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ECONOMIC EFFICIENCY OF WHEAT AND FABA BEAN PRODUCTION FOR SMALL SCALE FARMERS IN NORTHERN STATE - SUDAN

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ABSTRACT

The objective of this paper was to estimate the economic efficiency of wheat and faba bean production for small-scale farmers in Northern State-Sudan using the stochastic frontier production and cost functions. A sample of 120 farmers from Dongola locality in the north and Ed-abba locality in the south of the state in 2004/05 winter season was selected using a randomized multi-stage stratified sampling technique. Stochastic frontier production and cost functions were used to estimate the economic efficiency of farmers. The results showed that the mean technical efficiencies of wheat were 0.75 and 0.66 in Dongola and Ed-abba, respectively, while for faba bean they were 0.65 and 0.71, the overall mean allocative efficiencies of wheat in the two localities were 0.72 and 0.68, whereas, they were 0.86, 0.84 for faba bean. The predicated overall mean of economic efficiencies that estimated as inverse of their cost efficiencies of wheat were 0.41 and 0.45 in the two localities, while in faba bean production they were 0.57 and 0.62 in Dongola and Ed-abba, respectively. That means farmers who cultivated faba bean were more economically efficient than farmers who cultivated wheat in the two localities and their allocative efficiencies were sources of gain.

Key words: Economic Efficiency, Small Scale Farmers, Northern State, Sudan.

INTRODUCTION

Wheat is one of the most important cereals produced and consumed in Northern region of Sudan and is s the main staple cereal in urban areas. It is produced under irrigation and occupies the largest area in this system (Ahmed, 1996). In previous years, a tremendous growth had been reported in the wheat's consumption due to high growth rate of population, rural-urban migration, growing conscience of consumers about nutrition, and subsidized imported wheat that led to increase the gap between local production and consumption (Osman, *et al*, 2006). Sudan as many developing countries depends on small-scale farmers in its food production like wheat production. Nonetheless, wheat production has decreased in recent years compared with faba bean and other winter crops which insure acceptable financial profit for small-scale producers in Northern Sudan (Ministry of Agriculture and Forests, 2005). As compared to faba bean and other winter crops, wheat needs more irrigation, fertilizers and labor force, and this is associated with low a market price, that is why small-producer’s preferred to produce cash crops.

The expected utility theory in producers' decision-making identified that if farmers are uncertain about yields and are risk averse, they will alter their input use from profit-maximizing quantities (Nygaard *et al*, 1982). In the selected study area (Dongola, and Ed-abba), one of the farmers' strategies to avoid risk is by decreasing the amount of fertilizer or perhaps not to use it at all when growing faba bean instead of wheat. The best outlook for the sector is to look at it in the directions of change in the future guided by comparative advantage and economic efficiency (Osman, 2004). This paper tried to determine the present level of economic efficiency for the two important crops; wheat (food crop) and faba bean (cash crop) that compete for limited irrigated area of small-scale farmers in the Northern State of Sudan. A number of allocation efficiency studies have been conducted on the study area. (Mohammed (2000); Elfiel *et al* (2001); Saeed (2007), but none have concentrated on technical or economic efficiencies of small-scale farmers as considered in this paper. In addition, the paper identified and explained technical efficiency deferential practices among farmers in the selected localities of the study area.

MATERIALS AND METHODS

The stochastic frontier production and cost functions were used to estimate the economic efficiency of selected small-scale farmers in the two state's localities (Dongola, and Ed-abba). Economic or total efficiency is the product of technical and allocative efficiencies. The level of technical efficiency of a particular firm is characterized by the relationship between observed production and some ideal or potential production (Greene, 1993). Whereas, Farrell, (1957) defined allocative efficiency as the efficiency refers to the ability to choose optimum input levels for given factor prices. Farrell (1957) proposed a deterministic nonparametric frontier method to estimate production functions and to measure technical and allocative efficiency.

In this paper, the stochastic frontier production function proposed by Aigner, *et al*., (1977), Battese and Corra (1977) and Meeusen and Van den Broeck (1977) have been used. The translog Cobb-Douglas production function was chosen due to its flexibility and its no-restriction in returns-to-scale parameters. The model used for the analysis is specified as follows:

$$\ln Y_i = \alpha_0 + \sum_{k=i}^{n} \alpha_k \ln X_{ki} + \frac{1}{2}\sum_{k=i}^{n}\sum_{j=i} \alpha_{kj} \ln X_{kj} X_{ji} + \varepsilon_t$$

$$\varepsilon_t = v_i - \mu_i$$

(1)

i = 1, 2, … n

Where, ln denotes natural logarithms, y and x variables and□□'s are parameters to be estimated and □□□is the composed error term, v_i is a random error having zero mean and variance □²v and is associated with random factors such as measurement errors in production and weather which the farmer does not have control over, and it is assumed to be symmetric independently distributed. On the other hand, u_i is a non-negative truncated half normal random variable associated with farm-specific factors that lead to not attaining maximum efficiency of production in *i*th firm; u_i is associated with technical inefficiency of the farm and ranges between zero and one. However, u_i can also have other distributions such as gamma or exponential. The technical inefficiency was estimated using the following equation:

$$\mu_i = \delta_0 + \sum_{m=i}^{n} \delta_m Z_i$$

i = 1, 2, … n (2)

Where, Zi is m x 1 vector of variables which may influence the efficiency of a firm; and is an 1x m vector of parameters to be estimated.

