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Factors affecting Technical Efficiency of Sorghum Production in New Halfa Agricultural Production Corporation, Sudan

Abdelraouf I. Yousif Faculty of Agriculture and Environmental Sciences, University of Gadarif, Gadarif, Sudan

Ibrahim S. Mohamed Faculty of Agriculture and Environmental Sciences, University of Gadarif, Gadarif, Sudan

Ahmed M. El Naim* Faculty of Natural Resources and Environmental Studies, University of Kordofan, El Obeid, Sudan

Hashim A. Elobeid Faculty of Agriculture, University of Khartoum, Khartoum, Sudan

Adam E. Ahmed Faculty of Agriculture, University of Khartoum, Khartoum, Sudan

Abstract: This study was carried in New Halfa Agricultural Production Corporation, Sudan, season 2006/2007. To measure the factors affecting technical efficiency of sorghum production using a stochastic frontier production function. The study used multi-stage stratified random sampling by mean of a structured questionnaire to interview 150 tenants. The results revealed that the magnitude of technical efficiency varied from one tenant to another and ranged from 33% to 99%, with a mean of 78%. Which means that sorghum production could have been increased by 22% at the same level of inputs. The main factors that influenced the degree of sorghum efficiency were the irrigation number, tenancy location, weeding, labour and education. While experiences of tenant, Animal ownership and schooling years, had significant effects on tenants' technical inefficiency of sorghum production. To improve sorghum production technical efficiency, the study recommended usage of herbicides, provision credit to tenants.

Keywords: Productivity; Technical efficiency; Production function; New Halfa; Sudan.

1. Introduction

The agricultural sector is the mainstay of the Sudanese economy. It contributes about 41% of the GDP, 80% of exports (excluding oil). Agriculture employs 65% the labor force and provides 50% of the raw material for the industrial sector Ahmed [1]. New Halfa Agricultural Production Corporation (NHAPC) lies on the Eeastern Sudan in the Kassala State between15º-17 º longitude; it is 360 kilometers east of Khartoum. NHAPC with an area of 330000 feddans with 22367 tenancies of 15 feddan each, divided in to 6 and 19 administrative sectors and blocks, respectively. Sorghum is considered as a main staple food for most of the tenants in the NHAPC Sorghum is produced as summer crop; it is mainly grown in June and harvested between November and December. Sorghum residues represent major sources of animals' feeds. Yousif [2]. Sorghum production decreased from 59 thousand metric tons in 2003/2004 season to 29 thousand metric tons in 2004/2005 season, i.e. a decrease of 50%. This was due to reduction in the total area harvested, from 62 thousand feddan in 2003/2004 season to 50 thousand feddans in 2004/2005 season also yield dropped from 950 kg/feddan in 2003/2004 season to 570 kg/feddan in season 2004/2005 . fluctuation from season to season attributed to Several factors ranging from institutional to economics and from physical to natural climates can limit agricultural development. Production can be increased by increasing the technical efficiency of wheat using existing technology. If farmers are found to be technically inefficient, production can be increased to a large extent using the existing level of inputs and available technology. Several studies in other countries have shown that there is a significant potential for rising agricultural outputs or profitability by improving productive (technical and allocative) efficiency using existing resources. Moreover , these studies have also indicated that there may be significant efficiency differentials between different groups of farms and between different regions among all farms and it should be possible to improve the performance of the less efficient farms or regions without major investment from outside at least in the short run [3]. Ahmed [1] cited that the measure of firm efficiency consist of two component: technical efficiency, which reflects the ability of a firm to obtain the maximal output from a given set of inputs, and the allocative efficiency, which reflects the ability of the firm to use the inputs in optimal proportion, given their respective prices. These two measures combined to provide a measure of the total economic efficiency. The function can be estimated from sample data using non-parametric piece-wise-linear technique or a parametric function such as in the Cobb-Douglas form. The objectives of this paper,

*Corresponding Author

therefore are: (i) to estimation technical efficiency of Groundnut production (ii) To investigate the main factors behind tenants technical inefficiency Groundnut production. (iii) To draw some conclusions and recommendations for technical efficiency improvement .

