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Combine Harvester: Impact on paddy production in Bangladesh

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ABSTRACT

Due to migration of agricultural labor in non-farm sectors and increasing climate vulnerability it is a great challenge to keep pace of food production for the exponential growth of population in Bangladesh. For following the traditional paddy harvesting methods, significant amount of field losses has been occurred in every year. The study was conducted to evaluate performance of combine harvester in comparison to manual harvesting of paddy and identify the impact on agricultural production system in Bangladesh. The experiment was conducted at *Wazirpur* Upazila of *Barisal* district during *Aman*-2018 paddy harvesting using a combine harvester and also, manual harvesting was conducted at the same location. Financial analysis of combine harvester over manual method was carried out for the comparison. Cost savings in mechanical harvesting of paddy were found 57.61% for using combine harvester over manual harvesting. Similarly, labor savings for using combine harvester was found 70% over manual harvesting. The estimated BCR of combine harvester is found 1.55. The break-even use of combine harvester is 35 ha/yr which indicates a combine harvester must operate above 35 ha/yr to have profit. The combine harvester will run on fully profit basis if it could be used after that minimum hectares. The average total harvesting losses (including harvesting, threshing and cleaning) were also found 1.61% and 6.08% for using combine harvester and manual harvesting, respectively. The losses of paddy will be reduced 4.47% using combine harvester over manual harvesting. The above results revealed that manual harvesting is a labor and cost involving system. On the other hand, mechanical harvester like combine harvester is a time, labor and cost saving system along with reducing harvesting losses. As a result, total paddy production might be increased, and which will help to contribute significantly to the development of livelihood status of rural community of Bangladesh.

Introduction

More than 70 percent of Bangladesh's population and 77 percent of its workforce lives in rural areas. Nearly half of all of Bangladesh's workers and two-thirds in rural areas are directly employed by agriculture, and about 87 percent of rural households rely on agriculture for at least part of their income (World Bank, 2016). Agriculture sector contributes about 13.82 percent to the country`s Gross Domestic Product (GDP) and employs more than 45 percent of total labor force (BBS, 2017). Paddy is a major cereal crop in agriculture which contribute to national food security and socio-economic development. Timely harvesting of paddy is very important to reduce losses affecting the total yield. Due to unavailability of mechanical harvesting system, significant amount of field losses of paddy in every year has been occurred due to natural calamities and shortage of time during harvesting period (Noby *et. al.,* 2018). Now a days, timely harvesting of paddy is big challenge due to shortage of labor and high wages of labor. 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% year^{-1}, 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 labor requirements resulting from the country's increasingly profitable alternative forms of employment (Zhang *et al.,* 2014).

An important work is to minimize the post-harvest losses along with reducing the labor and time involvement. Bala *et al.* (2010) reported that post-

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harvest losses of paddy at farm level were 9.49%, 10.51% and 10.59% for *Aman*, *Boro* and *Aus* seasons, respectively. One way to increase the production is to minimize yield gap between research and farmers level. Another important task is to minimize postharvest loss. Introduction of appropriate machinery is one of the major factors for reducing time and labor requirements, production cost and also to help fitting another crop in between successive two crops (Zami *et al.*, 2014). Another important opportunity will be created for the unemployed people in the field operation of harvesting machinery and maintenance of harvesting technology in the engineering workshop. Miah *et al.* (2002) showed that farm mechanization has remarkable positive impacts in creating employment opportunities, higher income, increasing household assets and increasing the overall standard of living of rural laborers in Bangladesh. In that case appropriate harvesting machinery is crying need to develop and introduce for agricultural mechanization to increasing production through reducing harvesting losses with less drudgery and less labor involvement. Appropriate farm mechanization has been emphasized as an important policy and development goal in Bangladesh (Mandal, 2002; Zhang *et al.*, 2014). Farmers in Bangladesh are adopting harvesting machines slowly because of their lack of knowledge and economic support. The government has given the top priority in increasing the availability of food in the country, while paddy land is not expanding (MoA, 2013).

