

CHAPTER FOUR

RESULTS AND DISCUSSION

In this chapter, descriptive statistics, and technical efficiency analysis

4.1 Socioeconomic characteristics of the scheme farmers

4.1.1 Farmer age

Farmer age is expected to have influence on productivity and output of an individual as it affects his mental and physical abilities. Upton (1979) stated that the farmer age has an influence on management performance although the overall direction of this influence is not clear. On the one hand as man ages, he gains experience and would expect his decision making ability to improve. On the other hand, it was found that goals change, with increasing age people usually towards leisure and reducing work. There is generally a negative correlation between a farmer age and his rate of adopting innovations. He also found that younger farmers adopt new idea more readily than older farmers. The average age of the sampled farmers is 50 years. Table (4.1) shows the age distribution of the sampled farmers. As seen from the table most of the farmers 88.7% are within the active age of (25-65) and about 11.3% are over 65 years.

4.1.2 Education Level

As shown in Table (4.2), most of the farmers 98% have attained some sort of education. The level of illiteracy amounted to 2% of the sampled farmers, 10% of them received some khalwa, 18.7% of them have joined primary education, about 22.7%, 34%, 12.7% received intermediate, secondary and university education, respectively. This means about 69.45% of the farmers received good education.

Table (4.1): Distribution of Gezira scheme's tenants according to age

Age group	Frequency	Percent
25-35	19	12.7
36-45	43	28.7
46-55	34	22.7
56-65	37	24.7
66-75	12	8
>75	5	3.3
Total	150	100

Source: Field survey, season 2011/12

Table (4.2): Distribution of Gezira scheme's tenants according to education level

Education Level	Frequency	Percent
Illiterate	3	2.0
Khalwa	15	10.0
Primary	28	18.7
Intermediate	34	22.7
Secondary	51	34.0
University	19	12.7
Total	150	100.0

Source: Field survey, 2011/12

4.1.3 Family size

For the sampled farmers, the average family size was found to be 8 persons per household. Table (4.3) shows the distribution of the sampled tenants according to the number of persons per household. It is clear from the table that the majority of the sampled tenants (44%) have family size ranging between (6-10) persons. Families have ranging between (1-5) represent 42% and family of more than 10 members represent 14% of the sampled farmers.

Table (4.3): Distribution of Gezira scheme's the tenants according to family size

Family Size	Frequency	Percent
1-5	63	42.0
6-10	66	44.0
>10	21	14.0
Total	150	100.0

Source: Field survey, season 2011/12

4.1.4 Marital Status

All surveyed farms are managed by males farmers. Table (4.4) shows that about 10 % of the surveyed farmers were not married, and about 90% of farmers were married, their dividing to 87.3% married, 2% widow and 0.7% divorced. Tenants who had married pay more attention for farming than the other group. Married status has effect on crop production in the Gezira scheme.

Table (4.4): Distribution of Gezira scheme's tenants according to marital status

Marital status	Frequency	Percent
Married	131	87.3
Single	15	10.0
Divorced	1	0.7
Widow	3	2.0
Total	150	100.0

Source: Field survey, season 2011/12

4.1.5 Farm experience

The survey showed that the majority of the sampled farmers (71.4%) have spent more than 10 years in the agricultural work with on average experience in agricultural work of about 19.5 years (table 4.5). This long experience in farming activity is due to the land ownership in the Gezira scheme, as most of the farmers in the Gezira Scheme are owners. Experience has positive effect on the crop production in the Gezira scheme.

Table (4.5): Distribution of Gezira scheme's tenants according to experience

Experience years	Frequency	Percent
1-5	17	11.3
6-10	26	17.3
11-15	20	13.3
16-20	26	17.3
21-25	26	17.3
26-30	13	8.7
31-35	6	4.0
>35	16	10.7
Total	150	100.0

Source: Field survey, season 2011/12

4.1.6 Animal ownership

Farmers in the Gezira scheme raise animals usually not as a direct investment, farmers rear animal to use their products for home consumption or the animal itself may be used for some purposes in the farm. Sometimes the farmer may sell some of his livestock products or the animal itself when his production is less than his family needs or to meet cash needs. Animals are considered one of the sources of off-farm income. Table (4.6) shows the average number of animals owned by respondent farmers. Among the sampled farmers the largest average numbers of livestock were goat and sheep. Most of the interviewed farmers stated that the returns from livestock production are used to finance the agricultural operations.

Table (4.6): Respondent farmers average animal ownership

Type of stock	Average number/household
Cows	8
Goats	10
Sheep	10
Donkeys	2
Poultry	4

Source: Field survey, season (2011/2012)

4.1.7 Off- farm occupations

The off-farm activities are of a great importance in the Gezira scheme in providing alternative income sources to the farmers, (diversify their income sources). As shown in table (4.7), the majority of the sampled farmers (82.7%) were fully occupied with tenancy (i.e. had no off-farm activities), 17% were employee.8% were merchants, and 1% of sampled farmers were animals raisers.

Table (4.7): Off- farm occupations of the sampled farmers

Off- farm occupation	frequency	percent
No - occupation	124	82.7
Merchants	8	5.3
Animals rearing	1	.7
Employee	17	11.3
Total	150	100.0

Source: Field survey, season 2011/12

4.1.8 Farmer's income

Farmer's income is obtained from selling farm products (gross farm income), besides income from off- farm works.

4.1.8.1 Gross farm income

Gross farm income is the main source of income in the study area; it is obtained from selling farm products, which includes crops and animals reared in the farm. For previous season 2010/11 the maximum gross farm income was found to be SDG 65000, the minimum was SDG 400. On the average it was SDG 11666. Many farmers in the sample obtained a negative net farm income, which mean that, their total returns did not cover their total costs; hence the net returns were negative.

4.1.8.2 Off- farm income

Many studies have proven the significant effects of the off- farm income on the output of different agricultural field crops.

The survey showed the details of the previous seasons about off- farm income. The maximum off- farm income was found to be SDG 50000, the minimum was SDG zero and on average it was found to be SDG 5604.

4.2 Technical efficiency analysis

4.2.1 Socioeconomic characteristics affect the production technical efficiency

4.2.1.1 Age:

Farmer's age influences his decision and his attitude toward accepting new ideas (Siddig, 1999). As shown in table (4.8) and fig.(4.1), in general trend, the efficiency of sorghum, wheat and groundnut tend to decreased by 0.014, 0.035, and 0.02 units respectively when age of tenant increased. Cotton efficiency increased by 0.029 when tenant age increased. As seen from table (4.8), an interviewed tenant get older, their farm production efficiency decreased. This may be young tenants are more active than old ones.

