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Measuring technical efficiency of bottle gourd and brinjal farming in Dhaka district of Bangladesh: Stochastic frontier approach

Fazlul Hoque[1,2], Asma Akter[2,3] and Supawat Rungsuriyawiboon[1]

*[1] Faculty of Economics, Thammasat University, Thailand. [2] Faculty of Agribusiness Management, Sher-e-Bangla Agricultural University, Bangladesh. [3]Nanjng Agricultural University, China. *E-mail: fazlulhoque1991@gmail.com*

Abstract

Shortage and inefficient use of resource in agricultural activities in Bangladesh are emphasizing to measure efficiency for increasing productivity with the highest efficiency and ensure the sustainable development of the agricultural sector. The motive of the study is to estimate technical efficiency by using stochastic frontier analysis (SFA) of brinjal and bottle gourd cultivation in Dhaka, Bangladesh. Tobit regression was applied to determine the elements affecting the efficiency and Cobb-Douglas production model was applied to pick out elements affecting the gross return of bottle gourd and brinjal. 100 (50 Brinjal +50 Bottle gourd) farmers were selected randomly as well as interviewed for collecting information through one set of questionnaires. The result revealed that bottle gourd and brinjal farmers were not perfectly efficient in Bangladesh. The mean efficiency of bottle gourd and brinjal observed 0.79 and 0.81, respectively. According to mean efficiency, farmers can be efficient in bottle gourd and brinjal farming through increasing 21 % and 19 % output, respectively with on-hand resources and technologies. Tobit model suggests that the education level of farmer, training program, choosing high yielding variety and the size of the farm have an effect on farmers' efficiency positively and significantly. In addition, we observed that human labor cost, seed cost, irrigation cost, fertilizers cost, and pesticides and insecticides cost have a significant positive impact on bottle gourd and brinjal production.

Key word: Technical efficiency, brinjal, bottle gourd, agriculture, farmer.

Introduction

Agriculture is one of the major influential sectors in our economy which covers 14.75 % GDP and 40.6 % of employment of total labor force. The total land area of Bangladesh is about 14.3 million hectares of which about 59.8 % is available for cultivation having 8.56 million hectares with 192 % cropping intensity and net cropped are about 15.23 million hectares (BBS 2017). During the last 12 years, the agricultural land has been declining, on average, at the rate of about 1 % due to river erosion, industrialization, urbanization. According to BBS 2014-15, Total 0.989 million acres land were cultivated for vegetable production in Bangladesh and its annual production was 3.7874 million metric tons which are more than double in term of an area of land 1.959 million hectares, production 1.29 million metric tons of 1996-1997. Different types of vegetable comprising both local and exotic types are grown in Bangladesh such as major winter vegetables are cabbage, cauliflower, tomato, brinjal, radish, hyacinth bean, bottle gourd, *etc* while major summer vegetables are pumpkin, bitter gourd, cucumber, teasle gourd, ribbed gourd, ash gourd, okra, yard-long bean, and Indian spinach among others. Some vegetables like brinjal, pumpkin, okra, and red amaranth are found to grow in both the season.

Bottle gourd is one of the major winter vegetables which is low in saturated fat, cholesterol, excessive in dietary fiber, Vitamin C, riboflavin, zinc, thiamine, iron, magnesium, and manganese. Its water content is 96 %. 100 g of bottle gourd carries 15 calories. It covers 45058 acres of land with an annual production of 0.1984 million metric tons which is 5.2 % of total vegetable production in Bangladesh (BBS 2014-15).

Brinjal is enriched with soluble fiber and contains a lower stage of fat and calorie. It has 92 % of water content. 100g brinjal carries 25 calories energy. Consumption of brinjal reduces the danger of fatness, mortality, diabetes, and cardiac disease and improves a wholesome texture and hair, inflates vigor and decreases body weight. It is cultivated year-round in 0.122 million acres land with an annual production of 0.45 million metric tons which covers about 13.02 % of all total vegetable production in Bangladesh (BBS-2014-15).

