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ESTIMATION OF TECHNICAL EFFICIENCY OF GARLIC FARMS IN DISTRICT PESHAWAR, PAKISTAN: A STOCHASTIC FRONTIER ANALYSIS

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ABSTRACT: This study estimated technical efficiency of garlic farms in district Peshawar, Khyber Pakhtunkhwa, Pakistan. Data for this study was collected from 110 farmers through multistage sampling technique. Cobb-Douglas frontier production function was estimated through maximum likelihood estimation technique. Stata software was used for estimation. Results indicated that the mean technical efficiency of garlic farms was 84.60 per cent ranging from 57.62 to 96.07 per cent. This implies that if the average farm in the sample was to achieve the technical efficiency level of its most efficient counterpart, then the average farm could increase garlic yield by 11.94 per cent. Similarly the most technically inefficient farm could increase garlic yield by 40.67 per cent. These results suggest that output can be improved by using available resources efficiently with the existing technology. The estimated gamma value was 0.80 implies that 80 percent variation in the production of garlic was due to inefficiency factors. Results further showed that seed rate, labor, tractor hours, FYM and irrigation have positive and statistically significant effect on the production of garlic. Experience of garlic growers plays an important role in garlic production so arrangement of training programs for farmers is a policy option for enhancement of garlic productivity. Motivation of farmers to use recommended quantity of seed for higher productivity of garlic is another recommendation.

KEYWORDS: Stochastic frontier, Cobb Douglas production fuction, Technical efficiency, Productivity, ML estimates, Garlic, Peshawar-Pakistan.

1 INTRODUCTION

Vegetables and fruits are major sources of many vitamins, minerals and other natural substances which help to protect from cancer and other chronic diseases. Fruits and vegetables are naturally low in fats and calories whose different colors gives our body a wide range of valuable nutrients, like fiber, folate, potassium, and vitamins A and C. Insufficient intake of fruits and vegetables can cause gastrointestinal cancer deaths, ischaemic heart disease deaths and stroke deaths. In Pakistan 21 different kinds of fruits and 40 types of vegetables are grown in different climatic zones round the year. These fruits and vegetables are exported to European and Middle-Eastern countries, which earns huge foreign reserves for the country. The main reason of rise in consumers' price and hidden quality loss is due to post-harvest of fruits and vegetables ranging from 25-40 percent which brings low return to growers, processors and traders and country suffers in terms of foreign exchange earnings.

Garlic (*Allium sativum*) is specie in the onion genus, *Allium* belongs to the Alliaceae family. Garlic is used as culinary as well as medicinal purposes. It is grown throughout Pakistan and because of its pungent and spicy flavor; it is consumed by most of the people. Garlic is well-known to human over 7,000 years. The area of origin is not clearly known but is probably originated from Central Asia and spread to the Mediterranean region. It is valued high in the Mediterranean countries that's why it is mostly cultivated there.

According to United Nation's Food and Agriculture organization (FAO), the estimated garlic production of the world is about 17.67 million metric tones (MMT). Among the world, Asia is the largest garlic producing area contributing about 80 % of the total world production. In Asia, China is the leading garlic producer which produced about 13.66 MMT in 2010, which accounts for 77 % of the world production. India produced 0.83 MMT, South Korea 0.27 MMT, Egypt 0.24 MMT, Russia 0.21 MMT, Myanmar 0.18 MMT, Ethiopia 0.18 MMT, United States 0.16 MMT, Bangladesh 0.16 MMT and Ukraine 0.15 MMT, respectively [1].

