International Journal of Agricultural Economics
2023; 8(6): 238-244
http://www.sciencepublishinggroup.com/j/ijae
doi: 10.11648/j.ijae.20230806.12
ISSN: 2575-3851 (Print); ISSN: 2575-3843 (Online)

Technical Efficiency of Groundnut Production: The Case of North Western Ethiopia

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To cite this article:
Desalegn Teshale Wolde, Belete Woundefiraw, Welay Tesfaye. Technical Efficiency of Groundnut Production: The Case of North Western Ethiopia. *International Journal of Agricultural Economics*. Vol. 8, No. 6, 2023, pp. 238-244. doi: 10.11648/j.ijae.20230806.12

Received: April 28, 2023; **Accepted**: Jun. 19, 2023; **Published**: November 17, 2023

Abstract: This study was aimed to measure the technical efficiency of farmers and to investigate determinants of technical inefficiency of groundnut producers in the north western parts of Ethiopia. A Semi-structured questionnaire was used to collect the primary data from 201 randomly selected groundnut producers in the North western parts of Ethiopia. Descriptive statistics and stochastic frontier production model was employed. The result showed that the average technical efficiency of groundnut production was 0.68. This indicates, given the available existing technology, groundnut production can be increased by 32%. The SFP model revealed that area and labor were found to be statistically and positively significant at 1 and 5% significance levels respectively. The positive result suggests; a 1% increase can have a potential increase in the yield of groundnut. The maximum likelihood estimates of the SFP model showed that Age, livestock ownership, marital status and training of the household head was found to be negatively influenced the technical inefficiency; whereas, sex of the household head and proximity to the nearest market were positively influenced technical inefficiency of groundnut producers. Therefore, this study suggests that improving livestock ownership and productivity, integrating women with agricultural extension service and programs, and arranging farmers experience sharing will enhance the technical efficiency of the farmers.

Keywords: Technical Efficiency, Groundnut Production, Stochastic Frontier Production

1. Introduction

Groundnut (Arachis hypogaea) is an annual legume crop and one of the major food and oil crops in the world. The crop is originated in Latin America and was introduced to Africa by the Portuguese in the 16th century [1]. The crop was introduced to Ethiopia in the 1920s and is primarily grown for oil seed, food, and animal feed [2]. In Ethiopia, agriculture accounts for 42 percent of the GDP, employs about 85 percent of the labor force, and contributes around 90 percent of the export earnings of over 15 million smallholders who produce about 90 percent of the country's agricultural production. This shows that the overall economy of the country and the food security of the majority of the population depend on smallholder agriculture [3]. Groundnut is one of the most important agricultural crops in the world [1], and it is a suitable crop in tropical and subtropical regions due to its adaptability in dry conditions and low input requirements. It is a rich source of oil (45–56%), protein (25–30%), carbohydrates (9.5–19.0%), minerals (P, Ca, Mg, and K), and vitamins. Groundnut also improves soil fertility by fixing atmospheric nitrogen in to the soil [4].

India, China, Nigeria and Sudan are the largest groundnut producing countries in the world. The low land areas of Ethiopia have considerable potential for increased oil crop production including groundnut. Groundnut mainly grown in Oromia national regional state (particularly in East Harerghe, West Harereghe, East Wolega, Illubabor zones), Amhara National regional state, Benishangul Gumuzu National regional state (Metekel, Assossa, Kemashi, MaoKomo Zones), Southern nations Nationalities and people’s region (South omo, Konto special woreda) and Gambella National regional state and Dire dawa. More than 521,326 farmers have grown ground nut with area coverage of 80,841.57ha of land and the total production obtained was over 1.45million Quital. Regionally, Oromia constitutes the largest share of production (59%), followed by Benishangul Gumuzu (25%)

and Ahmara (7%) [3].

2. Statement of the Problem

During the past years, the government of Ethiopia has undertaken various development interventions to enhance agricultural productivity so as to achieve food security and reduce deep rooted poverty. Groundnut production in Ethiopia is found to be constrained by several biotic and abiotic factors i.e. critical moisture stress, lack of improved and appropriate production and post-harvesting practice, and diseases affecting both above and underground parts of the crop. The lowland areas of the country have considerable potential for increased oil crop production including groundnut. Different literatures showed that, given the available technologies the productivity of the crop can be increased. However, from the best of the authors' knowledge, no prior study was conducted in the area specific to efficiency. Therefore, this research will figure out the productivity efficiency of the groundnut farmers.

