TECHNICAL EFFICIENCY OF CUCUMBER PRODUCTIONIN JOS-EAST, PLATEAU STATE, NIGERIA.

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ABSTRACT
The efficiency levels of cucumber producers are declining; marginal differences in production and productivity were observed in the study, indicating the existence of inefficiencies in the production system and differences in the use of inputs. This study therefore analyzed the technical efficiency of cucumber production in Jos-East, Plateau State, Nigeria. Multi-stage sampling techniques were adopted in selecting 92 respondents for this study. Data collected were analyzed using descriptive statistics and stochastic frontier production function. The socioeconomic variables of the respondents affected their farm efficiency and level of farm output. The stochastic model revealed that the coefficients of farm size (0.368), agrochemicals (0.545) and labour (0.755) were statistically significant at $p < 0.05$ (5%) level of probability. Also, the inefficiency effect model revealed that the coefficients of farming experience (-0.468), educational level (-0.179) and farm capital (-0.422) were negative but statistically significant at $p < 0.05$ (5%) level of probability. Furthermore, the maximum technical efficiency index was 0.92 (92%), while the minimum technical efficiency index was 0.35 (35%). Mean technical efficiency index was 0.53, which implies that an average yield of 53% was obtainable and thus potential farm output is not maximized. Farmer sensitization, policy modifications, improved access to extension services, labour, farm capital; agricultural credit and production input subsidies and supply are strongly recommended.

Keywords: Determinants of production, efficiency index, farm output, production inefficiency, resource utilization, socioeconomic factors.

1.0 INTRODUCTON

Cucumber (*Cucumis sativus*) is an important vegetable. It is an annual vegetable vine crop grown for the fresh fruits. The crop originated from Europe and some part of Africa, including Nigeria it is thought to be one of the oldest vegetable crop cultivated by man with historical record, dating back to 5,000 years ago (Wehner and Cramer, 2004).In most Nigerian households, vegetables are consumed as a source of minerals and vitamins and in some case as substitutes to the more expensive animal protein. In spite of these economic potentials, in the Nigerian economy, most Vegetable Farming Households (VFH) are small scale producers (Asogwa *et al*., 2012).Poverty contributes to poor agricultural productivity, as many farmers cannot afford to purchase necessary farm inputs such as fertilizer, pesticides and improved seeds, which would bring about increased productivity. Smallholder farming is the predominant form of agricultural production in sub-Saharan Africa (SSA) and also an important tool in poverty eradication in the region. Nigeria is one of the countries (in SSA) where self-sufficiency in food production remains a critical challenge even in the absence of wars and natural disasters (FAO, 2005; Khan and Ali, 2013). A sustainable production of vegetables to meet the demands of an ever increasing population in the country has been an issue of great concern (Khan and Ali, 2013). This is because the domestic demand for vegetables is met essentially from local production with importation of fresh vegetables into Nigeria been uncommon. It is acknowledged that increased agricultural productivity would help in attaining the needed food security. Enhanced productivity is a combination of measures designed to increase the level of farm resources as well as to make efficient use of resources (Adeyemo and Kuhlmann, 2009). Efficiency in resource use must be sustained in order to improve productivity and maximize farm output. Technically efficient production is defined as the maximum quantity of output attainable by a given input (Pitt and Lee, 1981). According to Njeru (2004); technical efficiency is the ability of a firm to maximize output for a given set of resource inputs. Farm efficiency and productivity are indicators of agricultural production (Cechura et al., 2014). The efficiency, with which farmers use available resources and improved technologies, is important in agricultural production (Rahji, 2005). The efficient use of farm resources is germane for agricultural sustainability (Goni et al., 2013) and a prerequisite for optimum farm production since inefficiency in resource use can distort food availability and security (Etim et al., 2005). Efficiency measurement is germane in production studies. Cucumber can contribute to economic empowerment if efficiently produced due to the high unit price of the commodity compared to local fruit vegetables. Inefficiency in the use of available scarce resources has been the bane of increased food production. According to Njeru (2004), technical efficiency is the ability of a firm to maximize output for a given set of resource inputs. Agricultural economists always provide the guidance to farmers about efficient utilization of inputs. Efficient utilization of inputs is also important for food security (Irz e*t al.*, 2010). The modeling and estimation of stochastic frontier production functions are useful to provide information about the relationship between the amount of output and the inputs of production, given the level of technology involved. In recent years, stochastic frontier models in agricultural economics have been used. The stochastic frontier model was originally proposed for the analysis of the panel data by Battese and Coelli (1995). However, a general stochastic frontier production function for the cross-sectional data, which is considered in this paper, is defined implicitly in equation (1);

