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COMPARATIVE PROFITABILITY OF THE MODERN AND TRADITIONAL VARIETY OF T. AMAN RICE IN MYMENSINGH DISTRICT OF BANGLADESH

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ABSTRACT

This study was conducted to identify the socioeconomic characteristics of Transplant Aman (T. Aman) rice producers, compare the profitability of modern and traditional varieties and, analyze the factors affecting the production of modern and traditional T. Aman rice varieties. The multistage sampling procedure was used for selecting 60 farmers from Muktagacha, Ishworgonj and, Fulbaria Upazila under the Mymensingh district of Bangladesh. A semi-structured interview schedule was used for the purpose of collecting primary data. Tabular analysis, undiscounted BCR and, Cobb-Douglas production model were used for analyzing the data. The major findings of the study were that about 43.34% of the respondents belonged to the age between 46-65 years, 71.67% were male, 41.67% had primary education only, agriculture was the main occupation of 75% of the respondents and 53.33% had access to credit. The per acre average net return was Tk 16760.71 with a BCR of 1.47. The comparative analysis revealed that the per acre average net return and BCR of modern variety of T. Aman were Tk 23737.98 and 1.68 and of traditional variety of T. Aman were Tk 10601.58 and 1.27, respectively. The results of Cobb-Douglas production model showed that human labor cost, Urea cost, Boron cost, seed cost, pesticides cost, threshing and, drying cost had significant effects on the production of the modern variety. The findings of this study suggest that the production of the modern variety of T. Aman will be profitable which in turn will contribute to ensuring food security among the rural poor.

Contribution/Originality: This is one of the few studies in Bangladesh that has examined the profitability of modern and traditional T. Aman rice cultivars. This research also looks into the elements that affect profitability, which is critical for establishing rice production sustainability in the face of shrinking cultivable area.

1. INTRODUCTION

Agriculture is the single largest producing sector in the economy of Bangladesh. Throughout the country, agricultural activities are conducted actively for crop and allied sectors in times of scarcity of natural resources (Khushi, Moniruzzaman, & Tabassum, 2020). Since the independence of the country, agriculture has been a significant source of employment, livelihood, and food security for the majority of rural people besides providing the raw materials to industry and also contributes to the country's exports (Rahman, 2017). Despite the fact that agriculture's percentage of GDP in Bangladesh has decreased over time, agriculture continues to play an important role in the country's economic growth (Rahman, 2017). There are four sub-sectors: crops, livestock, forestry, and fisheries in the agriculture sector with the crop sub-sector as the predominant one (BBS, 2020; Prodhan, Sarker, Sultana, & Islam, 2017).

As whole agriculture contributes almost 13.48% to the GDP whereas crops and horticulture have a 7.13% share alone for the financial year 2019-20, and about 40% of the labor force of the nation is in this sector (BBS, 2020). Food security of the vast population of this country is deeply associated with the development of agriculture. A sustainable and environment-friendly cropping system is critical for ensuring the long-term food security of the nation. There are four main crops in Bangladesh: Rice, Jute, Wheat, and Potato, among them rice, wheat, and potato play a vital role in achieving self-sufficiency in food production (BBS, 2017).

Rice is a widely grown crop that has long been the staple food of more than half of the world's population (Maraseni, Deo, Qu, Gentle, & Neupane, 2018). In Bangladesh, it is also a staple dish. Bangladesh is the world's fourth largest rice producer, with an area of around 10.27 million hectares dedicated to rice production (FAO (Food and Agriculture Organization), 2016). It is one-third food requirement of the world population and a vital cereal crop in Bangladesh (Ahmed, Ahmad, Junaid, & Ali, 2015). Rice production accounts for over a quarter of all farmed land in Bangladesh with the greatest per capita consumption. More specifically, the nutritional demand of the majority of people is met with rice. In terms of output potentials, growing practices, and cropping patterns, rice production in Bangladesh has evolved over time. It is grown on around 10.5 million hectares, a statistics that has been nearly constant over the last three decades. Rice is cultivated on around 75% of the total farmed area and over 80% of the total irrigated area (Shelley, Takahashi-Nosaka, Kano-Nakata, Haque, & Inukai, 2016). Climate change and variability has the greatest impact on crop productivity, particularly rice and any climate changes will, thus, increase uncertainty in rice production as the climate is a major cause of year-to-year variability in rice cultivation (Rashid, 2012). Production of rice has increased since independence without further increase in rice area (Khalique, Touhiduzzaman, Islam, Murmu, & Rasel, 2019). Bangladesh is an agricultural country sacred with a climate favorable for rice cultivation. Aus, Aman, and Boro- three rice crops cultivation are possible in the same land in a year since soils are fertile, the rain-fed or irrigated flood plain land, fertilizer, and other inputs are available (Anwar, Zulfiqar, Ferdous, Tsusaka, & Datta, 2021; Chanda, Ali, Haque, Abdullah, & Sarwar, 2019; Mainuddin et al., 2021). In the case of high yielding variety (Aus, Aman, and Boro), growth rates of area, production, and yield have been increased significantly. During the period 1971/72 to 2015/16, the yields of Aus, Aman, and Boro increased dramatically at rates of 2.10%, 1.80%, and 1.30%, respectively (Khushi et al., 2020). Boro rice occupied 66%, Aman rice 31%, and Aus rice 3% of the total rice cultivable area of Sirajganj (Chanda et al., 2019). Among the three concurrent cropping seasons: Aus, Aman, and Boro of Bangladesh, Aman rice has been cultivated in 5559964 ha of land and the total production of this season was 14203197 metric tons approximately (BBS, 2020).

