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Assessment of paddy harvesting practices of Southern Delta Region in Bangladesh

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Abstract

Paddy in Bangladesh is an important cereal crop for national food security. Harvesting is the process of collecting mature paddy from the field. Timely harvesting operation is known as crucial and influential processes on quantity, quality and production cost of paddy. The aim of the study was to assess the manual and mechanical harvesting systems of paddy in southern delta region of Bangladesh in terms of labor cost, infield harvesting losses, and time required for harvesting. Several experiments were conducted to compare mechanical and manual harvesting systems. Mechanical harvesting of *Aman* paddy (November-December 2016) and *Boro* paddy (April-May 2017) was conducted using two models of reaper and a mini-combine harvester at Dumuria and Wazirpur Upazilas of Khulna and Barisal districts, respectively. An experiment was also conducted at the same locations to determine labor requirement and time for harvesting paddy manually. To determine manual harvesting loss, an experiment was conducted at BAU farm, Mymensingh. Total cost savings in paddy harvesting were found 52% and 37% for mini-combine harvester and reaper, respectively over manual harvesting system. Similarly, labor savings using mini-combine harvester and reaper were found 65% and 52%, respectively over manual harvesting system. The total harvesting losses (including harvesting, threshing and cleaning) were also found 1.24%, 4.22% and 6.36% for using mini-combine, reaper and manual harvesting systems, respectively. The results indicated that manual harvesting is a slow and cost involving system. On the other hand, lack of awareness among farmers about the benefits of mechanical harvesting system and lack of skill manpower for operating and servicing harvesters are major barriers for adopting mechanized harvesting system in southern delta region. This study revealed that mechanical harvesting of paddy using either reaper or mini-combine harvester will assist to strengthen food security in southern delta of Bangladesh.

Key words: Southern delta, paddy, harvesting, cost saving, losses

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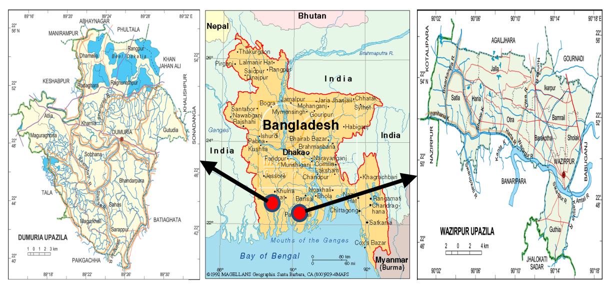
Introduction

Paddy is a staple crop in Bangladesh. Timely harvesting of paddy is very important to reduce losses affecting the total yield. In Bangladesh, most of the crops are generally harvested by sickle which is quite tedious, labor intensive job and costly. Nowadays, timely harvesting of paddy is a big challenge due to the shortage of labour and high cost of labour. At present, developed countries all over the world are using automatic combine harvester for harvesting cereal grains. Some developing countries of South and South East Asia are also using combine harvesters. As a medium grade technology, many developing countries are using reaper for harvesting paddy and wheat to minimize production cost, and are thereby, making agricultural production economical. Yet evidence indicates a progressive shrinking of rural labor availability, as workers migrate to cities or abroad to engage in more remunerative employment, particularly in the garments and construction sectors (Zhang *et al*., 2014). Projections also indicate that rice and wheat production will need to increase by 0.4 and 2.17% per year, to keep pace with the additional two million population added annually (Mainuddin and Kirby, 2015). However, the two conditions cannot be fulfilled due to the shortage of manpower at that particular time. At the same time, there is little scope to extend the agricultural land frontier: crop land availability in Bangladesh has declined by 68,760 ha year^{-1} (0.73%) since 1976 (Hasan *et al*., 2013). In other words, Bangladesh needs to produce more food from the same land, while at the same time easing farm labour requirements resulting from the country's increasingly profitable alternative forms of employment (Zhang *et al*., 2014). Bala *et al*.(2010) reported that post-harvest losses of rice at farm level were 9.49%, 10.51% and 10.59% for *Aman*, *Boro* and *Aus* seasons, respectively. Appropriate farm mechanization has been emphasized as an important policy and development goal in Bangladesh (Mandal, 2002, 2014; Zhang *et al*., 2014). So, suitable machinery specially for harvesting machinery is crying need to develop and introduce for agricultural mechanization to increasing production with less drudgery and increased efficiency.