2. Methods and Materials

To allow the estimation of these models, primary data were collected from Stratified random sampling techniques of 150 tenants in NHAPC using a structured questionnaire during the period April to May, 2007. The collected primary data were supplemented with secondary data collected from different relevant sources. In order to estimate the level of technical efficiency in a manner consistent with the theory of production function we have specified a Cobb-Douglas type stochastic frontier production function was specified. The Cobb-Douglas form of production function has some well-known properties that justify its wide application in economic literature [3]. To allow the estimation of these models, primary data were collected from Stratified random sampling techniques of 150 tenants in NHAPC using a structured questionnaire during the period April to May, 2007. The collected primary data were supplemented with secondary data collected from different relevant sources.

2.1. Technical Efficiency of Sorghum

The model is written as follows:

$$\ln y_i = \beta_0 + \sum_{j=1}^{8} \beta_j \ln x_{ij} + V_i - U_i$$

Where:

ln the natural logarithm; yi yield of sorghum (sack/ Feddan); X1 family size; X2= Tenancy location (1 when tenancy located at head of canal, 2 when tenancy located at the end of canal);X3 Irrigation number;X4 Weeding number;X5 hired labour (number of labor (manday); X6 off-farm income (SDG)and X7 Level of education (1 when illiterate, 2 when primary, 3 when secondary, 4 when intermediate and 5 when university) ;B_0 and B_1 are unknown parameters to be estimated for variables, respectively.

Vi represents statistic error and other factors which are beyond the farmers control such as weather, topography and other factors which not included and may be positive, negative or zero. U_i is a non-negative random variable.

2.2. Inefficiency Effect Model

The u_i in the stochastic production frontier model is a non-negative 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

$$U_i = \delta_0 + \sum_{s=1}^{5} \delta_s Z_{si}$$

Where:

Z_{1i} Experiences; (number of years spent as a tenant);Z_{2i} extension; (dummy variable which receives 1 if the farm had contact with extension agents and receives 0 if he did not have any contact with extension agents);Z_{3i} Credit **(**dummy variable which has the value of one if the tenant is not constraint by credit and zero, otherwise);Z_{4i} visits (numbers of visits by field inspectors); Z_{5i} Schooling years (years of tenants formal education)and Z_{6i} Animal ownership (dummy variable which receives 1 if the tenant owned animal and zero, otherwise);δ_o and δs coefficient are unknown parameters to be estimated, together with the variance parameters which area expressed in terms of

$$\sigma^2 = \sigma^2 u + \sigma^2 v \text{ and}$$

$$\gamma = \sigma^2 u / \sigma^2$$

Where the γ-parameters has value 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.

3. Results and Discussion

As shown in Table 1 the mean technical efficiency of sorghum production function is 78% in the NHAPC, with minimum efficiency of 33%, and maximum efficiency 99%. This means that on average, the NHAPC produced 78% of sorghum output that attainable by best practice, given their current level of production inputs and technology used. This implies that the respondents can increase their sorghum output by 22% from a given mix of production inputs if the tenants are technically efficient. Table 2 reveals that there are significant technical inefficiency effects in groundnut production, because the null hypotheses H_0 are fully efficient given the specification of (SPF) in Cobb-Douglas form. Then the (H_0: $\gamma = \mu = 0$): null hypothesis are rejected.