Aman is the country's second-biggest rice crop in terms of output volume, whereas Boro is the greatest. Moreover, Aman is the most widely planted monsoon-season rainfed rice, especially around the coast. In Bangladesh's Kharif-2 season, high yielding varieties (HYV) of Aman rice such as BR 11, BRRI Dhan 32, 33, 34 (aromatic), 39, 41, 49, 51, 52, 56, 62, 72, BINA 7, 11, Pajam, Ranjit, Swarna, and local rice such as Naijershail, Gainja, Patjag, Shailya, Khatobadha, Sapaher, Latishail, Bashi (Chanda et al., 2019). Aman is planted in two ways: direct seeding with Aus in March and April and transplantation in July and August, with both varieties harvested in November and December (Sarkar, Rahman, Haque, Islam, & Sultana, 2021; Shelley et al., 2016). The findings of a field experiment with six Aman rice types revealed that the highest growth was recorded in all rice varieties between 58 and 68 days after transplanting, with maximum dry matter output occurring at 68 days after transplanting (Khatun, Mondal, Khalil, Roknuzzaman, & Mollah, 2020). However, the present study considered seven traditional varieties (Shorna, Ranjit, Kalijira, Horidhan, Sada Mota, Lal Mota, and Mala) and seven modern varieties (Binadhan-7, BR-22, BR-11, BRRI-32, BRRI-34, BRRI-51, and Binadhan-17) of Transplant Aman (T. Aman) rice.

Cereal crops, particularly rice farming, occupy the majority of cultivable area in Bangladesh. The first most important factor for increasing crop productivity is asset endowment emphasizing the need to increase gross cultivated area, which may be accomplished by increasing cropping intensity, and the second is crop management methods, which include increased fertilizer, labor, and pesticide input use (Emran, Krupnik, Aravindakshan, Kumar, & Pittelkow, 2021). An increase in rice production by increasing land is not possible as total cultivable land is decreasing day by day due to the increased use of land for non-agricultural sectors. As a result, enhancing technical efficiency and implementing new technologies can boost rice production. Through the rampant use of improved technology like inputs (seed, fertilizer, irrigation technology) and their productivity, rice production has been increased under the adverse conditions of falling real rice prices, sharply rising agricultural wage rates and the declining availability of land for cultivation (Khalique et al., 2019). Moreover, off-farm activities, crop diversification, and using high-yield varieties are more sustainable adaptation strategies (Eyasmin, Ghosh, & Adeleye, 2021).

So, the study of socioeconomic issues, comparison between the performance of modern and traditional varieties of T. Aman rice, factors affecting the production is essential to formulate the appropriate policy for the sake of increasing rice output in Bangladesh. Therefore, this study was focused on identifying the socioeconomic characteristics of T. Aman rice producers, comparing the performance of modern and traditional varieties, and analyzing the factors affecting the production of modern and traditional varieties of T. Aman rice.

2. MATERIALS AND METHODS

This research was completed by using primary data collected from selected T. Aman rice producers in selected areas of Bangladesh. Data was gathered from 60 T. Aman rice producers from three Upazilas namely Muktagacha, Ishworgonj, and Fulbaria under Mymensingh district from January to March 2020. A multi-stage sampling procedure was used to select farmers for collecting data. A semi-structured interview schedule was designed to obtain farm and household-level information. Both tabular and econometric techniques were used for analyzing the collected data.