The first section of equation (1) is the stochastic frontier production function while the second part captures the inefficiency variables. The model generate variance parameters such as variance of the models □□ = (□□² /□□²v); variance of the stochastic models (□²v) and variance of the inefficiency models (□□²).

The model was run and estimated by using frontier 4.1 program. The following hypotheses were tested using generalized likelihood ratio test ((□□□LR = 2[L(H1)-L(H0)], where L(H1) and L(H0) are the maximum values of the log likelihood functions under the alternative and null hypotheses, respectively. The null hypothesis is rejected when □LR >XC2)):

1. H0=ßik=0, the null hypothesis that identifies the translog production function. It specifies that the cross terms are equivalent to zero.
2. H0; u=0, the null hypothesis specifies that each farm is operating on the technical efficient frontier and that the asymmetric and random technical efficiency in the inefficiency effects are zero. This is rejected in favor of the presence of inefficiency effects.
3. H0;□□□ =□0= □2=…□P =0, the null hypothesis specifies that the technical inefficiency effects are not present in the model at every level, and the joint effect of these variables on technical inefficiency is insignificant.

The estimated parameters of the inefficiency model only indicate the direction of the effects that the variables have on inefficiency levels (where a negative sign of a parameter indicates that the variable reduces technical inefficiency). Battese and Coelli (1993) showed that for i-th firm in the t-th time period, technical efficiency (TE) is predicted using the conditional expectation as follows:

$$TE = \mathrm{E}(\exp(-\mu_i)/\mathrm{E}_i = e_i$$

$$= \exp(-\mu* + \tfrac{1}{2}\sigma*^2)\left\{\Phi[(\mu*/\sigma*) - \sigma*]/\Phi(\mu*/\sigma*)\right\}$$

□□□□

Where,

$$\mu* = (1-\gamma)Z_{it}\delta - \gamma\varepsilon_{it}$$

$$\sigma*^2 = \gamma(1-\gamma)\sigma_s^2$$

$$\gamma = \frac{\sigma_v^2}{\sigma_s^2}, \sigma_s^2 = \sigma_v^2 + \sigma_u^2$$

□□= Vi-ui□□and □ represents the distribution of the standard normal random variable.

The stochastic frontier cost function model was used to estimate farm level overall economic efficiency in the selected localities. The used cost frontier is identical to the one proposed by Schmidt and Lovell (1979). Schmidt and Lovell note that the log-likelihood of the cost frontier is the same as that of the production frontier except for few sign changes. The stochastic frontier cost function model is specified as follows:

$$\ln C = \alpha_0 + \alpha_q \ln Q + \frac{1}{2}\ln \gamma_q Q^2 + \sum \ln Q \ln w_i + \sum \alpha_q \gamma_{qi} \ln w_i + \frac{1}{2}\sum\sum \gamma_{ij} \ln w_i \ln w_j + \varepsilon_t \quad (4)$$

□□= Vi+ui

Where, C is total cost that represents the allocation of total cost across the various inputs (i.e. input expenditure shares), Q is the firm's output level and w's are the input prices that the firm faces. α, represents the parameters of the cost function and □□ represents the error term that is composed of two elements; V i and Ui.

However, because inefficiencies are assumed to always increase costs, error components have positive signs. The farm specific economic efficiency (EE) is defined as the ratio of minimum observed total production cost (C*) to actual total production cost (C).

The model was also run by frontier 4.1 program and its hypotheses were tested through maximum likelihood method. It should be noted that the frontier 4.1 program estimates the cost efficiency (CE), which is computed originally as the inverse of equation (4). The economic efficiency (EE) was then obtained from the inverse of cost efficiency as follows:

$EE = 1/CE$ (5)

Allocation efficiency (AE) was estimated using the following relationship:

$AE = EE / TE$ (6)

This means that $0 \leq AE \leq 1$.

Data and Variables

This study was conducted in Northern State of Sudan in two localities; Dongola, and Ed-abba. Agriculture is the core economic activity in the Northern State, where three main production seasons are practiced, the winter season "shitwi", the summer season "seifi" and the flood season "damira". In winter season, which is the main agricultural season, many crops were grown like wheat, faba bean, common bean, fennel, garlic, fenugreek, onion, tomatoes and other vegetables. For this study a multi-stage stratified random sampling technique was used. The population stratified into strata to create homogenous sub-samples, and to reduce the costs and time. Sample size was determined according to production's statistical information from Northern state. Two localities that are famous for production of wheat and faba bean have been chosen, Dongola and Ed-abba. The data had been collected through a field survey for the production season 2004/05. The survey was carried out during May and June of the year 2005, the period that coincided with the end of the harvesting. The respondents at this time had fresh memory and ready to recall the relevant information thoroughly. Information was collected on inputs and outputs of the two crops. Outputs of wheat and faba bean were collected on their physical quantities and then converted into values using prevailing market prices. Inputs data includes land, labor (family and hired), seeds, and number of irrigations, agricultural operations and agro-chemicals. Land was measured in feddan (0.24 hectare) and its average rent was calculated. Labor was measured in man days and its cost was calculated using average wage rate. The number of irrigations applied by each farmer was recorded and their costs disaggregated into labor and machines (pumps) needs. The cost of agricultural operations, which include land preparation, weeding and chemical control and harvesting, were calculated using costs of machines (tractors) and labor. Socio-economic data was also collected on some variables such as farmer's age, level of education and farming experience. Farming experience and level of education were measured by the number of years while the active age is measured by a dummy variable ($X \leq 50 = 1$, $X > 50 = 0$).