Asian countries contribute more in the trade of garlic which is about $4/5^{th}$ of the world. South Korea is on the top in the import of garlic which is 153,141 tones. 2^{nd} is Indonesia (361,289 tones), 3^{rd} is Viet Nam (122,598 tones), USA (74,554 tones), Malaysia (80,751 tones), Bangladesh (50,898 tones), Italy (26,524 tones), France (23,850 tones), Germany (19,389 tones) and Netherland (28,483 tones) respectively while Pakistan (64,223 tones) ranks 13^{th} in the list of importing countries. While in exporting, china leads from the front having a net export of about 1,365.18 thousand tones followed by Spain (65,802 tones), Argentina (89,265 tones), Netherlands (26,932 tones), France (10,637 tones), Italy (10,409 tones), India (24,665 tones), USA (9,483 tones), Chile (6,156 tones) and Mexico (12,370 tones) respectively [1].

Pakistan produced about 55,300 tones of garlic on an area of 16,300 hectares in 2010-11, respectively, while area under garlic in Khyber Pakhtunkhwa was 4,460 hectares and there was production of 19,500 tones in 2010-11. Area under garlic crop in Punjab, Sindh and Baluchistan was 7,650, 2,220 and 1,970 hectares having 24,300, 4,600 and 6,900 tones in 2010-11 respectively. Punjab contributes about 44 % of the total garlic production, Khyber Pakhtunkhwa 35.2 %, Balochistan 12.5 % and Sindh 8.3 % [2]. Pakistan was among the top 20 garlic importer countries of the world from 2001 to 2010 except 2001 and 2004. In 2009 and 2010 Pakistan imported 83.79 and 64.22 thousand tons of garlic [2].

Foreign exchange reserve spends on garlic imports from abroad can be saved through achieving self sufficiency in garlic production. Increase in garlic production through increased use of improved hybrid varieties has proved not to bring about the expected productivity gains. Moreover, technological development is long run phenomenon. With the efficient utilization of available resources and technological, growth in garlic productivity and output can be achieved. Literature on vegetable productivity in Pakistan from different regions revealed that inefficiency exists. Moreover, studies show that socioeconomic and human capital characteristics and farm size are the major factors that cause inefficiencies in agricultural productivity. Efficiency is measured by comparing the observed output against the maximum possible (frontier) output. The appropriate allocation of available resources and technology is the major factor that makes the improvement in efficiency. The production function describes the transformation of physical inputs (resources) into physical output.

The findings of this study will provide insights into the technical efficiency of garlic producers in district Peshawar of Khyber Pakhtunkhwa province of Pakistan. It measures the performance of garlic producers that can be used to assist them in efficient allocation and utilization of available resources and technology. The findings of this study will also be helpful for policy makers and government in formulating policies for enhancing productivity and output of garlic in the country. The main objective of this study is to estimate the farm level technical efficiency of garlic production and to identify the sources of technical inefficiency among garlic farms.

2 DATA AND METHODOLOGY

This study was carried out in District Peshawar of Khyber Pakhtunkhwa province. For selection of sample size multistage sampling technique was used. In the first stage, district Peshawar was purposively selected. In the second stage, 3 villages namely Attozai, Maghdarzai and Tarlazai were randomly selected. In the third stage from each randomly selected village, 110 garlic growers were selected through proportional allocation sampling technique. Primary and secondary data were used for this study. Primary data was collected from the garlic growers by using questionnaire during April-May, 2012 and secondary data was collected from various official sources.

2.1 CONCEPTUAL FRAMEWORK

For measuring the relationship between output and input used and the mean technical efficiency and technical inefficiency in garlic production, data was analyzed by using the ML estimates of the stochastic frontier model. Technical efficiency may be defined as the usefulness to use a given amount of inputs to produce an output. Econometricians for long time have estimated average production function. Serious considerations have been given for estimating frontier production function after the pioneering work of Farrell (1957) in order to cover space between theoretical and empirical work [3].

Aigner *et al*. (1977) developed stochastic production model. Error term of the model was composed by Meeusan and van den Broeeck (1977) [4] [5].