Three types of harvesting machines like reaper, mini-combine and combine harvester are available in the worldwide. In addition to these, many developing countries like Bangladesh are using manual harvesting system widely due to unavailable of modern technologies. In technical and economical performances of any harvesting technology, the factor which greatly influences is the area covered by the system in unit time. According to the manufacturer's specifications of combine harvester, the area coverage per unit time of combine harvester is higher than that of reaper, mini-combine and manual harvesting system. Combine harvesters are one of the most economically important labor saving inventions, significantly reducing the fraction of the population engaged in agriculture **(**Constable et at., 2003***).*** The modern combine harvester, or simply combine, is a versatile machine designed to efficiently harvest a variety of grain crops. The Metal Private Limited, Bangladesh, has recently been imported a combine harvester (Model: DR150A) to use in the farmers field for paddy harvesting in Bangladesh. The machine has several advantages over mini combine harvester and reaper. Notable advantage of the machine is to use to harvest 100% fall down paddy in the field with water logged and wet conditions. Therefore, it will be suitable to use natural calamities prone vulnerable southern region of Bangladesh where mature large paddy area needs to harvest within short period. Before using the combine harvester in the farmers' level, it is necessary to test the machines technically and economically.

To facilitate mechanized harvesting, combine harvester was introduced in Bangladesh. The machines reduce harvesting losses and are calculated to save 52 percent of the costs (Hasan *et al.* 2019). Hossain *et al.* (2015) showed that average time, cost and grain saving by using combine harvester over manual methods were found to be 97.50, 35.00 and 2.75%, respectively. Meisner *et al.* (1997) showed that a reaper is 14 times more efficient than a daily laborer in cutting and placing cereals in the field. Considering the above matters, in southern region of Bangladesh, adoption of mechanical harvesting practices like using combine harvester is urgently needed to reduce the human drudgery, labor involvement, production cost, harvesting losses and increase the cropping intensity, crop productivity. Also, mechanical harvesting of paddy could be a great opportunity to intensify the percentage of GDP in Bangladesh through increasing the total agricultural production which will assist to strengthen livelihood status of Bangladesh. Under this situation, the main objectives of the study were to evaluate the technical and economic performances of combine harvester and to analyze the benefit of mechanical harvesting system over manual harvesting system.

Methodology

Study location

The experiment on both mechanical and manual harvesting of paddy were conducted at *Wazirpur*, upazila of Barisal district of Bangladesh as shown in Figure 1. Three (3) plots for mechanical harvesting and three (3) plots for manual harvesting were considered and harvested during *Aman*-2018 (November-December).

Selected combine harvester

A combine harvester (Model: DR150A) was selected and used for harvesting of paddy at the experimental site. The harvester is manufactured by Suzhou Wude Mechanical Parts Co., Ltd, China. Pictorial view of combine harvester is shown in Figure 2 and technical specifications of the combine harvester are presented in Table 1.

Paddy harvesting using combine harvester

For performance evaluation of the combine harvester, 03 (three) plots were selected and harvested during *Aman*-2018. During paddy harvesting using combine harvester, all activities (harvesting to cleaning tasks) were performed in a single pass of the combine as shown in Figure 3. After harvesting, farmers carry clean paddy bag directly to home.

