J. Bangladesh Agril. Univ. 2(1): 165–174, 2004 ISSN 1810-3030

Selection of economic machines for modern rice cultivation in Bangladesh

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Abstract

The main purpose of the study included appraisal of financial profitability and selection of economic set of machines and implements for tilling to threshing operations in modern rice cultivation. Secondary data from various sources were used in this piece of research. Some essential data were collected from primary sources through baseline survey. Operating costs were calculated and financial profitability was determined by three major on farm financial measurement techniques namely, Benefit-cost ratio, Gross and Net margin and Partial budget analysis. Among available machines used for modern rice cultivation in Bangladesh Power tiller, BAUZIA seed fertilizer distributor, Shallow tube well (STW), Knapsack Sprayer, Push Pull Weeder, Reaper and Open drum 00thresher were found suitable for tilling, fertilizer application, irrigation, spraying, weeding, harvesting and threshing operations, respectively.

Keywords: Economic Machines, Rice Cultivation, Benefit-Cost ratio, Gross and Net margin, Partial budget, Bangladesh

Introduction

Bangladesh is a developing country belonging to the third world. More than 78 percent of her population lives in the villages (BBS, 2001) and agriculture is the major occupation of the people. The future economic development of the country will depend largely on the progress made and goals achieved in the agricultural sector during the next decade. Agricultural sector of Bangladesh produced 32 percent of GDP (Gross Domestic Product) and it earned 24 percent of foreign exchange by exporting various agricultural commodities during 1996-97 (Planning Commission, 1998). Bangladesh has a population of 123.8 millions which has doubled in the last 27 years despite a decline in population growth rate of 1.75 percent per annum. Population density is currently about 875 persons per square kilometer (Planning Commission, 1998). Area under rice cultivation is 75.03% of total cultivated area which indicates that rice is major crop in Bangladesh. Total rice production in 2001 was 25.085 million metric tons, whereas in 2000 it was 23.067 million metric tons. The rice production increase in one year was 2.018 million metric tons (BBS, 2001). Despite the high population rise Bangladesh is emerging as a self-sufficient country in cereal production. To sustain this achievement selective mechanization of crop production operations, such as land preparation, irrigation, intercultural operations, harvesting, threshing and post-harvest processes are desirable.

Proper machinery and power selection is an important part of machinery management. The main aim of power and machinery selection studies is to complete a certain field operation during a specified time and at a minimum total cost (Ghassan *et al.*, 1986).The selection of technology is of prime importance for modern farm machinery that will improve timeliness in farm operation and facilitate farm expansion where land is available. Gradual evolution of agricultural mechanization from hand-tool technology through animal draught technology (where appropriate) to engine power technology is based on a careful analysis of the situation for which a programme of agricultural development is being planned. The key to progress is the identification and application of the appropriate and economic machines for individual farmers. Farmers have options for the selection of machines and implements from tilling to threshing for the rice production. For sustainability of machines and implements it should be economically viable for different farm holdings. Therefore, selection of economic set of machines from tilling to threshing for different farm sizes, cost of operations, farmers access to alternative machines and implements were felt important for sustainable mechanization in Bangladesh. In view of the urgent need for proper understanding of the situation, a study was felt necessary to select appropriate set of machines and implements for rice based farm holdings of Bangladesh.

At present Bangladesh is thriving as self-sufficient in cereal production. To sustain this development, mechanization is inevitable. Appropriate mechanization strategy formulation is an urge of the time for efficient use of agricultural machines and implements available at farmers' level. It is expected that the findings of this study would be helpful for the farmers involved in rice based crop production to select appropriate options for machines and implements, thereby speed up the agricultural mechanization in Bangladesh. Considering the problem stated above the specific objective was formulated to appraise the financial profitability of different technological options for rice based farm operations.

Methodology

The concept of selective agricultural mechanization primarily deals with the choice of power sources and associated implements or machinery for farm operations. Proper selection of suitable machinery is crucial to the profitability of farm considering the cost of owning and using. Therefore, economic selection of agricultural machinery is usually a complex problem because of the variations in farm sizes and differences in agro-climatology. Thus a methodology is developed in this study to assist in evaluating and selecting appropriate set of machines for mechanization of rice based farms in terms of economic benefit of the farmers. In this piece of research three major on farm financial measurement techniques namely Benefit-Cost ratio, Gross and Net Margin and Partial Budget analysis were included for determining the economic machinery options based on the financial profitability of modern rice production system.