The agriculture of Bangladesh has improved many folds in terms of production for major crops such as rice, wheat, maize, potato, *etc*. Recently we have achieved food security in term of food grain but vegetable, spice, oilseed production is in shortage according to our demand of the large population. Per person consumes only 166.1 gm vegetables daily whereas the required amount is 200gm in Bangladesh. In addition, it is seen that vegetables farmers use inputs recklessly to increase production without considering the cost of production. This unwise cost of production leads farmers to charge the higher price of their commodities for being profitable. As a result, all people have no equal to access to vegetable consumption.

Moreover, we have a huge potentiality to earn foreign currency by exporting fresh vegetable after meeting up domestic demand. The demand for vegetables is increasing in domestically as well as globally but our agricultural land is declining. The vegetable farmers of Bangladesh have to be not only technically efficient but also cost efficient as much as possible to produce more output with given level resources and technologies at minimum production cost for facing a dual negative situation of rising demand of vegetables while the land is declining. In this paper, I will try to estimate technical efficiency of brinjal and bottle gourd farming in Bangladesh as well as focus on factors affecting technical efficiency of the farmers which will provide a valid contribution in vegetable farming practices in Bangladesh and abroad.

There are relatively few studies carried on measuring the technical efficiency of various crops-growing households. Specifically, Krasachat (2000) measured the technical efficiency using data envelopment approach (DEA) of agricultural production in Thailand; Shantha *et al*. (2013) estimated the technical efficiency using stochastic frontier approach of rice farming under major irrigation scheme in Sri Lanka; Hossain *et al*. (2015) measured technical efficiency through stochastic frontier approach of Boro rice farms in Meherpur district of Bangladesh; Hasan (2008) compared the technical efficiency in rice cultivation between Dinajpur and Panchagarh districts of Bangladesh. On the other hand, Abay *et al*. (2004) studied on efficiency analysis of tobacco employing DEA method and identified factors affecting the inefficiency in Turkey; Tijani (2006) estimated technical efficiency by applying stochastic frontier approach of rice farms in Osun State of Nigeria and figured out several socioeconomic indicators affecting productivity and efficiency; Khan *et al*. (2010) assessed the technical efficiency of rice production and determinants of inefficiency in Jamalpur district of Bangladesh; Haider *et al.* (2011) conducted a study to measure technical efficiency of three sub-sectors such as rice cultivation, fish cultivation and farm animals rearing of agriculture in Khulna, Bangladesh. Mohapatra (2013) estimated the technical efficiency and the determinants of inefficiency of paddy production in Odisha, India; Laha (2013) measured the technical efficiency in agricultural production and access to credit by employing the stochastic frontier approach in West Bengal, India; Rajendran *et al.* (2015) estimated the technical efficiency using stochastic frontier approach for traditional vegetables and determined the socioeconomic factors affecting the inefficiency in Tanzania; Mitra and Yunus (2018) used input-oriented DEA method to measure the efficiency of tomato farming and pointed out the factors affecting inefficiency in Mymensingh district of Bangladesh;

Empirical results from these studies indicate the efficiency and factors influencing the inefficiency in rice cultivation are dissimilar. However, the farming experience, level of education, extension service, training, and modern high yield variety, easy access to credit, farm size were found to increase the technical efficiency of rice cultivation in Bangladesh and across the other countries in the world.

Materials and methods

The research was done on farmers of 10 villages of three Unions namely Amin Bazar, Tetulzora Hazratpur of Dhaka district of Bangladesh. There are about 5000 farmers are cultivating vegetables in the mentioned above Unions. Out of these 100 (50 brinjal +50 Bottle gourd) farmers had been selected randomly as well as had been interviewed for collecting data by one set schedule of the questionnaire in 2017. The total output of brinjal of farms was the output variable which was measured in kg per farm and output of bottle gourd farm was measured as number per farm. Input variables were labor man days, seed cost, fertilizer cost, pesticides cost, irrigation cost, land rent and power tiller cost, the bamboo cost which was measured in Bangladeshi taka. Labor input was the summation of both family and hired labor and eight hours are considered as one-man day (Khan, 2017; Iliyasu and Mohamed, 2016; Alam *et al*., 2012). Since, input and output markets of agricultural commodities are competitive thus we have used input and output values for analysis in the study.