$Yi= \beta iXi+Vi–Ui$ …….(1)

Where;

Y_i=denotes the output for the i^{th} sample farm;

βi = vector of unknown parameters to be estimated;

X_i = vector of explanatory variables for the i^{th} farm;

Vi = independent and identically distributed random errors which have normal distribution with unknown variance α^2; and

U_i = non-negative unobservable random variables associated with the technical inefficiency of production, such that for a given technology and levels of inputs, the observed output falls short of its potential output.

Technical inefficiency effect model proposed by Battese and Coelli (1995) is implicitly presented in equation (2);

$U_{it} = \delta_o + \delta_i Z_{it}$…….(2)

Where;

U_{it} = Technical inefficiency

δ_0 = vector of unknown parameters;

δ_i = vector of parameters to be estimated; and

Z_{it}= explanatory variables associated with the technical inefficiency effects.

Despite all the economic potential of the crop, the full production potential have not been realize in Nigeria, yields obtained by farmers is often low and especially in intensive cropping area due to low technical efficiency in production. Developing countries faced increasing demand of vegetable due to increase in population (Arsanti *et al*., 2007). Yield differences was observed among farmers due to variations in their input utilization; indicating the existence of inefficiency in input usage (Khan and Ali, 2013). In Nigeria today there is a decline in agricultural production because there is an apparent shift of interest from agriculture which further worsens the poverty index, hunger and unemployment of Nigerians, especially the youth (Shrestha *et al*, 2015). The study was also designed to give policy implication of improving cucumber production to ensure increased in output levels (Shrestha *et al*, 2015). Given that cucumber is an important crop of high nutrition and economic value, concerted efforts must be made to stimulate the interest in its production at a commercial scale. Many developing countries face major challenges to achieve food security in a sustainable manner, considering the increasing population, limited availability of land and water resources. In vegetable production, farmers adopt different cropping practices. These practices determine the quality and quantum of gross agricultural production and the crop-mix grown in an agricultural year. In Nigeria the output from cucumber production is low and therefore there is need to empirically investigate factors that affect farm productivity and efficiency. This research determines the factors of farm efficiency. In this light this research paper intends to study the farmer's demography, determinants of productivity and farm efficiency, hence this study seeks to provide answers to the following research questions:

i. What are the socioeconomic characteristics of the respondents?
ii. What is the technical efficiency of cucumber production in the study area?
iii. What is the efficiency index among the cucumber farmers?

1.1 Research Hypothesis

H_0: There is no significant relationship between inputs and output in cucumber production.

2.0 METHODOLOGY

2.1 Study Area

Jos-east Local Government Area (LGA) is in Plateau state, Nigeria. It is located between latitude 9°55N to 9°06E and longitude 917°N to 9.100°E. It has a total land mass of 1,020km^2 (390sq/m), scattered with bushes and grasses, rocky out crops and fragments; with a projected population of 115,700 (NPC, 2006). It has an average rainfall of 1411mm and comprises of five (5) districts; Fobor, Fursum, Shere, Maigemu and Federe. It is landscaped with high plains of rocks that range from 1220m to 1450m above sea level (DESA, 2000).

