



Profitability and Technical Efficiency of Vegetable Production in Bangladesh

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ABSTRACT

There is a substantial variation in profitability and efficiency among vegetables farms in Bangladesh. This study examined the level of profitability and technical efficiency of bean, brinjal and tomato production in Bangladesh. The study documented the crucial problems of vegetables producing farms. Data were collected through a field survey of 213 vegetable farmers selected by multi-stage random sampling technique in three districts from May to July 2014. Profitability of vegetable was analyzed using conventional farm income of farmers and the Benefit-Cost Ratio (BCR). Cobb-Douglas stochastic frontier production function model was used to estimate the farm level technical efficiencies. Analysis found that farmer's average age was 44.4 years. They had 5.51 years of education, 1.42 numbers of agricultural training and 12.2 years of farming experience. Results showed that total costs were Tk. 196,198 (US\$ 2,312.56)/ha for bean, Tk. 220,047 (US\$ 2,593.66)/ha for brinjal, and Tk. 240,063 (US\$ 2,829.59)/ha for tomato production. Net margin was Tk. 28,601 (US\$ 337.11)/ha for bean, Tk. 36,557 (US\$ 430.89)/ha for brinjal and Tk. 49,762 (US\$ 586.53)/ha for tomato production. The net margin and the BCR indicated that the above mentioned vegetables were profitable in the study areas. Cobb-Douglas stochastic frontier production function indicated that agricultural training and number of adult households reduce the vegetable producers' inefficiency. Overall technical efficiency was 87.3 % and there is opportunity for increasing technical efficiency by taking different management practices. Lack of capital and low prices of vegetables were the major problem of farmers. Department of Agricultural Extension (DAE) may provide some training to the farmers about storage of vegetables to ensure fair price of vegetables. Government may provide loan with a low interest rate which may solve capital shortage of farmers. There is scope for same type of further research in other vegetables producing districts in Bangladesh.

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Introduction

Bangladesh is a densely populated country and its population is increasing. The projected population was 163.08 million in the year 2017 and 165.21 million in the year 2018 (BBS, 2016). So, it is necessary to increase food production for the country's increasing population. Agriculture is the main source of income and employment for the poor people. Agriculture is an important component in the GDP of Bangladesh and it contributed 14.17% of GDP in the year 2016-2017 (BBS, 2017). Vegetables and crops sub-sector also contributes an important share to the agricultural GDP which is near about 9.71 % (BER, 2018). Vegetable contributes an important share of the total agricultural export in Bangladesh (Islam et al., 2020). Moreover, this country is still shortage of per capita vegetable consumption against per capita vegetable requirement. Per capita

vegetable consumption is 166.1 grams per day whereas per capita consumption of fruits is 44.8 grams. WHO/FAO minimum recommended level of vegetables and fruits is 400 grams per day (FAO, 2014). So, it is necessary to increase the production of vegetables and fruits to reach the recommended level of consumption. Farmers produce vegetables for their own consumption and sell. Vegetables are important for the economic and nutritional point of view (Akter et al., 2011). Farmers who are engaged in the production of vegetables often earn higher incomes than those engaged in the production of cereal crops alone (Weinberger and Lumpkin, 2005). Moreover, fresh vegetables are important sources of vitamin and minerals (Hasan et al., 2014a). In Bangladesh, vegetables are grown in two different seasons, one is summer (Kharif) vegetables and another is winter (Rabi) vegetables. The major winter

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vegetables are winter brinjal, cauliflower, cabbage, water gourd, rabi pumpkin, tomato, radish, bean, bengali spinach, red amaranth, and carrot. Conversely, major summer vegetables are summer pumpkin, summer brinjal, lady's finger, ridge gourd, bitter gourd, arum, ash gourd, cucumber, long bean, Indian spinach, snake gourd, sponge gourd, green papaya, and green banana. The area and production of summer vegetables are 191,477 hectares and 1660,993 metric tons respectively in the year 2016-2017 (BBS, 2017). In the same year, the area and production of winter vegetables are 217,872 hectares and 2363,939 metric tons respectively (BBS, 2017). The data imply that the area and production of vegetables in the country are increasing substantially in recent years. But sometimes farmers do not get expected price and profit by selling their vegetables. In the developing countries, these high-value crops tend to have higher profit variability due to variability in yields and prices (Weinberger and Genova II, 2005). It is necessary to investigate the level of profitability and technical efficiency in producing vegetables in Bangladesh. Some previous research highlights different aspect of vegetable production (Ogundari, and OJO, 2007; Adil et al., 2007; Lokapur et al., 2014; Shende and Meshram, 2015; Rajendran et al., 2015; Wahid et al., 2017; Kumar et al., 2018; Subedi et al., 2020) in different countries. Few socioeconomic studies were done earlier on some vegetables production (Mowla, 1998; Monayem et al., 1998; Ali et al., 2008; Khan et al., 2009; Nahar, 2009; Mamun et al., 2010; Zaman et al., 2010; Akter et al., 2011; Khayer et al., 2011, Somajpoti et al., 2016) in Bangladesh but no study emphasized on analyzing the profitability and technical efficiency of popular vegetables production at the same time in a single research in the well-known vegetables producing area.

To overcome the existing research gap the present study is undertaken in three well-known vegetables producing districts namely Mymensingh, Rajshahi, and Cumilla in Bangladesh and three popular vegetables namely Bean, Brinjal and Tomato are selected. Key research questions of the present study are i) What are the socioeconomic characteristics of vegetable growers ii) Are vegetables production profitable for farmers? iii) Are vegetables farms fully efficient to produce different vegetables? iv) What are the problems of farmers to produce different vegetables? The broad objective of the present study is to examine the profitability and technical efficiency of different vegetables in Bangladesh. The specific objective of this research is to identify the socioeconomic characteristics of vegetable growers. The study assesses the level of profitability in selected vegetable and examines the efficiency of different vegetable producing farms. Finally, the study documents the crucial problems of vegetables producing farmers in

the study area. This study will help to formulate future research and policy, which will help to increase vegetables production in Bangladesh.

Materials and Methods

The selection of area and vegetables were based on total production. According to BBS (2015) Dhaka division ranked second, Rajshahi division ranked fourth and Chattogram division ranked fifth in brinjal production in the year 2013-2014. Rajshahi division ranked first, Chattogram division ranked third and Dhaka division ranked fourth position in tomato production. Dhaka division ranked first and Chattogram division ranked third in bean production. Three districts namely, Mymensingh from Dhaka division, Rajshahi from Rajshahi division, and Cumilla from Chattogram division were purposively selected for the present study. According to BBS (2014) winter vegetables were ranked by the volume of production and tomato ranked first, brinjal ranked second and bean ranked eighth in the year 2013-2014. Three vegetables namely tomato, brinjal and bean were selected for the present study. The multi-stage random sampling technique was followed to select the sample. A total of 213 farmers were randomly selected from Char Kalibari village under Sadar Upazila of Mymensingh district, Quithipur village under Rajshahi Sadar Upazila of Rajshahi district and Nimshar village under Burichong Upazila of Cumilla district (presented in Table 1). Data were collected through field survey using a semi-structured interview schedule in the period of May to July 2014.