Table (4.8) Distribution of Gezira scheme’s tenants efficiency according to age

Age	%	Crop Efficiency			
		Cotton	Sorghum	Wheat	Groundnut
25-35	12.7	0.55	0.80	0.95	0.76
36-45	28.7	0.72	0.68	0.70	0.70
46-55	22.7	0.73	0.87	0.96	0.72
56-65	24.7	0.70	0.62	0.81	0.70
66-75	8	0.86	0.83	0.75	0.69
76&more	3.2	0.68	0.66	0.70	0.63

Source: Field survey, season 2011/12.

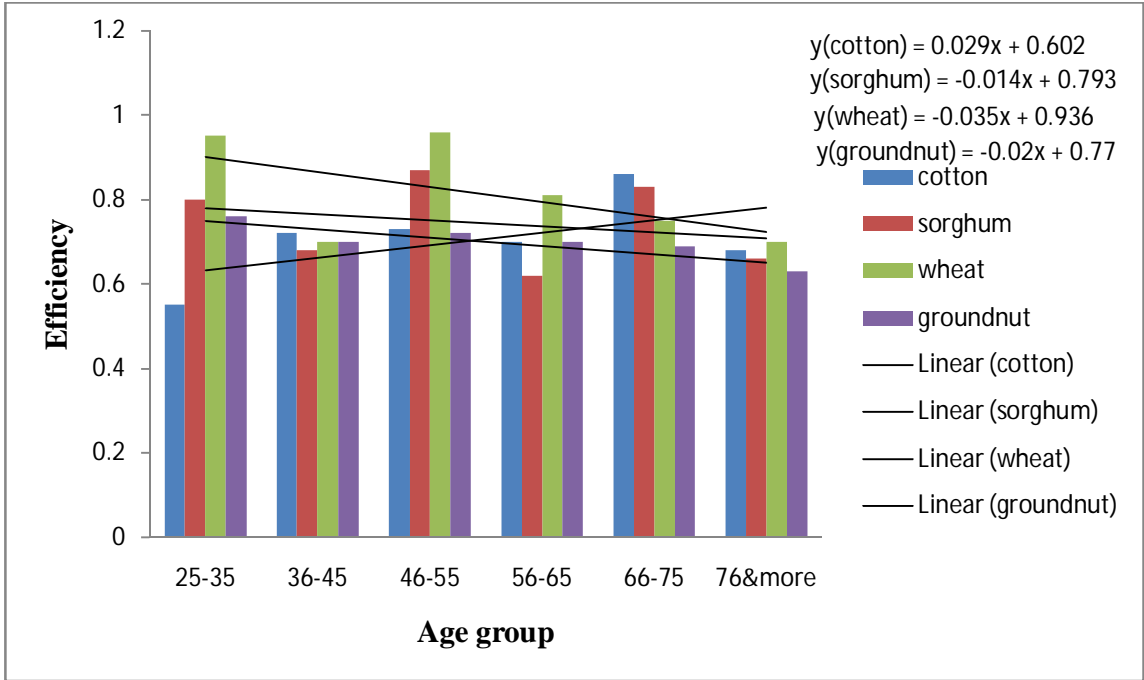


Figure (4.1): Distribution of Gezira scheme’s tenants efficiency according to age

4.2.1.2 Educational level:

Education in general can be defined as accumulation of knowledge and experience to prepare an individual for live (Ahmed, 1996 and Siddig, 1999). In developing countries, where technological change is radically altering life style, education is necessary for survival; it helps people to understand and benefit from change and obtain their economic rights (World Bank, 1980). As depicted in table (4.9) and fig.(4.2), in general trend, the efficiency of cotton, dura, wheat and groundnut tend to increased by 0.01, 0.015, 0.02 and 0.005 units respectively when shifted from one level of education to another. We conclude that education has positive on crops production in Gezira scheme, this result may be explained by the fact that tenant who have education were dealing with extension services hence adopted new innovations which raised production efficiency.

Table (4.9) Distribution of Gezira scheme's tenants efficiency according to education level

Education Level	%	Crop Efficiency			
		Cotton	Sorghum	Wheat	Groundnut
Illiterate	2	0.75	0.68	0.75	0.64
Khalwa	10	0.83	0.84	0.79	0.75
Primary	18.7	0.79	0.70	0.91	0.73
Secondary	22.7	0.77	0.91	0.91	0.68
Intermediate	34	0.77	0.67	0.66	0.70
University	12.6	0.86	0.85	0.97	0.64

Source: Field survey, season 2011/12.

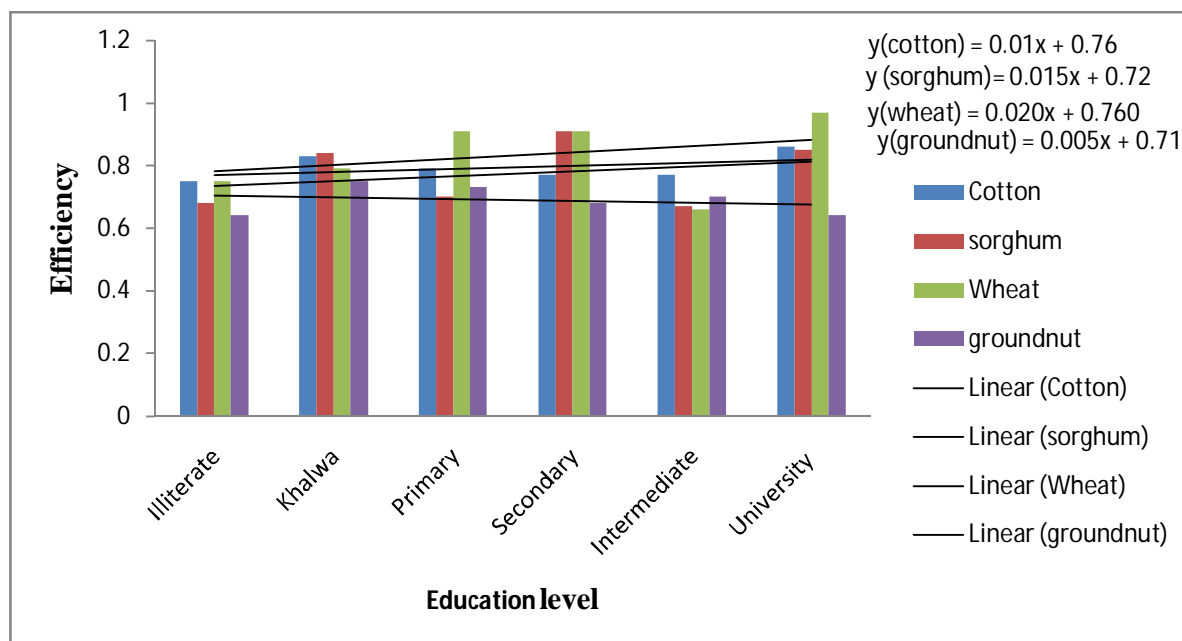


Figure (4.2): Distribution of Gezira scheme’s tenants efficiency according to education level

