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Crop Establishment Technologies for Lowland Rice Cultivation in Bangladesh: Hand Seeding vs. Machine Seeding

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ABSTRACT

Experiments were conducted to determine the field and economic performances of machines and techniques for crop establishment in lowland paddy in Bangladesh. In machine seeded field, the crops were grown in rows to allow the operation of rotary type weeder for weed control. In hand broadcasted field, crops were not arranged in rows and weed control operation was therefore done through traditional means. Results obtained showed that the effect of rice seeding techniques, using pre-germinated rice seed of BR-1 variety on the effective field capacity, was highly significant. The work rate of hand broadcasting was found to be one to one and a half times faster than that of seeding by manually driven drum type row seeder. Field efficiency of hand broadcasting was about 90 percent, and this was found to be significantly higher than those of machine seeding which ranged from 70-80 percent at both seed rates, since no time was lost in turning. BRRI modified drum type row seeder, with a seeding rate of 60 kg/ha, was shown to be better for an optimum crop yield. Based on partial budget analysis, a farmer can save about US$53.34 per hectare in a year using the BRRI modified drum type row seeder, followed by a rotary weeder as compared to hand seeding, followed by hand weeding.

Keywords: Drum seeder, effective field capacity, partial budget analysis, break even analysis

INTRODUCTION

Rice has been accepted as a staple food for more than half of the world's population and it is generally grown under wetland condition. It may be grown in direct seeded or in transplanted condition. The high yielding rice varieties have been growing in transplanted condition since their introduction, with a belief that transplanted rice usually produces 10-15% more yield than direct seeded rice (Ramiah and Hanumontha, 1936; Bautista, 1938; Ghose *et al.,* 1960; IRRI, 1971). Some recent studies reveal that there is no yield difference between direct seeding and transplanting practices of rice production when weed control and other intercultural operations are done properly. This finding is applicable for both high yielding and traditional varieties.

Due to the rapid industrialization in the region, such as that experienced by countries like Thailand and Malaysia, the labour cost has not only increased substantially but farm labourers have become scarce as well. Therefore, direct seeding is practiced extensively and most farmers in the areas are expected to eventually switch to direct seeding so as to reduce the cost of cultivation in some of the irrigated areas (De Datta and Nantasamsaran, 1991).

In central Luzon, Philippines, where rice has been traditionally grown in transplanted condition, the adoption of broadcast seeding rapidly increased, i.e. from less than 2 percent in 1979 to 16 percent in 1982 (Moody and Cordova, 1985). Erguisa *et al.* (1990) reported that farmers who were

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practicing a combination of transplanting and wet seeding in 1980 had entirely shifted to broadcast seeding by 1986. During the 1987 off season in Malaysia, 99 percent of the planted areas in the Muda irrigation scheme were direct seeded (Ho *et al.,* 1990).

In the case of hand seeding, the seeds are usually broadcast at random. As a result, the crops stand in the field without any specific rows. Therefore, the operation of rotary type rice weeder is not possible and the farmers are compelled to use indigenous hand tools for weed control operation. It is important to note that weed control, using indigenous hand tools, is a highly labour intensive farming operation. Islam and Haq (1985) found that weed control with the use of traditional hand tools required 300 man-hr/ha of labours, but this was only 25 man-hr/ha when the rotary type weeding machine was used. Other means of controlling weeds in the random planted rice field is by the application of chemicals, but this is rather discouraged as it has adverse effects on the environment. Therefore, a row type paddy seeder is necessary. The International Rice Research Institute (IRRI) had developed a manually operated drum type row seeder for lowland paddy, and this was later modified by the Bangladesh Rice Research Institute (BRRI).

The objectives of the study were: (a) to identify the advantages and limitations of the existing rice seeding techniques, (b) to determine their field performances, and (c) to determine the comparative economics of machine and hand seeding of paddy.

MATERIALS AND METHODS

Experiments were conducted at the Bangladesh Rice Research Institute (BRRI) farm in silty clay loam soil to evaluate the performances of the BRRI designed drum type row seeder, using two different seeding rates and the results were compared with those of the hand broadcasting method. The treatments were as follows:

T_1 = Seeding by drum type row seeder at the rate of 60 kg/ha
T_2 = Seeding by drum type row seeder at the rate of 80 kg/ha
T_3 = Hand broadcasting at the rate of 100 kg/ha

BRRI Designed the Drum Type Row Seeder

The BRRI drum type row seeder was designed based on the IRRI design prototype, which is a manually operated machine suitable for sowing pre-germinated paddy seeds in rows, as shown in *Fig. 1.* It consists of four metallic drums, one metallic axle, a main frame, a cage wheel, two skids, and a handle. It is made of mild steel pipe, mild steel rod, and galvanized iron sheet. The drums have holes through which seeds are dropped when the machine is pulled backward on the prepared field. It has 8 rows with a spacing of 20 cm between two consecutive rows.

