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PRODUCTION ECONOMICS OF EGYPTIAN RICE IN THE SALT-AFFECTED LAND

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Abstract

The agricultural sector is the backbone of the Egyptian national economy. Rice is the one of the main cultivated crops in the salt-affected land in northern Egypt. Investigating the production economics of rice in the salt-affected land is the main objective of the study. The relationship between the quantity produced and the rice production costs is estimated and studied. The levels of optimal and maximizing profits for the selected crop in the salt-affected land is identified and determined. The impacts of the salinity and grand water, shortage of irrigation water in summer and continuous shortage of irrigation water at the tail of irrigation channels on the yield of rice have been investigated and estimated. Field primary data concerning the inputs and outputs of rice in the selected farms have been collected and conducted from five targeted villages in Sharkia Governorate to achieve the study objectives.

The main results can be summarized as follows: (i) the relationship between the rice quantity produced and inputs used of seed, nitrogen, phosphorus fertilizers, human labor, mechanical work and irrigation water are positive, less than one and statistically significant. In addition, the returns to scale for rice production are increased. (ii) the rice farmers will minimize their total costs by producing 4.65 ton per feddan where the slopes of total cost curve and marginal cost curve are equal. The total production cost of rice at the minimum level of costs is estimated at 1518 LE/ton and 7354 LE/feddan. (iii) the rice farmers will maximize their profit by producing 5.43 ton/feddan. The total production cost of rice at the maximum-profit level is estimated at 1481 LE/feddan and 8040 LE/feddan. (iv) The weak and high levels of salinity, water table, shortage in irrigation water during the summer season and shortage in irrigation water at the end of irrigation channels have statistically significantly decreasing effects on the quantity produced of rice.

Key words: Salt-affected land, salinity, water table, irrigation channels.

Introduction

The agricultural sector is the backbone of the Egyptian national economy. The efficiency and activity of the national economy depends on the efficiency and activity of the agricultural sector. On agriculture, the greatest burden depends on sustainable economic and agricultural development. The contribution of the agricultural sector to the national product is about 14.8% and it accommodates about 26% of the workforce during 2013. The agricultural sector provides food and employment opportunities to more than half of the workers in Egypt. The agricultural sector is also a popular market for the most important agricultural industrial products, such as machinery, equipment, tools, fertilizers and pesticides. In addition, the agriculture sector contributes more amounts from the foreign currencies through Egyptian agricultural exports.

The rice crop is considered one of the basic foods for most Egyptian families. Rice is the second largest food ingredient for the Egyptian people. It is also an important export crop for the Egyptian economy. This explains Egypt's distinction in the quality and abundance of rice production, as Egypt ranks first in the amount of production and second in quality worldwide.

The productivity per feddan of rice in Egypt has achieved the highest productivity in the world. This is due to the field researches conducted in the Egyptian Agriculture Ministry and the specialized research institutes. Several high-yielding, disease-resistant, short-

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lived and salt-tolerant varieties were developed.

The Ministry of Agriculture represented by the Agricultural Research Center succeeded in devising new varieties of some strategic crops, especially hybrid rice, whose productivity ranges from 5.5 to 6 tons per feddan.

The cultivated area of rice in Egypt is estimated at one million and 76 thousand feddans. The water requirement per feddan of rice is about 7000 cubic meters of water. The amount of water consumed by rice crop in one season is estimated at 6 billion cubic meters, knowing that Egypt's water share from the Nile River is 55 billion cubic meters and its total share from all water sources is 79 billion cubic meters.

Materials and methods

Methodological Background

In simple words, the production function refers to the functional relationship among the quantity of a commodity produced (output) and factors of production (inputs). The production function is purely a physical and technical relation which connects factor inputs and output. A production function can be expressed in a functional form as the right side of

$$Q = f(X_1, X_2, X_3, ... X_n) \quad (1)$$

Where:

Q = Quantity of output

$X_1, X_2, X_3, ... X_n$ = quantities of factor inputs (such as capital, labour, land or raw materials).