4.2.1.3 Family size:

Family can be defined as all members living within a household having a blood relationship and who are supported by an income known as the family income (Siddig, 1999). Beside, that family plays a vital role in the agricultural economic and development. The average tenant family size between the studied tenants was estimated to be 8 persons per household. Family size (6-10) represents the highest percentage (44%). As depicted in table (4.10) and fig.(4.3), in general trend, the efficiency of cotton, sorghum, wheat and groundnut tend to increased by 0.155, 0.095, 0.005 and 0.02 units respectively when family size increased. The result indicates that increase in family size, increase the number of people who work in the farm. We conclude that family size has positive on crops production in the Gezira scheme, this result explained by the fact crop production is somewhat depending on family labour beside hired labours.

Table (4.10) Distribution of Gezira scheme's tenants efficiency according to family size

Family Size	%	Crop Efficiency			
		Cotton	Sorghum	Wheat	Groundnut
1-5	42	0.60	0.69	0.66	0.76
6-10	44	0.82	0.66	0.92	0.79
11&more	14	0.91	0.88	0.67	0.80

Source: Field survey, season 2011/12.

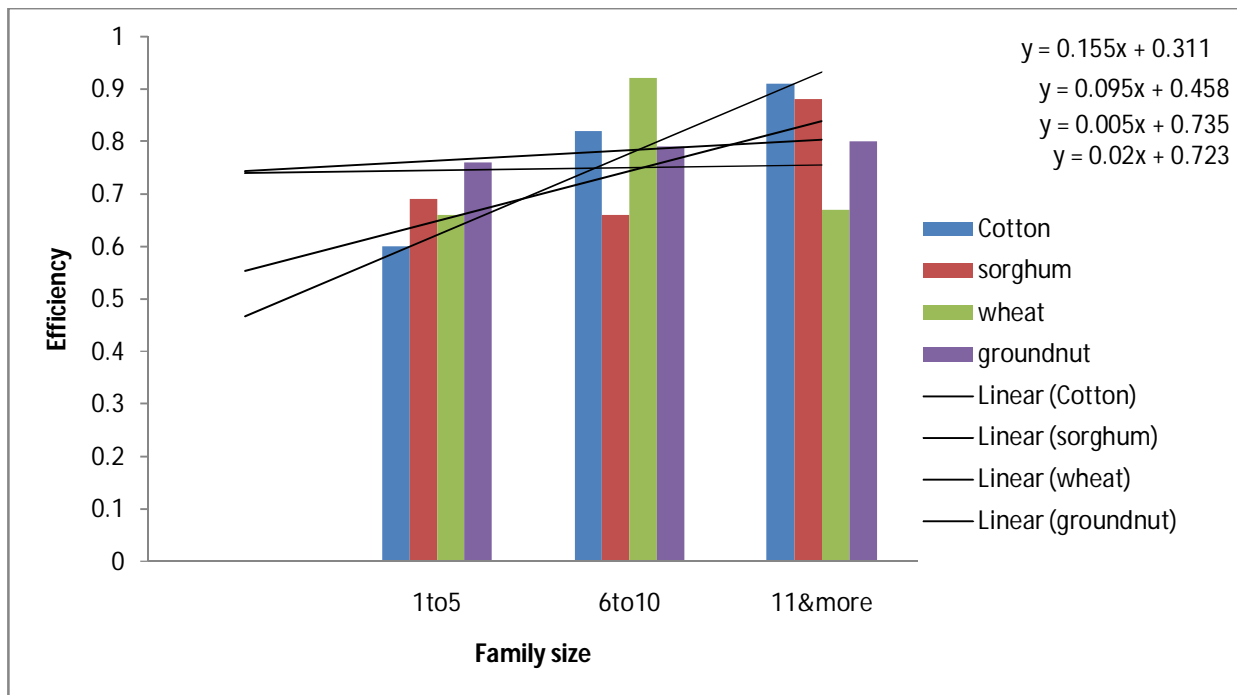


Figure (4.3): Distribution of Gezira scheme's tenants efficiency according to family size

4.2.1.4 Marital status:

Table (4.11) and fig.(4.4) shows that the majority of sample respondents (87.3%) are married and (10%) single, and as depicted in general trend, the efficiency of cotton, wheat and groundnut tend to decreased by 0.023, 0.022, and 0.026 units respectively when shifted from one level of Married Status to other, while for sorghum, efficiency increased by 0.022 unit. We conclude that Married Status has negative effect on crop production in Gezira scheme, this result explained by the fact that tenant who had married pay more attention for farming than other group.

Table (4.11) Distribution of Gezira scheme's tenants efficiency according to marital status

Marital Status	%	Crop Efficiency			
		Cotton	Sorghum	Wheat	Groundnut
Married	87.3	0.80	0.65	0.83	0.79
Single	10	0.72	0.69	0.70	0.71
Divorced	0.7	0.70	0.70	0.72	0.72
Widower	2	0.73	0.72	0.75	0.70

Source: Field survey, season 2011/12.