2.1. Profitability Analysis and Comparing the Performance of the Modern and Traditional Variety

Activity budget is the most used method in determining and comparing the profitability of enterprises (Dillon & Hardaker, 1993). Profit is the difference between the total revenue and total cost. For calculating the profitability of T. Aman producers, every cost and return item was included. Profit was computed using the following formula.

Profit, $\Pi = TR - TC$.

Where, Π, TR, and TC designate profit (Tk/acre), total return (Tk/acre), and total cost (Tk/acre), respectively. The total return can be achieved by multiplying price with the quantity of output whereas TC is the summation of all costs of production.

2.1.1. Gross Return/Total Return

The total volume of output of an enterprise multiplied by the average price over the harvesting season yields gross returns (Dillon & Hardaker, 1993). The following equation was applied to estimate GR in this study:

Gross return, $GR = Q \times P$.

Where, GR, Q, and P designate gross returns (Tk/acre), the quantity of the product (Kg/ acre), and the average price of the product (Tk/Kg), respectively.

2.1.2. Gross Margin

The gross margin of an enterprise is its output value less the variable costs attributed to it Barnard and Nix (1978). The difference between gross return and total variable costs is used to compute gross margin.

Gross margin, GM=GR – TVC

Where, GM, GR, and TVC designate gross margin (Tk/acre), gross return (Tk/acre), and total variable cost (Tk/acre), respectively.

2.1.3. Net Return

The whole production cost (variable and fixed) was subtracted from the gross return to arrive at the net return or profit. That is,

Net return, NR= GR – TC

Where, NR, GR, and TC designate net return (Tk/acre), gross return (Tk/acre), and total cost (Tk/acre), respectively.

2.1.4. Undiscounted Benefit-Cost Ratio (BCR)

In profitability measurement, the average return to each taka spent on production is an important criterion. Undiscounted BCR was estimated as the ratio of total return to the total cost per acre.

$$BCR = \frac{\text{Gross Benefit}}{\text{Gross cost}}$$

2.2. Empirical Cobb-Douglas production model

The cobb-Douglas production model was used to identify the contribution of the most important variables in the production process of T. Aman rice. The following model was used in this study.

$In\ Y = \ln a + b_1 \ln X_{1i} + b_2 \ln X_{2i} + b_3 \ln X_{3i} + ... + b_{13} \ln X_{13i} + U_i$

Where,

Y = Gross return of the modern and traditional variety of T. Aman production (Tk/acre).

a = Constant or intercept value.

X_1 = Cost of human labor for producing the modern and traditional variety of T. Aman (Tk/acre).

X_2 = Cost of plowing for producing the modern and traditional variety of T. Aman (Tk/acre).

X_3 = Cost of Urea for producing the modern and traditional variety of T. Aman (Tk/acre).

X_4 = Cost of muriate of potash (MoP) for producing the modern and traditional variety of T. Aman (Tk/acre).

X_5 = Cost of triple superphosphate (TSP) for producing the modern and traditional variety of T. Aman (Tk/acre).

X_6 = Cost of Gypsum for producing the modern and traditional variety of T. Aman (Tk/acre).

X_7 = Cost of Zink for producing the modern and traditional variety of T. Aman (Tk/acre).

X_8 = Cost of Boron for producing the modern and traditional variety of T. Aman (Tk/acre).

X_9 = Cost of cow dung for producing the modern and traditional variety of T. Aman (Tk/acre).

X_{10} = Cost of seed for producing the modern and traditional variety of T. Aman (Tk/acre).

X_{11} = Cost of pesticides for producing the modern and traditional variety T. Aman (Tk/acre).

X_{12} = Cost of harvesting for producing the modern and traditional variety of T. Aman (Tk/acre).

X_{13} = Cost of threshing and drying for producing the modern and traditional variety of T. Aman (Tk/acre).

$b_1 ... b_{13}$ = Co-efficient of relevant variables.

U_i = Disturbance term.

In = Natural Logarithm.

i =1, 2, 3,…, 13

This form of production function explains that agricultural production operates under either constant, increasing, or decreasing returns to scale.