Revenues and costs of vegetables were calculated for four months of the production season. Hasan et al. (2014b) used different equations to calculate the profitability of vegetables. The present study also used the similar equations to compute the profitability of different vegetables and the equations are as follows:

- Total variable cost = Seed and seedling cost + Power tiller cost + Hired labor cost + Fertilizer cost + Pesticides cost + Irrigation cost + Bamboo cost.
- Total cost = Family labor cost + Total variable cost + Interest on operating capital + Land rent.
- Total revenue = Total production × Average selling price
- Gross margin = Total revenue - Total variable cost
- Net margin = Total revenue - Total cost
- Benefit-Cost Ratio (Variable cost basis) =
$$\frac{\text{Total revenue}}{\text{Total variable cost}}$$
- Benefit-Cost Ratio (Total cost basis) =
$$\frac{\text{Total revenue}}{\text{Total cost}}$$

Table 1. Distribution of sample farmers in the study areas

Study areas	No. of farms under each vegetable category			Total households
	Bean	Brinjal	Tomato	
Mymensingh	24	30	21	75
Rajshahi	-	30	24	54
Cumilla	24	30	30	84
Total	48	90	75	213

Cobb-Douglas production frontier model (Aigner et al., 1977) was used to estimate vegetables farm’s technical efficiency. The model was specified as

$$Y = f(X_i\beta_i) + \varepsilon_i \quad i = 1, 2, \dots, n \quad (1)$$

Where Y is output, X_i denotes the actual input vector, β_i is a vector of parameters associated with X_i and ε is the error term that is composed of two elements. That is:

$$\varepsilon = V_i - U_i \quad (2)$$

Where V_i is the symmetric disturbances assumed to be identically, independently, and normally distributed as N(0, σ_v²). U_i is a one-sided error term that is independent of V_i and is normally distributed as (0, σ_u²). Following Jondrow et al. (1982), technical efficiency estimation is given by the mean of the conditional distribution of inefficiency term U_i given ε; and thus defined by

$$E(U_i/\varepsilon_i) = \frac{\sigma_u\sigma_v}{\sigma} \left(\frac{f(\varepsilon_i\lambda)/\sigma}{1-F(\varepsilon_i\lambda)/\sigma} - \frac{\varepsilon_i\lambda}{\sigma} \right) \quad (3)$$

Where, λ = σ_u/σ_v, σ² = σ_u² + σ_v² while f and F represent the standard normal density and cumulative distribution function respectively evaluated at ε_iλ/σ. The farm-specific technical efficiency is defined in terms of observed output (Y_i) to the corresponding frontier output (Y_i^{*}) using the available technology derived from the result of the equation (3) as above as:

$$TE_i = Y_i/Y_i^* = \frac{E(Y_i|u_i, X_i)}{E(Y_i|u_i=0, X_i)} = E[\exp(-U_i)/\varepsilon_i] \quad (4)$$

TE takes value 0 to 1, where 0 indicates a fully inefficient farm and 1 indicates a fully efficient farm. The Cobb-Douglas functional form has been used by many researchers in the developing countries (Brave-Ureta et al., 1997; Ajibefun et al., 2002; Ogundari, K. and S. O. OJO, 2007; Aminu et al., 2013; Alam et al., 2011, Todsadee et al., 2012).

The Cobb-Douglas functional form for the vegetable farms in the study area is specified as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + \beta_7 \ln X_{7i} + \beta_8 \ln X_{8i} + \beta_9 \ln X_{9i} + \beta_{10} \ln X_{10i} + \beta_{11} \ln X_{11i} + \beta_{12} \ln X_{12i} + \beta_{13} \ln X_{13i} + \beta_{14} \ln X_{14i} + V_i - U_i \quad (5)$$

Where, ln = Natural logarithm, Y_i = Vegetables yield (Kg/ha), X₁ = Seed (Kg/ha), X₂ = Power tiller cost (Tk. /ha), X₃ = Family labor (man-days), X₄ = Hired labor (man-days), X₅ = TSP (Kg. /ha), X₆ = DAP dummy using value 1 if the farmer used DAP, 0 for otherwise, X₇ = MoP (Kg /ha), X₈ = Zinc Sulfate dummy using value 1 if the farmer used Zinc Sulfate, 0 for otherwise, X₉ = Gypsum dummy using value 1 if the farmer used Gypsum, 0 for otherwise, X₁₀ = Boric Acid dummy using value 1 if farmer used Boric Acid, 0 for otherwise, X₁₁ = Manure (kg/ha), X₁₂ = Pesticides (liter/ha), X₁₃ = Irrigation cost (Tk./ha), X₁₄ = Land (ha), β₀ = Constant, β_i = Coefficient of parameter, i = 1,14, V_i is an independently and identically distributed random error and U_i is a non-negative variable, associated with technical inefficiency in production. i = 1, 2,....., 213.

Very few farmers used DAP, Zinc Sulfate, Gypsum, and Boric Acid and we used dummy variables for those inputs. “If zero cases are a significant proportion of the total number of sample observations, then the procedure may result in seriously biased estimators of the parameters of the production function. The problem can be solved by the use of a dummy variable such that efficient estimators are obtained using the full data set but no bias is introduced” (Battese et al., 1996 and Battese, 1997).

The technical inefficiency effects, U_i was defined (Coelli, 1995) as:

$$U_i = \delta_0 + \delta_j Z_i \quad (6)$$

Z₁ = Age of farmer (years), Z₂ = Farmer education (Years of schooling), Z₃ = Extension contact dummy using value 1 if the farmer made contact with extension worker, 0 for otherwise, Z₄ = Farm size (ha), Z₅ = Received agricultural training dummy showing value 1 if the farmer is trained, 0 otherwise, Z₆ = Adult household family members (number), Z₇ = Credit dummy showing value 1 if farmer received any credit, 0 otherwise, δ₀ = Constant, δ_j = Unknown parameters to be estimated, i = 1,j; j; i = 1, 2,....., 213

These socioeconomic variables are included in the model to determine their possible influence on the cost inefficiency of the farms. We test the presence of cost inefficiency using generalized likelihood-ratio statistics, as follows:

$$\lambda = -\ln\left(\frac{H_o}{H_A}\right) \quad (7)$$

Where, H_o : Inefficiency does not exist in the model. H_A : Inefficiency exists in the model.