Data Collection

Secondary data from various sources were used in this piece of research. The main sources of data were from the traders of Tractors, Power tillers and machines, the logbook of Bangladesh Agricultural University farm, Journals, published and unpublished reports and theses. Significant information was sorted out from several sources. Some essential data were collected from primary sources through a baseline survey for this purpose. The data were verified by the specialists in the relevant field.

Operating Cost of Machines

Annual machinery operating cost consists of fixed cost and variable cost, and was calculated as:

OC = Fixed cost + variable cost
Where, OC = operating cost, Tk./ha

For manual farm operations, the annual fixed cost was considered as zero since the farmer or the labourer owns the hand tools. The fixed cost of hand tools was therefore considered as the part of labour cost and the annual operating cost (Tk/ha) was determined as the product of number of man-days and labour rate.

Fixed cost

The fixed cost is dependent on calendar year time and consists of depreciation, interest on investment, taxes, insurance and shelter and is independent of use. Fixed costs are fixed in total, but decline per ha, as the annual use of the machine is increased (Barnard & Nix, 1979). A straight-line depreciation was assumed and calculated as follows:

i) Annual depreciation, $D = \frac{P - S}{L}$

Where,

D = Depreciation, Tk/yr
P = Purchase price of machine or implement, Tk
S = Salvage value, Tk
L = Life of machine or implement, yr.

The interest on investment in a farm machine was included in fixed cost estimation. Even if the investment money was not actually borrowed, a charge was made since that money was not used for some other interest paying enterprises. The following equation was used for the calculation of interest on investment.

ii) Interest on investment, $I = \frac{P + S}{2} \times i$

Where,

i = Interest rate, Percentage.

Variable cost

The variable cost is one which changes when the level of output alters. Variable costs vary in total in proportion to annual use, but are approximately constant per ha (Barnard & Nix, 1979). Variable cost depends on hourly labour, fuel, oil, repair and maintenance cost and the required working hours for each field operations. The cost of operator/labour was the labour rate in Tk/hr. The fuel and oil cost was estimated from consumption rate and multiplied by their respective prices.

Gross output

Gross output or Gross revenue is one which a farmer earns through renting of the machine to user. Different sets of factors were considered in calculating the Gross revenue of different operations. For Tilling, Irrigation and Spraying only hiring rate were considered, but for threshing different set of factors were considered and calculated as follows:

Traditional Threshing

Gross output = Labour rate (Tk/ha) + Hiring rate of Bullock (Tk/hr)

Pedal, Open Drum and Power Threshing

Recent studies (Zami, 2000; Alam *et al.*, 2002) revealed that the modern threshing techniques of rice such as Pedal, Open drum and Power threshing reduced the threshing loss of grain from 7% to approximately 2% as compared to traditional manual threshing and registered a grain saving of 5%. Therefore, the cost of saved grain was accounted in gross revenue calculation and a significant effect on gross output was observed. The gross output was calculated from the hiring rate (including labour) of the threshing machine and the price of saved grain in contrast to manual threshing loss.

Percentage of grain loss saved = loss of grain in manual operation – loss of grain of respective threshing method

Grain saved in kg/hr = grain loss saved in percentage × threshing capacity (kg/hr)
Price of saved grain = grain saved (kg/hr) × price (Tk/kg)
Gross output = Hiring rate (including labour) + Price of saved grain

Benefit-cost ratio

Benefit-cost ratio (B/C) is defined as the ratio of benefits to costs (expressed either in present or annual worth). The method of benefit-cost analysis is simple in principle, but considered as a systematic approach for selecting economic investment alternatives. The Benefit-Cost ratio above unity indicates the economic viability of the enterprise in question.

$$\text{B/C ratio} = \frac{\text{Benefits (Tk./ha)}}{\text{Costs (Tk./ha)}}$$

Gross Margin (GM) and Net Margin (NM)

The Gross Margin (GM) of an enterprise is its enterprise output (revenue) less its variable costs and the Net Margin (NM) is the enterprise Gross Margin less its fixed costs. The Gross and Net Margins are the simple way to measure the relative profitability of an enterprise. It can be used for planning changes in an enterprise, to take an account of possible changes in production price and the effect of changes in production technologies.

