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COMPARATIVE PERFORMANCE OF COMMONLY USED OPEN DRUM THRESHERS FOR RICE IN BANGLADESH

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Abstract

Threshing is one of the most important post harvest operation of grains. Along with Traditional threshing, mechanical threshing methods such as, Pedal threshing, Open-drum power threshing and Close-drum power threshing are being used in Bangladesh. In this study cost, capacities and benefit-cost ratios of the different open drum threshers (Farida, BRRI, Boby and MAWTS models) and cost of manual threshing were calculated and compared along with different economic and financial indicators to appraise financial profitability of these methods. Considering timeliness of post-harvest operations, cost of threshing, labour crisis at peak harvesting and threshing period, unavailability of animal power for traditional threshing (treading), drudgery of manual threshing, simplicity of design and price of mechanical threshers, open-drum threshers are becoming popular among the farmers and substituting traditional threshing options. The Farida open drum thresher model had given the highest threshing (359 kg/hr) and throughput (757 kg/hr) capacities. All other open drum thresher models also had substantially higher threshing and throughput capacities over manual threshing. Considering operating cost and benefit-cost ratio, Farida and BRRI model open drum threshers appeared as preferred options for the farmers compared to Boby and MAWTS models, though cylinder loss was high in Farida and BRRI models than MAWTS model. The substitution proposition by Partial Budget analysis clearly showed the economic profitability of BRRI model over other open drum models. But from the break-even analysis, the Farida and Boby model open drum threshers were found economical for farmers of Bangladesh having even very smaller land holding of 1 ha. The BRRI model was also found profitable for farmers having up to 2.5 ha of land. Therefore, considering the technical and financial aspects, Farida and Boby model open drum threshers may be recommended for all categories of farm holdings of Bangladesh.

INTRODUCTION

Among various post harvest activities threshing is one of the most important post harvest operations of grains. The removal or separation of grains from the panicles of the stalks is called threshing. In Bangladesh, the common methods of threshing of paddy are hand beating, bullock treading, power tiller treading, use of pedal thresher, open drum thresher and close drum power thresher. Presently different types of open drum threshers are being extensively used at farmer's level. The common models are MAWTS, BRRI, Boby and Farida. There are many local manufacturers fabricating open drum threshers meeting farmer's demand at peak threshing period. Traditional

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threshing consumes about 15 percent of the total energy required for HYV paddy cultivation and incurred a grain loss about 7 percent (BRRI and FAO, 1985). The amount of energy and loss of grain by traditional threshing pose a great challenge to present trend of intensive cultivation. In a recent survey, it is established that the farmers, especially the woman are very keen to adopt mechanical means of threshing to replace traditional one. Also pedal thresher operation for woman is physically exhaustive. The introduction of high yielding variety (HYV) of rice in the country coupled with double and triple cropping system has resulted in crop harvests in the wet season. This has generated an increased demand for mechanical threshers having higher capacity and the potential to thresh wet paddy without extensive grain losses.

Traditional threshing is the combination of beating and treading. In beating 84.86 percent threshing was completed in 25 percent time and 15.14 percent threshing through treading was completed in 75 percent of time (Baqui and Islam, 1994). In hand beating small bundles are beaten on Drum and Wooden Logs. In treading, thin layer of harvested stalks is spread over the threshing floor and animals are allowed to walk over it. The farmer threshes the small volumes of paddy bundles immediately. But in case of large quantity they stack the paddy bundles for several days and gradually complete the threshing. Late threshing of stacked materials causes both qualitative and quantitative losses due to warm and moist environment inside the stack. Some small farmers want quick threshing to reduce qualitative and quantitative losses. Both harvesting and threshing method affect the quality and yield of paddy. If the paddy is over mature, shattering occurs, cracking develops in the grain and some of the grains fall in the field and during transporting. The traditional method of grain separation is laborious, time consuming and uneconomical. This method of threshing consumes more time than other mechanical threshing methods. Traditional Threshing of paddy also causes grain loss as high as 6 percent (Miah *et. al.*, 1994). Karim and Rashid (1981) mentioned that about 3 percent paddy were lost during mechanical threshing in Aus season. BRRI (1999) found that open drum thresher was found suitable for both male and female worker. Economically this machine was found superior to traditional threshing, because it save an amount of Tk, 70 per ton of threshed grain However, The performance study of open drum thresher reveals that it reduces grain loss to 1.43 percent from 7 percent of manually threshing with much higher throughput capacity (Zami, 2000). If all paddy (estimated as 22.26 million tons) is threshed by open drum thresher, the estimated paddy saving could be 1.24 million tons of rice per year which is worth of taka 8320 millions. This saved amount of grain would be very beneficial for improving chronic shortage of food.