RESULTS AND DISCUSSION

Technical Efficiency: Table 1 illustrated the results of wheat and faba bean stochastic frontier production function (SFPF). The TE is computed for each farm in each locality according to stated equations on Frontier 4.1 program. The mean TEs' of wheat were 0.75 and 0.66 in Dongola and Ed-abba, respectively. This means in the short run, there are ranges for increasing wheat production by 25% and 34% in Dongola and Ed-abba, respectively, by adopting technologies used with the best practice of wheat farms. In other words, on average; about 25 % and 34 % of production in these localities are lost because of inefficiencies. Most of the variables determining inefficiencies are also statistically significant. It is evident from the same table that the estimate of □□ and □ are large in the two localities and significantly different from zero, indicating a good fit and correctness of the specified distribution assumption.□□ is ratio of variance of u (□□) over variance of v (□v) and it indicates that the one-sided error term u dominates the symmetric error v. Therefore, variation in actual wheat yield comes from differences in farmer's practice rather than random variability. Gamma□□□) =□□□□/(□v2+□□□), is also a measure of level of inefficiency in the variance parameter, it ranges between 0 and 1.□□ is estimated at 0.98 and 0.99 for Dongola and Ed-abba, respectively. This is can be interpreted as follows: 98% and 99 % of random variation in wheat production in Dongola and Ed-abba, is explained by inefficiency. For faba bean's, the mean TEs' were 0.65 and 0.71 in Dongola and Ed-abba, respectively. This means in the short run, there are scopes for increasing faba bean production by 35% and 29% in Dongola and Ed-abba, respectively, by adopting technologies used with the best practice of faba bean farms. These results confirm that, on average, about 38 % and 26 % of production in Dongola and Ed-abba, is lost because of inefficiencies. The variables determining inefficiencies are statistically significant. □□□ratio in every locality showed that the variation in actual faba bean yield comes from differences in farmer's practice rather than random variability. In faba bean translog stochastic models, □□□ is estimated at 0.99 and 0.85 in Dongola and Ed-abba, respectively. This means 98 % and 85 %, of random variation in faba bean yield in Dongola and Ed-abba, is referred to inefficiency.

Hypotheses Testing: To test the first null hypothesis, a nested hypothesis is performed to determine whether translog Cobb Douglas production function specification is an adequate representation of the frontier production function. The first null hypothesis (H0=ßik=0) was rejected in favor of translog production function in the two models. The second null hypothesis explores the test that specifies each farm is operating on the technically efficient frontier and that the systematic and random technical efficiency in the inefficiency effects are zero. This is rejected in favor of the presence of inefficiency effects. The final null hypothesis determines whether the variables included in the inefficiency effects model have no effect on the level of technical inefficiency. The null hypothesis is rejected confirming that the joint effect of these variables on technical inefficiency is statistically significant (table 2).

Table (1): The SFPF of Wheat and Faba bean in Northern State for (2004/05) Winter Season