2.2 Sampling Technique

A multi stage sampling technique was employed for this study, in the first stage, Jos east LGA was purposely selected due to the prevalence of cucumber farmers. The second stage entails random selection of some villages from each district. Sample size was estimated from the sample frame using a content sampling proportion to determine the number of respondents used for the study. The last stage involved the selection of hundred (103) respondents representing three percent (3%) of the total population. Table 1 presents the sample frame distribution. However, for the purpose of this study only 92 questionnaires were retrieved.

2.3 Method of Data Collection

Primary data were collected from cucumber farmers in the study area, through the administration of well-structured questionnaires, oral interviews and physical observation.

2.4 Analytical Techniques

Descriptive statistics (such as frequency counts, percentages and means) were used to analyze objective i and iii. The stochastic frontier model was used to analyze objective ii. The stochastic frontier approach which was introduced by Meeusen and Van den Broeck (1977) and Aigner *et al.*, (1977), reversed the conventional belief that deviations from the production frontier are due to inefficiency of the producing units (i.e., factors under the control of the producers, which may not be true). Hence, stochastic estimations of technical efficiency incorporate a measure of random error, which is one component of the composed error term of a stochastic production frontier. This model acknowledges the fact that factors, which are outside the farmers" control, can also affect the level of output. So it made possible to find out whether the deviations in production from the frontier output is due to firm specific factors or due to external random factors. The primary advantage of the stochastic frontier production function is that it enables one to estimate farm specific technical efficiencies. The measure of technical efficiency (TE) is equivalent to the production of the i_{th} farm to the corresponding production value if the farm effect U_i were zero. However, the estimation of efficiency using stochastic method requires a prior specification of functional form and needs distributional assumptions (half-normal, gamma, truncated, etc.) for the estimation of U_i (Coelli, *et al*, 1998). The stochastic frontier production model incorporates a composed error structure with a two-sided symmetric term and a one-sided component. The one-sided component reflects inefficiency, while the two-sided error captures the random effects outside the control of the production unit including measurement errors and other statistical noise typical of empirical relationships. Hence, stochastic frontier models address the noise problem that characterized early deterministic frontiers. Stochastic frontiers also make it possible to estimate standard errors and to test hypotheses, which were problematic with deterministic frontiers because of their violation of certain maximum likelihood (ML) regularity conditions (Schmidt, 1976). In stochastic frontier method, technical efficiency is measured by estimating a production function. Different production functions such as Cobb-Douglas, Trans-log, Transcendental, and Quadratic etc. can be used to estimate the frontier. The Trans-log and Cobb-Douglas specifications are commonly used functional forms to estimate the frontier; but both have their merits and demerits. Therefore, the method avoids the imposition of unwarranted structures on both the frontier technology and the inefficiency component that might create distortion in the measurement of efficiency (Shafiq and Rehman, 2000). The choice is made on the basis of the variability of agricultural production. The stochastic frontier analysis was also used to test the hypothesis for this study.

2.4 Model Specification

2.4.1 Stochastic Frontier Production Function

The parametric deterministic models used in estimating the technical efficiency of cucumber production are expressed as follows; we assume that production can be modeled as presented in equation (3);

$Y = f(X_{ij}\ \beta) + e_i\ (v_i, u_i)$……. (3)

Y = Yield in kg; X_{ij} = Vector of input quantities; β= is a vector of parameters to be estimated; and $e_i\ (v_i, u_i)$ = Error term.

