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Profitability of rice production using a drum seeder

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Abstract

An experiment was carried out to evaluate the profitability of rice production using a drum seeder developed in the department of Farm Power and Machinery, Bangladesh Agricultural University, during transplant aman seasons July-December, 2004 at Mymensingh. Three planting methods viz., direct seeding with drum seeder, broadcasting and transplanting were used in the experiment. The treatments were replicated three times in Randomized complete block design. The results revealed that all the treatments under the study had significant influence on the yield and yield attributes of rice. Drum seeded crop produced the highest plant height 101.49 cm, panicle length 22.84 cm, leaf length 52.39 cm, root length 11.11 cm, number of panicles 382.61 m^{-2}, number of effective tillers 8.55 $hill^{-1}$, number of total tillers 9.6 $hill^{-1}$, wt. of straw 29.84gm $hill^{-1}$, straw yield 6882kg ha^{-1}, harvest index 44.42 %, and biological yield 12902kg ha^{-1}. Crop in broadcasting method produced the highest number of non-effective tillers 2.3 $hill^{-1}$. Crop established with a drum seeder resulted in higher grain yield 5634 kg ha^{-1}, which was at par with transplanting 5213 kg ha^{-1} and superior over broadcasting 3505 kg ha^{-1}. Not only the yield, but also the highest net revenue of Tk 27541 ha^{-1} with benefit cost ratio of 1.92 was also recorded by the drum seeding. The cost of crop establishment in transplanting method was 1.71 times higher than that from seeding by the drum seeder. It might be concluded that the drum seeder technique would be more profitable than transplanting method of rice production in Bangladesh.

Keywords: Drum seeder, Comparative study and Profitability

Introduction

Rice cultivation in Bangladesh is predominantly practiced in transplanting method which involves raising, uprooting and transplanting of seedlings. This is rather a resource and cost intensive method. Since, preparation of seedbed, raising of seedling and transplanting are labour and time intensive operations. Research reports show that labour involvement in these operations consume nearly one third of the total cost of production in Bangladesh. In addition, transplanting is not a healthy method as the farmers are to bend their heaps and stoop while transplanting rice seedlings which cause often health hazard in the older age. The countries like Japan and Korea have shifted from conventional manual transplanting to machine transplanting because there is scarcity of labour in those countries (Husain, 2005).

Although, transplanting is a predominant method of rice establishment, wet and dry seeding methods are also becoming increasingly popular because the transplanted high-yielding rice cultivars require high inputs. Direct wet-seeded rice is an alternative to the practice of transplanting in puddle fields and this method is faster in raising the rice crop (Khan, 1990). This method has become popular to the farmers of many countries due to its manifold advantages. The production cost of rice can be greatly reduced by using direct seeding technology and consequently, improve its competitiveness in the world market. Drum seeder was first experimented in Bangladesh during Aman season of 2003 by the Adaptive Research Scientists of Bangladesh Rice Research Institute (BRRI), Gazipur. Direct-seeding curtail the cost of nursery bed preparation, uprooting and transplanting of seedlings. However, this transplanting involves long process and huge labor that are responsible for increasing a remarkable percentage of rice production cost. Transplanting typically takes about 20 man-days/ha. On the other hand, direct wet-seeding requires about 1-2 man-days/ha (Pandey, 1994). Islam *et al.* (2000) reported that about 400-450 man-hr/ha were necessary for hand transplanting in rows. Coxhead (1990) reported that direct-seeded rice (wet-bed) required substantially less labor than transplanting. Moody and Cordova (1985) reported that 16% of rice farmers in the Central Luzon, Philippines used direct seeding (wet-bed) for labor saving. With an increase in real wage in most rice producing areas, farmers have increasingly adopted direct wet-seeding method to save the labor cost. Direct wet-seeding not only saves labor but also saves time as (a) crop do not suffer from transplanting stress and (b) time-consuming transplanting operation is completely eliminated. These factors coupled with the availability of short duration varieties made double rice cropping possible in some areas if at least one crop is direct wet-seeded (Pandey, 1994). However, it is necessary to evaluate the profitability of direct seeding over transplanting and broadcasting rice culture. Based on the above discussion a study was undertaken to determine the profitability of rice production using a drum seeder over transplanting method.