Technical Efficiency: Technical efficiency of a farm is the ratio of farm's actual output to the technically maximum feasible output, at given level of resources (Battese and Coelli, 1988; Adedeji1 *et al*., 2013). We can broadly category estimation approaches for measuring efficiency as non-parametric method and parametric method. The non-parametric approach employs mathematical or linear programming analysis without considering any functional form of the production frontier. This approach does not accommodate any noise for efficiency and does not make any assumptions. That's why it cannot test hypotheses. The most widely used nonparametric approach is the Data Envelopment Analysis (DEA).

On the other hand, the parametric frontier approach uses maximum likelihood estimation (MLE) for the functional form of production frontier. Common functional forms include the Cobb-Douglas, Constant Elasticity of Substitution (CES) and Translog production functions. It can make an assumption on data and test hypotheses. It can accommodate noise which is effectively part of the efficiency score. This approach is widely called as stochastic frontier analysis (SFA).

The nonparametric approach assumes all the deviations from the frontier due to firms' inefficiency while stochastic (parametric) approach assumes that one part of the deviation from the production frontier due to a random event(noise) and another part of the deviation due to farm specific inefficiency(Forsund *et al*., 1980; Battese, 1992 and Coelli *et al*., 1998).Since the production of agricultural commodities not only depends upon on farm-specific characteristics but also other random events such as the climate of the cropping season, agro-ecological zone, socio-economic characteristics of a farmer, *etc*. That's why I have employed stochastic frontier analysis (SFA). The efficiency of farms has widely been studied by several researchers.

Many of them estimated the technical efficiency by applying stochastic frontier approach (Haider *et al*., 2011; Rajendran *et al*., 2015; Hossain *et al.*, 2015 and Laha, 2013). Based on these studies I have formulated stochastic parametric model to estimate the technical efficiency of bottle gourd and brinjal production in the study area.

Stochastic Frontier Analysis (SFA): Aigner, Lovell and Schmidt (1977), Meeusen and Van den Broeck (1977) independently proposed the stochastic production or cost frontier models. Stochastic frontier model suits with the specific parameterizations of the inefficiency term and can match the stochastic production frontier or cost frontier model. Suppose that a farmer has a production function for a single output without any inefficiency (maximum possible feasible production frontier) as

$Y_i = f(X_i, \boldsymbol{\beta})$ (1)

In Equation (3.1) Y_i indicates the yield of the *i-th* farm, X_i denotes variable inputs with K inputs used by farmer to produce vegetable and $\boldsymbol{\beta}$ indicates (K x 1) vector of technology parameters to be estimated.

Stochastic Frontier Approach considers that farmer (farm) produces less than maximum feasible production frontier from proposed due to the degree of inefficiency. Stochastic production function can be written by adding error term for inefficiency as

$Y_i = f(X_i, \boldsymbol{\beta}) \exp(\varepsilon_i)$ (2)

Where, ε_i is composed of two independent elements v_i and u_i, such that $\varepsilon_i = v_i - u_i$; u_i denotes one sided error while v_i is two sided error term. The random component v_i is assumed to be identically and independently distributed as N $(0, \sigma_v^2)$ and is also independent of u_i. This random error represents random variations in output due to those factors are impossible to control for farmer such as agro-climate, natural disasters, sudden failure of machines and quality of variable inputs (such as seed, fertilizer, manure, insecticides, *etc*.) as well as the effects of measurement errors in the output variable, statistical noise and omitted variables from the functional form (Aigner *et al*., 1977).

u_i is nonnegative random variable that represents the stochastic shortfall of outputs from the most efficient production. u_i is the one-sided disturbance form used to represent technical inefficiency and are assumed to be independently and identically distributed with the half normal truncated distribution as $N^+(0, \sigma_u^2)$ also independent of v_i (Kumbhakar and Lovell, 2000).

Maximum Likelihood Estimation (MLE) technique is employed to estimate the parameters ($\boldsymbol{\beta}, \boldsymbol{\sigma}, \boldsymbol{\gamma}$) of stochastic frontier. The variance of the parameters can be estimated as following way:

$$\sigma^2 = \sigma_u^2 + \sigma_v^2 ;\ldots.. \gamma = \frac{\sigma_u^2}{\sigma^2} = \frac{\sigma_u^2}{(\sigma_u^2 + \sigma_v^2)}$$

FRONTIER version 4.1software was used to estimate all parameters of the SFA of the maximum likelihood function (Coelli, 1996b). This software estimates the $\gamma = \sigma_u^2/\sigma_s^2$ parameter, which takes a value between zero (0) and one (1). When, $\gamma = 0$ denotes that deviations from the production frontier are due to noise. whereas $\gamma = 1$ represents that deviation from the frontier are due to technical inefficiency.

