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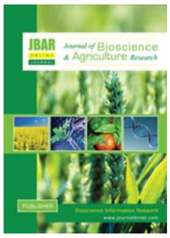

Commercial mechanical rice transplanting under public private partnership in Bangladesh

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ABSTRACT

This research work was done under public private partnership approach to reduce the tray consumption, increase the field capacity of mechanical transplanter and provide suggestion for wide scale adoption of mechanical transplanting. A 6-row ride on transplanter was used to carry out this research at Hatgobindapur, Chandpur in Natore district during aman 2014 season. This machine has ten seedling density setting, four depth controls and four space setting options. Data were collected from 149 plots covering 10.64 ha. It was observed that field capacity of the transplanter depended on plot to plot distance, plot size, seedling tray supply and number of plots under transplanting activity. Fuel consumption was obtained 19.28 litre per hectare. Results revealed that almost 92% trays were required in mechanical tansplanting, 2% for gap filling and 6% in pocket area filling by manual labour due to irregular shape of the plot. Throughout the operations, 52% time was spent in plot to plot movement and as idle time. One extra skilled labour was needed to load and unload the tray in the machine. Among the transplanting plots, 70% were uniform, 25% were irregular and 5% were mostly irregular. Irregular and mostly irregular plots should be avoided to increase effective field capacity of the transplanter. During study period, 25% trays were saved after providing technical support. Effectiveness of the transplanter was proposed to improve the business opportunity of mechanical transplanter in the fragmented land holding system. Calibration should be done on space and seedling density setting based on soil condition, soil type, seedling height, seedling density before operation in each plot to get optimum plant spacing and number of seedling dispensed in each stroke. Operator should keep the record of tray requirement in each plot and close contact with the help of a monitoring officer. Seedling tray requirement in each plot can be reduced by adjusting plant to plant spacing and seedling density setting. Smaller plot should be avoided to increase the daily area coverage of the transplanter.

Key words: *Rice transplanter, tray requirement, field capacity, missing hill and fuel consumption*

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I. Introduction

Rice is grown in three season-*Boro* (Dec-April), *Aus* (April-July), *Aman* (Aug-Nov) and production of about 48 million Mt on an area of 10.8 million ha which covers 77% (10.71 Mha) of the total cropped areas (BBS, 2011). There are many ways to transplant seedlings like manual, mechanical or throwing. Transplanting of seedlings into heavy puddled soils is the common practice of rice cultivation in Bangladesh. Transplanting activities are mostly done by manual labor. Manual paddy transplanting is the tedious, laborious and time consuming operations requiring about 250-300 man h ha^{-1} which is roughly 25% of total labor requirement of rice production (Singh *et al.,* 1985). It was reported that a delay in transplanting by one month reduces the yield by 25% and a delay of two month reduced the yield by 70% (Rao and Pradhan, 1973). Further, due to rapid industrialization and migration to urban areas, the availability of labor became very scarce and with hike in the wages of labor, manual transplanting found costly leading to reduced profits to farmers. Under such circumstances a less expensive and labor saving method of rice transplanting without yield loss is the urgent need (Tripathi *et al.,* 2004). Mechanical transplanting systems increased yield, improved labor efficiency, ensured timeliness in operation and faster transplanting (Islam *et al.,* 2015). Mechanical transplanter offers high field capacity compared to manual transplanting and thus, farmers can transplant rice seedlings within very short and appropriate time by mechanical transplanter. Rice transplanter is popular in industrialized countries where labor cost is high, for example in South Korea. Different models of transplanters are introducing in the country and farmers are encouraged to adopt mechanized method of transplanting. Tender aged seedlings are used in mechanical transplanter and the farmers are not aware of the use of infant seedling. Depending on the variety, the age of seedling in dry and cold season should be more than 12 and 25 days, respectively (Islam *et al.,* 2015).

