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# Analysis of Technical Efficiency of Irrigated Vegetable Production in Borno State, Nigeria

[1*]Shettima, B. G., [2]Amaza, P. S. and [3]Iheanacho, A. C.

[1]Department of Agricultural Economic, Faculty of Agriculture, University of Maiduguri, Borno State, Nigeria
[2]Department of Agricultural Economics, University of Jos, Nigeria
[3]Department of Agri-Business, University of Agriculture, Makurdi, Nigeria

**ABSTRACT**
This study analysed the efficiency of irrigated vegetable production among farmers in Borno State, Nigeria. Multistage sampling techniques were used to select respondents. Structured survey questionnaires were administered to 300 respondents to obtained primary data. Both descriptive and inferential statistics were used to analyze the data. Descriptive statistics used were mean, frequency and percentage. The inferential statistics used was stochastic frontier production function. The results of the levels of technical efficiencies showed mean technical efficiencies of the studied enterprises as 0.81, 0.87, 0.85, 0.80, and 0.77 for onion, tomato, pepper, onion/tomato and onion/pepper, respectively. The results of the maximum likelihood estimate for the enterprises indicated that the values of sigma square for onion, tomato, pepper, onion/tomato and onion/pepper enterprises were 1.909, 0.995, 1.453, 1.217 and 1.3465, respectively. The variance ratios also revealed the presence of technical inefficiencies among the enterprises with values of 0.994, 0.944, 0.966, 0.956 and 0.984 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively. Production variables had positive coefficients and were all significant at different levels. The most significant variables in the studied enterprises were farm size, family labour, agrochemicals and cost of seeds/seedlings. The inefficiency variables which includes farming experience, level of formal education, extension contact, membership of farmers' association, ownership of irrigation facilities and off-farm income had negative coefficients and were all significant. The two hypotheses tested for the absence of technical inefficiency in vegetable production and technical inefficiency is not influenced by farmers socio-economic factors were rejected for all the studied enterprises. The study recommended promotion of formal education, good market facilities and market information to enhance efficiency of vegetable production in the study area.

**Key Words**: Irrigated Vegetable, Technical Efficiency, Stochastic Frontier, Borno State

## INTRODUCTION

Vegetables are herbaceous plants and plant parts which sometimes can be consumed raw or with minimal cooking (Raman, 2011). Vegetables can be bulb; fruity; inflorescent; leafy; root and stalk. Vegetables can be grown in a wide range of climates with extreme heat, cold, excessive rainfall or drought (Babalola *et al*., 2007; Gambo, 2008). Vegetables form an important part of our daily food. They help in protecting body against diseases. Almost all vegetables are low in fat and calories and many of them are good sources of fibre. The high level of fibre in vegetable keeps the digestive system healthy and prevents constipation. Vegetable production also serves as sources of livelihood for small-scale farmers, create employment opportunities for the populace, generate income and reduce poverty (AVRDC, 2006; Oladoja *et al*., 2006).

Borno State is one of the States in Nigeria where vegetable production is highly practised. Production of vegetable is largely carried out during dry season under irrigation condition, although it is also grown under rain fed agriculture. About 10,000 hectares of land is devoted to vegetable cultivation in the State. The vegetable crops commonly grown in Borno State include onion, tomato, pepper, okra, egg-plant, amaranthus, sorrel, lettuce, cabbage and carrot. Most of these are grown as mixed crops especially onion, tomato and pepper, amaranthus and sorrel, cabbage and lettuce and so on. An average yield of about 15.25 tonnes per hectare, 6.09 tonnes per hectare and 9.65 tonnes per hectare of onion, tomato and pepper, respectively, were reported to be produced in the State (BOSADP, 1993; NFRA, 2008; NAERLS, 2009; Lawan *et al*., 2010). Production of vegetables in the State is still at small-scale level, inspite of its economic growth potentials. Studies involving farmers' efficiency and productivity measure could be a sound basis for harnessing the growth potentials in vegetables farming. Therefore,this study was concerned with the analysis of technical efficiency among irrigated

*Corresponding Author:

vegetable producers in Borno State, Nigeria, covering Mobbar, Bama and Hawul Local Government Areas (LGAs),Covering a single production season of 2012/2013. The enterprises considered were onion, tomato and pepper, which were known to be of high economic value in the study area and can be produced under similar production conditions. The objectives of this study were to estimate the levels of technical efficiency of irrigated vegetable producers and examine the determinants of technical efficiency of irrigated vegetable production in the study area

**Hypotheses of the Study**

The following hypotheses were tested:

i. Technical inefficiency is not present in vegetables production

ii. Technical inefficiency is not influenced by farmer's socio-economic factors.