The efficiency of a production unit involves the comparison between observed and optimal amount of its output and input (Lovel, 1993). The ratio of the observed output of the *i*-th farm relative to the potential output estimated by equation (1) provides the technical efficiency of *i*-th farm. Hence technical efficiency denoted by TE_i is given by:

$$TE_i = \frac{Actual\ Output(Y^0)}{Maximum\ Fesible\ Output(Y^m)} \quad (3)$$

$$TE_i = \frac{f(X_i, \beta)\exp(v_i - u_i)}{f(X_i, \beta)\exp(v_i)} = E\ \{exp(\hat{\mu}_i)\} \quad (4)$$

Technical efficiencies vary between zero and one.

Empirical Model: Following Coelli (1996), the stochastic production frontier with a Cobb-Douglas functional form was employed to estimate all parameters in maximum likelihood estimation.

$$ln\ Y = \beta_0 + \beta_1\ ln\ X_1 + \beta_2\ ln\ X_2 + + \beta_3 ln\ X_3 + \beta_4\ ln\ X_4 + \beta_5\ ln\ X_5 + \beta_6\ ln\ X_6 + \beta_7\ ln\ X_7 + \beta_8\ ln\ X_8 + (v_i - u_i) \quad (5)$$

Where,

Y = Gross return (Tk); X_1 = Human labor cost (Tk); X_2 = Tillage cost (Tk); X_3 = Machinery cost (Tk); X_4 = Seed/ Seedling cost (Tk); X_5 = Fertilizer and Manure cost (Tk); X_6 = Insecticides cost (Tk); X_7 =Irrigation cost (Tk); X_8 =Land use cost(Tk)

Factors affecting efficiency: Some previous researches used Tobit regression model for identifying the determinants affecting efficiency (Alam,2011; Nielsen, 2012; Zongli *et al*., 2016). Since the value of efficiency varies from zero (0) to one (1); Tobit regression model can be used to identify factors affecting efficiency of vegetable farming. The empirical Tobit regression is as follows:

$$TE_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + e \quad (6)$$

Where,

TE_i = Efficiency level of i-th farm; X_1 = Training (dummy); X_2 = Education (Years of schooling); X_3 = High yielding variety adoption (dummy); X_4 = Experience (Years); X_5 = Age (years); X_6 =Extension services (dummy); X_7 = Family member (number); and e = error term.

Reliability Test (cronbach alpha)

	Bottle gourd	Brinjal
Average inter item covariance	0.2687974	0.06669
Number of items in the scale:	9	8
Scale reliability coefficient:	0.9807	0.9819

According to Cronbach alpha (α), data set of bottles gourd and brinjal have higher level of internal consistency.

Results and discussions

Table 2 indicates that the technical efficiency of the brinjal and bottle gourd farm varies according to the size of the farm. The higher percentage of mean efficiency for brinjal 87.4 % and bottle gourd 84.6 % were observed in large farms whilst lowest percentage of mean efficiency for brinjal 72.2 % and bottle gourd

Table 2. Technical efficiency according to farm size

Brinjal						Bottle Gourd					
Size of farm	Mean	Max	Min	SD	N	Size of farm	Mean	Max	Min	SD	N
Small	0.722	0.790	0.660	0.047	15	Small	0.725	0.790	0.650	0.043	14
Medium	0.786	0.870	0.680	0.052	16	Medium	0.781	0.870	0.690	0.045	21
Large	0.874	0.940	0.780	0.036	19	Large	0.846	0.880	0.700	0.043	15
Total	0.810	0.940	0.660	0.077	50	Total	0.791	0.880	0.650	0.062	50

72.5 % were found in small farm size. It means that larger size farm being less fragmented is more efficient in brinjal and bottle gourd cultivation because the scale of economies for excellent allocation of inputs and resources while small farm being more fragmented suffers from misallocation of resources. Wadud (2003) obtained positive and significant relationship between technical efficiency and plot size. He explained that farmer having a larger plot (Less fragmented of land) operated with a greater level of technical efficiency.