Since the Traditional threshing is laborious and time consuming, farmers become inclined to partial mechanized to mechanized threshing techniques. The study includes a detail performance test of the existing open-drum threshers (Farida, Boby, BRRI and MAWTS) available in the market for clearer understanding of its overall technical and economic performance. The information would be helpful in formulating future mechanization policies and strategy formulation for Bangladesh agriculture with a view to increase crop yield and reduce post harvest losses. The specific objectives of the study were:

1. To study the performance of different open drum threshers for rice developed by Farida, Boby, BRRI and MAWTS.
2. To recommend best suited open drum thresher or threshers for the farmers of Bangladesh.

MATERIALS AND METHODS

Selection of Thresher

For the present study, commonly used open-drum threshers developed by BRRI, MAWTS, Boby and Farida Engineering have been selected for evaluating their comparative performance. The selected threshers were tested in Aus season 2001 (during the last week of August to first week of September) at the Farm Machinery and Post–harvest Technology division workshop of BRRI, Gazipur. The technical specifications of the selected open-drum threshers are shown in Table 1.

Table 1. Technical specification of different open-drum threshers and its prime movers

Specifica-tions	MAWTS		BRRI		BOBY		FARIDA	
	Thresher	Engine	Thresher	Engine	Thresher	Engine	Thresher	Engine
Make	MAWTS	China	BRRI	China	Boby	China	Farida	China
Model		Z175F		Z175F		XK06		XK06
Dimension								
(a) Length, cm	92		159		172.5		175	
(b) Height, cm	75		71.5		70		80	
(c) Width, cm	78		58.5		76		91	
Drum diameter, Cm	31		31.5		24		25	
Drum length, cm	76		151		151		151.5	
Engine horsepower hp		5		5		6		6
Rated speed (rpm)	2600		2600		2200		2200	
Bar material	Steel		Steel		Wooden		Wooden	
No of bar, no	10		8		12		12	
Loop in each bar, no	18/19 (alternate)		29/30 (alternate)		46		39	
Loop to loop distance, cm	4.2		5		3		4	
Fuel used		Diesel		Diesel		Diesel		Diese l

Collection of Test Data and Estimation of Technical Parameters

According to the Regional Network for Agricultural Machinery (RNAM) test code data related to crop variety, length of straw, prime mover and power transmission, dimensions of the threshing cylinder and threshers, speed of fan and threshing cylinder, environmental condition, labour requirement, time of operation, total grain at main outlet, un-threshed grain, loose grain with the straw, spilled grain and visible breakage of grain were collected for this study. The collected data were analyzed to find out the following key technical parameters for comparing performance of the selected threshers

Grain- Straw Ratio

Thirty bundles of paddy were collected from stack; grains were separated carefully from different bundles and weighed. Then grain- straw ratio was calculated as follows:

$$GSR = \frac{GW}{SW}$$

Where, GSR = grain straw ratio; GW = grain weight, kg and SW = straw weight, kg.

Grain moisture content

The average grain moisture content at the time of threshing paddy was determined from different samples using an electronic grain moisture meter. For straw, samples of straw of fresh paddy were collected and weighed. The straw samples were dried in an electric oven at 105° C for 24 hours and weighed. Moisture content of straw was then determined as follows:

$$MC = \frac{Ww - Wd}{Ww} \times 100$$

Where, MC = moisture content in wet basis, percent; W_w = weight of wet straw before drying, gm and W_d = weight of oven dried straw after drying, gm.

