Performance study of manual reaper compared to manual harvesting for rice and wheat

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Abstract: This research work was carried out to compare the performance of manual reaper against manual harvesting method for rice and wheat. The average field capacity of manual reaper was 0.3482 ha/day for rice and 0.3236 ha/day for wheat with fuel consumption of 0.755 L petrol/h and 0.625 L petrol/h respectively. In manual harvesting, the average field capacity was 0.0312 ha/man-day and 0.0452 ha/man-day for rice and wheat respectively. It was revealed that using manual reaper, harvesting cost could be saved 58% for rice and 53% for wheat, consequently harvesting of selected crops by reaper was efficient than manual harvesting. It was also observed that if manual reaper works below break-even point 0.32 ha and 0.52 ha for rice and wheat respectively, it would not be economically feasible to farmers. Finally, manual reaper could be suggested as better mechanization for harvesting of rice and wheat, cultivated on fragmented lands.

Keywords: reaper, performance study, manual harvesting

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1 Introduction

Rice (*Oryzae sativa*) is important cereal crop and staple food of people living in Bangladesh. The total production of rice was recorded about 749.1 Mt in the economic year of 2014 from 154 million hectares of cultivable land. In 2014, rice was cultivated on 12.25 million hectares of land, which occupied 88% of total cropped land of Bangladesh (Barman et al., 2015). Wheat (*Triticum aestivum*) is another important and second leading cereal crop after rice in Bangladesh. In Bangladesh, wheat production was 13.02 Mt in fiscal year of 2013-2014, which was 3.82% higher than that of the previous year (BBS, 2015).

Production of rice and wheat is increasing because of high yielding variety and proper agronomic practices. But harvesting of rice and wheat is done manually while harvesting is considered as an important agricultural operation because higher yield with better quality of goods largely depends on timely harvesting. Harvesting of any crop requires considerable amount of labors. Scarcity and high wages of labors are major problems during harvesting season. Moreover, timely harvesting may be faced problems of low work efficiency and adverse climacteric conditions, which cause great loss of cereals (Pandey and Devnani, 1985).

In Bangladesh, harvesting of rice and wheat is still done traditionally by sickle, whereas traditional harvesting is time consuming, costly and laborious. According to Nadeem (1983), traditional harvesting requires almost 25% of the total labor requirement of the cultivation of any crop. It is also reported that the labor requirement for harvesting of rice by sickle is 240 man-h/ha (Mondol, 1997 and shakoor and salim, 2005). Working capacity is the highest in traditional harvesting with an average value of 111.10 h/ha (Alizadeh and

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Allahmeh, 2013). A range of 4% to 8% loss is also estimated due to the harvesting methods (APHLIS, 2015). Considering scarcity and high wage of labor, higher shattering loss, mechanized harvesting is to be introduced as alternative of manual harvesting for rice and wheat. Reaper is found 14 times efficient in cutting and placing cereals compared to day labor (Meisner et al., 1997). Veerangouda et al. (2010) reported that field capacity varied from 2.88 to 3.60 ha/h for a self-propelled reaper.

Nowadays, reapers are being imported in Bangladesh from China and Vietnam for only rice harvesting. Manual reaper is found to be easy to operate in fragmented land, time and cost effective and reduces postharvest loss. Therefore, it is necessary to assess the operating performance of manual reaper for both of rice and wheat. As an intermediate technology, the manual reaper is also need to study and compare with manual labors. In view of the above discussion, the present research work was carried out to study the performance of manual reaper for rice and wheat and to compare mechanical harvesting with manual harvesting for selected crops.

