Omdurman Islamic University Journal(OIUJ)
مجلة جامعة أم درمان الاسلامية
https://journal.oiu.edu.sd/index.php/oiuj
https://doi.org/10.52981/oiuj.v18i1.2277
2022; 18(1):363-- 376
ISSN: 5361-1858

Estimation of Economic Efficiency of Sorghum and Sesame Crops Production in Habiella Agricultural Scheme in South Kordofan State

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To cite this article:

KH. N. AL, K., , H, H. A, M., & S, E, S. (2022). Estimation of Economic Efficiency of Sorghum and Sesame Crops Production in Habiella Agricultural Scheme in South Kordofan State. Omdurman Islamic University Journal, 18(1), 363-376. Retrieved from https://journal.oiu.edu.sd/index.php/oiuj/article/view/2277

ISSN: 5361-1858

Abstract

The study was carried out in Habiella Agricultural Scheme. The main purposes of the study were to measure economic efficiency of producing sorghum and sesame crops, to determine the main factors affecting economic inefficiency (Technical and Allocative), and to assess the maximum farmer's income level under optimum cropping pattern. The study mainly depended on primary data which was collected from a field survey conducted at Habiella Agricultural Scheme in season 2019/2020, by direct interviewing of farmers through a multi-stage stratified random sampling technique of about (191 farmers) using a structured questionnaire. Secondary data were collected from relevant institutional sources. Descriptive Statistics, Stochastic Frontier Model, Budget, and Linear Programming were used to analyze the collected data.

The results of descriptive statistics showed that; most farmers were males with a percent of 99.5%, and their active age group (45-60) age, the average family households members was (8) persons, with average of (2) members working in the farm. About 80.1% of the farmers have attained some sort of education; the average of the experience was 16 years.

Stochastic frontier production function analysis revealed that the mean technical efficiency of sorghum and sesame were 99%, 54%, respectively. The mean economic efficiency of sorghum and

sesame were 43%, 6%, respectively. Labors, area cultivated, seeds, and gasolines were significant variables for improving technical efficiency. Education, experience, and finance were significant in explaining technical inefficiency. The results of the linear programming showed that; the optimal land allocated to sorghum and sesame were 0.75, 1.25 feddans, respectively. The optimal returns were (7623 SDG) and the actual returns were (7190 SDG), the basic solution for the total costs plan increased from 5254 SDG to 5324 SDG, this increment was only 1.33%, comparing the optimal 2300 SDG and the actual 1936 SDG, net returns, the former outstripped the later by 18.80%. The budget analysis showed that the net returns were 230 SDG, 1704 SDG for sorghum and sesame, respectively.

The study recommended that: intensive extension programs to improve the economic efficiency (Technical and Allocative) of farmers, solving problems and obstacles that affect production of the two crops (sufficient financing at suitable time, efficient agricultural machineries, integrated pest management and improved seeds), adoption of using technical packages and full modern technologies recommended by Agricultural Research Centers.

Keywords: Economic Efficiency; Estimation; Habiella; Sesame; Sorghum; yield

1.Introduction

Sudan is the third largest country in Africa and seconds in the Arab counties occupying an area of about 1,882,000Km2. It lays in the North east part of Africa between longitude 21° 49 and 38° 34 E latitude 8° 45 and 22° 8 N. The total population of the country according to 2016 ensues is 39.60 million head with an annual growth rate of about 2.4% per year [1]. Agriculture in the Sudan represents the backbone of the Sudanese economy. Agriculture in the Sudan provides labor and livelihood for more than two thirds of the population, beside that agriculture contributes to GDP by more than one third of the total GDP of the Sudan. Despite the fact that oil sector and industrial sector have contributed in 2009 to the GDP by 13.1% and 23.8% respectively [2]. Agriculture remains the most important sector in the Sudan because it produces 60% the raw materials needed by the manufacturing sector [3]. The type of the agriculture in South Kordofanian is rain fed agriculture, which contributes in boosting the wheel of the country's economy. The rain fall in this area ranges between 450-900 mm per year [4]. The patterns of the agricultural production (animal and plant) are the most crucial economic activities in the area, with dearly seen domination of the traditional systems of cultivation. These agricultural characteristics represent factors of power and economic opportunities, which enable the area to flourish in producing set of products [5]. Licensed

