j. innov.dev.strategy. 2(1): 18-32 (April 2008)

ECONOMIC EFFICIENCY AND CONSTRAINTS OF MAIZE PRODUCTION IN THE NORTHERN REGION OF BANGLADESH

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Accepted for publication: March 03, 2008

ABSTRACT

Faruq Hasan M. 2008. *Economic Efficiency and Constraints of Maize Production in the Northern Region of Bangladesh.* **j. innov.dev.strategy 1(1): 18-32**

The study was conducted at the Sadar upazila of Dinajpur and Panchagarh to estimate the costs, returns and economic efficiency of maize production compared to Boro rice. The growth rate of maize in the country and constraints to maize production at farm level was also emphasized. The sample size of the study was 100 equally from each district. All the farmers used hybrid seeds for maize cultivation with an average yield of 6.27 ton/ha, which is higher in Dinajpur (6.35 ton/ha) compared to Panchagarh district (6.18 ton/ha). The returns of scale of the selected inputs were 0.72 and 0.68 for Dinajpur and Panchagarh respectively. The technical efficiency was found on an average 0.84 at Dinajpur and 0.80 at Panchagarh. It was also found that, farmers in the study area had scope to increase maize productivity by attaining full efficiency through reallocating the resources. Economic analysis of maize and maize-based cropping pattern in comparison to Boro rice and Boro-based cropping pattern indicates the high profitability of maize production system than that of Boro rice. Comparatively high growth rate was found in area, production as well as in yield of maize since 1987-88 to 2005-06 as the composite and hybrid varieties were introduced in this period. High seed price, low grain price, and unavailability of fertilizers at time when required are the top most three constraints as indicated by the maize farmers. It was suggested that, supply of inputs at fair price at time when required and an organized marketing system is essential for expanding the maize production in the country.

Keywords: Economic efficiency, maize production, constrains

INTRODUCTION

Maize is the third most important grain crop in the world. It is introduced as relatively new crop in the cropping patterns of Bangladesh especially in the northern region. Every year approximately 1.2 million ton maize is utilized of which only 42% is produced by the country and remaining is imported from other countries (BBS, 2005). More than 90% of maize is used as poultry feed and the remaining in fish sector and as human food products. The country has a great potentiality to improve and expand the maize production. Maize is a relatively new crop in Bangladesh and it has an enormous market potential. The country's poultry industry continues to grow and so there is also a growing demand for maize. Farmers cultivating maize are not completely aware of the benefits of maize cultivation. They are not interested to invest for maize cultivation as they do not have proper information on maize farming and marketing techniques.

Bangladesh is facing a problem of malnutrition due to her high population growth and low productivity of crops. The traditional crop including rice and wheat seems quite unable to meet up the nutritional requirements to the increasing population. So, it is a time demand to introduce a new crop like maize to the existing cropping pattern of the country. Maize can be a potential grain crop for nutritional support to the country population. Moreover, the country environment is more suitable for cultivation of this crop. The economics related to maize cultivation need to be exposed among the farmers for its proper diffusion. A number of studies have conducted concerning the economics of maize production including costs and returns (Hossain, 1990; BARI, 1988 and BARI, 1980). However, no study is conducted on the profitability of maize and maize-based cropping pattern compared to competitive crop Boro rice and Boro rice-based cropping pattern at farm level. In view of the above stated facts, the present study was undertaken with the overall objectives to characterize maize production system, estimate the profitability and input use efficiency, examine the growth rates, identify and analyze the constraints and opportunities for the higher production of maize and maize-based cropping patterns. However, followings are the specific objectives of the study:

1) To characterize the maize production system in terms of tillage, nutrient and water management practices, and their effect on maize production
2) To measure the technical and economic efficiency of maize production
3) To assess the profitability of maize and maize-based cropping patterns
4) To examine the growth rate of maize in terms of area, production and yield
5) To find out the main constraints to improve production of maize and
6) To suggest policy guidelines for sustainable maize production

METHODOLOGY

Study Area and Sample

The study was conducted in Sadar upazila of Dinajpur and Panchagarh district purposively as maize is grown here popularly. One hundred maize farming households from these two districts (covering fifty from each district) were selected randomly. A list of all maize-growing farmers in each selected upazila was prepared. Then from each upazila 50 farmers were selected from the list by systematic random sampling method. For each farmer, one maize plot and another Boro rice plot (for comparison) were selected for data collection. Data were collected from these selected plots in each crop season and was covered three crop seasons of the year.

Data Collection

Data on production technologies of maize and Boro based cropping patterns were collected seasonally from January 2007 to February 2008 in each crop season. For the purpose of characterization of production systems and profitability, data were collected on input use like seeds, fertilizers, pesticides, irrigation, implements, animal power, human labor etc., and all management operations like ploughing, seeding, fertilizing, irrigating, weeding, harvesting, threshing etc. and methods of cultivation of maize and Boro-based cropping patterns. Main yield and by-products of respective crops were also collected. Existing market prices of all inputs and outputs were collected for profitability analysis. During data collection an interview schedule was employed keeping the objectives of the study in mind.

Analytical Techniques

Characterization of maize production system

The collected data were entered into computer and analyzed using SPSS program. Descriptive statistics were mostly used to characterize the tillage, nutrient and water management practices for maize production.