The vegetables producers were asked to give their opinion about the eight selected problems. The weights were given for each response and a four-point rating scale was used to rank each problem. Weights 0, 1, 2 and 3 stand for no problem confrontation, low problem confrontation, medium problem confrontation, and high problem confrontation respectively. By adding weights of responses to the problems, we get a problem confrontation score. The problem confrontation score ranges from 0 to 24, where 0 indicates 'no problem' and 24 indicating 'highest problem'. Hossain and Miah, (2011) and Hasan et al., (2014b) used the Problem Confrontation Index (PCI) in their studies. The Problem Confrontation Index was computed by using the following formula:

$$PCI = P_h \times 3 + P_m \times 2 + P_l \times 1 + P_n \times 0 \quad (8)$$

Where, PCI = Problem Confrontation Index, P_h = Percentage of farmers with "high problem"; P_m = Percentage of farmers with "moderate problem", P_l = Percentage of farmers with "low problem", P_n = Percentage of farmers with "no problem"; The Problem Confrontation Index of the individual problems could range from 0 to 300, where 0 indicates "no problem" and 300 indicating "high problem" confrontation.

Results and Discussion

Socioeconomic characteristics of sample farmers

Data in Table 2 shows socioeconomic characteristics of farmers in different districts. Vegetable farmers' average age was 44.4 years and the farmers had 5.51 years of education. Farmers got 1.42 numbers of agricultural training and they had 12.2 years of farming experience. On average, farmers contacted local extension workers 1.26 times for solving their problems. Farmers' average farm size was 0.48 hectares and the survey plot area was 0.04 hectares. An average family size of the sample households was 3.24 and the average adult household member was 2.1. In the farmer's family, 52.7% of members were dependent. On average, the farmer took Tk. 11,784.5 credits and 36.3% of farmers received credit from different sources.

Structure of inputs used for bean production

Data in Table 3 shows the structure of inputs used in one hectare of land for bean production in different districts. On average, farmer's used 6.4 kg seed, 139.25 man-days family labor and 140.75 man-days hired labor for bean production. They also used 505.01 kg urea, 313.69 kg

Triple Super Phosphate (TSP), 22.86 kg Diammonium Phosphate, 84.84 kg Muriate of Potash (MoP), 28.67 kg Zinc Sulfate, 1.28 kg Gypsum, and 8.36 kg Boric Acid. Urea is the main fertilizer used by the farmers and 469.29 kg urea used in Mymensingh and 540.74 kg in Cumilla district. On average, 358.33 kg cow dung, 64.94 liters pesticides, and 65.54 times irrigation were used.

Structure of inputs used for brinjal production

Table 4 shows the structure of inputs used in a hectare of land for brinjal production in different districts. On average, farmer's used 2.58 kg seed, 180.61 man-days family labor and 119.23 man-days hired labor. They used 514.92 kg urea, 216.99 kg Triple Super Phosphate (TSP), 43.69 kg Diammonium Phosphate, 85.16 kg Muriate of Potash (MoP), 42.44 kg Zinc Sulfate, and 6.78 kg Boric Acid. An average, 523.62 kg urea used in Mymensingh, 498.87 kg in Cumilla, and 522.27 kg in the Rajshahi district. On average, 1,112.12 kg cow dung, 76.22 liters pesticides, and 64.76 times irrigation were used. The table reveals that farmers of the Rajshahi district used more cow dung and pesticides than the farmers of Mymensingh and Cumilla district for brinjal production.

Structure of inputs used for tomato production

Table 5 shows the structure of inputs used in a hectare of land for tomato production in different districts. On average, farmer's used 2.78 kg seed, 176.75 man-days family labor and 199.76 man-days hired labor. They used 498.72 kg urea, 391.13 kg Triple Super Phosphate (TSP), 82.24 kg Diammonium Phosphate, 158.05 kg Muriate of Potash (MoP), 48.87 kg Zinc Sulfate, 3.22 kg gypsum, and 7.83 kg Boric Acid. More urea used in Rajshahi than Mymensingh and Cumilla district. On average, 1,434.87 kg cow dung, 61.11 liters pesticides, and 60.32 times irrigation were used for tomato production. Farmers of the Rajshahi district used more cow dung and pesticides than the farmers of Mymensingh and Cumilla district.

Profitability of bean production

Table 6 shows the profitability of bean production in Mymensingh and Cumilla districts. On average per hectare cost of seed, power tiller, labor, fertilizer, pesticide and irrigation were Tk. 10,859 (US\$ 127.98)/ha, Tk. 13,562 (US\$ 159.85)/ha, Tk. 84,322 (US\$ 993.89)/ha, Tk. 38,715 (US\$ 456.32)/ha, Tk. 8,268 (US\$ 97.45)/ha and Tk. 13,562 (US\$ 159.85)/ha. Total cost of bean production was Tk. 196,198 (US\$ 2,312.56)/ha, and total revenues from bean was Tk. 224,799 (US\$ 2649.68)/ha. Gross margin was Tk. 53,720 (US\$ 633.19)/ha and net margin was Tk. 28,601 (US\$ 337.11)/ha. BCR based on the variable cost was 1.32 and BCR based on the total cost was 1.15, which indicates that bean production was profitable in both districts. Bean production was more profitable in the Mymensingh than the Cumilla district.

Bithi (2014) found that the total cost of bean production was Tk. 148,183/ha, gross margin was Tk. 242,500/ha, net margin was Tk. 94,317/ha and BCR was 1.63 in Gopalganj district of Bangladesh. Chowdhuri et al., (2014) found that the total cost of bean production was Tk. 162,337/ha, gross margin was Tk. 347,028/ha, net margin was Tk. 184,691/ha and BCR was 2.14 in Narshingdi district of Bangladesh.

Table 2. Different socioeconomic characteristics of the sample farmers

Particulars	Mymensingh	Rajshahi	Cumilla	All Areas
Age (years)	43.5	45.3	44.4	44.4
Education (years)	4.1	6.4	6.05	5.51
Number of training (lifetime)	1.4	1.2	1.66	4.26
Years of farming experience	14.8	11.7	10.3	12.2
Extension contact (per year)	1.1	1.4	1.3	1.26
Farm size (hectare)	0.57	0.35	0.54	0.48
Survey plot area (hectare)	0.05	0.03	0.05	0.04
Family size (no.)	3.02	3.1	3.6	3.24
Adult household member (no.)	2.0	2.1	2.2	2.1
Household dependent member (%)	46.2	48.1	63.8	52.7
Formal Credit used (Tk.)	6,740.0	13,185.1	15,428.5	11,784.5
The average number of credit users	36.0	38.0	35.0	36.3