Materials and Methods

Drum seeder: A drum seeder was developed with locally available materials in the Department of Farm Power and Machinery. A photographic view of the drum seeder is shown in Fig.1 and the technical specification of the seeder is presented in Table 1.

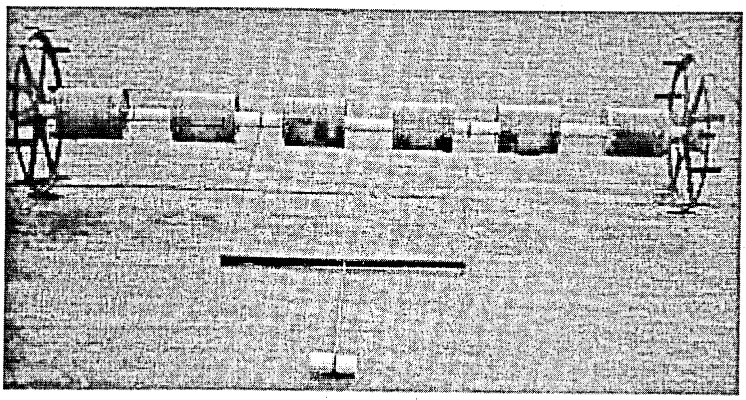

Figure 1. Photographic view of Drum seeder

Table 1. Details information of the seeder

Type of implement	Drum Seeder (Manually operated)
Model, Manufacturers name and address	Drum type seeder, Dept. of Farm Power and machinery, BAU, Mymensingh
Number of rows and row spacing	12 and 20cm
Nominal working width	2.4 m
Seeds and their condition for which the equipment is suitable	Paddy
Conditions	Germinated and non-germinated seeds
Suitable field condition	Puddle land
Overall dimensions	Length: 2.4 m, Width: 1.5 m, Height: 0.5 m
Overall weight without seed and with seeds	15 kg and 27 kg
Traveling	Walking type
Metering mechanism	Due to gravitational falling of seeds in row
Hopper	Number: 6 drums, Capacity: 2 kg/drum, Total 12 kg, Material: MS Sheet
Ground wheel	Size: Dia. 49 cm, Material: MS Sheet
Handle of seeder:	Construction: MS rod, Height of handle from ground level: Changeable
Recommended traveling speed	2-3 km/h
Seed metering	Gravitational falling of seed

Field experiment: Field experiments were conducted at the Bangladesh Agricultural University farm of Mymensingh district of Bangladesh. The treatments imposed were direct wet seeding by broadcasting with a seed rate of 100kg/ha (T_1); direct wet seeding by a direct seeder using 70 kg/ha (T_2) and farmer's practice of transplanting (T_3) in which 40 kg/ha seed was used to raise the nursery. The experiment was laid out in a Randomized Complete Block Design; with three replications. Seeds of BR-11 (T. aman) variety as per treatment were soaked first for 24 hours in water followed by seed incubation for next 48 hours for direct seeding treatments, while soaked seeds were incubated for 48-72 hrs for nursery raising for transplanting. Incubated seeds were sown by a direct seeder; broadcasting and transplanting were done as per treatments, respectively. Both direct seeding and broadcasting plots were kept without standing water and a boy was employed for protection of distributed seeds from birds until they germinate. Intercultural operations such as gap filling, weeding, irrigation, pesticides and fertilizer were applied as and when necessary in order to facilitate proper growth and development of the crop. From planting to harvesting, the crops were kept under constant observations. The crops established by different planting methods attained maturity at different dates. On maturity, the crops were harvested.

During the field experiments, care was taken to ensure that the drums of seeder were rotating correctly and that the seed outlets do not become blocked. Each of the drum was filled with 1.5 kg germinated seeds. At the end of the run, the hoppers were emptied and the remaining seed were weighed. The required number of labors and total operating time were recorded during seeding in each treatment. The time was recorded by a stopwatch and the effective field capacity was calculated dividing the area by required operating time. All sorts of costs from land preparation to drying were recorded to determine the rice production cost per hectare in different methods.

