Fundamental and Applied Agriculture
Vol. 5(1), pp. 124–132: 2020
doi: 10.5455/faa.79466

Agricultural Engineering
ORIGINAL ARTICLE

Financial analysis for custom hire business of mechanical rice transplanter in Bangladesh

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ARTICLE INFORMATION

Article History
Submitted: 26 Dec 2019
Accepted: 18 Feb 2020
First online: 24 Mar 2020

Academic Editor
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ABSTRACT

This study was conducted to analyze the financial parameters of a mechanical rice transplanter operation for local service providers and entrepreneurs with hybrid rice variety. Two walking type mechanical rice transplanters of model Daedong DP 480 and DP 488 were used in the experiment. Field data from farmers and local service providers and also some necessary secondary data were used to establish the results of this research. The experiment was carried out in two different cropping seasons, *Boro*-2018 at Bangladesh Agricultural University, Mymensingh and in *Aman*-2018 at Mothbaria village of Dumuria Upazila, Khulna. Daedong DP 480 transplanter was used in *Boro*-2018 season and in *Aman* season, Daedong DP 488 transplanter was used. The effective field capacity was found 0.173 ha h^{-1} and 0.189 ha h^{-1}. for DP 480 and DP 488 transplanter, respectively. Considering 10% discount factor, the NPV of DP 480 transplanter was found 7358 USD with IRR of 59% and for DP 488, NPV was 8037.97 USD at 63% IRR. The NPV and IRR indicate the financial viability of rice transplanter entrepreneurship as the IRR is much higher than the bank interest rate. The payback period of DP 480 was found 1.60 years whereas the DP 488 will return the capital in 1.51 years. By analyzing the BCR of the two rice transplanters, use of transplanter was also found profitable for entrepreneurs for custom hire services as the BCR of DP 480 and DP 488 transplanters were found 1.62 and 1.66, respectively. The minimum tenure for the economic use of the transplanters was found 20.36 ha and 21.01 ha per year for DP 480 and DP 488 transplanter, respectively. Evaluating the financial parameters of total procedure of mechanical transplanting, the machine transplanting was found to be more economic over manual transplanting with both hybrid and inbred rice varieties when it is subjected to cover up more than 10.1 ha and 6.7 ha yr^{-1}, respectively.

Keywords: BCR, Break-even point, financial analysis, hybrid rice, IRR, rice transplanter

Cite this article: Sarkar S, Basir MS, Rabbani MA, Hossain MM, Alam MM. 2020. Financial analysis for custom hire business of mechanical rice transplanter in Bangladesh. Fundamental and Applied Agriculture 5(1): 124–132. doi: 10.5455/faa.79466

1 Introduction

Globally, rice (*Oryza sativa* L.) is placed at the second position among the most significant cereal crops in terms of production area which pretends to be the staple food for nearly half of the world's seven billion people (Veltman et al., 2019). More than 90% of rice is consumed in Asia where it is staple food for mainstream of the population, together with the region's 560 million ravenous people (Mohanty, 2009). Rice as the staple food of Bangladesh covers 74.85% of agricultural land area for its cultivation (BBS, 2018) and the country ranks the fourth position as major paddy growing country of Asia (Kabir et al., 2015) where Agriculture contributes 13.41% of national GDP in FY 2016-17 (BBS, 2018).

In Rice production, transplanting of rice is one of the most significant activities and in most of the rice fields of Bangladesh, rice is transplanted manually where manual rice transplanting is the most tiresome, labor and time intense practice which necessitate 25% of total labor obligation (Singh et al., 1985). Again, agricultural labor is shrinking due to ongoing urbanization and industrialization. As labor wage increases, hand transplanting is becoming overpriced which leads to reduce revenues in rice production. A one-month delay in transplanting reduces the yield by 25% and if the delay is of two months, the yield is reduced by 70% (Rao and Pradhan, 1997). Time between harvesting of one crop to sowing or transplanting of the next one is very limited. Due to labor deficiency, farmers are constrained to practice delayed planting that results in decreased yield. To ensure the timeliness in planting rice seedlings it is therefore, indispensable to adopt mechanical transplanting for rice cultivation. Mechanization in transplanting will bring a major change in labor patterns in agriculture and cultivation process in Bangladesh. Mechanization in rice transplanting can generate employment and can also be alternate sources of income for rural youth through custom hire services on nursery raising for seedlings and transplanting. The adoption of mechanical rice transplanter has been considered the most effectual option, as it saves labor, ensures timeliness in transplanting and can maintain optimum plant density that contributes to high productivity.

