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FACTORS AFFECTING THE PRODUCTIVITY OF MAIZE (*Zea mays* L.) IN SELECTED AREAS OF BANGLADESH

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ABSTRACT

Though the production of maize and the area under cultivation has accelerated, the rate of increase in production is not satisfactory due to its increasing demand with the continuous expansion of the dairy and poultry sectors in Bangladesh. The intended study aimed to identify the factors affecting the production of maize and whether the resources were utilized optimally in the production process. Required data were gathered from 130 maize growers, who were taken through simple random sampling from two districts, Manikganj and Rajshahi, of Bangladesh, through the interview with a pretested questionnaire. The impact of several factors on the productivity of maize was computed with the help of the Cobb-Douglas production function. The study revealed a significant positive impact of seed, land preparation, fertilizer and water management on the final output of maize. Although maize cultivators earned a decent profit, inefficient uses of resources were practiced. Seed and fertilizer were underutilized while labour was over-utilized in the production process. The sampling frame was selected purposively to represent the intensive maize producing area. Farmers shifted to maize cultivation progressively, but the high price of seeds, natural calamities and low price of grains may affect production in future.

Keywords: BCR, Cobb-Douglas, Problems, Profitability, Resource use efficiency**.**

INTRODUCTION

Bangladesh is predominantly the ninth most populous agrarian country in the world with a total population of 162.7 million (BER, 2019). Agriculture is not only a claimant of ensuring food and nutritional security but also acts as a key driver in generating employment, developing human resources and alleviating poverty. The

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country possesses about 26.40% of its inhabitants in the countryside with an overall growth rate and density of population 1.37 and 1103, in 2017 (BER, 2019). The contribution of the agriculture sector to the betterment of such an enlarged population is beyond explanation since it creates employment opportunities for almost 40% of the manpower of the country (BER, 2019). Among the three broad sectors such as agriculture, industry and service sectors, the growth of agriculture increased to 4.19% of GDP. Although the share of other sub-sectors of agriculture (livestock, fisheries, and forestry) is maintaining an increasing trend, the share of the crops' sub-sector is conspicuous with 7.51% of GDP (BBS, 2018).

Over the years, the country is going through an era of increased food grains production. Though the country was able to produce 413.25 lakh metric tons (MT) of food grain, among the total cropped area, only 2.2% of the land was utilized for maize production (BER, 2019). On the other hand, rice production was dominant which occupied 74.85% of cultivated land (BBS, 2018). Maize (*Zea mays*) is one of the oldest, versatile photo-insensitive crops with the highest grain yield and is popular for multiple uses (Rahman et al., 2016). Maize is a promising crop due to its increasing importance in accelerating agricultural growth in Bangladesh (Rahman and Rahman, 2014). Developing countries utilize maize mainly as livestock feed and as a raw material for industrial products (Sadiq et al., 2013). Bangladesh has experienced explosive growth in the production of maize (Rahman and Rahman, 2014) from 1972 to 2018. Total maize cropped area and production of maize has increased from only 2654 ha to 400469 ha and 2249 t to 3288102 MT respectively from 1972 to 2018 (BBS, 2018). The dramatic increase in yield rate has been noticed from 0.85 t/ha to 8.3 t/ha which was almost ten times to the previous rate during the same period. Considering yield rate, maize (8.3 t/ha) ranked first among the cereals followed by Boro (dry winter) rice (4.1 t/ha) and wheat (3.2 t/ha) respectively (BBS, 2018). According to the Planning commission (2011), yearly more than 80 thousand hectares (1% annually) of arable land is being converted to non-agriculture purposes in Bangladesh. Though the total area under maize production is increasing gradually, the rate of increase is not satisfactory at all due to the increased demand of maize in the ever-expanding dairy (Uddin et al., 2011) and poultry (Begum et al., 2010) sectors in this country. Previous studies revealed that the production of maize is more profitable than rice (Hussain et al., 1995) and hybrid maize seed production was profitable too (Haque et al., 2012). Ali et al. (2009) revealed the expansion of maize-rice cropping systems as the demand and value of maize have been increasing for poultry feed in Bangladesh. Though the optimum use of input along with an appropriate growing period is important, hybrid maize has the prospects to provide a higher return to investment (Karim et al., 2010). According to Uddin et al. (2013), medium-scale maize farmers were able to accumulate greater profit compared to their small and large counterparts. However, Alam et al. (2016) represented that higher profit was earned by large-scale farming than small and medium-scale maize cultivation.

