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Unveiling the Factors Influencing Organic Tomato (*Solanum lycopersicum*) Production: An Empirical Evidence from the Mymensingh District of Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Tomato is one of the most popular and widely grown vegetables, and faces a demand-supply gap, prompting the need for enhanced production. As global agriculture shifts towards organic practices, this study was undertaken to explore the socioeconomic status of organic tomato producers,

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assess the factors impacting organic tomato production, and identify the production related constraints. Following the simple random sampling method, a total of 60 organic tomato producers were selected from two villages in Gouripur Upazila under the Mymensingh district and they were interviewed using a structured interview schedule. The research reveals that the majority of farmers were within the productive age range of 36-50 years, with male dominance in the field. Family sizes were diverse, with medium-sized families being the most prevalent. A substantial proportion of farmers possess secondary-level education. Experience in organic tomato farming ranges from 5 to over 15 years, indicating a diverse level of expertise. The Cobb-Douglas revenue type production function was used to determine the effect of selected inputs on organic tomato production. The findings of production function analysis revealed that costs related to human labor, seed, organic fertilizer, bio-pesticides, and land use positively impact organic tomato production. The study also identified major problems faced by farmers in organic tomato production in which high disease and pest attacks were the most significant problems in the study area. Therefore this study will be helpful for farmers to increase organic tomato production and relevant policymakers to support organic tomato producers and further promote sustainable agriculture in this region.

Keywords: Organic tomato; factors; Cobb-Douglas production function; problems; Bangladesh.

1. INTRODUCTION

Bangladesh is predominantly an agricultural country, where agriculture plays a vital role in boosting economic growth. Bangladesh's favorable, warm, moist, and fertile climate has made it possible and over 70% of people are directly and indirectly involved with agricultural activities [1]. The green revolution in cereal production helped many developing nations, including Bangladesh, although it did not significantly reduce poverty or malnutrition [2]. Gross domestic product (GDP) from the agriculture sector at current prices of BDT 4,455,313 million which has a sectoral share of 11.66% of the overall GDP in Bangladesh [3]. Though rice is the most significant crop, as labor prices and capital expenditures rise, many farmers will no longer be able to afford to produce rice. As a result, the majority of farmers are diversifying into vegetable crops [4]. Only the vegetable sector contributed approximately USD 718 million to Bangladesh's gross domestic product in 2016 [5]. Nearly 4 million individuals in Bangladesh, including over a million women, are employed in homestead or commercial vegetable farming. The cultivation of vegetables is expanding quickly in Bangladesh right now. Vegetable production currently occupies 2.57% of Bangladesh's total land area, producing 3.73 million tons of vegetables annually. Vegetables provide farmers with considerably greater returns than other types of crops [6]. So, growing vegetables is essential for achieving food and nutrition security [7].

Tomato (*Solanum lycopersicum*) is one of the most popular and widely grown vegetables. It is cultivated all over the country due to its adaptability to a wide range of soil and climate. With a total production of 442299.60 metric tons in Bangladesh, the total cultivated area under tomato production was 73151.55 acres where there were 6046.35 Kg per acre yield of tomato cultivation in the fiscal year 2022 [3]. Due to different types, seasons, meteorological conditions, planting schedules, management approaches, and soil characteristics, production varies in different places [8]. Today China is the leading tomato-producing country in the world whereas Bangladesh ranked 47th worldwide [9] and in Bangladesh, tomato has been expanding as Bangladesh's second-largest horticultural crop after the potato, which is grown throughout two seasons each year [10]. It has relatively shorter production cycles as compared to many field crops. Above all, the demand for tomatoes has been increasing. But tomato production is not sufficient in Bangladesh, as a result, a huge amount of tomato is imported every year. Mohiuddin *et al.* [11] studied that local tomato varieties are being grown by farmers, but they provide low yields. As it is essential to increase the production of tomatoes per year, improved tomato varieties may be crucial.

Globally, agricultural output has noticeably changed away from conventional inorganic techniques and toward organic ones in recent decades [12]. Even while Bangladesh uses inorganic farming and contemporary technologies to meet its food needs, but causes soil degradation which harms the environment over the long term and, more crucially, economic gains [13]. However, organic farming offers a solution to these issues. The farms on which only

organic materials are used as nutrients and plant protection are called organic farms that preserve the health of soils and ecosystems. Organic agriculture combines traditional innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. The goal of the organic farming system is to promote and maintain healthy soil, farmers, food production, communities, and economies. A clear indication that organic agriculture is gaining popularity around the world is the reduction and eradication of the harmful effects of synthetic fertilizers and pesticides on human health and the environment [8]. Yunus *et al.* [4] found that organic tomato production is more profitable than conventional tomatoes because it has lower production costs due to no use of expensive chemical fertilizers. The cost of producing organic tomatoes is more effective and affordable, it does not require expensive technical investment but provides more employment opportunities. It is a viable solution to increase the supply of organic vegetables by providing comparatively higher yields from low-input agriculture in food-deficient regions [14]. Charyulu *et al.* [15] found that organic farming has the potential to provide benefits in terms of environmental protection, conservation of non-renewable resources, and improved food quality.