Variety of paddy is one of the most vital indices for better production of rice. The quality and the yield of paddy depend on the variety of seed that is to be cultivated. Now-a-days, different hybrid and high yielding rice varieties are available in Bangladesh which has more yield potential than conventional inbred varieties (Akbar, 2004). For many years there has been evidence that hybrid rice has a more than 20 percent yield advantage over improved inbred varieties (Hari Prasad et al., 2014). Cropping area of hybrid rice only during the *Boro* season has been increased by 9.77% from the previous year. With the increase in land area for hybrid cultivation, the land area for inbred and HYV varieties are decreasing as 0.93% and 0.29%, respectively (BBS, 2016). This decreased land area is being used for hybrid variety (BBS, 2016). To meet up the growing food consumption for the growing population, the cultivation of hybrid varieties of rice is a must and it has been introduced to our farmers.

In rice cultivation, labor shortage and high labor wages are also major problems both in transplanting and harvesting period. It is estimated that the total labor requirement for rice production in 1 hectare of land was 156.2 man-days of which seedling raising and transplanting consume 44.5 man-days which is 28.24% of the total labor requirement (Rahman, 1997). The yield loss due to delayed planting was recorded as 60.0, 55.4 and 9.0 kg per ha d^{-1} in the *Boro*, *Aman*, *Aus* seasons respectively. From the year 2000 to 2010, the share of hired labor in agriculture decreased from 19.4% to 15.5% (Emran and Shilpi, 2014) due to accretive urbanization and industrialization. The labor wage is also high in *Boro* season than *Aman* season. According to the latest update of Trading Economics, in 2017 and 2018, the average wage for one labor is USD 5.5 d^{-1} in Bangladesh. This problem due to labor shortage and high wages as well as timeliness can be overcome by availing mechanization in rice production.

The use of mechanical rice transplanter is not yet prevalent enough due to its high purchase price and majority of the farmers can't afford a rice transplanter as their income is low. Not only in Bangladesh, but also in almost all South Asian countries, a rice transplanter is out of reach for a single farmer alone (Islam et al., 2016). The commercial use of mechanized transplanting with small scale machineries like transplanters has demonstrated reassuring possibility since marginal farmers have positive interest as the ultimate users. However, establishment of commercial transplanting service was observed lower than the recommendable margin as a consequence of several restraints that were identified in *Aman* 2014 (Islam et al., 2015). Those constrictions pointed a necessity of formulation of a rigid service business that can conceal the underlying performance of machine in operation at the farmer's field. However, the decision to adopt a business by a general user or a marginal service provider relies on his/her motivation that depends on the profitability of that particular business. So, to gear up the service providing business based on mechanical rice transplanting and for sustainability of transplanter use in terms of custom hire business, financial feasibility of mechanical rice transplanter needs to be evaluated. Therefore, the present study was undertaken to analyze the financial performance of mechanical transplanter for customer service providers and to analyze the profitability of mechanical rice transplanting business with hybrid and inbred rice varieties.

2 Materials and Methods

The research work was carried out in two different cropping seasons, *Boro* (December, 2017 to April, 2018) and *Aman* (June, 2018 to November, 2018) at Bangladesh Agricultural University research Field, Mymensingh and Mothbaria Village of Dumuria Upazilla in Khulna district, respectively.

Figure 1. ACI Daedong DP 480 rice transplanter

Figure 2. ACI Daedong DP 488 rice transplanter

In *Boro* season, Daedong DP 480 rice transplanter was used and in *Aman* season, a Daedong DP 488 transplanter was used. The rice variety used in the experiment was Hybrid Moyna (HTM303) of Laal-Teer Seed Company Ltd. for *Boro* season and in *Aman* season, Hybrid Dhanee Gold (H10001) of Bayer Crop Science Ltd. was used.