vaunts: such as Bromo, khader, Um shagra, Giza32, Toshki and schindwell3. Early maturity varieties such as kanana2, and kanana4 Aboa (Bromo) and al-shagra. Local varieties such as A-jabali, Hariri, Abu-Qaner, Jabrock, A-baladi, Abdul Razeg Red and white, Red and white mountains. Types of resistance to disease and wilting such as Shadwell3, Toshki and Giza32 [4]. Habiella Agricultural Scheme is the most important cultivated area in the South Kordofan State. It is famous of two crops sorghum and sesame production, because soil is suitable for the both crops. Some oil factories are established to use the available raw material of sesame. In the recent days, sesame production is facing many difficulties, which affected the size of the production and quality. This study was conducted to know the factors that affect the economic efficiency of sesame production, as well as to find out the optimal cropping patterns [6]. Studies Economic Efficiency of Sorghum and Millet Production for Small Scale Farmers in Traditional Rain fed, North Kordofan State, Sudan. The average economic efficiency score of millet was 15%. This means that the millet farms use the combination of inputs at a cost inefficiencies level, they could potentially reduce their overall cost by 85% and still attain the current output level [7]. Studies Analysis of production efficiency and profitability of Watermelon in Kaga and Kukawa Local Government areas of Borno State, Nigeria. Economic efficiency concept when measuring any phenomenon as phenomenon of efficiency must be preceded by the identification of what is meant by that phenomenon in order to have meaning to clarify the concept productive Efficiency in the light of economic theory through economic decisions mode at the level of production unite that may be correct on both sides or in one, [8]. Economic efficiency Is the product of technical and allocative efficiencies, Thus, if a firm has achieved both technical and allocative efficient levels of production, efficient and new investment streams may be critical for any new development [9]. Production efficiency: refers to a firm's costs of production and can be applied both to the short and long run; it is achieved when the output is produced at minimum average total cost. For instance, we might consider whether a business is producing close to the low point of its long run average total cost curve. When this happens the firm is exploiting most of the available economies of scale. Productive efficiency exists when producers minimize the wastage of resources in their production processes [10] cited that productive efficiency has two components.

Deification Economic efficiency: Is the amount reduction in the production cost achieved by using the ideal allocation of rescores for low level costs? [11]. Proposed his idea that the economic efficiency of a farm consisted of two components:

Technical efficiency: - recorded as possibility to achieve on the maximum of production with potential input of production.

The technical efficiency: - is the possibility to obtaining the maximum of production by using a specified amount of production inputs from Technical Point of view and the reduced range from (0-1).

Allocative efficiency: - the possibility of obtain an ideal or less expensive mixtures of production inputs used in production with certain quality of production and the values range from (0-1).

This, incorporative these measurements (TE and AE) in order to obtain the "economic efficiency" EE, [12].

Economic efficiency: Is the possibility to obtain the lowest cost mix from inputs production to achieving the maximum production it is possible by any specific amount of inputs of production and their values range from (0-1), [13].

The results of farm budgeting analysis showed a net farm income of N105, 002.95 per hectare. Mean technical efficiency of 86 percent was achieved by watermelon farmers in the study area meaning that there is a scope for increasing watermelon production efficiency by 14 percent in the study area

Problem statement: In recent years, the operating efficiency and the production and productivity efficiency in rain fed area has deteriorated and the income of tenants has consequently declined. Habiella Scheme is no exception.

Sorghum and sesame production in the Sudan, in general, and Habiella locality in South Kordofan (in particular) is facing many difficulties such as economic, agriculture, climate, lack of in extension services, lack of funding policies by the government, conflict between farmers and animal keeper, and image new type of grasses (bests) during animal movement difficulties.

These difficulties led sorghum productivity to decline, (10-12) sack/fed, which is considered the ideal productivity and optimum sesame productivity (2-3 kantar/fed), [14]. In addition, the cultivated area of Sorghum and sesame is reduced, beside, the quality of sorghum and sesame produced is the less than ever used to produce.