Though a handful number of studies were conducted on maize, most of the relevant studies were assessed the situation at least a decade ago and the recent explosive growth of maize yield remained unrevealed. The study was designed to assess present scenario and the crucial factors that affect the yield of maize. It aimed to analyze whether resources were optimally used in the production process. The study also provided insights into problems faced by maize farmers that may curtail the total national maize production if not addressed properly.

MATERIALS AND METHODS

The national production of rabi-maize increased by 16% whereas production increased by around 29% and 38% in Manikganj and Rajshahi districts respectively from 2016 to 2018. Notably, the area under rabi-maize cultivation increased by around 15% and 25% in Manikganj and Rajshahi districts (BBS, 2019b). The purposively selected sampling frame represented these areas where maize cultivation was intensive. Generally, 60 samples can be considered as representative (Poate and Daplyn, 1993). A total of 130 maize farmers were selected randomly as samples for the study from two districts. From each district, two sub-districts (Upazilas) were selected, and farm-level data were collected, through the interview method with pretested questionnaires from 65 maize growers from each sub-district, from September to December, 2018. Data were edited, coded and inserted in the computer using the Microsoft Excel and analyzed with MS Excel and SPSS software.

Profitability Analysis

In calculating profit, the cost-return assessment of a farm is crucial. Total cost (TC) is the aggregated value of the variable and fixed costs where the total variable cost (TVC) included the cost of land preparation, human labour, seed, fertilizers, pesticides, and water management. Since all of the operating costs were not employed at a single point in time but rather incurred over the crop growing season, interest on operating capital (IOC) was included in TVC. For this survey, IOC was calculated for months considering a 10% annual interest rate. Therefore, the following formula was applied while computing IOC:

$$IOC = Alit$$

Where, IOC= Interest on operating capital, i= Interest rate, AI= Aggregate investment / 3, t = Overall duration of a cycle.

Considering the opportunity cost of using land, per hectare for the cropping period of four months land use cost was estimated as fixed cost. Gross return is the summation of the monetary value of the final product, which is the multiplication of the aggregate amount of the final product with the average unit price of that product, and by-product. Gross margin is the difference between gross return and variable cost. Net return or profit was calculated by subtracting the aggregate cost of production from aggregate return.

Therefore, the profitability was assessed using the following equation:

$$\pi = P_r Q_r + P_b Q_b - \sum_{i=1}^{n}(P_{xi}X_i) - TFC \quad (1)$$

Where, π = Profit for producing maize (Tk/ha), P_r = Average unit price of maize (Tk /kg), Q_r = Aggregate amount of maize produced (kg/ha), P_b= Price of by-products (Tk/kg), Q_b= Aggregate amount of by-products (kg/ha), P_{xi}= Price of the i^{th} variable (Tk/kg), X_i = Aggregate amount of the i^{th} variable (kg/ha), i = 1, 2, 3……..n, and TFC = Total fixed cost.

Notable, one of the most important criteria for measuring profitability is the average return accumulated from the production process investing each taka is termed as benefit-cost ratio (BCR). Undiscounted BCR was calculated by dividing aggregate return by aggregate cost.

$$BCR = (P_r Q_r + P_b Q_b)/\{\sum_{i=1}^{n}(P_{xi}X_i) + TFC\} \quad (2)$$

Production Function

The Cobb-Douglas regression model was applied to find out the factors affecting maize production. The prime concern was to assess the impact of the essential variables producing maize. Hence, the production function is as follows:

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} U_i \quad (3)$$

To conduct the desired analysis, the designated function was transformed into the logarithmic form:

$$lnY = ln\beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + U_i \quad (4)$$

Where, ln represents natural logarithm, Y is the yield of maize (kg/ha), X_1 is the amount of seed (kg /ha), X_2 is land preparation cost (Tk/ha), X_3 is the number of labour (Man days /ha), X_4 is the amount of fertilizer (kg /ha), X_5 is the cost of irrigation (Tk/ha), β_0 is constant or intercept, β_1 to β_5 are coefficients of the adopted explanatory variables, and U_i represents the error term.