Source: Field survey, 2014

Table 3. Structure of inputs used for bean production

Inputs used (Quantity/ha)	Districts		All areas
	Mymensingh	Cumilla	
Seed (kg)	6.2	6.6	6.4
Power tiller (no.)	44.73	58.28	51.5
Labor (man-days)			
Family labor (no.)	119.74	158.76	139.25
Hired labor (no.)	142.72	138.78	140.75
Fertilizers (kg)			
Urea (kg)	469.29	540.74	505.01
Triple Super Phosphate (TSP) (kg)	298.26	329.12	313.69
Diammonium Phosphate (DAP) (kg)	6.86	38.87	22.86
Muriate of Potash (MoP) (kg)	79.70	89.98	84.84
Zinc Sulfate (kg)	25.44	31.90	28.67
Gypsum (kg)	2.57	-	1.28
Boric Acid (kg)	6.43	10.29	8.36
Cow dung (kg)	237.84	478.82	358.33
Pesticides (liter)	40.76	89.12	64.94
Irrigation (no.)	55.76	75.33	65.54

Source: Field survey, 2014

Table 4. Structure of inputs used for brinjal production

Inputs used (Quantity/ha)	Districts			All Areas
	Mymensingh	Rajshahi	Cumilla	
Seed (kg)	2.40	3.09	2.25	2.58
Power tiller (no.)	33.65	40.32	37.0	36.99
Labor (man-days)				
Family labor (no.)	163.10	214.04	164.71	180.61
Hired labor (no.)	119.61	88.98	149.11	119.23
Fertilizers (kg)				
Urea (kg)	523.62	522.27	498.87	514.92
Triple Super Phosphate (TSP) (kg)	240.46	200.91	209.61	216.99
Diammonium Phosphate (DAP) (kg)	39.78	68.78	22.53	43.69
Muriate of Potash (MoP) (kg)	79.76	99.78	75.95	85.16
Zinc Sulfate (kg)	59.14	40.06	28.14	42.44
Gypsum (kg)	-	-	-	-
Boric Acid (kg)	6.86	6.86	6.62	6.78
Cow dung (kg)	1,160.24	1,255.24	920.89	1,112.12
Pesticides (liter)	66.61	89.53	72.54	76.22
Irrigation (no.)	57.03	78.38	58.88	64.76

Source: Field survey, 2014

Profitability of brinjal production

Table 7 shows the profitability of brinjal production in different districts. On average, per hectare cost of seed, power tiller, labor, fertilizer, pesticides and irrigation were Tk. 19,162 (US\$ 225.85)/ha, Tk. 13,518 (US\$ 159.33)/ha, Tk. 101,082 (US\$ 1,191.43)/ha, Tk. 33,568 (US\$ 395.66)/ha, Tk. 8,163 (US\$ 96.21)/ha and Tk. 10,674 (US\$ 125.81)/ha respectively. Total cost of brinjal production was Tk. 220,047 (US\$ 2,593.66)/ha, and total revenues from brinjal was Tk. 256,604 (US\$ 3,024.56)/ha. Gross margin was Tk. 64,878 (US\$ 764.70)/ha and net margin was Tk. 36,557 (US\$ 430.89)/ha. BCR based on the variable cost was 1.33 and BCR based on the total cost was 1.16, which indicates that brinjal production was profitable in three districts. Brinjal production was more profitable in Mymensingh than Cumilla and Rajshahi district. Chowdhuri et al., (2014) found that total cost of brinjal production was Tk. 241,277/ha, gross margin was Tk. 483,500/ha, net margin was Tk. 242,223/ha and BCR was 2.0 in Narshingdi district of Bangladesh. Rahman et al., (2016) found that total cost of brinjal production was Tk. 144,656/ha, gross margin was Tk. 461,954/ha, net margin was Tk. 317,298/ha and BCR was 3.29 in Jamalpur district of Bangladesh.

Profitability of tomato production

Table 8 shows the profitability of tomato production in different districts. On average, per hectare cost of seed, power tiller, labor, fertilizer, pesticides and irrigation were Tk. 4,289 (US\$ 50.55)/ha, Tk. 10,558 (US\$ 124.44)/ha, Tk. 124,187 (US\$ 1,463.77)/ha, Tk. 45,570 (US\$ 537.12)/ha, Tk. 9,176 (US\$ 108.16)/ha and Tk. 10,531 (US\$ 124.12)/ha respectively. Total cost of tomato production was Tk. 240,063 (US\$ 2,829.59)/ha, and total revenues from tomato was Tk. 289,825 (US\$ 3,416.13)/ha. Gross margin was Tk. 78,340 (US\$ 923.38)/ha and net margin was Tk. 49,762 (US\$ 586.53)/ha. BCR based on the variable cost was 1.38 and BCR based on the total cost was 1.21, which indicates that tomato production was profitable in three districts. Tomato production was more profitable in Cumilla than Mymensingh and Rajshahi district. Hajong et al., (2018) found that the total cost of summer tomato production was Tk. 584,822/ha, gross margin was Tk. 1542,300/ha, net margin was Tk. 957,478/ha and BCR was 2.64 in Jashore district of Bangladesh. Mitra and Sharmin, (2019) found that total cost of tomato production was Tk. 228,058/ha, gross margin was Tk. 526,664/ha, net margin was Tk. 298,606/ha and BCR was 2.31 in Mymensingh district of Bangladesh.

Efficiency of vegetables producing farms

The maximum likelihood estimates of the parameters for the Cobb-Douglas frontier production function is

presented in Table 9. We specified the model using a double log form and normalized by urea fertilizer amount to satisfy the homogeneity condition. The estimated coefficients of the variable labor (both family and hired), TSP, and irrigation were positive and significant at the 1% level. An increase in the magnitude of labor, TSP and irrigation would result in a corresponding increase of the vegetable yield. However, the sign of the estimated coefficient of power tiller was negative and statistically significant at the 10% level. An increase in the magnitude of power tiller cost would decrease in a corresponding vegetable yield. This result is not logical. It might be due to most of the farmers' rent power tiller from other power tiller owner farmers. Sometimes they imposed more money per unit of land and farmers had to pay more money.

Among the inefficiency factors (equation 6), the coefficients of agricultural training (dummy) and the number of adult members were negative and significant at the 10% level. The estimated coefficient of agricultural training (dummy) was negative indicating that if the farmers received more agricultural training, their inefficiency in vegetable production would decrease. The estimated coefficient of adult household members indicated that the availability of more adult members in the household would decrease the level of inefficiency in vegetable production substantially. The overall producers' technical efficiency was 87.3 %, implying that there is scope for increasing the efficiency of the vegetable farms by taking different management practices. Mitra and Yunus, (2018) found that technical efficiency of tomato farms was 0.83 imply that tomato farmers can reduce their input use by 17% to get the same level of output. The study found that education, training, and high yielding variety adoption had a positive effect on efficiency while the age of tomato farmers had a negative effect on efficiency. Khandoker et al., (2016) found that the cost of labor, land preparation, seed, TSP, farming experience had a positive and significant effect on bean production in different areas of Bangladesh. They also found that the cost of labor, land preparation, insecticides, education and experience had a positive and significant effect on brinjal production.

