Cost of machine transplanting with nylon rope nursery seedling
T_5 = Cost of machine transplanting with plastic tray nursery seedling
T_6 = Cost of hand transplanting with wet bed nursery seedling

Experimental Design

The experiment was conducted under a Randomized Complete Block (RCB) design and the treatments were replicated thrice in each block.

Data Analysis

The data recorded for the costs of seedling production and transplanting were analyzed by partial budget method. This method of analysis is very effective in making a decision whether to switch over a new system as it take-care of the extra cost and revenue for the new system. Moreover, it takes care of the cost saving from the old system and loss of revenue due to the adoption of the new system. The break even analysis of the data was conducted in order to know the level of use (ha/yr), the transplanting cost for the old and whether it would be the same for the new system.

Dapog Nursery

The seedlings were raised in a modified Dapog bed. Each bed was 1 m wide and 20 m long and raised about 30-40 cm above the general surface of the field by putting mud. Then a plastic sheet was spread on the bed and boundaries were provided with frames. After that, a mud layer of approximately 2 to 2.5 cm thick was put on the plastic sheet. Pre-germinated rice seed (BR-1 variety) at the rate of 0.70 kg/m^2 was uniformly spread on the mud. The bed was mulched with rice straw to protect from bird damage. The straw was removed from the bed after three days. The nursery was cared with sufficient amount of water and proper doses of fertilizer and insecticide. Fourteen to eighteen days old seedlings were cut into 19 cm × 40 cm slices to feed into the machine for transplanting.

Wooden Frame Nursery

A wooden frame accommodated 10 compartments of the size of the transplanter tray. The size of the tray was 40 cm × 20 cm × 3 cm. For transplanting one hectare of land, 1100 seedling trays were necessary. Therefore, 110 frames were necessary. The cross section of the side wall of the frame was 3 cm × 1 cm and that of the inner partition wall was 3 cm × 0.7 cm. The frames were laid on the plastic sheet of the Dapog nursery and the compartments were filled with mud.

Bamboo Frame Nursery

A bamboo frame accommodated 10 compartments of the size of the transplanter tray. The size of the tray was 40 cm × 20 cm × 3 cm. For transplanting one hectare of land 1100 seedling trays were necessary. Therefore, 110 frames were necessary. The cross section of the wall of the frame was 3 cm × 0.5 cm. The frames were put on the Dapog nursery in the field seedling raising. The frames were laid on the plastic sheet of the Dapog nursery and the compartments were filled with mud.

Plastic Frame Nursery

A plastic frame accommodated 6 compartments of the size of the transplanter tray. The size of the tray was 40 cm × 20 cm × 3 cm. For transplanting one hectare of land, 1100 seedling trays were necessary. Therefore, 184 frames were necessary. The cross section of the wall of the frame was 3 cm × 0.2 cm. On both the sides of the frame, rectangular plastic tubes were used to increase the strength of the frame. The frames were put on the Dapog nursery in the field seedling raising. The frames were laid on the plastic sheet of the Dapog nursery and the compartments were filled with mud.

Nylon Rope Nursery

After putting the plastic sheet in the Dapog nursery, the bed was bounded by nylon rope and a 2 to 2.5 cm thick mud layer was applied. The seeds were then sown over the mud. When the seedlings were ready for transplanting, they were cut into 19 cm × 40 cm pieces.

Plastic Tray Nursery

The size of a plastic tray was 40 cm × 20 cm × 3 cm. For transplanting one hectare of land 1100, seedling trays were necessary. Therefore, 184 frames were necessary. The cross section of the wall of the frame was 3 cm × 0.2 cm. The trays were put either in the glass house or in the open field for seedling raising.

Wet Bed Nursery

For hand transplanting, the seedlings were raised in wet bed nursery. Each bed was 1 m wide and 20 m long and raised about 30-40 cm above the general surface of the field by putting mud. The pre-germinated rice seeds at rate of 15 .gm/m^2 were spread uniformly. The seedlings were provided with sufficient amount of water and proper doses of fertilizers and insecticides. Twenty five to 35 days old seedling were ready for transplanting.

