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Entrepreneurial opportunity of mechanical rice transplanting service for small holder farmer in Bangladesh

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Abstract

Mechanical rice transplanting is gaining attention to the Bangladeshi farmers. However, service business on mechanical rice seedlings transplanting has not yet been developed due to various reasons. The 4-row walking type transplanter (model DP488) was operated in 54 farmer's field at Ghaghatpara, Rangpur Sadar and Kaliganjpara, Pairaband, Rangpur in late *boro* 2016 season to explore the entrepreneurial opportunity of commercial mechanical rice transplanting service for small holder farmer in Bangladesh. The field capacity and field efficiency of rice transplanter was obtained 0.15 ha hr^{-1} and 75%, respectively. Field capacity depended on the size and shape of the plots. Small plots having less than 250 m^2 should be avoided for 4-row walking type rice transplanter to get the good machine performance. Fuel consumption was obtained 4 L ha^{-1} and varied over plot size, soil settlement time, presence of obstacle, plot to plot travelling distance and operator's skill. Scattered plots increased travelling distance hence fuel consumption raised and reduced daily area coverage. Soil setting time should be allowed for 12-24 hrs for satisfactory machine performance. Mechanical transplanting took 18 man-hr ha^{-1} whereas mat loading, machine transport and cleaning took 1.6 man-hr ha^{-1} labors. Depending on the combination of seedling density in tray and density settings in machine the tray requirement varies from 153 ha^{-1} to 222 ha^{-1}. Tray distribution was observed as 90% in transplanting, 6% in gap filling and 4% pocket area. Gap filling by manual labor required 18-20 man-hr ha^{-1}. Time distribution depended on managerial combination and relation between transplanting team and farmers. Seed rate showed negative correlation with seedlings population in tray and positive correlation with seedlings mortality. Number of turning events in plots can be minimized by selecting larger plot and operating transplanter in length-wise. Increasing daily coverage, minimizing fuel consumption and selection of sensible consumer group can draw good return from marginal input and establish business in secure environment.

Key words: Field capacity, fuel consumption, tray requirement, labor cost, commercial transplanting

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Introduction

Adoption of mechanical intervention in agricultural operations has been accelerated in Bangladesh since 1980s. Specific areas like tillage, irrigation and threshing are already under mechanization. At the same time, there are many areas untouched by mechanical interventions especially the seedlings preparation, transplanting and harvesting (Islam, 2010). Mechanizing these activities can serve to achieve greater efficiencies, resource conservation and reduction in cost of crop production. Mechanical transplanting is an emerging technology in Bangladesh. The rice transplanter has already attracted the interest of many farmers, traders and manufacturers and some farmers are already using this technology. Manual transplanting by laborers requires much more time, cost, and the crop maturity become difficult because of the transplanting shock (IRRI, 2007). This shock could be avoided and infant seedlings could be used without imposing any major damage by rice transplanter protecting the possibility for good yield. Manual transplanting required 123-150 man-hr ha-^{1} and it would take only 9-11 man-hr ha-^{1} for mechanical transplanting by four-row walking transplanter (Islam *et al.,* 2016b). Farmers are not habituated to use tender age seedlings. Mechanical transplanting in rice cultivation is being practiced around world for row crop establishment as it allows use of mechanical weeder and reaper to collect good input-output ratio. In Bangladesh, mechanical transplanting performed satisfactorily by four-row transplanter in small scale at different locations (Islam, 2016). Unlike tractor, power tiller and shallow engines, rice transplanter has limitation for multipurpose use keeping the machine idle in off season. It is a single use machine usable only for rice transplanting. Efficient rice transplanting in field could be affected by land condition, good management and seedlings quality in tray beside of the machine performance (Islam *et al.,* 2015). The possibilities of commercialization of mechanized transplanting using small scale machineries has also indicated positive results as the farmers showed huge interest. However, the performance of commercial transplanting service of 6-ride on transplanter was observed lower than the recommendable margin because of various constraints that are already identified in *aman* 2014 (Islam *et al.,* 2015). Those constraints indicated that there is a need of developing a rigid service business that can check the underlying performance of machine in operation at the farmer's field. The service business for rice transplanter is thus includes all these crucial factors. Proper diffusion of mechanical transplanting technology is a prerequisite of service business. Seedlings preparation and rice transplanting service could be attached together to establish proper synchronization. Seedlings preparation in tray requires skill and knowledge which should be provided to the farmers. Risk related to seedlings establishment must be safeguarded by company policies. Based on the previous findings of constraints of using small rice transplanter in transplanting operation at commercial level, there is need to develop service business of mechanical rice transplanter. Therefore, this study is thus aimed at developing an entrepreneur opportunity of mechanical rice seedlings transplanting service articulating possible values, obstacles and key factors of rice transplanting in small scale business.