The frequency distribution of farms efficiency

The frequency distribution of technical efficiency estimates is shown in Table 10. The technical efficiencies (TE) range between 0.36 and 0.97, with a mean of 0.87. Only one farm had a technical efficiency range between 0.36 – 0.50 and six vegetable farms have technical efficiencies range between 0.50 – 0.70. The highest number of farms had technical efficiencies range between 0.71 - 0.90 and 122 vegetable farms belong in this group.

Table 5. Structure of inputs used for tomato production

Inputs used (Quantity/ha)	Districts			All Areas
	Mymensingh	Rajshahi	Cumilla	
Seed (kg)	3.15	2.76	2.45	2.78
Power tiller (no.)	62.75	66.99	43.2	57.64
Labor (man-days)				
Family labor (no.)	192.67	190.42	147.18	176.75
Hired labor (no.)	207.39	200.49	191.41	199.76
Fertilizers (kg)				
Urea (kg)	474.39	517.77	504.0	498.72
Triple Super Phosphate (TSP) (kg)	378.51	394.43	400.47	391.13
Diammonium Phosphate (DAP) (kg)	106.78	95.12	44.84	82.24
Muriate of Potash (MoP) (kg)	170.18	183.46	120.53	158.05
Zinc Sulfate (kg)	72.49	33.67	40.46	48.87
Gypsum (kg)	5.48	3.08	1.10	3.22
Boric Acid (kg)	6.86	12.53	4.11	7.83
Cow dung (kg)	1,606.08	1,752.22	946.33	1,434.87
Pesticides (liter)	61.29	74.94	47.12	61.11
Irrigation (no.)	63.73	71.18	46.07	60.32

Source: Field survey, 2014

Table 6. Structure of costs and the level of profitability of bean production

Cost items	(Tk./ha)		
	Mymensingh	Cumilla	All Areas
Seed	11,097.8	10,619.2	10,858.5
Power tiller	11,720.1	15,403.3	13,561.7
Labor	72,157.7	96,486.6	84,322.1
Family labor	37,174.2	58,119.0	47,646.6
Hired labor	34,983.5	38,367.6	36,675.5
Fertilizers	40,392.0	37,037.2	38,714.6
Urea	13,108.6	13,445.2	13,276.9
Triple Super Phosphate (TSP)	13,108.6	13,445.2	13,276.9
Diammonium Phosphate (DAP)	205.8	2,416.2	1,311.0
Muriate of Potash (MoP)	1,445.6	1,349.8	1,397.7
Zinc Sulfate	11,504.6	4,785.6	8,145.1
Gypsum	54.0	-	27.0
Boric Acid	964.8	1,595.2	1,280.0
Cow dung	1,189.2	2,394.1	1,791.65
Pesticides	4,597.2	11,938.6	8,267.9
Irrigation	12,582.0	14,542.3	13,562.15
Total variable cost	153,736.0	188,421.3	171,078.65
Interest on operating capital (four months)	3,074.7	3,768.4	3,421.55
Land rent (Tk./ha/season)	16,229.1	27,166.6	21,697.85
Total cost	173,039.8	219,356.3	196,198.05
Yield (kg/ha)	10,089.6	10,722.2	10,405.9
Average price (Tk./kg)	21.5	21.7	21.6
Revenues (Tk./ha)	216,926.4	232,671.7	224,799.05
Gross margin (Tk./ha)	63,190.4	44,250.4	53,720.4
Net margin (Tk./ha)	43,886.6	13,315.4	28,601.0
BCR (variable cost basis)	1.41	1.23	1.32
BCR (total cost basis)	1.25	1.06	1.15

Source: Field survey, 2014; Note: Tk. means Taka, which is the national currency of Bangladesh. US\$ 1 = BDT 84.84 (XE Currency converter, 2020).

Table 7. Structure of costs and the level of profitability of brinjal production

Cost items	(Tk./ha)			
	Mymensingh	Rajshahi	Cumilla	All Areas
Seed	17,624.0	22,598.7	17,262.1	19,161.6
Power tiller	15,109.1	12,088.6	13,356.2	13,517.9
Labor	93,748.1	99,654.1	109,842.5	101,081.6
Family labor	57,864.8	72,957.6	57,651.1	62,824.5
Hired labor	35,883.3	26,696.5	52,191.4	38,257.1
Fertilizers	34,101.4	38,861.5	27,741.4	33,568.2
Urea	8,377.6	8,355.2	7,980.8	8,237.9
Triple Super Phosphate (TSP)	13,339.3	19,856.7	12,731.0	15,309.0
Diammonium Phosphate (DAP)	1,193.6	2,063.4	676.1	1,311.0
Muriate of Potash (MoP)	1,290.4	1,546.8	1,114.3	1,317.2
Zinc Sulfate	8,871.4	6,010.3	4,221.9	6,367.9
Gypsum	-	-	-	-
Boric Acid	1,029.1	1,029.1	1,017.3	1,025.2
Cow dung	5,801.2	6,276.2	4,604.4	5,560.6
Pesticides	7,827.8	9,462.1	7,197.5	8,162.5
Irrigation	10,714.3	11,061.4	10,246.3	10,674.0
Total variable cost	184,925.9	200,002.6	190,250.4	191,726.3
Interest on operating capital (four months)	3,698.5	4,000.0	3,805.0	3,834.5
Land rent (Tk./ha/season)	23,808.3	23,358.3	26,291.6	24,486.1
Total cost	212,432.7	227,360.9	220,347.0	220,046.9
Yield (kg/ha)	12,973.8	12,036.1	12,379.1	12,463.0
Average price (Tk./kg)	21.2	19.2	21.3	20.6
Revenues (Tk./ha)	275,044.5	231,093.1	263,674.8	256,604.1
Gross margin (Tk./ha)	90,118.6	31,090.5	73,424.4	64,877.8
Net margin (Tk./ha)	62,611.8	3,732.2	43,327.8	36,557.3
BCR (variable cost basis)	1.48	1.15	1.38	1.33
BCR (total cost basis)	1.29	1.01	1.19	1.16