Syngenta, a joint venture company of Syngenta AG Switzerland and BCIC, Bangladesh came forward to start business on mechanized transplanting in the name of Tegra. Tegra (rice solution) is a brand name developed by Syngenta. Tegra packages consist of providing healthy seedlings, mechanical transplanting, herbicide application and advisory support on agronomic service. Seedlings are grown in a special media. Tegra starts in our country during *aman* 2012. Mechanical transplanting is a crucial part to success of Tegra business. During promotional activity of Tegra program, they faced serious problem on tray consumption and lower field capacity of transplanter. In 2013, Tegra covered 9.5 ha in Bogra and Natore with the field capacity of 0.17 ha/hr and the tray consumption was 214 tray/ha (Syngenta, 2013), whereas for profitable commercial transplanting the recommended rate for tray consumption is 170 tray/ha with the field capacity greater than 0.2 ha/hr (BRRI, 2013). As a result, the company has to face a lot of compensation. BRRI took the challenge to start participatory research with Syngenta and provided one ride on type transplanter on rental basis to carry out the research activity during *aman* 14 season. The research works are done with the objectives to reduce the seedling tray requirement and increase the field capacity of mechanical transplanter; to identify the constraints of commercial service of mechanical transplanting and to suggest possible solution to overcome the problem.

II. Methodology

The research was conducted during *Aman* 2014 season at Hatgobindapur, Chandpur in Natore. Figure 01 indicates the study area. A 6-row ride on transplanter (supplied by BRRI) was used to carry out this research. This machine has ten seedling density setting, four depth control and four space setting options. Two rice varieties BRRI dhan49 and BINA dhan7 were grown in the study area. Data sheet was prepared to collect day to day information. Data were collected from 149 plots. Total operating time was recorded. After the completion of field operation, the fuel tank of machine was refilled and the amount of refill was recorded. Fuel consumption was measured by weighing refilled volume. Turning loss is an important factor in transplanting. The land of our country is small and fragmented. Lot of time is lost due to turn of the machine. To determine turning loss, at first average time of each turn is measured. Then total no. of turn was counted. Then the total turning loss for individual land was obtained by multiplying total number of turns with average time of each turn. Data were collected on seedling height, number of leaf, seedling spacing, seedling density setting, plot size and shape,

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machinery adjustment, labour requirement for gap filling and other pocket area, fuel consumption, movement time, number of tray required in each plot, daily area coverage of transplanting and identify machinery trouble. Farmers' attitude on mechanical transplanting was also collected. Data were analyzed using MS-Excel 2007 software and presented in table and graph.

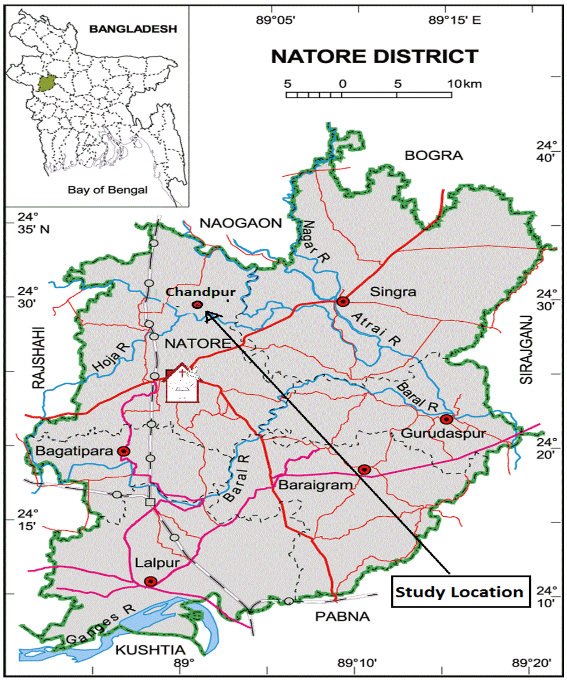

Figure 01. Location of study area (adapted from Map of Bangladesh)

Basic feature of DAEDONG rice transplanter

The DAEDONG rice transplanter used for commercial transplanting is imported by ACI motors Ltd. Dhaka, Bangladesh. The specifications of the rice transplanter are given in Table 01. Figure 02 shows the pictorial view of DAEDONG rice transplanter used in the study.

