*Bangladesh J. Agric. Econs. XXXIV, 1&2 (2011) 1-13*

# PROFITABILITY AND RESOURCE USE EFFICIENCY OF PRODUCING MAJOR SPICES IN BANGLADESH

M. Serajul Islam[1]
K. M. Mostafizur Rahman[2]
Md. Kamrul Hasan[3]

## ABSTRACT

The present study attempts to determine the productivity, profitability and resource use efficiency of four promising spices crops such as garlic, chilli, ginger and turmeric. The data were collected from 480 farm households in the crop year 2010-2011. Productions of all the crops were profitable as estimated by net returns and benefit cost ratios. Functional analyses showed that farm size, seed, inorganic and organic fertilisers, cost of power tiller and draft power, irrigation, education, farming experience and training had positive impact on the production of spices. Increasing returns to scale prevailed in the production process for garlic, chilli, ginger whereas constant returns to scale prevailed for the production of turmeric. All the models used fitted well to analyse the selected data for all crops. Small farmers were more efficient for garlic production only whereas the large farmers were more efficient for other spices crops. More educated and more experienced farmers were technically more efficient than less educated and less experienced farmers. Training reduced significantly the inefficiency of farmers in producing respective crops. The average estimated technical efficiencies for garlic, chilli, ginger and turmeric were respectively 88, 80, 69 and 79% which indicated that garlic production could be increased by 12%, chilli by 20%, ginger by 31% and turmeric by 21% with the same level of inputs without incurring any additional cost. As a policy option, training should be extended to all farmers to have a reduced inefficiency effect, which in turn would increase the profitability of spices crop production by saving resources. However, training should be provided frequently to improve the efficiency of farmer for spices production.

## I. INTRODUCTION

Spices are very important as food and also as medicine. They bring out the unique natural taste of cuisines and could be used to change the look of food to make it more attractive in colour. They are so important in ancient times and still today almost all people are habituated to use spices in curries and other food. They come in different flavours and aroma. Some spices are boiled in water to make tea. Some of them grow in the wild and are very good

[1] Professor, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh, Bangladesh.

[2] Professor, Department of Agricultural Statistics, Bangladesh Agricultural University, Mymensingh, Bangladesh.

[3] Ph. D. Student, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh, Bangladesh.

source of food preservative especially for industrially processed foods. As medicine or food, the importance of spices cannot be overemphasized.

Almost all curries are popular and testy which are made from a combination of several spices. Main ingredients of curry include ginger, turmeric, fennel, cumin, fenugreek, coriander and nutmeg. It provides flavour for meat, fish, vegetable and soup.

Turmeric is also helpful in reducing blood sugar. Valued for more than just taste and appearance, spices have nutritional and medicinal merits, as well, although they are sometimes better known as home remedies than proven treatments in medicine. Ginger, for example, is well known as a helpful digestive aid. Garlic is touted for preserving memory and keeping a heart healthy. Turmeric has long been used as a home remedy against common colds and influenza.

Species are also used as natural food preservatives. Pharmaceutically they have been used to flavour medicines. Spices are a broad term used to describe herbal by-products that add flavour and aesthetic, aromatic and therapeutic treatments to food, drink and other items. Taken from the leaf, flower, roots, bark or nuts of a plant, spices are usually dried and ground to be mixed with other ingredients. Spices appeal to the five senses and influence cultures and societies through trade and daily use (Kumar *et al.* 2011).

Because of the diversified use of spices, such as food, nutrition, medicine and preservatives, the demand for spices has increased manifold in Bangladesh unlike many other Asian and Arabian countries. Owing to its high demand, many countries have fought very hard in the past to control its production and trade. Presently 109 kinds of spices are cultivated in the world (ISO list of spices) but in Bangladesh we use only 27 and produce 17. On the basis of area, yield, demand and availability, spices are divided into three categories viz. major, minor and exotic. Major spices are regularly used in daily diet at large amount such as chilli, onion, garlic, turmeric and ginger. Minor spices are used in small scale in special items of food. These are coriander, fenugreek, black cumin, fenel, black pepper, dills, Joan etc. On the other hand, exotic spices are cumin, cardamom, cinnamon; clove, nutmeg, pistachio etc. are imported from outside the country.