Source: Field survey, 2014

Table 8. Structure of costs and the level of profitability of tomato production

Cost items	(Tk./ha)			
	Mymensingh	Rajshahi	Cumilla	All Areas
Seed	4,485.2	4,522.8	3,858.9	4,288.9
Power tiller	11,061.3	10,890.6	9,722.4	10,558.1
Labor	124,549.1	129,115.2	118,895.5	124,186.6
Family labor	60,903.1	68,966.8	51,900.7	60,590.2
Hired labor	63,646.0	60,148.4	66,994.8	63,596.4
Fertilizers	53,786.1	48,497.6	34,425.9	45,569.8
Urea	18,561.7	18,641.1	12,597.3	16,600.0
Triple Super Phosphate (TSP)	16,593.0	16,778.0	11,915.4	15,095.5
Diammonium Phosphate (DAP)	3,203.4	2,853.8	1,345.4	2,467.5
Muriate of Potash (MoP)	3,410.0	3,189.4	1,858.0	2,819.1
Zinc Sulfate	10,873.6	5,050.8	6,069.2	7,331.2
Gypsum	115.2	64.8	23.1	67.7
Boric Acid	1,029.2	1,919.7	617.5	1,188.8
Cow dung	8,030.4	8,761.1	4,731.6	7,174.4
Pesticides	9,435.6	12,321.1	5,772.2	9,176.3
Irrigation	10,743.3	10,799.3	10,049.2	10,530.6
Total variable cost	222,091.0	224,907.7	187,455.7	211,484.8
Interest on operating capital (four months)	4,441.8	4,498.1	3,749.1	4,229.7
Land rent (Tk./ha/season)	23,523.8	22,604.1	26,916.6	24,348.7
Total cost	250,056.6	252,009.9	218,121.4	240,062.6
Yield (kg/ha)	14,205.0	14,681.5	14,545.0	14,477.2
Average price (Tk./kg)	17.8	20.7	21.5	20.0
Revenues (Tk./ha)	252,849.0	303,907.0	312,717.5	289,824.5
Gross margin (Tk./ha)	30,758.0	78,999.3	125,261.8	78,339.7
Net margin (Tk./ha)	2,792.4	51,897.1	94,596.1	49,761.8
BCR (variable cost basis)	1.13	1.35	1.66	1.38
BCR (total cost basis)	1.01	1.20	1.43	1.21

Source: Field survey, 2014

Table 9. Maximum likelihood estimates of Cobb-Douglas stochastic frontier production model

Name of variables	Coefficients	Robust SE	P> z
Constant	2.97	0.612	0.353
InSeed	0.36 ^{NS}	2.60	0.887
InPower tiller	-0.087*	0.05	0.092
Labor (man-days)			
InFamily labor	0.94***	0.193	0.000
InHired labor	1.21***	0.172	0.000
Fertilizers			
InTriple Super Phosphate (TSP)	0.36***	0.123	0.003
InDiammonium Phosphate dummy (DAP)	0.096**	0.047	0.041
InMuriate of Potash (MoP)	0.041 ^{NS}	0.102	0.684
InZinc Sulfate dummy	-0.029 ^{NS}	0.037	0.437
InGypsum dummy	-0.064 ^{NS}	0.106	0.546
InBoric Acid dummy	0.0002 ^{NS}	0.053	0.997
InCow dung	0.054 ^{NS}	0.049	0.279
InPesticides	-0.388 ^{NS}	0.243	0.111
InIrrigation	0.124***	0.048	0.010
InLand	-0.045 ^{NS}	0.062	0.472
Inefficiency variables			
Age of respondent (years)	0.037 ^{NS}	0.029	0.207
Farmer education (Years of schooling)	0.10 ^{NS}	0.11	0.381
Extension contact (dummy)	-0.455 ^{NS}	0.51	0.377
Farm size (ha)	-0.89 ^{NS}	0.50	0.991
Received agricultural training (dummy)	-0.009*	0.86	0.074
Adult members in the household	-1.27*	0.68	0.062
Credit dummy	0.17 ^{NS}	0.40	0.664
Constant	-1.98 ^{NS}	2.13	0.353
Mean efficiency	87.3%		
Diagnostic statistics			
Log pseudo-likelihood	36.03		
Wald chi-square	600.56***		
Sigma square-v (σ^2_v)	-3.686999***	0.2701283	
Sigma square-u (σ^2_u)	-2.813792***	0.3516889	
Lamda ($\lambda = \frac{\delta v}{\delta u}$)	1.54	0.061	
Likelihood ratio test $H_0: \delta_u=0$ (H_0 = no inefficiency in the model)	4.83**		
Number of observation	213		

***, **and*indicates significance at the 1%,5%and 10% levels of probability respectively and NS = not significant

Table 10.Summary of farmers' technical efficiency of different vegetable-growing farms

Efficiency level	Technical efficiency	
	Frequency	Percentage
0.36-0.50	1	0.47
0.51-0.70	6	2.82
0.71-0.90	122	57.28
0.91-0.97	84	39.44
Mean efficiency	0.87	
Minimum	0.37	
Maximum	0.97	

Source: Field survey, 2014

Table 11. Major problems of vegetables production

Items of problems	Mymensingh (n=75)				PCI	Rank order
	Percentage of farmers					
	No	Low	Moderate	High		
Lack of capital	14.7	0	29.3	56.0	226.6	1
Low prices of vegetables	16.0	0	26.7	57.3	225.3	2
Price fluctuation	38.6	4.0	18.7	38.7	157.5	3
Lack of storage facilities	13.4	37.3	37.3	12.0	147.9	4
High prices of inputs	48.0	5.3	25.4	21.3	120.0	5
Disease damage	21.3	50.7	22.7	5.3	112.0	6
Insect damage	56.0	22.7	16.0	5.3	70.6	7
Unavailability of inputs	66.7	20.0	12.0	1.3	47.9	8
Rajshahi (n = 54)						
Low prices of vegetables	16.7	0	25.9	57.4	224.0	1
Lack of capital	18.5	9.3	31.5	40.7	194.4	2
Price fluctuation	27.8	12.9	27.8	31.5	163.0	3
High prices of inputs	27.8	11.1	37.0	24.1	157.4	4
Disease damage	22.2	42.6	31.5	3.7	116.7	5
Lack of storage facilities	48.2	14.8	25.9	11.1	99.9	6
Insect damage	38.9	44.4	16.7	0	77.8	7
Unavailability of inputs	79.6	11.1	7.4	1.9	31.6	8
Cumilla (n = 84)						
Low prices of vegetables	19.1	2.4	23.8	54.7	214.1	1
Lack of capital	27.4	0	20.2	52.4	197.6	2
Price fluctuation	25.0	8.3	29.8	36.9	178.6	3
High prices of inputs	32.1	3.6	28.6	35.7	167.9	4
Disease damage	19.0	46.4	29.8	4.8	120.4	5
Lack of storage facilities	36.9	30.9	27.4	4.8	100.1	6
Unavailability of inputs	47.6	38.1	14.3	0	66.7	7
Insect damage	66.7	19.0	13.1	1.2	48.8	8

Source: Field survey, 2014

Eighty four farms had technical efficiencies range between 0.91 – 0.97 and these farms are the most efficient farms among 213 farms. Most of the vegetables producing farms were fairly efficient. That is, given the available resources, the vegetable farmers were efficient in deriving maximum output from the given input.