2 Materials and methods

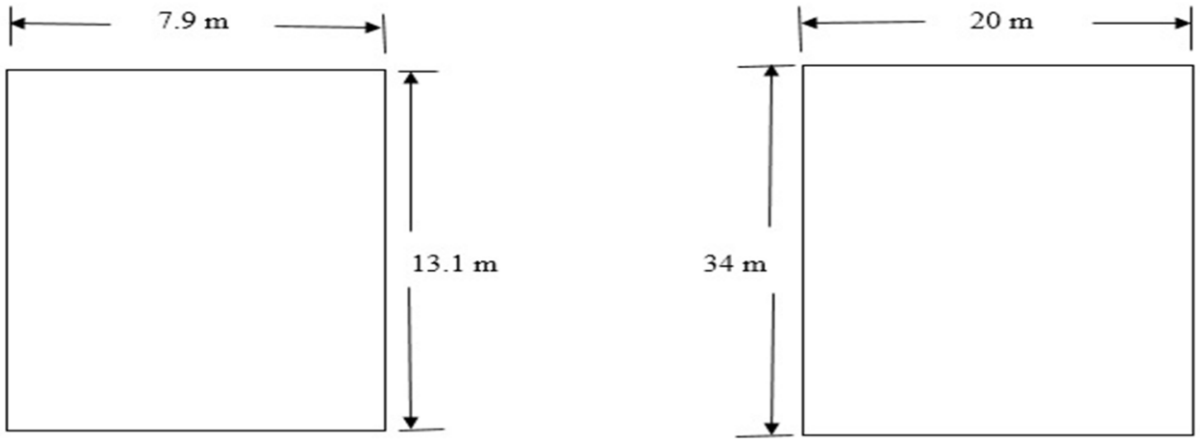
2.1 Harvesting method

The harvesting of rice and wheat was done both manually (with sickle) and mechanically (with reaper) (Figure 1). The operational time was recorded for both of mechanical and manual harvesting. Some operations were done in several times to calculate the average performance. The actual field capacity was calculated by dividing the total area harvested by total time taken to harvest a certain plots.

Figure 1 Harvesting of rice and wheat (mechanical and manual)

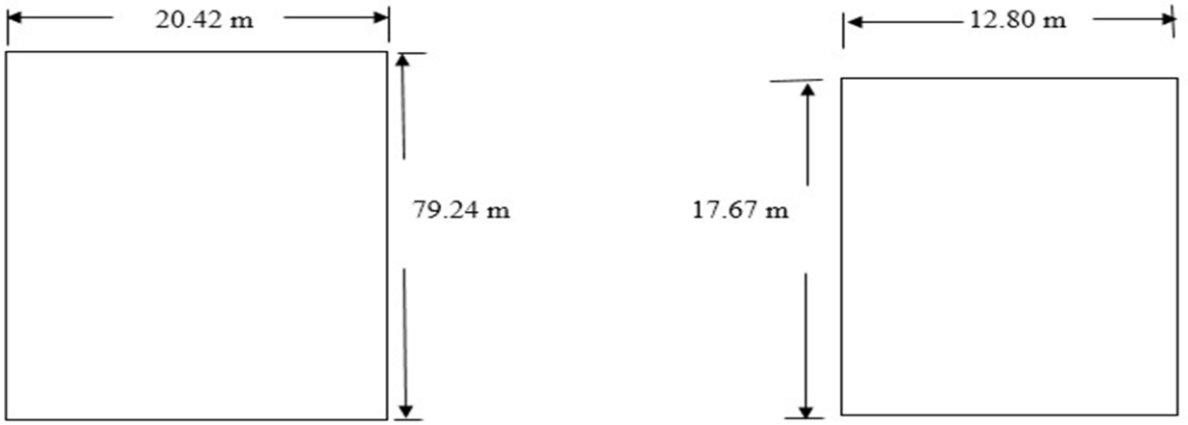
2.2 Operation time and cutting area

A total area of 103.49 m^2 (0.01ha) and 680 m^2 (0.068 ha) of rice were mechanically harvested by one labor taking 40 min and manually harvested by 12 labors taking 2.3 h respectively (Figure 2). On the other hand, a total area of 1618.081 m^2 (0.162 ha) and 226.176 m^2 (0.023 ha) of wheat were mechanically and manually harvested by one labor for 4 h respectively (Figure 3).



a- Mechanically harvested plot b- Manually harvested plot

Figure 2 Harvested plot



a- Mechanically harvested plot b- Manually harvested plot

Figure 3 Harvested plot

2.3 Selected parameters

Fuel consumption was calculated by following standard method as described by Zami et al. (2014). Field capacity and field efficiency of a machine were calculated by following methods of Hunt (1973). The harvesting cost for reaper was calculated on the basis of fixed cost and variable cost, whereas fixed cost includes depreciation, interest, shelter and taxes. Depreciation was determined by straight line method, described by Zami et al. (2014). Variable cost includes fuel, lubricant, repairs and maintenance costs. In this study, 3.5% of purchase price was considered as repair cost for every 100 h of effective operation. The fuel cost (petrol) was considered as Tk 100 per litter while lubricant cost was 3% of fuel cost. Useful life for reaper was considered 10 years. The purchase price of reaper was considered Tk 12000. The machine salvage value was considered 10% of purchase value.