A recent study revealed that the cropping intensity is lower in Barisal (own land- 126%, leased-in land- 100%) and Jhalakathi (own land - 117%, leased-in land- 109%) districts, because of low lying areas, where most of the land inundated during monsoon, thus, *Boro* rice as single crop mostly dominates cropping pattern. Most of the land in this region remains fallow during the winter season (BARI, 2012). Considering the above matters, adoption of mechanical harvesting practices like using reaper and mini-combine harvester is urgently needed to reduce the human drudgery, labor involvement, harvesting losses and increase the cropping intensity, crop productivity, economic emancipation. Also, mechanical harvesting of paddy could be a great opportunity to intensify the percentage of GDP in Bangladesh which will assist to strengthen the food security in southern delta of Bangladesh.

Materials and Methods

***Experimental site selection*:** The experiment in relation to mechanical harvesting of paddy using mini-combine harvester and reaper was conducted at *Dumuria* and *Wazirpur* upazilas of Khulna and Barisal districts, respectively of Southern Delta region of Bangladesh as shown in Figure 1. Two villages in each upazila were selected for the study. Selected villages were *Voroshakati* and *Ramzankati* in Wazirpur upazila of Barishal district and *Kulbaria* and *Mothbaria* in Dumuria Upazila of Khulna district.



Dumuria upazila **Wazirpur upazila**

Figure1. Experimental sites in Bangladesh map

***Farm households selection*:** Nine farm households in each village were considered for mechanical harvesting of *Aman* rice during November-December/2016 and *Boro* rice in April-May/2017. An experiment was also conducted for determining manual harvesting loss at BAU farm, Mymensingh.

***Harvesting methods*:** At present paddy harvesting is done mainly by manual method with hand tools like sickle. Modern rice harvesting technologies like reaper and combine harvester are found in few areas of Bangladesh. Based on this, two methods of paddy harvesting were used at experimental sites. These were:

i) Traditional method (manually using sickle) and

ii) Modern/mechanical method (using mini-combine and reaper)

***Traditional/manual harvesting using sickle*:** For the determination of manual harvesting cost, labor requirement, time and harvesting losses, 3 (three) plots were selected and all plots were harvested by manually. From harvesting to cleaning, all operations were done by manually. Manual losses were estimated considering a) shatter loss, b) cutting loss, c) gathering loss, d) carrying loss, e) threshing loss and f) cleaning loss since combine harvester does all these operations in single pass. All losses were calculated carefully as shown in Figure 2.

Figure 2. Pictorial views on manually paddy harvesting to cleaning. (a) reaping, (b) grain collection, (c) carrying, (d) threshing & (e) cleaning.

***Modern/mechanical paddy harvesting using mini-combine and reaper*:** For the determination of mechanical harvesting cost, labor requirement, time and harvesting losses, selected plots were harvested by using mini-combine and reaper. During harvesting using mini-combine harvester, from harvesting to cleaning all operations were done in a single operation as shown in Figure 3. On the other hand, after harvesting with reaper, remaining operations like threshing was done by power thresher (shown in Figure 4) and carrying, winnowing & cleaning were done by manually.

Figure 3. Harvesting by mini-combine

Figure 4. (a) Harvesting by reaper, (b) threshing by power

***Field test*:** Before field test of the machines, soil condition, crop condition, no of tiller/hill and yield conditions were recorded. For the field performance test, average plant height was also measured using ameasuring tape. The moisture content of the soil was measured by a digital moisture meter. The plot size was measured using measuring tape. Engine fuel and oil level were checked before operation. Fuel consumption was recorded after completing of harvesting operation of each plot. The time was recorded by stop-watch from the starting to end of reaping operation and time loss was also recorded. The field capacity was calculated using standard formula. The grain losses were also determined after completion of harvesting operation.

***Performance indicators*:** To determine the technical and economic performance of mechanical harvesting of paddy and also compare with manual harvesting system, the following performance indicators were identified: (i) grain yield, (ii) labor requirement for harvesting, (iii) operational time, (iv) field capacity, (v) working speed, (vi) effective time, (vii) fuel consumption and (viii) grain losses.

***Effective field capacity*:** The effective field capacity is the actual average rate of coverage by the machine, based upon the total field time. The area covered divided by the total time is the effective field capacity. The effective field capacity was determined from measuring all the time elements involved while harvesting (Hunt, 1973).