The error term consists of two components V_i and U_i; $e_i = V_i - U_i$. The components (V_i and U_i) are assumed to be independently distributed. V_i is the symmetric component and permits random variation of the production function across farms. It also captures factors outside the control of the farmer. V_i=0 indicates that production lies on the stochastic frontier, while if U_i=0, production lies below the frontier and is inefficient. While the inefficiency effects relative to the stochastic frontier is presented in equation (4);

$(U_i>0)$……. (4)

Here all variables are specified in logarithms, in this case;

$TE_i = \exp(-Ui)$……. (5)

Hence; $0 \le TE \le 1$…….(6)

The stochastic production frontier is explicitly specified in equation (7):

$Y_i = \beta_0 + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \beta_5 InX_5 + \beta_6 InX_6 + V_i - U_i\ (V_i)$……. (7)

Y = Yield of cucumber (kg); β_0 = vector of unknown parameters; $\beta_1 - \beta_6$ = vectors of parameters to be estimated;

In = Natural logarithms; X_1 = Farm size (ha); X_2 = Quantity of seed used (kg); X_3 = Quantity of fertilizer used (kg); X_4 = Agrochemical application (liter); X_5 = Labour (man-days); V_i = Random error associated with random factor under the control of cucumber farmers; and U_i = the asymmetric error component which represents the deviation from the frontier production.

The inefficiency effect model is explicitly specified in equation (8):

$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5$…….(8)

Where;

U_i = Technical inefficiency of the cucumber farmers; α_0= vector of unknown parameters; $\alpha_1 - \alpha_5$ = vectors of parameters to be estimated; Z_1 = Age (years); Z_2 = Gender (male = 1, female = 0); Z_3 = farming experience (years); Z_4 = Educational level (years); and Z_5 = Farm capital (₦).

Table 1: Sample Size of the Respondents.

District	Selected village	Sample frame	Sample size
Fobor	5	683	21
Fursum	5	667	20
Shere	3	308	9
Maigemu	7	922	28
Federe	5	840	25
Total	**35**	**3420**	**103**

Source: field survey, 2017

3.0 RESULTS DISCUSSION

3.1 Socioeconomic Characteristics of the Respondents

The socioeconomic characteristics of the cucumber farmers in the study area are presented below.

3.1.1 Age of Respondents

Table 2 revealed the distribution of the farmers based on their age, most (63%) of the respondents were in the age bracket of 20–39 years, this is an indication that majority of the farmers in the study area were relatively young and are engaged in agricultural production activities. The results corroborates with the findings of Oyediran *et al*. (2012) who also reported that the age bracket of 20–40 years is the economically active age bracket and was prevalent among most formers in their study.

Table 2: Distribution based on the Age of the Respondents

Age	Frequency	Percentage (%)
≤ 19	4	4.4
20-39	58	63.0
40-59	27	29.3
≥ 60	3	3.3
Total	92	100
Mean 34 years		

Source: field survey, 2017

3.1.2 Gender

Table 3 revealed the distribution of the farmers based on their gender, most (91%) of the respondents. This indicates that male respondents dominated cucumber Production in the study area, attributable to their access to more productive assets as compared to their female counterparts. This is in line with the findings of Oyediran, *et al*., (2014) and Tambo and Gbemu (2010), whose findings indicated that men were majorly involved in melon and tomato production in their respective study areas.

Table 3: Distribution based on the Gender of the Respondents.

Gender	Frequency	Percentage (%)
Male	84	91.3
Female	8	8.7
Total	92	100

Source: field survey, 2017

3.1.3 Marital Status

Table 4 revealed that most (54.3%) of respondents are married. This is an indication that the respondents may tend to be more committed in their farm production activities due to the responsibilities of marriage.

Table 4: Distribution Based on the Marital Status of the Respondents

Marital status	frequency	percentage (%)
Married	50	54.3
Single	42	45.7
Total	92	100

Source: field survey, 2017

3.1.4: Household Size

Table 5 revealed that most (57.6%) of the respondents have a household population of ≤ 5 people. The mean estimate of household population was 6 people. This is an indication that household population contributes significantly to farm labour supply in the study area. The results corroborates with the findings of Owombo, (2012) who also reported that household population contributes to farm labour supply for agricultural production.