Input use effect on yield

Many factors can affect maize yield, such as seed rate, human labor, manure, fertilizer, irrigation water use, etc. These variables were considered as a *priori* explanatory variables responsible for variation in maize yield. The individual effect of these inputs and factors can be explained to a certain degree by multiple regression analysis. The Cobb-Douglas model was selected for the present analysis as it is generally considered superior on theoretical and econometric grounds for determining the effects of variable inputs. It also allows for regression under Ordinary Least Squares (OLS) in logarithm, yields coefficients which represent production elasticity and if all the inputs related to the production are taken into account as the independent variables, the sum of the production elasticity's indicates whether the production process as a whole yield increasing, constant or decreasing returns to scale. Data were converted to per hectare basis to facilitate the analysis. Eight variables were selected and hypothesized to explain the yield of maize as those variables were found more relevant. The selected Cobb-Douglas production function model, in its stochastic from:

$$Y = aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}X_6^{b6}X_7^{b7}X_8^{b8}e^u$$

Transforming it into double log-linear form:

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + U$$

Where,

Y = Yield of maize (kg/ha)
a = Constant or intercept term
X_1 = Seed rate (kg/ha)
X_2 = Amount of manure (kg/ha)
X_3 = Amount of Urea (kg/ha)
X_4 = Amount of TSP (kg/ha)
X_5 = Amount of MP (kg/ha)
X_6 = Time require for irrigation (hrs/ha)
X_7 = Number of human labor (man-day/ha)
X_8 = Number of ploughing
ln = Natural logarithm
b_l……….b_8 = Coefficients of respective variables, to be estimated and
U = Stochastic error term

Measurement of resource use efficiency

Technical and allocative efficiencies were employed to measure the resource use efficiency. The technical efficiency in production was estimated by using the stochastic frontier production function. The primary advantage of a stochastic frontier production function is that it enables one to estimate Ui (Non-negative random variable which is under the control of the farm) and therefore also to estimate farm specific technical efficiencies. The technical inefficiency arises when less than maximum output is obtained from a given set of factors and allocative inefficiency arises when the factors are used in proportions which do not lead to profit maximization (Russel, 1983). Technical efficiency was measured by using the following equation:

$$\text{Technical efficiency (TE)} = (\ln Y_j/\ln Y_j^*) < 1$$

Where,

$\ln Y_j$ = Actual maize production and
$\ln Y_j^*$ = Potential maize production

The elasticities of production of factor input from Cobb-Douglas production function were used to calculate the Marginal Value of Product (MVP) at Geometric Mean Level (GM) for the average farms (Yamane, 1973). In order to test the resource use efficiency the ratio of Marginal Value Product (MVP) to the Marginal Factor Cost (MFC) for each input was compared and tested for its equality to 1, i.e. MVP/MFC = 1 (Yotopoulos, 1976).

Measurement of farmers' profits

Relative profitability of different crops is essential for decision making of farmers about a particular crop. For financial analysis of different enterprises, it is necessary to compute costs of inputs, which need to be deducted from the value of output. Farmers in the study areas used purchased as well as home supplied inputs. Though the cost of home supplied inputs are difficult to calculate in monetary terms those are calculated on the basis of opportunity cost principle. Opportunity cost of an input is defined as an income that it is capable of earning from alternative employment in or outside the farm (Bishop and Toussaint, 1958). In the study area, the land use cost per hectare differed from plot to plot depending on the location, fertility, topography and crop production facilities of the land. The average rental value of land per hectare for a particular year as reported by farmers was considered in calculating land use cost. The average land use cost was calculated at Tk. 3,500 per hectare for growing maize-based crops and Tk. 5,000 for Boro-based crops. Interest on operating capital involved all costs excluding those for which interest had already been charged and was charged at the prevailing bank interest rate, 9.5 per cent per annum. For calculating economic returns, per hectare returns from maize and Boro-based patterns and individual crops in the patterns were broadly classified into gross return, gross margin and net return. The value of the by-product was also added to estimate the gross returns. When by-products were not sold, the values of the by-products were estimated according to the farmers' assessment. Existing market prices were considered both for the product and byproduct. In calculating the production cost, the following components of cost were considered:

a) Seeds/seedlings
b) Manure
c) Fertilizers
d) Insecticides
e) Irrigation
f) Human labor
g) Animal power
h) Interest on operating capital
i) Land use cost.

Computation of gross return

Gross return was calculated by multiplying the total volume of production of an enterprise by the average prices (the average of the farm gate price) of that product in the harvesting period (Dillon and Hardaker, 1980). For maize/Boro based cropping patterns, each of the patterns included 2 to 3 crops. The following equation was used to calculate gross return.

$$\sum GR_i = \sum Q_{mi}P_{mi} + \sum Q_{bi}P_{bi}$$

Where,

GR_i = Gross return (Tk/ha) from ith crops of individual cropping pattern
Q_{mi} = Quantity of the main product (kg/ha) of ith crop in individual cropping pattern
P_{mi} = Per unit price (Tk/kg) of the main product of ith crop

Q_{bi} = Quantity of the by- product (kg/ha) of ith crop
P_{bi} = Per unit price (Tk/kg) of the by-product of ith crop
i = 1, 2, 3... n number of crops in respective cropping pattern

Computation of total cost

Total cost (TC) includes all types of variable and fixed cost items involved in the production process. The total cost was estimated as follows;

$$TC_{ij} = \sum P_{xi} X_i + TFC$$

Where,

TC_{ij} = Total cost (Tk/ha) of the ith crops in the jth pattern
X_i = Quantity (kg/ha) of the ith variable input
P_{xi} = Per unit price (Tk/kg) of the ith variable input
TFC = Total fixed cost of a crop, which includes cost of tools and equipment, land use cost, and the interest on operating capital.

Computation of farmers' profit (gross margin and net return)

Farmers' profits was computed in two ways by (a) gross margin (GM) analysis and (b) net return (NR) estimation with the following two equation:

a) $GM = \sum Q_{mi}P_{mi} + \sum Q_{bi}P_{bi} - \sum P_{xi} X_i$
b) $NR = \sum Q_{mi}P_{mi} + \sum Q_{bi}P_{bi} - \sum P_{xi} X_i - TFC$

Sensitivity analysis

Sensitivity analysis was carried out to determine the degree to which the profitability measures calculated under the set of base line assumptions are likely to be affected by changes in the values of key parameters (Baksh, 2003). These assumptions might change or be unrealistic due to vulnerable market price situation, which could lead to a change in the profitability of maize and Boro production. So, it is important to know the degree to which the empirical results are sensitive to change of the simplifying assumptions that were made.