Gross Margin (Tk/ha) = [Gross output] – [Total variable cost + Amount of threshing loss]
Amount of threshing loss = Grain loss × Unit price of Grain
Net Margin (Tk/ha) = [Gross Margin] – [Fixed costs]

Partial budget (PB)

Partial budgeting is a marginal analysis which attempts to determine the changes in inputs, outputs, costs, revenues and profits associated with proposed changes in action, where this action does not affect the overall structure and performance of the enterprises. In other words, it looks at the Marginal or partial changes. The effect of a partial budget is that it compares the cost of change with the benefits of change by examining the impact of that change as net income. Hence, the partial budget technique becomes a major decision making tool, allowing the user to assess the implementation of alternative courses of action.

The changes in Gross Margin for different methods and their fixed costs, the net gain or less incurred and the substitution options were calculated as follows:

Cost of changes	Benefits of changes
GM Lost :	**Extra GM :**
Expected GM of the existing system	Expected GM of the alternative system
Extra fixed costs :	**Fixed costs saved :**
Estimated new fixed cost	Estimated reduction of fixed costs
Total costs (X)	Total benefits (Y)
Net gain (Y>X)	**Net Loss (X>Y)**

Source: Alam (1997)

Results and Discussion

Until recently, rice production in Bangladesh was mostly traditional with a very limited mechanical intervention. Irrigation of crops was the only exception, which got due attention of farmers. In last decade, integrated effort of Govt. and Private sectors on achieving self-sufficiency in cereal production has resulted in an increase in cropping intensity and change in cropping pattern. As a result, Timeliness in rice production activities, such as tilling, irrigation, application of fertilizer, pesticides and insecticides, weed control, harvesting and threshing have become important and demand appropriate mechanical intervention. At present farmers' have few alternatives in each of the rice production activities and need to be selective among the machinery options based on the economic profitability. Selection of machinery is a crucial process and depends on many factors, such as size of machine and power source, size of land holdings, cropping pattern and intensity, agro-climatic conditions, skill and service related to the machine etc. Considering the existing condition of crop production, three on farm financial measurement techniques were employed namely Benefit-Cost ratio, Gross and Net Margin and Partial budget analyses for measuring the economic profitability of the alternative machine. The results are presented and discussed in the subsequent sections to select appropriate sets of machines for modern rice cultivation in Bangladesh.

Tilling Options

Operating cost, Gross Margin (GM) and Net Margin (NM): The operating costs, gross margins and net margins of different tilling options were calculated with appropriate assumptions and considerations, and are shown in Table 1. The operating cost of power tiller tilling was found as the lowest 528 Tk/ha compared to draught animal power (DAP) and tractor, 2154 and 774 Tk/ha, respectively.

It can be seen from Table 1 that the gross margin of the tractor tilling was marginally greater than that of the gross margin of the DAP and PT tilling. However, the net margin of the PT tilling was found greater than that of the DAP and the tractor tilling. This was because of hired fixed cost incurred by the DAP and tractor. The fixed costs of each option (DAP, PT and tractor) had been calculated as the products of fixed cost per hour and the operating hours per hectare. The logic behind this calculation was that the farmers who own DAP, PT or tractors usually hired out the extra Capacity. The fixed costs were spreaded over the full capacity and unit fixed cost became less. It was considered that as long as the full capacity of the draft cattle, power-tillers and tractors were utilized, the GMs and NMs appeared as positive otherwise it might be negative at smaller farm levels. In Bangladesh, farmers do not consider their own labour and resources used as inputs in calculating margins. As a result, they may find better margin compare to this study. The low gross and net margins of different farms were due to the lower level of technology and energy input and the poor management practices in Bangladesh agriculture.

Table 1. Operating Cost, Gross Margin (GM), Net Margin (NM) and Benefit-Cost ratios of different tilling options

		1	2	3=2+1	4	5=4-2	6=5-1	7=4/3
		Total Fixed cost (Tk/ha)	Total Variable cost (Tk/ha)	Operating cost (Tk/ha)	Gross Revenue (Tk/ha)	Gross Margin (Tk/ha)	Net Margin (Tk/ha)	Benefit-Cost ratio (B/C)
Land Preparation	Country Plough	154	2000	2154	2600	600	445	1.21
	Power Tiller	81	447	528	1976	1529	1448	3.74
	Tractor	220	554	774	2100	1546	1326	2.71

Benefit-cost ratio: It can be seen from Table 1 that the benefit-cost ratio of power-tiller (3.74) was higher than that of Tractor (2.71) and much higher than country plough (1.21) in tilling options. In the present context power tiller for tilling was found economically suitable for the farmers.

Partial budget: The GM and the fixed cost data of DAP, PT and tractor tilling obtained from Table 1 were used in partial budget format and the results are presented in Table 2. It could be seen from Table 2 that the substitution of DAP and Tractor by PT has ended with net gain. So, the proposed change was found worthwhile, as long as the prevailing situation remains unchanged.