2.1 Specification of transplanters

The Daedong DP 480 (Fig. 1) and Daedong DP 488 (Fig. 2) rice transplanters, imported by ACI Pvt. Ltd. are four-row walk behind type rice transplanters. Specifications of two transplanter machines are shown in Table 1.

2.2 Machine performance

The machine performance of two transplanters was evaluated as a measure of transplanting speed, theoretical field capacity, actual field capacity, field efficiency, and fuel consumption.

2.2.1 Transplanting speed

The transplanting speed was obtained by recording the time required for the transplanter to travel a distance before a turn in the field. The speed of transplanting can be computed using equation 1 (Kepner et al., 1978).

$$V = \frac{d}{t} \times 3.6 \tag{1}$$

where, V = transplanting speed (km h^{-1}), d = distance of travel (m), and t = time required to cover the distance d (sec).

2.2.2 Theoretical field capacity

Theoretical field capacity was estimated by the following equation (Kepner et al., 1978). The theoretical field capacity is the field coverage of the transplanter when it performs its work 100% at rated speed and in rated time using the total operating width of the machine.

$$C_t = \frac{W \times S}{C} \tag{2}$$

where, C_t = theoretical field capacity (ha h^{-1}), W = operating width of the transplanter (m), S = Forward speed (km s^{-1}). and C = constant, 10.

2.2.3 Actual field capacity

Equation 3 was used for estimating actual field capacity (Kepner et al., 1978). It's the actual area coverage by the machine at unit time.

$$C_a = \frac{A}{T} \tag{3}$$

where, C_a = actual field capacity (ha h^{-1}), A = total transplanted area (ha), and T = total operating time required for transplanting (h).

2.2.4 Field efficiency

It's the theoretical maximum productivity and it was calculated by equation 4 (Kepner et al., 1978).

$$e = \frac{C_t}{C_a} \times 100 \tag{4}$$

where, e = field efficiency (%).

2.2.5 Fuel consumption

Before starting field operation, the fuel tank of transplanter was filled with fuel. The total operating time was also recorded and after the completion of field operation the fuel tank of the machine was refilled and the amount of refill was recorded. Fuel consumption was determined by dividing the refill amount of fuel by time of operation.

Table 1. Specification of the rice transplanters

Parameters	Specification	Daedong DP480	Daedong DP488
Country of origin		South Korea	South Korea
Dimensions	L×W× H (mm)	2385×1530× 870	2380×1530×955
	Overall weight (kg)	160	185
Engine	Type Maximum output kW/rpm	4-stroke, air-cooled, gasoline 3/1800	4-stroke, air-cooled, gasoline 2.94/3200
Traveling section	Gearshift: Forward & reverse	2 speeds and 1 speed	2 speeds and 1 speed
Transplanting section	Number of rows Row to row distance (mm) Plant to plant distance (mm) Transplanting speed (ms^{-1})	4 300 110, 130, 150 0.6 to 1.0	4 300 120, 140, 160, 180, 200, 220 0.6 to 1.20

2.3 Operating cost of transplanter

Transplanter operation cost consists of fixed cost and variable cost. Fixed cost consists of depreciation, interest on investment and Shelter and variable cost has cost items as labor, fuel, oil, repair and maintenance costs (Barnard and Nix, 1980).

2.3.1 Fixed cost

Fixed cost is defined as one, which does not change when level of output. The sinking fund method was used for calculating depreciation. The equation for calculation of depreciation was as follows (Hunt, 1997):

$$D = (P - S)\frac{i}{(1+i)^{-L} - 1} \tag{5}$$

where D = yearly depreciation (USD yr^{-1}), P = purchase price (USD), S = salvage value (USD), L = machine life, assumed as 6 years, i = rate of interest (decimal), assumed as 10%.