Resource Use Efficiency

The ratio of marginal value product (MVP) to the marginal factor cost (MFC) for each input is considered as the resource use efficiency. The marginal productivity of an input represents the addition to total yield due to a one unit increase of that particular resource, while other resources remain constant. The MVP is the marginal physical product (MPP_{xi}) times the per unit price. The MPP_{xi} is the ratio of the geometric mean of output and input times the coefficient of respective input. The calculations are as follows:

$$MPP_{xi} \times P_{yi} = MVP \quad (5)$$

But, $MPP_{xi} = \beta_i \times (Y_g/X_g)$ (6)

So, $MVP = \beta_i \times (Y_g/X_g) \times P_{yi}$ (7)

Where, β_i indicates the regression coefficients, and Y_g, X_g, P_{yi}, and MFC denote the geometric mean of maize yield (kg/ha), the geometric mean of inputs (kg/ha), price of per unit of output (Tk/kg), and per unit price of inputs (Tk/kg) respectively.

The values of resource-use efficiency (RUE) are 1, < 1 and > 1 indicating optimal utilization, overutilization and under-utilization respectively.

RESULTS AND DISCUSSION

The outcome of the survey

Most of the maize farmers were middle-aged in both districts. Whereas, the average age of summer maize farmers was about 41years (Rahman and Rahman, 2013). More educated maize farmers were found in Manikganj than in Rajshahi district and the average level of education was 3.06 and 2.15 respectively where 1, 2, 3, 4, 5, and 6 indicated illiterate, literate, primary, secondary, higher secondary and degree or above the level of schooling respectively. A similar result was found for rice farmers (Rahman, 2003). Farmers of the Rajshahi district had 35.55 years of farming experience while it was 31.16 years for Manikganj. Notably, the farmers were more experienced than the findings of Rahman and Rahman (2013). Though extension service, training and credit facilities were inadequate in both areas, 68% of farmers from Rajshahi and 57% of farmers in Manikganj district were extension service recipients which were higher than the findings of Rahman (2003). Manikganj was ahead in terms of training received by farmers compared to the other region. Nearness to the capital city has an impact on the training facility. Situation was different for the availability of loans. Though a sufficient amount of funds was a crucial factor for maize farming, most of the farmers didn't have credit facilities. They invested their own funds for maize cultivation. The average size of land owned by a family was higher in Rajshahi as most of the households had fruit orchards. Hoever, more land was employed in maize farming in Manikganj than Rajshahi. The number of people living together with the same head of the family was considered as family size. The average family size was 5.37 and 4.74 in Manikganj and Rajshahi which were larger than the national average family size of 4.06 (BBS, 2019a) (Table 1).

Profitability of Maize Production

The yield was higher in Rajshahi (8771.27 kg/ha) compared to Manikganj (8352.37 kg/ha) which was similar to the national yield rate (BBS, 2018). The requirement of labour was more in Rajshahi compared to Manikganj for per hectare of land which were 112.63 and 108.49 man-days respectively. Farmers of Rajshahi used more urea and MoP but less TSP compared to Manikganj. However, the amount of fertilizers used by maize farmers in both districts were higher than the recommended doses, 151-225 kg urea, 41-60 kg TSP and 81-120 kg MoP per hectare, for cultivating maize in low-quality soil in Bangladesh (Ahmmed et al., 2018) (Table 2).

Table 1. Summery statistics

Variables	Unit	Manikganj (n=65)		Rajshahi (n=65)	
		Mean	SD	Mean	SD
Age	Years	50.24	13.74	50.28	10.88
Education	Dummy	3.06	1.29	2.15	1.16
Experience	Years	31.16	14.43	35.55	11.27
Extension facility	Dummy	0.57	0.50	0.68	0.47
Training facility	Dummy	0.45	0.50	0.34	0.48
Availability of loan	Dummy	0.31	0.46	0.48	0.50
Land ownership	Ha	0.60	0.68	1.48	1.39
Land under maize	Ha	0.14	0.13	0.17	0.13
Family Size	No of person	5.37	2.14	4.74	1.25
Family Member Engaged in Agriculture	No of person	1.40	0.75	1.16	0.41

Source: Field survey, 2018.

Table 2. Per hectare amounts and prices of items.