Materials and Methods

The 4-row walking type transplanter (model DP488) was operated in 54 (fifty-four) farmer's field at Ghaghatpara, Rangpur Sadar and Kaliganjpara, Pairaband, Rangpur in late *boro* 2016 season (Map 1). This machine featured ten seedlings density setting, separate transplanting and operating engage-disengage clutch, six depth control options and six (12.5, 14, 16, 18.5, 20, 21.5 cm) seedlings interval control. Depth, spacing and density setting are calibrated before proceeding to the main operation to obtain desired output in field. The high yielding rice varieties BRRI dhan28 and BRRI dhan48 having good germinations were used to raise seedlings in plastic trays.

Seedling raising: Plastic trays having dimenstion of 58×28×3 cm were used to prepare mat type seedlings. Seedlings were prepared in the respective farmer's field under instructions of trained personnel. Vigorous seeds were chosen by specific gravity method. Seeds were immersed in water for 24 hrs and placed in gunny bags. The seeds were started to germinate within next 48 hrs and sown after 72 hrs. Dry soil was sieved and poured in tray after removing stone, stubble or grass. Sprouted seeds were distributed uniformly on the soil. Water was applied twice a day until complete seed emergence. Mats were ready to transplant when seedlings attained 2-3 leaves and 10-12 cm height.

Map 1. Study area (adopted from Google Map)

Photo 1. Walking type transplanter

***Theoretical field capacity*:** The theoretical field capacity was calculated as a function of speed and operating width by following equation (Hunt, 1995):-

$$C_0 = \frac{W \times S}{C} \qquad (1)$$

Where,

C_0 = Theoretical field capacity, ha hr^{-1}
W = Operating width of the machine, m
C = Constant, 10

***Actual field capacity*:** The actual field capacity was calculated as a function of area and field time by following equation:-

$$Ca = \frac{A}{T} \qquad (2)$$

Where,

Ca = Actual field capacity, ha hr^{-1}
A = Total area covered, ha
T = Total operating time required for transplanting, hr

***Field efficiency*:** The field efficiency, as a function of theoretical and actual field capacity, calculated by following equation:-

$$Ef = \frac{Ca}{C_0} \times 100 \qquad (3)$$

Where,

Ef = Field efficiency, %

***Turning loss*:** Average time of each turn was measured. Then total number of turn was counted for each plot. The total turning loss for individual plot was obtained by multiplying total number of turns with average time of each turn.

***Fuel consumption*:** Fuel tank was filled up before starting field operation and fuel consumption was measured from the refill volume at the end using the following equation:

$$F = \frac{Ft}{T} \qquad (4)$$

Where,

F = Fuel consumption rate, L hr^{-1}
Ft = Fuel used during operation, L
T = Time needed for operation, hrs

***Economic analysis*:** Costs in various segments of transplanting operation were classified into two groups, fixed cost and variable cost.

Fixed cost: Fixed cost was determined by using the capital consumption method. Capital Consumption (CC) was expressed by the following equations.

$$FC= (P\text{-}S)\ CRF + Si \qquad (5)$$

$$CRF = \frac{i(1+i)^{n}}{(1+i)^{n}-1} \qquad (6)$$

Where,

FC% = Annual fixed cost percentage

P = Purchase price of the self-propelled rice transplanter, Tk

S = Salvage value of the self-propelled rice transplanter, Tk

CRF = Capital Recovery factor

i = Interest on investment, %

n = number of year

Variable cost (VC): Variable cost is the function of repair and maintenance cost, labor cost, fuel cost and oil cost depending upon specific type of machine.