To keep pace with the increased demand for spices, now-a-days many spices processing industries such as Square, Pran, Bangladesh Foods (BD Foods), Archu, Dipzol, Advanced Chemical Industries (ACI), Amrita, Dekho etc. have been established in the country. Demands for spices as raw material of these industries are increasing day by day with the extension of their production. Due to decreased production and increased demand for spices, a big gap was observed between production and demand. To meet up this gap the country has to spend a huge amount of foreign currency (about 6000-8000 million Taka) every year for importing spices from abroad (BBS, 2010). To lessen the pressure on the foreign currency, the spices production must be increased to meet up the country's demand.

Most of the spices are high value crops. Net returns of major spices are almost 2 to 3 times higher than any other crops. It can play a vital role to increase the farmers' income, generate employment, alleviate poverty, enhance food security, and empower women and to increase social development of Bangladesh. Bangladesh possesses a favourable agro-ecological condition for the production of spices crops. In the 50 decades spices were exported outside the country. But their production and per capita availability had decreased since 80 decades.

With the consideration mentioned above, the project entitled "Establishment of Spices Research centre" was drawn at a cost of Tk. 432.06 million for the implementation during July 1994 to June 2006 funded by Government of Bangladesh (GoB). Except this, a programme named " Action Plan for Increasing the Production of Spices Crop to Further 25%, 2005" has implemented by BARI, BAU, DAE, BADC, DAM, BARC and MoA. Another project entitled, "Strengthening of Spices Research Centre" has also been implemented during July 2006 to June 2009.

For the last two decades BARI developed and released 18 (major-12, minor-6) disease resistance improved variety of spices. On the other hand, 81 technologies on production, soil and water management; disease and insect management and post harvest management have been also been developed. BARI, BARC, DAE and NGO's have strengthened their works to extend these technologies. However, using these technologies, farmers are now immensely benefited in large scale. As a result, total production of spices has increased from 3.08 lac metric tons in 1996 to 13.59 lac metric tons in 2008 (BBS, 2009). The present study aimed at determining yield and economic returns and resource use efficiency in producing major spices in Bangladesh.

## II. METHODOLOGY

Four major spices (garlic, chilli, ginger and turmeric) released from Spices Research Centre (SRC) were considered for the study. Accordingly, spices growing areas were visited and then 480 spices farmers who commercially produced the spices were selected from 11 districts of Bangladesh (Table 1). Field survey was conducted for collecting data and information. However, required data for respective spices were collected from targeted 480 farmers. Required data and information were collected on production and cultural management of spices grown, and problems of storage and marketing system of selected spices.

During the field visit and data collection, it was observed and farmers also reported that irrespective of size of land under spices production, all of them used to produce respective spices commercially. However, all sample farmers were categorized as small, medium and large farmers depending on the size of land holding and analyses were done accordingly.

**Table 1. Sampling design and distribution of sample farmers**

| Selected spices crop | Study areas | Categories of farmers[1] selected | | | Total No. of farmers |
|---|---|---|---|---|---|
| | | Small | Medium | Large | |
| Garlic | Dinajpur | 28 | 11 | 1 | 40 |
| | Natore | 36 | 3 | 1 | 40 |
| | Rajshahi | 25 | 15 | 0 | 40 |
| Garlic total | | 89 | 29 | 2 | 120 |
| Chilli | Bogra | 21 | 11 | 8 | 40 |
| | Serajganj | 25 | 10 | 5 | 40 |
| | Sherpur | 22 | 14 | 4 | 40 |
| Chilli total | | 68 | 35 | 17 | 120 |
| Ginger | Khagrachari | 25 | 15 | 0 | 40 |
| | Panchagarh | 22 | 13 | 5 | 40 |
| | Rangpur | 22 | 12 | 6 | 40 |
| Ginger total | | 69 | 40 | 11 | 120 |
| Turmeric | Khagrachari | 26 | 13 | 1 | 40 |
| | Nilphamari | 28 | 10 | 2 | 40 |
| | Panchagarh | 20 | 14 | 6 | 40 |
| Turmeric total | | 74 | 37 | 9 | 120 |
| **All spices crops** | | **300** | **141** | **39** | **480** |

[1] According to BBS farmers were categorized as small, medium and large farmers having farm size 0.01 –1.00 hectare, 1.01 – 3.00 hectare and 3.01 hectare and above respectively.