3. RESULTS AND DISCUSSION

3.1. Socioeconomic Characteristics

The socioeconomic condition of the farmers is very important because numerous interrelated and constituent attributes characterize an individual and profoundly influence the development of his/her behavior and personality. In this study, sample farmers were classified into four age groups: age between 25 to 29 years of old, age between 30-45 years of old, age between 46-65 years of old, and above 65 years of old according to the working-age classification of Bangladesh Bureau of Statistics (BBS, 2015). Age classification of the sampled farmers was presented in Table 1. It showed that 18.33% of the respondents ranged in age from 25 to 29 years of old. About 35% of them ranged in age from 30 to 45 years of old. About 43.34% of the respondents ranged in age from 46 to 65 years of old and the rest 3.33% belonged above 65 years. This indicates that most of the T. Aman rice producers were between 46-65 years of old. Akter, Parvin, Mila, and Nahar (2019) found the respondents' average age was 48 years. However, Hasan, Osmani, and Hossain (2017) found in their study that age of the majority of respondents (75%) was between 30 to 49 years of old. Farmers between this age group are capable of generating higher profits as they are vivacious, eager and enough experienced. From Table 1, it was observed that about 71.67% of respondents were male and the rest 28.33% were female.

Education helps farmers understand technology in a better way and thus improves the productivity of the farmers. Farmer's education status, seed varieties, training, and the magnitude of extension services influence the profit inefficiency significantly (Anwar et al., 2021; Fazlul et al., 2021). The education status of the respondents had been shown in Table 1. According to their educational status, the respondents were divided into four categories: illiterate, primary, secondary, and higher secondary and above. It was observed that about 26.67% of the respondents were illiterate, 41.67% had primary education only, 18.33% had secondary education, 13.34% had higher secondary and above education. It was discovered that the majority of the sampled farmers had primary education only. This result is consistent with the study of Hasan et al. (2017). They also found that most of the farmers in their study area had primary-level education.

Table 1. Age, gender, education, occupation, credit availability of the respondents.

Variable	Group	No. of respondents	Percentage
Age (year)	25-29	11	18.33
	30-45	21	35
	46-65	26	43.34
	>65	2	3.33
Gender	Male	43	71.67
	Female	17	28.33
Education	Illiterate	16	26.67
	Primary	25	41.67
	Secondary	11	18.33
	Higher secondary and above	8	13.34
Primary occupation	Agriculture	45	75
	Day laborer	8	13.33
	Service	3	5
	Business	4	6.67
Credit	Yes	28	46.67
	No	32	53.33

Source: Field Survey, 2020.

Occupation is one of the most vital factors of socioeconomic characteristics. It affects the decision-making of the farmers. Besides agriculture, respondents were also involved in other occupations such as day laborer, service, business, etc. Table 1 shows that the primary occupation of the majority of the respondents (75%) was agriculture. About 13.33%, 5%, and 6.67% of the respondents were involved with a day laborer, service, and business, respectively. Availability of credit affects the production decision of the farmers. There is a positive and statistically significant relationship between access to credit and sustainable agricultural production (Adeleye, Osabuohien, &

Asongu, 2020). Efficiency, productivity and earnings, and profitability of the farmers mostly depend upon the accessibility to sufficient financial capital (Hasan et al., 2017). Table 1 shows that only 46.67% of the respondents had credit from different banks and NGOs, while 53.33% of them did not have. Unlike this study, Hasan et al. (2017) noticed most of the farmers took agricultural credit in the Jhenaidah district of Bangladesh. Farm size, credit access, as well as extension contact significantly affect sustainability (Eyasmin et al., 2021; Rahaman et al., 2021).

3.2. Estimation of the Gross Cost

Costs are the expenses incurred in organizing the production process (Doll & Orazem, 1984). The costs of all items were calculated to identify the total cost of production. Costs of T. Aman rice producer were classified into two major groups, such as (a) variable costs and (b) fixed costs. Under variable costs, there were human labor, plowing, seed, fertilizers, pesticides, herbicides, harvesting, threshing and drying costs, etc. Table 2 shows the per acre average cost of T. Aman rice production. Land preparation is the most important component in the production process. The average land preparation cost of T. Aman production was estimated to be Tk 1830.56 per acre, which was 4.97 % of the total cost. Human labor is one of the major cost components in the production process. It was measured in terms of man-day which usually consisted of 8 hours. The quantity of human labor used in T. Aman production was found to be about 15 man-days per acre and the average price of human labor was Tk 544.31 per man-day. Therefore, the total cost of human labor was calculated to be Tk 8327.93 per acre representing 22.61 % of the total cost. The cost of seed varied widely depending on its quality and availability. Per acre quantity of seed and total cost of seed for T. Aman production was estimated to be 12.01 Kg and Tk 810.19 respectively. In the study area, farmers used different types of fertilizers. Per acre costs of Urea, MoP, TSP, Gypsum, Zink, Boron, and cow dung were Tk 1178.55, Tk 364.65, Tk 463.44, Tk 246.24, Tk 399.6, Tk 223.89, and Tk 516.66, respectively. Per acre cost of pesticides and herbicides for T. Aman production was Tk 2839.43 and Tk 1037.47, respectively. Harvesting and threshing and drying costs were Tk 5060.07 and Tk 5420.48 per acre respectively. Interest on operating capital for T. Aman production was estimated at Tk 1435.96 per acre. The land-use cost of T. Aman rice producers was found to be Tk 6682.36 per acre which was 18.14 % of the total cost.