In economics, the Cobb–Douglas production function is a particular functional form of the production function. It is widely used to represent the technological relationship between the amounts of two or more inputs, particularly physical capital and human labor and the amount of output that can be produced by those inputs. The Cobb-Douglas form was developed and tested against statistical evidence by Charles Cobb and Paul Douglas during 1927–1947.

In its most standard form for production of a single good with two factors, the function is

$$Q = AL^{\beta} K^{\alpha} \quad (2)$$

Where:

Q = total commodity production, L = labor input (the total number man-days worked), K = capital input (the real value of all machinery, tools and buildings), A = total factor productivity

α and β are the output elasticities of capital and labor, respectively. These values are constants determined by available technology.

Output elasticity measures the responsiveness of output to a change in levels of either labor or capital used in production, ceteris paribus. Further, if $\alpha + \beta = 1$, the production function has constant returns to scale, meaning that doubling the usage of capital K and human labor L will also double output Y. If $\alpha + \beta < 1$, returns to scale are decreasing and if $\alpha + \beta > 1$, returns to scale are increasing. Assuming perfect competition and $\alpha + \beta = 1$, α and β can be shown to be capital's and human labor's shares of output.

An isoquant represents those combinations of inputs, which will be capable of producing an equal quantity of output; the producer would be indifferent between them. The isoquants are thus contour lines, which trace the loci of equal outputs. As the production remains the same on any point of this line, it is also called equal product curve. The Marginal Rate of Technical Substitution (MRTS) is the amount by which the quantity of one input has to be reduced when one extra or additional unit of another input is used, so that output remains constant. In other words, it shows the rate at which one input (e.g. nitrogen or water) may be substituted for another, while maintaining the same level of output. The MRTS can also be seen as the slope of an isoquant at the point in question. So it is diminishing.

In economics, a cost curve is a graph of the costs of production as a function of total quantity produced. In a free market economy, productively efficient firms use these curves to find the optimal point of production (minimizing cost) and profit maximizing firms can use them to decide output quantities to achieve those aims. There are various types of cost curves, all related to each other, including total and average cost curves and marginal ("for each additional unit") cost curves, which are equal to the differential of the total cost curves. Some are applicable to the short run, others to the long run.

Relationship between different costs curves

· Total Cost = Fixed Costs (FC) + Variable Costs (VC)

· Marginal Cost (MC) = dC/dQ; MC equals the slope of the total cost function and of the variable cost function

· Average Total Cost (ATC) = Total Cost/Q

· Average Fixed Cost (AFC) = FC/Q

· Average Variable Cost = VC/Q.

· ATC = AFC + AVC

· The MC curve is related to the shape of the ATC and AVC curves:

· At a level of Q at which the MC curve is above the average total cost or average variable cost curve, the latter curve is rising.

· If MC is below average total cost or average variable cost, then the latter curve is falling.

· If MC equals average total cost, then average total cost is at its minimum value.

· If MC equals average variable cost, then average variable cost is at its minimum value.

Dummy variable models have been used to measure the impacts of the main agriculture problems, *i.e.*, various levels of salinity and grand water, shortage of irrigation water in summer and continuous shortage of irrigation water at the tail of irrigation channels.

Empirical Model and Data Sources

Field primary data concerning the inputs and outputs of rice in the selected farms have been collected and conducted from five targeted villages in Sharkia Governorate. These villages are El Rewad, Tark Ben Ziad, El Ezdehar, El Salah and Khaleed Ben El Waleed. A random Stratified Cluster Sample Size of 102 holders from the previous five studied villages were targeted according the number of the population and the cultivated area in each village. Questionnaire sheets covering the inputs and outputs data have been used to collect the field primary data.