All grain and straw weights are converted to standard 14 % moisture content (dry basis) before loss calculation for comparison.

Throughput capacity

A stock of unthreshed harvested crop was weighed and fed into the thresher at normal running condition and threshing time was recorded. Throughput capacity was calculated from the following expression:

$$FR = \frac{WC}{T} \times 60$$

Where, FR = feeding rate, kg/hr; WC = weight of harvested crop, kg and T = recorded time, minute.

Peripheral speed

Peripheral speed of the threshing drum was calculated as follows:

$$S = \frac{\pi DN}{100}$$

Where, S= peripheral speed, m/min; D = diameter of threshing drum, cm and N = rotation, rpm.

Threshing capacity

The weight of grains (whole and damaged) threshed and received per hour at the main grain outlet is called capacity. At the end of each test, total threshed grain was collected from the main grain outlet. The capacity was calculated from the following expression:

$$\mathrm{TC} = \frac{\mathrm{WG}}{\mathrm{T}} \times 60$$

Where, TC = threshing capacity, kg/hr; WG = weight of total output grain, kg; T = recorded time, minute.

Cylinder loss

After threshing, the whole grain still attached to the straw is called cylinder loss. The percent of cylinder loss was calculated as:

$$CL = \frac{WCG}{WG + WCG + WSG + WPG} \times 100$$

Where, CL = cylinder loss, percent; WG = weight of output grain, kg; WCG = weight of cylinder loss grain, kg; WSG = weight of separating loss grain, kg; WPG = weight of spilled grain, kg.

Separating loss

The loose grain collected from threshed straw is called separating loss. The percentage of separating loss was calculated as follows:

$$SL = \frac{WSG}{WG + WCG + WSG + WPG} \times 100$$

Where, SL = separating loss, kg; WG = weight of output grain, kg; WCG = weight of cylinder loss grain, kg; WSG = weight of separating loss grain, kg; WPG = weight of spilled grain, kg.

Spilled grain loss

During threshing, the threshed straws were deposited at a distance in front of the thresher. After collecting the threshed grain as net output, the grains still scattered at a certain distance from the thresher was termed as spilled grain. The percent of spilled grains was calculated in respect to total grain as:

$$PL = \frac{WPG}{WG + WCG + WSG + WPG} \times 100$$

Where, PL = Spilled grain loss, percent; WG = weight of output grain, kg; WCG = weight of cylinder loss grain, kg; WSG = weight of separating loss grain, kg; WPG = weight of spilled grain, kg.

Gross threshing loss

Gross threshing loss included cylinder loss, separating loss and scattered grain loss. After threshing, the weights of un-threshed, scattered and threshed grains un-separated from straw were obtained and the loss was calculated as follows:

$$GL = \frac{WCG + WSG + WPG}{WG + WCG + WSG + WPG} \times 100$$

Where, GL = Gross threshing loss, percent; WG = weight of output grain, kg; WCG = weight of cylinder loss grain, kg; WSG = weight of separating loss grain, kg; WPG = weight of spilled grain, kg.

Threshing efficiency

The net threshed grain received at all outlets with respect to total grain input was expressed as percent by weight was termed as threshing efficiency. The threshing efficiency was calculated from the following expression:

$$TE = \frac{WG}{WG + WCG + WSG + WPG} \times 100$$

TE = Threshing efficiency, percent; WG = weight of output grain, kg; WCG = weight of cylinder loss grain, kg; WSG = weight of separating loss grain, kg; WPG = weight of spilled loss grain, kg.

