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Economics of maize cultivation at selected intensive areas of Bangladesh

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ABSTRACT

The study was undertaken to assess the input used pattern and profitability of maize in selected intensive maize-growing areas of Bangladesh from February to July 2019. The present study was conducted in four districts viz. Chuadanga, Jhenaidah, Meherpur and Kushtia were located at AEZ-11, an intensive maize-growing area. In this study, 160 farmers were selected, of which 40 from each district were randomly selected for data collection. The average farm size was 0.64 ha, whereas the maize cultivated area was 0.34 ha. It was observed that maize was cultivated from November to December in the study area. The average per hectare seed required was 20 kg ha^{-1} and the fertilizer requirement was 1532 kg ha^{-1}. The average labor required was 275 man-days in a season due to less use of technology. Total production cost was Tk. 162047 ha^{-1}, in which variable cost was Tk. 101066 ha^{-1} (62%) and the fixed cost was Tk. 60980 ha^{-1} (38%). The price of the main maize grain at Farmgate was Tk. 18 kg^{-1}. The gross margin was Tk.1 91962 ha^{-1} and the net margin was Tk. 40515 ha^{-1} average. The benefit-cost ratio on a cash-cost basis was 1.90 and on a total-cost basis was 1.18, meaning maize cultivation was profitable. Land preparation, seed, organic manure, TSP, Urea, MoP, DAP, Gypsum, Zinc and Boron had a positive influence on maize production. The high price of fertilizer and seed was the main problem farmers faced and due to high demand, there were no marketing problems. Though it had some problems, maize cultivation overall was a profitable crop.

Keywords: Economics, Maize, Cost and return, Profitability

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Introduction

Bangladesh is an agriculture-based country where agriculture is considered the backbone of its economy. Agriculture plays a vital role in poverty alleviation, employment generation, food security, and the living standard by increasing the farmer's income. Developing countries like Bangladesh benefited from the green revolution in cereal crop production in the past but could not substantially reduce malnutrition and poverty. Maize (*Zea mays*) was one of the most important food grains in the world and the third most important cereal crop after rice and wheat. In Bangladesh, maize became second after rice according to acres and production, followed by wheat from 2021 to 2022 (BBS, 2022). Maize was the most important food grain because it was the highest-yielding crop and could be used for many things in Bangladesh and worldwide. Maize was a great combination of low production cost, high market demand, and high yield, which has generated great interest in maize cultivation among farmers. It is gaining popularity daily in the country due to vast demand, particularly for the poultry industry (Karim *et al.*, 2018). Farmers were shifting to maize cultivation from rice and wheat due to the low cost of production, higher profitability, high demand in the poultry industry, and less risk-averse crops (Kausar and Alam, 2016). Maize supplies food for humans, feed and fodder for animals, fuel for domestic use and raw materials for industry in Bangladesh and the world. The commercial production of maize in Bangladesh started in the early 1990s, and since then, it has been increasing and has become a major cash crop (Uddin *et al.*, 2010). In Bangladesh, the maize area covered was 4,76,492 hectares and production was 4.26 million MT during 2021-22 (BBS, 2022). The production and consumption of maize in Bangladesh are increasing as its demand increases day by day, though there is a huge gap between demand and supply (Islam and Hoshain,2022). This demand increases, and the poultry and fish sector continues to grow day by day. Area and production also increased yearly in the study area (Table 1). This studied area supplies twenty-five percent of total maize production in Bangladesh. The cultivation area and production of maize are increasing in Bangladesh day by day (Fig. 1).