For determining the profitability some descriptive statistics, such as total per hectare cost, per hectare gross return, net return and benefit cost ratio were calculated. To estimate productivity and resource use efficiency, the Cobb-Douglas stochastic frontier production function analysis were performed. In this case both farm-specific and farm-size-specific stochastic frontier production functions were estimated.

**Profitability analysis**

Profit is the net gain of an enterprise. The primary and most common goal of a farm or farmer is profit maximization. Profit or net return is the difference between total revenue (gross return) or total value product (TVP) and the total factor cost (TFC). Total factor costs include all kinds of variable and fixed costs associated with the production process. A farm can not determine its maximum profit unless the TVP is compared with TFC. Farmer's profit is also shown by gross margin (GM) analysis, where only variable costs are to be deducted from total revenue.

The TVP are the value of output given by:

$$TVP = py = p * TPP = g(y) * f(x_i) = g[f(x_i)] * f(x_i) \qquad (1.1)$$

Where,

p is the unit price of output; y is the quantity of output and $x_i$ stands for ith input.

On the other hand, total factor cost (TFC) of a product includes all kinds of variable and fixed cost items involved in the production process; and are given by:

Total factor cost, $TFC = rx_i + b = h(x_i) * x_i + b$ (1.2)

Where,

r is the factor price, which in general is a function of the quantity of the factor uses $[i.e., r = h(x_i)]$ and b is the fixed costs.

The marginal factor cost (MFC) for the ith input is thus:

$$MFC_i = \frac{d(TFC)}{dx_i} = \frac{d[h(x_i)x_i + b]}{dx_i} \qquad (1.3)$$

Expanding the derivative in equation (1. 3), we get

$$MFC_i = h(x_i) + x_i \frac{d[h(x_i)]}{dx_i} + 0$$

or $$MFC_i = h(x_i) + x_i \frac{d[h(x_i)]}{dx_i} \qquad (1.4)$$

Given the definition of total value product (TVP) in equation (1. 1) and total factor cost (TFC) in equation (1. 2), we can define profit equation as follows:

Profit, $\pi$ = TVP – TFC (1.5)

or, $\pi = g[f(x_i)] * f(x_i) - [h(x_i) * x_i + b]$ (1.6)

To satisfy the first-order condition for profit maximization, derivative of the profit function given by equation (1. 6) with respect to $x_i$ are taken and by setting the result equal to zero, we get:

$$\frac{d\pi}{dx_i} = g[f(x_i)]\frac{d[f(x_i)]}{dx_i} + f(x_i)\frac{d\{g[f(x_i)]\}}{dx_i} - h(x_i) - x_i \frac{d[h(x_i)]}{dx_i} = 0$$

or, $$g[f(x_i)]\frac{d[f(x_i)]}{dx_i} + f(x_i)\frac{d\{g[f(x_i)]\}}{dx_i} = h(x_i) + x_i\frac{d[h(x_i)]}{dx_i} \quad (1.7)$$

That is,

$$MVP_i = MFC_i \text{ (Profit maximizing level)} \quad (1.8)$$

**Resource Use Efficiency by Cobb-Douglas Stochastic Frontier Production Function Specification of Production Model**

Two views exist in the efficiency measurement literature regarding the way that the issue of environmental factors or farm-specific factors should be addressed. The first approach assumes that the environmental factors influence the shape of the technology and hence these factors should be included directly in the production as regressors (Good et al. 1993; Coelli et al. 1999; Rahman et al. 1999; Rahman et al. 2002). The second approach assumes that the environmental factors influence the degree of technical inefficiency (and not the shape of the technology) and hence that these factors should be modelled so that they directly influence the inefficiency term. We, therefore, consider the first approach in our study. The first approach produces technical efficiency scores which are net of environmental or farm-specific factors influences.