The following data were collected from each of five rice plants collected from the middle of each sub plot at harvesting stage.

i. Plant height (cm)
ii. Panicle length (cm)
iii. Root length (cm)
iv. Leaf length (cm)
v. Effective tillers hill^{-1} (number)
vi. Non-effective tillers hill^{-1} (number)
vii. Total tillers hill^{-1} (number)
viii. Number of grains panicle^{-1}
ix. Number of sterile spikelets panicle^{-1}
x. Number of total spikelets panicle^{-1}
xi. Weight of 1000 grain (g)
xii. Weight of straw (gm hill^{-1})

An area of 1m^2 in the middle of each plot was selected randomly and the number of hills m^{-2} and panicles m^{-2} were recorded. The crops from each plot were harvested, dried in the field for three days, threshed, cleaned and dried. The weight of clean grain and straw were weighted by a balance. The moisture content of the grain and straw were determined by oven dry method. Finally, the yields of grain and straw from each plot were converted per hectare at a given moisture content (14% wb).The moisture content was determined using the following formula (Abedin and Chowdhury, 1982):

$$\% \text{ Moisture content} = \frac{\text{Fresh weight} - \text{Oven dry weight}}{\text{Fresh weight}} \times 100$$

$$\text{and adjusted yield at 14\% moisture content} = \frac{100 - \%MC}{86}$$

Where, MC = Percent moisture content of the grain, W = Fresh weight of grain

The biological yield of crop was determined by adding the amount of grain and straw for a given area. The harvest index (%) is the ratio of economic yield to biological yield and it was calculated with the following formula (Gardner *et al.,* 1985).

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}}$$

Cost Estimation

The annual cost (AC) of the machine was determined by using the following equation:

$$AC = \frac{(FC\%)P}{100} + \frac{10A}{SWe}[(RMP) + L\}$$

Where, AC = annual cost of machine, Tk/yr
FC = fixed cost, Tk/yr
P = purchase price of the machine, Tk
S = speed of seeder, km/hr
W = width of implement, m
e = field efficiency, decimal
A = annual use of the machine, ha/yr
RMP = Repair and maintenance cost, Tk/hr
L = labor rate, Tk/hr

Table 2. Parameters considered for determining the annual cost of the machine

Cost Item	Value assumed
Purchase price (P)	5000 Tk.
Salvage	0
Life	2 Yrs
Interest rate	6 %
Tax, Insurance & Shelter	4% of p, Tk
Annual use	2 ha/yr

The collected data were statistically analyzed using ANOVA technique and the mean differences were adjudged by the Duncan's Multiple Range Test (Gomez and Gomez, 1984) using MSTAT.

Results and Discussion

Effect of planting methods on the yield and yield contributing characters of rice

The plant height and the panicle length were not significantly affected by the methods of planting; however, these were numerically higher in the direct seeding crop than in the transplanting and broadcasting methods. The highest plant height (101.49 cm) and the highest panicle length (22.84 cm) were obtained in the direct seeding over transplanted and broadcasting method (Table 3). This result might be due to densely populated plant in the broadcast method of planting which could not produce long panicle. The root length was significantly influenced for the methods of planting at 5% level of significance but the leaf length was not significantly affected by the methods of planting, however, leaf length was higher in the direct seeding crop than in the transplanting and broadcasting methods (Table 3).

Table 3. Effect of planting methods on different parameters of plant

Planting methods	Plant height (cm)	Panicle length (cm)	Root length (cm)	Leaf length (cm)	Number of effective tiller hill^{-1}	Number of non-effective tiller hill^{-1}	Number of total tiller hill^{-1}	Number of total hills m^{-2}	Number of panicles m^{-2}
Direct seeding	101.49a	22.84 a	11.11 a	52.39a	8.55 a	1.85 b	9.60 a	44.75 a	382.6 a
Transplanting	96.89 a	22.35 a	9.84 b	48.58b	5.90 b	1.05 c	7.75 b	27.00 b	159.3 c
Broadcasting	99.04 a	21.23 a	10.51ab	51.91ab	4.90 c	2.30 a	6.98 c	46.75 a	229.1 b
Level of significance	NS	NS	*	NS	*	*	*	*	*
LSD	-	-	0.748	-	0.752	0.295	0.594	3.263	8.156
CV %	3.99	4.76	4.12	3.81	6.74	9.81	4.23	4.80	1.83

In a column, figures having same letter (s) do not differ significantly, whereas figures bearing different letter (s) differ significantly.
* = Significant at 5% level of probability, NS= Not significant