Table 2. Per acre average cost of T. Aman production.

Per acre average cost of T. Aman production				
Items of cost	**Quantity**	**Price unit^{-1} (Tk)**	**Total cost (Tk)**	**% of total cost**
Plowing (no. of tillage)	3	610.19	1830.56	4.97
Labor (man-day)	15.3	544.31	8327.93	22.61
Seed (Kg)	12.01	67.46	810.19	2.2
Urea (Kg)	65.59	17.97	1178.65	3.2
MoP (Kg)	23.05	15.82	364.65	0.99
TSP (Kg)	20.57	22.53	463.44	1.26
Gypsum (Kg)	9.76	25.23	246.24	0.67
Zink (Kg)	2.14	186.73	399.6	1.08
Boron (Kg)	1.25	179.11	223.89	0.61
Cow dung (Kg)	61.58	8.39	516.66	1.4
Pesticides (Tk)	-	-	2839.43	7.71
Herbicides (Tk)	-	-	1037.47	2.82
Harvesting (Tk)	-	-	5060.07	13.74
Threshing and drying (Tk)	-	-	5420.48	14.71
A. Total operating cost (TOC) (Tk)			28719.3	77.96
Interest on operating capital @ 10% for 6 months (Tk)			1435.96	3.9
B. Total variable cost (TVC) (Tk)			30155.2	81.86
Land cost (Tk)			6682.36	18.14
C. Total fixed cost (TFC) (Tk)			6682.36	18.14
D. Total cost (B+C) (Tk)			36837.6	100

Source: Field Survey, 2020.

The total cost was calculated by adding all the costs of variable and fixed inputs. In the present study, per acre total cost of producing rice was found to be Tk 36837.6. In some regions of Sirajganj district of Bangladesh, the total cost of rice production varied Tk 43031- Tk 69067 per ha and the cost of producing a kilogram of rice was Tk 14.98 - Tk 21.40 for the local variety of Aman and the total cost of rice production varied Tk 66111- Tk 78724 per ha and the cost of producing a kilogram of rice was Tk 9.87- Tk 14.45 for HYV of Aman (Chanda et al., 2019).

3.3. Estimation of Gross Return

The total amount of product and their by-products were multiplied by their respective farm gate prices to compute gross return. It is evident from Table 3 that the average yield of T. Aman per acre was 1948.7 kg and the average price of T. Aman was Tk 24.32 per kg. Thus, total product value per acre was Tk 47392.38 and the total by-product value per acre was Tk 6205.91. Therefore, the gross return was determined to be Tk 53598.29 per acre by adding the main product and by-product values of rice. By subtracting the total variable cost from the gross return, the gross margin was computed. Based on the data, the gross margin was found to be 23443.07 per acre Table 3. By subtracting the total production cost from the gross return, the net return or profit was calculated. Based on the data the net return was estimated as Tk 16760.71 per acre. The Benefit-Cost Ratio (BCR) is a relative metric for comparing benefit to expense per unit of cost. The BCR was discovered to be 1.47, implying that a taka invested in T. Aman rice production yields Tk 1.47. From the above calculation, it was clear that T. Aman rice cultivation is profitable in Bangladesh. In some regions of the Sirajganj district of Bangladesh, the gross returns of rice production varied Tk 57651- Tk 86889 per ha and BCR was 1.25-1.65 for the local variety of Aman and the gross returns of rice production varied Tk 123321- Tk 164439 per ha and BCR was 1.70-2.22 for HYV of Aman in some regions of Sirajganj district of Bangladesh (Chanda et al., 2019). On the other hand, per bigha gross profit margin for Aus, Aman, and Boro rice production was Tk 2603.223, Tk 6259.134, and Tk 10487.61, respectively (Hasan et al., 2017). On a total cost and variable cost basis, BCR was assessed to be 1.47 and 2.17, respectively, implying that Binadhan-17 production at the farm level was profitable (Sarkar et al., 2021). So, rice is a profitable farming activity.