The Cobb-Douglas stochastic frontier production function was used to analyse productivity and resource use efficiency of four spices crops. The functional form of stochastic frontier is as follows

$$Y = \beta_0 \; X_1^{\beta_1} \; X_2^{\beta_2} \ldots\ldots X_{12}^{\beta 12} e^{V_i - U_i} \quad (1.9)$$

The above function is linearised double-log form as below:

$$\text{In}Y = \ln\beta_0 + \beta_1\ln X_1 + \beta_2\ln X_2 + \beta_3\ln X_3 + \beta_4\ln X_4 + \beta_5\ln X_5 + \beta_6\ln X_6 + \beta_7\ln X_7 + \beta_8\ln X_8 + \beta_9\ln X_9 + \beta_{10}\ln X_{10} + \beta_{11}\ln X_{11} + \beta_{12}\ln X_{12} + V_i - U_i \quad (1.10)$$

Where

Y = Output (kg), $X_1$= area (decimal), $X_2$ = seed (kg), $X_3$ = human labour (man-days), $X_4$ = cost of irrigation (Tk.), $X_5$ = cost of insecticide (Tk.), $X_6$ = inorganic fertiliser, $X_7$= organic fertiliser, $X_8$ = cost of power tiller and draft power(Tk.), $X_9$ = age of farm operator (year), $X_{10}$ = education of farm operator (year of schooling), $X_{11}$ =experience of farm operator (year), $X_{12}$ = training of farm operator (Dummy variable which receives 1 if the operator had training and receives 0 if he did not have any training).

**Technical Inefficiency Effect Model**

$$U_i = \delta_0 + \delta_1 \text{ Farm size} + \delta_2 \text{ Age} + \delta_3 \text{ Education} + \delta_4 \text{ Experience} + \delta_5 \text{ Training} + W_i \quad (1.11)$$

Where Age, Education, Experience and Training are defined as earlier. Farm size is the total cultivable land under farm household. V is two sided uniform random variable beyond the control of farmer having N (0, $\sigma^2_V$) distribution, U is one sided technical inefficiency effect under the control of farmer having a positive half normal distribution ($U \sim | N(0,\sigma^2_U)|$) and $W_i$ is also one sided random variable. W is unobservable random variable having a positive half normal distribution. The models were estimated simultaneously using frontier package 4.1c.

## III. ESTIMATION OF PROFITABILITY AND RESOURCE USE EFFICIENCY

In previous section Table 1 showed that about 64% of sample farmers were small farmers and only 29 and 7% were medium and large farmers respectively. Irrespective of different categories of farmers, they produced respective spices crops commercially and considering all sample farmers, they allocated about 38% of cultivable land for spices production (Table 2).

**Table 2. Allocation of land for spices crop production**

| Spices crop grown | Categories of farmers | Cultivated land (decimal) | | % of land used for respective spices |
|---|---|---|---|---|
| | | Total cultivated land | Area under respective spices | |
| **Garlic** | Small farmers | 102 | 59 | 58.2 |
| | Medium farmers | 395 | 110 | 27.9 |
| | Large farmers | 788 | 174 | 22.1 |
| | All farmers | 184 | 74 | 40.0 |
| **Chili** | Small farmers | 123 | 53 | 43.3 |
| | Medium farmers | 401 | 103 | 25.8 |
| | Large farmers | 1545 | 492 | 31.9 |
| | All farmers | 500 | 156 | 31.2 |
| **Ginger** | Small farmers | 113 | 68 | 60.4 |
| | Medium farmers | 352 | 144 | 41.0 |
| | Large farmers | 1953 | 157 | 8.0 |
| | All farmers | 308 | 93 | 30.2 |
| **Turmeric** | Small farmers | 119 | 68 | 57.2 |
| | Medium farmers | 436 | 292 | 66.9 |
| | Large farmers | 1000 | 800 | 800 |
| | All farmers | 201 | 130 | 64.6 |
| - | **All average** | 291 | 110 | 37.7 |

**Note:** 1 ha = 247 decimal, 1 Acre = 100 decimal

Economic returns and revenue earned by producing different spices were estimated by multiplying the per hectare total amount of output (yield) by its average market prices. Spices farmers received average prices for garlic, chilli, turmeric, and ginger amounted to Tk 105, 180, 72 and 80 respectively.