Items	Unit	Manikganj			Rajshahi		
		Amount (unit/ha)	SD	Price (Tk./unit)	Amount (unit/ha)	SD	Price (Tk./unit)
Yield	kg	8352.37	971.30	15.73	8773.21	828.55	15.87
Seed	kg	18.50	3.33	422.92	19.79	3.17	403.23
Labour	Man days	108.49	9.04	459.08	112.63	8.61	269.66
Urea	kg	253.85	30.73	16.21	278.1645	41.85	16.78
TSP	kg	121.90	31.88	23.54	112.61	40.75	23.75
MoP	kg	241.52	36.21	18.12	267.05	43.58	15.11

Source: Field survey, 2018. US$1=BDT 83.60 in 2018. SD stands for standard deviation.

The average variable costs were 90476.16 and 74723.21 Tk/ha in Manikganj and Rajshahi districts respectively. The wage rate was higher in Manikganj than in Rajshahi. Labour costs was the major portions of variable costs which were 49814.48 Tk/ha and 30743.80 Tk/ha and responsible for 42.51 and 31.56% of total costs at Manikganj and Rajshahi respectively. The result is consistent with recent findings in Bangladesh (Adnan et al., 2021a) which claim labour costs accounted for one-third of total costs. The rental value of land was higher in Manikganj due to its proximity to the capital city compared to Rajshahi. According to the maize farmers of Manikganj and Rajshahi, the total fixed costs were found to be 26715.15 and 22684.85 Tk/ha, respectively (Table 3).

Table 3. Costs and returns of maize cultivation in two areas.

Items of Cost	Manikganj		Rajshahi	
	Cost (Tk/ha)	% Total Cost	Cost (Tk/ha)	% Total Cost
Land preparation	7243.03	6.18	8852.85	9.09
Human labour	49814.48	42.51	30743.80	31.56
Seed	7773.69	6.63	7959.65	8.17
Urea	4117.55	3.51	4670.23	4.79
TSP	2868.73	2.45	2687.14	2.76
MoP	3604.89	3.08	4032.32	4.14
Cost of Insecticides	1111.72	0.95	354.67	0.36
Cost of Irrigation	11023.48	9.41	13012.12	13.36
A. Total Operating Cost (TOC)	87557.57	74.71	72312.78	74.24
Interest on operating capital @ of 10% for months	2918.59	2.49	2410.43	2.47
B. Total Variable Cost (TVC)	90476.16	77.20	74723.21	76.71
The rental value of land	26715.15	22.80	22684.85	23.29
C. Total Fixed Cost (TFC)	26715.15	22.80	22684.85	23.29
D. Total cost (B+C)	117191.31	100	97408.06	100

Source: Field survey, 2018.

Farmers earned comparatively higher returns in Rajshahi and BCR was greater too than the values found in Manikganj. Gross return, gross margin and net return were Tk154407.10, Tk79683.89, and Tk56999.04 per ha in Rajshahi, whereas Tk148201.16, Tk57725.00, and Tk31009.85 per ha in Manikganj respectively. The results supported previous studies (Rahman and Rahman, 2013). BCRs were 1.26 and 1.59 for both districts, respectively. That is, by investing one taka in maize production, farmers could generate Tk1.26 and Tk1.59 in these two regions respectively (Table 4). The findings were consistent with similar studies (Moniruzzaman et al., 2009; Rahman and Rahman, 2014). Therefore, maize cultivation is profitable in Bangladesh which supports previous findings (Rahman, 2003; Rahman et al., 2016).

Table 4. Gross margin and benefit:cost ratio (undiscounted) of maize production.

Items	Manikganj	Rajshahi
Average yield (kg/ha)	8352.37	8773.21
Gross Return (Tk)	148201.16	154407.10
Gross Margin (Tk)	57725.00	79683.89
Net Return (Tk)	31009.85	56999.04
BCR (undiscounted)	1.26	1.59

Source: Field survey, 2018.

Factors Affecting the Yield of Maize

The impact of explanatory variables on maize-yield was estimated with the help of the Cobb–Douglas production function. The most dominant factor, seed, has a positive effect on yield, implying that a 1% increase in the seed would increase maize production by 0.38% (Table 5).

Table 5. The estimated value of coefficients of the Cobb-Douglas production function.