Estimation of growth rates

The time series data on maize area, production and yield in the respective year were collected from secondary sources like Bangladesh Bureau of Statistics (BBS). Secondary data for growth study covered the period from 1971-72 to 2005-06. The secondary data onthe above variables were manually extracted from the BBS census and web site data. For the growth study, the following statistical procedure was followed.

A simple growth model that relates output (Y) to time (t) used in the study can be represented by the following equation:

$$Y = ae^{bt}$$

Where, a and b are parameters to be estimated, and e is the natural exponential (2.71828). For simplicity, the error term was excluded. Because this equation is nonlinear in the parameters, it is necessary to linearize this equation in order to apply the classical regression model. This may be accomplished by taking the log of both sides (David, 1982);

$$\ln Y = \ln a + bt$$

Where,

$\ln Y$= Natural log of production, acreage and yield of maize
t = Time (1971-72 to 1986-87, 1987-88 to 2005-06 and 1971-72 to 2005-06 referred as the first, second and third period)
a = Intercept
b = Trend growth rate for the period, to be estimated.

Constraints of maize production system

As many as 13 major problems in connection with maize cultivation were included in constraints confrontation scale in the interview schedule after pre-testing of the interview schedule. The respondents were asked to give their response as 'high', 'medium', 'low' and 'not at all' for each constraints included in constraint confrontation scale based on their extent of constraint confrontation in maize cultivation. The weights for 'high', 'medium', 'low' and 'not at all' responses were 3, 2, 1 and 0 respectively. To ascertain extent of seriousness of constraints 'Constraint Facing Index (CFI) for each of the constraints was computed. Constraints were than ranked according to their CFI value. Similar procedure was followed for Dinajpur, Panchagarh and all sampled farmers.

FINDINGS AND DISCUSSION

1 Characterization of Maize Production System

Different inputs and management practices like land preparation and used implements, seed rate, seeding time, nutrient management, water management, effect of inputs on yield of maize and elasticity of production and return of scale are considered to characterize the maize production system are described below.

1.1 Land preparation and its implements

In the study area most of the maize crop is sown following transplanted Aman rice. Farmers used country plough (CP) and power tiller (PT) for land preparation. About 47, 35 and 18 percent farmers used only CP, only PT and both CP+PT, respectively. Farmers at Dinajpur used more PT than that of Panchagarh. To till the maize land better, farmers provided 2.50 pass on an average, but the Dinajpur farmers provide more pass (2.85) than that of Panchagarh farmers (2.15) (Table 1).

Table 1. Number of ploughing of maize plot by different ploughing implements

Location	% of farmers used				Number of ploughing per plot by		
	Sole country plough (CP)	Sole power tiller (PT)	CP + PT	Total	CP	PT	CP + PT
Dinajpur	32	46	22	100	2.01	1.28	2.85
Panchagarh	62	24	14	100	2.23	1.04	2.15
All samples	47	35	18	100	2.12	1.16	2.50

1.2 Seeding time

The optimum time of maize sowing is mid October to last November (BARI, 2006). In the study year, majority of the maize farmers seeded maize seed within mid to last November (Table 2). More than half of the maize farmers of Dinajpur used late sowing.

Table 2. Maize seeding time followed by the farmers during 2007

Location	% of farmers used				
	Oct. 16-31	Nov 01-15	Nov. 16-30	Dec. 01-15	Dec. 16-31
Dinajpur	2	4	40	36	18
Panchagarh	6	18	38	26	12
All samples	4	11	39	31	15

1.3 Seed rate

All maize plots were sown in row plantation with an average seed rate of 17.7 kg/ha (Table 3), which was similar to recommended rate (BARI, 2006). Dinajpur farmers used higher seed rate (18.15 kg/ha) compared to Panchagarh farmers (17.25 kg/ha) and most of the farmers of both regions used hybrid seeds for cultivation of maize.

Table 3. Seed rate used by the farmers

Location	% of farmers reported						
	<14 Kg/ha	14-16 Kg/ha	17-19 Kg/ha	20-22 Kg/ha	23-25 Kg/ha	>25 Kg/ha	Average
Dinajpur	8 (108)	24 (360)	38 (684)	20 (420)	8 (192)	2 (51)	18.15
Panchagarh	10 (135)	36 (540)	34 (612)	14 (294)	6 (144)	0 (0)	17.25
All samples	09	30	36	17	07	01	17.7

1.4 Nutrient management

Organic (FYM) and inorganic fertilizers were considered as a major priori explanatory variable responsible for variation in yield. Farmers in the study area applied both FYM and inorganic fertilizers in the form of urea, TSP, MP, gypsum etc. in the maize field as discussed below.

Organic fertilizer in the form of FYM (a combination of animal manure, animal urine and plant materials used for animal bedding and waste straw feed) was applied once per year in 73 percent of the maize fields (Table 4). On average, farmers applied about 3.29 t/ha of FYM. Panchagarh farmers applied more manure (4.21 t/ha) compared to farmers of Dinajpur (2.36 t/ha). FYM was typically applied before or after first ploughing, and was incorporated by follow up ploughing.

