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Comparative performance evaluation of DP 480 model and ARP-4UM rice transplanter

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ABSTRACT

Two types of rice transplanter model were hired to conduct the experiment at Bangladesh Agricultural University (BAU), Mymensingh in May-June, 2014 for Aman season to evaluate their comparative performances. Both the transplanters were tested in the departmental laboratory and in the field. During off-field test on concrete, the seedling per hill at high, medium and low position of seedling density controller was found 7, 5 and 4 in ARP-4UM model and it was14.3%, 20%, and 50% less in the DP 480 model compared to ARP-4UM model. During in field test the seedling per hill at high position of seedling density controller was found to be same in ARP-4UM model and DP 480 model but for medium and low position the seedling per hill was 6,3 and 1 in DP 480 model which was 25% and 50% more in ARP-4UM compared to DP 480 model. After the experiment, the transplanting depth for shallow, standard and deeper position of depth controller was found 2.39, 3.89 and 6.42 in DP 480 model and it was 10.3%, 6.9% and 30.99% less in ARP-4UM. On an average the percent of skidding was found 12.3% in DP 480 model and 16.2% in ARP-4UM model at the 15cm prefixed position of the plant to plant distance controller. Percent of missing hill in 120cm×200cm was found 4.35% in ARP-4UM model and 2.18% in DP 480 model. The field capacity was found 0.2052 ha/hr in DP 480 model and 0.1801 ha/hr in ARP-4UM model. The amount of Fuel consumed in ARP-4UM Model was obtained 1.43 lit/ha and in DP 480 Model rice transplanter it was 1.57 lit/ha. After calculating all the parameters related to the performance of the rice transplanter it was found that the DP 480 model was better compared to the ARP-4UM model in terms of break-even analysis.

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I. Introduction

Rice, one among the three most vital food crop in world forms the staple diet of 2.7 billion people. It's full-grown all the continents except Antartica, with total production of 661.3 million tonnes. The paddy production in Asia is 600.4 million tonnes. Its cultivation is of large to food security of Asia, wherever over ninetieth of the worldwide rice is produced and consumed (Ganapathi and Kumar, 2015). Being the staple food of Bangladesh, our national food security hinges on the expansion and stability of its production. Rice production in Bangladesh for the 2017-18 marketing year was forecast at 34.18 million tonnes, down from 34.578 million tonnes in 2016-17 and compared with 34.5 million tonnes in 2015-16 (Grain report, 2017). Thus mechanization in rice cultivation is essential to increase the per acre yield. It is estimated that the total labor requirement for rice production in 1 hectare of land was 156.2 man-days of which 44.5 man-days were consumed by seedling raising and transplanting which is 28.24% of the total labor requirement (Rahman, 1997). Singh et al. (1985) reported that manual transplanting takes about 250-300 man-hours/ha which is roughly 25% of the total labor requirement of the crop. In these circumstances, to meet up the crisis of agricultural labors in transplanting season, to minimize the total production costs of cultivation and to increase the production per hector, a suitable mechanical rice transplanter is needed for Bangladesh field condition. Consequently, there is an emphasis on conducting a comparative performance evaluation between two types of mechanical rice transplanter to obtain a sustainable and best-suited type of rice transplanter in real field condition of Bangladesh. At present, in some parts of Bangladesh, farmers are using mechanical rice transplanter for transplanting seedling (Munnaf, 2013). But farmers don't know which type of transplanter will provide better performance within available field condition. Thus comparative performance of two walking type mechanical rice transplanter was evaluated. The objectives of this research are to compare the specifications of the two types of rice transplanter, namely, DP 480 and ARP-4UM, to compare field performance of the rice transplanters under same field condition and to study the adjustments of walking type mechanical rice transplanter.

II. Materials and Methods

The comparative study was conducted at Bangladesh Agricultural University (BAU), Mymensingh in May-June 2014 for *Aman* season. The rainfall was 160.8 – 346.2 mm and the temperature ranged from 28.8-29.8° C during the experiment. The experimental field was located at FPM field. The soil type was loamy clay type. For seedling raising, BRRI Dhan-49 was used. Two types of rice transplanter, 60 trays of size 58× 28× 2.5 cm, sieve machine, measuring scale, measuring steel tape, water sprayer, seed treatment phenomena (*Rovastin*), stopwatch, calculator etc. were required for the experiment. Major specifications of the two rice transplanter are showed in Table 01 below and the photographic views are shown in Figure 01 and 02.