The net return was obtained by deducting all costs from gross returns. Table 3 reveals that the net returns per hectare of garlic, chilli, turmeric, and ginger were Tk. 243002, 169860, 103617 and 48911 respectively.

The Benefit Cost Ratio (BCR) is a relative measure which is used to compare the financial efficiency of the farmers. Considering the selected spices, the BCR came out to be 2.11, 2.09, 1.79 and 2.99 for garlic, chilli, turmeric and ginger respectively. The high output-input ratio indicated that it generated high returns with per taka of investment. However, spices production was profitable in the study areas and relatively larger portion of land was cultivated for the production of spices by the farmers.

The comparative profitability of spices revealed that the production of ginger, garlic and chilli were more profitable compared to other spices which indicated that higher cost of production yielded higher returns. Moreover, spices were sensitive to climate, temperature and topography, and accordingly, specific spices could be produced only in some particular areas of Bangladesh.

**Table 3. Per hectare yield and economic returns of major spices produced in Bangladesh**

| Particular/Crops | Garlic | Chilli (Dry) | Turmeric (Dry) | Ginger |
|---|---|---|---|---|
| Yield (Kg/ha) | 4392 | 1800 | 3250 | 9170 |
| Market price varied (Tk/kg) | 70-150 | 150-200 | 65-120 | 60-120 |
| Average price received (Tk/kg) | 105 | 180 | 72 | 80 |
| Gross-returns (GR ) (Tk/ha) | 461152 | 324869 | 233594 | 733667 |
| Total cost of production (TC) (Tk/ha) | 218150 | 155009 | 129977 | 244556 |
| Net return (NR) (Tk/ha) | 243002 | 169860 | 103617 | 489111 |
| Benefit- cost ratio (GR/TC) (BCR) | 2.11 | 2.09 | 1.79 | 2.99 |

Table 4 shows the simultaneous estimation of the Cobb-Douglas (C-D) stochastic frontier production function and technical inefficiency effect model using maximum likelihood (ML) method for garlic, chilli, ginger and turmeric production. In the C-D stochastic frontier, most of the coefficients of explanatory variables have significant and expected signs. The explanatory variables like farm size, seed, human labour, cost of irrigation, inorganic fertilizer, cost of power tiller and draft power and training of farmers have positive and significant impacts on the increase of garlic and chilli production at the aggregate level. In addition, the coefficients of organic fertiliser and experience were also significant for chilli production. The coefficients of farm size, seed, human labour, irrigation, organic fertiliser and farming experience were positive and significant for ginger production which implied increase of ginger production with the increased application of the above factors. Similarly, coefficients of farm size, seed, human labour, inorganic and organic fertiliser, cost of power tiller and draft power, and education of farmers were positive and significant for turmeric production whereas the coefficient of age was negative and significant. The negative coefficient of age indicated that older farmers were less productive than younger farmers. The positive and significant coefficient of training (dummy) indicated that farmers with training had higher productivity than farmers without training. The quasi-function coefficients for garlic, chilli, ginger and turmeric were respectively 1.83, 3.56, 1.98 and 1.01 which indicated that increasing returns to scale prevailed in the production process of garlic, chilli and ginger but constant returns to scale prevailed for turmeric production. All the models are well fitted to the data as suggested by significant F values.

**Table 4. Maximum Likelihood (ML) Estimates for parameters of Cobb-Douglas(C-D) Stochastic Frontier Production Function and Technical Inefficiency Model for all farms of garlic, chilli, ginger and turmeric production**