Table 4. Fertilizer use patterns by the farmers

Fertilizers	Dinajpur		Panchagarh		All sample farmers	
	% reported	Quantity (kg/ha)	% reported	quantity (kg/ha)	% reported	quantity (kg/ha)
Manure	68	2.36 (t/ha)	78	4.21 (t/ha)	73	3.29 (t/ha)
Urea: Basal	98		82		90	
1st TD (DAS)	100 (35-45)		98 (30-45)		99 (30-45)	
2nd TD (DAS)	08 (55-65)		00		04 (55-65)	
Urea (Total)	100	116.3	100	98.7	100	107.5
TSP	56	52.41	38	36.51	47	44.46
MP	48	33.57	34	25.71	41	29.64
Gypsum	32	41.13	18	37.23	25	39.18

Note: TD = Top dress, DAS = Days after sowing

All sample farmers used urea, among them, 90 percent applied urea basally. In the study area 99 percent farmers applied additional urea as the first top dress (TD) and only four percent applied a second top dress (Table 4). On average, 107.5 kg/ha urea was used for maize cultivation. The highest quantity was used by the Dinajpur farmers (116.3 kg/ha) followed by Panchagarh farmers (98.7 kg/ha).Table 4 also indicates that, on average 47, 41 and 25 percent farmers used TSP, MP and Gypsum fertilizer respectively. Farmers of the Dinajpur district used more fertilizer compared to Panchagarh district. The average fertilizer used by the farmers were 44.46, 29.64 and 39.18 kg/ha for TSP, MP and Gypsum respectively, which is very lower dose than that of national fertilizer dose for maize (BARI, 2006).

1.5 Water management

In general, four irrigations are recommended by BARI, the first at 15-20 days (4-6 leaf stage), the second at 30-35 days (8-12 leaf stage), the third at 60-70 days (Cob initiation stage) and the fourth at 85-95 days (before grain filling stage) after seeding. Excess water should be drained out during flowering and grain filling. Ninety four percent sample farmers applied irrigation water. Among them 67 percent irrigated one time, 22 percent two times and 05 percent three times (Table 5). Dinajpur farmers provided more numbers of irrigations compared to Panchagarh farmers. The average number of irrigations was 1.26. However, on average, about 84 percent sample farmers used shallow tube wells, nine percent used deep tube wells and hand tube wells used by only two percent.

Table 5. Irrigation management of the farmers

Location	No irrigation	% used irrigation			Average no. of irrigation	Irrigation source used (% of farmers)			
		1 no.	2 nos.	3 nos.		STW	DTW	HTW	Total
Dinajpur	10	60	26	04	1.24	90	0	0	90
Panchagarh	02	74	18	06	1.28	78	18	02	98
Total	06	67	22	05	1.26	84	09	01	94

1.6 Yield

The average grain yield was 6.27 t/ha (Table 6) and this is lower than national average hybrid maize yield (7.0-10.5 t/ha). The farmers of Dinajpur get more yield (6.35 t/ha) than that of Panchagarh farmers (6.18 t/ha). This might be due to use of more seed rate, more nutrient use and intensive management practices.

Table 6. Yield performance of maize at different locations

Location	Yield range (kg/ha)					Average yield (ton/ha)
	< 5001	5001-5500	5501-6000	6001-6500	6501-7000	
	% of farmers reported					
Dinajpur	0	06	14	52	28	6.35
Panchagarh	02	12	22	44	20	6.18
Total	01	09	18	48	24	6.27

1.7 Effect of inputs on production of maize

To determine the effects of variable inputs, eight variables were included which are given along with their respective coefficients in Table 7.

Table 7. Estimated value of coefficient of Cobb-Douglas production function model of maize yield

Variables/ Statistics	Coefficients	
	Dinajpur	Panchagarh
Intercept	5.08	5.21
Seed (X_1)	0.22**	0.096*
Manure(X_2)	0.077*	0.07*
Urea (X_3)	0.17**	0.11**
TSP (X_4)	0.10*	0.099*
MP (X_5)	0.038	0.03
Irrigation (X_6)	0.131**	0.107**
Human labor (X_7)	0.176**	0.171**
Ploughing (X_8)	0.25**	0.19**
R^2	84	79
R^2 (adjusted)	82	76
N	50	50
F	29.13**	30.01**
∑Ei (Returns of scale)	0.72	0.68

** and * significant at 1 and 5 percent level, respectively

The co-efficient of multiple determinations, R^2, was 82 percent and 76 percent for maize production at Dinajpur and Panchagarh, which means that the explanatory variables included in the model accounted for 82 and 76 percent of the variation in crop yield in Dinajpur and Panchagarh districts, respectively. The F-value of maize production was highly significant at 1 percent level of confidence. Highly significant F-value implied that the included variables collectively are important for explaining the variations of yield. The relative contribution of specified factors affecting productivity of maize can be seen from the estimates of regression equation. The contributions of the selected factors to return from maize are discussed below.

Input-output relationship

Seed (X_1)

The value of production coefficient for seed was 0.22 which was significant at 1% level in Dinajpur and 0.096 in case of Panchagarh and which was significant at 5% level. The positive sign indicate that yield form maize can be increased by using quantity of more seed. This implies that 1% increase in the quantity of seed with other factors remaining constant would increase the yield of maize by 0.22% in Dinajpur and 0.096% in Panchagarh.

Manure (X_2)

The regression coefficient of manure was 0.077 in Dinajpur and 0.07 in Panchagarh which were significant at 5% level. This implies 1% increase in manure use, keeping other factors constant would increase the yield by 0.077% in Dinajpur and 0.07% in Panchagarh.

Fertilizers (X_3, X_5, X_4)

The value of production coefficient of urea was 0.17 and 0.11 for Dinajpur and Panchagarh respectively and both were significant at 1% level. The positive sign implies that 1% increase in urea fertilizer use, keeping other factors constant, would increase the yield by 0.17% in Dinajpur and 0.11% in Panchagarh. The coefficient value for TSP was 0.10 and 0.099 for Dinajpur and Panchagarh respectively and both were significant at 5% level. The positive coefficient for TSP indicates that using more TSP can increase the yield of maize. This implies that 1% increase in TSP use keeping other factors constant would increase the yield by 0.10% in Dinajpur and 0.099% in Panchagarh. The value of the coefficient for MP was 0.038 and 0.03 for Dinajpur and Panchagarh respectively which were insignificant.

Irrigation (X_6)

The regression coefficient of irrigation was 0.131 and 0.107 for Dinajpur and Panchagarh respectively and both were significant at 1% level. The positive sign implies that 1% increase irrigation use, keeping other factors constant, would increase the yield by 0.131% in Dinajpur and 0.107% in Panchagarh.