RESULTS AND DISCUSSION

Cost of Seedling Production

The method of seedling production is an essential pre-requisite for rice transplanting by machine. The highest cost involvement in seedling production

was US$44.89/ha in plastic tray nursery and the lowest cost was US$19.32/ha in wet bed nursery (Table 1). The seedlings produced in the wet bed nursery were not suitable for machine transplanting, however, they were suitable for hand transplanting. For machine transplanting; the cost of seedling production in wooden frame, bamboo frame, plastic frame, and the nylon rope nurseries were US$ 27.21/ha, US$ 27.77/ha, US$27.20 and US$27.04/ha respectively which were almost identical. However, for the plastic tray nursery the cost was US$ 44.89/ha which was significantly greater than those produced in the above methods. The highest cost involvement in plastic tray method was due to the high initial cost of the plastic trays. Approximately US$ 625.00 was necessary to purchase 1100 trays needed for the production of seedlings for one hectare of land. Considering the longevity, the wooden and bamboo frames were identical, but for the bamboo frame it was difficult to maintain sharp, straight and rectangular strips necessary for partitioning of the seedling compartments.

Plastic frames were light weight and handy but their manufacture would not be as simple as the wooden or bamboo frames. In the manufacture of plastic frame, about 0.8m × 0.6m size moulds were necessary for casting of the frame containing six compartments. When the hot plastic materials were cooled in the mould, there was a possibility of bending of the frame walls due to shrinkage and surface tension. If this type of manufacturing difficulties could be overcome, the plastic frame might be a cheap and appropriate medium in which the seedlings for manually operated transplanter could be produced.

TABLE 1
Cost of seedling production and transplanting by different methods

Method of seedling production	Cost of Seedling production* (US$/ha)	Cost of frame (US$/ha)	Cost of transplanter operation (US$/ha)	Total cost (US$/ha)
Wooden frame nursery	27.21	18.92	14.83	60.96
Bamboo frame nursery	27.77	12.38	14.83	54.98
Plastic frame nursery	27.20	16.36	14.83	58.39
Plastic tray nursery	44.89	50.04	14.83	109.76
Nylon rope nursery	27.04	0.57	20.22	47.26
Wet bed nursery	19.32	0.00	73.86	93.18

** Seedling production cost to serve one hectare of land*

Cost of Transplanting

Partial Budget Analysis

The net benefit from machine transplanting with wooden, bamboo and plastic frame nursery seedlings were US$13.48, US$19.46 and US$16.05 respectively compared to hand transplanting method with wet bed nursery seedlings (Tables 2, 3 and 4). The highest net benefit i.e. US$ 26.61/ha could be achieved when seedlings were raised in nylon rope nursery technique and transplanted by BRRI manual transplanter (Table 5). On the other hand, when

TABLE 2
Partial budget analysis between machine transplanting with wooden frame nursery seedling and hand transplanting with wet bed nursery seedling

Added return	(US$/ha)	Added cost	(US$/ha)
(A) EXTRA REVENUE:		(B) EXTRA COSTS:	
1. Yield benefit from timely planting	11.93	1. Cost of transplanter (FC + VC)	14.83
2. Benefit from machine renting	9.10	2. Cost of wooden frame (FC + VC)	18.92
		3. Cost of seedling production	27.21
(C) SAVING IN COSTS:		(D) LOSS IN REVENUE:	
1. Labour saved in seedling uprooting and hand transplanting	73.86	1. Yield loss for missing hills	39.77
2. Cost saved in wet bed seedling production	19.32		
Total	114.21	Total	100.73

Net benefit (US$/ha) = Added return - Added cost
= (A + C) - (B + D)
= 114.21 - 100.73
= 13.48

TABLE 3
Partial budget analysis between machine transplanting with bamboo frame nursery seedling and hand transplanting with wet bed nursery seedling