## METHODOLOGY

### The Study Area

The study was conducted in Borno State, Nigeria. The State lies between latitudes $10^0 02'$N and $13^0 04'$N and longitudes $11^0 04'$ E and $14^0 04'$E (Agboola, 1987). The State shares borders with Adamawa State to the south, Yobe State to the west and Gombe State to the southwest. It also shares international borders with Cameroon Republic to the east, Chad Republic to the north-east and Republic of Niger to the north. The State has a land mass of about 69,434 square kilometers (Borno State Diary, 2013). Administratively, it has 27 LGAs with a projected population of about 4.8 million people based on 2.8 growth rate (NPC, 2006).

The State is divided into three agro-ecological zones; Sahel to the north, Sudan Savannah in the central and southern parts of the State and Guinea Savannah in the southern part. The average rainfall is 300mm in the north and about 1000mm in the south (Agboola, 1987). The rainy season usually starts in April and ends in October. The temperature ranges from $25^0$C - $47^0$C but instantaneous temperature might reach up to $47^0$C during the hottest months of March-May (BOSADP, 2010). The State is also blessed with lakes and rivers such as Lake Chad, Lake Alau, Lake Tilla, River Ngada, River Yazaram and River Yare, just to mention a few, where irrigation farming is carried out especially during dry season.

The major occupation of the inhabitants is farming. Food crops are commonly cultivated under rain-fed and fruits and vegetables are mainly grown under irrigation. The fruits and vegetable grown include mango, orange, guava, tomatoes, onion, pepper, carrot, amaranths and garden-egg. Most of the vegetables can be grown as sole or mixed crops. The vegetable production is carried out during dry and cool seasons under irrigation around November to January.

### Sampling Procedure

Multistage sampling techniques were used to select respondents for this study: The first stage involved purposive selection of three LGAs known for production of vegetables, one from each of the three main agro-ecological zones of the State. This is because vegetables are produced in all the agro-ecological region of the State and to cover the whole State, the selection was done based on the agro-ecological composition. The LGAs selected were Hawul in Guinea Savannah, Mobbar in Sahel Savannah and Bama in Sudan Savannah. The second stage involved selection of four villages purposively each from each LGA. They were selected because of their prominence in vegetable production. This was based on the list of major vegetables producing villages obtained from the Borno State Agricultural Development Programme (BOSADP). The third and final stage involved random selection of 300 respondents based on a 25% proportion of vegetable farmers in each of the selected villages. However, 296 questionnaires (about 98.6%) were retrieved and used for analysis. The sample frame was list of vegetable farmer obtained from BOSADP and membership list from registered members of vegetable farmers association.

### Sources of data

Primary data were used for this study. The relevant cross sectional/primary data were collected through administration of structured questionnaires. Trained enumerators were used to administer the questionnaires. Primary data were collected on input quantities, output quantities and socioeconomic characteristics of vegetable producers.

### Analytical techniques

Both descriptive and inferential statistics were used for the analyses of data obtained. Descriptive statistics used include means, frequencies and percentage distributions. The descriptive statistics were used to examine the distribution of technical efficiency levels. The inferential statistics used was stochastic frontier production function to analyze the determinants of technical efficiency of irrigated vegetables enterprises.

**Stochastic frontier production function**

The stochastic frontier production function approach was used to analyze technical efficiency of different farms. This model was used to analyze technical efficiency of the enterprises studied. The explicit form of the function is expressed as:

$\ln Y_i = \beta_o + \beta_1 \ln X_{1ij} + \beta_2 \ln X_{2ij} + \beta_3 \ln X_{3ij} + \beta_4 \ln X_{4ij} + \beta_5 \ln X_{5ij} + \beta_6 \ln X_{6ij} + \beta_7 \ln X_{7ij} + \beta_8 \ln X_{8ij} + V - U$……….(1)

Where:

$Y_i$ = quantity of output of the $i^{th}$ farmer (kg);

$X_1$= farm size (ha)

$X_2$ = family labour in man days

$X_3$ = hired labour (₦)

$X_4$ = inorganic fertilizer (kg)