Table 3 indicates that mean of the technical efficiency of brinjal farming is about similar to all areas (Amin bazar 81.6 %, Hazratpur 80.2 % and Tetulzora 81.0 %) while mean of the technical efficiency of bottle gourd farming is also about equal to all areas (Amin bazar 79.11 %, Hazratpur 79.06 % and Tetulzora 79.10 %). (Abay *et al.*, 2004; Rajendran *et al.,* 2015; Krasachat, 2000 found variation in technical efficiency and productivity according to agro-climate and zone). Since these regions located in the identical agro-ecological zone and being nearer to each other, their soil quality is also the same; so there is no considerable technical efficiency difference according to survey areas.

From Stochastic Frontier Analysis (SFA) estimation, Mean Technical Efficiency (TE) of bottle gourd is 0.791 which means Bottle gourd farming will be technically efficient by increasing 21 % output through better use of available resources while using current technology. Mean Technical Efficiency (TE) of brinjal is 0.81 which means Brinjal farming will be technically efficient by increasing 19 % output through better use of available resources while using current technology.

From Table 4, it has been indicated that technical efficiency of bottle gourd and brinjal farming is determined by age, education, training, family size, farm size, sources of fund and adoption of high yield variety. For Bottle gourd farming; education, training and choosing high yield variety found to have a positive impact on technical efficiency at 5 % level of significance whereas the size of the farm was positively significant at 1 % level. For Brinjal farming; Education, size of the farm found to have a positive influence on technical efficiency at 1 % level of significance while training and adoption of high yield variety were positive significant 5 % level.

Higher schooling years increase the efficiency level of the farmers. Education increases knowledge of farmers relating to farming practices as well as changes attitudes of the farmers. Educated farmers are found interested to attend training sessions, choose proper inputs, adopt new technologies. In addition, educated farmers are conscious of cultivating and harvesting of crops at a proper season and can avoid natural disaster to some extent. Thus education influences the technical efficiency of agricultural farming practices. Murthy *et al*. (2009) found that Educational level had a positively significant impact on technical efficiency of tomato farmers.

The training program was positively significant with the technical efficiency of the farmer means that farmers who attended a training session are more efficient than who did not attend a training session. Usually, the training session is arranged to introduce farmers with recent technologies available, advanced farming practices which increase productivity, the efficiency of the farmers. According to Schreinemachers *et al.* (2016) training program facilitate to inform updated farming practices that assist to increase productivity, efficiency and solvency of the farmer.

Choosing high yield variety was positively related with efficiency of the farmers. It denotes that farmers chosen high yield variety

Table 3. Technical efficiency according to region of the farm

	Brinjal					Bottle Gourd					
Region	Mean	Max	Min	SD	N	Region	Mean	Max	Min	SD	N
Amin bazar	0.816	0.920	0.670	0.076	20	Amin Bazar	0.7911	0.880	0.660	0.071	19
Hazratpur	0.802	0.930	0.660	0.080	16	Hazratpur	0.7906	0.880	0.650	0.055	17
Tetulzora	0.810	0.940	0.670	0.082	14	Tetulzora	0.7914	0.880	0.690	0.063	14
Total	0.810	0.940	0.660	0.077	50	Total	0.7910	0.880	0.650	0.062	50

Table 4. Tobit regression for factors affecting farmers' efficiency

	Bottle Gourd				Brinjal		
Efficiency	Coefficient	Standard Error	P-Value	Efficiency	Coefficient	Standard Error	P-Value
Constant	0.6322	0.0253	0.000	Constant	0.6507	0.0317	0.000
Age	0.0004	0.0005	0.360	Age	0.0001	0.0006	0.824
Education	0.0038**	0.0014	0.012	Education	0.0051***	0.0017	0.004
Training	0.0313**	0.0138	0.029	Training	0.0419**	0.0149	0.007
Size of farm	0.0234***	0.0061	0.000	Size of farm	0.0195***	0.0083	0.023
Sources of Fund	0.0013	0.0091	0.885	Sources of Fund	0.0072	0.0101	0.48
Family Member	0.0031	0.0056	0.582	Family Member	0.0014	0.0041	0.736
Variety	0.0365**	0.0146	0.016	Variety	0.0451**	0.0127	0.001

LR chi2 (7) = 96.38
Prob > chi2 = 0.0000
Log likelihood = 116.449

LR chi2(7) = 91.91
Prob > chi2 = 0.0000
Log likelihood = 103.517

(Significance level: *** for 1 %, ** for 5 % and * for 10 %)

for their farms are more efficient than farmers used any others variety. High yield variety is seen more disease resistant, better vegetative growth, earlier flowering and less harvesting time that less crop damages and ensure higher yield. Ali *et al*. (2014) found that earlier flowering; better growth performance, less virus infection and less harvest time of high yielding local varieties can save the production cost and management.