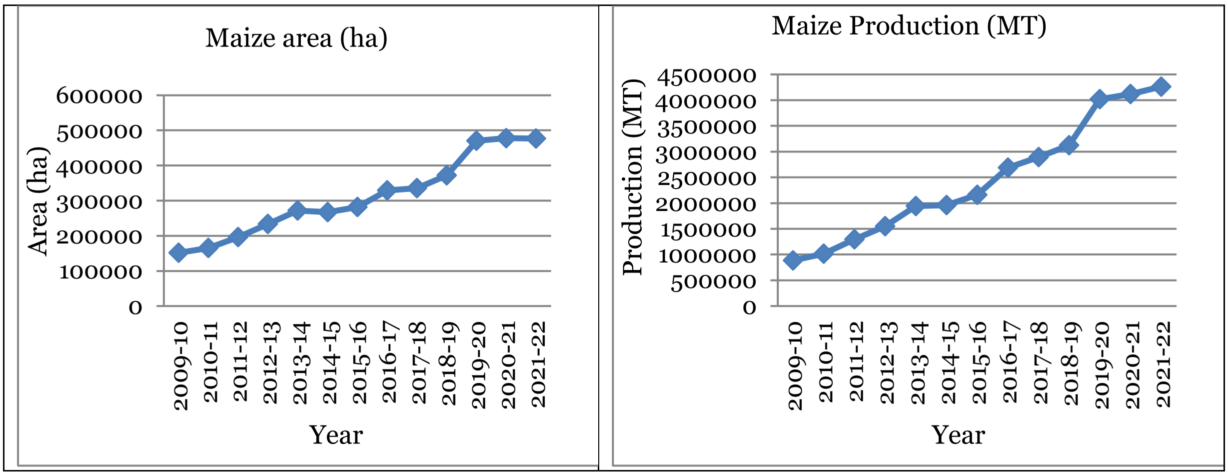

Fig. 1. Area and production trend of maize in Bangladesh.

Table 1. Areas (ha) and production of maize in study areas from 2013-14 to 2021-22.

Year	Maize area (ha)				Maize production (MT)			
	Jhenaidah	Chuadanga	Meherpur	Kushtia	Jhenaidah	Chuadanga	Meherpur	Kushtia
2013-14	6073	47329	14122	4081	36278	398317	110993	34504
2014-15	5794	43444	14321	2966	36278	422129	94769	23440
2015-16	5671	47017	9315	3646	36212	453262	73788	35024
2016-17	6999	48957	12531	7551	57648	474524	100385	82783
2017-18	6258	44733	14890	8481	58759	437590	135062	100678
2018-19	7183	47017	17170	11135	67920	419767	135062	123403
2019-20	17240	48133	11424	9450	166492	503179	129200	94545
2020-21	17350	47554	11411	9903	171445	517260	124916	97640
2021-22	18563	46563	11017	9598	179301	488723	125421	95423

Source: BBS, 2022

As a remunerative cereal crop, maize is grown in drought-prone and typical environments (Khandoker *et al.*, 2018). Most of these four districts were drought-prone, and cultivated maize grain became popular in these areas. As stated, maize production in drought-prone areas was lower than in normal areas. However, its production cost in drought-prone areas was higher than in normal land due to the high cost of irrigation, labour and other required inputs. Selected areas included AEZ-11 (High Ganges River Floodplain), predominantly most highland and some medium highland. The soil was calcareous brown and dark grey calcareous, with low organic matter content in the brown ridge and high dark grey soils. Soils were slightly alkaline in reaction to the low fertility level of that area. However, this region is intensively maize cultivation at present. With the increasing demand for maize for food and feed, researchers adopt heat-tolerant hybrid maize varieties for drought-prone areas to improve stable maize cultivation (Koirala *et al.*, 2021). Though there were different studies on maize cultivation, the present study was undertaken to provide information about the input use pattern and profitability of maize cultivation in the study areas.

Materials and Methods

Study areas with sample size

The present study was conducted in four consecutive districts, namely Meherpur, Kushtia, Chuadanga, and Jhenaidah, located at AEZ-11 and covering a large portion of that region. A purposely selected study area was considered for the higher concentration of maize production. The study was conducted using a formal survey method with a prepared questionnaire. The questions included socio-economic data, farm type, crop data, crop production, input use, cost of input and output price , problem identification, etc. The questionnaire was prepared in Bengali, and a face-to-face interview was done there for close interaction with the farmer. In this study, 160 sample farmers were selected, of which 40 were from each randomly selected district for the present interview. Data were collected through a pre-designed interview method from February to July 2019. For a cross-section of information, farmers were gathered in one place and interviews were taken together and individually.