The research addresses the following research question;

1) What are the socioeconomic characteristics of groundnut producing farmers in the study area?
2) Is there an efficiency differential among groundnut producers?
3) What are the sources of efficiency differentials among groundnut producers in the study area?

Specific objectives

1) To characterize the groundnut production systems in the study area.
2) To estimate technical efficiency of groundnut production.
3) To identify factors affecting technical inefficiency in groundnut production for growers.

3. Research Methodology

3.1. Description of the Study Area

This study was conducted in two groundnuts producing Districts found in North Western Ethiopia namely Pawe and Jawi. The Districts are found in Metekel and Awi zonal administrative. They are adjacent districts. Pawe is found at 575 Km to North Westen direction far away from Addis Ababa with geographical location at 36027'21.88''longitude and latitude of 11020'04.93'' It covers an area of 64,300 hectare with estimated population of 64,431 out of 33,302 (51.7% male) and 31,129 (48.3%female). The district is boarded with Jawi district in East and North, Mandura in the South and Dangur districts in the West directions. Similarly Jawi District is found at 612 Km far from Addis in the North Western direction with geographical location of 36029'17.58'' longitude and latitude of 11033'22.68'' with altitude of between 1000m to 1200m. It covers an area of 515,400 hectare with estimate population of 122,259 (53.03% male) inhabitants. The District is boarded Dangila in the East, Dangure and Pawe in the South, Quara District in the West and Alefa Tquesa in the North.

Both districts are characterized as mixed crop-livestock farming systems dominated by cereal and pulse crops. Groundnut is the leading pulse in terms of production and area coverage, followed by soya beans. It is also characterized as a warm, humid lowland area with high rainfall. The climate of both districts is relatively similar. It is characterized by a hot, humid, and unimodal rainfall pattern with high and heavy rain that extends from May to October with a mean annual rainfall of 1580 mm. The temperature ranges from 13.8 to 40.4°C [5].

3.2. Data Source and Methods of Data Collection

The primary data were collected with cross sectional survey design. Sampled groundnut households were subjected to give primary information with structured household questioner. Besides secondary data published and unpublished ones were also used for this study.

3.3. Sampling Technique and Size Determination

Three stage sampling procedure were employed to select respondent farmers in the study area. In the first stage two districts were purposively selected based on its high potential and production of ground nut. In the second stage, kebeles[1] were selected randomly. In the third stage, respondent households were selected from fresh list of the population in each kebeles (the smallest unit in Ethiopian administration). Following this the sample size were determined by the author [6].

$$n = \frac{N}{1+N(e^2)} \quad (1)$$

Where N refers to the total population size, n refers sample size and e level of precession set at 0.07 (at 90% confidence interval).

3.4. Methods of Data Analysis

Both descriptive and econometric methods were employed for data analysis. Descriptive methods like mean, min, maximum, percentage were used. T-test, and chi-square test were also used to test the significance level.

Efficiency models

Efficiency measurements basically are carried out using frontier methodologies, which shift the average response functions to the maximum output or to the efficient firm. Essentially there are two main methodologies for measuring TE: the econometric (parametric) approach, and the mathematical (non-parametric) approach. The parametric models are estimated based on econometric methods [7] and the non-parametric methods of measuring productive inefficiency are broadly speaking dependent upon classification of quantitative and qualitative variables under the well-known methodology of Data Envelopment Analysis [8]. Efficiency measures assume as production function of the fully efficient firm is known. But this is not possible in the reality; hence the efficient isoquant must be estimated from the sample data taking the relatively best performing firms as fully efficient [9]. Parametric approach is used in this study.

Parametric frontier model can further be classified into deterministic and Stochastic Frontier Production (SFP) model. The very basic difference between the two models is on their assumption about the error term. The deterministic model assumes that any deviation from the frontier is due to inefficiency, while the stochastic approach allows for statistical noise.

Non- stochastic/deterministic

According to [9], this model doesn`t take account the possible influences of measurement errors and other noises up on the shape and positioning of the estimated frontier. Alternatively, any deviation from the frontier will be taken as inefficiency. Non- stochastic/deterministic production frontier can be estimated using linear programming or econometric techniques such as Corrected Ordinary Least Square (COLS). Application of this model, especially in cases where there is high probability of measurement risk, will exaggerate the inefficiency estimates as compared to the models which decompose the error term in to two components. The author [10] specified a non-stochastic or deterministic frontier model of Cobb Douglas production function for a sample of N firms as;

$$\ln (Yi) = F (Xi; \beta i) - Ui \qquad (2)$$

$i = 1, 2, N$

Where re Yi is the output of the *i*th firm; *Xi* is the vector of input quantities used by the *ith* firm; β_i is a Vector of unknown parameters to be estimated; *F* (.) denotes appropriate function (Cobb Douglas); and *Ui* is a non-negative variable representing the inefficiency in production.

