Measurement of Technical Efficiency of Producing Sunflower in Irigated Sector in Sinnar State - Sudan, For the Season 2013/14 *[1] A Case Study: Elsuky Agricultural Schemes (Elsuky, Shshiena and Wad-Sulman)

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Abstract—This Study investigated the technical efficiency of sunflower production and its determinants, using cross-sectional data from 250 tenants from El-Suky schemes in irrigated sector in Sinnar State, season 2013/14. Also the study attempted to explain relationship between the production efficiency measures and other relevant variables. The Stochastic production frontier (SPF) model of the Cobb-Douglas form was employed to analyse the data. Most of the estimated β co-efficient of the SPF model for had the expected signs, and significant. The mean technical efficiency was 68% for the Sunflower compared to that best producer in those schemes. Accordingly there was a scope for increasing production of crop by 32%. This could be achieved through policy intervention by different agricultural institutions; the variance ratio parameters (γ) were large and significant and had a value of 0.96. Tenancy location, off-farm income, access to credit, sowing date, quantity of seed rate, quantity of fertilizer used, quantity of herbicide used, labour and number of waterings, were significant variables for improving technical efficiency. Age group, sex, education level, family size and extension contact were the significant factors that explained technical inefficiency in those schemes.

Key words— Cobb-Douglas, Elsuky, Sinnar State, Stochastic production frontier, Sunflower.

I. Introduction

SINNAR State located between latitudes 12.5 and 14.7 north and longitude 32.58 and 35.42 east, with an area 40680 km² equivalent 9.7 million feddans. Sinnar State total population is estimated at 1285058 in the year 2008.

In recent years, the operating efficiency and the agricultural production and productivity in Sudan have declined and the incomes of tenants have consequently been reduced. In this regard irrigated sector in Sinnar State is not an exception [1]. As a consequence, average yields of the main crops in the Sinnar State have trended downward [2].

The Stochastic production frontier (SPF) model was employed to analyse the technical efficiency (TE) of tenant in producing sunflower in Sinnar State

The concept of technical efficiency (TE) is based on input and output relationships. The measurement of firm specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier [3]. The SPF model is motivated by the idea that deviations from the production frontier may not be entirely under the control of the production unit under study [4]-[5]-[6]. These models allow for technical inefficiency, but they also acknowledge the fact that random shock outside the control of producers can affect output. They account for measurement error and other factors, such as effects of weather, luck, …etc., on the value of the output variable, together with the combined effects of unspecified input variables in the production function.

The (SPF) model is estimated using maximum likelihood procedures. This is because it is considered to be asymptotically more efficient than the corrected ordinary least square estimators [7]-[8]-[9] www.springerlink.com/index/h5x6j80852428mp1.

The maximum likelihood estimates for all the parameters of the Stochastic frontier and inefficiency model, defined by equations is simultaneously obtained by using the programme, FRONTIER VERSION 4.1, which estimates the variance parameters in terms of the parameterization.

The Cobb-Douglas production function is probably the most widely used form for fitting agricultural production data, because of its mathematical properties, ease of interpretation, and computational simplicity [10]-[11]

The objectives of this study were:

1) To investigate technical efficiency of sunflower production in Irrigated Sector in Sinnar State. in order to provide policy.
2) To determine variations in technical efficiency among tenants in producing the crop.

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3) In order to identify the factors affecting the level of tenants' inefficiency in the crop.
4) To draw some policies implications which will hopefully help in improving technical efficiency of sunflower production

II. METHODOLOGY

A cross-sectional data from 250 tenants was collected from El-Suky schemes in irrigated sector in Sinnar State season 2013/14. It was collected with the aid of structured questionnaires on households' sunflower production activities of the farmers and socioeconomic characteristics of the farmers. The study area was selected based on it is relative importance in sunflower production in Sinnar State. The sample size determined by the following equation: n=N/1+N(e)2 .Therefore the sample is equal to 250 tenants. Tenant's size in each village was selected based on their relative to the total number of tenants in El-Suky schemes. A systematic random sampling technique was used to select tenants to be interviewed.