Stochastic frontier function can be defined as:

$Yi = f(Xi; \beta) + \epsilon_i$ i = 1, 2, 3,………, n (1)

Where, Y_i represents output of garlic of *ith* farm in kgs/ha, f(X; ß) is a suitable function such as Cobb-Douglas production function, X_i are the inputs used in production of garlic in units/ha, β_i are the coefficients to be estimated, e_i is a composed error term that captures the error term and inefficiency component (v_i, u_i). v_i is a random error having zero mean and is assumed to be having symmetrical independent distribution as N (0, σ^2_v) random variables, independent of u_i and associated with those factors which is beyond the control of the farmers. The u_i is assumed to be non-negative truncated half normal N (0, σ^2_u) random variables and is known as farm specific factors, which has an association with the technical inefficiency of the farm and has a value between 0 and 1.

2.2 EMPERICAL MODEL OF TECHNICAL EFFICIENCY

So, the specified empirical model of the Cobb-Douglas production function for the garlic production is as follows:

$lnYield = \beta_0 + \beta_1\ lnSeed + \beta_2\ lnTrctrHrs + \beta_3\ lnLabor + \beta_4\ lnFert + \beta_5\ lnFYM + \beta_6\ lnIrrig + \beta_7\ lnWeed + (v_i - u_i)$ (2)

Where;

Yield = Yield of garlic in kg per hectare

Seed = Seed rate used in kgs per hectare

TrctrHrs = Total tractor hours used per hectare

Labor = Total labor man days per hectare

Fert = Fertilizers used in kgs per hectare

FYM = Farm yard manure used in kg per hectare

Irrig = Number of irrigations per season

Weed = Weedicides used in litres per hectare

β_i = Coefficients to be estimated

vi = Random error term

ui = Farm and farmer specific error term

ln = Natural logarithm

The inefficiency model which is based on [6] was specified as follows:

$\mu_i = g(Z_i : \delta_i)$ (3)

$\mu_i = \sigma_o + \sigma_1 AGE + \sigma_2 EXP + \sigma_3 EDU + \sigma_4 FARM\ SIZE + \omega_i$ (4)

Where;

μ_i = Technical inefficiency

AGE = Age of the garlic growers in years

EXP = Farming experience of the garlic growers in years

EDU = Education of the garlic growers in years

FARM SIZE = Farm size in hectares under garlic

δ_i = Coefficients to be estimated

ω_i = Random error term.

Technical efficiency for individual farmer can be defined as the ratio between observed output and corresponding frontier output, which can be expressed as follows:

$TE_i = Y_{ob} / Y_{fr} = f(\beta, X) + (v_i + u_i) / f(\beta, X) + (V_i)$ (5)

Where, Y_{ob} is the observed output produced by the individual farm and Y_{fr} is the frontier output i.e., the maximum output that a farm can produce from the given resources. TE takes the value between 0 and 1.

2.3 TEST FOR HETEROSCEDASTICITY

In OLS regression one of the assumptions is homoscedasticity i.e., variance of each disturbance term μi is a constant number equal to σ^2 for the chosen values of the dependent variables. It can be symbolically shown as:

$E(\mu i^2) = \sigma^2 \quad i = 1, 2, 3, \ldots, n$ (6)

When there is violation in the aforesaid assumption, it will cause the heteroscedasticity problem, which means that error term has no constant variance. Heteroscedasticity can cause coefficients of the estimates of variance of OLS to be biased, which leads to error type-I or error type-II. This means 'OLS' is not "Best Linear Unbiased Estimator" (BLUE). It is mainly the problem of cross sectional data as ours, than time series data [7]. In order to test the heteroscedasticity problem, there are several ways but we used Goldfeld Quandt test and Breusch-Pagan-Godfrey test.

2.3.1 GOLDFELD QUANDT TEST FOR HETEROSCEDASTICITY

The procedure used in Goldfeld Quant test is as follows:

1. First arrange the data in ascending order according to regressors.
2. Then omit the central values 'c' and divide the data into 2 groups, each of having $(n - c)/2$ observations (c = 20).