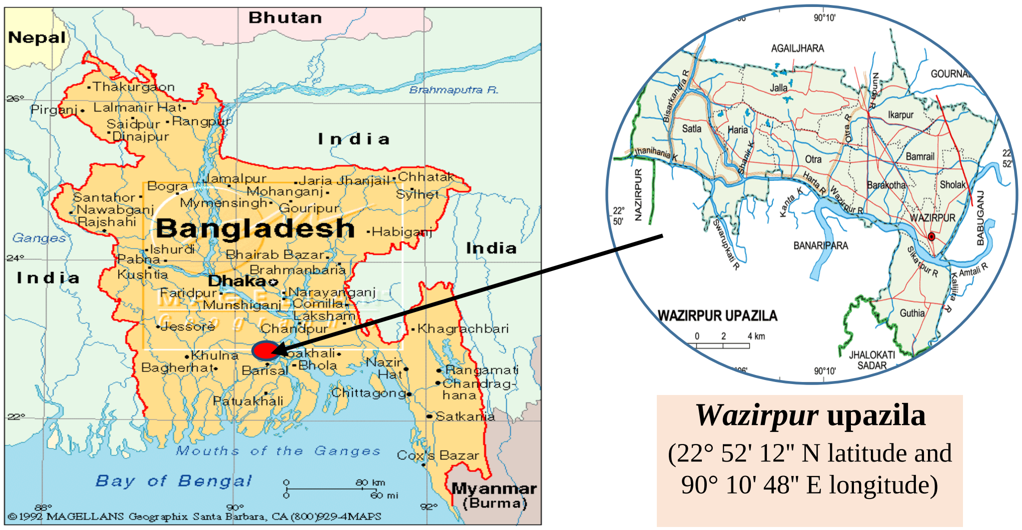

Fig. 1 Study location in Bangladesh map.

Fig. 2 Pictorial view of combine harvester

Table 1. Technical Specifications of combine harvester

Testing Item	Designed Value
Model	DR150A
Overall dimension (L×W×H) mm	4250×2400×2350
Weight (kg)	2600
Header width (mm)	1500
Forward Speed (km/hr)	0~9.72
Fuel consumption (L/hr)	10~12
Engine Power (hp)	70
Engine type	Diesel Engine
Engine Speed (rpm)	2700
Working Efficiency (ha/h)	0.27-0.47
Country of origin	China
Importer in Bangladesh	The Metal Pvt. Ltd.

Fig. 3 Paddy harvesting by combine (left), bagging after harvesting (middle), and paddy bag carrying to home (right)

Performance indicating parameters

To evaluate technical and economic performances of combine harvester during paddy harvesting and compare with manual harvesting, performance indicators were identified i.e. (i) operational time, (ii) labor requirement for harvesting, (iii) fuel consumption, (iv) field capacity, (v) working speed, (vi) effective harvesting time, (vii) grain yield and (viii) grain losses.

Field capacity

For evaluation of field capacity, the following data were taken during paddy harvesting operation: (i) area of the plot; (ii) forward speed of the machine; (iii) cutting width of the machine; (iv) time required to harvest the specified area.

Forward speed

Forward speed was measured by dividing the distance by time required to travel the machine of that distance. Same procedure was considered six times in each plot for determining average forward speed. The following equation was used to determine the forward speed of combine harvester (Hunt, 1995).

Forward speed (km/hr), $S = \frac{3.6D}{t}$ …………(i)

where, D = distance (m) and t = time (s).

Effective field capacity

The effective field capacity is the actual average rate of coverage by the harvester, 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, 1995).

Effective field capacity (ha/hr), $C_{eff} = \frac{A}{T}$ ....(ii)

where, T = total time for reaping operation (hr) and A = area of land reaping at specified time.

ii) Cutter bar loss

Cutter bar loss indicates grains those are lost due to rough handling by the cutter bar. Following equation was used to determine cutter bar loss (Hunt, 1995).

Cutter bar loss (kg/ha) =

$$\frac{\text{Average weight of grain lost due to rough handling of cutter bar, kg}}{\text{Area Covered, ha}}$$ ....…….(v)

iii) Cylinder loss

Grains lost out the rear of the combine in the form of threshed heads indicate cylinder loss. Following equation was used to determine cylinder loss (Hunt, 1995).

$$\text{Cylinder loss, kg/ha} = \frac{\text{Average weight of unthreshed heads lost out the rear of combine, kg}}{\text{Area Covered, ha}}$$ ....….(vi)

iv) Separating loss

Separating loss means the grains lost out the rear of the combine in the form of threshed grain. The following equations was used to determine separating loss (Hunt, 1995).

$$\text{Separating loss, kg/ha} = \frac{\text{Average weight of threshed heads lost out the rear of combine, kg}}{\text{Area Covered, ha}}$$ ....….(vii)

Fuel consumption

For economic analysis, fuel consumption was determined after harvesting of each plot. Before starting the harvesting operation, the fuel tank of the combine harvester was fill up and at the end of the harvesting operation of each plot the required fuel to fill the tank was determined by using measuring flask. For determining fuel consumption per unit area, following equation was used (Hunt, 1995).