The rice production, total costs and average costs functions approach as well as the multiple regression models have been used to accomplish the main objectives of the study. In addition the isoquant production curve for rice crop is used to estimate the impacts of technical changes on the quantities produced of rice. As well as the averages total and marginal costs for the improved rice varieties have been used to estimate the impacts of technical changes on the optimal and maximum production levels of rice crop.

Objectives of the study

Rice is the one of the main cultivated crops in the salt-affected land in northern Egypt. Investigating the production economics of rice in the salt-affected land is the main objective of the study. The correlation relationship among the rice output produced and the production factors. The impacts of production factors used to produce rice crop in salt-affected land have been described and estimated. The various combinations of nitrogen fertilizer and irrigation water inputs which produce or yield equal production to rice producers have been derived and studied. The impacts of bio-technical changes (broad grain varieties versus long grain varieties) on the rice quantities produced and on the optimal and maximum-profit production levels have been studied and measured. The relationship between the quantity produced and the rice production costs is estimated and studied. The total costs function and the averages cost function have been studied and estimated. The levels of optimal and maximizing profits for the select crop in the salt-affected land is identified and determined. The salt affected land is suffering from four main problems concerning the soil and the irrigation water. These problems are various levels of salinity and grand water, shortage of irrigation water in summer and continuous shortage of irrigation water at the tail of irrigation channels (*Mesqas)*. The impacts of the previous four main problems on the yield of rice have been investigated and estimated.

Results and discussion

The rice yield and the input quantities used

The rice farm numbers, the yield rice and the used input quantities according the five studied villages in 2019 are presented in table 1. Data in the table presents that: (1) the average rice yield is estimated at 2.812 ton/feddan. (2) the averages of the quantities used of seeds, nitrogen fertilizer, phosphorus fertilizer, human labor, mechanical work and irrigation water are estimated at 90.76 kg/feddan, 73.8 effective units/feddan, 20.66 effective units/feddan, 52.54 hours/feddan and 7381.77 cubic meter, respectively. The quantity of irrigation water is relatively

Table 1: The rice farm numbers, the rice yield and the inputs quantities used according to the five studied villages, 2019.

Village	Tarek Ebn-Ziad	El-Salah	El-Ezdhar	Khled Ebn-Elwalied	Al-Rowad	total or average
No of Rice Farms	14	14	25	22	20	95
Rice yield (ton/feddan)	3.146	2.464	2.724	2.864	2.875	2.812
Seeds quantity (kg)	86.43	84.29	86.80	97.73	96.00	90.76
nitrogen fertilizer quantity (effective units)	70.66	59.46	74.06	81.30	77.95	73.80
phosphate fertilizer quantity (effective units)	20	19.53	12.85	22.66	28.14	20.66
labour (man/day)	18.63	17.29	16.53	16.51	15.38	16.72
Mechanical work (hours)	48.25	62.21	52.14	53.20	48.28	52.54
Quantity of Irrigation water (M3/feedan)	7672.37	7449.80	7446.94	7401.25	7005.67	7381.77

Source: compiled and calculated from the field primary data, 2019 Production Function of rice Crop.

Table 2: The simple correlation coefficient matrix for the rice yield and input quantities.

Items	Rice: Main yield (ton)	seeds qua-ntity (kg)	nitrogen fertilizer quantity (kg)	phosphate fertilizer quantity (kg)	labour days of work	Machine hours of work	Quantity of Irrigation water per acre
Rice Main yield (ton)	1						
seeds quantity (kg)	0.41	1					
nitrogen fertilizer	0.401	0.271	1				
phosphate fertilizer	0.14	0.003	0.08	1			
labour (man-days)	0.105	-0.06	-0.116	-0.167	1		
Mechanical work (hours)	-0.234	-0.198	-0.316	0.122	0.544	1	
Quantity of Irrigation water (m3/feddan)	0.234	0.112	-0.139	-0.042	0.153	0.118	1

Source: compiled and calculated from the field primary data, 2019.

high because of the cultivated area are salt-affected lands.