| Variables | Garlic | Chilli | Ginger | Turmeric |
|---|---|---|---|---|
| | **Estimates (Asymptotic Std. error)** | **Estimates (Asymptotic Std. error)** | **Estimates (Asymptotic Std. error)** | **Estimates (Asymptotic Std. error)** |
| Intercept | 2.3880** (0.3359) | 4.8114 (10.1725) | 3.7862** (1.0876) | 3.8933 (1.9774) |
| Farm size ( $X_1$) | 0.6972** (0.0725) | 0.1633* (0.0807) | 0.852** (0.0613) | 0.6002** (0.0688) |
| Seed ($X_2$) | 0.3078** (0.0588) | 0.7706** (0.0116) | 0.0404** (0.0051) | 0.1614* (0.0712) |
| Human labour ($X_3$) | 0.2196** (0.0571) | 0.2122** (0.0573) | 0.1969** (0.0471) | 0.2369** (0.0864) |
| Irrigation ($X_4$) | 0.2045** (0.0439 | 0.2861** (0.0992) | 0.1329* (0.0502) | - |
| Insecticide ($X_5$) | 0.0741 (0.0324) | 0.1067 (0.1127) | 0.1392 (0.0961) | -0.1127 (0.0634) |
| Inorganic fertilizer ($X_6$) | 0.1201** (0.0344) | 0.2415** (0.1036) | 0.0310 (0.0405) | 0.1578** (0.0526) |
| Organic fertilizer ($X_7$) | 0.0320 (0.0200) | 0.5106* (0.2595) | 0.0567** (0.0224) | 0.0847** (0.0286) |
| Power tiller and draft power ($X_8$) | 0.0389* (0.0186) | -0.1225 (0.1442) | 0.0631 (0.0726) | 0.3013* (0.1364) |
| Age of farmer ($X_9$) | 0.1033 (0.0693) | 0.6996 (4.0916) | 0.242 (0.2105) | -0.4235* (0.2096) |
| Education of farmer ($X_{10}$) | 0.0077 (0.0099) | 0.0051 (0.0191) | -0.0129 (0.0177) | 0.0459** (0.0193) |
| Farming experience ($X_{11}$) | 0.0634 (0.0502) | 0.4454** (0.0670) | 0.2353** (0.0428) | 0.0982 (0.1284) |
| Training of farmer ($X_{12}$) | 0.1843* (0.0859) | 0.3372** (0.1330) | - | - |
| Function coefficient | 1.83 | 3.56 | 1.98 | 1.01 |
| Adjusted $R^2$ | 0.88 | 0.69 | 0.84 | 0.75 |
| F-value | 66.76** | 18.67** | 20.96** | 10.66** |
| Intercept | -1.7455* (0.8250) | 1.3486 (0.6667) | 2.2426 (1.7770) | 3.2089 (3.1577) |
| Farm size | 0.0021** (0.0006) | -0.0006 (0.0004) | -0.0014 (0.0077) | -0.0021 (0.0081) |
| Age of farmer | 0.0446** (0.0145) | 0.0278 (0.0282) | 0.0653* (0.0286) | -0.0814 (0.1087) |
| Education | -0.0340** (0.0263) | -0.0676 (0.0850) | -0.1091 (0.0732) | -0.0547 (0.1778) |
| Experience | -0.0359 (0.0108) | -0.0326 (0.0881) | -0.0685* (0.0291) | -0.0690 (0.1181) |
| Training (Dummy) | -1.0799** (0.4060) | -0.5819** (0.2304) | - | - |
| $\sigma^2$ | 0.1370** (0.0363) | 0.4120* (0.1720) | 1.2973** (0.3461) | 0.6362 (0.7105) |
| $\gamma$ | 0.6143** (0.1393) | 0.1162 (0.3213) | 0.9578** (0.0190) | 0.6857** (0.3017) |
| Log-likelihood function | -4.6879 | -73.8557 | -52.6758 | -56.3871 |

**Note:** Figures in the parentheses indicate standard errors. * and ** indicate significance at 0.05 and 0.01 probability level, respectively.

In the technical inefficiency effect model, farmers' education and training (dummy) have significant and negative (expected) sign for garlic production. The negative and significant coefficient of education indicates that farmers with higher education have less inefficiency than farmers with lower education or no education at all. That is, farmers with the higher education were technically more efficient than farmers with lower education. The negative and significant coefficient of training indicates that training of farmers helps reduce technical inefficiency. That is, farmers with training are technically more efficient than farmers without training. The coefficient of experience of farmers has also expected (negative) sign in the inefficiency effect model but the coefficients of farm size and age have significant and positive sign. The significant and positive coefficient of farm size implies that technical inefficiency increases with the increase in farm sizes. That is, farmers with larger farm holdings are technically less efficient than farmers with small farm holdings. The positive and significant coefficient of age implies that older farmers have more inefficiency than younger farmers for garlic production. For chilli production, trained farmers were more efficient than non-trained farmers.