Fuel consumption (L/ha), $F = F_a/A$ ....……...…(iii)

where, F_a = fuel used during operation (L) and A= area of operation, (ha).

Determination of mechanical harvesting losses

In general, there are four types of losses were considered to use a combine harvester. These are i) shatter loss, ii) cutter bar loss, iii) cylinder loss and iv) separating loss. In the experiment following procedures were considered for mechanical harvesting losses measurement.

i) Shatter loss

Shatter losses in direct combining include heads, pods, or ears, and free grain, lost during cutting and conveying operations. The following equation was used to determine the shatter loss (Hunt, 1995).

Shatter loss, kg/ha= D/A …………(iv)

Where,

D = average wight of dropped graon on the ground during cutting and conveying (kg), and A =area (ha)

Manual harvesting, carrying, threshing and cleaning of paddy

For the determination of manual harvesting cost, losses and labor requirement, 3 different plots were harvested manually using a sickle during *Aman*-2018 at the same location. From harvesting to cleaning, all operations were done by manually as shown in Figure 4. Manual harvesting was considered as a) manually reaping using a sickle, b) manually carrying using a bamboo bar, c) manual threshing using a drum and d) manual cleaning using a *kula* in open air. All operations were done carefully for precise estimation.

(i) (ii) (iii) (iv)

Fig. 4 Manual harvesting to cleaning operations: (i) reaping, (ii) carrying, (iii) threshing and (iv) cleaning.

Manual harvesting losses

The goal of appropriate harvesting method is to maximize paddy yield and to minimize paddy damage or losses and quality deterioration. During manual harvesting, losses were considered as i) shatter loss, ii) cutting loss, iii) gathering loss, iv) carrying loss, v) threshing loss and vi) cleaning loss. All paddy losses were collected and calculated carefully. Paddy loss measurement activities during manual reaping, carrying and threshing are shown in the Figure 5.

(i) (ii) (iii) (iv) (v) (vi)

Fig. 5 Paddy loss measurement activities during manual harvesting to cleaning operations: (i) dropped paddy collection after reaping, ii) uncut straw collection (iii) dropped paddy collection during gathering iv) rapping with polythene for carrying loss collection, (v) un-threshed paddy collection and (vi) cleaning loss measurement.

Total loss and percent of loss

Total manual harvesting loss was estimated by summation of all losses. The following equations were used to determine the total manual harvesting loss and the percent of loss.

$$\text{Total loss (g)} = \text{Shutter loss (g)} + \text{Cutting loss (g)} + \text{Gathering loss (g)} + \text{Carrying loss (g)} + \text{Threshing loss (g)} + \text{Cleaning loss (g)} \quad \text{..................(viii)}$$

$$\text{Loss (\%)} = \frac{\text{Total loss}}{\text{Total yield}} \times 100 \quad \text{.........................(ix)}$$

Grain weight measurement

After manual and mechanical harvesting of paddy, all losses were collected in a polythene bag and weighted by using the digital balance and recorded for analysis.

Financial analysis

For financial performance evaluation of combine harvester during mechanical harvesting of paddy especially cost of operation of harvesting machine was determined by calculating fixed cost and variable cost. Harvesting cost, time and labor involvement in mechanical harvesting were also compared with manual harvesting.

Total manual harvesting cost

For total manual harvesting cost estimation, labor involvement from harvesting to cleaning of paddy were counted and multiplied by the amount of wages per labor. The following equation was used to estimate the total manual harvesting cost.

$$\text{Total cost (BDT/ha)} = \text{Wages of labor (BDT/man)} \times \text{No. of labor (man/ha)} \quad \text{..................(x)}$$

Benefits of mechanical harvesting

The costs of two different paddy harvesting methods like combine harvester and manual harvesting were compared to determine the benefits of mechanical harvesting. For combine harvester following equations were used to determine cost saving and percent of cost saving.