Economic analysis

Operating cost

The operating cost was calculated as follows:

$$C_{oc} = \text{Fixed cost} + \text{Variable cost}$$

Where, C_{oc} = operating cost, Tk/hr

Cost of threshing

The cost of threshing per kg, C_{kg} was calculated by using the following formula:

$$C_{kg} = \frac{C_{hr} + C_{op}}{T_g}$$

Where, C_{kg} = cost of threshing, Tk/kg; C_{hr} = cost of threshing, Tk/hr and T_g = weight of total threshed grain, kg/hr.

Break–even analysis

The following formula was used to estimate the appropriate "break-even" point between open-drum thresher and manual threshing:

$$\text{Ton/yr} = \frac{\text{Total annual fixed cost for open drum threshing (Tk./yr)}}{\text{Manual threshing cost (Tk/ton)}}$$

Throughput Cost

Throughput cost may be defined as the ratio of operating cost to throughput capacity per unit time of a system.

$$\text{Throughput cost (Tk/kg)} = \frac{\text{Operating cost (Tk/hr)}}{\text{Throughput capacity (kg/hr)}}$$

Benefit-Cost Ratio (B/C)

Benefit-cost ration may be defined as the ratio of gross revenue to threshing costs (expressed either in present or annual worth). Present worth occurs one interest period before the first uniform payment.

$$\text{B/C ratio} = \frac{\text{Gross revenue (Tk/hr)}}{\text{Threshing costs (Tk/hr)}}$$

Calculation Procedure for Gross Margin (GM) and Net Margin (NM)

The Gross Margin (GM) of an agricultural enterprise is its output (revenue) less its variable costs and the Net Margin (NM) is Gross Margin less its fixed costs. The enterprise output includes the hiring rate of machine and grain loss saved by the open drum thresher. The gross revenue was calculated as hiring rate per unit time and price of saved amount of paddy. For paddy threshing the variable cost items were identified as costs of labour, fuel, oil and repair and maintenance.

Gross revenue = [Units] x [Hiring rate per unit] + [Loss saved by the open drum thresher]
Gross Margin = [Gross output] – [Total variable cost + Cost of threshing loss]
Net Margin = [Gross Margin] – [Fixed costs]

Calculation Procedure for Partial Budget (PB)

Partial Budgeting is a marginal analysis which attempts to determine the changes in inputs, outputs, costs, revenues and profits associated with a proposed change of action, where this action does not affect the overall structure and performance of the enterprise. In other words, it looks at the marginal or partial changes. The Partial Budget compares the costs of change with the benefits of change by examining the impact of that change as net income and the substitution options were analyzed as follows:

Partial Budget Calculation

Costs of Change	Benefits of Change
GM Lost: Expected GM of the existing system. **Extra fixed costs:** Estimated new fixed cost.	**Extra GM:** Expected GM of the alternative system. **Fixed costs saved:** Estimated reduction of fixed costs.
Total Costs (X)	**Total Benefits (Y)**
Net Gain (Y > X)	**Net Loss (X > Y)**

Source: Alam, M.M. (1997)

RESULTS AND DISCUSSION

Performance of Different Open-drum Threshers

The selected four models of open drum thresher were tested to evaluate the comparative performance of threshing operation. The effective drum length of the thresher machine manufactured by MAWTS was 72 cm and the effective drum length of other models was 151 cm (Table 1). After thorough calculation of throughput capacity, threshing capacity, chaff present in threshed grain, straw cleaning time and operating cost of different open-drum thresher models are shown in Table 2.

Table 2. Estimated parameters of different open drum threshers

Name of thresher	Throughput capacity (kg/hr)	Threshing capacity (kg/hr)	Grain moisture content (%) (wb)	Straw moisture content (%) (wb)	Chaff present (%)	Straw cleaning time (hr)	Threshing drum peripheral speed (m/s)
MAWTS	377.69	169.4	22.7	67.34	22.26	2.61	487
BRRI	734.14	337.77	27.9	72.2	17.30	2.54	426
Boby	692.44	338.70	25.6	70.9	16.62	2.33	332
Farida	756.47	359.01	24.27	69.5	24.17	3.25	455

Throughput capacity

Throughput capacity of 378 kg/hr, 734 kg/hr, 692 kg/hr and 757 kg/hr were obtained from MAWTS, BRRI, Boby and Farida open-drum thresher models, respectively (Table 2). Throughput capacity was also varied significantly from MAWTS at 1 percent level of significance. But, there was no significance variation in the throughput capacities of BRRI, Boby and Farida open drum thresher models. Highest throughput capacity was obtained from Farida model and lowest was obtained from MAWTS model.