Human labor (X_7)

The regression coefficient of human labor was 0.176 and 0.171 for Dinajpur and Panchagarh respectively and both were significant at 1% level. The positive sign implies that 1% increase in human labor use, keeping other factors constant, would increase the yield by 0.176% in Dinajpur and 0.171% in Panchagarh.

Ploughing (X_8)

The value of production function coefficient of ploughing was 0.25 and 0.19 for Dinajpur and Panchagarh respectively and both were significant at 1% level. The positive sign implies that 1% increase in ploughing, keeping other factors constant, would increase the yield by 0.25% in Dinajpur and 0.19% in Panchagarh.

1.8 Elasticity of production and return of scale

Elasticity concept can be applied to the production function to determine the stages of production in which farmers were allocating their resources. The sum of elasticity of all inputs were 0.72 and 0.68 for Dinajpur and Panchagarh respectively, which implies that if all the inputs specified in the production function were increased simultaneously by 100 per cent, the yield would increase by 72 and 68 percent at Dinajpur and Panchagarh, respectively. This indicated that the production function exhibited decreasing returns to scale at Dinajpur and Panchagarh. Farmers at both the sites allocated their resources in the rational stage of production. Still there was more scope to increase yield at Panchagarh by applying proper and improved management of inputs compared to Dinajpur.

2 Technical and Allocative Efficiency of the Maize Producing Farms

Estimation of the efficiency level helps to decide whether to improve the existing efficiency level or to develop new technologies to raise the productivity level. A farm is technically inefficient in the sense that if it fails to produce maximum output from a given input and the results in an equiproportionate over or under utilization of all inputs. It may also be allocatively inefficient in the sense that the marginal revenue product of input might not be equal to the marginal cost of that input and the results in utilization of inputs in the wrong proportions, at given input prices. Technical efficiency of maize cultivation at farm level estimation in the study area is shown in Table 8.

Table 8. Frequency distribution of technical efficiency

Efficiency level (percent)	Number of farmers and their respective percentage	
	Dinajpur	Panchagarh
51 – 60	0	02 (04)
61 – 70	05 (10)	10 (22)
71 – 80	09 (18)	15 (34)
81 – 90	21 (42)	14 (22)
91 – 100	15 (30)	09 (18)
Total farms	50 (100)	50 (100)

* Figures in the parenthesis indicate percentage of the total

From Table 8 it was observed that the farm specific technical efficiency coefficient varied among farmer to farmers and ranged from 0.64 to 0.93 with a mean of 0.84 at Dinajpur followed by efficiency range 0.52 to 0.94 with mean of 0.80 at Panchagarh. For better presentation of the efficiency result, farms were categorized into 5 different groups with intervals of ten points. It was found that 30 and 18 percent of the total farmers at Dinajpur and Panchagarh, respectively belonged to the most efficient category (91 to 100%) and 4% farms at Panchagarh were in the least efficient group (51 to 60%). However, majority of the maize farmers (42%) at Dinajpur belonged higher efficiency (81 to 90%) compared to Panchagarh farmers, majority of them belonged to a moderate efficiency (71 to 80%).

For estimating the marginal conditions for profit maximization, allocative efficiency was computed. To attain the goal of profit maximization i.e., for efficient resources allocation, one should use more of the resources as long as the value of the added product is greater than the cost of the added amount of the resources in producing it. The resources are to be considered efficiently used and profit will maximum, when the marginal value product (MVP) and marginal factor cost (MFC) for each input is equal. The MVP of a particular resource represents the addition to gross returns in value terms caused by an addition of one unit of that resource while other inputs are held constant.

The estimated MVP and MFC ratio i.e. allocative efficiency of different inputs in the study area are presented in Table 9. The ratio of MVP and MFC of all the inputs for both regions were greater than one and positive. It indicates that the farmers did not avail themselves of the opportunity of using the optimal amounts of those inputs. So, there are ample opportunities for farmers of both region to increase the output per hectare by judicious and increased use of these inputs i.e., more profit can be obtained by increasing investment in those inputs (Duloy, 1959).

Table 9. Allocative efficiency of sample farmers

Variable	Allocative efficiency		
	Dinajpur	Panchagarh	All sample farmers
Seed	1.06	1.13	1.10
Manure	1.23	1.11	1.17
Urea	3.49	3.87	3.68
TSP	1.73	2.08	1.91
MP	1.19	1.26	1.23
Irrigation	2.88	2.65	2.77
Human labor	1.51	1.27	1.39
Ploughing	2.07	1.84	1.96

Finally, considering maize production it appears that farmers in the study area had scope to increase maize productivity by attaining full efficiency through reallocating the resources. Thus the use of resources is to be adjusted to unity depending upon the ratio to achieve full efficiency.

3 Production Cost and Economic Returns of Maize and Boro-based Cropping Patterns

In Bangladesh Boro rice tends to be planted in low-lying and heavy textured soils that tends to puddle and are easier and cheaper to irrigate. In contrast, maize tends to be planted comparatively in high-lying and light-textured soils. Since Boro and maize grow in different situations, it would not be wise to compare each other. But for better understanding it is necessary to contrast and estimate the profitability of maize and Boro-based cropping patterns.

3.1 Crops and Cropping Patterns in the Study Area

More than 100 different crops are presently grown in Bangladesh (Baksh, 2003). Of these, 32 occupy 96 percent of the total cropped area (Task Force Report, 1991). Rice is by far the most important crop with jute, wheat, maize, potatoes, oilseeds, sugarcane and pulses as the followers. Rice occupied in 10529 hectare area compare to 99820 hectare area under maize cultivation during 2005-2006 (BBS web site).