The number of effective, non-effective and total tillers hill^{-1} was significantly influenced by the methods of planting (Table 3). Direct seeding method produced higher number of effective tillers hill^{-1} (8.55) over transplanting (5.90) and broadcasting method (4.90). The mean differences of number of hills m^{-2} and panicles m^{-2} between the three planting methods were highly significant (Table 3). Broadcasting method produced the highest number of hills m^{-2} (46.75) over direct seeded (44.75) method. However, direct seeding by drum seeder produced higher number of panicles m^{-2} (382.61) over transplanting and broadcasting methods. The number of panicles for transplanting and broadcasting were m^{-2} 229.08 and 159.30 respectively.

Methods of planting showed non significant effects on the number of grains panicle^{-1} but number of sterile spikelets panicle^{-1} had a significant influence on planting methods. The effect of planting methods on number of panicles, weight of grain and straw is presented in Table 5 The variation in the number of spikelets panicle^{-1} was not influenced significantly by the methods of planting. Weight of 1000 grains was not significant, only difference but weight of straw (g hill^{-1}) was significantly affected by planting method (Table 5). The results explained that the highest grain weight (21.53g for 1000 grains) was found in transplanted rice, and the highest total dry matter at harvesting period were 29.84 g hill^{-1} in direct seeding method. The second highest and lowest total dry matter at harvesting time were 18.20, 16.46 g hill^{-1} respectively in transplanting and broadcasting method and these were statistically similar.

Table 5. Effect of planting methods on spikelets panicle^{-1}, weight of 1000 grain, weight of straw (g hill^{-1}) and productions

Planting methods	Number of grains panicle^{-1}	Number of sterile spikelets panicle^{-1}	Number of total spikelets panicle^{-1}	1000 grain weight (g)	Weight of straw hill^{-1} (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Direct seeding	98.43 a	28.96 a	127.39 a	20.81 a	29.84 a	5634 a	6882 a	12902 a	44.42 a
Transplanting	105.84 a	22.82 c	128.66 a	21.53 a	18.20 b	5213 a	6762 a	12083 b	42.33 a
Broadcasting	95.03 a	26.04 b	130.14 a	20.43 a	16.46 b	3505 b	5010 b	8530.5 c	36.30 b
Level of significance	NS	**	NS	NS	**	**	**	**	**
LSD	-	1.824	-	-	1.824	465.00	801.80	5.63	3.27
CV %	6.68	4.06	4.09	5.52	4.90	5.62	7.45	0.03	4.61

In a column, figures having same letter (s) do not differ significantly, whereas figures bearing different letter (s) differ significantly.
** = Significant at 1% level of probability, NS= Not significant

The results showed that the grain and straw yields were affected significantly by planting methods. The maximum grain (5634 kg ha^{-1}) and straw yields (6882 $kgha^{-1}$) were recorded in seeding by the drum seeder. On the other hand, the transplanting method produced 5213 kg/ha and 6761 kg/ha respectively. This might be due to avoid of root injury and transplanting shock. The quicker tiller initiation lead to longer tillering period that possible to get greater number of tillers of heavier weight, which might have contributed to higher grain yield with the drum seeder method (Table 5). Higher grain yield under direct seeded method was achieved due to the higher number of panicles m^{-2} than that of transplanting method. The lowest grain yield was recorded from broadcasting method (3505 kg ha^{-1}). Biological yield and harvest index (HI) were significantly influenced by the methods of planting (Table 5).The highest HI (44.42%) was recorded in direct seeder method than that of transplanting (42.33%) and broadcasting (36.30%) methods. The increase of grain yield might be attributed due to increase of HI.

Annual Operating Costs of the machine

The annual cost, cost per hour and cost per hectare were determined on the basis of the highest and lowest value costing parameters. It was observed that the annual cost, cost per hour and cost per hectare of the machine was 2557 Tk/yr, 307 Tk/hr and 1278 Tk/ha, respectively. The investment and shelter costs were ignored in calculation for a little investment (Tk. 3000).

Effect of field efficiency on cost

A number of factors affect the cost of a machine. Therefore, the effects of field efficiency on the cost per hectare were also determined on given considerations and it is presented in (Fig.2).