Variables	Para.	Wheat		Faba bean	
		Dongola Locality	Ed-abba Locality	Dongola Locality	Ed-abba Locality
Stochastic Frontier					
Constant	ß0	0.095 (0.06)a*	-.07 (0.02)***	33.8(10.9)***	-50.3(13.1) ***
lnLand	ß1	-0.15(0.07)**	-0.13 (0.075)*	0.4(0.212) *	0.79(0.43) **
lnFertilizer	ß2	0.4(0.13)***	0.29 (0.10)***	-	-
lnSeed	ß3	0.64(0.40)	1.32 (0..45)***	1.6(0.475) ***	0.2(0.06) ***
lnLabor	ß4	-0.4(0.13)***	9.91 (2.75)***	0.01(0.003)***	0.7(0.437)
lnNo. of irrigation	ß5	-2.6(1.43)*	-0.52 (0.19)***	-0.8(0.23) ***	0.22(0.108) **
$lnLand^2$	ß6	-0.09(0.05)*	-0.08 (0.03)**	0.1(0.037) ***	-0.08(0.035) **
$lnFertilizer^2$	ß7	-0.39(0.23)	0.68 (0.42)	-	-
$lnSeed^2$	ß8	-0.60(0.50)	-0.12 (0.04)***	-0.23 (0.104)**	0.49(0.266) *
$lnLabor^2$	ß9	0.039(0.02)***	-0.83 (0.29)***	-0.87 (0.503) *	0.1(0.0479) **
lnNo of $irrigation^2$	ß10	0.44(0.29)	-1.94 (1.195)	0.2 (0.126)	-0.2(0.082) **
ln land*ln fert	ß11	0.29 (0.02) *	0.26 (0.145)*	-	-
lnland*ln seed	ß12	0.07(0.03)**	0.04 (0.021)**	0.06 (0.031) **	0. 5(0.187) ***
lnland*lnlabor	ß13	0.08(0.05)*	0.07 (0.023)***	0.12 (0.062) *	-0.9(0.479) **
lnland* lnno-irrig	ß14	0.04(0.024)	0.03 (0.019)*	0.02 (0.009) **	0.8(0.32) ***
lnfert* ln seed	ß15	0.85(0.52)	0.83 (0.30)***	-	-
lnfert* lnlabor	ß16	-0.79(0.22)***	-8.83 (3.2)***	-	-
lnfert*ln no-irrig	ß17	0.97(0.60)	6.49 (2.42)***	-	-
lnseed* lnlabor	ß18	0.36(0.12)***	0.34 (0.215)	0.2 (0.069) ***	-0.4(0.14) ***
lnseed* lnno-irrig	ß19	0.39(0.24)	-1.2 (0.43)***	0.41 (0.14) ***	-0.2(0.086)**
lnlabor*lnno-irrig	ß20	0.99(0.61)	-0.28 (0.085)***	1.69 (0.46) ***	0.6(0.158)***
Inefficiency Model			0.45(0.14) ***	0.18(0.07)**	
Constant	□□	-0.15(0.1)***	-0.07(0.31) **	-0.78(0.413)*	0.009(0.003)**
Age	□1	-0.49(0.20) **	0.28 (0.174)	0.16(0.105)	-0.008(0.005)*
School years	□□	0.25(0.15)	0.11 (0.075)	0.01(0.006)	0.003(0.0019)
Experience	□□	0.05(0.03)	-0.01(0.003)***	-0.02(0.0108)*	0.02 (0.0125)
Sch- years*exp	□4	-.006(0.002)**			-0.002(0.001)**
Variance Parameters			99	100	
lambda	□	49	0.2 (0.10479) *	0.56(0.175)***	1.86
Sigma	□	0.67 (0.23)***	0.04(0.02215) *	0.31(0.11)***	0.44(0.25)**
□$□^2$		0.44 (0.13)***	0.004	0.003	0.12(0.065)*
$□^2v$	□	0.009	0.99(0.33) ***	0.99 (0.32)***	0.07
Gamma		0.98 (0.32)***	9.6	0.28	0.85(0.37)***
Ln(likelihood)		-19.43	0.66	0.65	-7.3
TE		0.75			0.71

Source: Compiled by the authors, 2005.
Figures in parentheses are the standard errors.
***, **,* Significant at 1%, 5% and 10%, level respectively.

Socio-Economic Effect: The effects of socio-economic characteristics were studied according to their coefficients signs. A negative sign reduce technical inefficiency or increase technical efficiency and a positive sign increase technical inefficiency or decrease technical efficiency. As shown in table 1, the dummy variables for age are negative and significant at 5% in the two localities, suggesting that younger farmers, who are less than 50 years, are more efficient than the older ones. The reason for this is probably that the age variable picks up the effects of physical strength as well as farming experience of the household head. Although farmers become more skillful as they grow older, the learning by doing effect is attenuated as they approach middle age, when their physical strength starts to decline. Liu and Zhung, (2000), Awudu and Huffman (2000), Kibaara (2005), and Tahir *et al* (2008) made similar conclusions. Each variable of school years and experience has positive signs in the two localities that means each of them lonely increase technical inefficiency. This could probably attributed to the fact when a farmer get more educated, the desire for farming going to be weak and he will concentrate in salaried employment instead. While, the interactive dummy variables of school years and experience have negative signs and significant at 1% in the two localities that means increase technical efficiency. This finding is consistent with results from other studies for example Awudu, *et al*., (2001) in their study on technical efficiency during economic reform in Nicaragua found that education increases production efficiency. Also, a study by Seyoum, *et al*., (2001) on technical efficiency and productivity of maize producers in Eastern Ethiopia concluded that farmers with more education respond more readily to new technology and produces closer to the frontier output. This finding is also consistent with results on structural adjustment and economic efficiency of rice farmers in Northern Ghana by Awudu and Huffman (2000).