Data collection, analysis and descriptive statistics

The primary data was collected based on a field survey from farmers involved in maize cultivation. Different required information regarding the study was collected based on socio-economic characteristics and other related information of the farmers, crop production, input used and, input price and output gain, etc. The field immunerator, under the guidance of the researcher, collected field-level data. The respondent farmers were categorized into different groups such as small, medium and large. The categories were developed based on the percentage of respondent farmers concerning each technology. By analyzing data, a combination of descriptive statistics, statistical and mathematical techniques were used to gain the objectives and to get meaningful results. After collection data were edited, summarized, tabulated and analyzed to fulfill the objectives of the study. Descriptive statistics using different statistical tools like percentages, averages and ratios were used in presenting the study results were calculated using Microsoft Excel. Mean, range, maximum value, minimum value, standard deviation (SD), etc., were calculated using the SPSS statistical packages. Graphical data presentation such as graphs and figures were presented by the output results.

Profitability analysis of maize

The profitability analysis of maize was measured in gross output, gross margin, net return and benefit-cost ratio (undiscounted). The formulas required for the estimation of profitability were as follows:

$GR = \sum Pmj \times \sum Qmj$; $GM = \sum GR - \sum TVCmj$; $NR = GR - \sum(TFC + TVC)$; $BCR = GR \div (TFC + TVC)$

Where,

GR = Gross output;
Pmj = Selling price of maize of j farmer (Tk. ha^{-1});
Qmj = Yield of maize of j farmer (Ton ha^{-1});
GM = Gross margin;
TVCmj = Variable cost of maize of j farmer (Tk. ha^{-1});
NR = Net return; TFC = Total fixed cost (Tk.); and BCR = Benefit-cost ratio

The Cobb-Douglas production function model was used to calculate the contribution of factors to maize cultivation. The Cobb-Douglas production function model is given below.

$$Y = AX_1^{b1}X_2^{b2} \dots\dots\dots\dots\dots.. X_n^{bn}e^{ui}$$

The function was converted to logarithmic form so that it could be solved using the least square method, i.e.,

$$\ln Y = a + b_1 \ln X_1 + b_2 \ln X_2 \dots\dots\dots\dots\dots\dots. + b_n \ln X_n + U_i$$

The empirical model of production function is as follows:

$$\ln Y = a + b_1 \ln X_1 + b_2 \ln x_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + b_9 \ln X_9 + b_{10} \ln X_{10} + b_{11} \ln X_{11} + b_{12} \ln X_{12} + b_{13} \ln X_{13} + b_{14} \ln X_{14} + Ui$$

Where,

Y= Yield of maize (kg ha^{-1}),
X_1 = Land preparation cost (Tk ha^{-1}),
X_2 = Seed (kg ha^{-1}),
X_3 = Labour (man-days ha^{-1}),
X_4 = Manure (kg ha^{-1}),
X_5 =Insecticide cost (Tk. ha^{-1}),
X_6 = Irrigation cost (Tk. ha^{-1}),
X_7 = Urea (kg ha^{-1}),
X_8 = TSP (kg ha^{-1}),
X_9 = DAP (kg ha^{-1}),
X_{10} = MoP (kg ha^{-1}),
X_{11} = Gypsum (kg ha^{-1}),
X_{12} = Thiovit (kg ha^{-1}),
X_{13} = Boron (kg ha^{-1}),
X_{14} = Zinc sulfate (kg ha^{-1}),
a = Intercept,
$b_1, b_2 \dots\dots\dots\dots. b_{14}$ = Coefficients of the variables to be estimated,
U_i = Error term.

Results and Discussion

Socio-economic profile of maize farmer

Socio-economic characteristics are the reflection of persons positive and negative attitudes or qualities. Socio-economic profile of the sample farmers, including age, family size, level of education, social status, occupational status, professional training, land holding and distribution of land, etc. Maize production was influenced by some important factors such as education, cultivators neighbor, farm size, high output price etc. (Alam *et al*., 2016). About forty-six percent of farmers were young, 31-50 years old (Table 2). Thirty-one percent of farmers were below thirty years old, which means young people are involved in farming at an early age, especially profitable crops like maize. Aged old farmers were also involved in maize farming as they traditionally practiced farming activities. Thirty percent of farmers had mass education, meaning they could write their names, whereas twenty-one percent went to primary school to gather knowledge. About forty-two percent of farmers had gained secondary education and others were HSC and above. The average household size was 4.28, the same as the national average (4.06) (HIES, 2019). Among the family members, adult male members were 40%, adult female members were 34%, and 26% were children (Fig. 2). The average farming experience was 13.23 years. Most of the farmers are involved in farming as their main occupation. The average farm size was 0.64 ha, whereas the maize cultivated area was 0.34 ha, about fifty percent of the total cultivated land area.