Added return	(US$/ha)	Added cost	(US$/ha)
(A) EXTRA REVENUE:		(B) EXTRA COSTS:	
1. Yield benefit from timely planting	11.93	1. Cost of transplanter (FC + VC)	14.83
2. Benefit from machine renting	9.10	2. Cost of bamboo frame (FC + VC)	12.38
		3. Cost of seedling production	27.77
(C) SAVING IN COSTS:		(D) LOSS IN REVENUE:	
1. Labour saved in seedling uprooting and hand transplanting	73.86	1. Yield loss for missing hills	39.77
2. Cost saved in wet bed seedling production	19.32		
Total	114.21	Total	94.75

Net benefit (US$/ha) = Added return - Added cost
= (A + C) - (B + D)
= 114.21 - 94.75
= 19.46

TABLE 4
Partial budget analysis between machine transplanting with plastic frame nursery seedling and hand transplanting with wet bed nursery seedling

Added return	(US$/ha)	Added cost	(US$/ha)
(A) EXTRA REVENUE:		(B) EXTRA COSTS:	
1. Yield benefit from timely planting	11.93	1. Cost of transplanter (FC + VC)	14.83
2. Benefit from machine renting	9.10	2. Cost of plastic frame (FC + VC)	16.36
		3. Cost of seedling production	27.20
(C) SAVING IN COSTS:		(D) LOSS IN REVENUE:	
1. Labour saved in seedling uprooting and hand transplanting	73.86	1. Yield loss for missing hills	39.77
2. Cost saved in wet bed seedling production	19.32		
Total	114.21	Total	98.16

Net benefit (US$/ha) = Added return - Added cost
= (A + C) - (B + D)
= 114.21 - 98.16
= 16.05

TABLE 5
Partial budget analysis between machine transplanting with nylon rope nursery seedling and hand transplanting with wet bed nursery seedling

Added return	(US$/ha)	Added cost	(US$/ha)
(A) EXTRA REVENUE:		(B) EXTRA COSTS:	
1. Yield benefit from timely planting	11.93	1. Cost of transplanter (FC + VC)	20.22
2. Benefit from machine renting	9.10	2. Cost of nylon rope (FC + VC)	0.57
		3. Cost of seedling production	27.04
(C) SAVING IN COSTS:		(D) LOSS IN REVENUE:	
1. Labour saved in seedling uprooting and hand transplanting	73.86	1. Yield loss for missing hills	39.77
2. Cost saved in wet bed seedling production	19.32		
Total	114.21	Total	87.60

Net benefit (US$/ha) = Added return - Added cost
= (A + C) - (B + D)
= 114.21 - 87.60
= 26.61

TABLE 6
Partial budget analysis between machine transplanting with plastic tray nursery seedling and hand transplanting with wet bed nursery seedling

Added return	(US$/ha)	Added cost	(US$/ha)
(A) EXTRA REVENUE:		(B) EXTRA COSTS:	
1. Yield benefit from timely planting	11.93	1. Cost of transplanter (FC + VC)	14.83
2. Benefit from machine renting	9.10	2. Cost of wooden frame (FC + VC)	50.04
		3. Cost of seedling production	44.89
(C) SAVING IN COSTS:		(D) LOSS IN REVENUE:	
1. Labour saved in seedling uprooting and hand transplanting	73.86	1. Yield loss for missing hills	39.77
2. Cost saved in wet bed seedling production	19.32		
Total	114.21	Total	149.53

Net benefit (US$/ha) = Added return - Added cost
= (A + C) - (B + D)
= 114.21 - 149.53
= (-) 35.20

machine transplanting with plastic tray seedling was compared to hand transplanting, there was a net loss of US$ 35.32 per hectare (Table 6). The reason was that the initial cost for plastic trays and the labour requirement for soil preparation were very high. If the job of soil preparation could be mechanized, the labour requirement would be reduced and then the seedling production in trays would be economically attractive to the farmers.