Threshing capacity

Threshing capacity of 169 kg/hr, 338 kg/hr 339 kg/hr and 359 kg/hr were obtained from MAWTS, BRRI, Boby and Farida open-drum thresher models, respectively (Table 2). Threshing capacity of BRRI, Boby and Farida models significantly differed from MAWTS model at 1percent level of significance. This was due to longer length of the thresher and excess two labourers were involved during the operation. Highest threshing capacity was obtained as 359 kg/hr from Farida model, which was 119 percent higher than MAWTS model. The threshing capacity did not differ significantly among the BRRI, Boby and Farida models. Table 2 shows that the threshing capacity decreases beyond the mentioned moisture content level. Higher moisture content reduces threshing capacity because of the requirement of more impact force; therefore, more grains would remain un-threshed. Experimental results showed that at 16.5 percent moisture content of paddy provide maximum threshing capacity and minimized losses (Dash and Das, 1989).

Presence of chaff and cleaning time

The threshing operations of MAWTS, BRRI, Boby and Farida open-drum thresher models produced 22.26, 17.30, 16.62 and 24.17 percent chaffs with threshed grain, respectively (Table 2). Highest chaff was found from Farida model as 24.14 percent and lowest from MAWTS model as 16.62 percent. Chaff present in threshed grain during the threshing operation depends on operators, straw-grain ratio, moisture content in stalks, rotating speed of the threshing drum and late threshing after harvest etc. The time required for cleaning the chaffs from output depends on the amount of chaff present in the threshed grain. Highest chaff cleaning time was recorded for

Farida model as 3.25 hr/ton and the lowest for Boby model as 2.33 hr/ton. Production of chaff and time required for cleaning it is one of the major constraints of open-drum thresher operation.

Threshing losses and threshing efficiency

Cylinder loss, separating loss, spilled grain loss and gross threshing loss of selected open-drum threshers were expressed in percentage. During performance test, no damaged or cracked grains, nor separating loss were found for the selected open-drum threshers. Losses for manual and selected open-drum threshers are compared and shown in Table 3. Cylinder loss of MAWTS model was found lowest (1.70 percent) among the selected open-drum threshers, on contrast Boby model registered highest (2.23 percent) cylinder loss. Cylinder loss for BRRI and Farida models were found 1.81 and 2.06 percent, respectively. Spilled grain losses of MAWTS, BRRI, Boby and Farida models were found 0.39, 0.35, 0.35 and 0.33 percent, respectively. The gross grain loss was the combination of cylinder loss and spilled grain loss as separating and damaged grain losses were found zero. Gross threshing losses were found 2.09, 2.16, 2.39 and 2.58 percent for MAWTS, BRRI, Farida and Boby open-drum thresher models, respectively. These figures are much higher in comparison to 1.43 percent loss incurred by BRRI open-drum thresher during T. Aman season (Zami, 2000). Reasons behind this high gross threshing loss was identified as high grain and straw moisture content of 25.12 and 69.98 percent, respectively and delay in threshing after harvest. Due to high moisture content and delay in threshing some of the grains sprouted and incurred heavy loss of grains. However, these losses were much lower than that of manual threshing which was about 7 percent (Table 3). The mean threshing efficiency of the selected MAWTS, BRRI, Farida and Boby models were found 98.3, 98.2, 97.94 and 97.76 percent, respectively.