Table 3. Per acre average cost and return of T. Aman rice production.

Per acre average cost and return of T. Aman rice production			
Measuring Item	**Quantity (Kg)**	**Price kg^{-1}**	**Cost and return (Tk)**
A. Main product value	1948.7	24.32	47392.38
B. By product value	-	-	6205.91
C. Gross return (A+B)	-	-	53598.29
D. Total variable cost	-	-	30155.22
E. Total cost	-	-	36837.58
F. Gross margin (C-D)	-	-	23443.07
G. Net return (C-E)	-	-	16760.71
H. BCR (C/E)	-	-	1.47

3.4. Comparison Between the Traditional and Modern Variety of T. Aman Rice

A comparative analysis between the traditional and modern variety of T Aman rice had been done. It was observed from Table 4 that per acre total cost of the traditional and modern variety of T. Aman rice cultivation was to be Tk 38667.72 and Tk 34757.14 respectively. Cost and return of traditional and modern variety are presented in Table 5. Per acre gross return was found to be Tk 49269.3 and Tk 58495.12 for traditional and modern variety respectively. Based on the data, per acre, gross margin was found to be Tk 17848.98 for traditional variety and Tk 29780.66 for modern variety respectively. The net return was estimated for traditional and modern varieties to be Tk 10601.58 and Tk 23737.98 respectively per acre. Benefit-Cost Ratio (BCR) was calculated as 1.27 for traditional variety and 1.68 for modern variety. It is observed that the net return of modern variety was higher than that of the traditional variety. The BCR of modern variety was also high compared to the traditional variety. The findings comply with the results of Rahman, Hussain, Hossain, Rahaman, and Chowdhury (2015). Wet (Aman) season rice technology has a substantial positive influence on the welfare of the small farmers in rural Bangladesh as evaluated by the level of increases in rice yield, household income, household consumption expenditure and decreases in poverty gap over time (Islam, 2018).

Table 4. Per acre average cost of the traditional and modern variety of T. Aman production.

Items of cost	Traditional variety			Modern variety		
	Quantity	Price unit^{-1} (Tk)	Total cost (Tk)	Quantity	Price unit^{-1} (Tk)	Total cost (Tk)
Plowing (no. of tillage)	3	589.4	1768.19	3	633.73	1901.18
Labor (man-day)	16.62	621.78	10333.93	13.78	439.54	6056.91
Seed (Kg)	12.68	45.19	573.03	11.26	95.81	1078.86
Urea (Kg)	68.4	18.92	1294.08	62.4	16.79	1047.76
MoP (Kg)	23.84	15.82	377.06	22.15	15.83	350.61
TSP (Kg)	21.11	22.71	479.46	19.96	22.3	445.04
Gypsum (Kg)	10.2	25.11	256.16	9.27	25.37	235.2
Zink (Kg)	2.23	186.46	415.8	2.03	186.91	379.43
Boron (Kg)	1.35	178.87	241.47	1.14	178.54	203.54
Cow dung (Kg)	73.43	7.87	578.1	48.17	9.28	447.15
Pesticides (Tk)	-	-	3238.78	-	-	2386.18
Herbicides (Tk)	-	-	1500.9	-	-	512.4
Harvesting (Tk)	-	-	5978.46	-	-	4018.29
Threshing and drying (Tk)	-	-	2888.69	-	-	8284.55
A. Total operating cost (TOC) (Tk)			29924.11	-	-	27347.1
Interest on operating capital @10% for 6 months (Tk)			1496.21	-	-	1367.36
B. Total variable cost (TVC) (Tk)			31420.32	-	-	28714.46
Land Cost (Tk)			7247.4	-	-	6042.68
C. Total fixed cost (TFC) (Tk)			7247.4	-	-	6042.68
D. Total cost (B+C) (Tk)			38667.72	-	-	34757.14

Table 5. Per acre average return of the traditional and modern variety of T. Aman production.