The Linear Production Function

The correlation relationship among the rice yield per feddan and the quantity sued from the main inputs have been investigated and estimated as shown in table 2. The simple correlation coefficient matrix among the rice yield and the quantity sued from the inputs shows relatively reasonable positive correlation relationships among the rice yield and the seeds, nitrogen, phosphorus, human labor and irrigation water. In opposite the correlation relationship between the rice yield and the mechanical work is negative and unlogic.

The linear production function for rice in the salt-affected land has been estimated using the field primary data for the inputs and output quantities as follows:

$$Q_r = -0.724(-1.19) + 0.011\, seed\, (3.034)^{**} + 0.008\, nit\, (3.12)^{**} + 0.01\, phos\, (2.58)^{**} + 0.091\, labor\, (3.27)^{**} - 0.015\, mech\, (-3.09)^{**} + 0.00015\, wat\, (2.87)^{**} \qquad (1)$$

$R2$ = 0.42 F ratio = 10.61

Where:

Q_r = The rice production quantity in ton/feddan

Seed = The quantity used from rice seed in kg/feddan

Phos = The quantity used from phosphorus fertilizer in effective unit/feddan

nit = The quantity used from nitrogen fertilizer in effective unit/feddan

lab = The quantity of human labor used in man-day/feddan

mech = The mechanical work used in hours/feddan

Water = The quantities used from irrigation water in cubic meter/feddan

The numbers between brackets are t-statistical values

The previous estimated function among the rice yield and the studied inputs shows strong relationship among the rice yield and the inputs used in the salt affected land because the estimated parameters and the mathematical function are high significant and logic. Only the sign of the mechanical work is not logic. The unlogic sign of the mechanical work variable is due maybe to the over use of the irrigation pumps to discharge big quantities of irrigation water in the salt affected land. The changes in the input's quantities used explain 42% from the changes in the rice yield quantity.

The Cobb-Douglas Production Function

The Cobb–Douglas production function for rice crop is estimated as follow:

$$Q_r = 0.002\, (seed)^{0.448}\, (3.29)^{**}\, (nit)^{0.22}\, (3.05)^{**}\, (lab)^{0.336}\, (1.91)^{*}\, (mech)^{-0.205}\, (-2.16)^{*}\, (wat)^{0.465}\, (3.10)^{**} \qquad (2)$$

R\2 = 0.38 F-ratio = 9.72

The previous production function model indicates that: (i) The estimated parameters and the estimated model are statistically significant. The quantities used from seeds, nitrogen, human labor, mechanical work and irrigation water have great statically effect on the production quantity of rice in the salt-affected land. (ii) The production elasticities of seed, nitrogen fertilizers, human labor and irrigation water are positive and less than one, *i.e.*, the usage of those factors are in the second production stage or the economic production stage. On opposite, the production elasticity of mechanical work is negative and less than one, *i.e.*, the usage of this factor is in the third production stage or the uneconomic production stage. (iii) the variations in the studied factors explain only 38% of the variations in the quantity produced of rice in the salt-affected land. (iv) the returns to scale of the studied factors in rice production are increasing (*i.e.*,1.265). That means a 100% increase in the studied factors usage would lead to approximately a 127% increase in the rice output. (v) total factor productivity is positive and relatively very low (0.002).

An isoquant shows the extent to which the farm in question has the ability to substitute between the two different inputs (e.g., nitrogen fertilizer and irrigation water) at will in order to produce the same level of output. The isoquant curve for rice represents those combinations of two inputs, which will be capable of producing an equal quantity of output; the producer would be indifferent between them. The rice isoquant curve for the various combinations of nitrogen fertilizer and irrigation water Fig. 1 can be derived from the functional form number (1) using the average quantity produced of rice and the average quantities used of inputs shown in table 1 as follows:

$$\text{Water} = \{2.754/(0.01714)*(\text{nit})^{0.220}\}^{(1/0.465)} \quad (3)$$

Fig. 1 shows that: (i) The Marginal Rate of Technical Substitution (MRTS) between nitrogen fertilizer and irrigation water is diminishing. On the other word, the amount by which the quantity of nitrogen input has to be reduced when one extra or additional unit of irrigation water input is used, so that output of rice remains constant. (ii) the technological tradeoff between nitrogen and irrigation water in the rice production function is decreasing marginal returns of both inputs. Adding one input while holding the other constant eventually leads to decreasing marginal output and this is reflected in the shape of the isoquant.