The variable cost can be calculated by the following equation.

Variable cost (VC) = Fuel cost + Labor cost + R&M cost (7)

Data collection: Plot length and width (m) was measured using plastic tape and recorded carefully. Soil settling time was calculated at the time of transplanting from the time of puddling. Number of tray required in each plot, daily area coverage of transplanting, travelling distance (km) from machine shed to field, missing hill, labor requirement, water height, depth of puddled soil, machinery trouble were collected by direct monitoring. Data were analyzed using MS-Excel 2013 and presented in tabular and graphical form.

Results and Discussions

Seedlings mortality: Figure 1 shows that seedlings density and mortality was positively correlated with various seed rate. Both the number of seedlings in tray and mortality were increased with the increase in seed rate in tray preparation despite of varietal difference. The number of seedlings in tray was less for BRRI dhan48 than that of BRRI dhan28, perhaps due to variation of seed germination. High density seedlings influenced slender and low density produced plump seedlings due to micro-environmental space facility. Trays having high density seedling helped in reducing tray requirement in transplanting (Islam, 2016).

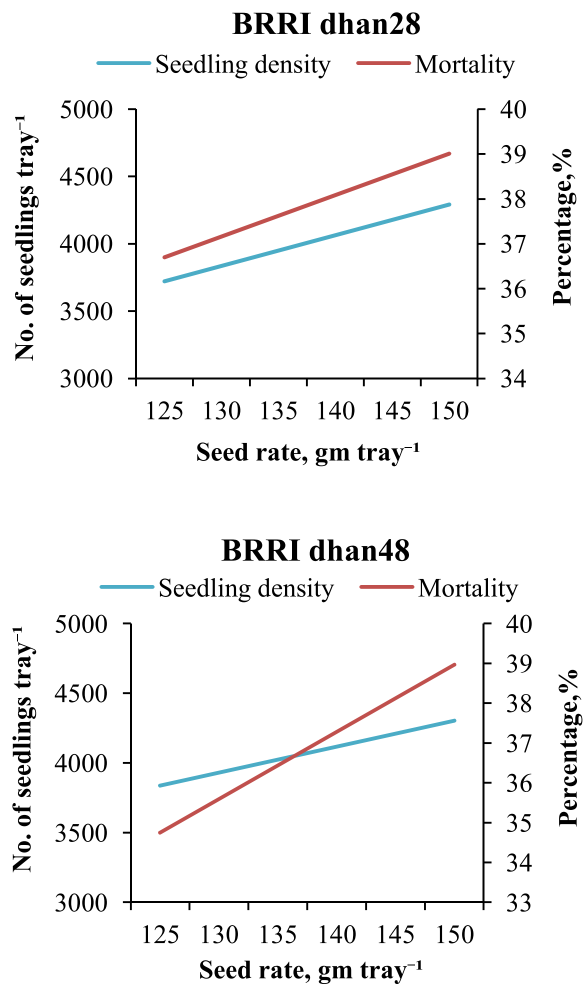


Figure 1. Effect of seed rate on seedlings mortality

Forward speed: Forward speed was depended on the soil settling period and ultimately influenced on field capacity (Figure 2). Puddled field condition and operators' comfort observed to vary with soil settling time. The forward speed of the transplanter was obtained 1.79 km hr^{-1} in less interrupted plots which was similar to that reported by Islam *et al.* (2016a). Plots that were puddled at the same day of transplanting observed to reduce 8.84% of the machine speed than those plots which were prepared before 24 hours or more. Loose mud in immediately prepared plots increased slippage of lugged wheel and reduced operator's walking speed as well as machine forward speed. Dixit *et al.* (2007) stated that the soil settlement period depended on the type of machine and type of soil. They recommended that for manually operated machine, the soil settlement period should be about 24 hours for heavy soils. The puddled field condition largely affected operator's comfort as the machine was walking type.