Stochastic frontier production function

To solve the limitation of deterministic approach [10, 11] designed a method that involves dropping a percentage of firms closest to the estimated frontier, and re-estimating the frontier using the reduced sample. The arbitrary nature of the selection of some percentage of observation to omit has meant, however, that Timmer's probabilistic approach has not been widely followed [9]. In the process of managing the outliers, so that the inefficiency level would not be exaggerated, firms/farmers who outperform will be considered as outliers.

Unlike the deterministic model, SFP function has a disturbance term with two components; the error component (v) and the stochastic noise (u). The other merit of the SFP function over the former (deterministic) is that the estimation of standard errors and tests of hypothesis is possible, which the deterministic model fails to fulfil because of the violation of the maximum likelihood regularity conditions [9]. Hence, stochastic frontier production (SFP) was employed to estimate technical efficiency as developed [12]. The production function for groundnut yield and input variables in its natural logarithmic form is as follows;

$$lnYi = \beta o + \sum_{n=1}^{n} \beta nlnXni + e \qquad (3)$$

Where *ln* denotes natural logarithm, Y_i is groundnut output of the i[th] farmer in kg, β is the parameter to be estimated, X_i is the vector of input quantities assumed to affect the production of groundnut production e is disturbance term or error term.

Output (OUTPUT): Output, which is the dependent viable in the estimation of production functions, is measured in kilograms (Kg). The data was collected using different local measurement units of output, however for uniformity it was changed to the standard measurement unit, kilogram. Hence output measured in Kg was used in the analysis.

Input: This refers to variables required for the production of groundnut used in the estimation of production functions.

The dependent variable in stochastic frontier production function (SFP) model is Groundnut yield; the independent or input variables and its expected influence on the dependent variable (Ground nut output) are stated in the following table 1.

Table 1. *Description of the variables included in SFP model.*

Variable	Variable Explanation	Unit of measurement	Expected sign
OUTPUT	Output obtained from GN	Kilograms	
LAND	Area allocated for groundnut crop production	Hectare	+
SEED	Groundnut seed sown	Kilograms	+/-
LABOR	Labor used for groundnut production	Man-days	+
OXEN	Oxen labor used for groundnut production	Oxen-days	+

Source: Review of empirical Literature

The technical efficiency of a farmer is between 0 and 1, and is inversely related with the level of technical inefficiency. Technical inefficiency effect (Ui) with mean *U* is defined as follows;

$$U_i = \alpha_0 + \alpha_i F_i + \ldots \alpha_n F_n + Zi \qquad (4)$$

Where F_i is the characteristics of the farmer (age, education…), α unknown parameters to be estimated along with the variances, the *Zi* is error term.

The technical inefficiency scores are taken as the dependent variable in the inefficiency models. Independent variables proposed to affect the inefficiency of ground nut production and their description is indicated in the table below.

Table 2. *The variables included in the inefficiency model.*

Variable	Variable Explanation	Unit of measurement	Expected sign
AGE	Age of the household head yrs		-
SEX	Sex of the household head	Dummy if male=1	-
EDUCATION	Educational level of the household head	Years	-
FAMILY SIZE	Total family size	Number	-
TLU	Tropical livestock Unit	Number	-
OFFINCOM	Off-farm income obtained	ETB	+/-
EXTFEQ	Extension frequency per month	Number	-
DSTMK	Distance to the nearest Market	Kilometer	+/-
COOPS	Cooperative Membership	Dummy if mem=1	-
MART_STAT	Marital Status	Dummy if married=1	-
TRAINING_GN	Training received on Groundnut	Dummy if recev=1	-
Mobile ownership	Mobile Ownership	Dummy if owns=1	-