The interest on investment is considered as an important fixed cost item as it is a direct expense item on borrowed capital. The interest on investment was calculated by the following formula (Hunt, 1997).

$$I = \frac{P+S}{2} \times i \tag{6}$$

where I = interest on investment (USD yr^{-1}), and i = rate of interest (decimal), assumed as 10%. An annual charge equal to 2.5% of the purchase price was considered as the sheltering cost (Hunt, 1997):

$$T = P \times 0.025 \tag{7}$$

where, T = shelter cost

$$FC = (D + I + T) \tag{8}$$

FC = total fixed cost per year; fixed cost in USD h^{-1} = fixed cost per year/yearly use in h.

2.3.2 Variable cost

Variable cost depends on hourly labor cost, fuel, oil, repair, and maintenance cost and the obligatory working hours for each field operations. Operations of the transplanter machine require one operator and a labor which is included in the cost of operation. The fuel cost is estimated as product of per hour fuel consumption (L) and per litter price of fuel. The lubrication cost is estimated as 15% of fuel cost. Repair and maintenance cost (R & M) are calculated as 0.035% of purchase price (Hunt, 1997).

$$TVC = LC + FlC + RC \tag{9}$$

where, TVC = total variable cost (USD h^{-1}), LC = labor cost, FlC = fuel and lubrication cost, and RC = repair and maintenance cost.

2.3.3 Total operating cost

Summation of fixed cost h^{-1} and variable cost h^{-1} was considered as operating cost in USD h^{-1}. Operating cost ha^{-1} was calculated as follows:

$$OC_{ha} = \frac{OC_h}{Ca} \tag{10}$$

where, OC_{ha} = operating cost (USD ha^{-1}), OC_h = operating cost (USD h^{-1}), Ca = actual field capacity (ha h^{-1}).

2.4 Rent out charge (benefit)

Rent out charge is the amount that the machine owner pretends to have including his machine operating costs and his profit. The transplanter rent-out cost for an entrepreneur was estimated from the following expression (Rahman et al., 2013):

$$ROC = OC + P_e \tag{11}$$

where, ROC = rent out charge (USD ha^{-1}), P_e = estimated profit (USD ha^{-1}).

2.5 Benefit cost ratio

Benefit cost ratio (BCR) is the ratio of present worth benefit to present worth cost. The machinery can be said profitable if the BCR is greater than unity (Gittinger, 2016). It was calculated by equation 12.

$$BCR = \frac{\sum PWB}{\sum PWC} \tag{12}$$

where, BCR =benefit cost ratio, PWB = present worth benefit, and PWC = present worth cost.

2.6 Financial analysis

2.6.1 Net present value

Net present value (NPV) is a scientific method of present value calculation of inflows and outflows of an investment proposal, using a discount factor and subtracting the present value of outflows to get the net present value. NPV was calculated by the following formula (Gittinger, 2016):

$$NPV = PWB - PWC \tag{13}$$

2.6.2 Internal rate of return

Internal rate return (IRR) is the value of discount factor when the NPV is zero. The transplanter can be said profitable if the IRR value is greater than the Bank interest rate. The IRR was computed with the help of equation (14) (Gittinger, 2016).

$$IRR = LDR + \left\{ DRD \times \frac{PWCF_{LDR}}{AD} \right\} \tag{14}$$

where, DRD = difference between the discount rate, $PWPC_{LDR}$ = present worth of cash flow at lower discount rate (LDR), and AD = absolute difference between the present worth of cash flow at the two discount.

2.6.3 Payback period

Payback period is the time within which the initial investment is returned. The payback period was calculated using the following formula (Rahman et al., 2013):

$$PB = \frac{P}{NB \times C_a} \tag{15}$$

where, PB = payback period (h), P = total initial investment (USD), NB = net benefit (USD ha^{-1}), and C_a = actual field capacity (ha h^{-1}).

2.6.4 Economic use of transplanter

Rice transplanter can only be used in rice transplanting operation and the time of operation is only 40-50 days in a year. The rest of the year, machine remains idle and there is no use of the transplanter. So, for determining the economic use, a break-even analysis was used to find out the minimum operation area per year. The break-even point of economic use was estimated by equation 16.

$$BE = \frac{FC}{ROC - TVC} \tag{16}$$

where, BE = break-even use (ha yr^{-1}).