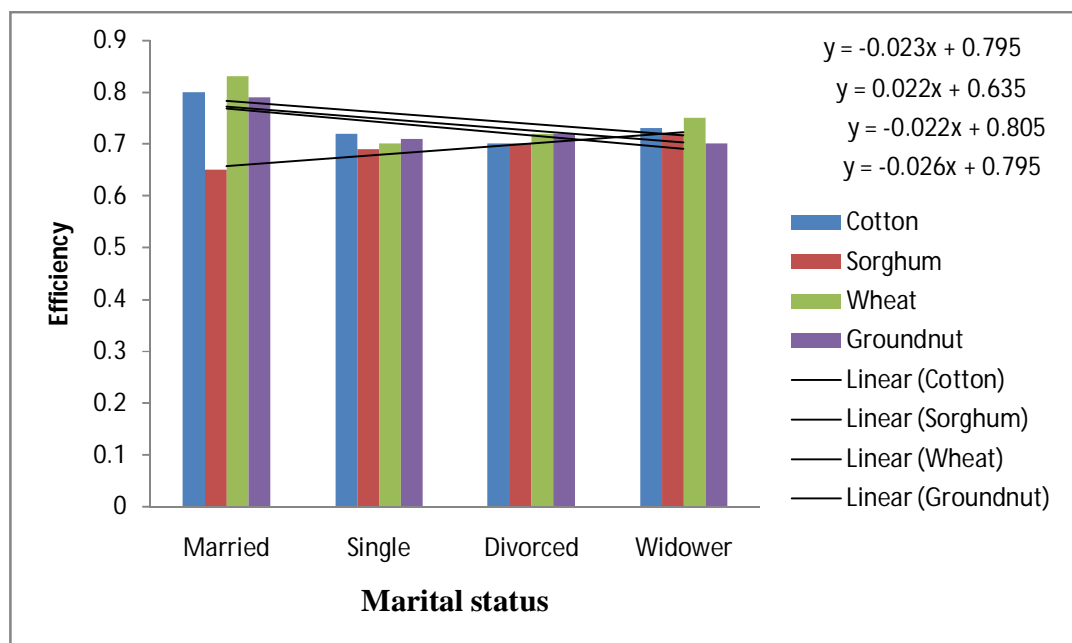


Figure (4.4) Distribution of Gezira scheme's tenants efficiency according to marital status

4.2.2 The Crops Technical Efficiency Analysis:

Stochastic Frontier version 4.1 program (Coelli, 1996) was used to estimate the level of technical efficiency for crops. The maximum likelihood (MLE) estimate of Cobb-Douglas stochastic production frontier model with the assumption of half-normal for cotton, sorghum, groundnut and wheat production efficiency, and technical in-efficiency were presented in Table (4.14),(4.15),(4.16) and (4.17), respectively.

Table (4.12): Summary Statistics of Efficiency Estimate from the Stochastic Frontier Model of cotton, sorghum, groundnut and wheat.

Statistic	Efficiency score			
	Cotton	Sorghum	Groundnut	Wheat
Mean	0.63	0.75	0.65	0.90
Minimum	0.25	0.27	0.40	0.54
Maximum	0.99	0.94	0.97	0.98

Source: Own estimation

4.2.2.1 Cotton Production Efficiency

As shown in Table (4.12), the mean technical efficiency of cotton production is 0.63 in the cotton model, with a minimum of 25% and maximum of 99%. This means that on average, the tenants in the scheme produced 63 percent of cotton output that attainable by best practice, given their current level of production input and technology used. This implies that the respondents can increase their cotton output by 37 percent from a given mix of production inputs if the tenants are technically efficient.

4.2.2.2 Sorghum Production Efficiency

As shown in Table (4.12), the mean technical efficiency of sorghum production is 0.75 in the sorghum model, with a minimum of 27% and maximum of 94%. This means that on average, the tenants in the scheme produced 75 percent of sorghum output that attainable by best practice, given their current level of production input and technology used. This implies that the respondents can increase their sorghum output by 25 percent from a given mix of production inputs if the tenants are technically efficient.

4.2.2.3 Groundnut Production Efficiency

As shown in Table (4.12), the mean technical efficiency of groundnut production is 0.65 in the groundnut model, with a minimum of 40% and maximum of 97%. This means that on average, the tenants in the scheme produced 65 percent of groundnut output that attainable by best practice, given their current level of production input and technology used. This implies that the respondents can increase their groundnut output by 35 percent from a given mix of production inputs if the tenants are technically efficient.

4.2.2.4 Wheat Production Efficiency

As shown in Table (4.12), the mean technical efficiency of wheat production is 0.90 in the wheat model, with a minimum of 54% and maximum of 98%. This means that on average, the tenants in the scheme produced 90 percent of wheat output that attainable by best practice, given their current level of production input and technology used. This implies that the respondents can increase their wheat output by 10 percent from a given mix of production inputs if the tenants are technically efficient.

The mean technical efficiencies in cotton, sorghum, groundnut, and wheat models that presented indicate that the respondents operate at 0.63, 0.75, 0.65, and 0.90 level of technical efficiency for cotton, sorghum, groundnut and wheat production, respectively in the Gezira scheme. An important result is that the variance ratio parameters γ is large and significant and has a value of 0.99, 0.87, 0.94, and 0.30. This result expresses that about 99, 87, 94, and 30 percent of cotton, sorghum, groundnut and wheat output deviation are caused by differences in tenant's level of technical efficiency as opposite to the conventional random variability. The significant estimates of γ and δ^2 s imply that the assumed distribution of u_i and v_i is accepted tables (4.14, 4.15, 4.16, 4.17).

4.2.3 Hypotheses Test of crops Production Models

Here were testing the coefficients of farm-specific variables on the technical inefficiency effect models using the generalized likelihood-ratio statistic. LR. Coelli (1995) suggested that the one-sided generalized likelihood-ratio test should be performed when ML estimation is involved because this test has the correct size (i.e. probability of a type 1 error). This is testing the null hypothesis that the inefficiency effects were not present. In other words, the null hypothesis is that

there are no technical inefficiency effects in the model. That is, $H_0: \gamma = \delta_0 = \delta_1 = \dots = \delta_5 = 0$ (Rhman, 2002).

Table (4.13): Crops models, test of hypothesis for the parameters of stochastic frontier production function.

	Model				Decision
	Cotton	Sorghum	Groundnut	Wheat	
$H_0: \gamma = \mu = 0$	96.62***	7.542***	19.913***	1.686*	H0: Rejected
LR H_0 . No technical inefficiency	77.274***	15.703***	2.293**	9.786***	H0: Rejected

Source: Author calculation.

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

As shown in table (4.13), test hypothesis of cotton, sorghum, groundnut, and wheat likelihood ratio test (LR), which tests the null hypothesis for the technical efficiency effect for crops production in the Gezira scheme 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 $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the null hypothesis and alternative hypothesis, respectively (Rahman, 2002 & Ahmed, 2004). Table (4.13) reveals that there are significant technical inefficiency effects in crops 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.