Figure 02. Pictorial view of DAEDONG Rice transplanter

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Table 01. Specification of riding type rice transplanter

Country of Origin			Korea
Model			DAEDONG RICE TRANSPLANTER
Type			Ride on Type
Dimensions	Overall length (mm)		3120
	Overall width (mm)		2140
	Overall height (mm)		1655
	Overall weight (kg)		620
	Type		4-stroke, air-cooled OHV gasoline
	Displacement (CC)		437
	Maximum output kW/rpm		10.5/3600
	Fuel tank capacity (L)		15-20
	Starting method		Electric motor start mode
Section	Steering		Hydraulic power steering mode
	Tires	Type	Solid rubber, Anti-puncture tire
		Front Diameter, mm	650
		Rear Diameter, mm	900
	Gearshift	Forward	2 speeds (Steeples variable speed)
		Reverse	1 speed
Transplanting Section	Transplanting mechanism		Rotary type
	Number of rows		6
	Transplanting distance, cm Row to row		30
	Transplanting distance, cm (plant to plant)		16, 18, 19, 21
	Planting pitch control		Adjustable
	Planting depth control		Adjustable
	Planting depth, cm		0.8-4.4
	Number of spare seedling rack		6
	Transplanting speed, m/sec		0 to 1.36

III. Results and Discussion

Daily area coverage

Daily area coverage of mechanical transplanting is given in Table 02. Area coverage varied depending on the plot to plot distance, plot size, land preparation, land leveling, irrigation facility, seedling tray supply etc. Number of plots under transplanting activity also influenced the field capacity of the transplanter. Smaller plot should be avoided to increase the daily area coverage of the transplanter.

Fuel consumption

Daily fuel consumption varied from 14 to 30 litre per hectare depending on the plot size, shape, transplanting area, movement from one field to another, plot to plot distance and distance from machinery shed to transplanting field (Table 02). Average fuel consumption obtained 19.28 litre per hectare. Monitoring officer should maintained the fuel stock depending on the next day area coverage of transplanting, number of plot to be transplanted and travelling distance from machinery shed to transplanting field.

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Table 02. Daily area coverage and fuel consumption

Date	Area coverage, ha	No. of plot	Average plot size, ha	Daily fuel requirement, L	Fuel consumption, L/ha
10/7/2014	0.89	7	0.13	17	19.07
11/7/2014	1.25	23	0.05	17	13.61
12/7/2014	1.23	19	0.06	20	16.23
13/7/2014	1.16	14	0.08	20	17.28
14/7/2014	1.36	20	0.07	20	14.74
15/7/2014	1.34	20	0.07	20	14.96
16/7/2014	1.10	17	0.06	20	18.18
17/7/2014	0.78	12	0.07	20	25.51
18/7/2014	0.88	11	0.08	20	22.81
19/7/2014	0.66	6	0.11	20	30.44
Total	10.64	149	0.07	194	19.28

Seedling tray requirement

Daily seedling tray requirement was given in Figure03. Tray requirements varied from 148 to 183 trays/ha. Daily average tray requirement obtained 167 trays/ha. Seedling tray requirements during transplanting were categorized as tray required in mechanical transplanting, gap filling and pocket area filling. Almost 92% trays required in mechanical tansplanting (Figure 04). Missing hill was found minimum (2%) which required manual transplanting. The most important thing to be considered that 6% tray was required in pocket area filling by manual labour due to irregular shape of the plot. This type of plot could not be avoided due to fragmentation of land holdings.

