Technical Report on

Yanmar Combine Harvester (Model-AG600GA)

(Marketing Company: ACI Motors Ltd.)

Reported by

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Executive Summary

Mechanized agriculture plays a key role in the overall socio-economic development of any community in terms of food security, value addition, employment, poverty alleviation and export earnings. In Bangladesh, it is essential to ensure agricultural mechanization, especially in paddy harvesting system to increase production through reduction of harvesting losses and labor involvement. The study was conducted to evaluate the technical and economic performances of Yanmar combine harvester (Model-AG600GA) in comparison to manual harvesting of paddy in Bangladesh. The experiment was conducted at *Basail*, upazila of Tangail district of Bangladesh. Three (3) paddy plots were harvested during *Boro*-2019 (May 2019) by using the Yanmar combine harvester. Technical and financial analyses of Yanmar combine harvester over manual harvesting were carried out for comparison. Effective field capacity of the combine harvester was found 0.45 ha/hr. Cost saving of Yanmar combine harvester was found 60.98% over manual harvesting. Similarly, labor savings for using Yanmar combine harvester was found 70% over manual harvesting. The estimated BCR of Yanmar combine harvester was found 1.62 which is quite impressive. The payback period (PP) of Yanmar combine harvester was estimated 2.08 year with an initial investment size of BDT 28,00,000. The average total harvesting losses (including harvesting, threshing and cleaning) were found 1.62% and 6.36% for combine harvester and manual harvesting, respectively. Therefore, a paddy loss of 4.74% can be reduced by using Yanmar combine harvester. The above results revealed that Yanmar combine harvester is a time, labor, cost and harvesting loss saving harvesting machine. The introduction of Yanmar combine harvester in Bangladesh agriculture definitely improve the productivity of paddy production and improve the socio-economic status of rural farming community of Bangladesh.

Key Words: Paddy, Yanmar Combine, Harvesting, Labor, Losses, Profit

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Introduction

Paddy is a major cereal crop in Bangladesh which contributes to national food security and socio-economic development. Timely harvesting of paddy is very important to reduce postharvest losses. 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 day, timely harvesting of paddy is a big challenge due to shortage of labor and high wages of labor during harvesting season. Moreover, 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 paddy 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 labor 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 by reducing farm production cost though mechanization. Three types of harvesting machines like reaper, mini-combine and combine harvester are available worldwide. In addition to these, many developing countries like Bangladesh are using manual harvesting widely due to unavailable of modern technologies. In technical and economical performances of any harvesting technology, the factor which greatly influence is the area covered in unit time. According to the manufacturers' specifications of combine harvester, the area coverage per unit time of combine harvester is higher than that of reaper, mini-combine and manual harvesting. ACI Motors Limited, Bangladesh, has recently imported a Yanmar combine harvester (Model-AG600GA) to adopt in farmers field for paddy harvesting in Bangladesh. Before using the combine harvester in farmers' level, it is necessary to test the combine harvester technically and economically. Under this situation, the main objectives of the study were to evaluate the technical and economic performances of Yanmar combine harvester (Model-AG600GA) in Bangladesh condition.

Methodology

Study Location

The performance study of the combine harvester for harvesting of paddy was conducted at *Basail*, upazila of Tangail district of Bangladesh as shown in Fig.1. Three (3) paddy plots were harvested during *Boro*-2019 (May 2019).

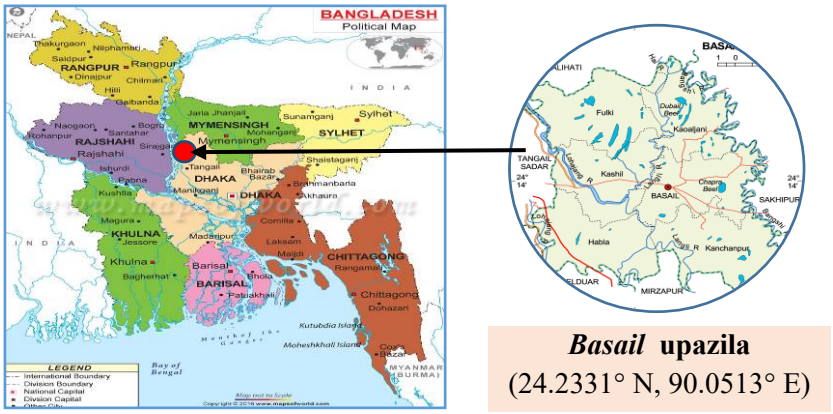

Fig.1 Study location in Bangladesh map

Selected Yanmar Combine Harvester

The selected harvester is manufactured by Yanmar Company Ltd., Japan. Pictorial view of Yanmar combine harvester is shown in Fig. 2 and technical specifications of the Yanmar combine harvester are presented in Table 1.