Table 3. Mean grain losses of different models of open-drum thresher

Thresher's name	Cylinder loss(%)	Spilled grain loss (%)	Gross threshing loss (%)	Threshing efficiency (%)	*Manual threshing loss (%)
MAWTS	1.703	0.387	2.09	98.30	
BRRI	1.807	0.353	2.16	98.20	7.09
Boby	2.23	0.35	2.58	97.76	
Farida	2.06	0.33	2.39	97.94	
CV (%)	12.27	6.67	9.7	0.24	.
Level of significance			**	**	–

***Source: BRRI (1999, unpublished data)**
**** Significant at 1% level**

Labour and Power Requirement

The Farida and BRRI open-drum threshers required the lowest amount of labour (16.71 man-hr/ton) and power (10.89 kW-hr/ton), respectively (Table 4). On the other hand MAWTS open-drum thresher required highest amount of labour (23.61 man-hr/ton) and power (21.72 kW-hr/ton). Labour requirement of BRRI open-drum thresher was almost similar to that of the Boby open-drum thresher. But power requirement of BRRI open-drum thresher was significantly lower to that of Boby open-drum thresher. As in the case of power consumption, the BRRI open-drum thresher required the least amount of power 10.89 kW-hr/ton. Thus, the BRRI open-drum thresher appeared to be the best for threshing paddy considering the scarcity of both labour and power.

Table 4. Labour and power requirement of different models of open-drum thresher

Name of thresher model	Number of labour	Engine power (kW)	Threshing capacity (ton/hr)	Labour requirement (man-hr/ton)	Power requirement (kW-hr/ton)
MAWTS	4	3.68	0.1694b	23.61	21.72
BRRI	6	3.68	0.338a	17.75	10.89
Boby	6	4.48	0.339a	17.70	13.21
Farida	6	4.48	0.359a	16.71	12.48
CV (%)	18.18	0.687	10.14	16.62	33.35
Significance	*	*	*	*	ns

Economic Performance

Operating cost

Operating cost incurred from MAWTS, BRRI, Boby and Farida model were 416.84 Tk/ton, 294.03 Tk/ton, 283.57 Tk/ton and 265.79 Tk/ton, respectively (Table 5). Operating cost of MAWTS model was higher than other three models.

Table 5. Economic parameters of different open-drum threshers and manual threshing

Name of the Thresher	Operating cost (Tk/ton)	Operating cost (Tk/hr)	Cost of threshing loss (Tk/hr)	Threshing cost (Tk/hr)	Threshing cost (Tk/ton)	Threshing cost (Tk/ha)	Gross Revenue (Tk/hr)	Benefit – cost ratio	Gross Margin (Tk/hr)	Net Margin (Tk/hr)
MAWTS	416.84a	70.70	24.78	95.48	564	2594.4	126.37	1.32	39.64	30.89
BRRI	294.03b	98.79	51.1	149.89	445	2047	211.62	1.41	73.03	61.73
Boby	283.57b	95.14	61.11	156.25	461	2120	205.11	1.31	56.51	47.76
Farida	265.79b	95.14	60.06	155.20	432	1987.20	216.27	1.40	66.06	61.04
Manual	474.20	31.25	32.69	63.94	970.26	4463.2	65.22	1.02	1.28	1.28

Threshing cost

The threshing cost of MAWTS, BRRI, Boby and Farida open drum model were found 564, 445, 461 and 432 Tk/ton, respectively (Table 5). The threshing cost of Farida, BRRI and Boby models were similar but significantly lower in compare to Manual threshing and MAWTS model. Considering the cost of threshing in terms of Taka per hectare, the cost of threshing of Farida model (1987.20 Tk/ha) was found significantly lower in comparison to other types of open drum threshers and manual threshing. The threshing cost of Farida, BRRI and Boby model were found almost same and appeared economic.

Benefit-Cost Ratio

The Benefit-Cost ratio of BRRI model (1.41) and Farida model (1.4) were found almost same, whereas MAWTS (1.32) and Boby (1.31) models were almost similar and much higher than manual (1.02) threshing (Table 5). The highest benefit-cost ratios were found for BRRI (1.41) and Farida (1.4) models, respectively. Considering all the economic parameters of the different open drum models, Farida model might appear as the better option for Bangladeshi farmers.