Table 01. Major specifications of DP 480 & ARP-4UM Model

Description of items		DP 480	ARP-4UM
Country of origin		South Korea	South Korea
Name		Daedong rice Transplanter	Asia Rice Transplanter
Model		DP 480	ARP-4UM
Type		Vertical, air cooled, 4-cycle and 1 cylinder	Air cooled, 4-cycle and 1 cylinder
Dimensions	Overall length (mm)	2385	2350
	Overall width (mm)	1530	1480
	Overall height (mm)	870	800
	Overall weight (kg)	160	175
	Type	4-strocke, air-cooled OVH gasoline	4-strocke, air-cooled OVH gasoline
	Displacement (CC)	147	141
	Maximum output (ps/rpm)	3/1800	3/2000
	Starting method	Recoil	Recoil

Travelling section	Steering		Hydraulic power steering mode	Hydraulic power steering mode
	Wheel Type		Rubber lug wheel	Rubber lug wheel
	Gearshift	Forward	2 speeds	2 speeds
		Reverse	1 speed	1 speed
Transplanting section	Transplanting Mechanism		Rotary	Rotary
	Number of rows		4	4
	Transplanting Distance, cm(row to row)		30	30
	Transplanting Distance, cm (plant to plant)		11, 13, 15	11 to 20
	Seedling/ hills control		Adjustable (9 options)	Adjustable (3 options)
	Seedling depth control		Adjustable(single point)	Adjustable(multi point)
	Transplanting Speed, m/sec		0.6 to 1.0	0.3 to 0.7

Figure 01. DP 480 walking type rice transplanter.

Figure 02. ARP-4UM walking type rice transplanter.

Field experiment

The experimental plot was ploughed by a power tiller and the weeds were removed from the field. Water was applied to the field for creating a steady state condition for transplanting operation. The water was drained out before 24 hours of transplanting. Two technically skilled operators, one for the ACI-**DP480** and other for the METAL-**ARP-4UM** type rice transplanter operated the rice transplanters on the same field at same field condition. Then all observation was done after the experiment. The performance of the two rice transplanter in the same field is represented in figure 03.

Figure 03. Transplanting operation performed by DP 480 and ARP-4UM rice transplanter.

Data collection

The following parameters were collected or measured during the experiment for each plot: seedling height, leaf number, seedling density in tray, field size and shape, machinery adjustment, seedling spacing, seedling density per hill, missing hill, floating hill, damaged hill, fuel consumption, depth of seedling, number of tray required in each decimal, number of turn, total time of operation, actual time of operation.

Performance contributing characters of rice transplanter

Transplanting speed: The transplanting speed was obtained by recording the time required for the mechanical rice transplanter to travel a 20 m distance in the field. The speed of transplanting can be computed using the following equation (Hunt, 1995).

$$S = \frac{D}{t} \times 3.6 \quad \text{.. (i)}$$

where, S is the transplanting speed in Km/hr; D the distance in m; t the time required to cover the distance D in s

Fuel consumption: The fuel consumption was calculated by using the following equation (Hunt, 1995)

$$F = \frac{F_t}{T} \quad \text{...(ii)}$$

where, F is the fuel consumption rate in lit/hr; F_t the fuel used during operation in lit.; T the total time needed for operation in hr

Theoretical field capacity: The theoretical field capacity was calculated by using the following equation, (Hunt, 1995)

$$C_0 = \frac{w \times s}{c} \quad \text{...(iii)}$$

where, C_0 is the theoretical field capacity in ha/hr; w the operating width of the transplanter in m; S the transplanting speed in km/hr; C the constant, 10

Actual field capacity: It is the ratio of actual average rate of field coverage by the machine to the total time during operation (Hunt, 1995). Therefore,

$$C = \frac{A}{T} \quad \text{..(iv)}$$

where, C is the actual field capacity in ha/hr; A the total transplanted area in ha; T the total operating time required for transplanting in hr

Field efficiency: It is the ratio of effective field capacity to the theoretical field capacity of a machine under field conditions and the theoretical maximum productivity and it can be calculated by the following equation, (Hunt, 1995)

$$e = \frac{c}{c_0} \times 100 \quad \text{.....................................(v)}$$

where, e is the field efficiency in %; C the actual field capacity in ha/hr; C_0 the theoretical field capacity in ha/hr

Percent damage hills: It is the ratio of the total number of hills with seedlings damaged by cutting, bending or crushing during transplanting to the total number of hills expressed in percentage. It can be calculated by the following equation (Islam and Rahman, 2014)

$$H_{pd} = \frac{H_d}{H_t} \times 100 \quad \text{..................................(vi)}$$

where, H_{pd} is the percent damaged hills in %; H_d the number of damaged hills in the sampling area; H_t the total numbers of hills in the sampling area

Percent missing hills: It is the ratio of the total number of hills without seedlings to the total number of hills expressed in percentage and can be calculated by the following equation, (Islam and Rahman, 2014)

$H_{pm} = \frac{H_m}{H_t} \times 100$ ………………………………(vii)

where, H_{pm} is the percent missing hills; H_m the total number of missing hills in the sampling area and H_t the total number of hills in the sampling area

Plants per hill: At first 5 no. of hills was selected from an individual section of the experimental plot. Then the number of plants per hill was measured and an average was made by summing the amount of seedlings in 5 individual hills and divided by the total number of hill.