Farm size was found to influence farmers' efficiency positively and significantly. It implies that farmers having larger plots are more efficient than farmers cultivating in small plots. Farmers can enjoy in economies of scale in larger plots by appropriate allocation of resources while farmers with smaller plots suffer from misallocation of resources. Rajendran *et al* (2015) found positive relationship between size of farm and technical efficiency.

Other factors like source of fund, family size and age were found insignificant. That means technical efficiency of bottle gourd and brinjal farming is not influenced significantly by age, sources of fund and family size.

Results of the Cobb-Douglas production function analysis (Table 5) indicate that the gross return of bottle gourd and brinjal is determined by human labor cost, tillage cost, seed cost, fertilizer and manures cost, pesticides cost, irrigation cost, and land rent while bamboo cost also influences the gross return of bottle gourd.

For bottle gourd, the human labor cost was found to have a positive effect on gross return at 1 % level of significance. Seed cost and irrigation cost were related to gross return positively with 5 % level of significance while fertilizer and manure cost was positively significant at 10 % level. Whereas Brinjal, the human labor cost had a positive influence on gross return at 1 % level of significance. Seed cost, fertilizer and manure cost were found to have a positive impact on gross return at 5 % level of significance. In addition, pesticides and insecticides, the cost had a positive significant effect on gross return at 10 % level.

Hoque *et al.* (2018) employed Cobb-Douglass production model on brinjal cultivation in Dhaka district and obtained that the human labor cost, seed cost, and fertilizers and manure cost have a positive significant impact on the output of vegetables and gross revenue.

Human labor cost is one of the major cost items in vegetable production that includes land preparation, seed sowing/ seedling planting, earthing up, weeding, fertilizerand manure application, insecticides application, harvesting, grading, sorting of vegetables, *etc*. Higher labor cost is required for better land preparation, appropriately seed sowing or seedling planting keeps land free from weeds, application of fertilizer and pesticides carefully, harvesting at the right time which ensure better yield and gradingand sorting ensure the better price of vegetables. So higher labor cost affects the gross return of vegetables positively.

Akter *et al.* (2016) found that human labor cost and tillage cost had positive significant influence on gross return for cauliflower production in Brahmanbaria district of Bangladesh.

Seed cost had a positive effect on the gross return of vegetable production significantly. Higher seed cost indicates better quality of seed or seedling. Better quality seed yields better that ensures a higher gross return.

Irrigation cost affected the gross return of bottle gourd positively. For vegetative growth as well as flowering require a certain amount of water. During winter in Bangladesh, we can see very little rainfall so irrigation is necessary for vegetable production. So higher irrigation cost ensures better vegetative growth of a plant which ultimately increases the yield of vegetables and gross return.

Fertilizers and manures improve the structure of the soil and fertility by releasing nutrients in the soil. In addition, fertilizers and manures ensure soil–and plants–healthy and strong. The thus higher cost of fertilizersand manures increases the better yield of vegetables and gross return.

Brinjal is more susceptible to disease caused by insects and pests. Sometimes a severe attack of insects and pests can cause entire yield loss of brinjal. Pesticides and insecticides cost was found to have a positive significant impact on the gross return of brinjal.

Table 5. Maximum-likelihood estimates of parameters of the Cobb-Douglas frontier function for bottle gourd and brinjal in Dhaka district of Bangladesh.