Table (2): Wheat and Faba bean Likelihood Ratio Tests

Crop Locality	**Wheat**				
	Null hypothesis	**C***	**DF**	**P-Value**	**Decision**
Dongola	H0=ßik=0	23.69	14	0.05	Rejection of H0
	H0; u=0	23.69	1	0.05	Rejection of H0
	H0;□1=,,,□P=0	23.69	3	0.05	Rejection of H0
Ed-abba	H0=ßik=0	24.2	14	0.05	Rejection of H0
	H0; u=0	24.2	1	0.05	Rejection of H0
	H0;□1=,,,□P=0	24.2	3	0.05	Rejection of H0
Crop	Faba bean				
Locality	Null hypothesis	C*	DF	P-Value	Decision
Dongola	H0=ßik=0	25	9	0.05	Rejection of H0
	H0; u=0	25	1	0.05	Rejection of H0
	H0;□1=,,,□P=0	25	3	0.05	Rejection of H0
Ed-abba	H0=ßik=0	23.35	9	0.05	Rejection of H0
	H0; u=0	23.35	1	0.05	Rejection of H0
	H0;□1=,,,□P=0	23.35	3	0.05	Rejection of H0

Source: Calculated by the authors. C*= Calculated value

Marginal Effect: Table 3 shows the calculations of inputs elasticities of wheat and faba bean in Northern state due to its translog stochastic frontier production functions. In case of wheat, a 1% increase in land will increase the wheat yield by 0.15% and 0.11% in Dongola and Ed-abba, respectively. Al-Awad (1994) found that wheat area was not significant, because the majority of wheat producers were having more or less the same area. Concerning fertilizer quantity per feddan a 1% increase in the level of fertilizer will increase the wheat yield by 0.65 % and 0.40% in Dongola and Ed-abba, respectively. Mohammed (1996) have got the same result, arguing that the actual amount of fertilizer applied is very little (50 kg/feddan) relative to the recommended rate (100 kg/feddan). This represents a big difference, reflected how much this input is constraining wheat production. The low quantity of fertilizer used may be due to its high prices, lack of knowledge about its importance and the recommended rate applied per feddan as a consequence to the absence of extension services. In case of seed rate, a 1% increase in seed per kilogram will increase wheat yield by 1.04 % and 1.05% in Dongola and Ed-abba, respectively. This means wheat yield is slightly elastic with respect to seed rate. A 1% increase in labor will increase wheat yield by 0.24 % and 0.20% in Dongola and Ed-abba, respectively. This revealing that labor supply is inelastic. This was probably due to shortage of labor at periods of peak labor demand. A 1% increase in irrigation numbers will increase wheat yield by 0.63% and 0.64% in Dongola and Ed-abba, respectively. Many previous studies showed that irrigation shortage is considered to be the most agricultural constraints in the Northern state as it is in many parts of the Sudan (Nimir, (1986), Saied (1988), El-fiel (1993). Furthermore, Al-Awad (1994) found that the number of irrigation significantly affect the crop production in the state. The irrigation shortage is due to inadequate supply of irrigation inputs (fuel, spare parts.etc), and their availability in proper time and at reasonable price. Although the government supports wheat farmers in fuel prices, they shifted it to produce faba bean. However, Mohammed (1995) concluded that the high elasticities are enough to explain how intensive is the problems associated with irrigation inputs are constraining the crop production of “Matarat”. In sum, the results indicating that the increases in wheat yield has its highest responsiveness to seed rate followed by irrigation numbers, fertilizer, labor and land in Dongola and Ed-abba localities. The sums of the elasticites of the considered variables are 2.71 and 2.4 for the two localities which means an increasing returns-to-scale, therefore, an increase in all inputs by 1%, increase wheat output by more than 1 %.

In case of faba bean, a 1% increase in land will increase the faba bean yield by 1.34% and 1.03% in Dongola and Ed-abba, respectively. This indicates that faba bean is elastic with respect to land increase. Concerning seed rate, a 1% increase in seed rate will increase faba bean yield by 1.75 % and 1.08% in Dongola and Ed-abba, respectively. This means that faba bean yield is elastic with respect to seed rate. Ahmed (2004) and Mohammed (1995) attributed application of low seed rate by farmers to the high price of crop seeds at the sowing time, infected seeds, poor financial resources, unavailability of formal credit to purchase this input, and to the absence of extension services. A 1% increase in labor will increase the faba bean yield by 0.28 % and 0.20% in Dongola and Ed-abba, respectively. This means that labor is inelastic in faba bean production. In case of irrigation numbers, a 1% increase will lead to an increase of faba bean yield by 1.7 % and 1.02% in Dongola and Ed-abba, respectively. Mohammed (1995) has got the same results i.e. faba bean yield is more elastic with respect to irrigation number. In sum, These results indicating that the increases in faba bean yield has its highest responsiveness to seed rate followed by irrigation numbers, land and labor in Dongola locality, while in Ed-abba locality the faba bean yield has highest responsiveness to seed rate followed by land, number of irrigation and labor. The sums of the elasticites of the all variables are 5.07 and 3.33 in Dongola and Ed-abba, respectively, indicating an increasing return to scale..

Table (3): Wheat and Faba bean Inputs Elasticities in Northern State

Input variable	Wheat		Faba bean	
	Dongola locality	Ed-abba locality	Dongola locality	Ed-abba locality
Land	0.15	0.11	1.34	1.03
Fertilizer	0.65	0.40	-	-
Seed	1.04	1.05	1.75	1.08
Labor	0.24	0.20	0.28	0.20
Irrigation No.	0.63	0.64	1.7	1.02

Source: Calculated by the authors.