Percent floating hills: It is the ratio of the total number of hills floating after transplanting to the total number of hills expressed in percentage and it can be calculated by the following equation (Islam and Rahman, 2014).

$H_{pf} = \frac{H_f}{H_t} \times 100$ ………………………………(viii)

where, H_{pf} is the percent floating hills; H_f the total number of floating hills in the sampling area and H_t the total number of hills in the sampling area

III. Results and Discussion

Comparison based on construction of machine

The overall weight of ARP-4UM was more compared to the DP 480 model rice transplanter. Transplanting speed of ARP-4UM was less than DP 480 model. The hydraulic control system was easy in DP 480 model compared to ARP-4UM Model. There were 9 options of seedling density selection in DP 480 model whereas only 3 options in the ARP-4UM.Transplanting depth of DP 480 could be controlled from single point whereas in ARP-4UM, three individual points were available. The theoretical field capacity for both model DP 480 and ARP-4UM was found to be same for transplanting speed of 2.1km/hr.

Comparison based on field performance

Transplanting depth: For shallow condition, the depth of transplanting in ARP-4UM model was found to be 10.3% more than the DP 480 model rice transplanter. For standard position, the transplanting depth was found to be 6.9% more in DP 480 model compared to the ARP-4UM model. For deeper position, the depth was found to be 30.99% more in DP 480 model compared to the ARP-4UM model. So, at a glance from figure 04, it can be noticed that the transplanting depth in DP 480 model is more than the ARP-4UM model.

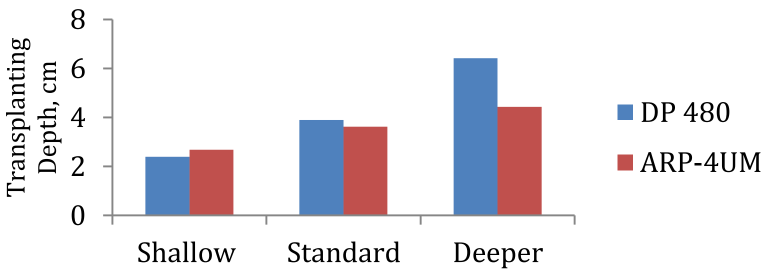

Figure 04. Transplanting depth at different position of depth controller.

Seedling per hill at off field condition: During the off-field test on concrete, the seedling per hill at the high position was found to be 14.3% more in ARP-4UM compared to DP 480 model. Similarly, for the medium and low position, the seedling per hill was found to be 20% and 50% more in ARP-4UM compared to DP 480 model respectively. Figure 05 shows the comparative verification of seedling per hill between the two models.

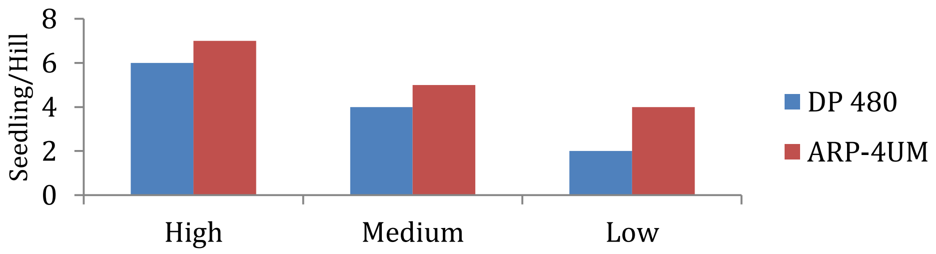

Figure 05. Seedling per hill at different position for off field condition.

Seedling per hill at in field condition: During in field test, the seedling per hill at the high position was found to be same in both ARP-4UM and DP 480 model. For medium and low position, it was found to be 25% and 50% more in ARP-4UM compared to DP 480 model respectively. Figure 06 represents the comparative verification of seedling per hill between the two models.