Table 2. Socio-economic profile of respondent farmers.

Features	Categories	% of farmers	Range	Mean	SD
Age of farmer	<30 years	31			
	31-50 years	46	20-65	40.81	12.22
	Above 51 years	23			
Education	Mass education	30			
	Primary level	21			
	Secondary level	42	1-15	5.78	3.89
	Above HSC	7			
Household size (No.)			2-9	4.28	1.35
Average farming experience (years)			1-35	13.23	9.28
Farm size (ha)			0.12-1.62	0.64	0.38
Maize cultivated area (ha)			0.12=1.21	0.34	0.23

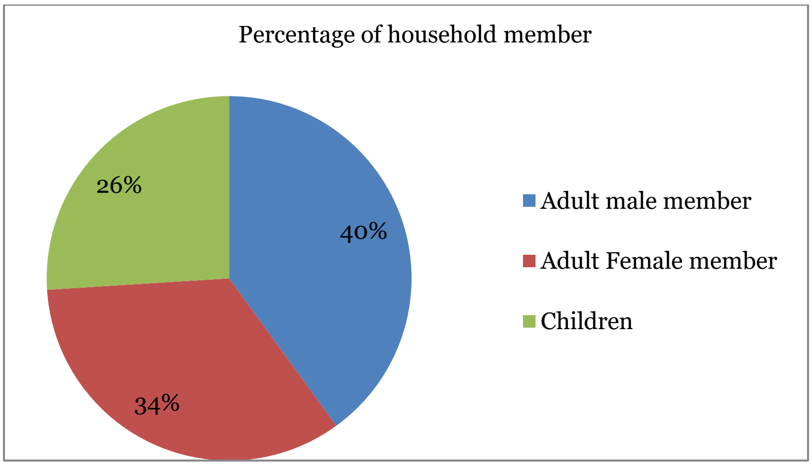

Fig. 2. Percentage of household members of the selected sample.

Agronomic management of maize cultivation

Maize is cultivated both in the robi and kharif seasons in Bangladesh. In the study area, both seasons of maize were cultivated, but only the Robi season was considered in this study. Maize was cultivated from mid-November to December in the selected area, whereas it was stated that most farmers sown maize hybrid seeds during the first week of December (Karim *et al.*, 2010). However, in other cases, some maize farmers sow maize seed in the 3rd week of October and extend it to the last week of December (Moniruzzaman *et al.*, 2010). The recommended sowing time of maize for the Robi season was October to November and for the kharif season, mid-February to March (Azad *et al.*, 2020). If the seed was primed by hydroprimed, it gets a high yield (Ahammad *et al.*, 2020). Most of the farmers cultivated hybrid maize varieties collected from different companies. Among the cultivated maize variety was Pioneer V-92 (21%), Pacific-60 (19%), Kaberi (14%), NK-40 (12%), Supershine-2760 (10%), Elite (9%), Sunshine (7%), 981 (5%) and 987 (4%) in the study areas (Fig. 3). There did not found BARI and BWMRI maize variety in the selected areas that farmer cultivated. The main reason for the non-adoption of BARI varieties would be less availability of seeds in the study. The extent of use of maize cultivating variety depends on the availability of seeds at the local market from which farmer collect their necessary seeds (Khandoker*et al.*, 2018).