i) Cost saving for using combine harvester (BDT /ha) = Cost of manual harvesting (BDT /ha) – Cost of mechanical harvesting using a combine harvester (BDT/ha) ....(xi)

ii) Cost saving, (%) =

$$\frac{\text{Manual harvesting cost}(\frac{BTD}{ha}) - \text{Mechanical harvesting cost}(\frac{BTD}{ha})}{\text{Manual harvesting cost}(\frac{BTD}{ha})} \times 100 \quad \text{.................................(xii)}$$

Benefit-cost ratio

The benefit cost ratio is an important factor to measure the profitability of using combine harvester. If the benefit cost ratio (BCR) is greater than unity, then it will be economically viable. BCR was calculated by using the following formula (Gittinger, 1982):

BCR = ∑ Present worth of Benefits (PWB)/ ∑ Present worth of costs (PWC) ....(xiii)

Break-even use

The break-even analysis is a useful tool to study the relationship between operating costs and returns. It is the intersection point at which neither profit nor loss is occurred. Above which the machine use can be considered as net gain (Gittinger, 1982). The break-even use of a combine harvester depends on its capacity of harvesting, power requirement, labor requirement and other charges. Break even use was calculated by using the following formula:

Break even use for capital recovery (ha/yr) =

$$\frac{\text{Fixed Cost (BTD/yr)}}{\text{Return}(\frac{BTD}{ha}) - \text{Variable Cost}(\frac{BTD}{ha})} \quad \text{...........(xiv)}$$

Results and Discussion

Technical performance of combine harvester

After mechanical harvesting using a combine harvester during *Aman*/2018 at *Wazirpur*, Barisal of Bangladesh, average values of forward speed, fuel consumption and effective field capacity were determined as presented in Table 2. The average values of forward speed, fuel consumption and effective field capacity were found 6.71 km/h, 10.76 L/h and 0.33 ha/h, respectively. Total area was 0.28 ha for conducting the experiment with mechanical harvester. Small variations of these parameters in three plots are mainly due to the variation of operator's skill, soil condition and plot size.

Table 2. Technical performance of combine harvester

Plot	Forward speed	Fuel Consumption		Effective Field Capacity
	(km/h)	(L/ha)	(L/h)	(ha/h)
1	6.48	29.63	10.37	0.35
2	6.98	34.09	11.25	0.33
3	6.66	34.39	10.66	0.31
Average	6.71	32.70	10.76	0.33

Comparison of combine and mini-combine harvesters

It is also necessary to know the performance status of mini combine harvester over combine harvester. Identifications of usable conditions of combine and mini-combine harvesters are also necessary to know for providing information to farmers and extensions service holders. Average effective field capacity of the combine harvester (Model: DR150A) was found 0.33 ha/h as presented in Table 3 which is higher than that of mini-combine harvester (Model: 4LBZ-110) (0.09 ha/h) (Ali *et al.*, 2017). Due to higher field capacity in comparison to mini-combine harvester and manual harvesting system, combine harvester will definitely be appropriate to harvest large area within short time. In addition to this, 100% fallen crops are possible to harvest without any hazard by using the combine harvester which is not possible by mini-combine harvester. Southern region of Bangladesh is vulnerable area. Crops fall on the field at the matured stage is common phenomena in the region. Due to climate vulnerability, it is also necessary to harvest large area of paddy within short time. All the mentioned issues are possible to resolve using only combine harvester. So, the combine harvester will be very much suitable in the southern delta of Bangladesh which area is affected severely by the natural calamities like *Sidr*, *Aila*, flood, cyclone, tidal, etc. On the other hand, mini-combine will be useful to small and medium farmers where such kinds of problems are not faced by farmers.

Table 3. Performance comparison between combine and mini-combine harvesters

Technology	Avg. effective field capacity (ha/h)
Combine harvester (Model: DR150A)	0.33
Mini-combine harvester (Model: 4LBZ-110) (Ali *et al.*, 2017)	0.09

Economic analysis of combine harvester

Economic analysis was carried out and all results are presented in Table 4. The results supported that investment on a combine harvester is highly profitable. Cost saved during mechanical harvesting over manual harvesting was found 57.61%, on the other hand, the BCR for the combine harvester is 1.88 that is higher than unity with an initial investment of BDT 18,00,000. Khadr *et al.* (2009) obtained similar result as costs saved 58.3% for using Yanmar combine and 56.7% for using Kubota combine harvester over manual harvesting system. Cost saving depends on machine conditions as the increasing of fuel consumption and repair & maintenance cost and decreasing field capacity day by day.