Effective Field Capacity, $C_{eff} = \frac{A}{T}$ ………….…….(1)

where,

C_{eff}= Effective field capacity (ha/hr)

T= total time for the reaping operation, hr

A= area of land reaping at specified time, ha

***Fuel consumption*:** For economic analysis and performance of harvesting machine, fuel consumption was determined after harvesting each plot. Before starting the harvesting operation, the fuel tank of the mini-combine/reaper was fill up and at the end of the harvesting operation of any particular plot the required fuel to fill the tank fully was determined by using measuring flask (Figure 5) for determining fuel consumption in L/ha. Also the following equation was used:

Fuel consumption, $F = F_a/A$ ……………………..(2)

Where,

F = Fuel consumption (L/ha),

F_a = Fuel used during operation (L),

A= Area of operation, (ha)

Figure 5. Fuel measurement after harvesting of paddy.

***Economic analysis*:** Economic performance evaluation of mini-combine harvester and reaper for the harvesting of paddy especially cost of operation of an agricultural machine was determined by calculating fixed cost and variable costs. Harvesting cost and time of mechanical harvesting system were also compared with manual harvesting.

***Fixed costs*:** The fixed cost is the cost which is involved irrespective of whether the machine is used or not. These costs include i) depreciation cost, ii) interest on investment and iii) taxes, shelter and insurance.

i) Depreciation cost: Depreciation is the reduction in value of a machine with the passes of time. Depreciation cost was calculated by straight line method.

The annual depreciation, $D = \frac{P - S}{L}$ (Tk/Yr)………..(3)

Where,

P = purchase price, Tk.,
S = selling price, Tk. and
L = time between buying and selling, yr.

ii) Interest on investment: Interest on the investment in a farm machine is a legitimate cost, since money spent in buying a machine cannot be used for other productive enterprises, it was calculated by Straight Line Method.

Interest on investment, $I = \frac{P + S}{2} i$ ……………………(4)

Where,

P = Purchase price, Tk;
S = Re-sale value, Tk;
i = annual interest rate.

iii) Taxes, shelter and insurance: In the experiment, shelter, tax and insurance, STI = 2.5 % of P was considered for calculating fixed cost of harvesting machine.

***Total fixed cost*:**

Total fixed cost (Tk/yr) = $D + I + STI$......................(5)

$$\text{Fixed cost (Tk/ha)} = \frac{\text{Total Fixed Cost (Tk/Yr)}}{\text{Total Area Coverage (ha/Yr)}}$$

***Variable costs*:** Fuel cost, oil cost, labor cost and repair & maintenance cost were determined using following equations.

$$\text{Fuel cost, F (Tk/ha)} = \frac{\text{Fuel consumed (L/day)} \times \text{Price (Tk/L)}}{\text{Area covered (ha/day)}}$$

Oil cost, O (Tk/ha) = 15% of Fuel cost, F

$$\text{Lobor cost, L (Tk/ha)} = \frac{\text{Sum of wages of labor (Tk/day)}}{\text{Area covered (ha/day)}}$$

Repair and maintenance cost, R&M (Tk/ha)=0.025 % of purchase price, P

Total Variable cost = (F + O + L + R&M) Tk/ha

Total cost of harvesting (Tk/ha) = Fixed cost (Tk/ha) + Variable cost (Tk/ha)

In case of harvesting with reaper, an additional manual cost for binding of straw, threshing and cleaning were included in variable cost.

***Cost for manual harvesting, threshing and cleaning*:**

Total cost (Tk/ha) = Wage of laborer (Tk/man) × No. of laborer (man/ha)

***Benefits in using mechanical harvesting system*:** The costs of three different paddy harvesting methods like mini-combine harvester and reaper, and manual harvesting system were compared to determine the benefits of mechanical harvesting system. For mini-combine harvester and reaper following equations were used to determine cost saving and percent of cost saving.

i) Cost saving for using mini combine (Tk/ha) = Cost for manual method (Tk/ha) – cost for mini-combine harvesting system (Tk/ha).

ii) Cost saving for using reaper (Tk/ha) = Cost for manual method (Tk/ha) – cost for harvesting through reaper (Tk/ha).

$$\text{Cost saving, (\%)} = \frac{\text{Cost for manual method (Tk/ha)} - \text{Cost for mechanical harvesting (Tk/ha)}}{\text{Cost for manual method (Tk/ha)}} \times 100$$

Results and Discussion

***Performance evaluation of mini-combine harvester*:** From two harvesting seasons (*Aman/*2016 and *Boro/*2017) average value of fuel consumption and effective field capacity of mini-combine harvester were found (a) 17.3L/ha, 0.09 ha/hr and (b) 18.0 L/ha, 0.10 ha/hr, respectively for *Wazirpur*, Barisal and *Dumuria*, Khulna. The estimated field performance as indicated in Table 1 was varied due to soil condition and plot size.