Table 2. Partial budget for substituting DAP and Tractor by PT

	Benefit of change for PT (Tk/ha)		Total benefits for PT (Tk/ha)	Cost of Change for PT (Tk/ha)		Total costs for PT (Tk/ha)	Net gain for PT (Tk/ha)
	Extra GM	Fixed cost saved		GM lost	Extra fixed cost		
DAP	1529	154	1683	600	81	681	1002
Tractor	1529	220	1749	1546	81	1627	122

Fertilizer Application Options

Operating cost: The operating costs of Manual distribution and BAUZIA seed-fertilizer distributor were found to be 741 and 38 Tk/ha, respectively. Considering the cost, uniformity of seed and fertilizer distribution, time economy and performance BAUZIA seed-fertilizer distributor was found convenient for the farmers.

Irrigation Options

Operating cost, gross margin (GM) and net margin (NM) : The operating cost of the selected irrigation options dependent on various factors such as, market price of fuel, oil, spare parts, daily labour, government policy e.g. tariff rates; command area efficiency; social factors e.g. ownership, management etc. The operating cost of DTW and STW are presented in Table 3. The operating cost of STW and DTW were found 1486 and 1442 Tk./ha respectively. The operating cost of STW was found slightly higher than DTW.

Table 3. Operating cost, Gross Revenue, Gross Margin (GM) and Net Margin (NM) of different irrigation methods

		1	2	3=2+1	4	5=4-2	6=5-1	7=4/3
		Total Fixed cost (Tk/ha)	Total Variable cost (Tk/ha)	Operating cost (Tk/ha)	Gross Revenue (Tk/ha)	Gross Margin (Tk/ha)	Net Margin (Tk/ha)	Benefit-Cost ratio (B/C)
Irrigation	STW	35	1451	1486	5434	3983	3948	3.66
	DTW	134	1308	1442	4940	3632	3498	3.43

For comparison purpose GM and NM were calculated with appropriate assumptions and consideration for STW and DTW and are presented in Table 3. The GM analysis revealed that the GM of STW was found higher than that of DTW because of increased output at higher rate than the variable cost.

The NM analysis depicted that STW performed better than DTW. This was because of higher fixed cost incurred by DTW compared to STW. If the extra capacity of STW engines as used to other purposes could provide an edge to STW users. Moreover, management of irrigation methods played an important role in profit making. Therefore, proper care is needed for utilizing full capacity of DTW and STW along with its management.

Benefit-cost ratio: The benefit-cost ratio of STW (3.66) was found slightly higher than that of DTW (Table 3). This method was found economically suitable for the farmers. Again, the engine used to power STW could be used in other agricultural operations, which further reduced the cost of operation.

Partial budget: The GM and fixed cost data of DTW and STW obtained from previous calculation were used in partial budget format to take substitution decision. The partial budget revealed that the substitution of DTW by STW ended with net gain. The proposed change is worthwhile as long as the prevailing situation remains unchanged.

Table 4. Partial budget for substituting DTW by STW

	Benefit of change for STW (Tk/ha)		Total benefits for STW (Tk/ha)	Cost of Change for STW (Tk/ha)		Total costs for STW (Tk/ha)	Net gain for STW (Tk/ha)
	Extra GM	Fixed cost saved		GM lost	Extra fixed cost		
DTW	3983	134	4117	3632	35	3667	450

In the pretext of market economy both the government and donor agencies turned against subsidies on fuel, oils, DTW installation and maintenance etc. As a result operation, adequate provision of spare parts and major repair facilities for existing DTW engines and pumps had been concern of DTW users. In this stead STWs were overtaken the place of DTWs and became the most important irrigation technology of Bangladesh. So, the question of substitution decision of DTW by STW is major concern of the specialists and the users. Though, this purely economic study advocate substitution decision of DTW by STW, but the area specific situation might encourage the use of DTW, especially where ground water table is beyond the reach of STW.

Spraying Options

Operating cost, gross margin (GM) and net margin (NM): With appropriate assumptions and considerations the operating costs of different spraying options are shown in Table 5. The operating cost of Hand sprayer, Compression sprayer and Knapsack sprayer were found 428, 319 and 261 Tk./ha, respectively. Time economy in operation is one of the important objective of mechanization. Field capacity of knapsack sprayer (0.06 ha/hr) was found significantly higher in compared to other spraying methods. Hand sprayer and compression sprayer required more time and physical labour. Therefore, in terms of time requirement, cost and capacity, knapsack sprayer appeared as better option for the farmers.