Variables	Coefficients	Standard Error	T-stat	P-value
Intercept (β_0)	5.26***	0.53	9.94	0.00
Amount of Seed (β_1)	0.38***	0.05	7.66	0.00
Cost of Land preparation (β_2)	0.07*	0.04	1.85	0.07
Number of Labor (β_3)	-0.02^{NS}	0.09	-0.17	0.86
Amount of Fertilizer (β_4)	0.24***	0.07	3.38	0.00
Cost of Irrigation (β_5)	0.06**	0.02	2.35	0.02
R Square		0.6994		
Adjusted R Square		0.6873		
Return to scale		0.73		
F- ratio		57.70***		

Source: Field survey, 2018.

Notes: (a) ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

(b) NS: Not significant.

A significant positive impact of seed on onion-yield was available (Anik et al., 2017). The significant positive impacts of fertilizer, land preparation, and irrigation were identified on the output of maize. Therefore, by increasing those factors by 1%, the yield of maize could be increased by 0.26, 0.07 and 0.06%, respectively. The relationship here was in line with Karim et al. (2010) who presented similar relationship of those variables on the return from maize production. Nevertheless, the estimated insignificant negative coefficient of labour

contradicted with the earlier study (Karim et al., 2010). The summation of the coefficients of all inputs of maize production was 0.73 which exhibited decreasing returns to scale as found by Gani and Omonona (2009). The coefficient of multiple determination (R^2) was 0.6994 which indicated that other things remaining the same, the explanatory variables included in the function could explain about 69.94% variability of maize-yield. The highly significant F-value (57.70) justified the importance of the explanatory variables in the model for explaining the variability of the output (Table 5). Although seed and fertilizer were underutilized in the maize production, overutilization of labour was observed (Table 6) which were consistent with previous studies (Awunyo-Vitor et al., 2016).

Table 6. Estimated resource use efficiency in maize production.

Variables	GM	MVP	MFC	RUE	Comment
Seed	18.88	2711.72	413.08	6.56	Underutilized
Labor	110.17	-19.38	364.37	-0.05	Over utilized
Fertilizer	632.88	51.56	17.57	2.93	Underutilized

Source: Field survey, 2018

Problems of maize cultivation

Problems of maize cultivators were assessed and ranked based on their severity. The high price of seeds was a major hindrance to 73.85% of respondents which supports findings of Moniruzzaman et al. (2009). Farmers were the worst sufferer of the effect of climate change which was the second most severe problem (Table 7).

Table 7. Problems of maize production in the study areas.

Type of Problems	No. of farmers	Percentage of farmers	Rank
The high price of seeds	96	73.85	1st
Natural Calamities	93	71.54	2nd
Low price of grains	78	60.00	3rd
Lack of credit facility	62	47.69	4th
Lack of irrigation facilities	56	43.08	5th
The high price of fertilizers	53	40.77	6th
Lack of Quality Seed	46	35.38	7th
Inadequate extension service	27	20.76	8th
Lack of suitable land	18	13.85	9th
Lack of Scientific Knowledge	15	11.54	10th

Source: Field Survey, 2018

With increasing national yield, the low price of grains appeared as a crucial reason for the reluctance in maize farming. Maize production is capital intensive. Although various factors influenced farmers' adoption decision of credit (Adnan et al., 2021b), credit unavability was severe problem to 48% of farmers. Cultivable land is decreasing and farmers applied a high amount of fertilizer to obtain the expected yield rate. Consequently, the cost of fertilizers increased. About 35% of farmers didn't have the access to quality seeds. A few farmers (about 21%) reported that they didn't receive the required extension services regarding improved cultivation methods. Few growers (11.54%) had little knowledge of the right doses and methods of using modern inputs and technologies. A lack of knowledge of farmers was identified earlier (Hasan, 2008; Moniruzzaman et al., 2009).

CONCLUSION

The study areas had tremendous potential for maize cultivation since maize cultivation was profitable in these areas. By optimizing input use, farmers could decrease the cost of production to some extent and increase the production. Hence, it is necessary to make them aware of the efficient use of resources. There are huge opportunities to encourage farmers in investing more in maize cultivation by minimizing the constraints they faced. Otherwise, those problems may create unbeatable hurdles in flourishing the maize-yield in future. The impact of new technology adoption, to ensure optimization of resource use, on welfare of the maize farmers can be explored.

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