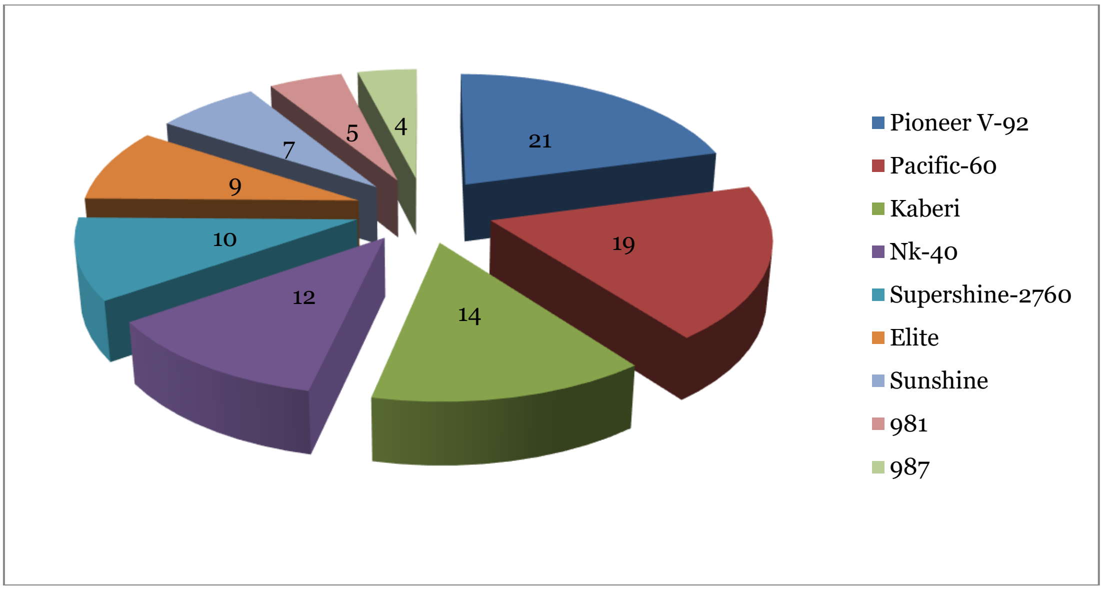

Fig. 3. Maize variety cultivated in the study area (% of farmers).

Input use pattern

Inputs are necessary for agricultural production. Inputs in agriculture include such as seed, labor, organic fertilizer (manure, compost, vermin compost and co-compost), inorganic fertilizer (Urea, TSP, MoP, Gypsum, DAP, Thiovit, Boron and Zinc etc.), irrigation, pesticide etc. were necessary for smooth production of any crops. Land, labor, capital and the farmer were the key elements of any agricultural production system. In maize production, the average seed required was 20 kg ha^{-1}, whereas all the selected study areas required seed amounts to be the same as the average amount. Labor required for land preparation, seed sowing, weeding, fertilizer application, pesticide spray, irrigating, harvesting the crop, carrying, threshing, cleaning, drying, weighing, storing and marketing of the products. There is a huge amount of labor for maize cultivation because technology is not developed and adapted. The average labor required was 275 man-days in a season for maize cultivation (Table 3). Organic fertilizers such as manure and compost have required an average of 1585 kg ha^{-1}. Average fertilizer applications such as Urea, TSP, MoP, DAP, Gypsum, Thiovit, Boron and Zinc were 497 kg ha^{-1}, 418 kg ha^{-1}, 266 kg ha^{-1}, 159 kg ha^{-1}, 155 kg ha^{-1}, 12 kg ha^{-1}, 13 kg ha^{-1} and 12 kg ha^{-1}, respectively. All the study areas spend too much fertilizer for maize cultivation, which affects its production cost. The average total fertilizer requirement was 1532 kg ha^{-1} in all areas. Studies have stated that proper nutrient management at maize fields maximizes maize yield and provides a good margin for farmers (Mahamood *et al.*, 2016).

Table 3. Input used pattern in maize cultivation.

Input	Amount	% of fertilizer
Seed (kg ha^{-1})	20	-
Labor (Man-days ha^{-1})	275	-
Manure (kg ha^{-1})	1585	-
Urea (kg ha^{-1})	497	32.45
TSP (kg ha^{-1})	418	27.28
MoP (kg ha^{-1})	266	17.37
DAP (kg ha^{-1})	159	10.38
Gypsum (kg ha^{-1})	155	10.14
Thiovit (kg ha^{-1})	12	0.79
Boron (kg ha^{-1})	13	0.80
Zinc (kg ha^{-1})	12	0.79
Total fertilizer (kg ha^{-1})	1532	100.00

Source: Field survey, 2019.