   $LnYield_{SV} = \beta_0 + \beta_1 LnSeed + \beta_2 LnTrctrHrs + \beta_3 LnLabor + \beta_4 LnFert + \beta_5 LnFYM + \beta_6 LnIrrig + \beta_7 LnWeed + \mu_1$; (n = 110) (c = 20) (7)

   $LnYield_{LV} = \beta_0 + \beta_1 LnSeed + \beta_2 LnTrctrHrs + \beta_3 LnLabor + \beta_4 LnFert + \beta_5 LnFYM + \beta_6 LnIrrig + \beta_7 LnWeed + \mu_1$; (n = 110) (c = 20) (8)

3. Run 'OLS' regressions separately for each $(n - c)/2$ observations and we get residuals sum of squares (RSS) for each regression i.e. RSS1for smaller values (small variance group) and RSS2 for larger values (large variance group). Each RSS having $(n - c - 2k)/2$ df, where k =7, is parameter numbers along with intercept term.
4. Then calculate ratio: λ = RSS2 / df ÷ RSS1 / df, if we consider assumption of normal distribution for "μi" homoscedasticity then λ for the F-distribution of above equation follow with $(n - c - 2k)/2$ df for numerator and denominator correspondingly. When value of calculated λ (= F) is greater than tabulated value of 'F' at specified significance level, so homoscedasticity hypothesis can be rejected otherwise not [7].

2.3.2 BREUSCH-PAGAN-GODFREY TEST FOR HETEROSCEDASTICITY

The following model was run:

$LnYield = \beta_0 + \beta_1 LnSeed + \beta_2 LnTrctrHrs + \beta_3 LnLabor + \beta_4 LnFert + \beta_5 LnFYM + \beta_6 LnIrrig + \beta_7 LnWeed + \mu_1$; (n = 110) (9)

Suppose, the error variance (σ_i^2) is illustrated as under:

$\sigma i^2 = f(\alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7)$ (10)

Equation (10) shows that σi^2 is function of the Z-variables while for the above equation X's can hand out as Z's. In particular, assume that:

$\sigma i^2 = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7$ (11)

Equation (11) shows that $\sigma i^2 = \alpha 0$ is constant term while 'σi^2'is linear function of the Z, if α2= α3= …….. = α7= 0. So the basic theme behind the BPG test is we have to test the hypothesis that α1= α2= …….. = α7= 0 to examine whether σi^2 is having constant variance (homoscedastic) or not [7].

The Procedure of Breusch-Pagan-Godfrey test is given as follows:

1. Run OLS regression of the equation (9) and obtain μ_1, μ_2, μ_3, μ_4,……… μ_n error terms.
2. Obtain $\sigma^2 = \Sigma \mu i^2/n$.
3. Construct '*pi*' by using the following equation.

   $pi = \mu i^2 / \sigma^2$
4. Run the "p_i" regression on Z as given.

   $$pi = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7 + v_i \quad (12)$$

   '*vi*' is error term in above regression.
5. Now obtain 'ESS' (explained sum of squares) from equation (12) and compute 'Θ', as Θ = 1/ 2 (ESS). By considering normal distribution of 'μi', when sample size *n* increases and we have no heteroscedasticity, '$\theta \sim X^2 m\text{-}1$' which shows, chi-square distribution with (m-1) df is followed by θ. Now when calculated value of Θ (= X^2) exceed the critical chi-square value at selected significance level, the hypothesis of homoscedasticity can be rejected otherwise accept it [7].

2.4 Test for multicollinearity

One of the basic assumptions of the classical linear regression model (CLRM) is that, there should be no correlation between explanatory variables and if this assumption is violated then we face a problem of multicollinearity. For the detection of multicollinearity correlation matrix test is used [7].