2.4 Break-even point

The break-even point, at which the harvesting cost per unit area is equal for machine and manual, was determined according to Alizadeh et al. (2007).

3 Results and discussion

3.1 Field performance

The field capacity of reaper and manual harvesting is shown in Table 1. Results revealed that field capacity of reaper was 435.27 m^2/h (0.348 ha/day) and 404.52 m^2/h (0.3236 ha/day) with fuel consumption of 0.755 L/h and 0.625 L/h for rice and wheat respectively. In manual

harvesting with sickle, a labor could harvest 387.1 m^2/h (0.03107 ha/8h and 56.544 m^2/h (0.0452 ha/8h) for rice and wheat respectively. From the performance test, harvesting by reaper was found 11.2 and 7.16 times faster than manual harvesting for rice and wheat respectively. This amount might be differed due to crop condition, labor ability and climatic conditions.

Table 1 Performance test of reaper and manual for rice and wheat

Crop	Method	Area, m^2	Fuel consumption, L/h	Field capacity, m^2/h	Field capacity, ha/h	Average Field capacity, ha/day
Rice	Reaper	26.35	0.755	435.27	0.04352	0.3482
	Manual	106.57	_	39.08	0.00390	0.0312
Wheat	Reaper	1618.08	0.625	404.52	0.04	0.3236
	Manual	226.176	_	56.544	0.0056	0.0452

3.2 Harvesting cost

Harvesting cost of rice and wheat by reaper and manual is shown in Table 2 and Table 3. The total fixed cost of reaper was 2172 Tk/yr, therefore total variable cost was 175.72 Tk /h for rice and 163 Tk /h for wheat. The total harvesting cost of rice and wheat by reaper was 4032 Tk /ha and 3266 Tk /ha and manually 9600 Tk /ha and 6900 Tk /ha respectively. In this study, labour requirement for collecting and bundling of harvested crop in the field was also included as a part of machine operation. From the field study of manual harvesting, it was observed that usually 32 labors were required for harvesting one hectare of rice, whereas 23 number of labors for wheat. The working hour of each labor was considered eight hours.

Table 2 Estimated total cost of reaper and manual harvesting for rice [1US$ ≈ 78.67Tk]

Machine harvesting cost				Manual harvesting cost	
Cost items	Tk/yr	Tk/ha	Tk/h	Tk/ha	Tk/h
Fixed cost					
Depreciation	1080				
Interest	792				
Taxes, insurances and shelter	300				
Total fixed cost	2172	498	21.72		
Variable cost				Considered 32 nos. labors per hectare	37.5
Fuel		1733	75.5		
oil		52	2.3		
labor		1721	75		
Repair and maintenance		28	1.2		
Total variable cost		3534	154		
Total cost of harvesting		4032	175.72	9600	37.5

Table 3 Estimated total cost of reaper and manual harvesting for wheat [1US$ ≈ 78.67Tk]

Machine harvesting cost				Manual harvesting cost	
Cost items	Tk/yr	Tk/ha	Tk/h	Tk/ha	Tk/h
Fixed cost					
Depreciation	1080				
Interest	792				
Taxes, insurances and shelter	300				
Total fixed cost	2172	498	21.72		
Variable cost				Considered 23 nos. labors per hectare	37.5
Fuel		966	62.5		
oil		53	2.3		
labor		1721	75		
Repair and maintenance		28	1.2		
Total variable cost		2768	141		
Total cost of harvesting		3266	163	6900	37.5

Cost savings of rice and wheat harvesting by reaper and manual is presented in Table 4. In this study, 58% harvesting cost with 86% labor for rice and 53% harvesting cost with 85% labor for wheat could be saved by reaper over manual harvesting.