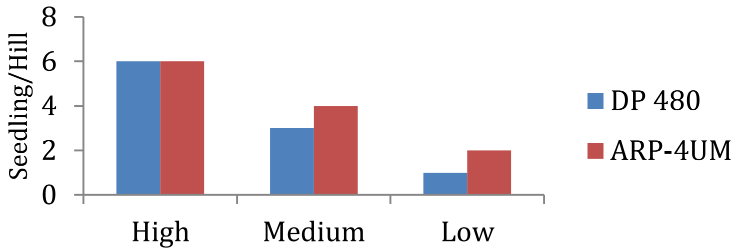

Figure 06. Seedling per hill at different position for in field condition.

Percent of skidding: The percent of skidding was found to be more in ARP-4UM model compared to DP 480 model in a different sample from a different section of the experimental field. During this time before the experiment, the plant to plant distance at both models was fixed to 15 cm. Figure 07 shows the variation of percent of skidding for two types of rice transplanter.

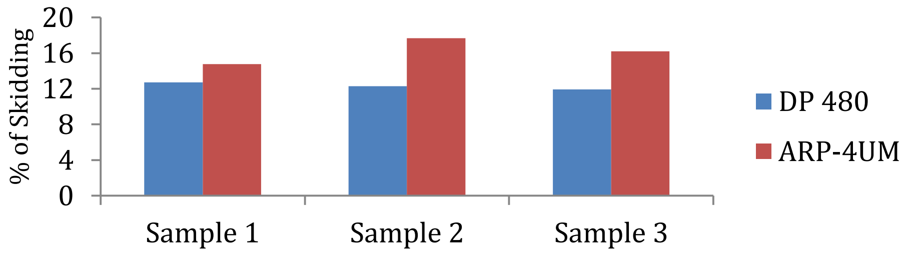

Figure 07. Percent of skidding between two models.

Percent of missing hill: The percent of floating, buried and damaged hill was found to be in negligible condition as shown in Figure 08.

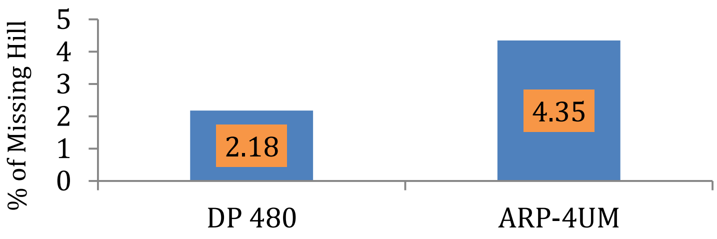

Figure 08. Percent of missing hill during field operation.

Actual field capacity: The field capacity was measured considering the area of coverage to be 8.60 decimal. The field capacity was found to be 12.7% more in DP 480 model compared to ARP-4UM model. The comparative values of field capacity are noted in the table 02.

Table 02. Field capacity of DP 480 and ARP-4UM rice transplanter

Model name	Starting time	End time	Total operation (min)	Area covered (Decimal)	Field capacity (decimal/hr)
DP 480	10:35:36	10:45:44	10.13	8.60	50.94
ARP-4UM	09:58:24	10:09:55	11.6	8.60	44.48

Fuel consumption: The amount of Fuel consumed was found 1.43 lit/ha in ARP-4UM Model and 1.57 lit/ha in DP 480 Model rice transplanter which was almost same. Table 03 appears the corresponding values of fuel consumption for two models.

Table 03. Fuel consumption of DP 480 and ARP-4UM rice transplanter

Model name	Starting time	End time	Total operation (min)	Area covered(Decimal)	Total fuel consumption (ml)	fuel consumption (l/hr)	fuel consumption (l/ha)
`1`DP 480	10:35:36	10:45:44	10.13	8.60	55.00	0.32	1.57
ARP-4UM	09:58:21	10:09:55	11.6	8.60	54.75	0.29	1.43

Field efficiency: From the obtained value finally, the field efficiency was calculated and it was found that the field efficiency for DP 480 was 81.7% which was 12.7% more than the field capacity of model ARP-4UM. Figure 09 illustrates the field efficiency of two models of rice transplanter.

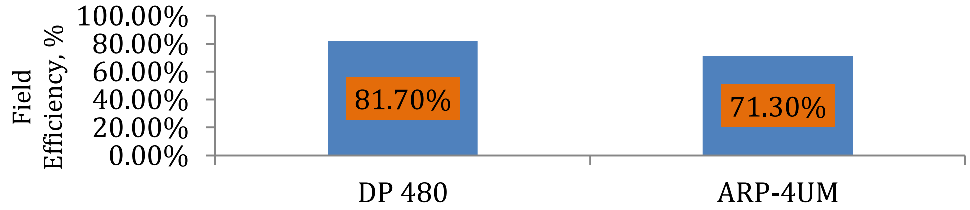

Figure 09. Field efficiency of model DP 480 & ARP-4UM.