Measuring Item	Traditional variety			Modern variety		
	Quantity (Kg)	Price Kg^{-1}	Cost and return (Tk)	Quantity (Kg)	Price Kg^{-1}	Cost and return (Tk)
A. Main product value	1824.42	23.87	43548.91	2088.62	24.78	51756
B. By product value	-	-	5727.11	-	-	6747.97
C. Gross return (A+B)	-	-	49269.3	-	-	58495.12
D. Total variable cost	-	-	31420.32	-	-	28714.46
E. Total cost	-	-	38667.72	-	-	34757.14
F. Gross margin (C-D)	-	-	17848.98	-	-	29780.66
G. Net return (C-E)	-	-	10601.58	-	-	23737.98
H. BCR (C/E)	-	-	1.27	-	-	1.68

3.5. T-Test

Lepcha, Mankeb, and Suwanmaneepong (2021) applied an independent sample t-test to compare the profitability and productivity of conventional potato and organic potato. In the present study, a t-test had been done at a 5% level of statistical significance to see whether there was a significant difference between the profitability of modern and traditional varieties. Table 6 shows that for the one-tailed test, P-value (0.0056) is less than the significant level at 5%, so, we cannot accept the null hypothesis. Therefore, the profitability of modern and traditional varieties is significantly different. The findings comply with the results of Mabe, Sarpong, and Asare (2013).

Table 6. T-test: two-sample assuming unequal variances.

Parameters	Value
P(T>=t)one-tail	0.0056
P(T>=t)Two-tail	0.0112

3.6. Factors Affecting the Production of T. Aman Rice

The Cobb-Douglas production function was used to determine the impacts of various inputs on T. Aman rice output, both traditional and modern varieties. Human labor cost, power tiller cost, seed cost, fertilizer cost, and insecticides cost are positively significant for the cultivation of the Binadhan-17 variety of Aman rice (Sarkar et al., 2021). The Gross return of T. Aman was used as the independent variable in both models. The explanatory variables were cost of human labor, cost of plowing, cost of Urea, cost of MoP, cost of TSP, cost of Gypsum, cost of Zink, cost of Boron, cost of cow dung, cost of seed, cost of pesticides, cost of harvesting, and cost of threshing and drying in both models. The F-values of the equation derived for modern and traditional variety were 56.68 and 302.52 which were highly significant at the 1% level implying that all the explanatory variables were important for explaining the variations in gross returns of the selected rice varieties in the study area.

Table 7 shows that human labor cost, Urea cost, Boron cost, seed cost, pesticides cost, threshing, and drying cost had a significant effect on the modern variety of T. Aman. On the other hand, human labor cost, plowing cost, Gypsum cost, Boron cost, threshing, and drying cost were significant factors in traditional Variety. The coefficient for human labor cost was 0.716 which was positive and significant for modern variety production at the 1% level of significance. It indicates if all other conditions remain constant, a 1% increase in human labor cost would increase the gross return of modern variety by 0.716%. Again, the coefficient for human labor cost was 0.724 which was positive and significant at the 1% level for traditional variety. The coefficient indicates that leaving other factors unchanged, a 1% increase in human labor cost would increase the gross return by 0.724%. Therefore, there is a possibility to increase output by using more of this input. The coefficient for plowing cost was 0.125 which was negative and significant for traditional variety at the 1% level of significance indicating that a 1% increase in the cost of plowing, remaining other factors unchanged, would reduce the gross return of traditional variety by 0.125%. The regression coefficient of urea cost was negative but significant at the 10% level for modern variety which indicates that a 1% increase in urea cost, remaining other factors constant, would decrease gross return by 0.065%.

The coefficient for Gypsum cost was negative and significant for traditional variety at the 5% level. It revealed that a 1% increase in the Gypsum cost, leaving other factors unchanged, would reduce gross return by 0.188%. The coefficient for Boron cost was 0.032 which was significantly positive at the 10% level for modern variety production. Again, the coefficient for Boron cost was 0.085 which was significantly positive at the 1% level for traditional variety. It implied that a 1% increase in Boron cost would raise the gross return of traditional variety by 0.085%, assuming all other factors remained unchanged. For modern variety, the regression coefficient of seed cost was 0.176 and significant at the 1% level, indicating that a 1% rise in seed cost would improve gross return by 0.176% while leaving other factors constant. The regression coefficient of pesticides cost was 0.089 and significant at 5% level for modern variety which indicates that a 1% increase in the cost of pesticide cost, remaining other factors unchanged, would increase gross return by 0.089%. For modern variety, the regression coefficient of threshing and drying cost was 0.014 and significant at the 5% level, indicating that a 1% increase in that cost, while holding all other components unchanged, would increase gross return by 0.014%. The regression coefficient of threshing and drying cost, on the other hand, was negative but significant at the 5% level for traditional variety, indicating that a 1% increase in threshing and drying cost, while holding other factors equal, would reduce gross return by 0.023%.