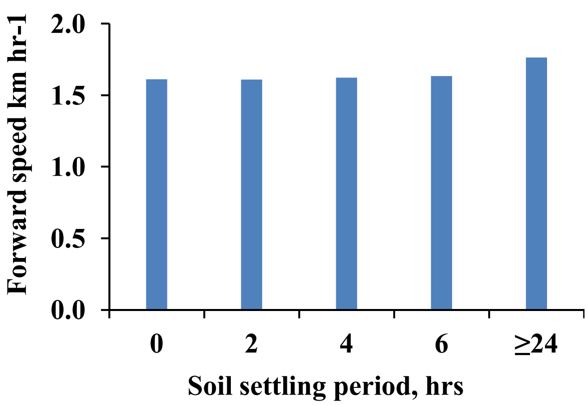


Figure 2. Forward speed in relation to soil settling time.

Turning loss**:** The loss time during turning in headland depended on the frequency of turning which was affected by the plot length. As per observation, turning loss was reduced with the increase in plot length (Figure 3). The turning loss was observed 5 times more in the plots having the length of <25 m than that of 45-55 m which could be used to cover an additional area of 0.04 ha at the same time. It is preferable to choose the plot length having more than 25 m for getting the reasonable machine performance especially 4-row walking type rice transplanter.

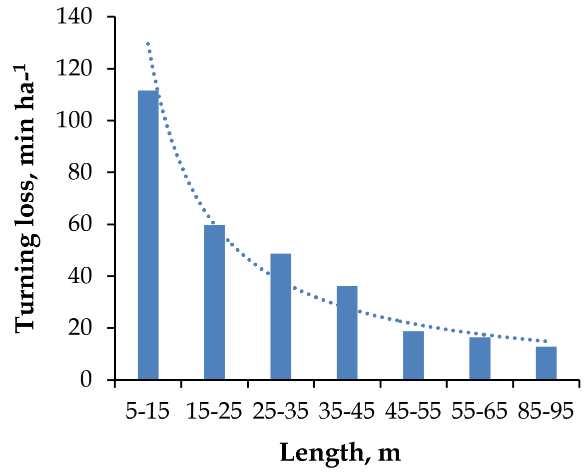


Figure 3. Effect of plot length on turning loss.

Field capacity: Field capacity was varied on the size of the plots (Figure 4). Plots belongs to 1000 m^2 or higher seemed to attain field efficiency of 75% or higher with a field capacity of at least 0.15 ha hr^{-1}. Field capacity was very low for the field size less than 250 m^2. Larger plots were favorable in increasing daily area coverage than smaller plots.

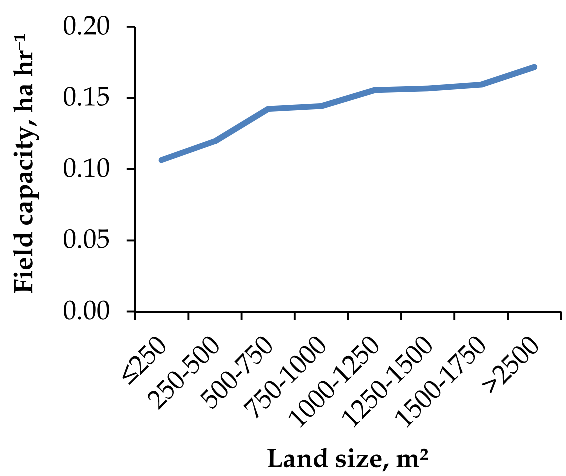


Figure 4. Field capacity with respect to plot sizes.

Smaller plots were not favorable to operate transplanter and not possessed economic feasibility. Plots that were not leveled properly caused zigzag of transplanting line. Field capacity could be improved by maintaining water height of 1-2 cm in puddled field at the time of transplanting, operating transplanter in lengthwise and removing obstacles. Small plots having less than 250 m^2 should be avoided for 4-row walking type transplanter. Islam *et al.* (2015) reported that field sizes less than 400 m^2 should be avoided to get the good performance of 6-row riding type transplanter. Field capacity was influenced by the plot length and increased with the increase in plot length due to less turning loss (Figure 5).