Table 5: Distribution Based on Household Size of the Respondents

Household size	frequency	percentage (%)
≤ 5	**53**	**57.6**
6-10	28	30.4
≥ 11	11	12.0
Total	92	100
Mean	6 people	

Source: field survey, 2017

3.1.5 Educational Level

Table 6reveals the distribution of the respondents based on their educational level; the results indicate that most (38%) had secondary education. The mean educational level of the respondents in the study area was estimated to be 13 years, i.e., secondary education. These levels of educational attainment tend to improve their capacity of adoption of improved agricultural practices and technology necessary to improve their level of farm efficiency and agricultural output.

Table 6: Distribution Based on Educational Level of the Respondents

Educational level (years)	Frequency	Percentage (%)
Non formal (≤1)	16	17.5
Primary (1-6)	29	31.5
Secondary (7-13)	35	38
Tertiary (≥14)	12	13
Total	92	100
Mean	13 years	

Source: field survey, 2017

3.1.6: Farming Experience

Table 7reveals the distribution of the respondents based on their farming experience in cucumber production; most (64.1%) had farming experience of ≤ 19 years. The mean farming experience among respondents in the study area was estimated to be 12 years, suggesting that cucumber farming is one of the major agricultural livelihood activities prevalent in the study area. The study area is an agrarian community and hence most of the respondents had several years of farming experience. These years of farming experience provides the respondents with adequate knowledge and information on agricultural practices and technology that can enhance farm efficiency and productivity. This result agrees with the inference of Nandi *et al*. (2011) who also reported adequate years of farming experience among farmers.

Table 7: Distribution based on Farming Experience of the Respondents

Farming experience	frequency	percentage (%)
≤ 19	59	64.1
20-40	23	25
≥ 41	10	10.9
Total	92	100
Mean 12 years		

Source: field survey, 2017

3.1.7: Farm Size

Table 8 revealed that most (68.5%) of the respondents had a farm size of ≤ 1.9ha. The mean farm size of the respondents in the study area was estimated to be 1.6ha. This is an indication that the farmers in the study area operate on a subsistent level due to their small farm holdings. However, the farm efficiency of subsistent production tend to be higher due to better operational capacity, hence access to agricultural technologies for commercial production are absent. This result is in line with the findings of Olubunmi and Iyabo (2016) who also reported that most rural farmers operate on fragmented farm holdings.

Table 8: Distribution Based on the Farm Size of Respondents

Farm size (ha)	frequency	percentage (%)
≤ 1.9	63	68.5
2-3.9	19	20.7
≥ 4	10	10.8
Total	92	100
Mean 1.6ha		

Source: field survey, 2017

3.1.8 Access to Credit Institutions

Table 9 shows the distribution of farmers based on their access to credit institutions. It was revealed that most (87%) of the respondents do not have access to credit institutions in the study area; this is an indication that the respondents relied mainly on their personal savings and low remunerative farm incomes as their primary source of capital, which is grossly inadequate for the acquisition of farm assets and agricultural inputs.

Table 9: Distribution based on Access to Credit Institutions by the Respondent

Access to credit institutions	frequency	percentage (%)
Yes	12	13.0
No	80	87.0
Total	92	100

Source: field survey, 2017

3.1.9: Membership of Cooperative of Respondents

Table 10 revealed that most (96.7%) of the respondents do not belong to any cooperative society. This affects the ability to boost levels of farm efficiency and output through synergy in agricultural resource utilization among farmers. Also, membership of farm associations or cooperative societies avail farmers the opportunity to have more access to agricultural credit, receive agricultural inputs at subsidized rates and for effective information dissemination on improved agricultural practices and technology that boost levels of farm efficiency and output. Consequently, farmers who belong to the cooperative societies enjoy the benefits accruable to members through the pooling of resources together for better expansion of their production frontier; efficient and effective management of resources and for profit maximization.

Table 10: Distribution based on Membership of Cooperatives

Membership	frequency	percentage (%)
Yes	3	3.3
No	89	96.7
Total	92	100

Source: field survey, 2017

3.1.10 Farm Income of the Respondents

Table 11 revealed that most (59.8%) of the respondents earned farm incomes between ≤₦99,000/ha. This farm income was relatively low, attributable to their subsistent level of production and consequently low output subject to their farm sizes. With increased remunerative income farmers tend to adopt improved agricultural production technology and practices that boost their levels of farm efficiency and output.