***Performance evaluation of reaper*:** From two harvesting seasons (*Aman/*2016 and *Boro/*2017) average fuel consumption and effective field capacity of reaper were found (a) 3.19 L/ha, 0.21 ha/hr and (b) 3.19 L/ha, 0.24 ha/hr, respectively for *Wazirpur*, Barisal and *Dumuria*, Khulna. The estimated field performance as indicated in Table 2 was varied due to soil condition and plot size.

Table 1. Technical performance of mini-combine harvester.

Place	Fuel Consumption L/ha	Effective Field Capacity, ha/hr
Wazirpur-Barishal	17.3	0.09
Dumuria-Khulna	18.0	0.10

Table 2. Field performance of reaper.

Location	Avg. Fuel Consumption, L/ha	Avg. Effective Field Capacity, ha/hr
Wazirpur-Barishal	3.19	0.21
Dumuria-Khulna	3.19	0.24

***Economic performance of mini-combine harvester and reaper over manual harvesting*:** Economic performance of mini combine harvester and reaper over manual harvesting is shown in Table 3. The harvesting costs of using mini-combine harvester, reaper and manual harvesting were found Tk. 9880, Tk. 13152 and Tk. 20847 per ha, respectively. Also percentage of cost save were found 52 % and 37 %, respectively for using mini-combine harvester and reaper over manual harvesting.

***Labor required during harvesting*:** Labor requirement during paddy harvesting by mini-combine harvester, reaper and manual system is shown in Table 4. Total labor required was found 21 man-day/ha, 29 man-day/ha and 61 man-day/ha for using mini-combine harvester, reaper and manual system, respectively

***Labor saved for mechanical vs. manual harvesting*:** Labor saved during paddy harvesting by mini-combine harvester or reaper over manual system is shown in Table 5. Labor could be saved 65% and 52% for using mini-combine harvester and reaper, respectively over manual harvesting system.

Table 3. Economic performance of mini-combine and reaper over manual harvesting.

Harvesting method	Total harvesting cost, Tk/ha (Including reaping, threshing and cleaning cost)	Cost saved, %
Mini-combine harvester	9880	52
Reaper	13152	37
Manual harvesting	20847	

Table 4. Labors required during harvesting by mini-combine, reaper and manual system.

Item	Labor required (man-day/ha)		
	Mini-combine	Reaper	Manually
Harvesting	5	1	23
Paddy bag carry from field to home	8		
Threshed straw binding and transfer from field to home	8		
Straw with paddy transfer from field to home after reaping by reaper or manually		15	15
Threshing using power thresher		5	
Threshing manually			15
Cleaning		8	8
Total labor (from harvesting to cleaning)	**21**	**29**	**61**

***Grain losses during harvesting*:** Estimated harvesting losses during paddy harvesting by mini-combine harvester, reaper and manually are shown in Table 6. Harvesting losses were found 1.24%, 4.22% and 6.36%

respectively for using mini-combine harvester, reaper and manual harvesting system. Loss reduce over manual harvesting were found 5.12% and 2.14%, respectively for using mini-combine harvester and reaper.

Table 5. Labor saved mechanical vs. manual harvesting of paddy.

Harvesting method	Total labor required (man-day/ha) (From harvesting to cleaning operation)	Labor saved, %
Mini-combine harvester	21	65
Reaper	29	52
Manual harvesting	61	

Table 6. Grain losses during harvesting.

Harvesting method	Total grain losses, % (From harvesting to cleaning operation)	Loss reduce over manual harvesting
Mini-combine harvester	1.24	5.12 %
Reaper	4.22	2.14 %
Manual harvesting	6.36	

Conclusions

Total cost savings in paddy harvesting were found 52% and 37% for mini-combine harvester and reaper, respectively over manual harvesting system. Similarly, labor savings using mini-combine harvester and reaper were found 65% and 52%, respectively over manual harvesting system. The total harvesting losses (including harvesting, threshing and cleaning) were also found 1.24%, 4.22% and 6.36% for using mini-combine, reaper and manual harvesting systems, respectively. The 5.12% and 2.14% losses of paddy can be reduced using mini-combine harvester and reaper, respectively. The results indicated that manual harvesting is a slow and cost involving system. It is necessary to build awareness among farmers about the benefits of mechanical harvesting system for adopting mechanized paddy harvesting in southern delta region. Based on technical and financial performances, both reaper and mini-combine harvester are found suitable for the farmers of the southern region of Bangladesh. However, the farmers found the mini-combine harvester more attractive as it performs several tasks like harvesting, threshing, cleaning and bagging in a single operation.

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