- In recent years, the operating efficiency and the production and productivity efficiency in rain fed area has deteriorated and the income of tenants has consequently declined in Habiella Agricultural Scheme.
- The Habiella Agricultural Scheme is considered one of the most important schemes in the South Kordofan State start economic.
- Dose the weakness and absence of the finance in area consider one of the difficulties facing the economic efficiency of both crops?

- To what extent conflicts are affecting economic efficiency of the sorghum and sesame production in the area?
-

2. Methodology

This study was carried out during 2019/20 in Habiella Agricultural Scheme in South Kordofan State- Sudan**;** the study depended mainly on primary data which were collected through a field survey carried out in Habiella Agricultural Scheme among scheme farmers, the data collected by direct interviewing of farmers through a multi-stage stratified random sampling technique of about (191 farmers) using a structured questionnaire. Secondary data were collected from relevant institutional sources. Descriptive Statistics, Stochastic Frontier Model, Budget [15] were used to analyze collected data so as to estimate technical, allocative and economic efficiencies. Moreover, linear programming was applied to estimate the optimum crop pattern in the scheme. Moreover, linear programming was applied to estimate the optimum crop pattern in the scheme. Linear programming deals with problems in which the objective function is to be optimized (i.e. maximized or minimized) subject to linear equality constraints and sign restrictions on variables. The LP model may include constraints. Moreover, the variables maybe non-negative or unrestricted in sign .The objective function of this model were to maximize farmer's net return from crop production. The mathematical from the model followed the gnarl maximization function (Dent et al.1986 Hazel, 1986): [16]

$$\text{Max } Z = \sum_{t-1}^{n} RjXj$$

Subject to

1- Constrains of the from = $\sum_{t-1}^{n} aijxj \leq bi$

2 – And non- negativity Constrains = $xj \geq 0$, j =

1, 2… n

The equation model

This study used Attribute Sample formula for the sample size**:**

$S = Z^2 * N * E (1 – E) / [(A^2 * N) + (Z^2 * E (1 – E))]$

Where: S = required sample size (175),

Z = Factor for the desired confidence level (1.96). N =Population size (3332).

E= Expected error rate (5%). A = Precision range (3%).

- Using statistical package for social sciences (SPSS), and Frontier 4.1version to measure the indicters of sorghum production and their technical efficiency.

- Descriptive statistics was be used to identify the socio-economic characteristics.
- Technical efficiency will be addressed to determine the factors affecting both crops production.
- Partial budget analysis was used estimate to the costs and profits of both crops production.

Technical Efficiency of sorghum and sesame production model,

$$\text{Inyi} = \beta_0 + \sum_{j=1}^{n} \beta_j \text{Inx}_{ij} + v_i - u_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1) [17]}$$

$$\text{LnYi} = \ln\beta i + \beta 1 \ln X1i + \beta 2 \ln X2i + \beta 3 \ln X3i + \beta 4 \ln X4i + \beta 5 \ln X5i + VI - Ui$$

Where Y = annul total sorghum and sesame production (kg).

ln = the national logarithm.

Yi = yield of sorghum and sesame production (kg).

X_1= cost of seed of sorghum and sesame (SDG) /fed.

X_2 = cost of gasoline of sorghum and sesame (SDG)/ Gallon/ fed.

X_3 = cost labors of sorghum and sesame (numbers) (SDG) /fed.

X_4 = cost of pesticide of sorghum and sesame (SDG) /fed.

X_5 = area cultivated of sorghum and sesame / fed.

$\boldsymbol{\beta}0$, βj, V_I and Ui as previously defined in equation.

ei = error threshold consisting of white noise.

ui = represents the effect of technical efficiency

Inefficiencies model equation

$$\text{Ui} = \delta_0 + \sum_{s=i}^{n} \delta_i z_{si} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

$$R = \boldsymbol{\beta}0 + \boldsymbol{\beta}_1 Z_1 + \boldsymbol{\beta}_2 Z_2 + \boldsymbol{\beta}_3 Z_3 + \boldsymbol{\beta}_4 Z_4 + \boldsymbol{\beta}_5 Z_5 + \boldsymbol{\beta}_6 Z_6 + e$$

Technical inefficiency of Sorghum and sesame crops

Where

R = in technical efficiency. Z_1 = experience years.