In the analysis, 0.25 ton/ha yield loss costing about US$40.00/ha was estimated due to missing hills in the machine transplanted field. But in the added return, the summation of the benefit from the timely planting and machine renting was only US$ 20.00/ha. Therefore, the adoption of such a transplanter by a farmer would be a safe and profitable investment.

Break-even Analysis

Using a manually operated transplanter with the seedling raised in a wooden frame nursery, for a farmer who used only one hectare per year, the cost of transplanting was US$142.43 per hectare and the cost of hand transplanting was US$93.18 per hectare. However, with the increase of annual use, the cost of machine transplanting decreased and at the yearly use level of 2.0 ha, the costs of machine transplanting and hand transplanting were the same (*Fig. 1*). Therefore, machine transplanting with wooden frame nursery seedling, when the annual use exceeded 2.0 hectares, would benefit the farmer compared to hand transplanting method. On the other hand, when the annual use level was

less than 2.0 ha, the farmer would be advised not to buy the transplanter and he should continue with the existing hand transplanting method.

Similarly the break even use levels per year of machine transplanting with bamboo frame, plastic frame and nylon rope nursery seedling were 1.6, 1.8 and 0.5 hectares respectively compared to hand transplanting method (*Figures 2, 3* and *4*). For a farmer owning 2 hectares of land and considering the possibility of triple cropping, the annual work load was 6 hectares. Therefore, a farmer having only 2 hectares of land could be advised to buy a transplanter because the yearly break-even use level was less than 2 hectares with seedlings produced by any one of the above methods. The break-even use level of the transplanter with plastic tray nursery seedling was found to be 13.0 ha/year (*Fig. 5*). Therefore, machine transplanting with plastic tray seedling was not recommended for an average size farmer. Considering all the factors, the machine transplanting with plastic frame nursery seedling would be

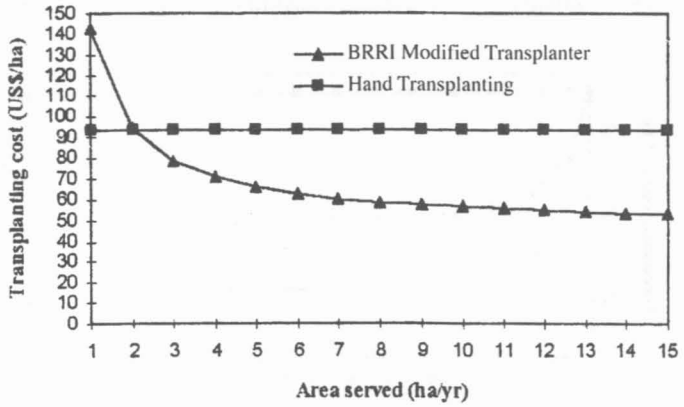

Fig 1. Transplanting cost by BRRI modified transplanter with wooden frame nursery seedling compared to hand transplanting with wet bed seedling in different levels of use.

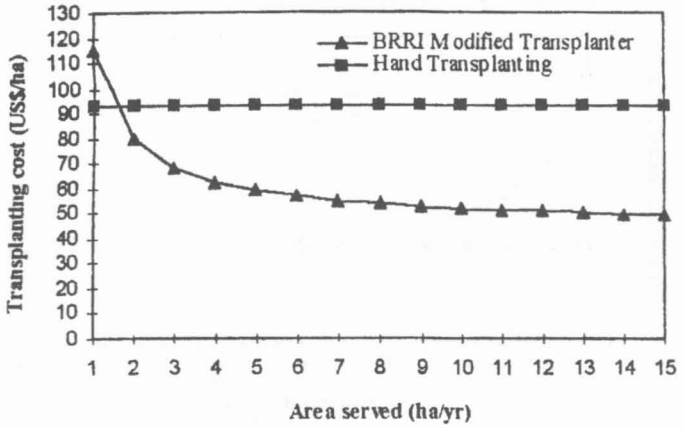

Fig 2. Transplanting cost by BRRI modified transplanter with bamboo frame nursery seedling compared to hand transplanting with wet bed seedling in different levels of use.