Cost of maize cultivation

The cost was the expenses for accumulating, organizing and carrying out the production process. For calculating the cost of production of maize, all variable costs like land preparation, human labor, seed, fertilizers, manures, insecticide, irrigation, etc., were calculated per hectare basis. The fixed cost of maize production included family labor cost and the cost of lease value of land use. The cost of land use was calculated based on the annual lease value of the land. Among the cost items, fertilizer buying cost was the highest Tk. 36921 ha^{-1} (23%) followed by hired labor Tk. 24641 ha^{-1} (15%), irrigation Tk. 10214 ha^{-1} (6%), land preparation Tk. 7362 ha^{-1} (5%), seed Tk. 5964 ha^{-1} (4%), organic fertilizer Tk. 5686 ha^{-1} (4%) and pesticide were Tk. 3596 ha^{-1} (2%), respectively. Maize shelling was important for maize cultivation. Generally, shelling was done by the shallow engine-operated maize sheller machine, whose average cost was Tk. 3738 ha^{-1}. It was noted that BARI-developed maize sheller increases maize productivity by 34-65% at the farm level than the non-user (Begum *et al.*, 2022). In the maize field, there was less infestation of pests and insects. Recently, there was an attack by an insect called the fall army worm, which wreaked havoc and significantly affected maize cultivation. For this reason, farmers applied different pesticides in maize fields to control insect pests. Maize cultivation required huge amounts of irrigated water because the weather was dry and arid in this region during the Rabi season. Therefore, it requires a lot of irrigation water, and in the early stages, it needs to be irrigated many times for good yield. Irrigation has a great impact on its yield, and the highest yield was gained at different stages of water management (Kobir *et al.*, 2019). Besides, interest in organizing capital was considered as variable cost. The average total production cost was Tk. 162047 ha^{-1}, in which variable cost was Tk. 101066 ha^{-1} (62%) and fixed cost was Tk. 60980 ha^{-1} (38%).

Table 4. Production cost of maize per hectare.

Cost item	Cost (Tk. ha^{-1})	% of cost
Variable Cost		
Land preparation cost	7362	4.54
Seed	5964	3.68
Hired labor	24641	15.21
Shelling cost	3738	2.31
Fertilizer	36921	22.78
Manure	5686	3.51
Pesticide	3596	2.22
Irrigation	10214	6.30
IOC	2944	1.82
Total variable cost	101066	62.37
Fixed cost		
Family labor	38540	23.78
LUC	22440	13.85
Total fixed cost	60980	37.63
Total cost	162047	100.00

Source: Field survey, 2019.
Note: IOC: Interest on operating capital was calculated on 9% interest rate basis.
LUC: Land use cost was calculated annual lease value and it was Tk. 9000 per bigha (33 decimal) basis.

Profitability of maize cultivation

Profitability is one of the major determining criteria for acceptance of a crop. Output was calculated by multiplying yield with its price. Farmers get a good yield of maize by cultivating hybrid varieties of maize in the study areas. Maize cultivation was profitable and marginal farmers gained higher profits than small and large farmers (Biswas *et al.*, 2023). The average maize production was 10.66 MT ha^{-1} (Table 5). The price of the main maize grain at the Farmgate was Tk. 18 kg^{-1}. The prices of by-products did not count in this study. The average gross margin was Tk. 191962 ha^{-1} and the net margin was Tk. 40515 ha^{-1}. Maize residue utilization is also important for crops (rice) and livestock, as maize supplied fodder (Uddin and Goswami, 2016). Large farmers get higher profits than medium and small farmers (Hasan *et al.*, 2017). However, per hectare gross margin and net return were higher for medium farmers than for small and large farmers (Uddin *et al.*, 2010). Another study was conducted where the gross margin and net return of large farmers were higher than those of small and medium farmers (Ferdausi *et al.*, 2014). In case of Nepal farmers, maize seed production was more profitable for large farmers than other small farmers (Sapkota *et al.*, 2018). For higher profit, some farmers store their maize in a granary for some weeks (Baksh *et al.*, 2017), and storage benefit of the products (Hajong *et al.*, 2014). Besides this arathdar and wholesalers also store maize at storehouses for two to three months to get high prices(Kausar *et al.*, 2015). The benefit-cost ratio on a cash-cost basis was 1.90, and the undiscounted benefit-cost ratio was 1.18 on a total-cost basis, which means maize cultivation was the profitable crop in the selected area.