Z_2 = level of education years. Z_3 = mean extension visits in a season.

Z_4 = finance (SDG). Z_5 = age of project (years).

Z_6 = rain and the range distribution (mm).

3. Results and discussion

The results of the descriptive statistics, most farmers were males with percent 99.5%, and their active age group 45 – 60 years, the average family household's members was 8, with average of 2 members working in the farm. About 80.1% of the farmers have attained some sort of education; [18]. the average of the experience was 16 years.

Stochastic frontier production function model is analytical method to study the phenomenon of economic efficiency of crop production, table (2) shows that the Technical Efficiency Analysis of the sorghum is Sigma-squared 0.92242102E+10.

Log likelihood function = -0.22529576E+04.

Gamma 0.50000000E-01.

Maximum possible t- test probabilities.

Table (1) presents ML estimate of sorghum crop farms. Stochastic frontier [19]. And inefficiency affects models in Habiella Agricultural scheme farms. Most of the estimate $\boldsymbol{\beta}$ coefficients of the stochastic frontier model for all farms models have the expected sings**.**

Seed(X_1)

Seeds coefficient has insignificant effect on the efficiency model of sorghum crop, and has a significant effect on efficiency model for sesame crop, the coefficient has a positive sign in both crops.

Gasoline (X_2)

Gasoline variable has a negative sign and a significant effect on the efficiency model for sorghum at (0.10) level of significance, and has a positive significant effect on the efficiency model at (0.01) level of significance for sesame crop.

Labor (X_3)

Labour has a positive sign and significant effect on the efficiency model for both crops, sorghum and sesame, at (0.01, 0.10) level of significance, respectively. Labour factor is very important in increasing output of sorghum and sesame crops.

Pesticide (X_4)

Pesticide coefficient has an insignificant effect on the efficiency model for both crops, it has a positive sign for sorghum and a negative one for sesame.

Cultivated area (X_5)

Cultivated area coefficient has significant effect on efficiency model for sorghum, while it has insignificant effect for sesame. Both crops coefficients have positive signs.

Technical inefficiency discussion:

Table (2) present ML estimates of presents ML estimates of sorghum and producers stochastic inefficiency, the estimated δ coefficients associated with explanatory variables in the model for

inefficiency effects for the Habiella scheme farmers. Most of the estimated δ coefficients of the stochastic frontier model for all farmers' models have expected signs. .

Eleven parameters were estimated in the stochastic production frontier model including five (5) parameters in the efficient stochastic frontier model and six (6) parameters in the inefficient model. The determinants of inefficiency which were experience, education level [20], extension services [21], finance, project age, and rain distribution.

The estimated (σ) coefficients associated with the explanatory variables in the model for inefficiency effects for stud area.

Table (2): shows that only experience and education level coefficients have significant effect at 1%, 10% level of significance with negative and positive signs, respectively for sorghum crop, while those variables have insignificant effect and positive sign for sesame crop.

Table (1): The estimated frontier production function model of sorghum and sesame crops

Statements	**Sorghum**		**Sesame**	
Variable	**Coefficient**	**Standard-error**	**Coefficient**	**Standard-error**
Constant	-24	1.21	775.09	81.7
Seeds	27.84*	35.32	44.6***	4.6
Gasoline	-53.63*	35.43	28.5***	5.04
Labor	679.1***	48.00	5.71*	3.4
Pesticides	59.6	60.6	-6.03	5.7
Area cultivated	138.7***	41.7	4.13	10.3
Yield of Scale	**227.61**			
Model of inefficiency				
Constant	0.57	1.01	-149.1	94.6
Experience	-36.51***	4.66	143.0	90.95
level of education	20.9 **	3.22	88.9	119.9
Service extension	0.14	1.00	-1154.9	733.7
Finance	0.00004	0.00003	0.0000034***	0.0000013
Age of project	-0.33	1.12	-50.6	167.06
Rain distribution	0.66	1.01	203.8	130.19
Sigma – square	9.2	1.00	35988980	1.1
Gamma	0.00	0.00	0.74	0.07

Source: Filed Survey, Season 2019/ 2020

*** Significant level 1%, ** Significant level 5%, * Significant level 10%

The coefficient of finance has a positive sign and has a significant effect at 1% level of significance for sesame crop; other variables coefficients have insignificant effect for sesame with variations in signs. According to the results obtained in table 3, the most active producer's technical efficiency ranged between 90-99 Percent 61.