2.6.5 Payment for machine replacement

It's a matter of consideration that the machine, after its working life will be obsolete and a new machine is needed to be purchased. To purchase a new machine after the old one, a fixed amount of money is to be saved in bank per year. It can be estimated by the following equation (equation 17):

$$P_R = (P - S)\,\frac{i}{(1+i)^{-L} - 1} \tag{17}$$

where, P_R = payment for machine replacement, P = purchase price (USD), S = salvage value (USD), L = machine life (yr), and i = bank interest rate (%).

2.6.6 Break-even analysis

The use of transplanter in custom hire business depends on the decision of which amount to be transplanted per day to earn profit. It is also true for farmers who are the ultimate concessionaires. To decide whether to use a transplanter or not and which level of operation allows the service provider to make profit, it's important to analyze the operational costs required for rice transplanting. It includes seedling raising costs and transplanting costs. The break-even analysis of manual transplanting with machine transplanting is the measurement of area beyond which the transplanting cost is higher in manual practice than in mechanical transplanting. This break-even point gives a clear idea of yearly machine use for profitable business. Equation 18 was used to calculate the break-even point for shifting the transplanting system from manual to mechanical.

$$BEP = \frac{FC_{mt}}{C_{mt} - VC_{mt}} \tag{18}$$

where, BEP = break-even point (ha yr^{-1}), FC_{mt} = fixed cost of mechanical transplanting (USD yr^{-1}), C_{mt} = manual transplanting cost, and VC_{mt} = variable cost of mechanical transplanting (USD ha^{-1}).

3 Results and Discussion

3.1 Performance of transplanters

Little differences in field capacity and efficiency were found due to difference in forward speed (Table 2). Daedong DP 488 gives more satisfactory performance than Daedong DP 480 rice transplanter.

Table 2. Machine performance of transplanters

Parameters	DP 480	DP 488
Machine width (m)	1.2	1.2
Area covered (ha)	0.03	0.05
Time required (min)	10.4	15.9
Forward speed (km h^{-1})	2.06	2.12
Fuel consumption (L ha^{-1})	4.62	4.73
Theoretical field capacity (ha h^{-1})	0.247	0.254
Effective field capacity (ha h^{-1})	0.173	0.189
Field efficiency (%)	70.01	74.17

3.2 Cost items and operating cost

The fixed cost of the two transplanters is same as the purchase price was assumed to be same. The purchase price was 4268 USD. Interest rate was considered as 10%. Variable cost is related to the use of transplanter and field capacity. The detailed cost items are presented in Table 3. Machine use is considered 40 d y^{-1} on an average 8 h d^{-1}. Fuel cost is assumed 1.05 USD L^{-1}.

Table 3. Cost items for transplanters

Cost item	Model	
	DP 480	DP 488
Fixed cost items		
Depreciation (USD yr^{-1})	640.24	640.24
Interest on invest. (USD yr^{-1})	234.76	234.76
Shelter (USD yr^{-1})	106.71	106.71
Total fixed cost (USD yr^{-1})	981.71	981.71
Total fixed cost (USD h^{-1})	3.07	3.07
Variable cost items		
Fuel (USD h^{-1})	0.84	0.94
Lubricant (USD h^{-1})	0.13	0.14
Repair and maint. (USD h^{-1})	1.49	1.49
Cost of operator (USD h^{-1})	1.22	1.22
Cost of labor (USD h^{-1})	1.83	1.83
Tot variable cost (USD h^{-1})	5.51	5.62
Tot operating cost (USD h^{-1})	8.57	8.69
Tot operating cost (USD ha^{-1})	49.56	45.97

3.3 Transplanter rent out charge

Transplanter rent out charge is the sum total of operating cost and profit. The rent-out charge for DP 480 transplanter was estimated at 80 USD ha^{-1} where the amount is 76 USD ha^{-1} for DP 488 model. The estimated profit was determined as 31 USD ha^{-1} depending on the daily income of a rural family.