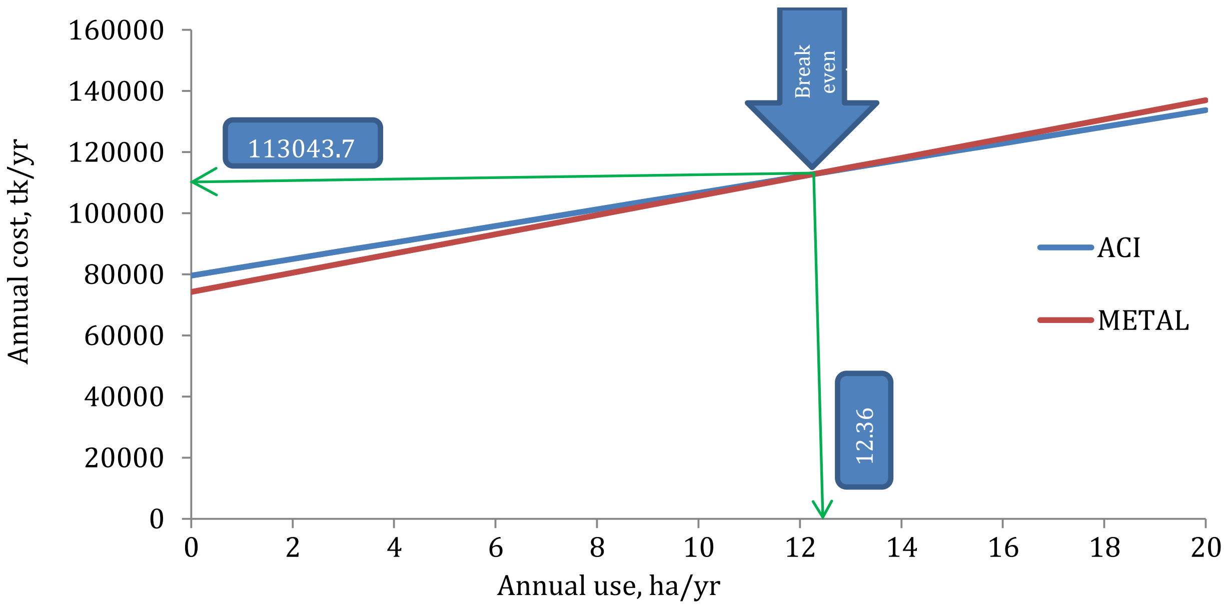

Figure 10. Effect of annual use on annual cost for DP 480 model and ARP-4UM model.

Break-even point analysis: Break even analysis indicates that the minimum hectare coverage per year for economic utilization of machinery (Munnaf, 2013). The effect of annual use of rice transplanter on costs was also determined and it is represented in figure 10. The analytical values show that as the annual use increases with the passage of time, the total annual cost also increases gradually for both DP 480 and ARP-4UM. The break-even points was found to be 12.36 ha/yr with a total annual cost of 113043.7 tk/yr. that means if the 12.36-hectare land is cultivated in 01 year using both types of the rice transplanters individually, the same amount of cost will be needed to invest. From the figure 10, it can be noted that the annual cost of DP 480 is a little bit higher than ARP-4UM just before the break-even points but after the break-even point, the annual cost of DP 480 is a little bit lower than ARP-4UM as the annual use increases with the time.

IV. Conclusion

Field performance of both the transplanter was found apparently satisfactory. But depth control mechanism was found more comfortable in DP 480 model compared to ARP-4UM. In addition, fuel consumption was found almost same in DP 480 and ARP-4UM model. The field capacity of the DP 480 model was found more compared to the ARP-4UM model (Table 2). Transplanting parameters such as plants per hill and percentage of skidding was found good in DP 480 model compared to ARP-4UM model. From this point of view, it can be concluded that the performance of a rice transplanter largely depends on some parameters which should be off in proper values to achieve the best output result after field performance. Further proper adjustment of the plant to plant distance can minimize the percent of skidding as well. Percent of missing hill floating hill, damaged hill, and buried hill can be minimized by maintaining proper transplanting depth and transplanting speed. Under all of this consideration and after studying the overall experiment, it can be concluded that DP 480 model rice transplanter is more efficient and suitable rice transplanter compared to the ARP-4UM model rice transplanter.

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