

Performance Evaluation of Manual Reaper Available in Bangladesh

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ABSTRACT---- *Considering fragmented lands, time consumption of manual harvesting and postharvest loss during harvesting, the performance of manual reaper was evaluated in this study. An ACI imported manual reaper was used to harvest rice on different plots in Aman season. Average field capacity of ACI imported manual reaper was found 0.3485 ha/day where manual harvesting field capacity was 0.03107 ha/man-day. Labor requirement for harvesting including making bundle and collecting was 24 man-hr/ha and 180 man-hr/ha for manual reaper and manual harvesting respectively. Average fuel consumption (0.755 L/hr) was observed for ACI imported manual reaper, which was proved to be 11.2 times more efficient compared to manual harvesting. The break-even point of an ACI imported manual reaper was 0.4 ha. Therefore, application of a manual reaper would be efficient mechanization for harvesting rice in Agricultural sector of Bangladesh.*

Keywords--- Reaper, Performance, Manual harvesting, Rice field

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the leading cereal crops in the world. It belongs to the grass family oryzae and feed for over 50% of the world's population, especially in Asia [1, 2]. In the year of 2014, the annual production of rice was recorded about 749.1 million tones with 154 million hectares of cultivable lands under the 113 countries in the world [3]. Bangladesh is an agro- based and the most densely populated country in the world, with not less than 160 million population under 14.47 million hectares of the area. Agriculture plays a vital role in the economy of this country and contributes 18.64% of GDP [4]. About 12.25 million hectares are under the cultivation of rice in Bangladesh that is 88% of the gross cropped land of the country.

Approximately, 850 to 900 man hours are needed to cultivate one hectare of rice [5]. It seems that a considerable amount of day labor is required. The cost of day labors is increasing day by day and nowadays, it is tough to manage day labors. The activities of harvesting are done individually or by a combine harvester to perform the operations simultaneously to maximize yield and minimize the post-harvest losses. The time required to harvest one hectare is the maximum an average 111.10 hr/ha in case of manual harvesting [6]. Timely harvest of the rice is essential to gain better quality and higher yields. Higher losses of yields are occurred due to lack of labors and vagaries condition of weather so that the mechanical operations is necessary and harvesting operations should be performed timely for minimizing the yield losses.

In Bangladesh, traditional harvesting is done by labors with sickle, which is laborious, costly and time consuming [7]. During harvest time, the peak demands of labors are 240 man hr./ha using sickles [8, 9]. So, suitable machinery specially for harvesting machinery is crying need to develop and introduce for mechanization. The agricultural mechanization in Bangladesh is increasing day by day. According to Bangladesh Agricultural Research Council (2014) total amount of reaper is only 500. However it is necessary to introduce agricultural machinery especially harvesting machinery for agricultural mechanization in Bangladesh.

Manual reaper is important for fragmented land, poor and uneducated farmers in Bangladesh. Considering the grain quality, post-harvest losses, more yield, poverty and illiterate farmers, it is highly preferable to use manual reaper. Indeed, the use of manual reaper could be a great opportunity to intensify the percentage of GDP in Bangladesh. In this research work, performance of manual reaper available in Bangladesh was evaluated to identify the problems and prospects of reaper in harvesting.

2. MATERIALS AND METHODS

This research work was carried out in Aman season in the research field of Hajee Mohammad Danesh Science and Technology University.

Working Procedure

Paddy field of 103.49 m² and 680 m² were selected for harvesting by selected reaper and manual respectively. Harvesting time was counted by a stop watch. The actual field capacity was calculated by dividing the total area harvested by total time required to harvest a certain plot. The area of 103.49 m² was harvested using reaper by one labor in 40 minutes. On the other hand, a total area of 680 m² was harvested by 12 labors in 2.3 hr. Harvested plot by reaper as shown in Figure 1(a), (b). The area of 103.49 m² was harvested using reaper by one labor in 40 minutes. On the other hand, a total area of 680 m² was harvested manually by 12 labors in 2.3 hr.

Parameter studied

Operating speed of an intermittent reaper was measured as a ratio of distance travelled to the required time and expressed as km/hr.

Fuel consumption was calculated by using standard method as described by Zami *et al.* [10]. Field capacity of a machine is defined as the ratio of actual rate of area covered to the actual harvesting time.

Field capacity was calculated by using formula developed by Hunt [11]: Theoretical field capacity was measured based on the forward speed and the cutting width of reaper suggested by Hunt [11].

Field efficiency is defined as the ratio of the actual field capacity to the theoretical field capacity and expressed in percent.