3.4 Financial analysis

3.4.1 Profitability analysis

The project appraisal method of financial analysis shows the acceptability of rice transplanter from the owners or service providers' point of view. From the analysis, at 10% discount factor, NPV, BCR, IRR and payback period of DP 480 and DP 488 transplanter are shown in Table 4. As the two transplanters performs different in field, so, there is a difference in their financial parameters. Financial parameters of the two transplanters gave satisfactory result as IRR is greater than the interest rate and BCR is higher than unity. It indicates that the use of transplanter, for both the models is profitable for an individual investor or group to make a custom hire business.

Table 4. Financial parameters

Parameters	Model	
	DP 480	DP 488
NPV	7358.13	8037.97
IRR	59%	63%
BCR	1.62	1.66
Payback period (yr)	1.60	1.51

3.4.2 Economic use of transplanters

The break-even analysis shows that the break-even area of the Daedong DP 480 transplanter and the Daedong DP 488 is 20.35 ha yr^{-1} and 21.93 ha yr^{-1}, respectively (Fig. 3). The break-even amounts of area to use transplanters are much lower than the transplanters capacity of coverage in a year. When the transplanters meets their break-even amounts, it will start to bring profit.

3.4.3 Payment for replacement

The amount of payment for replace for Daedong DP 480 and Daedong DP 488 transplanter was found 497.90 USD yr^{-1}. This amount has to be saved in bank so that the investor or service provider can access another machine when the machine life of the old transplanter is over and the machine is obsolete.

3.4.4 Financial analysis of cost and benefit for transplanting service providing business

The total cost from seedling raising to field transplanting is shown in Table 5. As seedling raising for machine transplanting can be done in trays or mats, it does not require any prepared land. The seedling

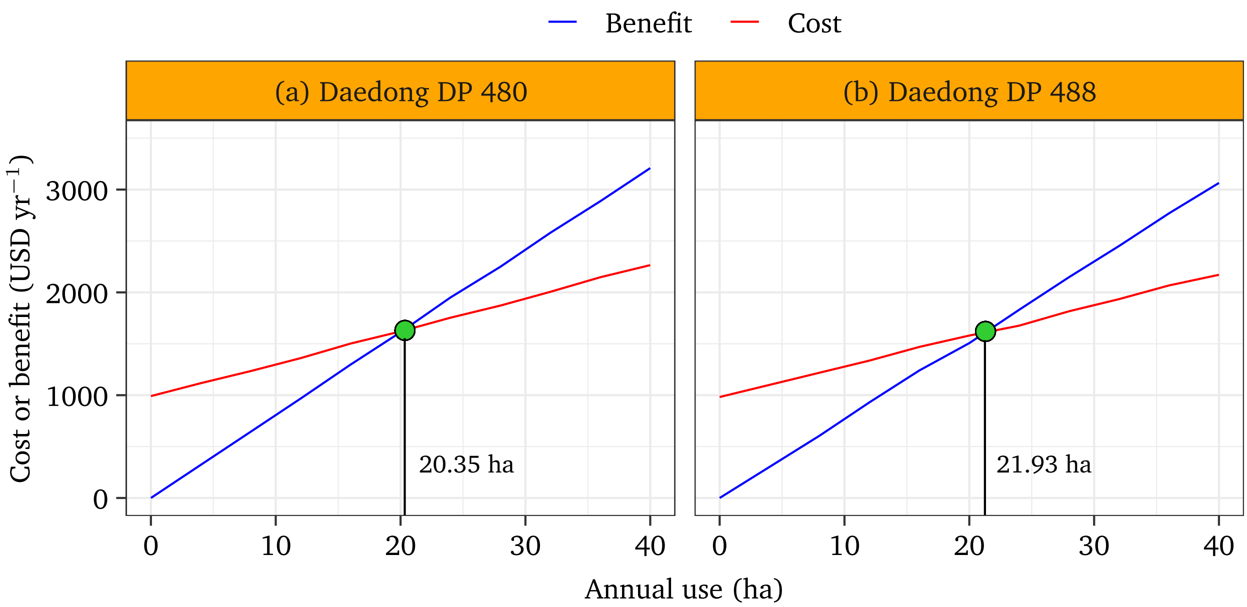

Figure 3. Economic use of (a) ACI Daedong DP 480 and (b) ACI Daedong DP 488 rice transplanter