Table 11: Distribution based on the Farm Income of the Respondents

Farm income (₦/ha)	frequency	percentage (%)
≤99,000	55	59.8
100,000-199,000	27	29.3
≥200,000	10	10.9
Mean 87,000		
Total	92	100

Source: field survey, 2017

3.1.11 Extension Contact

Table 12 revealed that most (87%) of the respondents in the study area had no access to extension contact. This indicates that they respondents do not have access to agricultural information and technology that will boost their level of farm efficiency and output. Based on their literacy levels the respondents would have easily adopted improved agricultural technology. Extension contact is germane to build farmers capacity, resilience to agricultural risks, poverty reduction strategies, innovation and practices that will ensure sustained farm efficiency and food security in the study area.

Table 12: Distribution based on the Extension Contact of the Respondents

Extension contact	frequency	percentage (%)
No	80	87
Yes	12	13
Total	92	100

Source: field survey, 2017

3.2 Stochastic Frontier Analysis

The maximum likelihood estimate of the parameters of the stochastic frontier production model for cucumber production is presented in Table 13. The table contains the estimates of parameters of the stochastic frontier production function, the inefficiency effect model and the variance parameters of the stochastic frontier model.

Table 13: Stochastic Frontier Analysis of Factors Affecting Cucumber Production.

Variable	Parameter	Coefficient	Standard error	T-value
Efficiency model:				
Constant	β_0	2.401**	0.932	2.574
Farm size (x_1)	β_1	0.368**	0.128	2.861
Seed (x_2)	β_2	$0.152^{n.s}$	0.134	1.130
Fertilizer (x_3)	β_3	$0.183^{n.s}$	0.168	1.085
Agrochemical (x_4)	β_4	0.545**	0.207	2.622
Labour (x_5)	β_5	0.755**	0.301	2.501
Inefficiency model:				
Constant	α_0	2.075**	0.746	2.778
Age (z_1)	α_1	$0.163^{n.s}$	0.154	1.061
Gender (z_2)	α_2	$0.312^{n.s}$	0.284	1.096
Farm experience (z_3)	α_3	-0.468**	0.119	-2.603
Education (z_4)	α_4	-0.179**	0.065	-2.723
Farm capital (z_5)	α_5	-0.422**	0.152	-2.769
Diagnostic statistics				
Sigma $(\sigma)^2$		0.795**	0.283	2.807
Gamma (γ)		0.836		
Log likelihood		-61.48		

Source: field survey, 2017; n.s = not significant; ** = significant at 5%.

3.2.1 Stochastic frontier model

The estimated stochastic frontier function revealed the significant determinants of farm efficiency. The coefficients of farm size, agrochemical application and labour were all significant and positive; suggesting that a percentage increase in any of these inputs would lead to a percentage increase in output, *ceteris paribus*.

Farm size

The coefficient of farm size (0.368) was positive and statistically significant at 5% ($p< 0.05$) level of probability, implying that a 1% increase in the use of land will increase farm output by about 3.7 % and *vice versa*. Farm size is a significant determinant of farm efficiency; it influences farmer's adoption decisions as regards agricultural technology, practices and management systems that tend to boost farm output. This is in line with the findings of Nwachuckwu and Onyenweaku (2007) and Tambo and Gbemu (2010), who also reported a positive relationship between farm size and level of farm output among farmers in telfairia and tomato production. Thus, to ensure sustainable production the capacity of the farmers to employ improved techniques should be given due attention.

Agrochemical

The coefficient of agrochemicals (0.545) was positive and statistically significant at 5% ($p< 0.05$) level of probability. This implies that a 1% increase in efficient agrochemical application would increase cucumber yield by 5.5%. Farmers should therefore be encouraged to use appropriate dosage of agrochemicals and to adhere strictly to manufacturers' instructions. This result is in line with the study of Cechura *et al*., (2014) who also reported a positive correlation between appropriate agrochemical application and farm output.