Several studies have been conducted on tomato production such as Mitra and Yunus [16] estimated the factors affecting the efficiency of tomato farmers. Fariha *et al.* [13] contributed to the field by offering valuable insights for organic producers in Bangladesh. Their study identified key inducements and barriers for potential and established organic farming practitioners, thereby aiding the organic farming community. Islam *et al.* [8] analyzed the combined impact of organic and inorganic fertilizers on tomato growth, yield, quality, and soil characteristics. Ferdous *et al.* [17] gave a general overview of the possibilities of organic farming in Bangladesh by looking at its historical evolution, present situation, and growth barriers. Mohiuddin *et al.* [11] explained the level of adoption and yield performance of enhanced tomato varieties in farmers' fields to gauge their profitability and pinpoint opportunities and barriers for increased tomato production.

These previous studies addressed several important issues ranging from opportunities to constraints as well as efficiency, growth, quality, adoption level, yield performance of tomato varieties, etc. However, there is still a gap in Bangladesh regarding the evaluation of organic tomato farming systems and a limited number of studies on functional analysis of organic tomato cultivation in the selected areas of Mymensingh district. Most of these studies dealt with the economic, environmental, and social benefits of organic tomato production for present and future generations. Still, some other issues have been left which are very important. Therefore, this study aims to bridge the gap by identifying the factors affecting organic tomato production in the Mymensingh district of Bangladesh.

2. MATERIALS AND METHODS

2.1 Selection of the Study Area and Data Collection

Gouripur Upazila of Mymensingh district is one of the major vegetable-producing areas in Bangladesh and commercial vegetable production is practiced largely in the area. Hence, two villages namely Uzankashiar Char village under the Bhangnamari Union and Gobindanagar village under the Bokainagar Union of Gouripur Upazila in Mymensingh district were selected for the study. A total of 60 organic tomato producers were interviewed following the simple random sampling technique and using a structured interview schedule from January to March 2021. For supplementary information, many concerned organizations like the Department of Agricultural Extension (DAE), and Bangladesh Agricultural Research Institute (BARI) were visited. The Bangladesh Bureau of Statistics (BBS), and different websites were also visited to collect reports and publications for secondary information.

2.2 Data Analytical Methods

2.2.1 Descriptive analysis

The socioeconomic variables of the farmers were used for comparative descriptive analysis of the study sample. Variables such as sex, family size, age, occupation, education level, and land holding of the organic tomato growers and the problems they faced were analyzed by descriptive tools such as frequencies and percentages.

The farm size of the organic tomato growers was measured by using the following formula:

> Farm size = Own cultivated land + Leased in land + Mortgaged in the land - Leased out the land- Mortgaged out the land [18].

2.2.2 Functional analysis

Functional analysis was employed to show the individual effect of input use and other related factors of organic tomato farming. Cobb-Douglas production function was used to estimate the effects of key variables on the production of organic tomato farming. The following Cobb-Douglas revenue type production function was used in organic tomato production:

$$Y_S = a x_1^{b1}\, x_2^{b2}\, x_3^{b3}\, x_4^{b4}\, x_5^{b5}\, x_6^{b6}\, x_7^{b7}\, e^{u}$$

By taking log in both sides of the Cobb-Douglas production function were transformed into the following logarithmic form:

$$\ln Y_S = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + U_i$$

Where,

Y_S = Gross return (Tk./acre);
X_1 = Human labor cost (Tk./acre)
X_2 = Power tiller cost (Tk./acre)
X_3 = Seed cost (gm./acre)
X_4 = Irrigation cost (Tk./acre)
X_5 = Organic fertilizer cost (Tk./acre)
X_6 = Bio-pesticides cost (Tk./acre)
X_7 = Land use cost (Tk./acre)
a= Intercept
Ui = Random error term
b_1-b_7 = Production co-efficient to be estimated

3. RESULTS AND DISCUSSION

3.1 Socio-Economic Characteristics of Organic Tomato Farmers

Analysis of the socio-economic condition of the sample farmers is very important because numerous interrelated and constituent attributes shape an individual and profoundly influence the development of his/her behavior and personality. The following variables such as age and sex-wise distribution of farmers, the composition of family size, level of education, occupational status, experience status, farm size, etc. have been taken into consideration. All categories of organic tomato farmers in the study area were classified into different age groups such as 20 to 35 years, 36 to 50 years, and 51 to 70 years. Out of the total number of tomato growers, about 23.33% belong to the age group 20 to 35 years, 65% fall into the age group of 36 to 50 years, and 11.67% belong to the age group of 51 to 70 years (Table.1). It is evident that most of the organic tomato farmers were in the age group of the most productive ages, ranging between 36-50 years. Among 60 organic tomato farmers, 55 (91.67%) were male and 5 (8.33%) were female. It showed that the number of female entrepreneurs in organic tomato farming was very low as compared to male farmers. Table 1 shows that 21.67% of families were small (≤4 members), 51.67% were medium (5-6 members) and the remaining 26.67% were large (>6 members) in the organic tomato farming.