Table 4. Different financial features of combine harvester operation business

Item	Unit*	Amount
Purchase price of combine (P)	BDT	1,800,000.00
Working life (L)	yr	10
Fixed cost per hectare	BDT/ha	2803.98
Variable cost per hectare	BDT/ha	7538.26
Operating cost per hectare	BDT/ha	10,342.24
Average working area	ha/yr	105.60
Total fixed cost	BDT/yr	296,100.00
Total variable cost	BDT/yr	796,040.72
Manual harvesting cost	BDT/ha	24400.00
Cost saved	%	57.61
Rent out charge	BDT/ha	16,000.00
Benefit-cost ratio (BCR)	-	1.55
Break-even use	ha/yr	35

** BDT: Bangladeshi Taka (Approximately 84 Taka = 1 US $), Average effective field capacity = 0.33 ha/h, Average daily working hour = 8h; Yearly use = 40 days.*

Manual harvesting cost

During paddy harvesting to cleaning, all operations were done manually. Average cost of manual reaping, straw binding and carry to home, threshing and cleaning of paddy were estimated as presented in Table 5. Costing was calculated according to considering the necessary man-day per hectare. The necessary man-day/ha were 23, 15, 15 and 8, respectively for paddy reaping, straw binding and carry to home, paddy threshing and paddy cleaning. Total necessary man-day/ha was 61 and total manual harvesting to cleaning cost was found 24400 BDT/ha.

Table 5. Total manual paddy harvesting cost

Type of work	No of man-day/ha	BDT/man-day	Total cost, BDT/ha
Paddy reaping	23	400	9200
Straw binding & carry to home	15	400	6000
Paddy threshing	15	400	6000
Paddy cleaning	8	400	3200
Total manual paddy harvesting cost			**24400**

Break-even use

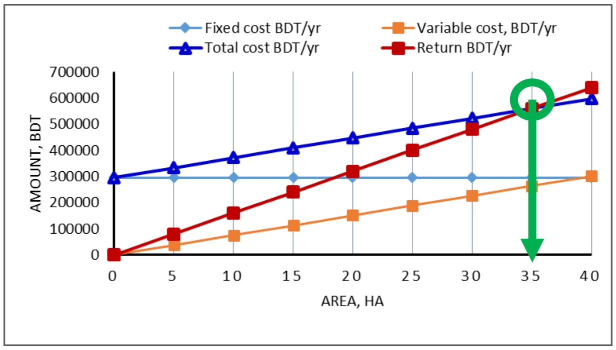

Fig. 6. Break-even analysis for a combine harvester

The break-even use of the combine harvester was found about to be 35 ha/yr as shown in Figure 6. It indicates that a combine harvester should operate above 35 ha/yr to have profit. The combine harvester will run on fully profit basis if it can be used more than 35 ha/yr. For getting break-even use, rent-out charge was conisidered 16,000 BDT/ha on the basis of field survey and total cost was estimated from the summation of annual fixed cost and variable cost. Annual fixed cost will not vary but total variable cost will vary along with the annual area coverage.

Manual paddy harvesting losses

Paddy harvesting losses (harvesting to cleaning) were determined during manual harvesting. All losses of paddy grain from harvesting to cleaning during *Aman*-2018 harvesting were measured and summarized as presented in Table 6. Average shatter loss, cutting loss, gathering loss, carrying loss, threshing loss and cleaning loss were found 0.74%, 0.68%, 0.31%, 0.23%, 3.35% and 0.78 %, respectively. Finally, the total manual harvesting loss was found 6.08% which is greater than mechanical harvesting. Kannan *et al.* (2013) reported similar post-harvest loss of paddy. They found 6.87 percent manual harvesting loss.