$X_5$ = organic fertilizer (Dummy = 1 if used and 0 otherwise)

$X_6$ = agrochemicals (liters)

$X_7$ = cost of seed/seedling (₦)

$X_8$ = cost of irrigation (₦)

$\beta_0$= constant

$\beta_1 - \beta_8$ = estimated parameters;

i =1, 2, 3,…………….296, farmers

j = 1, 2, 3,…………..8, production inputs

$V_i$s = random variable assumed to be independently and identically distributed as $\mu$ (0, $\sigma^2_v$) and independent of $U_i$s; that represent the stochastic effect outside the farmer's control$U_i$s = one sided error ($U_i \geq 0$) efficiency component that represent technical inefficiency in production which is assumed to be independently and identically distributed at truncation (at zero) of the normal distribution with mean, $Z_i$ σ and variance $\sigma_u^2(|\mu Z_i\sigma, \sigma^2 u|)$ .

The $U_i$ was estimated as:

$\mu_i = \delta_0 + \delta_1 \ln Z_{1ij} + \delta_2 \ln Z_{2ij} + \delta_3 \ln Z_{3ij} + \delta_4 \ln Z_{4ij} + \delta_5 \ln Z_{5ij} + \delta_6 \ln Z_{6ij} + \delta_7 \ln Z_{7ij} + \delta_8 \ln Z_{8ij} + W_i$……………..(2)

Where:

$\mu_i$= Technical inefficiency

$Z_1$= farming experience (years)

$Z_2$ =level of formal education (years)

$Z_3$= extension contacts (number of visit)

$Z_4$= credit availability (Dummy = 1 if available and 0 otherwise)

$Z_5$= distance to markets (km)

$Z_6$= membership in farmers association (Dummy = 1 if member and otherwise)

$Z_7$= own irrigation facility (Dummy = 1 if yes and 0 otherwise)

$Z_8$= off-farm income (₦)

$\delta_0$ = constant

$\delta_1$- $\delta_8$ = vector of unknown parameters estimated.

$W_i$ = random variable defined by the truncation of the normal distribution with zero mean and variance $\sigma^2_u$such that the point of truncation is $Z_i\sigma_i$

i.e $W_i \geq -Z_i \sigma$.

The inefficiency component of the stochastic frontier production function comprised socioeconomic variables that were expected to be the determinants of technical inefficiency. The technical efficiency of the $i^{th}$ sample farmer, denoted by $TE_i$ was expressed as: $TE_i$ = exp ($-U_i$)

= $y_i / f(X_i\beta) \exp(V_i)$

= $\mathbf{y_i/y^*}$ **………………………………………**(3)

Where:

$y_i$ = observed output

y*= frontier output

if$y_i = y_i^*$

then $TE_i$ = 1, reflecting 100% efficient.

The difference between $y_i$ and $y^*$ is embedded in $U_i$. If $U_i$ = 0, it implies that production lies on the stochastic frontier, the farm obtains its maximum attainable outputs given its level of inputs. If $U_i$> 0, production lies below the frontier, this is an indication of inefficiency. The Maximum Likelihood Estimate (MLE) of the parameters of the model defined by equations (1) and (2) and the farmer specific TE defined in (3) were estimated using the computer programme FRONTIER version 4.1 package (Coelli, 1994) The efficiencies were estimated using a predictor that is based on the conditional expectation of exp(-U*i*). In the process, the variance parameters $\sigma^2_u$ and $\sigma^2_v$ are expressed in terms of parametization as:

$\sigma^2 = (\sigma^2_u + \sigma^2_v)$…………………………………………………………………………………………(4)

$\gamma = (\sigma^2_u / \sigma^2)$………………………………………………………………………………………………..(5)

Where: $\gamma$ = total variation in output from the frontier which is attributed to technical inefficiency.The value of $\gamma$ ranges between zero and one. When $\gamma$ equals zero, variation in output is due to factors outside farmer's control. A value close to one indicates that a random component of the inefficiency has a significant contribution to the analysis of the production system.