Farmer's problems of vegetable production

Farm-level problems as opined by the farmers were evaluated and analysis is presented in Table 11. PCI was used to rank each problem in which farmers were confronted with vegetable production. Lack of capital ranked first in the rank order with the highest PCI-226.6 in Mymensingh district. Low prices of vegetables ranked second in the rank order with PCI-225.3. Price fluctuation was the third ranked order problem with PCI-157.5. According to ranked order, farmers other problems in Mymensingh district were lack of storage facilities, high prices of inputs, disease damage, insect damage, and non-availability of inputs. Both Rajshahi and Cumilla districts, low prices of vegetables was the first ranked order problem. Lack of capital was the second ranked order problem with PCI-194.4 in Rajshahi district. According to ranked order, other problems in the Rajshahi district were price fluctuation, high prices of inputs, disease damage, lack of storage facilities, insect

damage, and non-availability of inputs. Lack of capital was the second ranked order problem with PCI-197.6 in Cumilla district. According to ranked order, other problems in the Cumilla district were price fluctuation, high prices of inputs, disease damage, lack of storage facilities, non-availability of inputs, and insect damage.

Conclusions and Policy Recommendations

This paper assesses the probability and efficiency of vegetable production at farm level in three different regions of Bangladesh. There is no previous research investigated profitability and technical efficiency of popular vegetables at a time in a single research including major vegetables producing districts in Bangladesh. Results reveal that total production and total cost were highest for tomato production, but brinjal production was more profitable than other vegetables in Mymensingh district. In Cumilla district, total cost was highest for brinjal production, but total yield was highest for tomato production and tomato production were more profitable than other vegetables. In Rajshahi district, total variable cost and total cost were higher for tomato than brinjal production and tomato production were more profitable than brinjal production. Cobb-Douglas production function showed that both the inefficiency variable, coefficient of farmer's agricultural

training (dummy) and adult household size (number) were negative and significant at the 10% level. It implied that more agricultural training (dummy) and more adult household size may raise the vegetable producers' efficiency. It is evident that the vegetable producers' efficiency may increase by increasing farmer's agricultural training in the study area. The overall technical efficiency was 87.3 % and still, there is some scope for increasing the farm's efficiency. Farmer's mentioned different problems for producing vegetables in the study area. Based on the findings of the study the following recommendation may be followed to increase vegetables production in Bangladesh:

- i. The study found that the vegetable farms efficiency increased by increasing farmer's agricultural training in the study area. So it is necessary to increase training facilities for the farmers by the government organizations and NGOs to increase farm's efficiency.
- ii. The research found that vegetable farms are not fully efficient in production and still, there is some scope to increase the farm's efficiency by using efficient management practices and efficient use of inputs.
- iii. According to the farmers' opinion, there were several problems in vegetable production, and out of those, lack of capital, low prices of vegetables, and price fluctuation, were the important ones. Lack of capital may be solved by agricultural policy to provide farmers credit with a low-interest rate. Low prices of vegetables and price fluctuation may be solved to give training to the farmers about modern storage technologies and marketing practices by DAE.
- iv. Finally, government continuous support and favorable agricultural policy will increase vegetable production in Bangladesh.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

References

Adil, S.A., Chattha, M.W.A., Hassan, S., and Maqbool, A., 2007. Economics of vegetable production by farm location. *Pakistan Journal of Agricultural Sciences*, 44(1):179-183.

Aigner, D.J., Lovell, C.A.K., and Schmidt, P., 1977. Formulation and estimation of stochastic frontier function models. *Journal of Econometrics*, 6(1): 21-37.

Akter, A., Hoque, F., Mukul, A.Z.A., Kamal, M.R., and Rasha, R.K., 2016. Financial analysis of winter vegetables production in a selected area of Brahmanbaria district in Bangladesh. *International Research Journal of Agricultural and Food Sciences*, 1(6):120-127.

Akter, S., Islam, M.S., and Rahman, M.S., 2011. An economic analysis of winter vegetables production in some selected areas of Narsinghi district. *Journal of the Bangladesh Agricultural University*, 9(2): 241-246.

Alam, M.S., Islam, M.S., and Islam, M.A., 2011. Farmer's efficiency enhancement through input management: The issue of USG application in modern rice. *Bangladesh Journal of Agricultural Research*, 36(1):129-141.

Ali, M.Y., Ahmed, M.M., and Islam, M.B., 2008. Homestead vegetable gardening: meeting the need of year round vegetable requirement of farm family. Paper presented in the National workshop on multiple cropping held at Bangladesh Agricultural Research Council, Farm gate, Dhaka-1215, Bangladesh.

Ajibefun, I. A., Battese, G. E., and Kada, R., 2002. Technical efficiency, technological change and productivity of hired and family labor in the Japanese rice industry. *Empirical Economics Letters*, 1(1): 21-31.

Aminu, F.O., Ayinde, I.A., and Ambali, O.I., 2013. Effect of ill health on technical efficiency of dry season vegetables farmers in Ojo local government area of Lagos State Nigeria. *World Journal of Agricultural Research*, 1(6): 108-113.

Bangladesh Bureau of Statistics (BBS), 2014. Yearbook of Agricultural Statistics of Bangladesh. Agricultural Statistics Division, Ministry of planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Bangladesh Bureau of Statistics (BBS), 2015. Yearbook of Agricultural Statistics of Bangladesh. Agricultural Statistics Division, Ministry of planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Bangladesh Bureau of Statistics (BBS), 2016. Statistical Pocketbook of Bangladesh. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

Bangladesh Bureau of Statistics (BBS), 2017. Yearbook of Agricultural Statistics of Bangladesh. Agricultural Statistics Division, Ministry of planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Bangladesh Economic Review (BER), 2018. Economic Adviser's Wing. Finance Division, Ministry of Finance, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Battese, G.E., Malik, S. J., and Gill, M.A., 1996. An investigation of technical inefficiencies of production of wheat farmers in four districts of Pakistan. *Journal of Agricultural Economics*, 47(1): 37-49.

Battese, G.E., 1997. A note on the estimation of Cobb-Douglas production functions when some explanatory variables have zero values. *Journal of Agricultural Economics*, 48(2): 250-252.

Bithi, S.Z., 2014. Comparative economic analysis of bean and bottle gourd production in selected area of Gopalganj district. M.S. Thesis, Department of Agricultural Economics, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

Bravo-Ureta, Boris, E., and Antonio Pinheiro, E., 1997. Technical, economic and allocative efficiency in peasant farming: Evidence from the Dominican Republic. *The Developing Economics*, 35 (1): 48-67.

Coelli, T.J., 1995. Recent developments in frontier modeling and efficiency Measurement. *Australian Journal of Agricultural Economics*, 39 (3): 219-245.

Chowdhuri, N.Y., Haque, S., Shammi, S.A., Jannat, A., and Sannyashi, P.R., 2014. Profitability analysis of winter vegetables production in a selected area of Narshingdi district in Bangladesh. *Progressive Agriculture*, 25: 47-53.

Food and Agriculture Organization of the United Nations (FAO), 2014. Country nutrition paper Bangladesh, International conference on nutrition 21 years later, 19-20 November 2014, Rome, Italy.