The adoption of an organic farming system also depends on the educational status of the farm families. It is observed from Table 1 that about 13.33% of organic tomato farmers did not have formal education, about 25% had primary, 46.67% had secondary, and 15% had higher secondary and above degrees respectively. The land is the most important asset for farmers. The land was used for producing diversified crops and productive enterprises. Table 1 shows that no landless farmers in the study area were engaged in organic tomato production. About 6.66% of organic tomato growers were marginal farmers, 66.67% of the selected organic tomato farmers were small farmers, while medium and large farmers represented 21.67% and 5% respectively. Experience is the most important factor for organic tomato farmers. Table 1 shows that experience in (5-10) years represented 53.33%, (11-15) years represented 41.67%, and (16 to above) years represented 5% of organic tomato farmers respectively. The result of the socioeconomic characteristics of the organic tomato growers was also supported by Parvin [19], Donkoh *et al.* [20], Naik [21], and Kafle [22].

3.2 Factors Affecting Organic Tomato Production

An attempt was made to examine the effects of selected inputs on organic tomato production in the framework of production function analysis. Production function refers to the relationship between the inputs or factor services and the output of production. In the present study, the log-linear form of the Cobb-Douglas production function was used it has an important application in economics and it is therefore, widely used by many researchers in economic studies [23]. Estimated values of the coefficients and related statistics for organic tomato production are presented in Table 2.

Table 1. Socio-economic characteristics of the organic tomato growers

Particulars	Categories	Number	Percentage (%)
Age (Years)	20-35	14	23.33
	36-50	39	65.00
	51-70	7	11.67
Sex	Male	55	91.67
	Female	5	8.33
Family Size (Number of family members)	Small family (≤4)	13	21.67
	Medium family (5-6)	31	51.67
	Large family (>6)	16	26.67
Educational status (Years of schooling)	Illiterate (below primary)	8	13.33
	Primary (class 1-5)	15	25.00
	Secondary (class 6-10)	28	46.67
	Higher secondary and above (class 11 to above)	9	15.00
Farm size (acres)	Landless farmers (<0.05)	0	0.00
	Marginal farmers (0.05-0.49)	4	6.66
	Small farmers (0.5-2.49)	40	66.67
	Medium farmers (2.5-7.49)	13	21.67
	Large farmers (≥7.5)	3	5.00
Experience in organic tomato farming (Years)	5-10	32	53.33
	11-15	25	41.67
	16 to above	3	5.00

Source: Authors' calculation, based on field survey, 2021

Table 2. Estimated values of coefficient and related statistics of Cobb-Douglas production function for organic tomato

Explanatory variables	Organic tomato			
	Estimated coefficient	Standard errors	t-values	P-values
Intercepts	7.730	4.054	1.907	0.005
Human labor cost (X_1)	0.065**	0.030	2.167	0.026
Power tiller cost (X_2)	0.050	0.120	0.417	0.541
Seeds cost (X_3)	0.493***	0.239	2.063	0.000
Irrigation cost (X_4)	-0.069	0.232	-0.297	0.423
Organic fertilizer cost (X_5)	0.542***	0.264	2.053	0.001
Bio-pesticides cost (X_6)	0.307**	0.133	2.308	0.030
Land use cost (X_7)	0.965**	0.395	2.443	0.041
R^2	0.814			
Adjusted R^2	0.701			
F-value	7.181			

Source: Authors' calculation, based on field survey, 2021

**** Significance at 1 percent level; ** Significance at 5 percent level; * Significance at 10 percent level*

It is evident from Table 2 that the intercept's estimated coefficient is 7.730, with a t-value of 1.907 indicating that the intercept might be statistically significant. The associated p-value is 0.005, which is less than the conventional significance level of 0.05. This suggests that the intercept is statistically significant and indicates a potential baseline value for organic tomato production when all predictor variables are zero. In organic tomato production, the calculated regression coefficient of human labor cost 0.065 is accompanied by two asterisks (**) and has a p-value of 0.026. This indicates that the coefficient is statistically significant at the 0.05 significance level. Therefore, an increase in human labor cost is associated with a statistically significant increase in organic tomato production. Similarly, the other explanatory variables like Bio-pesticides cost (X6), and Land use cost (X7) are statistically significant at the 0.05 significance