Bottle Gourd			Brinjal		
Gross Return	Coefficients	Standard Error	Gross Return	Coefficients	Standard Error
Intercept	0.021	0.2502	Intercept	0.0017	0.0075
Human Labor Cost	0.0972***	0.0319	Human Labor Cost	0.2940***	0.1075
Tillage Cost	0.0719	0.0907	Tillage Cost	0.0523	0.0708
Bamboo cost	0.0408	0.0982	Seed Cost	0.2189**	0.1134
Seed cost	0.1920**	0.1155	Fertilizers & Manures Cost	0.1928**	0.0852
Fertilizer& Manure Cost	0.1983*	0.04	Pesticides& Insecticides Cost	0.2188*	0.0896
Pesticides& Insecticides Cost	0.1699	0.1177	Irrigation Cost	0.0503	0.0546
Irrigation Cost	0.1857**	0.1176	Land Rent	0.013	0.06
Land Rent	0.0605	0.1119			
σ^2 = 0.0109716			σ^2 = 0.02197		
γ = 0.790			γ = 0.762		
LR chi2 (8) = 32.56			LR chi2 (7) = 26.039		
Log likelihood Value=126.749			Log likelihood Value = 103.793		
Return to Scale	1.02 (increasing)			1.04 (Increasing)	

Note: *** Significant at 1 percent level ** Significant at 5 percent level * Significant at 10 percent level

Higher pesticides and insecticides cost protect brinjal from the attack of disease and pests which reduces yield loss and ensure better yield as well as gross return.

In addition to land rent, tillage cost and bamboo cost were insignificantly related to the gross return of bottle gourd and brinjal farming.

Return to scale: Return to scale is calculated by summation of the coefficient of all input value of vegetable cultivation (RTS= $\sum_{i-1}^{n} \beta i$). We found that return to scale 1.02 (bottle gourd) and 1.04 (brinjal) which were more than one meaning that 1 % increase of all input value leads to increase the total gross return of bottle gourd 1.02 and brinjal 1.04 % during the course production season.

Based on of the current study, we can suggest for policymakers of Bangladesh those are directly or indirectly related with agriculture sector in the country: (a) The farmers who cultivated vegetables are not perfectly efficient (79 % efficient for bottle gourd and 81 % efficient for brinjal). We found that the efficiency level of the farmers is positively influenced by the education level of the farmers, farm size, training program and variety of vegetables. Since the demand for vegetables is increasing in domestically and globally so the policy makers should take an effective measure to increase productivity by making farmers more efficient. Although the overall literacy rate is 72.89 % in Bangladesh but the literacy rate of the farmer is very low. That's why government and other policymakers should adopt a pragmatic measure like mass education for farmers to introduce with modern farming practices. (b) Agricultural extension services should be ensured at the grass root level to find out problems those are farmers facing and training session needs to be arranged for farmers to introduce them with advanced technologies such as high yield variety, disease resistant and stress tolerant variety, fertilizers, pesticides, insecticides, *etc*. (c) Maximum vegetables farming plot size is small which suffer from misallocation of farming inputs. Farmers should be encouraged to practice cooperative farming to make farm size bigger. As larger size farm can allocate resources wisely and enjoy economies of scale production.

As a sub-sector of agriculture, the contribution of vegetables to the economy is no longer negligible. To ensure sustainable development of agriculture, vegetable farming needs to be efficient with other crops such as rice, wheat, maize, oilseeds, and pulses, *etc,*. The result indicated that bottle gourd and brinjal farmers were not completely efficient in Bangladesh. The mean efficiency of bottle gourd and brinjal observed 0.79 and 0.81, respectively. The brinjal farmers had been 4 % more efficient than bottle gourd farmers in Bangladesh. According to estimated mean efficiency farmers can be efficient in bottle gourd and brinjal farming by increasing 21 % and 19 % output, respectively with on hand resources and technologies. In addition, we observed that human labor cost, seed cost, irrigation cost had a considerable positive impact on bottle gourd and brinjal production. Insecticides and pesticides cost were found to have a significant advantageous influence on the production of brinjal.

The education level of farmer, training program, choosing the high yielding variety and farm size affect farmers' efficiency positively and significantly. That signals that vegetable farmers should be encouraged to attend agricultural farming practices training and to adopt high yield variety of seed and new available technologies which assist to increase of efficiency and productivity. Finally, it might be said that agricultural extension service should be ensured at the grass root level of vegetable farmers to train them inefficient farming practices focusing on the ideal use of inputs as well as changing their attitudes for adopting new technologies instead of traditional and superstitious farming practices.

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