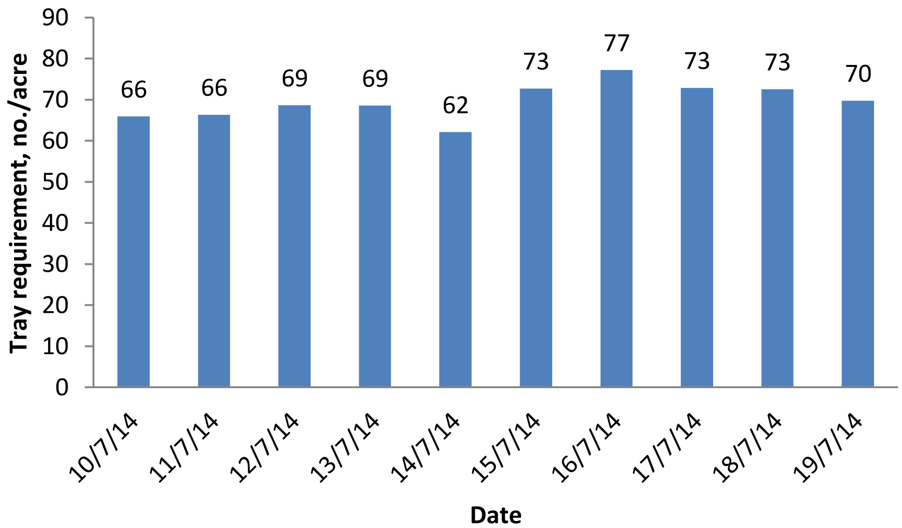

Figure 03. Daily seedling tray requirement

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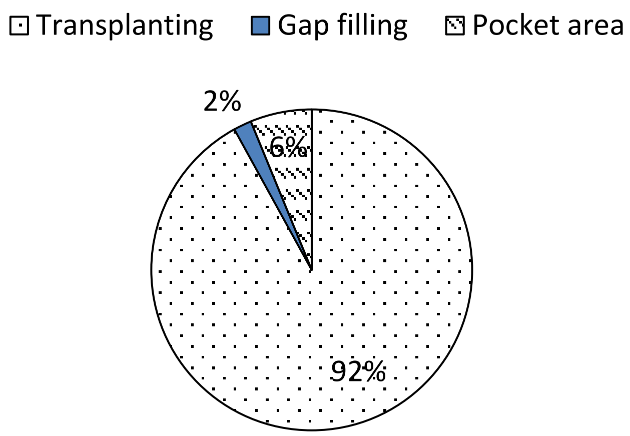

Figure 04. Seedling tray requirement

Time distribution

Time distribution of transplanting activity was given Figure 05. Transplanting activity was categorized as operating, movement, cleaning and idle time. On an average 52% times were spent as plot to plot movement and idle time. Idle times are categorized as avoidable and unavoidable. Avoidable idle time included that the plots were not ready, shortage of seedling, excess water height. Careful management can improve the situation. Unavoidable idle time included heavy rainfall and machine breakdown.

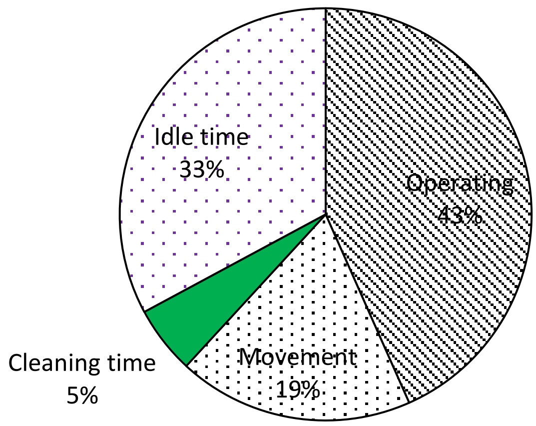

Figure 05. Percentage of time distribution in different activity

Travelling distance

In some situation, traveling distance was very high, i.e., 5-6 km far from crop field to machinery shed. Wear and tear occurs in the rubber wheel if travelling on the concrete road. Travelling distance should be reduced to increase the effective time of operation. It is advisable to operate machine within one kilometer radius.

Labour requirement

In addition of operating the machine, operator should keep the record of tray requirement in each plot and close contact with the monitoring officer. One skilled labour was needed to load and unload the tray in the machine. Depending on the distance of plot from road, one to two laoburs were needed to continuous supply of tray.

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Land geometry

Land size and shape is very much important for proper operation of the machine. Most of the lands under transplanting activity were small. It was difficult to get land of uniform size.

Plot shape and size

Plot shape is important to increase field capacity and seedling tray requirement. Among transplanting plots, 70% were uniform, 25% were irregular and 5% were mostly irregular (Photo 01). Irregular and mostly irregular plots should be avoided to increase effective field capacity of the transplanter.

Plot size also affects the effective field capacity of the transplanter. Ride on type machine required large plot for successful operation of the machine. Among the transplanting plots, 15% are under <10 decimal and 14% are under 11-13 decimal. These plots should be avoided to transplant seedling by ride on type transplanter. The size of plot should be more than 20 decimal for ride on type transplanter. Length of plot was also another indicator to decrease the turning time as well as increase the field capacity.

Photo 01. Irregular plots

Plot to plot movement of machine

Most of the plots were scattered and increased the loss time due to shifting the machine from one plot to another. Plot shape was not uniform (zigzag). Land was not leveled uniformly. Obstacles were also found the plot which hampered the machine movement (Photo 02). In Natore area, some lands were under mango tree plantation as it appeared profitable than rice cultivation. Some lands are smaller in size and headland turning took more time.