2.4.1 Correlation matrix

Correlation can be defined as the positive (direct) or negative (inverse) correlation between explanatory variables of a given model. To draw the correlation matrix for our data, *k(k-1)/2* (k = number of variables) zero order correlation coefficients must be estimated and then it can be put into "M" correlation matrix as:

$$M = \begin{bmatrix} r11\ r12\ r13 \dots \dots r17 \\ r21\ r22\ r23 \dots \dots r27 \\ \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \\ \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \\ r71 \dots \dots \dots \dots \dots . \dots . r77 \end{bmatrix}$$

From the above "M" matrix, we can calculate the correlation coefficients of the explanatory variables. r_{12} indicates the correlation coefficient between X_1 and X_2, and so on [7].

3 Results And Discussion

3.1 Results of heteroscedasticity Test

3.1.1 Result of Goldfeld Quandt test for heteroscedasticity

Following procedure of the above test, at 5% of significance level the results of our data for λ is 1.60 with 7 df. At 5% significance level for 35 denominators and numerators the critical value of F is 1.69 which indicates that F (=λ) estimated value is less than tabulated. This means that results are insignificant, so the hypothesis of homoscedasticity can be accepted.

3.1.2 Result of Breusch-Pagan-Godfrey test for heteroscedasticity

The results of the regression model (7) and (8) are given as follows:

Table 1 Regression results of BPG test for estimation of σ²

Variables	Parameters	Co-efficients	Std. errors	t ratios
Constant	B_0	5.079	-0.887	-5.723
LnSeed	B_1	0.111	0.055	1.986
LnTrctrHrs	B_2	-0.008	-0.003	2.272
LnLabor	B_3	-0.068	-0.027	2.514
LnFert	B_4	0.203	0.065	3.118
LnFYM	B_5	0.081	0.022	3.595
LnIrrig	B_6	0.024	0.033	0.721
LnWeed	B_7	0.103	-0.085	-1.201
R^2	0.34			
ESS	6.154			
Df	91.00			
σ^2	0.056			

Source: Estimated results from survey data, 2012

Table 2 Regression results of BPG test for estimation of Θ

Variables	Parameters	Co-efficients	Std. errors	t ratios
Constant	B_0	-34.512	6.030	-5.723
LnSeed	B_1	1.104	0.555	1.986
LnTrctrHrs	B_2	1.075	0.473	2.272
LnLabor	B_3	1.599	0.636	2.514
LnFert	B_4	1.706	0.547	3.118
LnFYM	B_5	1.298	0.361	3.595
LnIrrig	B_6	0.294	0.407	0.721
LnWeed	B_7	-0.731	0.608	-1.201
R^2	0.37			
ESS	4.220			
Df	91			
Θ	2.110			

Source: Estimated from survey data, 2012.

So the tabulated Θ results were 14.0671. Now the critical "X^2" value at 5% with 7 df is 2.110 which is greater than our calculated value, so the hypothesis of homoscedasticity is accepted.

3.2 RESULT OF CORRELATION MATRIX

The results of correlation matrix are shown in table 3. These results of correlation matrix between explanatory variables shows that there is a positive correlation of FYM with Labor (0.950) while a negative correlation of Tractor with Labor (-0.970) and FYM (-0.961). It means that there is violation of the basic assumption of multicollinearity and there exist multicollinearity problem amongst these explanatory variables.

Table 3 Results of correlation matrix

	lnSeed	lnLabor	lnFert	lnFYM	lnTrac	lnIrri	LnWeed
lnSeed	1.000						
lnLabor	-0.280	1.000					
lnFert	-0.142	0.441	1.000				
lnFYM	-0.271	0.950	0.424	1.000			
lnTracHrs	0.307	-0.970	-0.362	-0.961	1.000		
lnIrri	-0.011	0.575	0.515	0.545	-0.498	1.000	
lnWeed	0.015	0.503	0.525	0.554	-0.415	0.659	1.000

Source: Estimated from survey data, 2012.