The lowest cost was 55Tk/ha when the field efficiency was 95% and the highest cost was 104Tk/ha for a field efficiency of 40%. This result indicated that the cost was decreased with the increase of field efficiency. A strong relation was found between cost and field efficiency for a given condition.

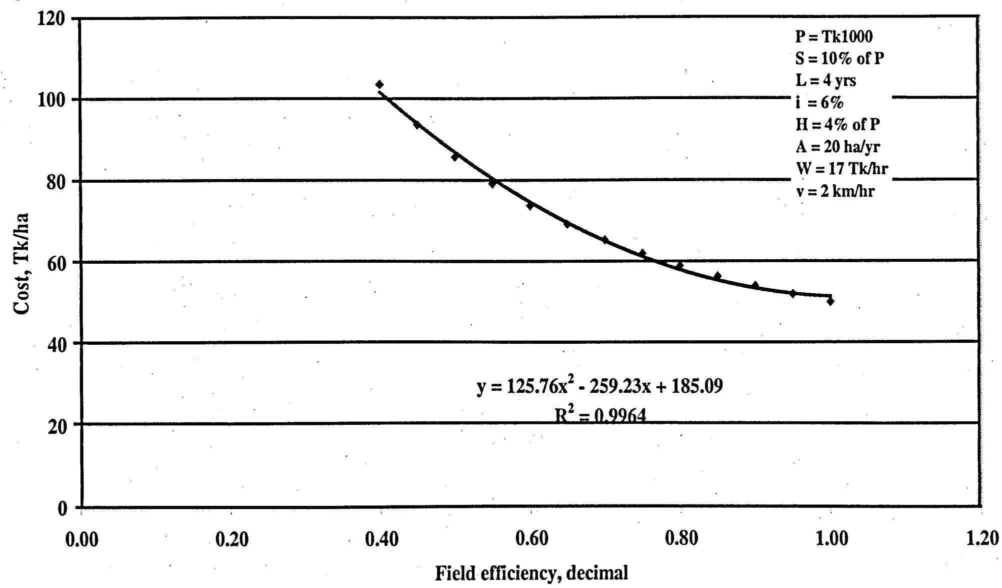

Fig. 2. Effect of field efficiency on cost

Effect of machines life on cost

The effects of machine life on the cost were also determined. A relation was found between cost and the life of the machine (Fig. 3). From the figure, it was found that the cost was decreased with the increased of the life of the machine upto 8 years. Beyond 8 years, the cost was again increased. The results indicate that the economic life of the machine would be 8 years for the given conditions.

Effect of annual use of machine on cost

The effects of annual use of the machine on the costs were also determined and it is presented in (Fig. 4). It was observed that the cost was very high (649 Tk/ha) when the machine was used only 0.5ha/yr. The costs were sharply decreased with the increase of the area upto 5ha/yr. After that, the costs were slowly decreased with increase of area upto 10ha/yr. Beyond 10ha/yr, the costs were decreased very slowly.