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(H0) and L(H1) are the values of the likelihood function under the null hypothesis and alternative hypothesis, respectively [1, 3]. Table (3.4) reveals that there are significant technical inefficiency effects in crops production, 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. The tenants in NHAPC have a wide range of technical efficiency ranging from 33% up to 99% for sorghum crop. The frequency distribution of the efficiency estimates obtained from the stochastic frontier Figure 1 shows that 52% of tenants operate with efficiency ranged between (30% - 80%) and 48% operate with efficiency ranged between (80% -100%). This implies that on average, the tenants producing dura in NHAPC achieved almost 78% of the potential stochastic frontier sorghum production level given their current level of production inputs and technology used. Tables 3 and Table 4 present ML estimates of sorghum stochastic frontiers and inefficiency effects model for NHAPC. Most of the estimated β co-efficient of the stochastic frontier model have the expected sign.

Tenancy location has a negative sign and significant at 5% level of significance, possible explanation of the negative 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 first one received high number of irrigation beside more timely irrigation which is the same result obtained by Ahmed [1]. The coefficient of off-farm income has a positive sign and insignificant, The coefficient of irrigation number has a positive sign and highly significant at 1%. That means irrigation is one of the main determinants of sorghum production in NHAPC .This result is in conformity with findings of Yousif, *et al.* [4], Ahmed [1] and Yousif [2]. The coefficients of weeding number has a positive sign and significantly different from zero. This result is in accordance with the recommendation from the New Halfa Research Station that weeds infestation adversely affect crops yield. NHAPC tenants face critical position due to coincidence of weeding of cotton, groundnut and sorghum in the same period beside little time coupled with rainy season and lack of credit. Sorghum is labour intensive crop. Sorghum required 28 (man-days) per feddan Yousif [5]. The coefficient of labour is a positive sign and significantly different from zero, Labour is required to carry out crop activities timely, particularly weeding and harvesting. That means labour is one of the main determinants of sorghum production in NHAPC .This result is in conformity with findings of Ahmed [1], El Naim and Eldoma [6] and Yousif [2]. The coefficient of education has a negative sign and significantly different from zero.

Table 4 represents Inefficiency model of sorghum indicates that most of the estimated δ co-efficient of the stochastic frontier model has the expected sign.

Table 4 shows that the experiences of tenant has a positive sign and high significant. Positively significant parameters of experiences of tenant means that the inefficiency effects increase with the increase in age of tenant's operator. The result is that elder tenants are not able to adapt the improved technologies. The positive association found between efficiency and experience has been documented by Ahmed, *et al.* [7]. Extension contacts and Credit have insignificant effects on sorghum. Field inspectors visit has a positive sign and significant for sorghum. Schooling years has a positive sign and significant. Positively significant parameter of Schooling years means that the inefficiency effect of production of sorghum increases with increase in Schooling years of tenant. It is unlikely but not surprising since most of educated tenants were found to be reluctant in farming practices and they have alternative income sources similar result obtained by Rahman [3].

Table-1. Summary Statistics of Efficiency Estimate from the Stochastic Frontier Model of sorghum