Fig.2 Pictorial view of Yanmar combine harvester

Table 1 Technical Specifications of Yanmar combine harvester

Testing Item	Designed Value
Model	Model-AG600GA
Overall dimension (L×W×H) mm	4290×1940×2410
Weight (kg)	3117
Reaping width (mm)	1400
Forward Speed (km/hr)	0~7.38
Fuel consumption (L/hr)	08~12
Engine Power (hp)	70
Engine type	Diesel Engine
Engine Speed (rpm)	2500
Working Efficiency (ha/h)	0.25-0.50
Country of origin	Japan
Importer in Bangladesh	ACI Motors Ltd.

Paddy Harvesting with Yanmar Combine Harvester

For the performance evaluation of Yanmar Combine harvester, three (3) plots of paddy field were used. During paddy harvesting, all activities (harvesting to cleaning tasks) were performed in a single operation as shown in Fig.3. After harvesting, farmers carry clean paddy bag directly to home.

(i) (ii) (iii)

Fig.3 (i) Paddy harvesting by harvester, (ii) bagging after harvesting (iii) Paddy bag carrying to home.

Performance Indicating Parameters

To evaluate technical and economic performances of Yanmar combine harvester and compare with manual harvesting, the following performance indicators were considered, namely: (i) operational time, (ii) labor requirement for harvesting, (iii) fuel consumption, (iv) field capacity, (v) working speed, (vi) effective harvesting time, and (vii) 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; (v) time loss due to refueling, cleaning, machine adjustments, minor repair and turning of the machine.

Forward Speed

Forward speed was measured dividing the distance by time required to travel the machine of that distance. Same procedure was considered five times in each plot for determining average forward speed.

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.

Fuel Consumption

For economic analysis, fuel consumption was determined after harvesting of each plot. The fuel tank of the combine harvester was filled up before starting the harvesting operation and after the harvesting operation of each plot. The amount of fuel to be added was measured by measuring flask. The amount of fuel added to fill completely the combine harvester's fuel tank after the harvesting of each plot was the fuel consumption.

Determination of Mechanical Harvesting Losses

In general, four types of losses are occurred in 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.

Shatter loss	Cutter bar loss	Cylinder loss	Separating loss
Shatter losses in direct combining include heads, pods or ears, and free grain, lost during cutting and conveying operations.	Cutter bar loss indicates grains those are lost due to rough handling by the cutter bar.	Grains lost at the rear of the combine in the form of unthreshed heads indicate cylinder loss.	Separating loss means the grains lost at the rear of the combine in the form of threshed grain.

Grain Weight Measurement

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

Financial Analysis

For financial performance evaluation of Yanmar combine harvester especially cost of operation of harvesting was determined by calculating fixed costs and variable costs. Harvesting cost, time and labor involvements in combine harvesting were also compared with manual harvesting.

Benefits of Combine Harvesting

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

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

ii) Cost saving, (%) = $\frac{\text{Cost of manual harvesting } (\frac{\text{Tk}}{\text{ha}}) - \text{Cost of mechanical harvesting } (\frac{\text{Tk}}{\text{ha}})}{\text{Cost of manual harvesting } (\frac{\text{Tk}}{\text{ha}})} \times 100$.....(ii)

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) ……..…..(iii)

Payback Period

Payback refers to the time period within which the costs of investment can be covered by revenues. Payback period can be computed by applying the following formula:

Payback period = Investment (total initial), Tk/ Net benefit (Tk/yr).……..……...(iv)

Results and Discussion

Technical Performance of Yanmar Combine Harvester

After harvesting with a Yanmar combine harvester during *Boro*/2019 at *Basail,* Tangail of Bangladesh, average values of forward speed, fuel consumption and effective field capacity were determined as presented in Table 2. Small variations of these parameters in three plots are mainly due to the variation of operator's skill and soil conditions. Field efficiency is comparatively lower due to small plot size, frequent turning time and unloading time of paddy though average effective field capacity was 0.4545 ha/hr (1.12 acre/hr) . Therefore, efficient time management is necessary.