Gross Margin (GM) and Net Margin (NM) for different open drum threshers

After thorough calculation of Gross Margins and Net Margins with appropriate assumptions and considerations the results are shown in Table 5. It can be seen that Gross Margins of different types of open-drum threshers namely MAWTS, BRRI. Boby, Farida model open-drum threshers and manual threshing were found 39.64, 73.03, 56.51 , 66.06 and 1.28 Tk/hr, respectively. The Gross Margin of BRRI open-drum thresher (73.03 Tk/hr) was found significantly greater in comparison to other types of open-drum threshers and manual threshing (1.28 Tk/hr) appeared as the lowest.

Partial Budgets for substitution

The Gross Margin and Fixed cost data of different types of open-drum threshers obtained from previous calculation (Table 5) were used in Partial Budget format and the results were presented in Table 6. It can be seen from Table 6 that for different types of open-drum threshers, the substitution of manual threshing by MAWTS, BRRI, Boby and Farida open-drum threshers had ended with net gains, but BRRI open-drum thresher appeared as most impressive one. The inclusion of timeliness of operation may also increase the net gain figures of BRRI open-drum thresher, especially in case of medium to large holdings. Again substitution of Boby and Farida open-drum threshers by BRRI open-drum thresher had ended with net loss. The substitution proposition by partial budget analysis showed that the BRRI open-drum thresher was the most suitable threshing technique, which could replace the existing open-drum threshers.

Table 6. Substitution proposition by Partial Budget

	MAWTS	BRRI	Boby	Farida
Manual Threshing	**Net gain** 26.61 Tk./hr	**Net gain** 60.45 Tk/hr	**Net gain** 50.21 Tk/ hr	**Net gain** 59.76 Tk/ hr
MAWTS		**Net gain** 33.84 Tk/ hr	**Net gain** 20.6 Tk/ hr	**Net gain** 33.15 Tk/ hr
BRRI			**Net loss** 10.24 Tk/ hr	**Net loss** 0.69Tk/hr
Boby				**Net gain** 9.55 Tk/ hr

The results of break-even analysis are presented in Figures1and 2. The cost of manual threshing was estimated considering the present wages level in Bangladesh, which was Tk 100 per day. Manual threshing cost also included hiring charge for animal at the rate of Tk 50 per animal per day and price for grain losses during manual threshing.

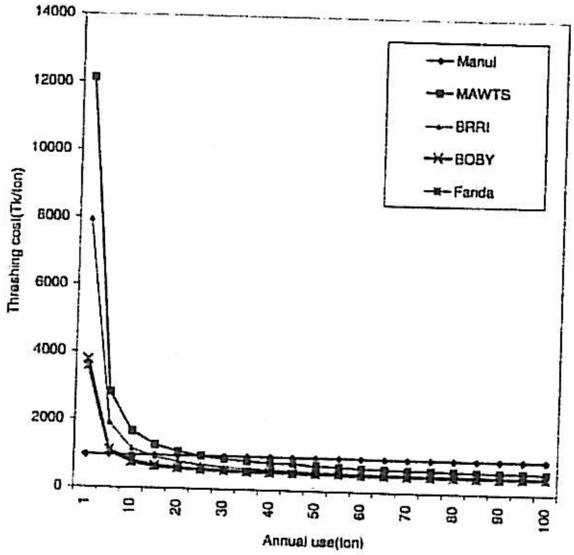

Fig.1. Threshing cost (Tk/ton) of different ODT models compared to manual threshing in different levels of use