4.2.4 Factors Affecting Crop Technical Efficiency

Table (4.14, 4.15, 4.16, and 4.17), present ML estimates of cotton, sorghum, groundnut, and wheat stochastic frontier and inefficiency effects models in the Gezira scheme. Most of the estimated β co-efficient of the stochastic frontier model for all crops production models have the expected sign.

- **Tenancy location:** Tenancy location has a negative sign and significant at 5 percent level of significance for cotton. A 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 because the first one received high number of irrigations beside more timely irrigation which the same result obtained by Ahmed (2004). For sorghum, groundnut, and wheat coefficients of tenancy location is positive but not significant.
- **Age:** Age years has positive sign and significant at 5 percent level of significance for groundnut. Age has an important effect on productivity and output of the individual as it affects the mental and physical abilities. Positively significant parameter of age means that technical efficiency increases with the increase of age of farmers due to accumulate experience and a knowledge, for cotton, sorghum, and wheat were not significant and negatively sign, but wheat had positive sign.
- **Education:** The coefficient of education years had a positive sign and significantly different from zero at 10 percent level of significance for sorghum and groundnut, but non-significant and had negative signs for cotton and wheat. Positively significant parameter of education means that technical efficiency increases with the increase in education of farm operators. The reasons is that the level of education of tenants are indicators of the farmers awareness and their abilities of taking decisions on how and

what to produce, approaching credit, allocating their available resources and adopting new agricultural technologies (Rahman,2002).

- **Sowing date:** Sowing date is an important factor affected crops yield. The coefficient of the sowing date had a negative sign and highly significant at 1 percent level of significance for sorghum and groundnut, at 5 percent level of significance for wheat. The negative sign reflects the bad effects of late sowing on production level of those crops; similar result was obtained by Khalid (2010). Sowing date coefficient for cotton had negative sign and not significant.
- **Farm income:** The coefficient of farm income had positive sign and highly significant at 1 percent level of significance for sorghum and wheat, at 5 percent level of significance for cotton and groundnut. The may be reason is that a high percent of income directed toward crops production in the Gezira scheme. This result is in conformity with the findings of Ahmed (2004) and Yousif (2008). Farm income is assumed to be very important factor that affected technical efficiency of producing crops and the coefficients expected to have very high significance with respect to the variable.
- **Off- farm income:** Most of the tenants in the scheme have an off-farm income from other sources. The estimated coefficient of the part of the off-farm income that is used in agriculture had positive signs and insignificant for cotton, sorghum, groundnut and wheat, but groundnut had a negative sign. A possible explanation of this result is that a part of off- farm income is used for other crops in the scheme like (chickpea and onion) ; education fees for students and live expenditures rather than sorghum, groundnut, and wheat production, for cotton the most agricultural operations financed by the Sudan Cotton Company.

- **Irrigations number:** The most important factor affecting crops production is the availability of irrigation water. Watering depends on the crop condition and soil type. The coefficient of irrigation number had a positive signs and significant at 1, 5, and 10 percent level of significance for cotton, wheat, and groundnut, respectively. A positively significant parameter of irrigation means that technical efficiency increases with the increase in irrigation number. That means irrigation is one of the main determinants of crops production in the Gezira scheme. The coefficient for sorghum had a positive sign but insignificant. A continues rainfall coincide with the establishing of the sorghum crop reducing the expected effect of the shortage of irrigation number. This result is in conformity with the findings of Ahmed (2004), Yousif (2001) and Khalid (2010).
- **Weeding number:** Weeds control also is a very important factor affecting yield of the crop. Hand weeding is one of the ways to control weeds in the Gezira scheme. Coefficient of the weeding number had positive signs and significant at 10 percent level of significance for cotton, but sorghum and groundnut were not significant. Gezira scheme tenants face critical position due to coincide of weeding of cotton, sorghum and groundnut in the same period beside little time coupled with rainy season and lack of credit and hired labour.
- **Labour (in man-days):** The coefficient of labour had positive signs and significant at 1 and 5 percent level of significance for each cotton, sorghum, groundnut, and wheat, respectively. Labour is required to carry out crop activities timely, particularly weeding and harvesting. That means labour is one of the main determinants of crops production in the Gezira scheme mainly for cotton, sorghum, groundnut and wheat. This result in conformity with the findings of Ahmed (2004) and Yousif (2001).

Table (4.14): Maximum Likelihood Estimate for the Parameters of the Stochastic Frontier Production Function and Technical Inefficiency Effect Model for cotton.

Parameters	Variable	Coefficient	Standard -error	T- ratio
β_0	Constant	-0.193	0.928	-0.208
β_1	Tenancy location (x ₁)	-0.109	0.046	-2.386**
β_2	Age (x ₂)	-0.129	0.197	-0.665
β_3	Education years (x ₃)	0.060	0.063	0.949
β_4	Sowing date (x ₄)	-1.300	0.893	-0.145
β_5	Farm income (x ₅)	0.049	0.026	1.889**
β_6	Off- farm income (x ₆)	0.001	0.008	0.140
β_7	Irrigation (x ₇)	0.378	0.134	2.813***
β_8	Weeding (x ₈)	0.394	0.250	1.577*
β_9	Total labour (x ₉)	0.443	0.114	3.869***
Inefficiency model				
δ_0	Constant	-0.918	0.408	-2.251**
δ_1	Education level (z ₁)	-0.166	0.077	-2.155 **
δ_2	Experience (z ₂)	0.006	0.006	1.032
δ_3	Family size (z ₃)	-0.485	0.205	-2.366 **
δ_4	Marital status (z ₄)	0.047	0.126	0.372
δ_5	Credit (z ₅)	0.649	0.100	6.477***
Sigma-squared	$\sigma_s^2 = \sigma_v^2 + \sigma^2$	0.083	0.024	3.329***
gamma	$\gamma = \sigma^2 / \sigma_s^2$	0.99	0.010	96.62***
	Mean Efficiency		0.63	
	Log likelihood function		9.198	

Source: author calculation

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

Table (4.15): Maximum Likelihood Estimate for the Parameters of the Stochastic Frontier Production Function and Technical Inefficiency Effect Model for sorghum