Table (2): Distribution frequency of technical efficiency for Sorghum producers

Technical efficiency	Frequency	Percent (%)
Less than 90	3	2
90-99	107	61
99-100	65	37
Total	175	100

Source: Filed Survey, Season 2019/ 20

Mean technical efficiency of sorghum = 0.99

Technical efficiency = 0.82

Allocative efficiency = 0.52

Economic efficiency of Sorghum = Technical efficiency * Allocative efficiency = (TE% * AE %) = EE%, 0.82 *0.52 =0.43

Then economic efficiency of the Sorghum in Habiella Scheme season 2019/20 was 43%. according [6] Studies Economic Efficiency of Sorghum and Millet Production for Small Scale Farmers in Traditional Rain fed, North Kordofan State, Sudan. The average economic efficiency score of millet was 15%. This means that the millet farms use the combination of inputs at a cost inefficiencies level, they could potentially reduce their overall cost by 85% and still attain the current output level. [3]. The results of stochastic frontier cost function revealed that the estimated economic efficiency of the sorghum and millet farmers obtained was found the mean economic efficiency to be 39% and 15%, respectively. The economic efficiency is very weak, because most parameters and inefficiency effect factor found to be not significant; these determinants may give a clear picture of farmers that could be targeted in order to increase efficiency

Table (3): Distribution Frequency of technical efficiency for sesame producers in study area:

Technical efficiency	Frequency	Percent (%)
Less than 30	18	11
30-60	86	51
60-90	55	33
More than 90	9	5
Total	168	100

Source: Filed Survey, Season 2019/ 20

Mean technical efficiency of sesame = 0.54, allocative efficiency of the sesame = 0.11

Mean economic efficiency of the sesame =Technical efficiency *Allocative efficiency = TE% * AE% = EE%, 0.53*0.11 was = 0.06, Then economic efficiency of the sesame crop in the Habiella Agricultural Scheme (season, 2019/20) = 6%. According to [13] studied economic efficiency of

sorghum and millet Production for small Scale farmers in traditional rain fed, North Kordofan State, Sudan

The results of the descriptive statistical analysis indicated that 76% of farmer's males, and the mean age was 44.08 years; also most farmers (85.4%) were married and (63.4%) have attained some sort of education. An average economic efficiency estimated of sorghum and millet farmers obtained was found to be 0.39 (39%) and 0.15 (15%), respectively

Sigma-squared = 0.24966775E+08.

Log likelihood function = -0.16661035E+04. Gamma = 0.52000000E+00.

Table (4): Summary statistics of efficiency estimates

Statistics	Efficient score					
	Sorghum			Sesame		
	TE	AE	EE	TE	AE	EE
Mean	0.99	0.52	0.43	0.54	0.11	0.06
sample firm	175				168	

Source: Filed Survey, Season 2019/ 20

Linear programming model analysis [22].

Optimal cropping pattern:

Micro Soft Excel Solver was used to solve linear programming problems; linear programming models Tutor2u. (2006). results show that; sorghum and sesame entered in the optimal plan with 0.75 and 1.25 feddans, respectively. The cost of cultivating sorghum and sesame were 2487.53 SDG and 2767 SDG respectively, in Habiella agricultural scheme as shown (Table 5)

Resources use:

The actual seeds costs in Habiella Agricultural Scheme was 305 SDG compared with the basic solution 345 SDG, (13.11% more). The other resources shown no or rear differences between optimal and actual situation. Accordingly the basic solution for the total costs plan increased from 5254 SDG to 5324 SDG.