The Impacts of Technological Changes on Production Level

The studied villages cultivate two varieties of rice crop, e.g., board grain Vs long grain. The broad grain varieties yields are exceeding the long grain varieties by 25%. The impacts of technological changes *i.e.*, broad grain varieties) on the rice production using isoquant curves will investigate in this part of the study. The

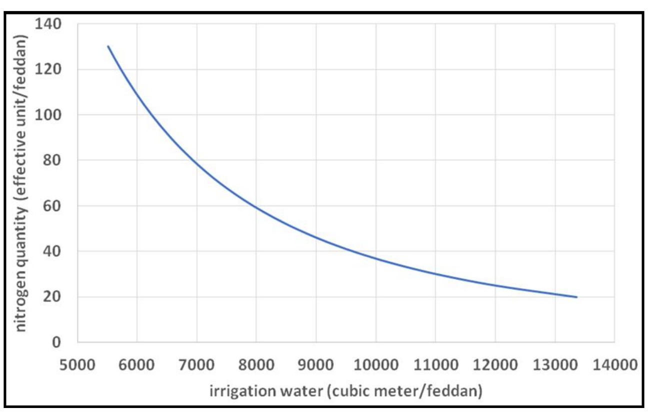

Fig. 1: The rice isoquant curve for the various combinations of nitrogen fertilizer and irrigation water (Equation 3 and the rice field primary data, 2019).

interviewed farmers indicate that the improved varieties of rice increase the average yield of rice from 2.81 ton/feddan to 3.51 ton/feddan, *i.e.*, an increase of 25%. Using this fact and recalculation the models number (2) and (3), the rice isoquant curve can be derived in model number 4 as follows:

$$\text{Water} = \{3.254/(0.01714)*(\text{nit})^{0.220}\}^{(1/0.465)} \quad (4)$$

Fig. 2 shows that the farmers will produce high level of rice output when they use improved varieties, *i.e.*, broad grain varieties. The rice isoquant curve for the improved varieties (ISQ_2) is higher than the rice isoquant curve for the long grain varieties (ISQ_1). Consequently, the farmers can produce more output of RICE under the same quantity used of irrigation water and nitrogen fertilizers.

The Production Cost Function of Rice Crop

The production costs for rice crop

The averages costs items for seed, chemical fertilizers, pesticides, human labor, mechanical work, animal work, irrigation pump operating, irrigation channels clearance are presented in table 3. The results in the table show that the averages costs items for seed, chemical fertilizers, pesticides, human labor, mechanical work, animal work, irrigation pump operating, irrigation channels clearance are estimated at 622.8 LE/feddan, 1162.8 LE/feddan, 599.7 LE/feddan, 483.9 LE/feddan, 2164.1 LE/feddan, 189 LE/feddan, 467.7 LE/feddan and 50 LE/feddan, respectively.

The Averages Total Cost Function

The average total cost and the variable costs functions of rice can be estimated as a quadratic functions using the collected field primary data, equations no. 5, 6 and Fig. 3.