Parameters	Variable	Coefficient	Standard -error	T- ratio
β_0	Constant	0.684	0.949	0.720
β_1	Tenancy location (x ₁)	0.055	0.084	0.655
β_2	Age (x ₂)	-0.007	0.159	-0.048
β_3	Education years (x ₃)	0.131	0.080	1.632*
β_4	Sowing date (x ₄)	-8.014	1.154	-6.942***
β_5	Farm income (x ₅)	0.084	0.022	3.795***
β_6	Off- farm income (x ₆)	-0.006	0.016	-0.386
β_7	Irrigation (x ₇)	0.091	0.133	0.685
β_8	Weeding (x ₈)	0.299	0.316	0.945
β_9	Total labour (x ₉)	0.562	0.155	3.623***
Inefficiency model				
δ_0	Constant	-1.192	2.266	-0.526
δ_1	Education level (z ₁)	-0.002	0.191	-0.012
δ_2	Experience (z ₂)	0.004	0.016	0.029
δ_3	Family size (z ₃)	-0.681	0.007	-1.972**
δ_4	Marital status (z ₄)	-0.706	1.041	-0.296
Sigma-squared	$\sigma_s^2 = \sigma_v^2 + \sigma^2$	0.454	0.414	1.396*
gamma	$\gamma = \sigma^2 / \sigma_s^2$	0.872	0.115	7.542***
	Mean Efficiency		0.75	
	Log likelihood function		49.348	

Source: author calculation

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

Table (4.16): Maximum Likelihood Estimate for the Parameters of the Stochastic Frontier Production Function and Technical Inefficiency Effect Model for groundnut.

Parameters	Variable	Coefficient	Standard -error	T- ratio
β_0	Constant	-1.038	1.007	-1.030
β_1	Tenancy location (x_1)	0.008	0.360	0.022
β_2	Age (x_2)	0.517	0.219	2.351**
β_3	Education years (x_3)	0.277	0.155	1.789*
β_4	Sowing date (x_4)	-12.393	1.578	-7.851***
β_5	Farm income (x_5)	.922	.045	2.021**
β_6	Off- farm income (x_6)	0.005	0.018	0.323
β_7	Irrigation (x_7)	0.507	0.289	1.749*
β_8	Weeding (x_8)	0.206	0.333	0.618
β_9	Total labour (x_9)	0.683	0.232	2.938***
Inefficiency model				
δ_0	Constant	0.414	0.185	2.519**
δ_1	Education level (z_1)	0.064	0.100	0.645
δ_2	Experience (z_2)	0.012	0.009	1.797**
δ_3	Family size (z_3)	-0.051	0.025	-1.646*
δ_4	Marital status (z_4)	-2.909	3.567	-0.815
Sigma-squared	$\sigma_s^2 = \sigma_v^2 + \sigma^2$	0.162	0.039	2.413**
gamma	$\gamma = \sigma^2 / \sigma_s^2$	0.94	0.05	19.913***
	Mean Efficiency		0.65	
	Log likelihood function		17.081	

Source: author calculation

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

Table (4.17): Maximum Likelihood Estimate for the Parameters of the Stochastic Frontier Production Function and Technical Inefficiency Effect Model for wheat

Parameters	Variable	Coefficient	Standard -error	T- ratio
β_0	Constant	-0.785	1.122	-0.699
β_1	Tenancy location (x_1)	0.111	0.192	0.577
β_2	Age (x_2)	0.090	0.206	0.436
β_3	Education years (x_3)	0.098	0.086	1.150
β_4	Sowing date (x_4)	-2.744	1.15	-2.281**
β_5	Farm income (x_5)	0.126	0.043	2.873***
β_6	Off- farm income (x_6)	-0.004	0.021	-0.197
β_7	Irrigation (x_7)	0.524	0.216	2.422**
β_8	Total labour (x_8)	0.211	0.138	1.633*
Inefficiency model				
δ_0	Constant	1.671	0.945	1.767*
δ_1	Education level (z_1)	-0.181	0.105	-1.717*
δ_2	Experience (z_2)	-0.037	0.019	-1.964**
δ_3	Family size (z_3)	-0.097	0.199	-0.487
δ_4	Marital status (z_4)	-0.475	0.459	-1.634*
Sigma-squared	$\sigma_s^2 = \sigma_v^2 + \sigma^2$	0.106	0.023	4.563***
gamma	$\gamma = \sigma^2 / \sigma_s^2$	0.30	0.173	1.686*
	Mean Efficiency		0.90	
	Log likelihood function		16.180	

Source: author calculation

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

4.2.5 Frequency Distribution of Tenants Technical Efficiency

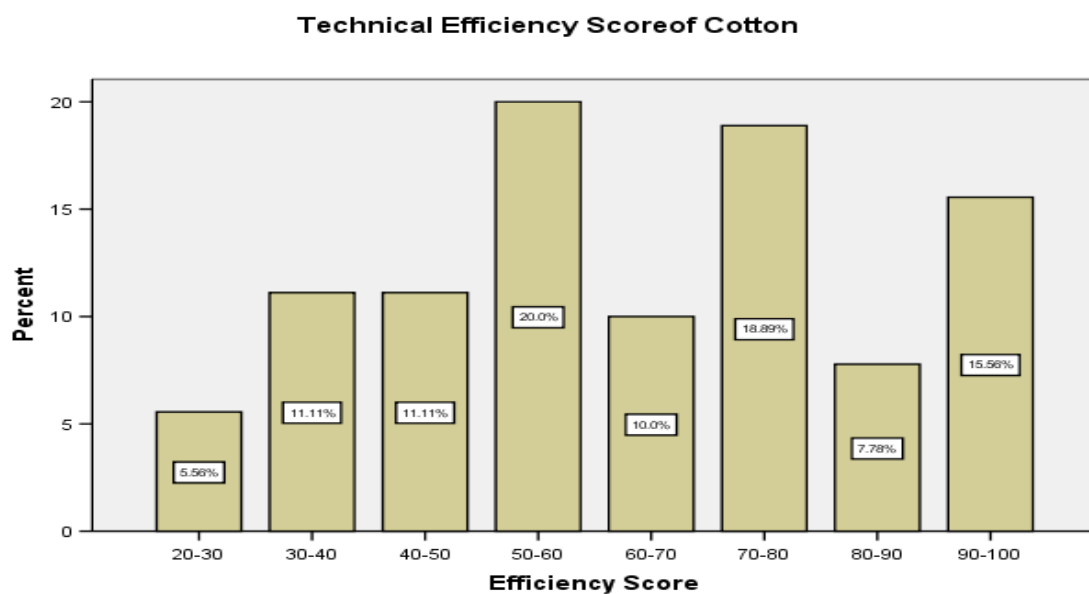
The tenants in Gezira scheme have wide range of technical efficiency ranging from 25 percent up to 99 percent for cotton crop. The frequency distribution of the efficiency estimates obtained from the stochastic frontier for cotton (Figure 4.5) shows that 76.7 percent of the tenants operate with efficiency ranged between (20-80) and 23.3 percent of the operate with efficiency ranged between (80-100). This implies that on average, the tenants producing cotton in Gezira scheme achieved almost 63 percent of the potential stochastic frontier cotton production level given their current level of production inputs and technology used. 76.7 percent of cotton production model for farmers in the Gezira scheme operated below 80 percent of the maximum cotton production, obtained by the fully efficient and 23.3 percent operated above the 80 percent level of technical efficiency in the cotton model.