**Hypotheses testing**

This study used two different models for testing the hypotheses stated. The first model was the traditional response model in which the inefficiency effects are not present. It is a special case of the stochastic frontier production function model whereby the total variation of output from the frontier output due to the technical or economic inefficiency is zero, that is $\gamma = 0$. The second model was the general model where there is no restriction and thus $\gamma \neq 0$. The two models were compared for the presence of technical or economic inefficiency effects (as the case may be) using the generalized likelihood ratio test which was defined by the test statistic chi-square ($\chi^2$) expressed as:LLR = -2{ln [L ($H_0$) – L ($H_a$) ]}………………………………………………………………………… (6)

LLR = log likelihood Ratio

$\chi^2$ = mixed chi-square distribution with 16 degree of freedom.

$H_0$ = Null hypothesis that $\gamma = 0$. This was given by value of likelihood function for the frontier model.

$H_a$ =Alternate hypothesis that $\gamma = 0$ for general frontier model.

## RESULTS AND DISCUSSION

### Level of Technical Efficiency for irrigated Vegetable Producers

The result obtained from the analysis of vegetable production for the studied vegetable enterprises is presented in Table 1. The result revealed that the mean levels of technical efficiency among the respondents were 0.81, 0.87, 0.85, 0.80 and 0.77 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper enterprises, respectively. This means that if an average farmer in a sample was to achieve the technical efficiency level of his most efficient counterpart, the average farmer could increase his/her output by 19, 13, 15, 20 and 23 percent for the enterprises, respectively, using the same level of inputs and technology. The distribution of the technical efficiency results in Table 1 also indicated that the respondents were operating at high levels of technical efficiency on the average. The high level of technical efficiency among the respondents might be due to the fact that variables included in the model adequately explained factors influencing technical inefficiency in vegetable production.

**Table 1:** Distribution of the Levels of Technical Efficiency of Vegetable Producers

| | Enterprise | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sole onion | | Sole Tomato | | Sole Pepper | | Onion/Tomato | | Onion/Pepper | |
| Efficiency Level | *F* | % | *F* | % | *F* | % | *F* | % | *F* | % |
| <0.40 | 1 | 1.1 | 00 | 00 | 00 | 00 | 1 | 1.4 | 5 | 12.5 |
| 0.40-0.50 | 3 | 3.4 | 00 | 00 | 00 | 00 | 2 | 2.7 | 00 | 00 |
| 0.51 - 0.60 | 5 | 5.7 | 00 | 00 | 00 | 00 | 4 | 5.4 | 1 | 2.5 |
| 0.61 - 0.70 | 12 | 13.6 | 5 | 10 | 4 | 9.1 | 16 | 21.6 | 9 | 22.5 |
| 0.71-0.80 | 17 | 19.4 | 7 | 14 | 12 | 27.3 | 14 | 18.9 | 3 | 7.5 |
| >0.80 | 50 | 56.8 | 38 | 76 | 28 | 63.6 | 37 | 50.0 | 22 | 55 |
| Total | 88 | 100 | 50 | 100 | 44 | 100 | 74 | 100 | 40 | 100 |
| Mean | 0.81 | | 0.87 | | 0.85 | | 0.80 | | 0.77 | |
| Min | 0.30 | | 0.62 | | 0.60 | | 0.45 | | 0.21 | |
| Max | 0.99 | | 0.99 | | 0.99 | | 0.99 | | 0.99 | |

Source: Field Survey, 2013.

*F* = Frequency, % = Percentage

**Determinants of technical efficiency of vegetable production**

Technical efficiency for different vegetables production enterprises studied were estimated and discussed. The enterprises considered were sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper. The maximum likelihood estimates of the stochastic production frontier function were obtained. The result is presented in Table 2. The findings revealed that the value of sigma square for the enterprises as 1.909, 0.995, 1.453, 1.217 and 1.345 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively, and significant at one percent level. This indicates goodness of fit, and correctness of distributional form assumed by the composite error term in the model. The variance ratio (gamma) was also significant for the studied enterprises with 0.994, 0.944, 0.966, 0.956 and 0.984 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively. The values of gamma indicate the systematic influence that is unexplained by the production in the dominant source or error terms. This means that more than 90 percent of the variations in the output among the vegetable producers were due to disparities in technical efficiency. The gamma result also show a presence of inefficiency in the production of vegetable under different enterprises in the study area. Hence, the hypothesis that inefficiency is not present in vegetable production enterprises is rejected. The estimated maximum likelihood coefficients of all the variables in the production function for the studied enterprises were positive, except those associated with cost that was negative. This conformed to the *a priori* expectation, indicating that the estimated production is an increasing function of inputs used. The coefficients of farm size for all the enterprises were positive and significant at one percent level. The values of the coefficients were 0.125, 7.225, 2.261, 0.171 and 2.090 for sole onion, sole tomato, sole pepper, onion/tomato and onion/ pepper enterprises, respectively. This means that one percent increment in farm size will lead to increase in outputs by 0.125, 7.225, 2.261, 0.171 and 2.090, respectively. The implication is that there is a chance for increasing output by expanding farm land.