Economic Efficiency: Table 4 showed the results of estimated stochastic frontier translog cost function (SFCF) of wheat and faba bean in the two localities. The estimated coefficients of average wage rate per man days of labor, average price per kg of seed, average price per kg of agrochemicals, average cost of irrigation and total value of output of wheat or faba bean have expected positive sign. The results of t-ratio tests showed that all the variables are statistically different from zero at 1%, 5% and 10 % levels of significance. Hence, these variables are important determinants of wheat and faba bean in the study area. The EEs' analysis of wheat farmers revealed that there were presences of costs inefficiency effects in wheat production as confirmed by the significant gammas values of 0.61 and 0.68 in Dongola and Ed-abba, respectively. This implies that about 61% and 68% variation in the total wheat production costs in Dongola and Ed-abba, respectively, are due to differences in their costs efficiencies. In faba bean production, cost inefficiency is confirmed by the significant gammas values of 0.57 and 0.58 in Dongola and Ed-abba, respectively. This indicates that about 57% and 58% in the total faba bean production costs are caused by differences in costs efficiencies. The overall means of EEs', which were estimated as the inverse of CEs' of wheat, were 0.41 and 0.45 in Dongola and Ed-abba, respectively.

In Dongola, the EE of wheat was ranging between 0.11 and 0.92 with a mean of 0.41, which means that if the average farmer were to reach the EE level of its most efficient counterpart, then he could experience a cost saving of 55%. The same computation for the most economically inefficient farmer suggests an improvement in economic efficiency of 88%t. To give a better indication of efficiency distribution, a percentage distribution of TEs', AEs' and EEs' was illustrated in table 5. The highest numbers of farmers in Dongla locality (73% of the respondents) have EEs' between 0.10-0.60, while the rest have EEs' above 0.60. This is considered as indication of weak to moderate EEs' of wheat farmers in producing wheat at a minimum cost for a given level of technology and they have to increase it.

In Ed-abba, EE of wheat range between 0.13 - 0.80 with an average of 0.45 indicating that the average farmer must have a cost saving of 43% to reach the most efficient farmer in the locality and a cost saving of 84% for the most inefficient to do the same. The percentage distributions of EEs', revealed that 73% of farmers have economic efficiencies ranged between 0.10 - 0.60. This means, the majority of the wheat farmers in Ed-abba like their counterparts in Dongola were working in a weak to moderate level of EE in producing wheat.

The faba bean's EE were 0.57 and 0.62 in Dongola and Ed-abba, respectively. In Dongola, the EE of faba bean was ranging between 0.15 and 0.92 with the mean of 0.57 indicating that an average farmer has to achieve a cost saving of 37% to reach the most efficient one, while the most inefficient would achieve it by a cost saving of 84%. The percentage distributions were 0.15 for the EE range of 0.10 - 0.30, 0.42 for the range of 0.30 - 0.60 and 0.43 for the range of 0.6-0.90 as revealed by table 5. This means a 85% of farmers have an EE range of 0.30-0.90, which was considered highly efficient than wheat farmers in the locality. In Ed-abba, faba bean's EE was ranged between 0.21 to 0.89, with an average of 0.63 indicating that the average farmer has to realize a cost saving of 30% and the most inefficient farmer has to realize a cost saving of 76% reach the most efficient farmer. The percentage distributions were as follows: 0.12 for the EE range of 0.10 - 0.30, 0.35 for the range of 0.30 - 0.60 and 0.53 for the range of 0.60-0.90. 88% of farmers were in the range of 0.30-0.90, which relatively high than wheat farmers in the same locality and from the same farmers in Dongola locality.

Table (4): Wheat and Faba bean (SFCF) in Northern State in (2004/05) Winter Season