Hajong, P., Sikder, B., Mondal, S., and Islam, M.A., 2018. Adoption and profitability of summer

- tomato cultivation in Jashore district of Bangladesh. *Bangladesh Journal of Agricultural Research*, 43(4): 575-585.
- Hasan, M.R., Hu, B., and Islam, M. A., 2014a. Profitability of important summer vegetables in Keranigonj Upazilla of Bangladesh. *Journal of the Bangladesh Agricultural University*, 12(1): 111-118.
- Hasan, M.R., Mutatisse, A.A., Nakamoto, E., and Bai, H., 2014b. Profitability of cauliflower and bean production in Bangladesh. *Bangladesh Journal of Extension Education*, 26(1&2): 63-75.
- Hossain, M.S., and Miah, M.A.M., 2011. Poor farmers' problem confrontation in using manure towards integrated plant nutrition system. *Bangladesh Journal of Extension Education*, 23 (1&2): 139-147.
- XE currency converter, 2020. Online currency converter. <https://www.xe.com/currencyconverter/convert/?Amount=1&From=USD&To=BDT> (Accessed on 26/9/2020).
- Islam, M.S., Salehin, F., and Nayeem, A.R., 2020. Cauliflower cultivation productivity and resource utilization of Agro-economics: A study on selected areas of Jamalpur district in Bangladesh. *Globus An International Journal of Management and IT*, 11(2): 10-16.
- Jondrow, J., Lovell, C.A.K., Materov, V., and Schmidt, P., 1982. On the estimation of technical efficiency in the stochastic frontier production function model. *Journal of Econometrics*, 19 (2&3): 233-38.
- Khan, M.H.A., Ali, M.Y., Quayyum, M.A., Nazrul, M.I., and Hossain, M.J., 2009. Year round homestead vegetable production: A means of reducing poverty and nutritional deficiency for small farm. *Bangladesh Journal of Agricultural Research*, 34(1): 169-174.
- Khayer, U., Akhter, S., and Mondal, R.K., 2011. Comparative economics of bean and bottle gourd production in some selected areas of Bangladesh. *Developing Country Studies*, 1(2): 34-40.
- Khandoker, S., Miah, M.A.M., Khatun, M., Akhter, N., and Kundu, N.D., 2016. Profitability and resource use efficiency of winter vegetables production in selected areas of Bangladesh. *Bangladesh Research Publications Journal*, 12(2): 127-137.
- Kumar, A., Rohila, A.K., and Pal, V.K., 2018. Profitability and resource use efficiency in vegetable cultivation in Haryana: Application of Cobb-Douglas production model. *Indian Journal of Agricultural Sciences*, 88 (7): 153-157.
- Lokapur, S., Kulkarni, G.N., Gamanagatti, P.B., and Gurikar, R., 2014. Resource use efficiency of major vegetables in Belgaum district in Karnataka. *International Research Journal of Agricultural Economics and Statistics*, 5(1): 108-110.
- Mamun, M.H.A., Bashar, H.M.K., Islam, M.S., Howlader, M.H.K., and Hasan, M.S., 2010. A case study on homestead vegetables cultivation: food security and income. *International Journal of Sustainable Crop Production*, 5(1): 5-10.
- Monayem, M.A., Rahman, A.K.M.M., Haque, A.K.M.H., and Jabbar, M.A., 1998. Economics of some winter vegetables production and their farm level marketing in five villages of Comilla District. Research report, Agricultural Economics Division, BARI, Joydebpur, Gazipur, Bangladesh.
- Mowla, M.G., 1998. An economic analysis of some selected winter vegetables in a selected area of Narsingdi District. M.S. Thesis, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh, Bangladesh.
- Mitra, S., and Sharmin, S., 2019. Risk attitudes and financial profitability of tomato farmers- A study in Bangladesh. *Journal of Agricultural Sciences-Sri Lanka*, 14(3): 207-217. doi.org/10.4038/jas.v14i3.8604
- Mitra, S., and Yunus, M., 2018. Determinants of tomato farmers efficiency in Mymensingh district of Bangladesh: Data envelopment analysis approach. *Journal of the Bangladesh Agricultural University*, 16(1): 93-97.
- Nahar, A., 2009. An economic study of year round vegetables production in selected areas of Jessore District. M.S. Thesis, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh, Bangladesh.
- Ogundari, K. and Ojo, S.O., 2007. Economic efficiency of small scale food crop production in Nigeria: A Stochastic Frontier Approach. *Journal of Social Sciences*, 14(2): 123-130.
- Rahman, M.Z., Kabir, H., and Khan, M., 2016. A study on brinjal production in Jamalpur district through profitability analysis and factors affecting the production. *Journal of the Bangladesh Agricultural University*, 14(1): 113-118.
- Rajendran, S., Sefa, V.A., Karanja, D.K., Musebe, R., Romney, D., Makaranga, M.A., Samali, S., and Kessy, R.F., 2015. Technical efficiency of traditional African vegetable production: A case study of smallholders in Tanzania. *Journal of Development and Agricultural Economics*, 7(3): 92-99.
- Shende, N.V., and Meshram, R.R., 2015. American International Journal of Research in Formal, Applied and Natural Sciences, 11(1): 46-54.
- Somajpoti, P., Ahmed, J.U., Mannaf, M., Mozahid, M.N., and Alam, 2016. Economics of cauliflower and cabbage production in selected areas of Sylhet district. *Journal of the Sylhet Agricultural University*, 3(2): 253-262.
- Subedi, M., Pandey, M., Ojha, R.K., and Acharya, B., 2020. Production economics and resource use efficiency of tomato under open field condition in Kapilvastu, Nepal. *Journal of Agriculture and Natural Resources*, 3(1): 282-289.
- Todsadee, A., Kameyama, H., Ngamsomsuk, K., and Yamauchi, K., 2012. Production efficiency of broiler farming in Thailand: A stochastic frontier approach. *Journal of Agricultural Science*, 4(12): 221-231.
- Wahid, U., Ali, S., and Hadi, N.A., 2017. On the estimation of technical efficiency of tomato growers in Malakand. *Sarhad Journal of Agriculture*, 33(3): 357-365.
- Weinberger, K., and Genova II., C.A., 2005. Vegetable production in Bangladesh: Commercialization and rural livelihoods. Technical Bulletin no. 33, Taiwan: AVRDC-The World Vegetable Centre, Tainan, Taiwan.
- Weinberger, K., and Lumpkin, T.A., 2005. Horticulture for poverty alleviation—the unfunded revolution. Shanhua, Taiwan: AVRDC – The World Vegetable Center, AVRDC Publication No. 05-613, Working Paper No. 15, 20.
- Zaman, M., Hemel, R.A., and Ferdous, T., 2010. Comparative profitability of winter vegetables in a selected area of Dhaka district, *ASA University Review*, 4(1): 217-223.