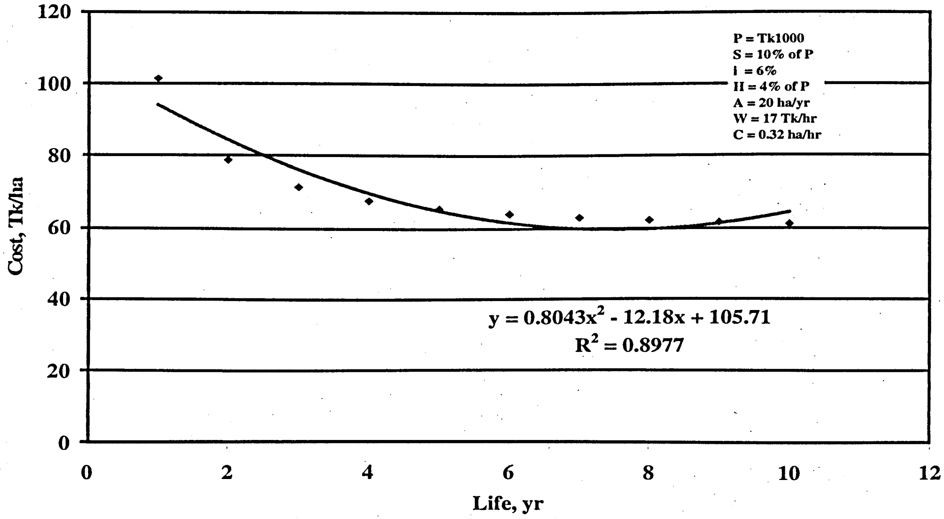

Fig. 3. The effect of machine's life on cost

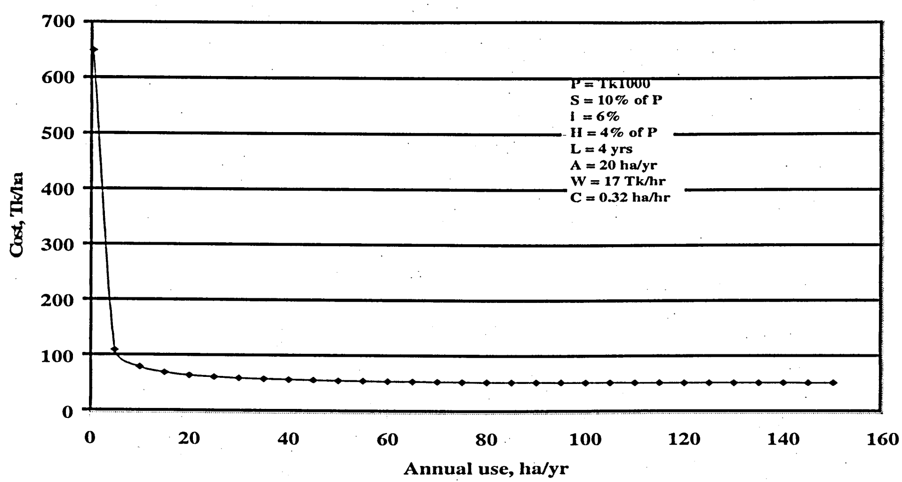

Fig.4. The effect of annual use of the machine on cost.

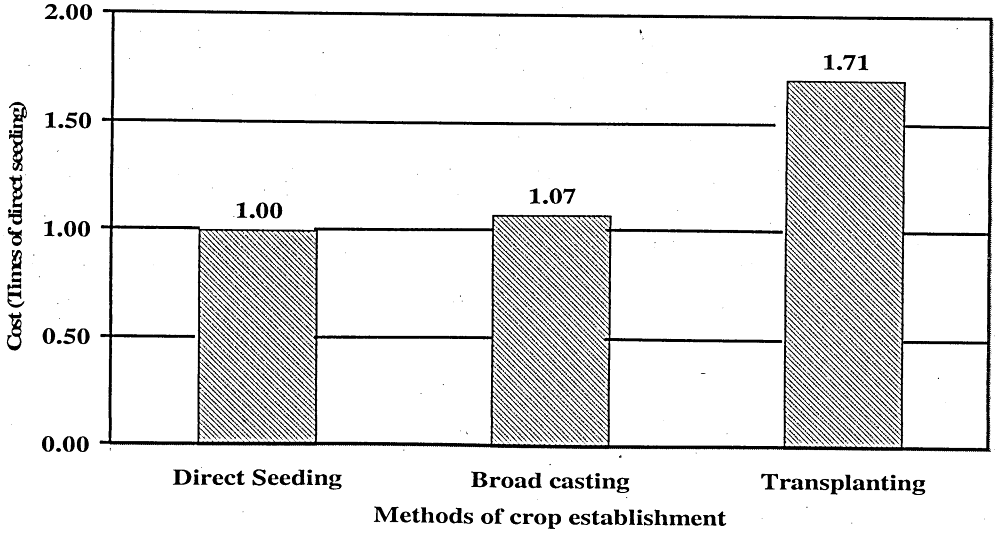

Fig. 5. Comparison of cost for crop establishing in different methods

Costs of crop establishment in different methods

The crops were established in three different methods. These were i) distribute germinated seed in manually broadcasting method, ii) dropping germinated seed with the help of direct seeder, and iii) transplanting seedling as farmer's practices. The comparison of cost for crop establishing from different methods is presented in Fig.5 and Table 6. It was found that the total cost of crop establishment in transplanting method was 1.71 times higher than that from seeding by direct seeder.