The IRRI designed machine has no mechanism to collect seeds while turning at headlands. As a result, some seeds are lost in every turn, and this consequently reduces the crop yield. A seed collector assembly made from galvanized iron sheet and rod was therefore incorporated to overcome the unwanted seed dropping at the headlands. Every drum is provided with a tray with the size of 36cm long and 30 cm wide. The trays are engaged at the headlands and disengaged during seeding operation. The presence of seed collector during turning was found to be able to save 5-7 kg of the seeds per hectare as compared to the IRRI seeder. The modified prototype of the drum type row seeder, termed as the BRRI modified drum seeder, is shown in *Fig. 2.* The operating principle is similar to that of the IRRI designed seeder, with the advantage of having a seed collecting assembly to collect seeds while turning at the headlands.

Fig. 1: IRRI designed drum type row seeder

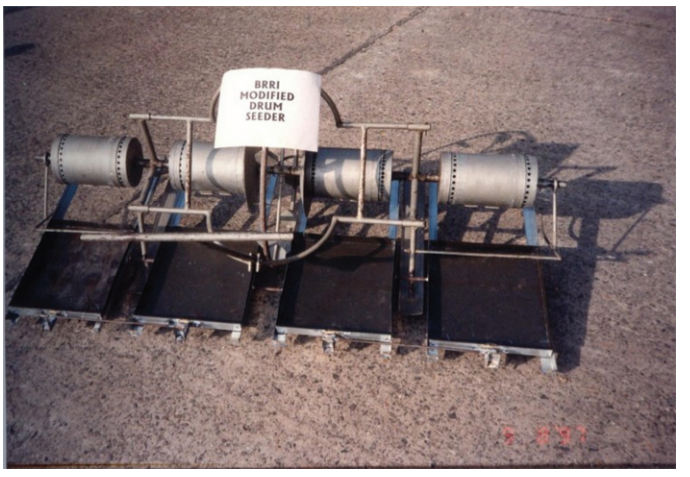

Fig. 2: BRRI modified drum seeder

Design of the Experiment

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

Experimental Procedure

Before field test, the drum seeder was tested in the laboratory to ensure the workability of all the functional components. The seeder was tested for two seeding rates, namely 60 and 80 kg/ha, and a comparison was made with the conventional hand broadcasting method. The experimental plots were selected as per treatments and layout plan. The plot was well puddled with a sufficient number of ploughing and levelled by laddering. The seeds were soaked in clean water three days prior to the final land preparation. After 24 hours of soaking, the water was drained out and the seeds were put in a gunny bag for sprouting. The duration of sprouting was 48 hours. The degree of sprouting

was observed very carefully so that the seeds could easily be passed through the seeder holes. After loading the sprouted seeds in the drums, the seeder was pulled backward and the seeds were dispensed by the action of gravity. After seeding, about a week of bird watching was necessary, depending on the cropping pattern of the surrounding field. The effective field capacities and field efficiencies were calculated from the collected data. Data on plant population, plant spacing, plant height, and root length were recorded. The crops were managed with irrigation, drainage, weeding, fertilizer, and insecticide application. The data on the yield parameters such as tiller/m^2, panicle/m^2, filled grain/panicle, and percentage of filled grains were recorded. Finally, they were harvested, threshed, cleaned and dried and the yields were expressed in tonnes per hectare at 14% moisture content dry basis. The data recorded from the experiment were subjected to analysis of variance and Duncan's Multiple Range Test (DMRT) using the IRRISTAT package.

The partial budget analysis between hand and machine seeding was also carried out. The seed rates for hand and machine seeding were 100 kg/ha and 60 kg/ha, respectively. In the analysis, the costs for two operations (seeding and weeding) were considered. In the hand broadcast field, weeding was carried out by indigenous hand tools as the crops did not have specific rows. In the machine seeded field, on the other hand, weeding was done using the rotary type rice weeder as crops were arranged in specific rows. The parameters, such as fixed and variable costs for seeder and weeder, were taken into account. An additional benefit from the drum seeder renting was considered, however, the crop yields for hand and machine seeding were considered as identical. A break-even analysis was conducted to find out the minimum acreage at which the machine seeding was profitable over hand seeding.