Table 5. Operating cost, Gross Margin (GM), Net Margin (NM) and Benefit-cost ratio of spraying options

		1	2	3=2+1	4	5=4-2	6=5-1	7=4/3
		Total Fixed cost (Tk/ha)	Total Variable cost (Tk./ha)	Operating cost (Tk/ha)	Gross Revenue (Tk/ha)	Gross Margin (Tk/ha)	Net Margin (Tk/ha)	Benefit-Cost ratio (B/C)
Spraying	Hand Sprayer	11.47	417	428	460	43	32	1.07
	Compression Sprayer	37	313	349	450	138	101	1.29
	Knapsack Sprayer	52	208	261	400	192	139	1.53

The calculated gross margins and net margins of different spraying options are show in the Table 5. The gross margin of the Knapsack sprayer was found significantly greater in compared to other (Table 5). As the output was near about similar for different spraying options, the difference of gross margin was because of difference in the variable costs. Net margin of knapsack sprayer (139) was found also higher compared to other options (Table 5). From the view point of operating cost, capacity, gross margin and net margin knapsack sprayer was found economic among the options.

Benefit-cost ratio: It can be seen from Table 5 that the benefit-cost ratio of knapsack sprayer (1.53) was slightly higher than that of hand sprayer (1.07) and compression sprayer (1.29).

Partial budget: The gross margin and fixed cost data of different spraying methods shown in Table 5 had been used in partial budget format and the results are presented in Table 6. Table 6 revealed that among spraying options, the substitution of hand sprayer by compression sprayer and knapsack sprayer had ended with net gain, but knapsack sprayer appeared as more impressive. The inclusion of timeliness of operation may also increase the net gain figures of knapsack sprayer, especially in case of large holdings. Again substitution of knapsack sprayer by compression sprayer had ended with net loss. The substitution proposition by partial budget analysis showed that the knapsack spraying was the most suitable spraying technique, which could replace the existing spraying options.

Table 6. Substitution proposition by partial budget for spraying options

	Compression Sprayer	Knapsack Sprayer
Hand Sprayer	Net gain (68.75 Tk/ha)	Net gain (107.54 Tk/ha)
Compression Sprayer		Net gain (38.75 Tk/ha)

Weeding Options

Operating cost: The operating cost of manual weeding and Push-Pull Weeder were found 2600 and 1255 Tk/ha, respectively, and the use of Push-Pull Weeder was found beneficial compared to manual weeding.

Harvesting Options

Operating cost: The operating cost of manual harvesting and mechanical reaper was found 3705 and 223 Tk/ha, respectively. In addition to the huge advantage in operating cost, capacity, timeliness of operation and reduction of human drudgery provides substantial advantage of mechanical reaper over manual harvesting.

Threshing Options

Threshing cost, gross margin (GM) and net margin (NM): With appropriate assumptions and considerations the components of threshing cost, Gross and Net Margins were calculated, and are shown in the Table 7. The threshing cost of traditional threshing, pedal threshing, open-drum power threshing and power threshing were found 3825, 1783, 1569 and 1873 Tk./ha, respectively. The operating cost of open drum threshing was found lower in compare to other threshing options and the operating cost of traditional threshing was found highest among the threshing options. Throughput capacity of an open drum power thresher (405 kg/hr) was found significantly higher in compared to other threshing options, and traditional threshing (52 kg/hr) appeared as the lowest. As a slow manual process, traditional threshing required more time and cost for the threshing operation.

Time economy of threshing operation is one of the important objective of mechanization, as turnaround period between two successive crops is limited. In irrigated areas having two cropping seasons, harvesting of first crop is very close to the land preparation of the second. In this situation, the harvesting operation needs to be done very quickly in order to catch up the planting season of the next crop. But, traditional threshing and pedal threshing require more time and physical labour. Therefore, from the view point of time requirement, control, threshing cost and capacity, open drum threshing might appear as best option for the farmers.

The calculated gross margins and net margins of different threshing options are shown in the Table 7.The gross margin of the open drum threshing (1922 Tk./ha) was found significantly superior among the options.The gross margin of pedal threshing (1730 kg/ha) and power threshing (1614) were almost similar and the gross margin of traditional threshing (-113 Tk./ha) was the lowest and also incured loss. The output varied for different threshing options, therefore, the difference in gross margin was because of difference in the variable costs and cost of threshing losses. Net margin of open drum power threshing (1896 Tk/ha) was found significantly higher in compared to other options (Table 7) Net margin of traditional threshing (-621 Tk/ha) appeared lowest in compared to other options at large extent.