Table 5. Profitability of maize cultivation.

Particular	Amount
Yield (MT ha^{-1})	10.66
Gross margin (Tk. ha^{-1})	191962
Production cost (Tk. ha^{-1})	162047
Net margin (Tk. ha^{-1})	29915
BCR (cash cost basis)	1.90
BCR (total cost basis)	1.18

Source: Field survey, 2019.

Contribution of inputs to maize cultivation

Various variable inputs were employed for producing maize, which were included in the model. Cobb-Douglas production function with estimated values of coefficients and related statistics were presented (Table 6). The coefficient of determination (R^2) explains how well the sample regression line is fitted with data. Land preparation, organic fertilizer, seed, TSP, Urea, DAP, MoP, Boron, Gypsum and Zinc had a positive impact on maize cultivation. Labor, pesticide, thiovit and irrigation had a negative influence on maize cultivation. Seed, MoP, Gypsum and Boron had a positive effect and were significant at 1% level, indicating that 1% increase in the use of seed, MoP, Gypsum and Boron, keeping all other different factors remaining constant would increase the yield of maize by 0.054%, 0.099%, 0.063% and 0.406%, respectively. A study stated that Boron played a significant role in increasing maize yield at a certain level (Rahman *et al.*, 2018). The coefficient of determination (R^2) was 0.706, which implies that around 70.6 percent of the variations in maize yield were implied by the independent variables covered in the model. The statistical F-value of the equation is significant at 1% level, exposing that the variation in yield from maize production predominantly depends on the independent variables inserted in the model.

Table 6. Coefficients and related statistics of production function for maize cultivation.

Exponential variables	Coefficient	Standard error	t-values
Intercept	8.686***	.475	18.288
Land preparation (X_1)	0.381**	.046	2.516
Seed (X_2)	0.054***	.083	0.477
Labor (X_3)	-0.131	.044	-1.062
Manure (X_4)	0.138**	.052	0.799
Insecticide (X_5)	-0.058	.031	-.461
Irrigation (X_6)	-0.064	.060	-.400
Urea (X_7)	0.245**	.059	1.752
TSP (X_8)	0.230**	.045	1.671
DAP (X_9)	0.109**	.030	0.784
MoP (X_{10})	0.099***	.035	0.879
Gypsum (X_{11})	0.063***	.027	0.521
Thiovit (X_{12})	-0.155	.040	-1.241
Boron (X_{13})	0.406***	.038	3.377
Zinc (X_{14})	0.210**	.040	1.754
R^2	0.706		
F-value	2.954***		

*Note: ***, ** and * indicate significant at 1%, 5% and 10% level, respectively.*

Constraints of maize cultivation

Maize cultivation was the most profitable crop. High prices of hybrid seeds, fertilizer and natural calamities (Sampa *et al.*, 2022) were the main problems faced by the farmers. Maize cultivation was costly in that it required a huge amount of fertilizer. Lack of quality seed, credit facilities, and high input costs were the constraints for maize cultivation. Farmers reported that insect infestation, mainly cutworm and fall armyworm, which was new in that area, was another problem in maize cultivation. In a study, it stated that there were many maize diseases (17) and causal organisms (30) identified in Bangladesh (Faruq *et al.*, 2014), though it did not hamper maize cultivation. However, in drought-prone regions, it was hard to cultivate maize, though its cultivation was increasing day by day. The farmer did not face any marketing problems in the study area due to the high demand for maize.

Conclusion

Farmers cultivated hybrid seeds, which had a high cost. For this reason, research organizations must develop high-yielding hybrid maize varieties and disseminate them to farmer fields. Though BARI and BWMRI had developed and released some hybrid maize varieties, the yield did not, hopefully, according to other hybrid seeds. Maize grain helps in the income generation of farmers and the nutrition status of poor people as its flour can be consumed along with wheat flour. The technology used in different stages of maize cultivation, such as seeder, weeder, harvester, grain sheller, etc., can reduce labour and improve the system productivity and profitability of maize cultivation. Due to high market demand and use in poultry and fish feed mills, the cultivation was increasing day by day. The main constraint faced by the farmer was the high price of hybrid seed and fertilizer as well as other inputs.

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