3.2.1 REMEDIAL MEASURES FOR MULTICOLLINEARITY

One of the remedial measures of multicollinearity is to drop the most correlated variables. But it is not an easy task to drop the relevant variables from the model as the economic model do not permit, due to which it may cause specification error which is a more serious problem than that of multicollinearity [7].

It is also suggested to transform the data into log form which reduces the problem to some extent. But after log transformation there still exist the problem of multicollinearity. So here in our study we do nothing which is the last option for the rule of thumb.

3.3 SUMMARY STATISTICS OF THE VARIABLES USED IN THE STOCHASTIC FRONTIER ANALYSIS

Table 4 shows summary statistics of inputs and output variables collected from a sample of 110 farmers which were implicated in the stochastic frontier production analysis. The estimated mean yield was 3600.60 kg/hectare having a standard deviation of 2540.90 which shows that the farmers have a large variability. Their minimum yield per hectare was 700 kg and maximum yield was 13650 kg.

Table 4 Summary statistics of the survey variables used in the stochastic frontier production analysis

Variables	Unit	Mean	Std. dev.	Minimum	Maximum
Yield	Kgs	3600.60	2540.90	1700.00	9650.00
Farm Size	Hectares	0.44	0.33	0.05	1.82
Labor	MD	130.06	80.93	70.00	276.00
Seed	Kgs	243.80	207.73	168.00	600.00
Fertilizer	Kgs	173.54	170.60	126.00	532.00
FYM	Kgs	5376.00	4022.11	00	18000
Weedicide	Liters	1.01	0.55	00	2.50
Tractor Hours	Hours	2.97	1.66	0.33	8.00
Age of farmer	Years	46.36	9.40	25.00	70.00
Level of education	Years	4.48	3.68	0.00	12.00
Farming experience	Years	10.80	6.33	2.00	31.00

Source: Estimated from survey data, 2012.

Table 5 Maximum likelihood estimates of the stochastic frontier production function for garlic

(Dependent variable = Log yield of garlic in kg/ha)

Variables	Parameters	Co-efficients	Standard error	t ratios
Constant	B_0	3.6096	0.7898	4.5700
Seed rate	B_1	0.1812	0.0739	2.4526*
Labor	B_2	0.1001	0.0617	1.6212***
Fertilizer	B_3	0.1000	0.0786	1.2722
FYM	B_4	0.2599	0.0680	3.8196*
Tractor Hours	B_5	0.1695	0.0507	3.3415*
Irrigation	B_6	0.1002	0.0540	1.8548**
Weedicides	B_7	0.0365	0.0752	0.4851
Inefficiency Effect Model				
Constant	σ_0	1.9787	0.7574	2.6123
Age	σ_1	-1.5951	0.6341	-2.5155*
Experience	σ_2	-0.0367	1.7718	-2.0705*
Education	σ_3	-0.0084	1.4323	-0.5922
Farm Size	σ_4	-0.0096	1.2510	-0.7671
Sigma square	σ^2	0.1727	0.0582	2.9640*
Gamma	Γ	0.8066	0.1126	7.1635*
Mean efficiency	X	0.8460	-----	----

Source: Estimated from survey data, 2012.

Note: *, **, *** are significant at 1, 5 and10% level respectively.

Their mean farm size was 0.444 hectares having a minimum farm size 0.050 and maximum farm size 1.82 hectares having a 0.32 standard deviation. On average, employed human labor, both family and hired labors were 130.6 man days/hectare having 80.93 man days/hectare of standard deviation. The minimum man days were 25.0 and maximum man days 376.0 per hectare. Farmers used seed of 243.8 kg/ hectare, fertilizer 170.6 kg/ hectare, FYM 5376.0 kg/ hectare and weedicides 1.01 liter/hectare on average. The average age of the farmers in the study area was 46.36 years having a standard deviation of 9.40, the level of education of the farmers were 3.68 years on average having 4.48 standard deviation and the experience of the farmers was 10.80 years having a standard deviation of 6.33.