**Table 2: Maximum Likelihood Estimates of the Cobb-Douglas Production Frontier Function for Vegetable Production Enterprises**

| **VariablesEnterprises** | | **Sole Onion** | | **Sole Tomato** | | **Sole Pepper** | | **Onion/Tomato** | | **Onion/Pepper** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Parameters** | **Coefficient** | **t-value** | **Coefficient** | **t-value** | **Coefficient** | **t-value** | **Coefficient** | **t-value** | **Coefficient** | **t-value** |
| Constant | $\beta_0$ | 3.902 | 8.751*** | 6.956 | 7.670*** | 3.245 | 3.621*** | 7.370 | 14.249*** | 1.766 | 16.522*** |
| Ln farm size ($X_1$) | $\beta_1$ | 0.125 | 9.784*** | 7.228 | 12.776*** | 2.261 | 8.275*** | 0.171 | 4.520*** | 2.090 | 11.073*** |
| LnFamily labour($X_2$) | $\beta_2$ | 0.311 | 8.599*** | 1.233 | 1.969* | 0.284 | 2.314** | 0.314 | 7.112*** | 0.415 | 2.845*** |
| Ln Hired labour($X_3$) | $\beta_3$ | 0.095 | 3.533*** | 0.594 | 2.173** | 0.100 | 2.840*** | 0.160 | 6.393*** | 0.245 | 2.777*** |
| Ln Inorganic fert($X_4$) | $\beta_4$ | 0.061 | 2.102*** | 0.246 | 2.003** | 0.105 | 7.140*** | 0.070 | 2.008*** | 0.135 | 2.620*** |
| Ln Organic fert($X_5$) | $\beta_5$ | 2.307 | 23.892*** | 2.488 | 2.828*** | 1.249 | 1.538$^{NS}$ | 3.180 | 10.221*** | 1.605 | 1.968* |
| Ln Agrochem ($X_6$) | $\beta_6$ | 0.149 | 2.3085*** | 1.742 | 3.812*** | 2.269 | 3.445*** | 0.337 | 3.810*** | 1.407 | 4.649*** |
| Ln Cost of seed/seedling ($X_7$) | $\beta_7$ | -0.693 | -16.144*** | -1.358 | -12.69*** | -1.398 | -15.796*** | -0.090 | -3.368*** | -0.171 | -5.409*** |
| Ln Cost of Irrg($X_8$) | $\beta_8$ | -0.177 | -4.075*** | -4.024 | -3.791*** | -0.196 | -1.956* | -0.201 | -4.551*** | -0.217 | -2.271** |
| **Inefficiency** | | | | | | | | | | | |
| Ln Farming exp. ($Z_1$) | $\alpha_1$ | -0.013 | -4.571*** | -7.178 | -16.142*** | -3.151 | -7.070*** | -0.272 | -3.313*** | -0.857 | -5.414*** |
| Ln Level of formal Edu. ($Z_2$) | $\alpha_2$ | -0.184 | -2.677*** | -1.086 | -4.141*** | -3.312 | -16.413*** | -0.043 | -0.993$^{NS}$ | 0.069 | 1.035$^{NS}$ |
| Ln Ext. Contact ($Z_3$) | $\alpha_3$ | -0.358 | -12.100*** | -2.299 | -9.284*** | -0.572 | -12.440*** | -0.271 | -1.725$^{NS}$ | -2.023 | -4.968*** |
| Ln Credit Avail. ($Z_4$) | $\alpha_4$ | -0.134 | -1.622$^{NS}$ | -7.139 | -10.961*** | -3.396 | -5.977*** | -1.273 | -7.560*** | -0.540 | -2.109** |
| Ln Dist. to Mkt. ($Z_5$) | $\alpha_5$ | -0.086 | -1.629$^{NS}$ | -3.350 | -7.021*** | -0.226 | -0.649$^{NS}$ | -8.065 | -4.982*** | -1.145 | -5.650*** |
| Ln M/ship of Farmer Ass. ($Z_6$) | $\alpha_6$ | -0.754 | -15.627*** | -2.109 | -2.787*** | -9.513 | -14.357*** | -2.207 | -9.164*** | 0.259 | 1.059$^{NS}$ |
| Ln Owned Irrg. Facility ($Z_7$) | $\alpha_7$ | -0.494 | -3.115*** | -9.996 | -13.608*** | -1.076 | -13.845*** | -2.028 | -4.760*** | -4.124 | -6.366*** |
| Ln Off- farm Income ($Z_8$) | $\alpha_8$ | -0.103 | -2.709*** | -0.116 | -15.207*** | -0.067 | -12.990 *** | -0.112 | -7.629*** | -0.996 | -13.181*** |
| Sigma Square | $\delta^2$ | 1.909 | 7.026*** | 0.995 | 4.437*** | 1.453 | 9.875*** | 1.217 | 10.649*** | 1.345 | 5.300*** |
| Gamma | $\Gamma$ | 0.994 | 10.970*** | 0.944 | 20.535*** | 0.966 | 11.785*** | 0.956 | 5.265*** | 0.984 | 3.513*** |
| Log likelihood ratio | | -92.376 | | -45.220 | | -47.551 | | -65.804 | | -38.636 | |