The SPF of the Cobb-Douglas form was used to estimate the tenant technical efficiency for the crop production in Sinnar State [12]

A total 14 parameters were estimated in the SPF model, nine of which were in the Stochastic frontier model whereas the remaining five were in the inefficient model. A Stochastic Cobb-Douglas production frontier model may be written as :

$$Y_i=f(XiB)\ \exp.\ (V_i-U_i) \qquad i=1, 2 \ldots\ldots\ldots N$$

Where the SPF is $(X_iB)\ \exp(V_i)$, Vi having some symmetric distribution to capture the random effects of measurement error and exogenous stocks, which cause the placement of the deterministic kernel $f(X_iB)$ to vary across firm. The technical inefficiency relative to the stochastic production frontier is then captured by the one side error component $U_i \geq o$

The explicit form of the Stochastic Cobb-Douglas production frontier is given by:

$$y_i = \beta_0 + \sum_{j=1}^{n} \beta_j \ln x_{ij} + V_i - U_i$$

Where y_i is the frontier output, β_0 is intercept, β_j the elasticity of y_i with respect to x_{ij}, x_{ij} is the physical input, $V_i - U_i$ a composed error.

Inefficiency Effect Model:

The u_i in the Stochastic production frontier model is a positive random variable, associated with the farmers technical inefficiency in production and assumed to be independently distributed, such that the technical inefficiency effect for the i-th farmers, u_i, will be obtained by truncating (at zero) of the normal distribution with mean, μ_i, and variance, δ^2, such that

$$U_i = \delta_0 + \sum_{s=1}^{6} \delta_s Z_{si} \qquad (2)$$

Where:

Z_{1i} = Age group.

Z_{2i} = Gender (dummy 1 for male and 0 female).

Z_{3i} = Education level (number of years of education).

Z_{4i} = Family size. (number of persons in household)

Z_{5i} = Extension contact (number of visits by extension agents).

δ_o and δs coefficients are unknown parameters to be estimated, together with the variance parameters which are expressed in terms of

$\sigma^2 = \sigma^2 u + \sigma^2 v$ and $\gamma = \sigma^2 u / \sigma^2$

Where the γ-parameters has values between zero and one. The parameters of the stochastic frontier production function model are estimated by the method of maximum likelihood, using the computer program, FRONTIER Version 4.1.

Technical Efficiency Sunflower

The model is written as follows:

$$\ln y_i = \beta_0 + \sum_{j=1}^{9} \beta_j \ln x_{ij} + V_i - U_i \qquad (3)$$

Where:

ln = the natural logarithm;

Yi = yield (kg/ feddan)

X_1 = tenancy location (1 when location at the head of the canal, 2 when location at the middle and 3 when location at the tail).

X_2 = off-farm income (SDG);

X_3 = access to credit (SDG);

X_4 = Sowing Date (a dummy variable which receives one when at optimum and a zero, when otherwise).

X_5 = quantity of seed rate (kg)

X_6 = quantity of fertilizer use (kg), X_7 = quantity of herbicide used (litres).

X_8 = Labour (number of labour in mandays).

X_9 = Number of waterings

B_0 , B1, Vi and Ui as previously defined in equation (3.2)

III. RESULTS AND DISCUSSION

As shown in Table (I), the mean technical efficiency of sunflower production function in irrigated sector in Sinnar State is 0.68, with minimum efficiency of 21%, and maximum efficiency 96 % (Table, II). This means that on average, Sinnar State tenants 68 % of sunflower output that is attainable by best practice, given their current level of production inputs and technology used. This implies that the tenants can increase their sunflower output by 32 % from a given mix of production inputs if the tenants are technically efficient.

TABLE I
MAXIMUM-LIKELIHOOD ESTIMATE FOR THE PARAMETERS OF THE (SPF) AND TECHNICAL INEFFICIENCY EFFECT MODEL FOR SUNFLOWER IN ELSUKY AGRICULTURAL SCHEMES

Parameters	Variable	Coefficient	Standard-error	T-ratio
beta 0	Constant	0.6	0.274	2.193**
beta 1	Tenancy location	0.049	0.26	4.9***
beta 2	Off-farm income	0.039	0.023	1.983*
beta 3	Access to credit	0.031	0.017	0.365
beta 4	Sowing date	0.03	0.035	0.865
beta 5	Seed rate	0.06	0.019	3.091***
beta 6	Fertilizer	0.004	0.006	2.80**
beta 7	Laour	0.246	0.09	2.810**
delta 8	Watering number	-0.011	0.072	3.891***
delta 9	Herbicide	-0.113	0.049	2.786**
Inefficiency model				
delta 0	Constant	0.595	0.877	-2.839**
delta 1	Age group	-0.097	0.082	-2.176*
delta 2	Gender	0.064	0.378	-0.734
delta 3	Education level	0.088	0.057	-2.801**
delta 4	Family size	-0.016	0.032	-2.767**
delta 5	Extension contact	0.115	0.053	2.151**
sigma-squared	$\sigma_s^2 = \sigma_v^2 + \sigma^2$	0.082	0.025	3.255***
Gamma	$\gamma = \sigma^2 / \sigma_s^2$	0.96	0.00178	520.842***
	Mean Efficiency		0.68	
	Log likelihood function		44.341	