Table 2 Technical performance of Yanmar combine harvester

Plot	Forward speed		Fuel Consumption		Theoretical Field Capacity (ha/hr)	Effective Field Capacity (ha/hr)	Field Efficiency (%)
	(km/hr)	(m/s)	(L/ha)	(L/hr)			
1	5.62	1.56	20.56	8.63	0.79	0.4196	53.29
2	6.13	1.70	22.26	10.43	0.86	0.4688	54.62
3	6.51	1.81	21.64	10.28	0.91	0.4751	52.12
Average	6.09	1.69	21.49	9.78	0.85	0.4545	53.32

Economic Performance of Yanmar Combine Harvester over Manual Harvesting

Economic performance of Yanmar combine harvester over manual harvesting is shown in Table 3. The results supported that investment on a combine harvester is highly profitable. Cost saved during mechanical harvesting over manual harvesting was found 60.98%. On the other hand, the BCR for the combine harvester was 1.62 that is higher than unity with an initial investment of BDT 28,00,000. Cost saving depends on machine conditions such as increasing of fuel consumption and repair & maintenance cost with the age of the machine. The payback period (PP) of Yanmar combine harvester was estimated as 2.08 year with an initial investment size of BDT 28,00,000 that means the stream of cash proceeds produced by an investment to equal the initial expenditure incurred after 2.08 years.

Table 3 Different financial features of combine harvester operation business

Item	Unit*	Amount
Purchase price of combine (P)	BDT	2,800,000
Working life (L)	yr	10
Fixed cost per hectare	BDT/ha	2789
Variable cost per hectare	BDT/ha	6731
Operating cost per hectare	BDT/ha	9520
Average working area	ha/yr	145
Total fixed cost	BDT/yr	405,666
Total variable cost	BDT/yr	979,039
Manual harvesting cost (Ali *et al.,* 2017)	BDT/ha	24400
Cost saved	%	60.98
Rent out charge	BDT/ha	16,000
Benefit-cost ratio (BCR)	-	1.62
Payback period	yr	2.08

** BDT: Bangladeshi Taka (Approximately 84 Taka = 1 US $)*

Mechanical Harvesting Losses

Measured total mechanical paddy harvesting losses (harvesting to cleaning operation) are presented in Table 4.

Table 4 Grain losses during harvesting by Yanmar combine harvester

Items	Plot1	Plot2	Plot3
Shatter loss (g/m^2)	2.12	4.33	3.05
Cutter bar loss (g/m^2)	4.20	6.10	3.98
Cylinder loss (g/m^2)	2.87	1.28	2.98
Separating loss (g/m^2)	2.10	2.50	3.90
Total loss (g/m^2)	11.29	14.21	13.91
Total crop yield (g/m^2)	716.26	889.98	818.76
Loss %	1.58	1.60	1.70
Average loss %		**1.62**	

Average total paddy harvesting loss was found 1.62% using a combine harvester. Harvesting loss of using the combine harvester is comparatively less than that of manual harvesting.

Paddy Loss Saved using Yanmar Combine Harvesting

Paddy loss saved using the Yanmar combine harvester over manual harvesting is presented in Table 5. Paddy loss could be saved 4.74% using Yanmar combine harvester over manual harvesting. Paddy loss might vary with the operator's skill, soil condition, harvesting time and agronomic characteristics of the paddy.

Table 5 Loss saved using mechanical harvesting over manual harvesting of paddy

Harvesting method	Total loss, % (From harvesting to cleaning operation)	Loss saved, %
Manual harvesting (Ali *et al.,* 2017)	6.36	4.74
Yanmar combine harvester	1.62	

Labor Saved over Manual Harvesting

Labor requirement during paddy harvesting by Yanmar combine harvester and manual harvesting is shown in Table 6. Total labor required was found 18 man-days/ha and 61 man-days/ha for Yanmar combine harvester and manual harvesting, respectively. Labor saved was 70% for using the Yanmar combine harvester over manual harvesting of paddy.

Table 6 Labor saved using mechanical harvesting over manual harvesting

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

Conclusion

Technical and financial performances of the Yanmar combine harvester were determined carefully and all financial parameters were compared with manual harvesting. Investment for Yanmar combine harvester is highly profitable in terms of cost savings, labor savings and reduction of grain losses. The losses of paddy can be reduced by 4.74% using Yanmar combine harvester over manual harvesting. However, notable advantage of the machine is that this combine can harvest 100% shattered (paddy laying on the field) paddy in the field with water logged and wet conditions. Therefore, the combine will be suitable for using all over Bangladesh including the natural calamity prone vulnerable southern region where large area of paddy needs to harvest within short period. The payback period of the combine harvester is less than three years. The introduction of Yanmar combine harvester in Bangladesh agriculture definitely improves the productivity of paddy production and improves the socio-economic status of rural farming community of Bangladesh.

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