Cropping patterns refers to the relative arrangement of crops on a farm, region, province or country with due consideration of natural features (soil and climate), crop efficiency, land availability, socioeconomic structures, technological and extension infrastructure (changeable) and the natural agricultural policy (Pal *et al*., 1985). A cropping pattern is efficient when it ensure the greatest efficiency of land, fertilizer, irrigation water and other inputs. Farmers in Bangladesh practice numerous cropping patterns; the choice is made depending upon the agro-ecological conditions and availability of irrigation facilities (Bhuiyan, 1995). Given the available technology, the farmers prefer those patterns that involve fewer risks and offer the best economic returns from investment. Rice-maize rotations are the major maize-based cropping systems in the study area. Depending on the topography and rainfall, maize is grown in three crop rotation, such as Maize - T. Aman rice - Fellow, Maize – Aus – Potato. In rice-maize systems, rice is grown in puddle soil under submerged conditions.

3.2 Profitability of Maize

Yield

Average yield was 6.27 t/ha. But the highest yield was obtained by Dinajpur farmers (6.35 t/ha) followed by Panchagarh (6.18 t/ha).

Costs

Variable cost: Average variable cost of maize cultivation was Tk. 22,836/ha, which was the highest at Dinajpur (Tk. 23,458/ha) and the lowest at Panchagarh (Tk. 22,006/ha). Major portion of variable cost was occupied by human labor (50.5%) followed by fertilizers (15.7%) and seed cost (15.5%) in Dinajpur, while in Panchagarh those variable costs were 47%, 15.7% and 12.4% for human labor, seed and fertilizer respectively (Table 10).

Table 10. Cost and economic returns of maize cultivation in the study area, 2007

Cost/ returns items	Cost/ returns (tk/ha)		
	Dinajpur	Panchagarh	All samples
Seed	3630	3450	3540
Manure	1416	2526	1974
Fertilizer: Urea	698	593	645
TSP	1887	1314	1601
MP	1007	771	889
Gypsum	89	58	74
Total fertilizer cost	3681	2736	3209
Irrigation cost	1106	1142	1124
Human labor cost	11856	10350	11103
Animal power cost	843	786	815
Power tiller cost	926	1016	971
Total variable cost (VC)	23458	22006	22836
Interest on operating capital	928	871	904
Land use cost	3500	3500	3500
Total fixed cost	4428	4371	4414
Total production cost	27886	26377	27240
Returns: Grain	55372	53846	54613
Straw	6463	6273	6368
Gross return	61835	60119	60981
Gross margin	38377	38113	38145
Net return	33949	33742	33741
Benefit cost ratio:			
Considering VC	2.64	2.73	2.67
Considering TC	2.22	2.28	2.24

Fixed cost: Fixed cost included interest on operating capital and land use cost. On an average, total fixed cost was Tk. 4414/ha, major portion of which was covered by land use cost (Tk. 3,500/ha). The fixed cost varied only for interest on operating capital which was Tk. 928/ha in Dinajpur and Tk. 871/ha for Panchagarh (Table 10).

Total cost: Total production cost of maize was Tk.27240/ha, which was higher at Dinajpur (Tk. 27,886/ha) and lower at lower at Panchagarh (Tk. 26,377/ha).

Returns

Average gross return was Tk. 60,981/ha, gross margin was Tk. 38,145/ha and net return was Tk. 33,741/ha. Among the two regions, gross return, gross margin and net returns were the higher at Dinajpur compared to Panchagarh.

3.4 Profitability of Boro Rice

Yield

Average yield was 4.15 t/ha. But the higher yield was obtained by Dinajpur farmers (4.10 t/ha) compared to Panchagarh (4.21 t/ha).

Costs

Variable cost: On an average, total variable cost of Boro cultivation was Tk. 19,678/ha, which was higher at Panchagarh (Tk. 20,156/ha) and lower at Dinajpur (Tk. 19,195/ha). Higher portion of variable cost was incurred for using human labor (37.9%) followed by irrigation (27.5%) and fertilizers cost (16.4%) (Table 11).

Table 11. Cost and economic returns of Boro rice cultivation in the study area, 2007

Cost/ returns items	Cost/ returns (Tk/ha)		
	Dinajpur	Panchagarh	All samples
Seed	732	623	678
Manure	801	927	864
Fertilizer: Urea	1803	1653	1728
TSP	765	829	797
MP	524	605	565
Gypsum	129	156	143
Total fertilizer cost	3221	3243	3233
Irrigation cost	4932	5879	5406
Human labor cost	7314	7632	7473
Animal power cost	1308	1117	1213
Power tiller cost	887	735	811
Total variable cost (VC)	19195	20156	19678
Interest on operating capital	760	798	779
Land use cost	5000	5000	5000
Total fixed cost	5760	5798	5779
Total production cost	24955	25954	25457
Returns: Grain	30720	31530	31125
Straw	1324	1105	1215
Gross return	32044	32635	32340
Gross margin	12849	12479	12662
Net return	7089	6681	6883
Benefit cost ratio:			
Considering VC	1.67	1.62	1.64
Considering TC	1.28	1.26	1.27

Fixed cost: Average fixed cost for Boro cultivation was Tk. 5,779/ha, consisted of land use cost (Tk. 5,000/ha) and interest on operating capital (Tk. 779/ha). The land use cost was higher for Boro land compared to maize land as because Boro land was comparatively good in quality than maize.

Total cost: The average total cost of Boro cultivation was Tk. 25,457/ha, which was relatively higher at Panchagarh (Tk. 25,954/ha) and lower at Dinajpur (Tk. 24,995/ha).

Returns

The average gross return was Tk. 32,340/ha, being higher at Panchagarh (Tk. 32,635/ha) and lower at Dinajpur (Tk. 32,044/ha). Gross margin is the return over the variable cost and it was higher at Dinajpur (Tk. 12,849/ha) and lower at (Tk. 12,479/ha). The average gross margin and net return were Tk. 12,662/ha and Tk. 6,883/ha, respectively. Net return was higher in Dinajpur (Tk. 7,089/ha) and lower in Panchagarh (Tk. 6,681/ha) (Table 11).