Table 6. Average manual harvesting losses

Activities	Percentage, %			
	Plot-1	**Plot-2**	**Plot-3**	**Average**
Shatter loss	0.79	0.69	0.73	0.74
Cutting loss	0.77	0.55	0.72	0.68
Gathering loss	0.27	0.25	0.41	0.31
Carrying loss	0.14	0.20	0.34	0.23
Threshing loss	3.73	3.58	2.74	3.35
Cleaning loss	0.57	0.56	1.21	0.78
Total loss	**6.27**	**5.84**	**6.15**	**6.08**

Mechanical paddy harvesting losses from harvesting to cleaning operation

Mechanical paddy harvesting losses (harvesting to cleaning operation) were measured as presented in Table 7. For calculating mechanical harvesting losses 3 (three) plots were harvested using the combine harvester and harvesting losses were found 1.66%, 1.55% and 1.63%, respectively in plot-1, plot-2 and plot-3. These results represent the total harvesting loss of each plot during mechanical harvesting. Finally, average total paddy harvesting losses was found 1.61% using a combine harvester. This average mechanical harvesting loss of using the combine harvester is comparatively less than that of manual harvesting system.

Table 7. Grain losses during harvesting by combine harvester

Plot	Total loss, %	Average loss, %
Plot-1	1.66	
Plot-2	1.55	1.61
Plot-3	1.63	

Loss of paddy saved using mechanical harvesting

Loss of paddy saved using the combine harvester over manual harvesting system is presented in Table 8. Paddy loss could be saved 4.47% using combine harvester over manual harvesting. Amponsah *et al*. (2017) mentioned grain loss using combine ranging from 1.43% to 4.43% and 1.85% to 5.6% for the IR841 and Nerica L20 rice varieties, respectively. Kannan *et al*. (2013) reported similar post-harvest loss of paddy. They found 6.87 percent manual harvesting loss. Hossain *et al*. (2015) estimated average grain saving from loss reduction by combine harvester over manual methods was 2.75%. Paddy loss might vary with the operator's skill, soil condition, harvesting time and agronomic characteristics of the paddy. Generally early harvesting reduced pre-harvest and shattering loss in operation, on the other hand, delayed harvesting caused more loss due to low moisture content and faces natural calamities.

Table 8. Loss saved using mechanical harvesting over manual harvesting of paddy

Harvesting method	Total loss, % (From harvesting to cleaning operation)	Loss saved, %
Manual harvesting	6.08	4.47
Combine harvester	1.61	

Labor saved over manual harvesting

Labor requirement during paddy harvesting by combine harvester and manual system was measured as presented in Table 9. Total labor required was found 18 man-day/ha and 61 man-day/ha for using combine harvester and manual system, respectively. Labor requirement during paddy harvesting by combine harvester was less than the manual harvesting system. Labor could be saved 70% for using the combine harvester over manual harvesting of paddy.

Table 9. Labor saved using mechanical harvesting over manual harvesting

Item	Labors involvement (man-day/ha)	
	Combine	Manually
Paddy harvesting	2	23
Paddy bag carry	8	-
Straw binding and carrying	8	-
Straw with paddy carrying	-	15
Manual threshing	-	15
Cleaning	-	8
Total labor (harvesting to cleaning)	**18**	**61**
Labor saved over manual harvesting (%)	**70**	-

Conclusion

Technical and financial performances indicating parameters of the combine harvester were determined carefully and all financial parameters were compared with manual harvesting system. From cost savings, labor savings and BCR in mechanical harvesting of paddy using combine harvester indicate that, investment for combine harvester is highly profitable. Harvesting cost and labor savings in combine harvester was found 57.61% and 70%, respectively over manual harvesting. The estimated BCR of combine harvester is found 1.55. The break-even use of combine harvester is also found 35 ha/yr which indicates the combine harvester must operate above 35 ha/yr to have profit. The losses of paddy can be reduced 4.47% using combine harvester over manual harvesting. Also, all results revealed that mechanical harvester like combine harvester is a time, labor and cost saving system along with reducing harvesting losses, human drudgery and increasing cropping intensity and crop productivity. For that, total agricultural production might be increased, and which will contribute significantly to the development of livelihood status of rural community of Bangladesh.

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