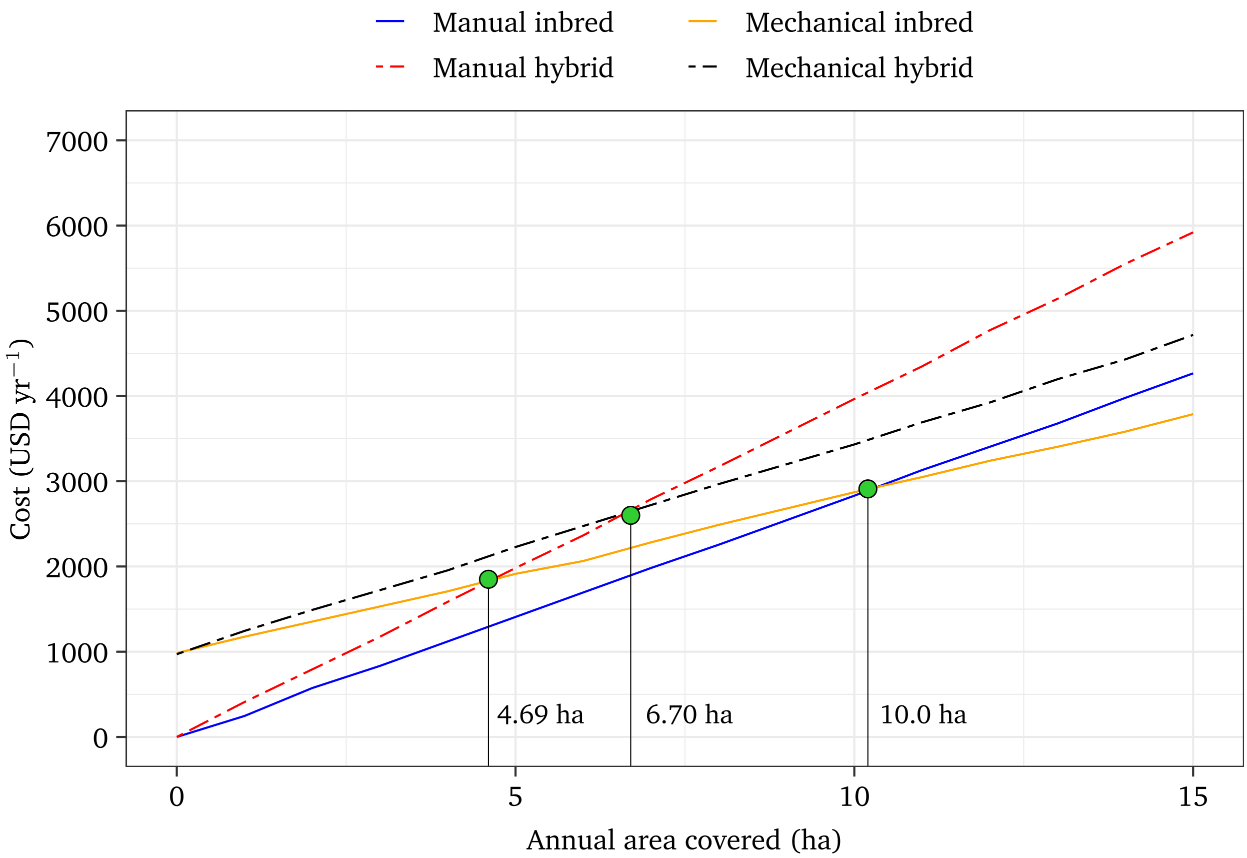

Figure 4. Break-even point of using mechanical transplanting over manual transplanting

Table 5. Cost and benefit in mechanical transplanting business compared to traditional practice