Source: Computed from Field Survey Data, 2013.*** Significant at 1%, ** Significant at 5%, * Significant at 10%, NS Not significant**.**

The coefficients for family labour were found to be positive and significant for all the enterprises. Family labour for sole onion, onion/tomato and onion/pepper were significant at one percent level, while those of sole pepper and sole tomato were significant at five percent, and ten percent, respectively. The values of the coefficients for family labour for all the studied enterprises were 0.311, 1.233, 0.284, 0.314 and 0.415 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively. This indicates the importance of labour in vegetable production. This might be due to the fact that vegetable production involves a lot of agronomic practices which are done manually using hand tools, indicating labour intensity in vegetable production in the study area. This result is similar to the findings of several studies (Umoh, 2006; Okezie and Okoye, 2006; Udoh and Etim, 2008; Okon *et al.,* 2010)

The result shows coefficients of hired labour for the enterprises studied were also positive and significant at one percent level except for sole tomato enterprise which was significant at five percent level. The magnitudes of the coefficients of hired labour were 0.095, 0.594, 0.100, 0.160 and 0.245 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively. This indicates that one percent increase in hired labour in vegetable production would lead to increase in output equal to the magnitude of the coefficients of the respective enterprises studied.

Inorganic fertilizer had a positive coefficient as *a priorily* expected and was statistically significant. The results revealed that inorganic fertilizer is an important factor in vegetable production with coefficients 0.016, 0.246, 0.105, 0.070 and 0.135 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively. This means that an increase in inorganic fertilizer leads to increase output by value equal to that of the coefficient of the variable in the respective enterprises. The significance of this variable may be due to the nutritional requirements of vegetables which depend on fertility of soil (Gambo, 2008), hence sustenance of soil fertility is of paramount importance in vegetable production.

Agrochemicals play important role in vegetable production as indicated by the positive and significant coefficients (one percent) for the studied enterprises. The results revealed that magnitudes of the coefficients of agrochemicals were 0.149, 1.742, 2,269, 0.337 and 1.407 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper. This implies that one percent increase in the use of agrochemical leads to increase in output equal to the values of the coefficients in each of the enterprises. The implication is that agrochemical contributes positively to the output of vegetable in the study area.

The result also revealed that the coefficients of costs of seed/seedling and irrigation materials were found to be negative and significant at one percent. Since the dependent variable is output, increased use of these variables leads to increased output. This means that more utilization of the variables had implications for cultivation of large farm size. The value of the coefficient of seed/seedlings were -0.693, -1.388, -1.398, -0.090 and 0.171 while for irrigation materials were -0.177, -0.024, -0.196, -0.201 and -0.217 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively. This implies that output can be increased with increased employment of these resources which adds to the cost of production of the enterprises. The negative sign implies that all things being equal increasing the use of these resources have negative effect on farm profit.
The estimate of inefficiency variables is also presented in Table 2. The results revealed that the estimated coefficients of inefficiency variables were found to be negative and significant. The negative sign on the estimated parameters is an indication that the variables had negative effects in explaining technical inefficiency. This is because the dependent variable in the model was inefficiency; hence negative sign means reduction in inefficiency.