More experienced farmers were more efficient for ginger production whereas older farmers were less efficient than younger farmers. The coefficients of farm size, education and experience had negative sign but they were not significant for turmeric production. Significant value of $\gamma$ indicated that there were significant inefficiency in the production of garlic, ginger and turmeric production.

Table 5 shows frequency distribution of farm-specific technical efficiency for garlic, chilli, ginger and turmeric. It revealed that average estimated technical efficiencies for garlic, chilli, ginger and turmeric are respectively 88, 80, 69 and 79% which indicated that garlic production could be increased by 12%, chilli by 20 %,, ginger by 31% and that of turmeric by 21% with the use of same level of inputs without incurring any additional cost. Increase of managerial skills entailed a substantial increase of output for every spices crop. A careful examination of the results revealed that only about 49, 34, 8 and 14% farmers obtained outputs close to the maximum output (efficiency is 90 to 100%) for garlic, chilli, ginger and turmeric production respectively. For garlic and chilli production maximum farmers attained respectively 49 and 34% efficiency at the level 90 to 100%.

But for ginger production, maximum farmers (about 27%) attained efficiency at the level 70 to 80% whereas for turmeric production maximum farmers (about 46%) attained efficiency at the level 80 to 90%. However there were wide variations of efficiency among different farms and also among different crops (Table 5).

The generalised likelihood ratio (LR) test is produced in Table 6. The LR tests reveal that there were significant inefficiency effects in the production of garlic, ginger and turmeric. Detailed results show that small farms were efficient in garlic production but medium and large farmer and all of them were efficient in producing chilli. But for ginger and turmeric, all the farm categories were technically inefficient.

**Table 5. Frequency distribution of farm-specific technical efficiency estimates for five major spices crops**

| Efficiency level (%) | Number of farm | | | |
|---|---|---|---|---|
| | Garlic | Chilli | Ginger | Turmeric |
| < 40 | 1 (0.83) | 5 (4.17) | 12 (10.00) | 2 (1.67) |
| 40-50 | - | 4 (3.33) | 6 (5.00) | 6 (5.00) |
| 50-60 | 2 (1.67) | 14 (11.67) | 12 (10.00) | 10 (8.33) |
| 60-70 | 4 (3.33) | 12 (10.00) | 24 (20.00) | 10 (8.33) |
| 70-80 | 8 (6.67) | 20 (16.67) | 32 (26.67) | 20 (16.67) |
| 80-90 | 46 (38.33) | 24 (20.00) | 24 (20.00) | 55 (45.83) |
| 90-100 | 59 (49.17) | 41 (34.16) | 10 (8.33) | 17 (14.17) |
| Total number of farms | 120 (100) | 120 (100) | 120 (100) | 120 (100) |
| Mean efficiency | 88 | 80 | 69 | 79 |
| Minimum efficiency | 21 | 28 | 8 | 27 |
| Maximum efficiency | 96 | 96 | 94 | 95 |

**Table 6. Test of hypothesis for coefficients of the explanatory variables for the technical inefficiency effects producing different spices crops**

| Null hypothesis | Log-likelihood value | Test statistic LR | Critical value | Decision |
|---|---|---|---|---|
| $H_0$: $\gamma = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ | | | | |
| **Spices crops:** | | | | |
| **Garlic** | | | | |
| Small farms | -6.46 | 4.29 | 12.02 | Accepted |
| Medium & large farms | -24.17 | 23.92 | 12.02 | Rejected |
| All farms | -4.6879 | 29.02 | 12.02 | Rejected |
| **Chilli** | | | | |
| Small farms | -54.94 | 15.85 | 10.65 | Rejected |
| Medium & large farms | -48.35 | 4.08 | 10.65 | Accepted |
| All farms | -73.8557 | 3.28 | 10.65 | Accepted |
| **Ginger** | | | | |
| Small farms | -24.22 | 98.29 | 10.65 | Rejected |
| Medium & large farms | -21.73 | 63.23 | 10.65 | Rejected |
| All farms | -52.6757 | 29.73 | 10.65 | Rejected |
| **Turmeric** | | | | |
| Small farms | -57.37 | 22.23 | 10.65 | Rejected |
| Medium & large farms | -43.33 | 67.93 | 10.65 | Rejected |
| All farms | -56.3871 | 13.55 | 10.65 | Rejected |