Variables	**Para.**	**Wheat**		**Faba bean**	
		Dongola Locality	**Ed-abba Locality**	**Dongola Locality**	**Ed-abba Locality**
Stochastic Frontier					
Constant	ß0	7.94(2.47)a***	8.72(3.22)***	6.9(2.36)***	8.64(3.2)***
ln(Qi)	ß1	0.109(0.052)**	4.63(1.46)***	0.907(0.30)***	4.71(1.7)***
ln (si/wi)	ß2	0.208(0.11)*	0.129(0.0698)*	0.530(0.274)*	0.450(0.25)*
ln(agci /wi)	ß3	0.351(0.12)***	0.688(0.32)**	0.451(0.265)*	0.343(0.18)*
ln(iri /wi)	ß4	-0.120(0.06)*	0.314(0.094)***	0.757(0.27)***	0.336(0.18)*
ln (Qi) 2/2	ß5	0.368(0.15)**	0.170(0.095)*	0.712(0.18)***	0.171(0.09)*
ln(si/wi)2/2	ß6	0.210(0.116)*	0.178(0.096)*	0.692(0.25)***	0.278(0.17)
ln(agci /wi)2/2	ß7	0.161(0.085)*	0.178(0.098)*	0.125(0.0796)	0.300(0.18)
ln(iri /wi) 2/2	ß8	0.134(0.088)	0.504(0.187)***	0.735(0.25)***	0.126(0.078)
lnQi)ln(si/wi)	ß9	0.111(0.0645)*	0.025(0.008)***	0.288(0.183)	0.116(0.062)*
ln(Qi)ln(agc /wi)	ß10	0.313(0.123)***	0.341(0.166)**	0.341(0.12)***	0.174(0.11)
ln(Qi)ln(iri /wi)	ß11	0.362(0.143)***	0.751(0.47)	0.306(0.08)***	0.505(0.14)***
ln(si/wi)ln(agci/wi)	ß12	0.587(0.199)***	0.366(0.226)	-0.384(0.25)	0.290(0.19)
ln(si/wi)ln(iri/wi)	ß13	0.149(0.0835)*	0.183(0.112)	-0.319(0.20)	0.526(0.14)***
ln(agci/wi)ln(iri/wi)	ß14	0.114(0.0745)	0.769(0.4913)	0.510(0.32)	0.113(0.075)
Variance Parameter					
Sigma Squired	□S2	0.319(0.096)***	0.390(0.13)***	0.24 (0.09)***	0.30(0.11)***
Gamma	□	0.61(0.235)***	0.680(0.23)***	0.57(0.19)***	0.58 (0.21)***
Mu		0.05(0.031)	0.03(0.018)	0.02(0.013)	0.03(0.020)
ETA		0.001(0.00065)	0.001(0.0007)	0.001(0.00075)	0.01(0.006)
Log-likelihood		16.56	9.87	42.13	12.92

Source: Compiled by the authors, 2005
Figures in parentheses are the standard errors.
***. **.* Significance level at 1%, 5% and 10%, respectively.

Table (5): Percentage Distribution of Wheat and Faba bean Technical, Allocative and Economic Efficiencies in Northern State

Efficiency Level	**Wheat**						**Faba bean**					
	Dongola locality			**Ed-abba locality**			**Dongola locality**			**Ed-abba locality**		
	TE	AE	EE	TE	AE	EE	TE	AE	EE	TE	AE	EE
0.10-0.30	0.17	-	0.37	0.08	-	0.28	0.08	-	0.15	0.03	-	0.12
0.30-0.60	0.42	0.25	0.37	0.36	0.44	0.44	0.28	0.02	0.42	0.20	0.05	0.35
0.60-0.9	0.31	0.60	0.26	0.32	0.48	0.28	0.35	0.60	0.43	0.47	0.62	0.53
90>	0.10	0.15	-	0.24	0.08	-	0.28	0.38	-	0.30	0.33	-
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Authors calculations.
*TE=Technical Efficiency, AE= Allocative Efficiency and EE= Economic Efficiency

Allocative Efficiency: The AE was calculated as a product of EEs' over TEs' of the two localities. The overall mean of AE of wheat were 0.72 and 0.68 in Dongola and Ed-abba, respectively. While, the overall mean of AE of faba bean were 0.86 and 0.84 in Dongola and Ed-abba, respectively. This means that the average

AE of faba bean was more than their counterparts of wheat in these localities. This implies that wheat farmers are fairly efficient and faba bean farmers are highly efficient in producing faba bean at a given level of output using the cost minimizing input ratio. These results are consistent with Shultz (1964) “poor – but – efficient hypothesis” that peasant farmers in traditional agricultural setting are efficient in their resources allocation behavior giving their operating circumstances. Elfiel, *et al*., (2001) found the same conclusion in studying the economic analysis of wheat, faba bean and sorghum in Northern state. Commenting that it was to be relevant with Schultz hypothesis for the variable factor of labor and that producers appear to be allocating their labor efficiently between the two competing winter crops. Saeed (2007) found in his analysis of resources in Northern state that land was used more optimally in Merawe than Dongola followed by Ed-abba, labor was used efficiently in Ed-abba followed by Dongola, while Halfa farmers followed by Merawe could be described as efficient capital resource allocators.

Conclusion: Although wheat and faba bean farmers appeared to have fair technical efficiencies in Northern state; there are still gab have to be covered by adopting technologies and techniques used by the best practice of wheat and faba bean production in the short run. While age of farmers, farmers' experience and education appear to influence the technical efficiency of the farmers, the results have to be cautiously interpreted, as there could be correlation between the last two variables. The overall means of economic efficiencies of faba bean farmers were greater than wheat farmers. This means that faba bean producers used minimum costs of inputs at a given level of technology and that seemed relevant with the prior expectation of its low inputs cost. The results revealed that despite of higher allocative efficiencies of faba bean farmers comparing with wheat farmers efficiencies, the later appeared to be fairly efficient.

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REFERENCES

Ahmed, E. A. (2004). Economics of Faba bean Production and Marketing in the RiverNile State, a case Study of Ed-damer District. M.Sc. thesis (unpublished), University of Khartoum, Sudan.

Ahmed, A. T. (1996). Food Legumes Production Situation. In: Production andImprovement of Cool-season Legumes in Sudan .Salih, H.Ageeb, O.A. Saxena, M.C. and Solh, M.B. (Eds.), ICARDA.