Labour

The coefficient of labour (0.755) was positive and statistically significant at 5% ($p< 0.05$) level of probability. This implies that a 1% increase in efficient labour utilization would increase cucumber yield by 7.6%. Farm labour is an essential factor of production required in carrying out farm operations such as weeding, fertilizer and agrochemical application and harvesting. This result is in line with the study of Cechura, *et al*., (2014) who also reported a positive correlation between labour supply and farm output.

3.2.2 The Inefficiency Effect Model

The variables of the inefficiency model explained the determinants of inefficiency of production among the cucumber farmers. The sign of the variables in the inefficiency model is very important in explaining the observed level of technical efficiency of the farmers. A negative sign implies that the variable had the effect of reducing technical inefficiency, while a positive coefficient indicate that the variable has the effect of increasing inefficiency. The estimated coefficients of farming experience, educational level and farm capital were negative and statistically significant. This is an indication that these factors are important determinants of technical efficiency in cucumber production in the study area.

Farming Experience

The estimated coefficient of farming experience (-0.468) was negative and statistically significant at $p< 0.05$ (5%) level of probability, suggesting that years of farming experience was positively correlated with farm efficiency; farmers with more years of experience tend to become more efficient through 'learning-by-doing'. An increase in efficiency may also be attributable to the experience they have gained over time especially with regard to production techniques and combination of resources. This result corroborates the findings of Abdulai and Eberlin (2001) who also reported a positive correlation between farming experience and farm output.

Educational Level

The estimated coefficient of educational level (-0.179) was negative and statistically significant at $p< 0.05$ (5%) level of probability. The number of years spent in school is a proxy of the literacy level of the farmers. The results revealed an inverse relationship to technical inefficiency in cucumber production. This implies that farmers with better education were technically more efficient; hence literacy increases farmer's capacity to adopt and efficiently utilize agricultural technology and information that tend to boost farm output. Higher level of education results in better evaluation of management systems, farm decision making and efficient input utilization. This result corroborates the findings of Dey *et al.* (2000), who also reported that improved farm efficiency can be attributable to increase in the level of education.

Farm Capital

The coefficient of farm capital (-0.422) was negative but statistically significant at 5% ($p< 0.05$) level of probability, suggesting that a 1% increase in farm capital will increase cucumber yield by 4.2%, suggesting that farm capital increases efficiency in cucumber production. The negative sign indicates an inverse relationship with technical inefficiency. This implies that farmers with improved farm capital tend to be more efficient in their farm operations through increased capacity to acquire and adopt improved agricultural technology and inputs that will boost the level of their farm output. This result is consistent with the findings of Abdulai and Eberlin (2001) who also reported that improved farm efficiency can be attributable to increase in farm capital.

3.2.3 Diagnostic Statistics

Sigma squared (σ)

Table 13 revealed that the estimated value of Sigma (σ) was 0.795. This value was significantly different from zero at 5% level of probability. This indicates that the stochastic frontier model was a good fit for the variables specified in the regression model.

Table 13: Stochastic Frontier Analysis of Factors Affecting Cucumber Production.

Variable	Parameter	Coefficient	Standard error	T-value
Efficiency model:				
Constant	β_0	2.401**	0.932	2.574
Farm size (x_1)	β_1	0.368**	0.128	2.861
Seed (x_2)	β_2	0.152$^{n.s}$	0.134	1.130
Fertilizer (x_3)	β_3	0.183$^{n.s}$	0.168	1.085
Agrochemical (x_4)	β_4	0.545**	0.207	2.622
Labour (x_5)	β_5	0.755**	0.301	2.501
Inefficiency model:				
Constant	α_0	2.075**	0.746	2.778
Age (z_1)	α_1	0.163$^{n.s}$	0.154	1.061
Gender (z_2)	α_2	0.312$^{n.s}$	0.284	1.096
Farm experience (z_3)	α_3	-0.468**	0.119	-2.603
Education (z_4)	α_4	-0.179**	0.065	-2.723
Farm capital (z_5)	α_5	-0.422**	0.152	-2.769
Diagnostic statistics				

Sigma $(\sigma)^2$	0.795**	0.283	2.807
Gamma (γ)	0.836		
Log likelihood	-61.48		

Source: field survey, 2017; n.s = not significant; ** = significant at 5%.