Table 6. Cost of crop establishment (Tk/ha) in different methods

Item	Transplanting	Seeding by drum seeder	Seeding by broad casting
Cost of seedling	3,092	1990	2,500
Ploughing	2,000	2,000	2,000
Leveling	1,000	2,000	2,000
Removal of weeds & stubbles	1,000	1,000	1,000
Labour cost for seed sown/transplanting	5,000	62	47
Total (Tk/ha)	12,092	7,052	7,547
Rate of labor, Tk100/day			

Cost and Profit

It was observed that the production cost was the highest 32298 Tk ha^{-1} for broadcasting and that was the lowest 30045 Tk ha^{-1} for direct seeding by the seeder. Total incomes were calculated on the basis of market price of paddy and straw. The profit was maximum in case of direct seeding and the lowest profit was recorded for broadcasting method. The statistical analysis of rice cultivation cost, gross return and net return of different methods are presented in Table 7. The profit was highest (27541 Tk/ha) for direct seeding, followed by transplanting (22596 Tk/ha) and broadcasting method (4254 Tk/ha). It was found that the cost, gross return and net return of different methods is varied significantly at 1% level of probability.

Benefit cost ratio

The benefit cost ratio (BCR) for different methods were also calculated, and presented in Table 7.The BCR were 1.92, 1.73, and 1.13 for direct seeding, transplanting and broadcasting methods, respectively. The statistical analysis of BCR from different methods showed that they are significantly difference among each other at 1% level of significance.

Table 7. Effect of planting methods on economic return

Planting methods	Cost of cultivation Tk ha^{-1}	Return from grain Tk ha^{-1}	Return from Straw Tk ha^{-1}	Gross Return Tk ha^{-1}	Net Return Tk ha^{-1}	Benefit Cost Ratio (BCR)
Direct seeding	30045 c	50706 a	6882 a	57588 a	27541 a	1.92 a
Transplanting	31081 b	46917 a	6762 a	53679 a	22596 b	1.73 b
Broadcasting	32298 a	31545 b	5010 b	36555 b	4254 c	1.13 c
Level of significance	**	**	**	**	**	**
LSD	0.49	4145.00	801.80	4570.00	4570.00	0.15
CV %	0.00	5.62	7.45	5.36	14.57	5.56

In a column figures having same letter(s) do not differ significantly whereas figures having dissimilar letters differ significantly (as per DMRT).
** = Significant at 1% level of probability

Thus, from the results presented above, in the direct seeder method , the highest benefit cost ratio of 1.92 were obtained whereas the transplanted rice recorded Benefit Cost Ratio (BCR) of 1.73 and for the broadcast method it was only 1.13. The results indicated that the direct seeder method gained 19% profit over the transplanting and 79 % over the broadcast method. That was clearly indicated the direct seeder technique more profitable and best method of rice cultivation in Bangladesh.

Conclusion

The effect of planting methods (Direct seeding, transplanting and broadcasting) was significant in respect of all the yields and yield contributing characters of rice except, plant height, panicle length, leaf length, 1000 grain weight, total number of spikelets $panicle^{-1}$ and number of grains $panicle^{-1}$. Direct seeding method produced higher number of total tillers $hill^{-1}$, bearing tillers $hill^{-1}$, highest panicle length, root length, leaf length, and plant height, weight of straw $hill^{-1}$ (g), grain yield, straw yield and biological yield. From the study observed that the total cost of crop establishment in transplanting method was 1.71 times higher than that from seeding by drum seeder. It was found that 59% of total costs for crop establishment in transplanting method come from uprooting and transplanting. The maximum grain and straw production was respectively 5634 kg ha^{-1}, 6882 kg ha^{-1} in direct seeding method. The net profit was highest (27541 $Tkha^{-1}$) for direct seeding with BCR 1.92, on the other hand net profit for transplanting was 22596 Tk ha^{-1} with BCR 1.73 and broadcasting 4254 Tk ha^{-1} with BCR 1.13. The highest and the lowest cost of the direct seeder was 855 Tk/ha and 55 Tk/ha, respectively. The economic life of the machine was 8 years and the cost per hectare was Tk 68 for planting 20 hectares of land in a year.

Based on the results of the study, it can be summarized that direct seeding provides more yield than broadcasting and transplanting system. The direct seeder technique can provide definitely more sustainable production in those areas where labour is costly. However, careful water management and proper leveling of the field would be required in the direct seeded crop.

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