### Farm-size-specific technical efficiency of different spices crops

In addition to farm-specific technical efficiency, farm-size specific technical efficiencies have also been estimated for different farm groups to show which farm group was technically more efficient in producing different spices crops. Large farms were pooled into medium farms as the number of large farms was far below to perform any statistical analysis. That is why, technical efficiency of large and medium farms was estimated together and was compared with that of small farms. Mean technical efficiencies for different farm groups and for different crops have been presented in Table 7. The results revealed that medium and large farms attained higher efficiencies for chilli, ginger and turmeric while small farms attained significantly higher efficiency for garlic production only. In other words, it may be noted that technical efficiency increased with the increase in farm sizes for the crops chilli, ginger and turmeric but it decreased with the increase in farm sizes for garlic only.

**Table 7. Farm-size-specific technical efficiency estimates for five spices crops**

| Farm size | Mean efficiency of crops | | | |
|---|---|---|---|---|
| | Garlic | Chilli | Ginger | Turmeric |
| Small | 93 | 75 | 68 | 77 |
| Medium and large | 79 | 82 | 71 | 81 |
| Overall | 88 | 80 | 69 | 79 |

## IV. CONCLUSIONS AND POLICY IMPLICATIONS

Productivity, profitability and resource use efficiency of four promising spices crops such as garlic, chilli, ginger and turmeric have been estimated by applying descriptive and Cobb-Douglas stochastic frontier production function analyses. Productions selected spices were profitable as farmers earned higher level of net returns from spices they produced. Functional analyses showed that farm size, seed, inorganic and organic fertilisers, cost of power tiller and draft power, irrigation, education, farming experience and training had positive impact on the production of spices. Increasing returns to scale prevailed in the production process for garlic, chilli, ginger whereas constant returns to scale prevailed for the production of turmeric. All the models were well fitted to data for all crops. Small farmers were more efficient for garlic production only whereas the large and medium farmers were more efficient for other spices crops. More educated and more experienced farmers were technically more efficient than less educated and less experienced farmers. Training reduced significantly the inefficiency effects. The average estimated technical efficiencies for garlic, chilli, ginger and turmeric were respectively 88, 80, 69 and 79% which indicated that garlic production could be increased by 12%, chilli by 20 %, ginger by 31% and turmeric by 21% with the using same level of inputs without incurring any additional cost.

As a policy option, training should be extended to all farmers to have a reduced inefficiency effect, which in turn would increase the profitability of spices crop production by saving resources.

### References

Bangladesh Bureau of Statistics (BBS) (2009 and 2010). Statistical Year Book of Bangladesh, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

Coelli, T. J., S. Perelman and E. Romano (1999). “Accounting for Environmental Influences in Stochastic Frontier Models: With Application to International Airlines”, Journal of Productivity Analysis, 11: 251-273.

Good, D., M. Nadiri, L. H. Roeller, and R. C. Sickles (1993). “Efficiency and Productivity Growth Comparisons of European and U. S. Air Carriers: A First Look at the Data”, The Journal of Productivity Analysis, 4: 115-1225.

Kumar, A., A. Kumar, V. Kaushal, S. Patil, C. Payal and A. Kumar (2011). "Antibacterial potential of some natural food preservations against staphylococcus aureus isolated from various food samples of Himachal Pradesh (India)", World Journal of Science and Technology, 1(10): 48-53.

Rahman, K. M. M., M. A. Quddus and M. E. Haque (2002). “Estimation of Gross and Net Technical Efficiencies of Wheat Production in Bangladesh under two Alternative Functional Forms”, The Bangladesh Journal of Agricultural Economics, 25 (2): 85-101.

Rahman, K. M. M., P. M. Schmitz and T. C. Wronka (1999). “Impact of Farm-Specific Factors on the Technical Inefficiency of Producing Rice in Bangladesh”, The Bangladesh Journal of Agricultural Economics, 22 (2): 19-42.