RESULTS AND DISCUSSION

Advantages and Limitations of the Existing Rice Seeding Techniques

From the analysis of variance, it was evident that the effect of rice seeding techniques using pre-germinated rice seed of BR-1 variety on the effective field capacity was highly significant. In the drum type row seeder operations, 75-78% of the time was actually required for seeding, 10-12% for turning, and 10-13% in loading. The addition of seed collectors increased the overall weight of the machine by 3 kg and its pulling force by 20%, but these were still within the capability of an average size labour. Similarly, the seeder also has a problem of lateral stability as it moves on one steel wheel and requires an experienced worker to keep it straight while pulling it backwards. In the case of hand broadcasting, about 88% of the time was engaged in actual broadcasting, while 12% was lost in loading the seed pot.

Field Performance

The effective field capacities of the BRRI drum seeder, with the seeding rates of 60 kg/ha and 80 kg/ha, were 0.15 ha/hr and 0.12 ha/hr, respectively, and there were statistically not significant. On the contrary, the field capacity of hand broadcasting at the rate of 100 kg/ha was 0.22 ha/hr, and this was found to be significantly higher than the drum seeder seeding at both rates (Table 1). The field efficiencies of the drum seeder, at the rates of 60 kg/ha and 80 kg/ha, were 73.91 and 77.77 percents, respectively, whereas that of hand broadcasting, at the rate of 100 kg/ha was 87.30 percent. The results revealed that the field efficiency of the hand broadcasting was significantly higher than those of the machine seeding at both seed rates because no time was lost in turning in the case of hand seeding.

TABLE 1
Field performance of the drum seeder compared to hand broadcasting method

Operations	Different methods of seeding		
	BRRI drum seeder (60 kg/ha)	BRRI drum seeder (80 kg/ha)	Hand broadcasting (100 kg/ha)
Effective field capacity (ha/hr)	0.153 b	0.117 b	0.223 a
Theoretical field capacity (ha/hr)	0.207 ab	0.150 b	0.257 a
Field efficiency (%)	73.91 b	77.777 ab	87.307 a
Plant population 18 days after seeding (no/m^2)	238.3 c	358.3 b	502.5 a
Average plant spacing (cm)	5.86 a	5.73 b	8.30 a
Average plant height (cm)	23.27 a	22.60 a	23.72 a
Average root length (cm)	4.41 a	5.53 a	5.20 a

In a row, means followed by a common letter are not significantly different at 5% level by DMRT.

Test conditions:

Soil type	:	Silty clay loam	Parameters	:	LSD (5%)
Plot size	:	4 m x 20 m	Theoretical FC	:	0.07149
Variety	:	BR1	Effective FC	:	0.3998
Seeder speed	:	16.95 m/min	Field efficiency	:	10.37
Walking speed	:	40 m/min	Plant population	:	63.83
			Average plant spacing (cm)	:	1.72
			Average plant height (cm)	:	2.03
			Average root length (cm)	:	1.6

The average plant population, taken at 18 days after seeding in the drum seeder plot at the seeding rates of 60 kg/ha and 80 kg/ha, was 238.33 and 358.33 Nos/m^2, respectively, whereas that of the hand broadcasting at the rate of 100 kg/ha was 500 Nos/m^2, and this was found to be significantly different at 5% level (Table 1). In the drum seeder plot, the distance between rows was 20 cm, however the distance between hill to hill along the rows varied with the seeding rates. In the drum seeder, the seeding at the rates of 60 kg/ha and 80 kg/ha for the hill to hill distances were 5.86 cm and 5.73 cm, and they were not statistically different, as compared to the higher seeding rate, where the seedling per hill was found to be higher as well. The average plant spacing in the hand broadcasting field was 8.30 cm, and this was higher than the hill to hill distance of the machine seeded field.

The average root lengths in the drum seeder plots were 4.41 cm and 5.53 cm for the seeding rates of 60 kg/ha and 80 kg/ha respectively, whilst that of the hand broadcasting plot the root length was 5.20 cm with a seeding rate of 100 kg/ha and was found to be not statistically different.

Meanwhile, the results revealed that at 18 days of seedling, the methods of seeding did not have any effect on the root development. The rice yield in the drum seeder fields at the seeding rates of 60 kg/ha and 80 kg/ha were 3.13 ton/ha and 2.84 ton/ha, respectively. On the other hand, the yield

at the hand broadcasting field at the seeding rate of 100 kg/ha was 2.73 ton/ha (Table 2). The results indicated that there was no significant yield difference among the three seeding practices.

TABLE 2
Yield parameters in the fields for different seeding methods

Parameter	BRRI drum seeder (60 kg/ha)	BRRI drum seeder (80 kg/ha)	Hand broadcasting (100 kg/ha)
Tiller/m^2	562.3 c	623.7 b	694.3 a
Panicle/m^2	435.7 b	483.7 a	503.3 a
No. filled grain/panicle	64.47 a	59.14 a	61.33 a
Filled grain (%)	70.46 a	68.55 ab	64.24 b
Grain yield (ton/ha)	3.13 a	2.84 a	2.73 a

In a row, means followed by a common letter are not significantly different at 5% level by DMRT.