Parameters		Manual transplanting		Machine transplanting	
		Inbred rice	Hybrid	Inbred rice	Hybrid
Seedling cost[§]	Seed rate (kg ha^{-1})	70.00[†]	40[†]	20.04[‡]	26.72[†]
	Cost of seed (USD/kg)	0.49	3.66	3.66	0.49
	Cost of seed (USD ha^{-1})	34.15	146.34	73.32	13.03
	Seed bed area needed for 1 ha land (ha)	0.03	0.03	0.003	0.003
	Land preparation (USD ha^{-1})	8.54	8.54	0	0
	labor cost (USD ha^{-1})	3.66	3.66	5.49	5.49
	Irrigation (USD ha^{-1})	1.83	1.83	2.44	2.44
	Fungicide (USD ha^{-1})	1.22	1.22	1.22	1.22
	Fencing (USD ha^{-1})	2.44	2.44	2.44	2.44
	Tray cost (USD ha^{-1})	0	0	20.37	20.37
Transplanting	Land preparation (USD ha^{-1})	90.37	90.37	90.37	90.37
	Irrigation (USD ha^{-1})	18.29	18.29	18.29	18.29
	Labor (USD ha^{-1})	121.95	121.95	49.56	49.56
Total seedling cost (USD ha^{-1})		51.83	164.02	105.27	44.99
Total cost till transplanting (USD ha^{-1})		282.44	394.63	263.49	203.2
Total estimated profit till transplanting (USD ha^{-1})		10.37	32.8	51.54	39.48
Total revenue (total cost + total profit) (USD ha^{-1})		292.8	427.44	315.03	242.69

[§] 1 USD = 82 BDT; [†] Islam (2017); [‡] Sarkar et al. (2019)

for machine transplanting can be done in homestead garden or on open yard of farmers' house even in the field with no soil preparation as it is done by collected sieved soil or mud. Thus, as a whole, the total cost for seedling raising for machine transplanting is lower than manual. Moreover, the total transplanting cost ha^{-1} shows that the machine transplanting is a cost saving mode of operation. The cost of hybrid variety transplanting is higher than inbred variety for manual transplanting system which can be overcome by mechanical transplanting (Table 5). The profit for seedling raising service in both manual and machine transplanting system was considered according to the total seedling raising cost. In mechanical transplanter custom hire service, the service provider charges a profit that is included to his total revenue.

3.4.5 Economic analysis

The break-even analysis shows that for inbred variety, the manual transplanting of rice will be more expensive than machine transplanting for service providers when the land area is 10.1 ha (Fig. 4). It indicates that the transplanting will be preferable over manual transplanting if the transplanter can transplant 10 ha yr^{-1}. For hybrid variety, the break-even point is found is 6.7 ha yr^{-1} and beyond these amounts, the transplanter use will be more cost effective than manual transplanting. The mechanical transplanting of inbred variety will be profitable than manual transplanting of hybrid rice if the area of transplanting is more than 4.69 ha yr^{-1}.

4 Conclusions

It is estimated that a Daedong DP 480 or DP 488 transplanter can be operated 40 days a year and can transplant around 55-60 ha yr^{-1}. From the break-even analysis, the minimum operating area was found much lower than the estimated area. So, the custom hire business of transplanter is highly profitable. From the financial analysis the transplanter was found as a profitable machine. The economic analysis of total rice transplanting procedures reveals that activities related to machine transplanting possess cost-effectiveness compared to manual system. It is also a concern that the price of rice transplanter is too high to purchase for the farmers. Comparing transplanting methods using hybrid and inbred variety rice, mechanical transplanting was found profitable than manual system and mechanical transplanting of hybrid variety was found profitable when yearly land area is more than 6.7 ha over manual transplanting of hybrid variety. So, it can be concluded that the rice transplanter can be a great opportunity for custom hire business as well as entrepreneurship development not only for inbred rice but also for hybrid varieties.

Acknowledgements

This paper as part of Appropriate Scale Mechanization Consortium (ASMC) project 'Appropriate Scale Mechanization Innovation (ASMIH) - Bangladesh' is made possible by the support of the American People provided to the Feed the Future Innovation Lab for Sustainable Intensification through the United States Agency for International Development (USAID) and University of Illinois at Urbana-Champaign, USA (Subaward Number: 2015 -06391 -06, Grant code: AB078).

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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The Official Journal of the **Farm to Fork Foundation**
ISSN: 2518–2021 (print)
ISSN: 2415–4474 (electronic)
http://www.f2ffoundation.org/faa