Photo 02. Obstacle in land

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Seed rate

Seed rate is very much important to maintain proper growth of seedling. The seed germination should be more than 95% and seed vigor should be more than 80%. Seedling growth appeared good and less mortality observed in *aman* season due to warm environment. Seed rate observed higher in *aman* 2014 than *aman* 2013 season (Table 03). Higher seed rate influenced on slender seedlings. Number of seedlings per unit area and uniformity of seedlings are very much important to minimize missing hill.

Table 03. Seed rate and seedling density of two rice variety

Variety	1000 grain weight, gm	Aman, 2013 Seed weight, gm/tray	Seedling/tray, no.	Aman, 2014 Seed weight, gm/tray	Seedling/tray, no.
BINA dhan7	22	150	5000	190	6500
BRRI dhan49	20	150	5200	165	6600

Varietal characteristics

Seedling characteristics varied with rice variety. Seedling characteristics also attracted the farmers. BRRI dhan49 was more attractive due to dark green color, optimum seedling height strong erect stem and good vigour seedling (Photo 03). Whereas BINA dhan7 possessed the excessive seedling height (>16 cm), light green colour, slender stem and prone to tilting. In case of BINA dhan7, farmers were unhappy due to number of seedling dispensed per hill was low (Photo 04). They requested to transplant more seedlings in each hill which influenced the seedling tray requirement.

Photo 03. Seedling of BRRI dhan49

Photo 04. Seedling of BINA dhan7

Depth of seedling placement

It was observed that water height ranged from 2-4 cm and depth of puddled field range from 9-15 cm. Depth of seedling placement depended on water height and depth of puddled land.

Spacing adjustment

Tray requirement depended on space setting. Figure 06a showed the histogram of plant spacing where spacing was set 16 cm. In practical situation, most of the places plant to plant spacing was higher than 16 cm. This might be due to skidding of the transplanter. Water height and puddled depth may also influence the actual plant spacing. In this situation, plant spacing should be set at 14 cm. Figure 06b also showed the histogram of plant spacing where spacing was set at 19 cm. In practical situation, most of the places plant to plant spacing was lower than 19 cm. This might be due to slippage of the transplanter. It was the common phenomenon which occurred frequently in the field. Calibration should be done on space setting before operation in each plot to get optimum plant spacing.

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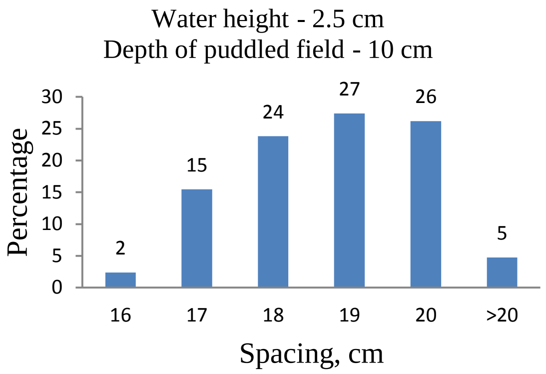
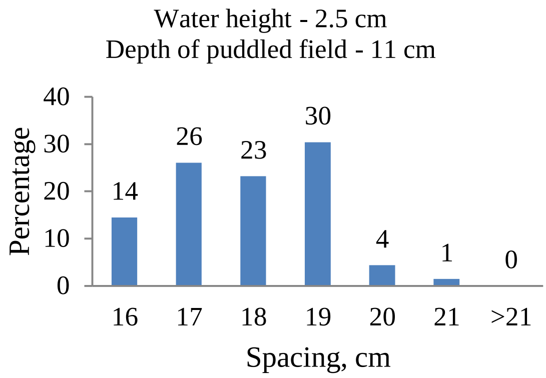