The harvesting cost for a manual reaper is calculated on the basis of fixed cost and variable cost. Fixed cost includes depreciation cost, interest, shelter and taxes as a function of purchase value, useful life and interest rate. Annual interest was calculated on average investment on the machine over its full life. Depreciation was determined by straight-line method. Useful life for manual reaper was considered to be 10 years. The purchase price of manual reaper was considered Tk.12000. The machine salvage value was considered to be 10% of purchase value. Interest is an actual cost in agricultural machinery and was determined by straight line method.

Variable costs include fuel, lubricant, repair and operational costs and directly related to the amount of work done by the machine. Repair cost for manual reaper was considered 3.5% of purchase value for every 100 hours of effective operation. Lubricant cost was 3% of fuel cost. The fuel cost (Petrol) in retail market was 100 Tk per liter. The wage of labor in manual method of harvesting using sickle was 300 Tk per day (eight hours of working day). The interest rate for agricultural machinery was assumed 12% of purchase value.

Fixed cost was calculated as: $FC = \text{Depreciation} + \text{Interest on investment} + \text{Tax, insurance and shelter}$

Break-even Area

The break-even area is that area in which the harvesting cost per unit area is equal for machine and manual and determined by the following equation described by Alizadeh [6].

3. RESULTS AND DISCUSSION

Field Performance

The weight of manual reaper was 9.2 kg and enough light to be operated by a reference labor. The manual reaper consisted of a single blade and operated by hand, the normal forward speed was adjusted to cover all plants in the field. Table 1 shows that the field capacity of manual reaper ranged from 155.235 to 836.56 m²/hr with an average value of 435.53 m²/hr (0.05 ha/hr). The fuel consumption was also recorded 0.755 L/hr (Table 1). In the case of manual harvesting, field capacity range from 411.08 to 857.71 m²/hr with an average value of 523.67 m²/hr was found (Table 2).

From the performance test, harvesting by manual reaper was found to be 11.2 times more efficient than manual harvesting. In earlier study, Bienvenido [12] reported that 2.3% grain loss (approximately) might be resulted during harvesting by manual reaper against 1% loss of manual harvesting.

Economic analysis

The local purchase price of manual reaper was 12000 Tk. including the attached metal- rubber assembly. The annual fixed cost (2172 Tk) and variable cost (175.72 Tk per hour) were found in this research. The working hour of manual reaper was considered 100 hours per year. The fixed cost and variable cost for both manual harvesting and harvesting by manual reaper are presented in Table 3. In this study, manual harvesting required 32 man-days to harvest one hectare of rice field. Considering the labor cost, 9600 Tk/ha was required for manual harvesting, whereas 4032 Tk/ha was calculated for reaper harvesting (Table 3).

Net savings per hectare area are shown in Table 4. Results indicated that 4398 Tk/ha could be saved by reaper harvesting against manual harvesting (Table 4) because of higher field capacity of reaper. In a previous study, net savings (1770 Bhat/ha) was found by Bora and Hansen [13] who harvested rice by a reaper (40 Bhat = 1US\$). In addition, reaper harvesting was 7.5 time faster compared to manual harvesting (Table 5).

Break-even Area

The break-even area is showed in Figure 2. It shows that the harvesting cost by a reaper is found 12222 Tk, whereas manual harvesting requires 9600 Tk for 0.25 ha of harvesting land. Harvesting cost by a reaper is found to be decreased gradually with the increase of harvesting area. However, break-even point is 0.4 ha of land where same cost will be found for both of reaper and manual harvesting. This break-even point indicates that reaper would be beneficial to the farmers when the area of the harvesting land is more than 0.4 ha.

4. CONCLUSION

Manual reaper is a new addition in mechanization for harvesting of paddy in Bangladesh where land holdings are very small and capital resource availability is very low. Manual reaper can cover 435.5 m² harvesting area with a fuel consumption of 0.755 L petrol/hr. Considering working time 8 hr/day, the field capacity was 0.3485 ha/day and it was 11.2 times faster than manual harvesting. Harvesting cost of one hector rice field by manual reaper is 4032 Tk against 9600 Tk required in manual harvesting. If this reaper works below break-even point 0.4 ha, it would not be economically feasible to farmers. Considering the same amount of postharvest loss in both mechanical and manual harvesting, this machine could save 4398 Tk/ha in harvesting rice.

However, this manual reaper could be easily fabricated by local artisans, this might be an alternative to the traditional harvesting of rice by sickle. Additionally, women would be able to use this reaper in harvesting rice cultivated in upland terrace or hill tracks because of it's light weight and easy operation. Therefore, manual reaper would be economically efficient than self-propelled reaper or combine harvester for fragmented land in Bangladesh.