,* and ******* asterisks on the value of the parameters indicate its significant at 1,5, and 10 percent level of significance, respectively.
The significant estimates of γ and δ^2s imply that the assumed distribution of u_i and v_i is accepted, (**Table** I).

TABLE II
SUMMARY OF STATISTICAL ANALYSIS OF EFFICIENCY STIMATES FROM THE STOCHASTIC FRONTIER MODEL OF SUNFLOWER ; IN SINNAR STATE

Statistic	Efficiency score in producing sunflower
Mean	0.68
Minimum	0.21
Maximum	0.96

Hypotheses test of crops production

The coefficients of farm-specific variables on the technical inefficiency effect models were being tested using the generalized likelihood-ratio (LR) statistic. Coelli [7] suggested that the one-sided generalized likelihood-ratio test should be performed when Maximum-likelihood (ML) estimation is involved because this test has the correct size (i.e. probability of a type 1 error). Testing the null hypothesis which is: the inefficiency effects were not present is rather important. In other words, the null hypothesis is that there are no technical inefficiency effects in the model. That is, H0: $\gamma=\delta0=\delta1=\ldots=\delta5=0$ [13].

TABLE III
SUNFLOWER MODEL, TEST OF HYPOTHESIS FOR THE PARAMETERS OF STOCHASTIC FRONTIER PRODUCTION FUNCTION

		Decision
H_0: $\gamma = \mu = 0$	520.842***	H_0: Rejected
LR H_0: No technical inefficiency	36.512^{***}	H_0: Rejected

***, ** and * asterisks on the value of the parameters indicate its significance at 10,5 and 1 percent level, respectively.

Table (III) gives the test of hypothesis of sunflower likelihood ratio test (LR), for the technical inefficiency effect for these crops produced in the Sinnar State.

The value of the test is calculated as:

$LR = -2\{\ln[L(H_0) / L(H_1)]\} = -2\{\ln[L(H_0)] - \ln[L(H_1)]\}$

Where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the null hypothesis and alternative hypothesis, respectively [13]-[14]

Data in table (III) reveal that there are significant technical inefficiency effects in production the crop, because the null hypotheses H0 are fully efficient given the specification of (SPF) in Cobb-Douglas form. Then the (H0: $\gamma = \mu = 0$): null hypothesis are rejected.

Factors Affecting crop Technical Efficiency

Tables (I), present ML estimates of sunflower Stochastic frontiers and inefficiency effects models in Sinnar State. Most

of the estimated β co-efficient of the Stochastic frontier model for the two crops production models have the expected sign.

Tenancy location**:** Tenancy location has a positive sign and significant at 10 % level of significance for sunflower. A possible explanation of the positive sign is that the tenants who are located at the head of the canal, have a higher yield than those who are at the tail due to the fact that the first ones received high numbers of waterings beside more timely irrigation, furthermore, there is no weeds and siltation constraints.

Off- farm income**:** Most of the tenants in the scheme have an off- farm income from other sources, part of which is used in agricultural finance. The estimated coefficient of the part of the off-farm income that is used in agricultural finance has a positive sign and significantly different from zero at 1 % level of significance for sunflower. Similar result was obtained by Ahmed [14] and it is in line with that of Hamid [15].

Credit: The coefficient of credit has a positive but insignificant. A possible explanation of this result is that, credit mainly directed to sorghum and groundnuts production rather than sunflower production which mainly financed by companies in the study area.

Sowing date: The coefficient of sowing date has a positive sign, but is insignificant. The positive sign of the variable could be attributed to the fact that tenants has been planted the crop not exactly in the optimal sowing date.

Seed rate: The coefficient of seed was also positive which confirms to a prior expectation and significant at 10 % level. This indicated that higher seed rate would result in high sorghum yield except where there is overcrowding leading to competition of available nutrients which will consequently lead to lower yield.