The timeliness factor was not considered in calculating gross margin and net margin of these threshing options. The fixed cost of traditional threshing was found much higher, that lead the net margin to a minimum. When timeliness of operating is taken into account, this method might not found suitable for Bangladesh agriculture. The throughput capacity of open drum threshing was found significantly higher in compared to other threshing options along with impressive net margin. Therefore, when timeliness of operation is considered the open-drum power threshing might appear as the most suitable threshing option for the farmers.

Table 7. Threshing Cost, Gross Margin (GM), Net Margin (NM) and Benefit-cost ration of different threshing options

		1	2	3=2+1	4	5=4+3	6	7=6-(4+2)	8=7-1	9=6/5
		Total Fixed cost (Tk/ha)	Total Variable cost (Tk./ha)	Operating cost (Tk/ha)	Threshing loss cost (Tk/ha)	Threshing cost (Tk/ha)	Gross Revenue (Tk/ha)	Gross Margin (Tk/ha)	Net Margin (Tk/ha)	Benefit-Cost ratio (B/C)
Threshing Method	Traditional Threshing	508	1082	1590	2235	3825	3204	-113	-621	0.84
	Pedal Threshing	47	1078	1125	657	1783	3465	1730	1683	1.94
	Open Drum Threshing	26	885	911	658	1569	3465	1922	1896	2.21
	Power Threshing	167	918	1085	788	1873	3320	1614	1447	1.77

Benefit-cost ratio: The benefit-cost ratio of open-drum threshing (2.21) was found slightly greater than that of pedal threshing (1.94), power threshing (1.77) and much higher than traditional threshing (0.84) (Table 7). Therefore, the open-drum threshing is economically suitable for the farmers. Again, the engine used in open drum power threshing could be used in other agricultural operations, which could further reduce the cost of operation of this option.

Partial budget: The gross margins and fixed cost data of different threshing options shown in Table 7 had been used in partial budget format and the results are presented in Table 8. It can be seen from Table 8 that for all different threshing options, the substitution of traditional threshing by pedal threshing, open-drum threshing and power threshing had ended with net gains, but open-drum power threshing appeared as the most impressive one. The inclusion of timeliness of operation may also increase the net gain figures of open-drum power threshing, especially in case of large holdings. Again substitution of open-drum power threshing by power threshing had ended with net loss. The substitution proportion by partial analysis showed that the open-drum power threshing was the most suitable threshing technique, which could replace the existing threshing options.

Table 8. Substitution proposition by partial budget for threshing options

	Pedal threshing	Open-drum power threshing	Power threshing
Traditional threshing	Net gain 2303 Tk/ha	Net gain 2517 Tk/ha	Net gain 1727 Tk/ha
Pedal threshing		Net gain 213 Tk/ha	Net loss 235 Tk/ha
Open-drum power threshing	Net loss 213 Tk/ha		Net loss 449 Tk/ha

Conclusions

The financial profitability of different technological options was verified through important economic analyses in order to appraise the economic machines for different activities of modern rice cultivation in Bangladesh condition. Based on the above discussion the following conclusions were made.

1. Among tilling options, Power tiller was found to be the most economic one followed by tractor and bullock drawn country plough. The result was confirmed by gross and net margins, Benefit-cost ratio and Partial budget analysis.
2. Seeding and transplanting of rice was found manual and options for alternative are yet to adopt in Bangladesh condition.
3. BAUZIA fertilizer distributor was found significantly superior over manual operation for application of seed and fertilizer. Similarly, Push Pull Weeder was found superior compared to manual weeding.
4. Among irrigation options, Shallow Tube Well (STW) was found profitable compared to Deep Tube Well (DTW) in terms of gross and net margins, Benefit-cost ratio and partial budget analysis.
5. For spraying options, Knapsack sprayer appeared as best option among Knapsack, Compression and Hand sprayer on the basis of operating cost, gross and net margins, Benefit-cost ratio and partial budget analysis.
6. Harvesting with small capacity Reaper was found significantly beneficial to the farmers, although manual harvesting is dominating in rice crop production.
7. Among traditional, Pedal, Open-drum and Power threshing operations, Open-drum threshing appeared as most economic option, and supported by operating cost, gross and net margins, Benefit-cost ratio and partial budget analysis.

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