Parameters	LSD (5%)
Tiller/m^2	65.58
Panicle/m^2	39.52
Filled grain/panicle	8.06
Filled grain (%)	5.76
Grain yield	0.639

Economic Performances

In the conventional hand broadcasting, the seeds were randomly scattered so there were no specific rows, and that the operation of rotary type weeder was not possible for weed control. Meanwhile, the weed control operations for the machine seeded and hand seeded fields were different. In the partial budget analysis, the costs of two operations (i.e. seeding and weeding) were therefore taken into account. The partial budget analysis revealed that a farmer could earn a net benefit of US$53.34 per hectare using the drum type seeder and the rotary type weeder as compared to hand broadcasting method followed by hand weeding (Table 3).

Table 4 shows the labour wage rate and the prices of goods. The price of the rotary weeder is much lower and for this reason, every farmer will be able to afford it. Therefore, renting of weeder is assumed to be impossible. Based on the wage rate and the prices of goods, as presented in Table 4, the break-even analysis showed that the farmer could own a drum type seeder and a rotary type weeder if he had only 0.3 hectare of land, as shown in *Fig.3*.

TABLE 3
Partial budget analysis of seeding and weeding costs between machine and hand system

Added return	(US$/ ha)	Added cost	(US$/ ha)
(A) EXTRA REVENUE:		(B) EXTRA COSTS	
1. Benefit from drum seeder renting	1.53	1. Cost of drum seeder (FC + VC)	16.14
		2. Cost of rotary weeder (FC + VC)	12.24
(C) SAVINGS IN COSTS:		(D) LOSS IN REVENUE:	
1. Labour saved from hand seeding labour	0.64		
2. Cost saved from seed in hand seeding	22.73		
3. Cost saved from hand weeding	56.82		
Total	81.72	Total	28.38

Net benefit from machine seeding over hand seeding (US$/ha)

= Added return - Added cost
= (A + C) - (B + D)
= 81.72 -28.38
= 53.34

TABLE 4
Labour wage rate and prices of goods

Price of seed paddy	:	US$0.23/kg
Price of non-seed paddy	:	US$0.16/kg
Labour wage for machine operation	:	US$1.36/day
Helpers' wage	:	US$1.14/day
Rotary weeder price	:	US$6.82/piece
Drum seeder price	:	US$68.18/piece
Farmer's yearly work load for drum seeder	:	3 ha
Drum seeder yearly renting service	:	27 ha
Drum seeder renting charge	:	US$1.70/ha

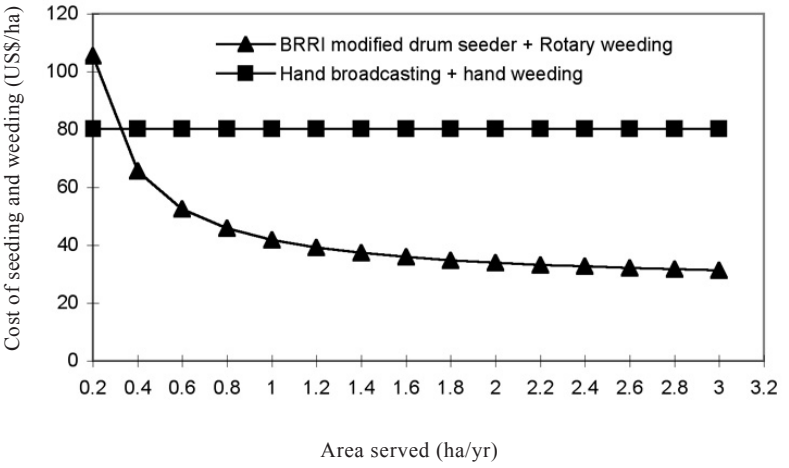

Fig. 3: A comparison between cost of seeding and weeding between machine and hand systems

CONCLUSIONS

Based on the results from the above experiments, it can therefore be concluded that:

1. The effect of rice seeding techniques using pre-germinated rice seed of BR-1 variety on the effective field capacity was highly significant.
2. The field efficiency of hand broadcasting was significantly higher than those of machine seeding at both seed rates since no time was lost in turning.
3. The BRRI modified drum type row seeder with a seeding rate of 60 kg/ha was better for an optimum crop yield.
4. A shift from manual to mechanised seeding and weeding operations with drum type seeder and rotary type weeder in lowland rice culture would benefit the farmers of Bangladesh at about US$53.34 per hectare.

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