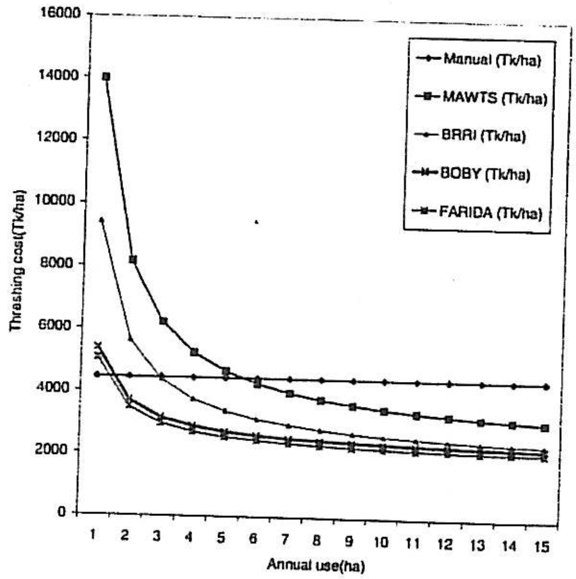

Fig.2. Threshing cost (Tk/ha) of different open drum thresher compared with manual threshing

Fig-1 showed that a farmer having only one ton of paddy had to incur a threshing cost of Tk 12134, Tk 7938, Tk 3781 and Tk 3564 per ton, respectively, when MAWTS, BRRI, Boby and Farida models were used, and the cost of manual threshing was Tk 970 per ton. With the increase of annual use (of threshed paddy), the cost of mechanical threshing decreased rapidly upto tons. Reduction in threshing cost was only slight above 10 ton/yr. At the yearly use level of 7, 7.5, 17 and 22 tons, the costs of Farida, Boby, BRRI, MAWTS models and manual threshing were the same (Fig.1.). Therefore, threshing with Farida and Boby open-drum thresher models could be beneficial to the farmer, when the annual use is exceeded 7-7.5 tons of paddy. On the other hand, when the annual use level is less than 1 hectare, the farmer should continue with the existing manual threshing method.

Fig-2 showed that a farmer having only one hectare of land had to incur a threshing cost of Tk 13977, Tk 9415, Tk 5389 and Tk 5070 per hectare, respectively, when MAWTS, BRRI, Boby and Farida models were used, and the cost of manual threshing was Tk 4463 per hectare. With the increase of annual use (of land), the cost of mechanical threshing decreased exponentially from 1-6 ha, and after than reduction in threshing cost was only slight. At the yearly use level of 1 hectare, 1.2 hectares, 2.5 hectares and 5.5 hectares the costs of Farida, Boby, BRRI, MAWTS models and manual threshing were the same (Fig.2.). Therefore, threshing with Farida and Boby open-drum thresher models could be beneficial to the farmer when the annual use exceeded 1-1.2 hectares. On the other hand, when the annual use level is less than 1 hectare, the farmer should continue with the existing manual threshing method.

CONCLUSIONS

Considering timeliness of post-harvest operations, cost of threshing, labour crisis at peak harvesting and threshing period, unavailability of animal for traditional threshing (treading), drudgery of manual threshing, simplicity of design and price of mechanical threshers, open-drum threshers are becoming popular among the farmers and substituting traditional threshing options.

The Farida open drum thresher model registered the highest threshing (359 kg/hr) and throughput (757 kg/hr) capacities. All other selected open drum thresher models also provided substantially higher threshing and throughput capacities over manual threshing. Among the four different open drum thresher models, Farida model was appeared as appropriate one considering the socioeconomic and agro-technological conditions of Bangladesh.

Considering operating cost and benefit-cost ratio, Farida and BRRI model open drum threshers appeared as better options for the farmers compared to Boby and MAWTS models, though cylinder loss was high in Farida and BRRI models than MAWTS model. However, the substitution proposition by Partial Budget analysis clearly showed the economic profitability of BRRI model over the entire open drum models. But from the break-even analysis, the Farida and Boby model open drum threshers were found economical for the farmers of Bangladesh having even very smaller land holding of 1 ha. The BRRI model was also found profitable for farmers having up to 2.5 ha of land. Therefore, considering the financial aspects, Farida and Boby model open drum threshers may be recommended for all categories of farm holdings of Bangladesh to minimize threshing cost, improve timeliness of post-harvest operation and overcome labour crisis at the peak period of harvesting and as well as threshing.

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