Gama (ϒ)

The estimated value of Gamma (γ) parameter (The variance ratio), which was associated with the variance of technical inefficiency effects in the stochastic frontier model, is estimated to be 0.836, suggesting that technical inefficiency is highly significant in the production activities of cucumber farmers, which implies that systematic influences that are unexplained by the production function were the dominant sources of random errors, hence 84% of the variations in the output of cucumber farmers are due to differences in technical inefficiency. This confirms that in the specified model, there is presence of one-sided error component.

3.3 Technical Efficiency Index

The distribution of farmers technical efficiency index derived from the analysis of the stochastic frontier production function is presented in Table 14. The technical efficiency index of the respondents was less than one (<100%), implying that all the farmers in the study area are producing below maximum efficiency frontier. The distribution of the efficiency index of the farmers revealed that, most (34.8%) of the cucumber farmers had an efficiency index ranging between 0.41-0.50 and also an index ranging between 0.51-0.60 (21.7%). The magnitude of the efficiency index is a reflection of the fact that most of the respondents carry out their farm operations under poor and inadequate technical conditions. From this estimation, maximum technical efficiency is not yet achieved suggesting a need for more effort at improving the farm efficiency of cucumber production in the study area. From the observed range of technical efficiency index across the respondents, the estimate of maximum efficiency index was 0.92 (92%); which implied the optimal farm output obtainable in the study area, while the estimated minimum efficiency index was 0.35 (35%). In addition, the estimated mean efficiency index was 0.68 (68%); suggesting that the average estimate of farm output obtainable from a given mix of production inputs in the study area was 68%. This mean efficiency index is an indication that farm output can still be increased by about 32% through intensification and efficient resource utilization. This result corroborates the findings of Albogudady and Sheta (2014) who investigated the technical efficiency of off-season cucumber production under green house and open field systems, also reported variations in the efficiency index among various farmers and cultivation systems.

Table 14: Distribution of Respondents based on their Efficiency Index

Efficiency Index	Frequency	Percentage (%)
0.31–0.40	11	12
0.41–0.50	32	34.8
0.51–0.60	20	21.7
0.61–0.70	14	15.2
0.71–0.80	8	8.7
0.81–0.90	5	5.4
0.91–1.00	2	2.2
Total	92	100
Minimum 0.35		
Maximum 0.92		
Mean 0.68		

Source: Computed from MLE results 2017

4.0 CONCLUSION AND RECOMMENDATIONS

The socioeconomic factors of the respondents affected their farm efficiency and level of farm output. The variables in the stochastic frontier model significantly affected the technical efficiency and output of cucumber production in the study area. The efficiency index of the cucumber farmers in the study area also revealed that they were not producing at optimal capacity. Based on the findings of this study, the following recommendations are made for policy actions to improve the technical efficiency of cucumber production in the study area;

i. Stakeholders should increase sensitizing farmers on appropriate application and utilization of agricultural resources.
ii. Livelihood modifications to ensure adequate farm labour supply.
iii. Policy modifications to ensure availability of land for farming activities.
iv. Improve frequency of farmer's extension contact for efficient dissemination of agricultural information, techniques and interventions.
v. Formulation of polices to improve access to farm capital and agricultural credit.

vi. Formulation of polices to improve the level of farm efficiency and output.
vii. Formulation of polices to subsidize the cost of agricultural inputs.

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