Source: Review of empirical literature

4. Result and Discussion

4.1. Descriptive Results

The mean groundnut per hectare yield is 1123.5 kg with minimum of 70kg and maximum of 4000 kg production per hectare (see Table 3). According to the research [3], the national average of groundnut yield per hectare is 1.6ton, this shows that the yield obtained in the study area is below the national average. The total average land allocated for groundnut production in the study area was about 0.85ha with minimum of 0.15ha and maximum of 3.5 ha. The amount of labor used for ground nut production included family and hired labor irrespective of sex. Hence, the number of labor involved for ground production from planting up to harvesting on average was 62.2 man-day with minimum 7.9 man-day and with maximum of 163.3 man-day. The average seed used per hectare of groundnut was about 76.3kg with minimum 14.3kg and maximum of 240kg. In the study area the groundnut production is entirely done by human labor and oxen animals. It is to mean that mechanization is yet to entre at the time of this study. Hence, ploughing, planting, transporting from the farm were done by the help of available draught animals. The average pair of oxen used for the production of groundnut in the study area was 4.2 with minimum of 0.5 and 16.3 oxen days. Most of the farmers (78%) in the study area weeded their plots twice.

Table 3. *Descriptive results of variables used in the SFP estimation.*

Variable	Observation	Mean	St.dev	Minimum	Maximum
Groundnut (Kg/ha)	201	1123.5	603.7	70	4000
Land (ha)	201	0.85	0.5	0.15	3.5
Labor (manday)	201	62.2	33.5	7.9	163.3
Seed (Kg)	201	57.3	32.4	10	200
Oxen days	201	4.2	2.7	0.5	16.3

Source: Own computation (2020)

The average age of sampled households was 42.7 years ranging from 25years to 85years old. The educational level of households in the study area was 1.3 years of schooling ranging from zero class to 10 years of schooling. Average agricultural extension contact per month was 2.6. The average farming experience of groundnut production of sampled households was 11.2 years with minimum one year and maximum of 35 years. The livestock holding of sampled households in the study area were 7.7 in terms of TLU which ranges from no livestock holding to maximum of 38.3 TLU as shown in table 4.

Table 4. *Socioeconomic characteristic variables used in the inefficiency model.*

Variable	Observation	Mean	Min	Max	Std.Dev
Age of the household head	201	42.7	25	85	11.8
Educational level of the household head	201	1.3	0	10	2.1
Family size	201	5.3	1	2	2.4
Livestock in terms of TLU	201	7.7	0	38.3	6.2
Off and or non-farm income	201	1636.8	0	60000	6196.7
Extension frequency per month	201	2.6	0	24	5.2
Distance from home to the nearest market in minutes	201	59.8	0	360	81.9
Groundnut production experience in years	201	11.2	1	35	7.5

Source: Own computation (2020)

Most of the household heads in the study area were male headed (96 percent). Majority of sampled households did not received training specific to ground nut production (86%). Mobile ownership will help obtain agricultural information. Most of the sampled household heads do have at least one mobile phone in the family (78%). In the study area some of the *kebeles* (lowest administrative unit) have their own cooperatives. However, majority of the respondent households were not member of the cooperatives (Table 5).

Table 5. *Summary of dummy variables used in the inefficiency models.*

Variables	Observation	Frequency		Percentages	
		Yes	No	Yes	No
Sex of household head (Male=1, 0 otherwise)	201	192	9	95.52	4.68
Training received on groundnut production	201	28	173	13.93	86.07
Cooperative membership	201	45	156	22.83	77.61
Mobile ownership	201	155	46	78.11	22.88

Source: Own computation (2020)

4.2. Econometric Results

Before running the econometric model basic assumptions of the regression model tested for multicollinearity and hetrosekedasticity issues. In both cases the test result was in the acceptable range. The result of econometric model estimation is presented by comparing the results of this study with other studies done in various areas. The maximum likelihood estimation of the parameters of the frontier production function is presented.

Out of four variables included in the production model, two of them had a significant effect in explaining the variation in groundnut production. These variables are area coverage and labor used for groundnut production. The coefficients of these variables are positive indicating there were significantly different from zero. The coefficients of land were significant at 1% significance level and the coefficient of labor was significant at 5% significance level. Keeping all other input variables constant, a one percent increase in the area of land allocated for ground nut production would increase the output of groundnut by 0.225%. Likewise, a one percent increase in labor for the groundnut production would increase the output by 0.174% (see table 6 below).

Table 6. *Maximum likelihood estimation of SFP.*

Input Variable	Coefficient	Std. Error	Z-value
lnArea	0.225	0.083	7.5***
lnSeed	0.031	0.075	0.40
Lnlabor	0.174	0.069	2.49**
lnOxenday	0.225	0.498	0.45
Constant	0.634	0.361	17.55***
Mean TE (%)	0.68		

Source: Survey result (2020)

Determinants of technical inefficiency

As indicated the table below from twelve expected inefficiency variables, seven variables were found to significantly affect groundnut production in the study area. Accordingly, the negative and significant coefficients of the age of the household head, total livestock unit, marital status of the head and training indicate that improving these factors would reduce the technical inefficiency. Whereas the positive and significant variables like sex of the household head, family size and distance to the nearest market indicate that increasing in the magnitude of these variables would aggravate the technical inefficiency of the groundnut production in the study area (Table 7).