The coefficient of farming experience for the studied vegetable enterprises were -0.013, -7.178,-3.151,-0.272 and -0.857 sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively, and significant at one percent level. This implies that farming experience significantly reduces inefficiency in vegetable production. Therefore, increase in years of farming would lead to decrease in technical inefficiency by amount equivalent to the corresponding coefficient in each enterprise. The finding goes in consonance with the findings of Ayinde*et al* (2011) that experienced farmers were more efficient in farm productivity than new farmers. The implication of this result is that farmers are more comfortable when they have experience in production techniques.

As expected the coefficient of level of formal education was negative and significant for all the enterprises. The values of the coefficients were -0.184, -1.086, -3.312, -0.043 and -0.069 sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, and significant at one percent level. The levels of formal education for onion/tomato and onion/pepper were not significant. The results indicate that increase in level of formal education by a unit leads to reduction of technical inefficiency by amount equal to the values of the coefficient in each enterprise. The implication is that with higher level of education, a vegetable farmer can reduce technical inefficiency by adopting required agronomic practices. This result is in line with the findings of

Obwona (2006), Bifarin*et al.*( 2010) and Asogwa*et al.* (2011), that education of farmers had negative and significant effect on technical inefficiency.

The result further revealed that coefficients of extension contact for the studied vegetable enterprises were negative and significant at one percent level. The value of the coefficients of extension contact for the enterprises were -0.358, -2.299, -0.572,-0.271 and -2.023 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively. This means that with one percent increase in the number of contact between the respondents and extension agents, there will be reduction in the technical inefficiency among the respondents by value equivalent to coefficient of the respective enterprises. This result is in line with the findings of Alam (2012) and Vanisaveth (2012), that extension contact received by farmers negatively affect technical inefficiency. This implies that there is a negative relationship between extension contact and technical inefficiency among the respondents.

The coefficient of credit availability was found to be -0.134, -7.139, -3.396, -1.273 and -0.540 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively. The results indicate that technical inefficiency of vegetable farmers' increases by a value equal to those of the respective coefficients as the level of availability of credit increases by one percent. This may be due to the fact that with credit, farmers acquire more and relevant production inputs which enable them acquire improve inputs to perform better, hence reduces technical inefficiency. This result goes in conformity with the findings of Abdulai and Huffman (1998) in a study in Ghana where the estimated coefficient of credit availability was negative in explaining profit inefficiency among rice farmers.

Most vegetables are perishable and proximity to market from point of production plays an important role in getting them disposed. The results revealed that the coefficient of proximity to market for the studied vegetable enterprises were found to be -0.086, -3.350, -0.226, -8.068 and -1.145 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively and significant at one percent level. This means that the respondents' level of technical inefficiency reduces with proximity to market. This may be due to the fact that farmers can sell their produce at ease and can acquire relevant inputs and information to enhance production. Proximity to market was not significant in sole onion and sole pepper enterprises. This might be due to less perishability of these crops as compared to other vegetables especially tomato. Onion and pepper can be processed and preserved for longer periods without fear of spoilage. Hence, proximity to market may not significantly affect technical inefficiency of onion and pepper productions.

The coefficient of membership of farmers' association was negative as expected and significant at one percent level for the studied enterprises except for onion/pepper enterprises. The values of the coefficients were -0.75, -2.11, -9.51, -2.21 and 0.26 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper enterprises, respectively. This indicates that farmers who are members of associations tend to be less technically inefficient. This may be due to the fact that associations facilitate access to market, relevant information on farm practice and provision of technical assistance. Moreover, membership confers better opportunities to access to credit.

The results also revealed that coefficient of ownership of irrigation facilities for the studied enterprises were found to be negative and significant at one percent level. The value of the coefficients were -0.494, -9.996,-1.076, -2.028 and -4.124. This means that with one percent unit increase in ownership of irrigation facilities, there will be reduction in technical inefficiency among vegetable farmers in the study area. This may be due to the fact that with adequate irrigation facilities, respondents would be able to carry out farming practices especially irrigating crops timely and effectively.

The coefficients of off-farm income were negative and significant at one percent level. The values of the coefficients were -0.103, -0.116, -0.067, -0-112 and -0.996 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper enterprises, respectively. This means that increase in off-farm income would lead to reduction in technical inefficiency equal to values of respective coefficients of the enterprises. The implication is that respondents could have more funds at their disposal to be able to purchase more inputs required for production of vegetable.