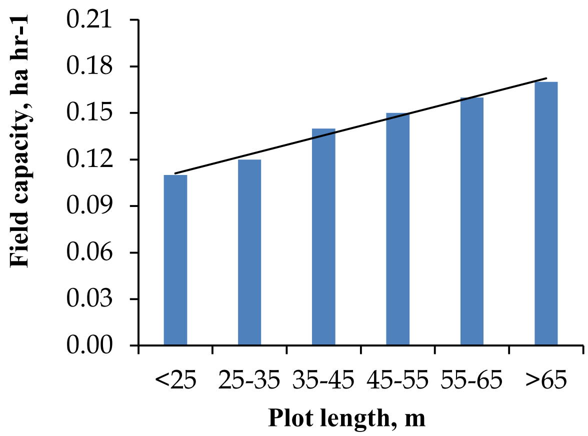


Figure 5. Effect of plot length on field capacity.

Fuel consumption: Fuel consumption was decreased with the increase in field capacity of the rice transplanter (Figure 6).

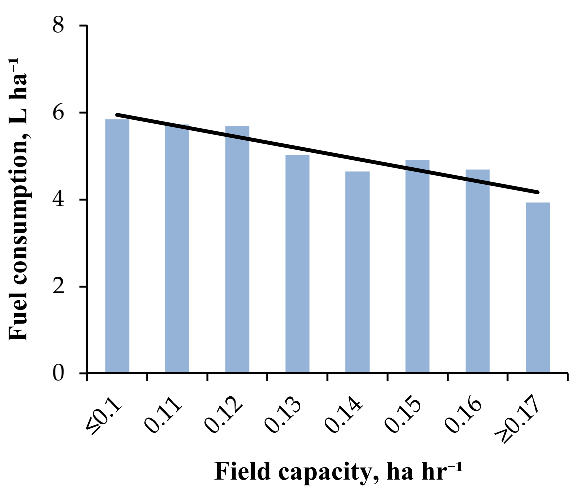


Figure 6. Fuel consumption with respect of field capacity.

Fuel consumption was varied 3.0-5.0 L ha^{-1} depending on the number of turning in plots, distance between plots and additional travelling by the machine. Fuel was fully utilized in easily accessible regular shape and large size plots because of high field capacity. Distance from one plot to another caused additional fuel consumption of the machine. The average distance travelled in each day by the transplanter from homeyard to plot and plot to plot movement was one kilometer. Fuel consumption of the transplanter in travelling was obtained 0.33 L km^{-1} (Figure 7). Fuel consumption would be lower when adjacent plots in the fields were transplanted sequentially.

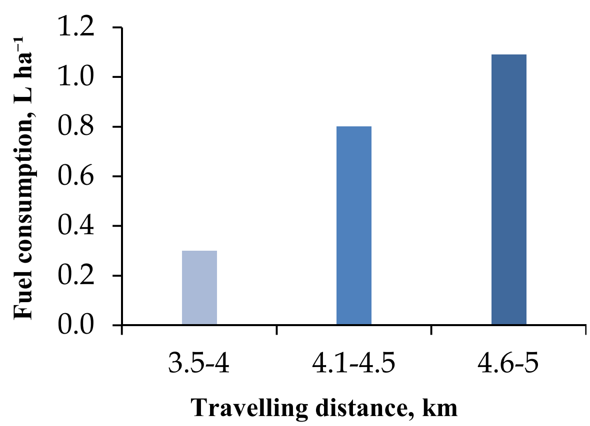


Figure 7. Fuel consumption with respect to travelling distance.