Age of the household head: The age of the household head can be a proxy for farming experience. The result of this study indicates that age of the household heads influenced technical inefficiency negatively at 10% significant level. This indicates that as the age of the farmer increases her/his experience of farming also increases. This might be due to older farmers have cumulative crop production experiences. Besides, experienced farmers can better manage and assess the complex farming practices and techniques for decision making. The result was consistent with the findings [13].

Sex of the household head: Different from prior expectations sex of the household head influenced technical inefficiency positively at 5% significance level. The result suggests that female headed households are more efficient in groundnut production than male counterparts. The result was consistent with the arguments [14].

Family size: Individuals who are living with the household head are counted as family members. Family size, measured in numbers, found to be statistically and positively influence the level of technical inefficiency of groundnut producers at 5% level of significance. The result argues that, as the number of individuals living in a house increases the technical efficiency of groundnut production would decrease. The possible reason might be as most farmers use hired labor for the groundnut production. The result is similar with the findings [15].

Livestock ownership: The coefficient of livestock in tropical units affects the technical inefficiency of crop production negatively at 1% significant level. This might be livestock provides manure for the farm, source of cash income which helps to finance inputs like inorganic fertilizer, chemicals, and purchase of oxen. The result was in line with findings [16].

Distance to the nearest market: The hypothesis in this study was that households located near markets were expected to have higher technical efficiency than those located in remote areas. It was assumed that proximity to markets increased the opportunities of farmers to sell their products and purchase input at nearest distance. This result showed that proximity to the nearest market would have positive effect on technical inefficiency of groundnut producers at 5% significant level. The possible reason might be access to markets might increase the non-farm employment opportunities with higher returns than from farming, leading farmers to reallocate labor from farm to non-farm activities. Similar findings were obtained [17, 18].

Marital status of the household head: The coefficients of marriage status were found to be negative effects on technical inefficiency of groundnut production at 5% significance level. It is to mean that married household heads were more efficient in groundnut production than unmarried households. The result is consistent with the findings [19].

Training: Through training a farmer could gain the basic production techniques and build managerial capacity. A farmer who receives training on crop production and marketing of agricultural products would likely efficient than those who didn't. As expected, the coefficient of training influenced technical inefficiency negatively at 10% significance level. This result shows that those farmers who received training were more technically efficient than those didn't receive training on groundnut production. The result is consistent the findings [20].

Table 7. *Inefficiency variable estimation.*

Inefficiency Variables	Coefficient	Std.Err	Z-value
Age	-0.0068	0.035	-1.92*
Sex	3.934	1.211	3.25**
Education	-0.053	0.126	-0.42
Family size	0.309	0.128	2.4**
Total livestock in TLU	-0.757	0.245	-3.09***
Off farm and/or non-farm income	0.456	0.886	0.51
Extension contact	-0.025	0.085	-0.3
Distance to the nearest market	0.117	0.005	2.05**
Coops membership	-0.576	0.964	-0.6
Marital status of the head	-2.089	0.859	-2.43**
Training Received on groundnut production	-1.545	0.839	-1.84*
Mobile ownership of the head	-0.097	0.803	-0.12

Source: Survey result (2020)

5. Conclusion and Recommendation

Efficiency is widely believed as the heart of agricultural production. This is because the scope of agricultural production can be expanded and sustained through efficient use of resources. This study was conducted to analyse technical efficiency of smallholder farmers and identify factors contributing to technical inefficiency of groundnut production in north western parts of Ethiopia. Household level data were collected from 201 households using structured questioner. This study implied that the technical efficiency of farmers can be increased by better allocation of the existing input variables, mainly land and labor. Hence, due focus is needed to improve the efficiency of groundnut producers in the study area. Age, livestock ownership and training specific to groundnut production were significantly and negatively affect the technical inefficiency, whereas sex of household head and proximity to the nearest market had positive and significant effect on the technical inefficiency of groundnut producers in the study area. Thus, the result of this study provides information to policy makers and extension workers on how to improve efficiency level and specific determinants of technical inefficiency.

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