**Hypothesis testing for technical efficiency**

The test of two null hypotheses associated with the model of stochastic frontier production function were carried out using the generalized Likelihood Ratio(LR) statistics and the results is presented in Table 3. The result revealed that the first null hypothesis $H_0$: $\gamma= 0$, that is inefficiency is absent from the model was rejected at 5 percent level of significance.

**Table 3:** Generalized Likelihood Ratio Test of Hypothesis for the Parameters of the Stochastic frontier production for vegetable farmer in Borno State

| Enterprise | Null Hypothesis | Log-likelihood | Chi-square | Critical value* | Decision |
|---|---|---|---|---|---|
| | $H_0$:γ=0 | -168.96 | 86.5 | 26.98 | Reject |
| Sole onion | $H_0$: $\alpha_1$+…..+ $\alpha_{16}$=0 | -118.62 | 52.9 | 26.98 | Reject |
| | $H_0$:γ=0 | -115.80 | 50.5 | 26.98 | Reject |
| Sole tomato | $H_0$: $\alpha_1$+…..+ $\alpha_{16}$=0 | -163.87 | 37.3 | 26.98 | Reject |
| | $H_0$:γ=0 | -116.34 | 33.2 | 26.98 | Reject |
| Sole pepper | $H_0$: $\alpha_1$+…..+ $\alpha_{16}$=0 | -157.99 | 74.2 | 26.98 | Reject |
| | $H_0$:γ=0 | -150.21 | 41.2 | 26.98 | Reject |
| Onion/tomato | $H_0$: $\alpha_1$+…..+ $\alpha_{16}$=0 | -188.19 | 40.0 | 26.98 | Reject |
| | $H_0$:γ=0 | -114.5 | 39.0 | 26.98 | Reject |
| Onion/pepper | $H_0$: $\alpha_1$+…..+ $\alpha_{16}$=0 | 147.41 | 57.6 | 26.98 | Reject |

Source: Computed Chi-square Analysis, 2013.

The result indicates that chi-square computed for the presences of technical inefficiency effect in the different vegetable enterprises studied were 86.5, 50.5, 33.2, 41.2 and 39.0 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively. The critical value of the chi-square at 5 percent level of significance with 16 degree of freedom was 26.98 for each of the enterprises. The null hypothesis of no technical inefficiency in vegetable farmers production (γ= 0) was rejected at 5 percent level. Thus traditional response function will not adequately represent the data for vegetable production in the study area. Hence, stochastic frontier model was the preferred model for analysis.

The estimated gamma parameter (γ) of the stochastic frontier production function for the studied vegetable production enterprises function were 0.99, 0.94, 0.97, 0.97 and 0.98 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper, respectively, indicating that 99, 94, 97, 97 and 98 percent of variation in outputs of the studied vegetable farmers were due to technical inefficiency. The second null hypothesis $H_0$: $\delta_1$+………+ $\delta_8$, which is coefficients of the explanatory variables in the inefficiency model are simultaneously zero is also rejected as shown in Table 3. This indicates that the eight explanatory variables included in the model made a significant contribution to the inefficiency associated with the outputs of the different vegetable production enterprises studied.

## CONCLUSION AND RECOMMENDATIONS

The study concluded that inefficiency was present in irrigated vegetable production in the study area. The production variables for the studied vegetable enterprises were significant in contributing to the production of vegetables under irrigation. Farm size, labour (both family and hired) and costs of irrigation contributed immensely to vegetable outputs. The technical inefficiencies variables which includes experience, level of formal education access to credit and distance to market contributed positively to the technical and allocative efficiencies.

Based on the findings of the study, it was recommended that concerned agencies should promote both formal and non-formal education as the way forward to increasing efficiency in vegetable production. The vegetable farmers should be mobilized and encouraged to strengthen the activities of farmers' clubs and associations. This could help the vegetable farmers to acquire professional advice, inputs and credit facilities and use them efficiently, giving rise to efficiencies in vegetable production. Synthetic fertilizers should also be made available to farmers at affordable and cheaper rate to supplement contribution of organic fertilizers to increasing output and profit of the vegetable farmers. Provision of efficient agricultural market and information could increase the efficiency in vegetable production.

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