Table 4 Mechanical and manual harvesting cost for rice and wheat [1US$ ≈ 78.67Tk]

Crop	Harvesting cost, Tk/ha		Harvesting time, h/ha		Cost saved over manual harvesting, %	Labor saved over manual harvesting, %
	Reaper (including labor for binding and collecting)	Manual	Reaper (including labor for binding and collecting)	Manual		
Rice	4032	9600	24	180	58	86
Wheat	3266	6900	25	177	53	85

3.3 Break-even point

The break-even point for rice and wheat is shown in Figure 4. It shows that Tk 12,222 for rice and Tk11456 for wheat were required to harvest 0.25 ha of land by using reaper. On the other hand, manual harvesting of one hectare land required Tk 9600 and Tk 6900 for rice and wheat respectively. On the other hand, harvesting cost decreased gradually with the increase of area. Figure 4 indicates break-even area 0.32 ha and 0.52 ha for rice and wheat respectively. From this analysis, it was found that reaper would be beneficial to the farmers when the harvesting area exceeds the break-even point.

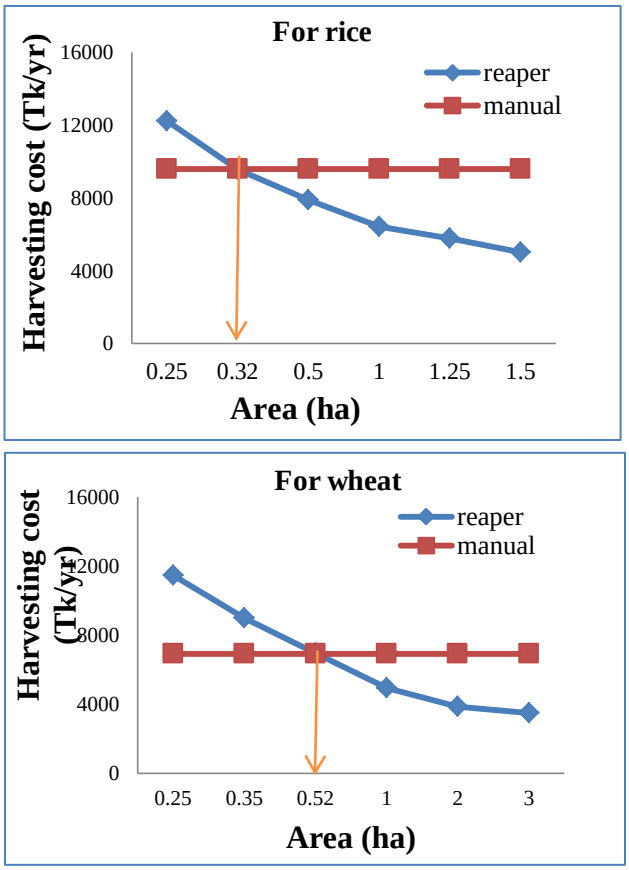


Figure 4 Break-even area

4 Summary and conclusion

Manual reaper is a new addition in the mechanization for harvesting of rice and wheat in Bangladesh where small land holdings with low capital resource are common. Manual reaper can cover 435.5 m^2 and 404.52 m^2 of harvesting area with a fuel consumption of 0.755 L petrol/h and 0.625 L petrol/h for rice and wheat respectively. Considering working time of 8 h/day, the field capacity was 0.3485 ha/day for rice and 0.3236 ha/day for wheat, and it was 11.2 times (rice) and 7.15 times (wheat) faster than manual harvesting. Cost saving from both of rice and wheat harvesting using manual reaper was remarkable. Therefore, it was found that the use of the manual reaper might be saved 53% (for wheat) and 58% (for rice) of harvesting cost against manual harvesting. In this study, break-even points were measured 0.32 ha (for rice) and 0.52 ha (for wheat). In addition, this manual reaper could be easily fabricated by local manufacturer and this would be an alternative of the traditional harvesting of rice and wheat by sickle. Therefore, manual reaper would be economically efficient than self-propelled reaper or combine harvester for fragmented lands.

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