Statistic	Efficiency score
Mean	0.78
Minimum	0.33
Maximum	0.99

Source: author calculation

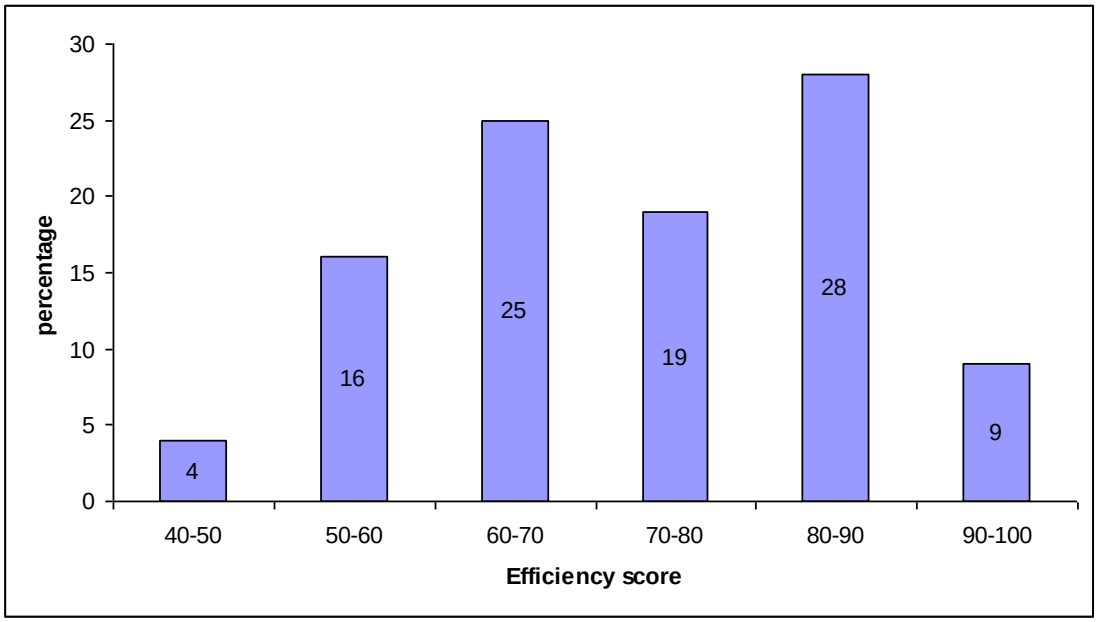
Table-2. Test of hypothesis for the parameters of stochastic frontier production function sorghum.

Groundnut Production Model		Decision
H_0: $\gamma = \mu = 0$	79.441^{***}	H_0: Rejected
LR H_0: No technical inefficiency	29.74^{***}	H_0: Rejected

Source: Author calculation.

******* asterisks on the value of the parameters indicate its significant at 5 percent level of significance**.**

Figure-1. Technical Efficiency score of sorghum



Source: author calculation

Table-3. Maximum-likelihood Estimates for the Parameters of the Stochastic Frontier Production Function and Technical Efficiency Effect Model for sorghum.

Parameters	Variable	Coefficient	Standard-error	T-ratio
β_0	Constant	-2.17	0.496	-4.375***
β_1	irrigation	0.59	0.107	5.539***
β_2	education	-0.004	0.023	-1.607**
β_3	labour	0.327	0.062	5.3***
β_4	Tenancy location	-0.109	0.046	-2.386**
β_5	Farm income	0.052	0.038	1.383
β_6	Weeding	0.255	0.093	6.509***
β_7	Off-farm income	0.001	0.003	0.271
σ_s^2	$\sigma_s^2 = \sigma_v^2 + \sigma^2$	0.097	0.014	6.821***
γ	$\gamma = \sigma^2 / \sigma_s^2$	0.997	0.013	79.441***
Mean Efficiency			0.78	
Log like lihood function		`	34.609	

Source: author calculation

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

Table-4. Inefficiency model

Parameters	variable	Coefficient	Standard-error	T-ratio
β_0	Constant	-1.068	0.418	-2.556**
β_1	Experiences	0.012	0.007	1.938*
β_2	Extension	-0.127	0.16	-0.791
β_3	Credit	-0.1	0.119	-0.843
β_4	Inspectors visits	0.214	0.066	3.259***
β_5	Schooling years	0.036	0.02	1.743*
β_6	animal ownership	0.282	0.123	2.294**

Source: author calculation

****** asterisks on the value of the parameters indicate its significant at 5 percent level of significance**.**

4. Conclusions

Agricultural yield varied according to differences in technology and efficiency of production process. The Stochastic Frontier Production function analysis effectively modeled the sorghum production technical efficiency in NHAPC. The result shows that Tenants in NHAPC are technically efficient. Therefore there is a scope for increasing groundnut production by 22% with present technology. Thus most sorghum output discrepancy caused by differences in tenant's level of technical efficiency as opposite to the conventional random variability, The irrigation number, tenancy location, weeding, labour and education appeared to be the main factors affecting sorghum yield in

NHAPC . While experiences, field inspector visit, and animal ownership have significantly positive effects upon the inefficiency for sorghum yield.

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