level. Nazir *et al.* [24] found similar results in the case of sugarcane production. Furthermore, the magnitude of the regression coefficient of seeds cost (X3) and organic fertilizer cost (X5) were 0.493 and 0.542 respectively with three asterisks (***) and very low p-values (close to 0), indicating strong statistical significance. This suggests that increases in these variables are associated with statistically significant increases in organic tomato production. Different studies proved that seed is one of the important production factors in producing crops. Quality seeds are one of the factors that determine productivity. This result is consistent with the research of Purnamasari *et al.* [25]. However, the calculated regression coefficient of irrigation cost in organic tomato production was 0.069 with a negative sign which means they are statistically insignificant and can't influence organic tomato production much. Similarly, the magnitude of the regression coefficient of power tiller cost was 0.050 and the sign of this coefficient had a positive but insignificant effect on organic tomato production (Table 2). It is evident from Table 2 that the value of the coefficient of multiple determination (R^2) was 0.814 which indicates that approximately 81.4% of the variability in organic tomato production is explained by the predictor variables included in the model. A high R^2 suggests that the model is a good fit for explaining the variability in the dependent variable. The value of adjusted R^2 0.701 accounts for the number of predictors in the model and may provide a more conservative estimate of how well the model generalizes to new data. Table 2 shows the F-value that assesses the overall significance of the regression model is 7.181. It compares the variability explained by the model to the variability that is not explained. If the F-value is larger and the associated p-value is smaller, it suggests that at least one of the predictor variables is contributing significantly to explaining the variation in the response.

In summary, the regression analysis suggests that several predictor variables (Human labor cost, Seed cost, Organic fertilizer cost, Bio-pesticides cost, and Land use cost) have statistically significant effects on organic tomato production. The model, as a whole, is statistically significant, as indicated by the F-value. The R^2 values suggest that the model explains a substantial portion of the variability in organic tomato production.

3.3 Problems Faced by the Organic Tomato Producers

The present study also identified some problems, which were faced by the selected growers in conducting organic tomato production.

Table 3 shows that about 88.33% of the respondents reported that high disease and pest attacks were the most significant problem in the study area. About 81.67% of the producers reported that they were facing high input prices. Several studies found similar results and in the Mymensingh district, most of the farmers use chemical pesticides to prevent the huge amount of disease, pest, and insect attacks in the vegetable fields which is very harmful to the environment and may disrupt the normal ecosystem [26]. Approximately 78.33% of the producers reported a problem related to the lack of quality seed which was similar to the findings of Samshunnahar *et al.* [27]. Similarly, lack of quality organic manures and bio-pesticides, lack of irrigation water, poor weather conditions, labor shortage, and poor soil quality were identified as problems by the organic tomato producers. The findings were also supported by the studies of Mohiuddin *et al.* [11], Haque *et al.* [28] and Yunus *et al*. [4].

Table 3. Production related constraints faced in organic tomato production

Production related constraints	Frequency	Percentage (%)	Rank
1. Disease and pest attack	53	88.33	1
2. High input price	49	81.67	2
3. Lack of quality seed	47	78.33	3
4. Lack of quality organic manures and bio-pesticides	45	75.00	4
5. Lack of irrigation water	39	65.00	5
6. Poor weather condition	36	60.00	6
7. Shortage of labor	31	51.67	7
8. Poor soil quality	24	40.00	8

Source: Authors' calculation, based on field survey, 2021

4. CONCLUSION

Organic tomato farming sustains the health of soils, ecosystems, people and relies on ecological processes, biodiversity, and cycles adapted to local conditions rather than the use of inputs with adverse effects. Several studies have been conducted on tomato production. However, still a lack of evaluation of organic tomato farming systems and a limited number of studies on functional analysis of organic tomato cultivation in the selected areas of the Mymensingh district. So, to bridge the gap this study attempts to identify the socioeconomic characteristics of organic tomato farmers, such as age, education, occupation, and farm size, significantly influencing their behavior about organic tomato production. Factors that affect organic tomato production such as human labor cost, seed cost, organic fertilizer cost, bio-pesticides cost, and land use cost were found to have a positive impact on organic tomato production. The major production related problems including high disease and pest attacks, high input prices, and a lack of quality seed posed significant obstacles to organic tomato production. To enhance organic tomato production, the relevant policymakers and Government should encourage the farmers to adopt holistic measures like integrating IPM strategies with bio-pesticides, resistant varieties, and crop rotation. The Government should provide targeted training for diverse practices; and ensure access to certified organic inputs, support small and medium-sized farmers through tailored services and cooperatives, focus on research for disease-resistant varieties and innovative pest management; strengthen market access. These will aim to empower organic tomato producers, enhance their productivity, and contribute to the sustainable growth of organic agriculture while meeting the demands of the market and supporting local communities.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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