3.4 Comparative profitability of maize and boro

Maize produced higher gross return, gross margin and net return (60,981 Tk/ha, 38,145 Tk/ha and 33,741 Tk/ha respectively) compared to Boro rice (32,340 Tk/ha, 12,662 Tk/ha and 6,883 Tk/ha respectively). But maize incurred higher variable cost for human labor, seed and fertilizer. On the other hand, irrigation cost for Boro rice is near about five times higher than that of maize.

3.5 Sensitivity analysis of returns of maize and boro rice

As the input output price variability over the season and over the year is a common phenomena of Bangladesh agriculture, the effects of price variability were examined through sensitivity analysis. To know the profitability status of Boro and maize under price changed situation, this analysis was done considering some input-output price change. Among inputs, fertilizer price is more vulnerable compared to seed, labor and draft power. Maize grain price is more stable compared to rice price. Keeping these circumstances in mind the assumed uncertain situations are as follows:

I. If fertilizer price will increase by 5%,
II. If Boro price will increase by 15% and maize price remain the same,
III. If Boro price will increase by 15% and maize price by 5%
IV. If fertilizer price will increase by 5% and Boro and maize prices will increase by 15% and 5%, respectively.

Considering these situations comparative economic performance of maize and Boro rice cultivation is given in Table 12.

Table 12. Comparative economic performance of maize and Boro rice cultivation after sensitivity analysis considering the four situations for sensitivity analysis

Varibales	Original situation		Changed situations							
			I		II		III		IV	
	Maize	Boro	Maize	Boro	Maize	Boro	Maize	Boro	Maize	Boro
Variable cost (VC) (Tk/ha)	22836	19678	22997	19840	22836	19678	22836	19678	22997	19840
Fixed cost (Tk/ha)	4404	5779	4410	5786	4404	5779	4404	5779	4410	5786
Total cost (TC) (Tk/ha)	27240	25457	27407	25626	27240	25457	27240	25457	27407	25626
Gross return (Tk/ha)	60981	32340	60981	32340	60981	37009	64030	37009	64030	37009
Gross margin (tk/ha)	38145	12662	37984	12500	38145	17331	41194	17331	41033	17169
Net return (Tk/ha)	33741	6883	33574	6714	33741	11552	36790	11552	36623	11383
% change	-	-	(-0.5)	(-2.5)	(0)	(67.8)	(9.0)	(67.8)	(8.5)	(65.4)
BCR (undiscounted)										
Considering VC	2.67	1.64	2.65	1.63	2.67	1.88	2.80	1.88	2.78	1.87
Considering TC	2.24	1.27	2.23	1.26	2.24	1.45	2.35	1.45	2.34	1.44

Considering the assumptions of sensitivity analysis it was revealed from the analysis that the gross margin and net returns were little bit reduced for maize and Boro rice considering situation I. In situation II net returns of Boro rice was increased by 67.8% from the original situation. Similar increasing trend of net return and BCR were also found in situation III and IV, where gross return, gross margin as well as net returns for both the crops increased compared to original returns. However, in the entire assumed situation, maize remained more profitable than Boro rice.

3.6 Profitability of maize-based and Boro-based cropping patterns

Selection of cropping pattern is a prime concern for a farmer to make his farm more profitable. Economic analysis of adopted cropping pattern and potential cropping pattern should also be considered in this regard. In the study area widely adopted one Boro rice based cropping pattern and two maize based cropping patterns are observed during study time. Those patterns are:

Boro	Fellow	Transplanted Aman
Maize	Aus	Potato
Maize	Fellow	Transplanted Aman

As potato is a high value crop and need more inputs compared to rice and maize, it will not be suitable to compare potato based cropping pattern with the other two. For compare the profitability of maize and Boro rice based cropping patterns cost of production of each crop and subsequently the cropping pattern were computed. The summary results having gross return, gross margin and net returns per hectare of the selected cropping patterns are presented in Table 13.

Table 13. Comparative profitability of maize based and Boro rice based cropping pattern in the study areas, 2007

Study area and respective economic returns (Tk/ha)	Cropping patterns	
	Maize- Fellow-T. Aman	Boro- Fellow-T. Aman
Dinajpur		
Gross return	86297	52104
Gross margin	52886	24613
Net return	46031	18307
Panchagarh		
Gross return	84589	50332
Gross margin	54422	24450
Net return	45615	18221
All sample farmers		
Gross return	85443	51218
Gross margin	53654	24532
Net return	45823	18264

It is revealed from Table 13 that, among these two cropping patterns, farmers received the highest gross return (Tk. 85,443/ha), gross margin (Tk. 53,654/ha) as well as net return (Tk. 45,823/ha) from maize based cropping pattern. Similar returns received by the farmers of both regions. This situation is mainly due to low market price of Boro rice compared to maize.

3.7 Sensitivity analysis of returns of cropping patterns

Considering price change situation mentioned in assumptions II and III of sensitivity analysis, the profitability of maize and Boro-based cropping patterns are presented in Table 14.

Table 14. Comparative profitability of maize based and Boro rice based cropping pattern after changed situation

Economic returns (Tk/ha)	Cropping patterns	
	Maize- Fellow-T. Aman	Boro- Fellow-T. Aman
Assumption II		
Gross return	85443	55887
Gross margin	53654	29201
Net return	45823	22933
Assumption III		
Gross return	88174	55887
Gross margin	56385	29201
Net return	48554	22933

The situation:

II. If Boro rice price will increase by 15% and maize price remain same

III. Boro rice price will increase by 15% and maize price by 5%

It is revealed from Table 14 that under the present price situation, as well as changed price situation maize-based pattern gave higher profit. So, it is more profitable to cultivate maize based cropping pattern. Moreover, considering the underground water level for irrigation and electricity supply situation in Bangladesh, it is wise to cultivate maize-based cropping pattern with adequate manure supply to the soil. The findings of the study indicate that a maize and maize-based cropping pattern is profitable compare to Boro rice and Boro rice based cropping pattern.