Quantity of Fertilizer use (kg): The estimated coefficient of Fertilizer input is positive as expected and significant at 5% level. The significance of the fertilizer variable shows that used of fertilizer improves the productivity of the land.

Labour (in mandays): The coefficient of labour has a positive sign and has significant effect upon the efficiency model for sunflower. The levesl of significance is 5%. Labour is required to carry out cultural operations in time, particularly weeding and harvesting. "Reference [14] reported that, labour was significantly important factor of agricultural production in Gezira Scheme".

Number of Waterings: The most important factor affecting crop production is the availability of irrigation water. Watering depends on the crop condition and soil type. The amount of irrigation water per tenancy depends on the location of the tenancy, water intake (Abu xx) and the amount of the rainfall.

The coefficient of the number of waterings has a positive sign and significant at 10% level significance. A positively significant parameter of irrigation means that irrigation is one of the main determinants of crops production in El-Soky schemes. This result is in conformity with the findings of Ahmed [14].

Quantity of herbicide used (litres): The coefficient of herbicide has a positive sign and significantly different from zero at 5% level of significance. The significance of the variable could be attributed to its importance in crop production in the sense that the deviation between the actually applied and the recommended quantity herbicides would have a direct effect on the efficiency of productivity.

Inefficient model

The results of the SPF used in this study to identify the determinants of inefficiency among the tenants in Sinnar State in Sunflower production are presented in Tables (I)

Table (I and II) present ML estimates of Sunflower Stochastic inefficiency, the estimated δ coefficient associated with explanatory variable in the model for inefficiency effects for Sinnar State. All of the estimated δ co-efficient of the stochastic frontier model of crops production models have the expected sign.

Age groups: The age groups of tenants have positive sign and It is significant at 5 percent level of significance for sunflower Positively significant parameters of tenants age means that the inefficiency effect increases with the increase in age of a tenant. "Reference [16] argued that the positive effect of age upon the size of economic inefficiency effects could be expected due to the fact that older farmers are likely to be more conservative and thus less willing to adopt new practices". This is in conformity with the findings of Hamid [15].

Sex: The tenant's sex has a negative sign but has insignificant effect upon the inefficiency model for the crops. In this regard "Dafallah [17] stated that, efficiency of sunflower increased by 0.03 and 0.02 units respectively when shifted from male to female".

Education: The coefficient of education has a negative sign and significantly different from zero at 10 % for sunflower. A negatively significant parameter of education means that technical inefficiency decreases with the increase in education of tenants. This result conformed with the result obtained by Dafallah [17] which indicated that "the efficiency of sorghum and sunflower increased by 0.008 and 0.059 units respectively when shifted from one level of education to another". It can be conducted that education has positive effect on crop production in the schemes. This result is in line with the findings of Raphael [18] who have stated that "education of the household has positive and significant influence on the technical efficiency of farmers".

Family size: The coefficient of family size of tenants in the efficiency model has a negative sign and significant at 1 percent. Negative sign indicates that tenants with large family size tend to have smaller inefficiency effects than that of tenants with small families.

Extension contact: Extension contact has a negative sign and significant at 5 % level of significance. This means that, the technical inefficiency effect decreases with the increase in the extension with tenants. This is in contrast with that of Raphael [18].

IV. Conclusions

This paper shows that variations in maximum output can occur either as a result of Stochastic effects (e.g., good and bad weather states), or from the fact that tenancies may be operating at various levels of inefficiency due to

mismanagement, poor incentive structures, inappropriate input levels or combinations.

SPF Model of the Cobb-Douglas form used to estimate the tenant technical efficiency of production of sunflower crops in Sinnar State. Results identified the determinants of inefficiency among the tenants. Age group, sex, education level, family size and extension contact were significant in explaining technical inefficiency in Sinnar State. Results displayed the significant efficiency differentials between tenants and among all tenancies and it should be possible to improve the performance of the less efficient farms without major investment from outside at least in the short run. Number of waterings and herbicide, were significant variable for improving technical efficiency. Sowing date sunflower must be as recommended, i.e. sunflower normally be planted be planted in the second half of September to the first of October). More coordination between Ministry of Irrigation and Water Resources, and Ministry of Agriculture and Forestry could solve the problem of irrigation by follow-up, maintaining, and cleaning water canals for supplementary irrigation. The extension services in the scheme should be overhauled and progressed.

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