Tray requirement**:** Tray requirement in transplanting and gap filling were shown in Table 1. Tray requirement varied from 153 to 222 trays ha^{-1} depending on the seedlings density, uniformity in tray, density setting of machine, seedlings dispensed per stroke in the field and number of tray required for gap filling. Islam *et al.* (2015) mentioned that tray requirement in each plot was influenced by both the seedlings density in tray and the density setting in machine. The number of seedlings dispensed in each stroke of picker fork can be controlled from the density setting panel of the transplanter. Higher density setting allowed more seedlings dispensed per hill causing higher tray consumption hence increased the tray requirement. The density setting in machine usually set on the basis of seedlings density obtained from trays. Setting 3 was the most frequent selection and 5-6 seedlings were picked up in each stroke. The tray requirement was positively correlated with the density setting in machine and negatively correlated with missing hill (Table 1). Missing hill was observed more when density set to 2. The possibility of missing hills reduced with higher density setting as more seedlings (5-6) dispensed per stroke mitigating random gap of seedlings in tray.

Table 1. Effect of seedlings density setting on seedlings dispensed in each stroke

Number of seedlings dispensed stroke^{-1}	Density setting				
	2	3	4	5	7
<3	13%	8%	6%	4%	2%
3-4	75%	9%	13%	9%	8%
5-6	12%	83%	75%	20%	13%
7-8			13%	67%	77%
Tray requirement, no. ha^{-1}	153	163	186	196	222
Missing hills, %	6	5	3	2	<2

***Seedlings tray* distribution:** Tray requirements during transplanting were categorized as tray required in mechanical transplanting, gap filling and pocket area filling (Figure 8).

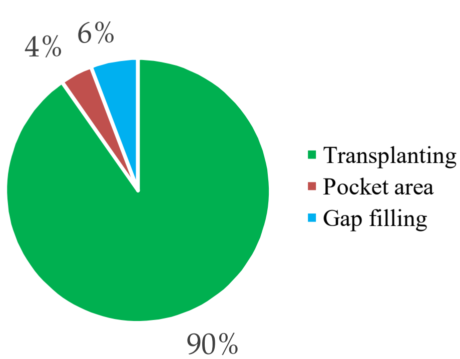


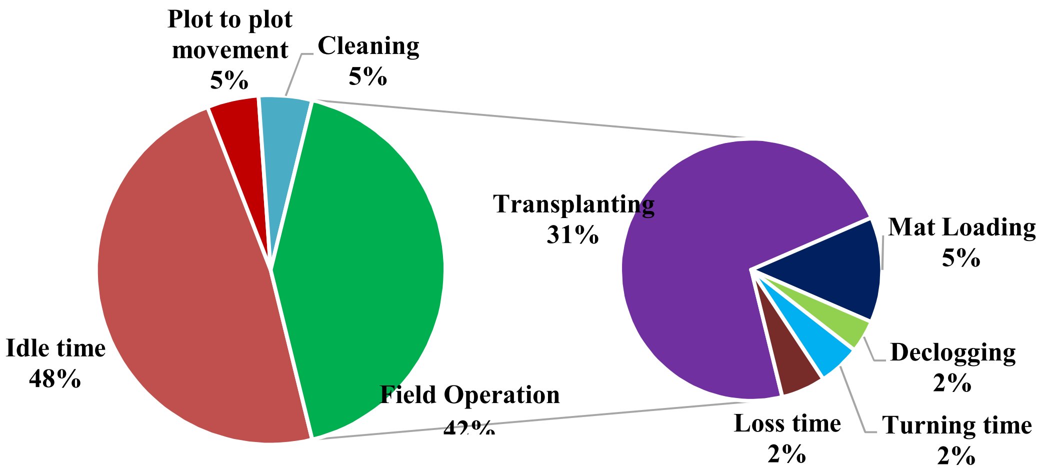
Figure 8. Seedlings tray distribution

Almost 90% of the trays were used in transplanting. Tray requirement in transplanting operation was vitally affected by the variation of seedlings density in trays. Amount of trays required in gap filling was largely affected by the seedlings density in trays and density adjustment in the machine (Islam et al., 2015). Besides, extra laborer was required for gap filling. Transplanting in pocket area required almost double time because of frequent turning events, and tray slots unloading time for row adjustment.