Optimum net returns:

Optimum returns were 7623 SDG compared to 7190 SDG the actual return. The optimum returns were greater than actual returns by 6%, clear in the (table 5).

Table (5): Linear programming model analysis

		Sorghum	Sesame			7190
	Returns/fed	2729	4461			
	Changing(area)	0.75	1.25			
						RHS
	Seeds cost/SDG/fed	71	234	345.75	<=	305
	land preparation	173	179	353.5	<=	352
	Ploughing	178	186	366	<=	364
	Planting	192	186	376.5	<=	378
	Chemical Pesticides	16.53	20	37.3975	<=	36.53
	First weeding	205	205	410	<=	410
	Second weeding	37	26	60.25	<=	63
	Pesticides	44	29	69.25	<=	73
	Gasoline	55	55	110	<=	110
	Oils and refineries	37	35	71.5	<=	72
	Labor	125	140	268.75	<=	265
	Machine cost	23	24	47.25	<=	47
	cutting &collecting	739	834	1596.75	<=	1573
	Harvesting	163	201	373.5	<=	364
	Transportation	79	70	146.75	<=	149
	Food for labor	150	145	293.75	<=	295
	Sacks	75	63	135	<=	138
	Machines maintenance	30	30	60	<=	60
	Storage	12	13	25.25	<=	25
	Others	83	92	177.25	<=	175
	Total	**2487.53**	**2767**	5324.3975		**5254.53**
max z	7623					

Source: Filed Survey, Season 2019/ 20

The sorghum area total cultivate was 48629 fed

The sesame area total cultivate was 20479 fed

Budget net profit in study area was 1934 SDG

Linear programming net profit in study area was 1966 SDG

The ratio was 1966/1934 = 1.01.

In the table (5) above despite that the linear programming analysis increase cultivates area of the sesame crop, against decrease in sorghum crop in the study area. The sesame crop farmers not able to cultivate that all area because sesame area cropped need more labours and fiancés especially in

harvesting region. Compared that area cultivated by sorghum area. We recommend that be is subject of the study to look up importance.

4. Conclusions and Recommendation

The study concluded that, most farmers (producers) in Habiella Agricultural Scheme agricultural (season, 2019/20), were in the active age group, and also has attained some sort of education, The average family size of the sample producers was 8 and had good experience in sorghum and sesame crops farms. The producers' socio-economic characteristics had positive effect on technical efficiency of producers and negative effect on in technical efficiency in Habiella Agricultural Scheme farms. Mean technical efficiency of sorghum 0.99%, efficiency compared to the best farmers sorghum crop field survey in the study area and this ratio is not a ratio of the efficiency of real compared agricultural research, and economic efficiency of sorghum was 43%. Mean technical efficiency of sesame 54%**,** and also 54% efficiency compared to the best farmers sesame crop field survey in the study area and this ratio is not a ratio of the efficiency of real compared agricultural research. But technical efficiency sesame crop lower than technical efficiency sorghum, economic efficiency was 6%. Also, the results revealed that sex, age, family size, number of working members, educational level, and farm experience, secondary economic activities, contract producer, were significant variables for improving technical efficiency.

The study showed that increase of sorghum and sesame crops expenditures had positive effects on production level of sorghum and sesame farms. The results of linear programming (LP) models revealed that the total return was 2729 SDG for sorghum and 4461 SDG for sesame farms. And also result of the linear programming model, optimum net returns was 433 SDG, presented 6% in study area.

There are some **r**ecommendations such as:-

- The activation some government policies in agriculture flowing an increase production and productivity.
- The exception services in the Habiella Agricultural scheme should be over hauled and progressed. This is with the aim of enlisting the confidence of the tenants on usefulness of exception information.
- Provide input of output (production) at the time the appropriate the region.
- To follow the packets technical recommended.
- The establishment of stores specifications required for the region in the study area.

- Availability of industries manufacturing micro- and macro-, the proliferation of the culture of the value-added or value change the region.
- Raise the current level of efficiency of producers.
- The peak period labour could be solved by mechanization of Agricultural operations.
- Adoption of the recommended improved technologies will increase farmers' income.

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