3.4 MAXIMUM LIKELIHOOD ESTIMATES OF THE STOCHASTIC FRONTIER PRODUCTION FUNCTION FOR GARLIC

Table 5 shows maximum likelihood estimates of Cobb-Douglas frontier production frontier along with technical inefficiency factors affecting technical efficiency of garlic growers in the study area. Results revealed that seed rate, FYM and tractor hours were positively affecting garlic yield and were found statistically significant at 1 per cent level. The coefficient of Irrigation was statistically significant at 5 per cent level of significance with positive coefficient. The estimated coefficient of labor was positive and statistically significant at 10 per cent level of significance. Chemical fertilizer and weedicides were positively affecting garlic yield but statistically insignificant.

Technical inefficiency model is presented in lower part of table 5. Results indicated that age of farmers and experience of garlic farming were negatively related with technical inefficiency and were found statistically significant at 1 per cent level of significance. This implies that technical efficiency increases with the increase in age of farmers and experience of garlic farming. The estimated coefficients of education and farm size were found statistically insignificant. The value of gamma (γ) was 0.8066 and significant at 1% level of significance. This implies that 80.66 per cent of variation was due to inefficiency factors included in the model.

The average technical efficiency was 0.8460; implies that if the average farmer in the sample was to achieve the technical efficiency level of its most efficient counterpart, then the average farmer could realize 11.94 per cent cost savings. Similarly the most technically inefficient farmer reveals cost savings of 40.67 per cent. Comparing average technical efficiency of this study with other studies revealed that the average technical efficiency is not far from the findings of [8], [9], [10] with an average technical efficiency of 84%, 89%, and 84% respectively. The average technical efficiency this study is higher than the one recorded by [11], [12], [13], [14] with the mean technical efficiency of 68, 67, 67 and 68% respectively.

3.5 FREQUENCY DISTRIBUTION OF TECHNICAL EFFICIENCY OF GARLIC GROWERS

Table 6 shows the estimated technical efficiency's frequency distribution of garlic growers. The minimum and maximum values of estimated technical efficiencies are 0.57 and 0.96, with a mean efficiency of 0.84. So these results indicate that by using the available resources efficiently and technology, garlic production can be improved.

Table 6 Frequency distribution of technical efficiencies of garlic growers

Technical efficiency	Frequency	Percentage
< 0.57	2	1.82
0.57 - 0.67	7	6.36
0.68 - 0.78	12	10.92
0.79 - 0.90	53	48.18
>0.90	36	32.72
Sample size	110	
Minimum	0.5762	_
Maximum	0.9607	_
Mean	0.8460	_

Source: Estimated from survey data, 2012.

4 CONCLUSION AND RECOMMENDATIONS

Stochastic frontier Cobb Douglas production function was applied for the estimation of technical efficiency of garlic growers in the study area. Results fevealed that seed rate, FYM and tractor hours were positively affecting garlic yield and were found statistically significant at 1 per cent level. The coefficient of Irrigation was statistically significant at 5 per cent level of significance with positive coefficient. The estimated coefficient of labor was positive and statistically significant at 10 per cent level of significance. Chemical fertilizer and weedicides were positively affecting garlic yield but statistically insignificant. The socio-economic characters such as age, and experience significantly and negatively affected technical inefficiency while education and farm size were found to be statistically insignificant. Results further revealed that the mean technical efficiency was 84.60 percent; implies that if the average farmer in the sample was to achieve the technical efficiency level of its most efficient counterpart, then the average farmer could realize 11.94 per cent cost savings. Similarly the most technically inefficient farmer reveals cost savings of 40.67 per cent.

Based upon these results most of the farmers were appling small amount of seed due to lesser experience which resulted in low production. So the government should motivate the farmers to use recommended quantity of seed for higher productivity. Garlic farming is labor intensive so there is an intense requisite of latest technology to replace labor in production of garlic. Experience of garlic growers plays an important role in garlic production so training programs need to organized for enhancement of garlic productivity.

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