The tenants in Gezira scheme have wide range of technical efficiency ranging from 26 percent up to 94 percent for sorghum crop. The frequency distribution of the efficiency estimates obtained from the stochastic frontier for sorghum (Figure 4.6) shows that 47.7 percent of the tenants operate with efficiency ranged between (20-80) and 52.3 percent of the operate with efficiency ranged between (80-100). This implies that on average, the tenants producing sorghum in Gezira scheme achieved almost 75 percent of the potential stochastic frontier sorghum production level given their current level of production inputs and technology used. 47.7 percent of sorghum production model for farmers in the Gezira scheme operated below 80 percent of the maximum sorghum production, obtained by the fully efficient and 52.3 percent operated above the 80 percent level of technical efficiency in the sorghum model.

The tenants in Gezira scheme have wide range of technical efficiency ranging from 40 percent up to 97 percent for groundnut crop. The frequency distribution of the

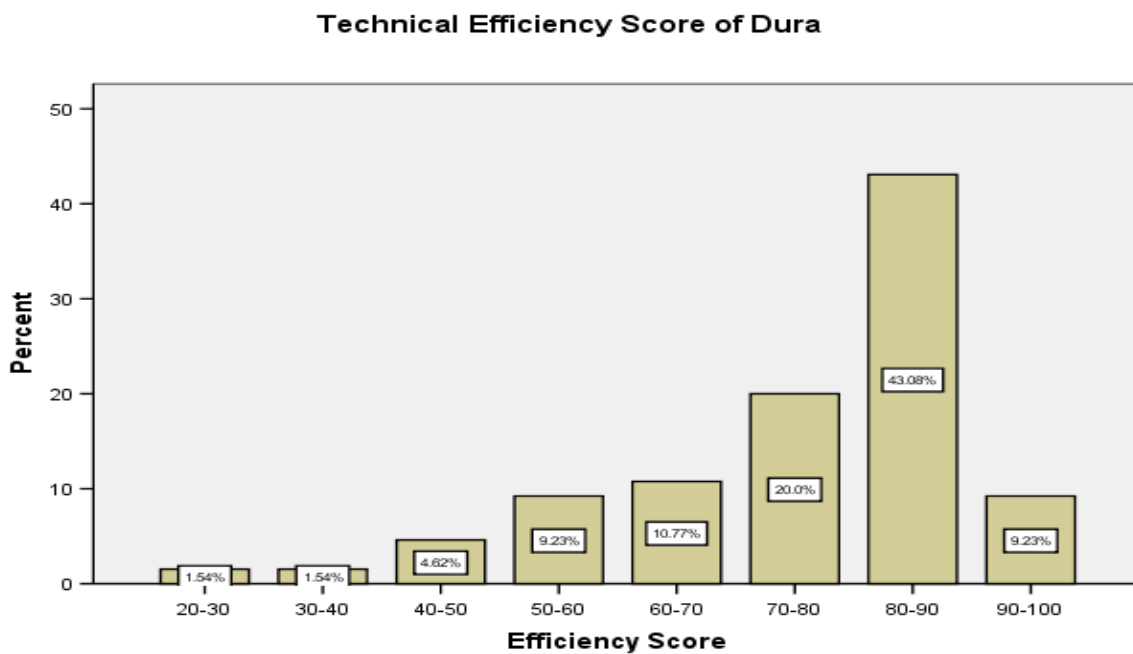
efficiency estimates obtained from the stochastic frontier for groundnut (Figure 4.7) shows that 82.2 percent of the tenants operate with efficiency ranged between (40-80) and 17.8 percent of the farmers operate with efficiency ranged between (80-100). This implies that on average, the tenants producing groundnut in Gezira scheme achieved almost 65 percent of the potential stochastic frontier groundnut production level given their current level of production inputs and technology used. 82.2 percent of groundnut production model for farmers in the Gezira scheme operated below 80 percent of the maximum groundnut production, obtained by the fully efficient and 17.8 percent operated above the 80 percent level of technical efficiency in the groundnut model.

The tenants in the Gezira scheme have wide range of technical efficiency ranging from 54 percent up to 98 percent for wheat crop. The frequency distribution of the efficiency estimates obtained from the stochastic frontier for wheat (Figure 4.8) shows that 13.2 percent of the tenants operate with efficiency ranged between (50-80) and 86.8 percent of the operate with efficiency ranged between (80-100). This implies that on average, the tenants producing wheat in Gezira scheme achieved almost 90 percent of the potential stochastic frontier wheat production level given their current level of production inputs and technology used. 13.2 percent of wheat production model for farmers in the Gezira scheme operated below 80 percent of the maximum wheat production, obtained by the fully efficient and 86.8 percent operated above the 80 percent level of technical efficiency in the wheat model.