(a) Spacing set at 16 cm

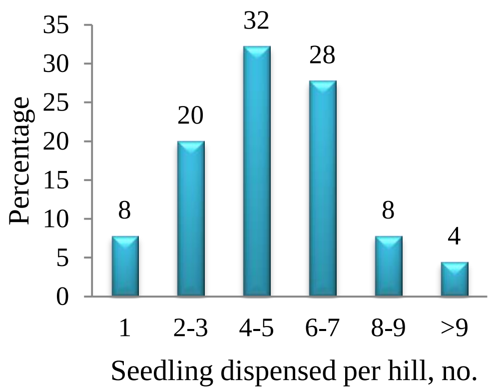


(b) Spacing set at 19 cm

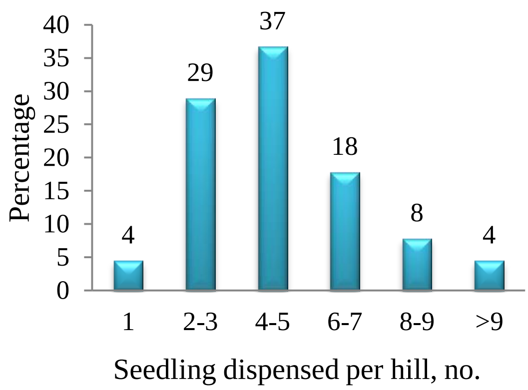
Figure 06. Histogram of plant to plant spacing

Seedling density adjustment

Tray requirement in each plot largely depended on the seedling dispensed per stroke. More number of seedling dispensed per hill increased the tray requirement. Figure 07 showed the histogram of seedling density per hill. Seedling density setting depended on seedling density in tray. Poor metering of seedlings increased the number of seedling per hill as well as increased the tray requirement. In seedling density setting 4, 2-7 number of seedling dispensed in 82% places. This setting appeared as optimum plant density setting.



a. Seedling density setting 4



b. Seedling density setting 3

Figure 07. Histogram of seedling density per hill at different seedling density setting

Tray savings

During study period, area coverage under mechanical transplanting was 10.64 ha and 621 trays i.e. 25% trays were saved after providing technical support (Figure 08). It was possible to synchronize the seedling density in tray, plant height, seedling density setting, plant spacing setting, water height and depth of puddled field.

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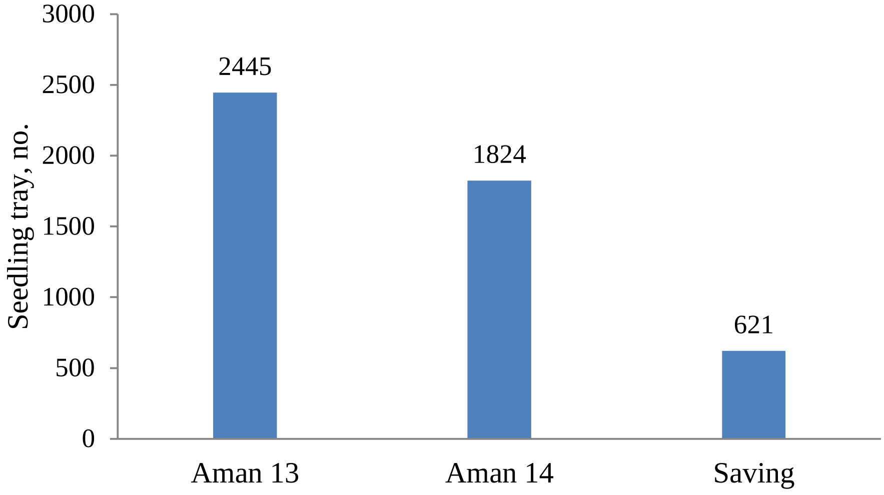

Figure 08. Tray savings

Suggestion for the entrepreneur

Small and irregular shape plot should be avoided to increase field efficiency of the transplanter. Plots should be clustered to reduce plot to plot movement time and plots should be nearer to nursery plot to reduce transportation cost. Log book should be strictly maintained to record the of number seedling trays used in each day. Care should be taken to level the land before transplanting. Water height should be maintained uniformly to avoid seedling submergence and floating hill. Operators should know the technique to operate the machine in the headland. Operate the machine in lengthwise to reduce the headland turning. Target on area coverage in each day should be fixed for the operator. Operator should calibrate the machine in terms of soil condition, soil type, seedling height, seedling density, actual seedling spacing and number of seedling dispensed in each stroke. Manpower having agricultural engineering background should be recruited to monitor the transplanting activity for seedling density adjustment, depth setting and machine movement.

IV. Conclusion

It can be concluded that tray requirement in each plot can be reduced by adjusting plant to plant space and seedling density setting. Various factors affected the field capacity i.e. plot size and shape, land preparation, land leveling, water height, plot to plot distance etc. Operator should calibrate the machine before operation in the field to reduce the tray requirement, optimize seedling density and maintaining plant to plant distance. Standby mechanic, monitoring officer and also few manual labors required for effective and complete transplanting of a field.

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