5. REFERENCES

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Table 1: Performance test of manual reaper

Plot No.	Length (m)	Wide (m)	Area (m ²)	Fuel consumption (L/hr)	Average fuel consumption (L/hr)	Field capacity (m ² /hr)	Field capacity (ha/day)	Average (ha/day)
01	8.1	1.75	14.175	0.71		836.56	0.669	0.3485
02	8.1	1.3	10.53	0.82	0.755	344.62	0.276	
03	8.1	1.6	12.96	0.78		405.7	0.325	
04	13.1	7.9	103.49	0.71		155.24	0.124	

Table 2: Performance test by manually harvested plot

Plot No.	Length (m)	Wide (m)	Area (m ²)	Field capacity (m ² /hr)	Field capacity (ha/man-day)	Average (ha/man-day)
01	36.57	25.91	947.52	411.08	0.027	0.0311
02	34	20	680	302.22	0.030	
03	55.17	53.64	2959.10	857.71	0.036	

Table 3: Harvesting cost of manual reaper and manual harvesting (78Tk = 1US \$)

Machine harvesting cost				Manual harvesting cost	
Cost items	Tk/yr	Tk/ha	Tk/hr	Tk/ha	Tk/hr
Fixed cost				9600	37.5
Depreciation	1080				
Interest	792				
Taxes, insurances and shelter cost	300				
Total fixed cost	2172	498	21.72		
Variable cost					
Fuel		1733	75.5		
oil labor		53	2.3		
Repair and maintenance		1721	75		
Total variable cost		28	1.2		
		3354	154		
Total cost of harvesting		4032	175.72	9600	37.5

Table 4: Comparison of savings by the manual reaper per hectare (78Tk = 1US \$)

Particulars	Calculation	Amount (Tk.)
Cost of manual harvesting (32 man-days/ha)	32×300	9600
Cost of machine harvesting	4032	4032
Gross savings	9600–4032	5568
Cost of total output (5000 kg/ha @ 18Tk/kg)*	18×5000	90000
Loss in reaper harvesting, (2.3%)	9000×0.023	2070
Loss in manual harvesting (1%)	90000×0.01	900
Excess loss due to reaper harvesting	2070–900	1170
The net savings per hectare	5568–1170	4398

*Considered the production of paddy 5 tons per hectare

Table-5: Comparison of time between manual reaper and manual harvesting

Reaper (including labor for binding and collecting)	24 (hr/ha)
Manual	180 (hr/ha)



Figure 1(a): Field operation by a reaper



Figure 1(b): Plot harvested by a reaper

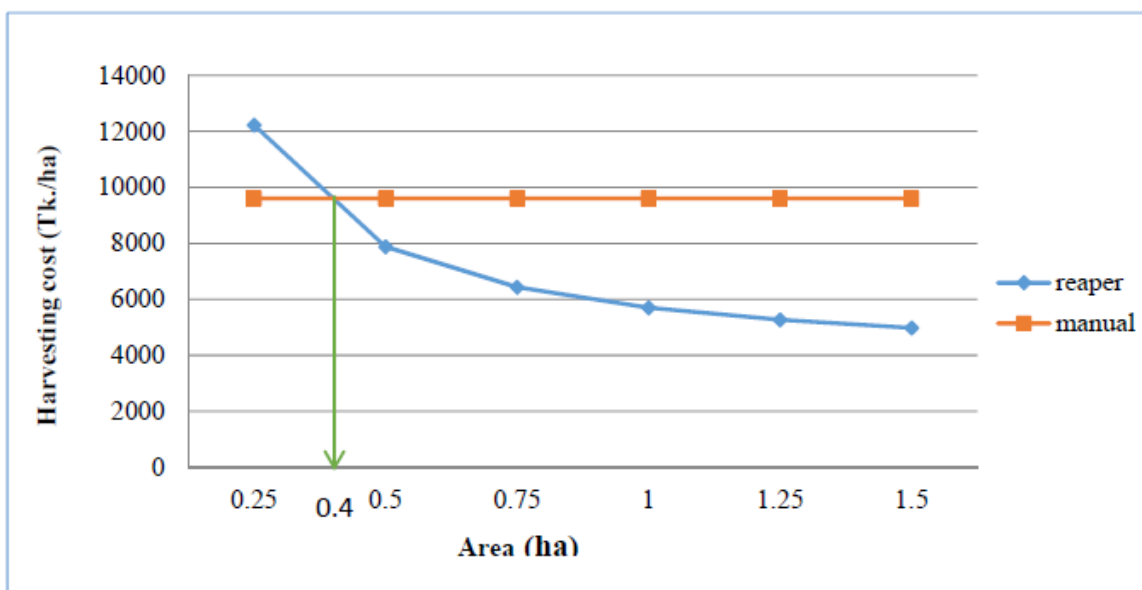


Figure 2: Break-even area analysis