***Time* distribution:** Time distribution in plot was categorized under time required in transplanting, idle condition, plot to plot movement and cleaning (Figure 9). The transplanting time was further categorized as mat loading, declogging, turning and loss time (rest and stop time). Total mat loading time depended on the frequency of loading mat. Mat loading near the border required less effort than at the middle of the plot. Mat loading time could be reduced by good co-ordination between operator and laborer. Time required for cleaning (de-clogging) mud and garbage from the tray shifter depended on the frequency of clogging events. Islam et al. (2015) mentioned that the performance of the transplanter was depended on the frequency of loading mat, time required for carrying mat and machine breakdown or clogging**.**

***Labor requirement*:** Labor requirement in transplanting activities are shown in Table 2. Only 19 man-hr ha^{-1} was required to perform transplanting, carrying and loading mat in the field. Labor requirement in gap filling was obtained 20 man-hr ha^{-1} to cover 2% missing hill. Labor requirement in cleaning was not varied over area coverage, however, depended on the mud attached to the machine.

***Rental charge calculation*:** The rental charge for unit (1 ha) area depends on machine price, fuel, labor, shed (temporary charge to keep transplanter in farmer's home during transplanting period), transport cost, annual usage and profit.



a. Daily activities **b. Plot activities**

Figure 9. Time distribution

Table 2. Labor requirement in different activity

Activity	Labor type	man-hr ha^{-1}
Transplanting	Operator	18
Mat carrying, loading	Skilled laborer	1
Machine transport (plot to plot)	Operator	0.30
Cleaning	Skilled laborer	0.31
Gap filling (2% missing hill)	Traditional laborer	20

Assumptions: Following assumptions are taken for calculating rental charge of rice transplanter:-

- Purchase price of the 4-row walking type transplanter is Tk 4,00,000.
- The machine is in good condition to perform its task in same rate (ha hr^{-1}) without varying over its lifetime.
- Daily use, annual use
- The bank rate for interest on investment is 12%.
- The repair and maintenance cost of rice transplanter is taken as 5% of its purchase price.
- The life of the transplanter is considered 6 years.
- Fuel price is taken as Tk 90 L^{-1}.
- Operator charge is considered Tk 500 per day.
- Labor cost can fluctuate depending on location and labor availability and taken as Tk 300 day^{-1}.
- Use of machine per year ….. days with … hours/day.

Measuring only the hourly fixed cost doesn't completely cover practical situations, but the range of field capacity availed in varying field conditions (i.e. land shape, size, operator skill, soil settling condition, etc.) also has competency to be taken into account while calculating cost per hectare. The occurrence of field capacity values were plotted based on the field observation and found maximum occurrence of events at 0.15 ha hr^{-1} (Figure 10). These values were used to determine the annual area coverage and transplanting cost. Figure 11 shows the fixed and variable cost over small area coverage.

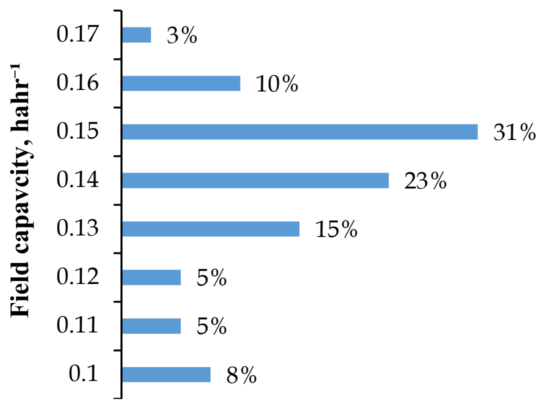


Figure 10. Field capacity in 50 trials

Fixed cost decreased with the increase in annual area coverage Entrepreneur will consider these two graphs to calculate the rental charge of mechanical transplanting. Rental charge of the mechanical transplanting service depended on the annual and daily area coverage, fuel and labor price, machine breakdown, puddled condition, loss time minimization and payback period. Seedlings raising cost was not included in this calculation. An example, transplanting service cost will be Tk 6135 per hectare (Fixed cost, Tk 3745 and variable cost, Tk 2390 ha^{-1}) for the area coverage of 30 hectare. Entrepreneur will add the profit according to the payback period and annual area coverage to get the return on investment. Islam (2016) mentioned that at the initial stage of mechanization, transplanting business would be profitable with 70% cash incentive and 30% loan at reduced interest rate to procure transplanter for the annual area coverage of 30 hectare of land. Therefore, entrepreneur must be aware to increase the annual area coverage in order to fix up the competitive rental charge.