4 Growth Analysis of Maize

The spread of maize cultivation in Bangladesh is in an increasing trend with the increase of poultry industry as well as increase of wheat price. Increasing trend in area, production level and yield need to be identified for better understanding the potential productivity of maize in Bangladesh. This type of information is essential for proper planning for any further development of this crop. Three periods were considered for the growth rate calculation of maize. First, form 1971-72 to 1986-87, i.e., before the release of the composite varieties and hybrids of maize, second, from 1987-88 to 2005-06, i.e., from the beginning of the released varieties up to the study period considered and third from whole study period it was 1971-72 to 2005-06.

Growth rates experienced in maize area, production and yield after independence of the country (1971) and phenomenon of acceleration/deceleration or no change in growth rates over time in Bangladesh is presented in Table 15.

Table 15. Growth rate of area, production and yield of maize in Bangladesh during 1971-2006

Growth rate indicators	Period	Growth rate (%)	Mean	CV
Area	I (1971-72 to 1986-87)	0.257 (-0.001)	2.65	23.77
	II (1987-88 to 2005-06)	0.985** (0.969)	22.03	115.16
	All (1971-72 to 2005-06)	0.892** (0.790)	13.17	158.69
Production	I (1971-72 to 1986-87)	0.049 (-0.069)	2.06	35.92
	II (1987-88 to 2005-06)	0.978** (0.954)	103.56	134.47
	All (1971-72 to 2005-06)	0.896** (0.796)	57.16	198.71
Yield	I (1971-72 to 1986-87)	-0.108 (-0.059)	0.77	20.77
	II (1987-88 to 2005-06)	0.834** (0.677)	2.77	58.12
	All (1971-72 to 2005-06)	0.842** (0.7.01)	1.85	83.78

**indicates significance at 1% level and Figures in the parenthesis indicate the value of adjusted R^2

Table 15 indicate that during first 16 years from 1971-72 to 1986-87, the annual rate of change of area, production and yield of maize were 0.257, 0.049 and -0.108 percent respectively. After the release of composite varieties and hybrids of maize, i.e., after 1986-87, the average area, production and yield of maize increased sharply and the rate of change were 0.985, 0.978 and 0.834 percent respectively. This might be due to release of composite and hybrid varieties and subsequently the adoption of those varieties by the farmers. The respective mean and coefficient of variation values also support such findings.

5 Constraints of Maize Production System

Maize cultivation in farm level has different socioeconomic and environmental hindering factors those need to be identifying for further research and taking necessary curative measures. Ranking order of the constraints as indicated by the sample farmers of both region as well as for the all sampled farmers is given in Table 16.

Table 16. Distribution of the constraints faced by the maize farmers

Sl. No.	Constraints	Ranked order for Dinajpur farmers	Ranked order for Panchagarh farmers	Ranked order for all sample farmers
1.	Negative attitude and obstacles from extension personnel	7th	9th	8th
2.	Lack of suitable land	12th	13th	12th
3.	Destruction of plants by cattle and other animals	13th	10th	13th
4.	Cobs stolen by thief	9th	12th	11th
5.	Destruction of plants by storm, drought and flood	11th	8th	10th
6.	Unavailability of seeds at time when required	10th	11th	7th
7.	High price of seeds	1st	1st	1st
8.	Unavailability of fertilizers at time when required	5th	3rd	3rd
9.	High price of fertilizers	8th	4th	9th
10	Lack of irrigation facilities	6th	6th	6th
11.	Lack of technical knowledge	3rd	7th	5th
12.	Low price of grains	2nd	2nd	2nd
13.	Inefficient marketing system	4th	5th	4rd

From the Table 16 it is revealed that 'high price of seeds' ranked first among the identified problems as faced by the maize farmers in both regions. During the study time it was found that the maize seed price was Tk. 200-225/kg. Due to unstable high seed price, farmers ranked this problem as first. 'Low price of grains' ranked second ordered constraints faced by the maize farmers in both regions. It was found during the study time that the maize price was Tk. 7-9/kg at farm gate. But the same product was found to sell at price of Tk. 10-13/kg in the district town. An organized marketing system starting form farm gate may resolve this constraint. 'Unavailability of fertilizers at time when required' ranked third constraints for all sample farmers but the scenario is quite different for Dinajpur farmers, where they faced 'lack of technical knowledge' as third constraint. The fertilizer distribution system in Bangladesh is very much uncertain and vulnerable to seasonality of crop production. Artificial crisis is also an important factor in this context. Recently the government in collaboration of army and Department of Agricultural Extension has taken initiatives to resolve this situation. Technical facilities governed by the Department of Agricultural Extension need also to be emphasized for the maize farmers.

CONCLUSION AND RECOMMENDATIONS

The economic analysis of maize production and maize based cropping pattern is profitable in both of the study area. Extensive program should be undertaken for obtaining and sustaining the higher yield by updating the technical knowledge of the farmers on maize production. Farmers' consciousness about the recommended package of the required inputs to increase the maize yield needs to be informed among the farmers. Motivational programs including training on seed production and storing of high yielding maize should be emphasized to meet up the problem of seed crisis and high price of the seed. However, followings are the policy issues need to be emphasized:

1. Quality seed should be made available timely at farm level. Farmers' seed production and storage program and BADC (Bangladesh Agricultural Development Corporation) seed distribution program should be strengthened by making the marketing system more efficient.
2. Marketing information for the maize farmers need to be broadcasted through community radio programs and local newspapers.

3. Fertilizer distribution system should be strengthened and regularly monitored by the grass-root level DAE (Department of Agricultural Extension) personnel. Block level fertilizer distribution monitoring agent might be recruited for this purpose. Government subsidy will be increased to make the fertilizer cheaper at farmer's door-step.
4. Focusing the economic efficiency of maize among the farmers through different mass media need to be emphasized.
5. Utilization of maize grain as human food need to be focused to resolve the country malnutrition situation. For this purpose different communication channels as well as motivational campaign can be accomplished.

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