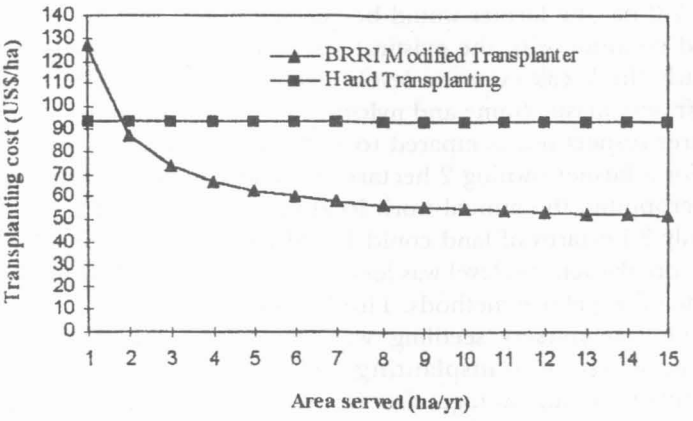

Fig 3. Transplanting cost by BRRI modified transplanter with plastic frame nursery seedling compared to hand transplanting with wet bed seedling.

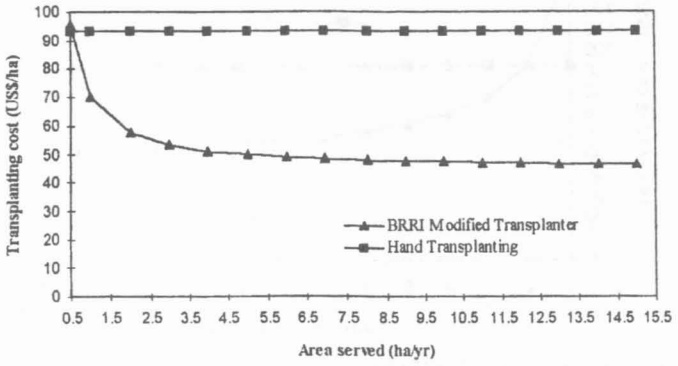

Fig 4. Transplanting cost by BRRI modified transplanter with nylon rope nursery seedling compared to hand transplanting with wet bed seedling.

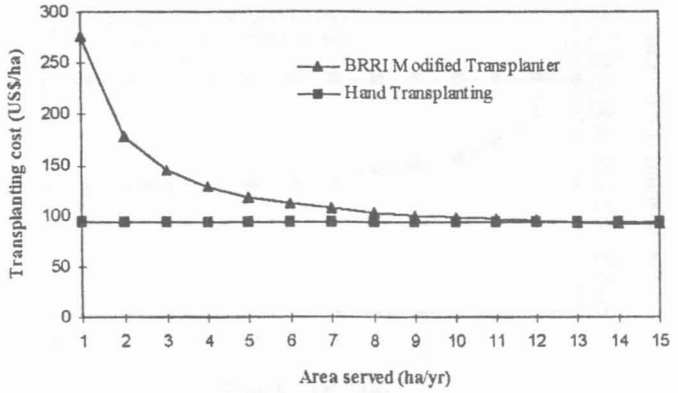

Fig 5. Transplanting cost by BRRI modified transplanter with plastic tray nursery seedling compared to hand transplanting with wet bed seedling.

recommended where the break even use level per year was only 1.8 ha. This process would be workable if the plastic frames are available in the market. Otherwise the farmers are advised to practice machine transplanting with wooden frame nursery seedling where the break even use level is 2.0 ha.

CONCLUSION

Among the five seedling raising methods for machine transplanting, the plastic frame method was the most appropriate, where the break-even area per year was only 1.9 ha. Using this method and transplanting by BRRI transplanter, a farmer could save about US$16.00 per hectare compared to the conventional hand transplanting method.

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