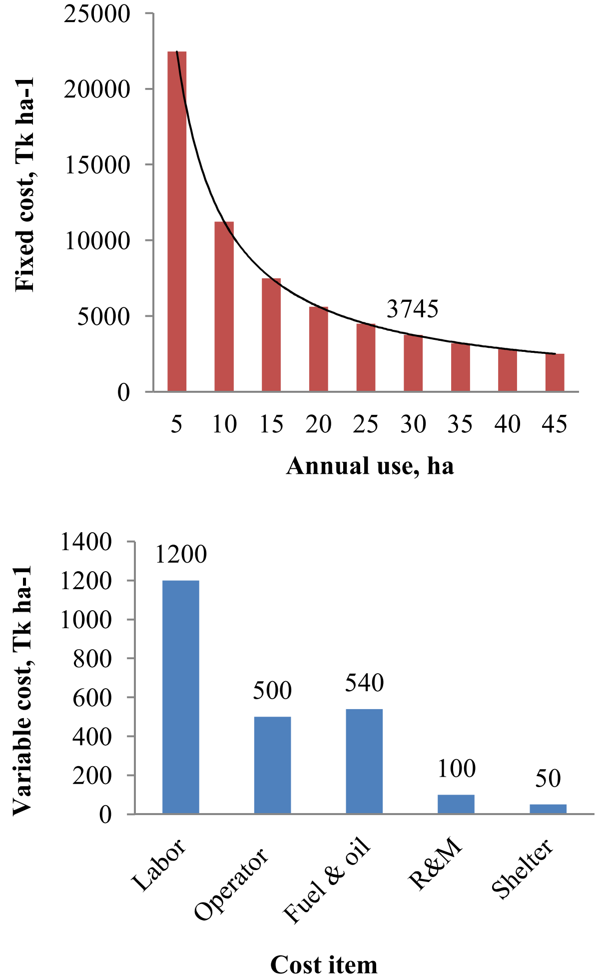


Figure 11. Transplanting cost scenario over small scale area coverage

Limitations: The business model developed for small scale based on data and attributes collected from one district. This model could impose following limitations:-

- The model doesn't initiate any control on farmer's attitude and post-transplanting management of field to secure good yield.
- The daily area coverage (1.0 ha day^{-1}) is difficult to meet if farmer's doesn't prepare land in time or fails to prepare good seedlings trays (≥5000 seedlings $tray^{-1}$).

- The socio-cultural status of farmers is not sufficiently up-to-date to harness mechanical transplanting as well as the business model.

***Constraints in transplanting operation*:** The following constraints were observed during commercial operation of the rice transplanter.

- Plots are dispersed, highly fragmented and absence of passage for machine movement in field
- Farmers were worried about the crop establishment and yield due to use of tender aged seedlings
- Farmers in rural area lacks in adequate knowledge and nursery management skill for preparing good seedlings trays
- Farmers have the tendency of using more seed rate and application of chemical pesticide and fertilizers to enhance seedlings growth
- Transplanting schedule often broken down or delayed due to delayed land preparation, seedlings age and farmer's attitude toward timely transplanting.

Conclusions

Effective use of transplanter machine, good nourishment of seedlings and decent management of trays from farmer's nursery to field were found the major impact points and should be carried cautiously to obtain successful business environment on small scale transplanting service. Entrepreneurial role for the advanced farmers could be developed in seedlings preparation. The target area coverage, unit price of transplanting service, unit price of trays, business period were found interconnected with each other and jointly affected profit generation.

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