Aigner, D. K., C. K. Lovell, and P. Schmidt, (1977). Formulation and Estimation of Stochastic: Frontier Production Function Models. J. of Econometrics, 6:21-37.

Al-awad, A. A. (1994). Economics of Crop Production in the Northern State, A Case Study of Rubatab Area. M.Sc. thesis (unpublished). University of Khartoum, Sudan.

Awudu, A. and E. Richard (2001). Technical Efficiency during Economic Reform in Nicaragua: Evidence from Farm Household Survey Data. Economic Systems, 25: 113-125.

Awudu, A. and W. Huffman, (2000). Structure Adjustment and Economic Efficiency of Rice Farmers in Northern Ghana. Economic Development Cultural Change, 503-519.

Battese, G.E. and G. S. Corra, (1977). Estimation of a Production Frontier Model: With Application to the Pastoral Zone of Eastern Australia., Australian J. of Agricultural Economics 21, 169-179.

Battese, G. E and T. J. Coelli, (1993). A Stochastic Frontier Production Incorporating a Model for Technical Inefficiency Effects. Working Papers in Econometrics and Applied Statistics, No.69, Department of Econometrics, University of New England, Armidale, pp.22.

Elfeil, M. A., B. Babikir, and J. Davis (2001).An Economic Analysis of Wheat, Broad beans and Sorghum Production in the Northern State of the Sudan.U.of .K. J.Agric.Sci.9 (1), 139-152.

Elfeil, M. A. (1993). Economic Constrains of Agriculture Production in the Northern Province of Sudan: An Econometric Approach. Ph.D thesis (unpublished). University of Khartoum, Sudan.

Farrell, M. J. (1957). The Measurement of Productive Efficiency. J. of the Royal Statistical Society, 120, 252-902A, 120, 3-255-281.

Greene, W. H. (1993). Frontier Production Functions, EC-93-20, Stern School of Business, New York University.

Kibaara, B. W. (2005). Technical Efficiency in Kenyan’s Maize Production: An Application of the Stochastic Frontier Approach. M.Sc. thesis (unpublished). Colorado State University, U.S.A.

Liu, Z. and J. Zhuang, (2000). Determinants of Technical Efficiency in Post-Collective Chinese Agriculture: Evidence from Farm- Level Data. J. of Comparative Economics, 28: 545- 564.

Meeusen, W. and J. Van den Broeck, J. (1977). Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error. International Economics Rev., 18:435-444

Ministry of Agriculture and Forests, (2005). Annual Report. Khartoum, Sudan.

Mohamed, A.S. (1996). Economics of Crop Production in Dongola Province. M.Sc. thesis (unpublished). University of Khartoum, Sudan.

Mohamed, A. S. (2000). Economics of Crop Production in Matarat in Dongola Province- Northern State. M.Sc. thesis (unpublished). University of Khartoum, Sudan.

Nimir, F. E (1986). Irrigation Amount and Frequency in Wheat Production. M.Sc. thesis (unpublished), University of Khartoum, Sudan.

Nygaard, D and A. M. Basheer, (1982). How Yield Stability Can Influence Farmers Decisions to Adopt New Technologies: The Case of Faba Bean Production in Egypt. In: Faba Bean Improvement, Hawtin, G. and Webb, C. (Eds.), ICARDA.

Osman, A. A. and A. A. Ijami. (2006).Production, Consumption and Processing of Wheat in Sudan. General Planning and Agricultural Economics Administration, Food Security Department, Ministry of Agriculture and Forests: In Arabic.

Osman, A. H. (2004). The Sudanese Agricultural Development Strategy (SADS) 2003-2007: A critical Review. M.Sc. thesis (unpublished), University of Reading, U.K.

Saied, M. N. (1988). The Economics of Crop Production in the N.S Province: A case Study of Selaim Basin. M.Sc. thesis (unpublished), University of Khartoum, Sudan.

Saeed, A. I. E. (2007). Optimizing Resource Use for Winter Crops and Improving Farmers' Income (Case Study: Northern State, Sudan). Ph.D. thesis (unpublished), University of Khartoum, Sudan.

Schmidt, P. and C. A. K. Lovell, (1979). Estimating Technical and Allocative Inefficiency Relative to Stochastic Production and Cost Frontiers. J. of Econometrics, 343-366.

Schultz, T. W. (1964). Transforming Traditional Agriculture. Yale University Press, New Haven and London.

Seyoum, B., A. Getnet,, T. Abate, (2001): Present Status and Future Direction in Feed Resources and Nutrition Research Targeted for Wheat Based Crop-livestock Production System in Ethiopia. In: Wheat and weeds: food and feed. Proceedings of two stakeholder workshops, Wall, P. C. (Ed.), CIMMYT, Santa Cruz, Bolivia. pp 207-226.

Tahir, M. A. M. S. Sardar, M. A. Quddus, and M. Ashfaq, (2008). Economics of Zero Tillage Technology of Wheat in Rice-Wheat Cropping System of Punjab-Pakistan. The J. Anim. Plant Sci., 18, (1): pages.