Akighir and Shabu (2011) found a positive relationship of inputs with output, unlike this study that found both the positive and negative relationship of inputs with output. Gao (2012) found a negative linkage between labor cost and output, unlike this study. The cost of power tiller, hired labor and fertilizer are significant factors in determining the level of profit earned from rice production for all the small, medium, and large category farmers in different study areas (Akter et al., 2019). In another study, Islam, Begum, Sharmin, and Khan (2017) found that the cost of seed, fertilizer, power tiller, irrigation, and human labor had a significant impact on gross return.

Table 7. Estimated values of coefficient and related statistics of Cobb-Douglas production function for modern and traditional variety.

Explanatory variables	Modern variety		Traditional variety	
	Coefficient (std. error)	P-value	Coefficient (std. error)	P-value
Intercept	5.393 (1.561)	0.005	10.425 (0.684)	0.000
Total cost of labor	0.716*** (0.131)	0.000	0.724*** (0.042)	0.001
Total cost of plowing	-0.0005 (0.006)	0.927	-0.125*** (0.031)	0.001
Total cost of Urea	-0.065* (0.030)	0.052	0.054 (0.100)	0.601
Total cost of MoP	0.042 (0.025)	0.122	-0.061 (0.079)	0.455
Total cost of TSP	-0.009 (0.017)	0.606	-0.012 (0.012)	0.340
Total cost of Gypsum	-0.001 (0.054)	0.806	-0.188** (0.072)	0.024
Total cost of Zink	-0.009 (0.013)	0.492	0.156 (0.010)	0.155
Total cost of Boron	0.032* (0.016)	0.075	0.085*** (0.013)	0.000
Total cost of cow dung	0.032 (0.021)	0.162	0.021 (0.022)	0.375
Total cost of seed	0.176*** (0.033)	0.000	0.042 (0.018)	0.822
Total cost of pesticides	0.089** (0.035)	0.028	-0.046 (0.044)	0.325
Total cost of harvesting	0.002 (0.001)	0.855	-0.005 (0.014)	0.711
Total cost of threshing and drying	0.014** (0.014)	0.038	-0.023** (0.008)	0.019
R^2	0.985	-	0.997	-
Adjusted R^2	0.967	-	0.993	-
F-value	56.689	0.00	302.523	0.00

Note: *, ** and *** indicates the significance at 10%, 5% and 1% level, respectively.

4. CONCLUSION AND POLICY RECOMMENDATIONS

Over the years, Bangladesh has made great success in agricultural growth and structural reform. The agricultural commodity of crops, livestock, fisheries, and forestry sectors has increased and diversified. Bangladesh's most pressing issue is food security. To improve the food security status and standard of living of households, existing resources must be properly utilized through boosting technical efficiency. This research studied the socioeconomic characteristics of T. Aman rice producers, comparison between the performance of modern and traditional variety and factors affecting the production of modern and traditional variety of T. Aman rice through the collection of primary data from 60 T. Aman rice producers from three Upazilas of Mymensingh district in Bangladesh. The majority of the sampled farmers were between the ages of 46 and 65 years and 71.67% of the respondent farmers were male, according to socioeconomic characteristics. The majority of the farmers that is 41.67% had primary education only. Agriculture was the principal occupation for 75% of those surveyed. The profitability analysis showed that per acre average net return was Tk 16760.71 with a BCR of 1.47. The comparative study revealed that the average net return and BCR of the modern variety of T. Aman were Tk 23737.98 per acre and 1.68, respectively which was significantly higher than that of the traditional variety. So, the production of modern variety is more profitable than the production of the traditional variety of T. Aman rice. Human labor cost, Urea cost, Boron cost, seed cost, pesticides cost, threshing, and drying cost had a significant effect on the production of the modern variety. The findings of this research suggest that the profitability of the farmers of the study area would be significantly increased by producing the modern variety of T. Aman rice. Therefore, educational facilities should be enhanced along with vocational training on required fertilizer doses, pesticides, seed selection, intercultural operations, and other topics that will improve productivity and technical efficiency by strengthening the farmers' technical knowledge. Both government and non-government organizations (GOs and NGOs) should make extension services available with a view to providing training on modern technology use and disseminating new varieties to the grassroots level. Access to credit should be made equally available for all the small, medium, and large farmers for the betterment of the country.

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