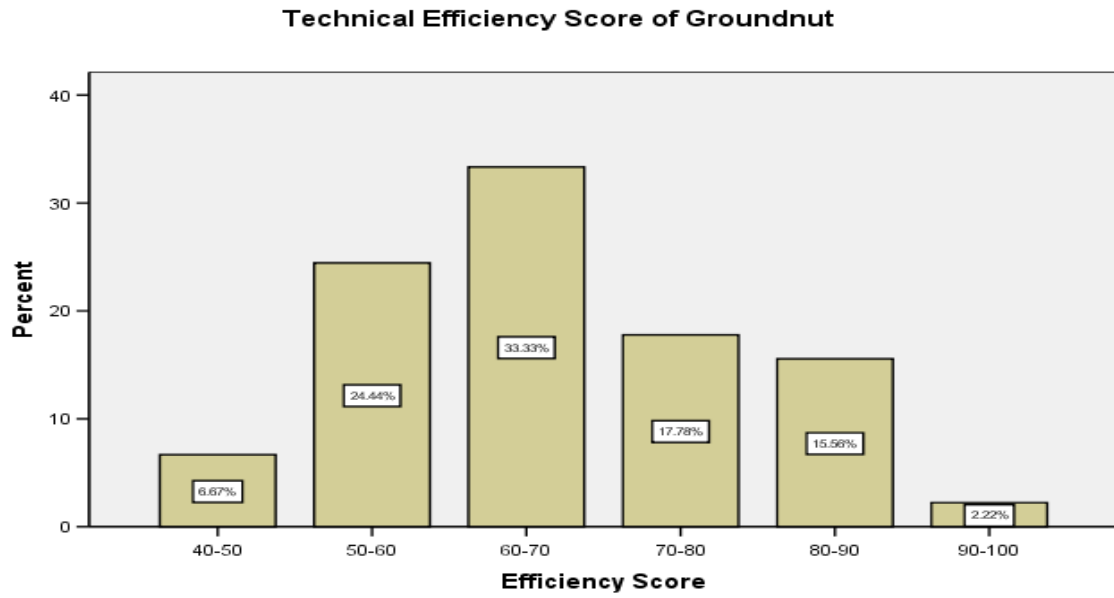
Source: author calculation

Figure (4.5): Technical Efficiency Score of Cotton



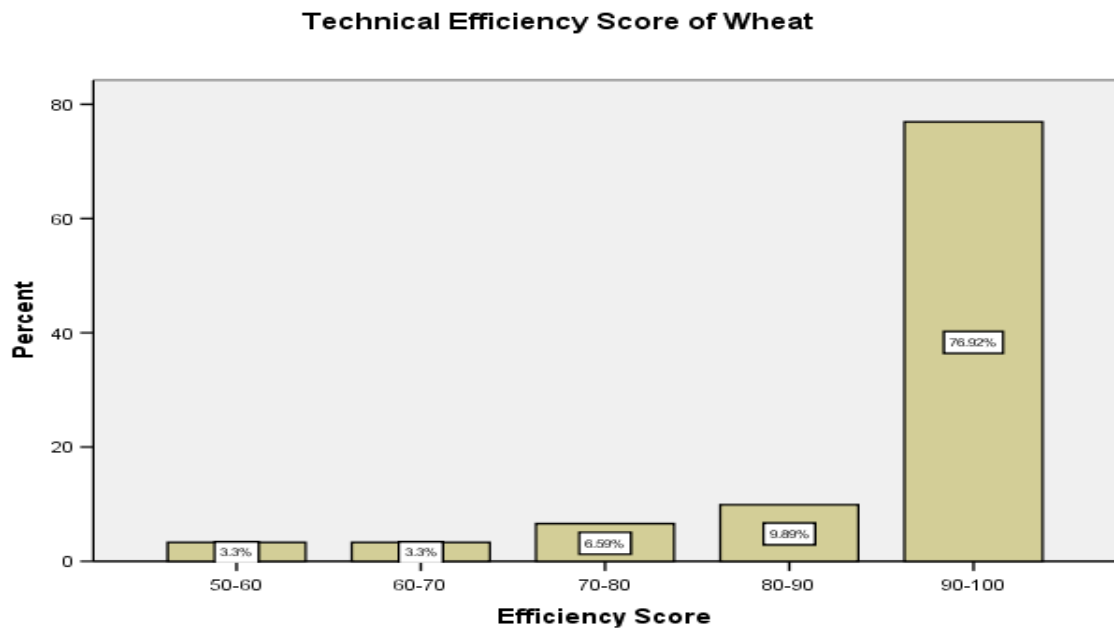
Source: author calculation

Figure (4.6): Technical Efficiency Score of sorghum



Source: author calculation

Figure (4.7): Technical Efficiency Score of Groundnuts



Source: author calculation

Figure (4.8): Technical Efficiency Score of Wheat

4.2.6 Inefficiency Model

Tables (4.14, 4.15, 4.16, and 4.17), present ML estimates of cotton, sorghum, groundnut and wheat stochastic inefficiency, the estimated δ coefficients associated with explanatory variable in the model for inefficiency effects for the Gezira scheme. Most of the estimated δ coefficients of the stochastic frontier model for all crops production models have the expected signs.

- **Education level:** The coefficient education level had a negative sign and significantly different from zero at 5 and 10 percent level of significance for cotton and wheat, but not significant for sorghum and groundnut. A negatively significant parameter of education level means that technical inefficiency decreases with the increase in education of farm operators. This is a normal result, which means education adds to farmer's knowledge and indicators of their awareness and their abilities of taking decisions on how and what to produce, approaching credit, allocating their available resources and adopting new agricultural technologies (Rahman, 2002). Therefore education, awareness and knowledge reduce the inefficiency. We conclude that education has positive effect on crop production in the Gezira scheme.
- **Experience:** The coefficients of experience had negative signs and significantly different from zero at 5 % percent level of significance for wheat and groundnut, but positive signs for groundnut, cotton and sorghum was insignificant which was not expected. A negatively significant parameter of experiences of tenant means that the inefficiency effects decrease with increase in experience years. This result is in conformity with the findings of Rahman (2002). He found a negative association between the technical inefficiency and farmer experience. Tenants

experience show a positive association with tenants' technical inefficiency, indicating that the technical inefficiency increases with increasing number of years the tenant engaged in agricultural production. This unexpected coefficient sign can be attributed to the fact that, tenant with relatively high number of years as a tenants are expected to be relatively old. Old tenants may be less educated, as well as, they are more conservative to adopt the new technologies and hence expected to be more inefficient.

- **Family size:** Family size coefficient had negative signs and significant at 5 percent level of significance for cotton, sorghum, and 10 percent for groundnut, but not significant for wheat. Family size is negative signs indicate that farmers with large family size tend to have smaller inefficiency effects than farmers with small family size. Family size is assumed to influence technical efficiency positively. It is expected that as the family size increases the number of the members who participate in farming activities increase, wheat production practices depend almost on machinery. We concluded that family size has a negative effect on the inefficiency of almost crops produced in the Gezira scheme.
- **Marital status:** The marital status has negative sign and significant for wheat and insignificant for cotton, sorghum and groundnut. Negative sign means that the increasing of number of farmers who married reduces inefficiency. This means that tenants producing wheat who were married are expected to be less technically inefficient than those who were not married. Married farmers are more technically efficient than other.
- **Credit:** Credit was highly significant and had positive sign for cotton. This result can be explained by the fact that increasing the gap between credit amount and the actual costs will lead to delays of weeding and harvesting.

These delays negatively affect cotton yield and hence the tenant's technical efficiency. This result in conformity with the findings of Ahmed (2004).