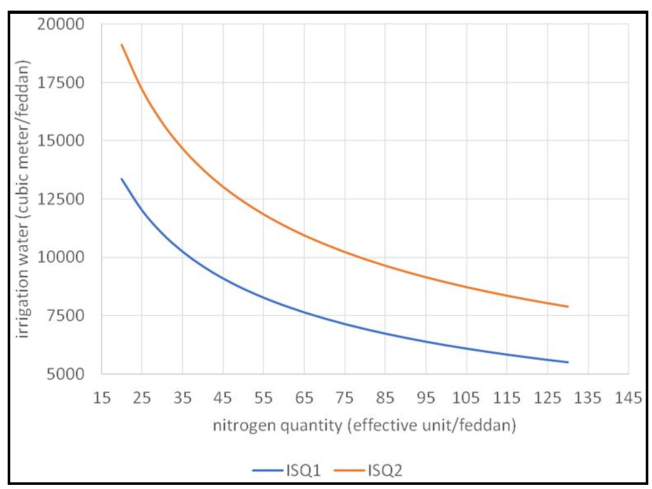

Fig. 2: The impacts of improved varieties on the rice isoquant curve of rice crop in salt-affected land (Equation 4 and the rice field primary data, 2019).

Table 3: Averages of cost items for rice crop according to the studied villages, 2019.

Costs items	Tarek Ebn-Ziad	El-Salah	El-Ezdhar	Khled Ebn-Elwalied	Al-Rowad	Averae
seeds cost	528.57	595.63	612.00	685	693.00	622.84
fertilizers cost	821.4286	1094.69	1008.6	1400.91	1488.25	1162.78
Pesticides cost	367.14	630.00	760.00	653.18	588.00	599.66
human labor cost	646.4286	575	253.6	479.32	465.25	483.92
Mechanical work cost	2112.143	2106.25	2141.2	2248.64	2212.00	2164.05
Animal work cost	200	200	178.5714	177.2727	188.8889	188.95
Operation Costs of irrigation pump	464.29	450.00	478.00	486.36	460.00	467.73
Irrigation channel clearance	50.00	50.00	50.00	50.00	50.00	50.00

Source: compiled and calculated from the field primary data, 2019.

$ATC_c = 5348.4\ (6.33)^{**} - 1618.7\ Q\ (-3.03)^{**} + 173.9\ Q^2\ (2.08)^{*}$ (5)

$R\backslash^2 = 0.35$ F- ratio = 21.37

$AVC_c = 4790.5\ (5.7)^{**} - 1440.7\ Q\ (-2.7)^{**} + 155.8\ Q^2\ (1.9)^{*}$ (6)

$R\backslash^2 = 0.29$ F- ratio = 16.5

Where:

ATC_r = the average total production cost of rice in LE/ton

AVC = the average variable costs of rice in LE/ton

Q = the quantity produced from rice in ton/feddan

The marginal cost (MC_r) function of rice can be derived from equation 5 as follows:

$MC_c = 5348.4 - 3237.4\ Q + 521.7\ Q^2$ (7)

The average total costs, average variable and marginal cost functions are showed in Fig. 3. The previous three functions indicate that: (i) all estimated parameters and the models are statistically significant. (ii) the variation in the quantity produced (Q) explain 34% of the variation in average production costs. Fig. 3 present that: (i) the average total cost, variable cost and marginal cost curves take U shape (logically agree with the economic theory). (ii) the marginal cost curve intersects the average total and variable cost curves at the minimum point. (iii) the rice farmers will minimize their total costs by producing 4.65 ton/feddan where the slopes of total cost curve and marginal cost curve are equal. (iv) The total production costs of rice at the minimum level of costs are estimated at 1518 LE/ton and 7354 LE/feddan. The total returns for the rice farmers are estimated at 14620 LE/feddan and then the average net profit is estimated at 1562 LE/ton and 7265 LE/feddan. (v) the rice farmers will maximize their profit by producing 5.43 ton/feddan where the marginal cost curve equal the farmgate price of rice (e.g., 3144 LE/ton). The total production cost of rice at the maximum-profit level is estimated at 1663 LE/ton and 9032 LE/feddan. The total return for the rice farmers is estimated at 17072 LE/feddan and then the average net profit is estimated at 1481 LE/feddan and 8040 LE/feddan.

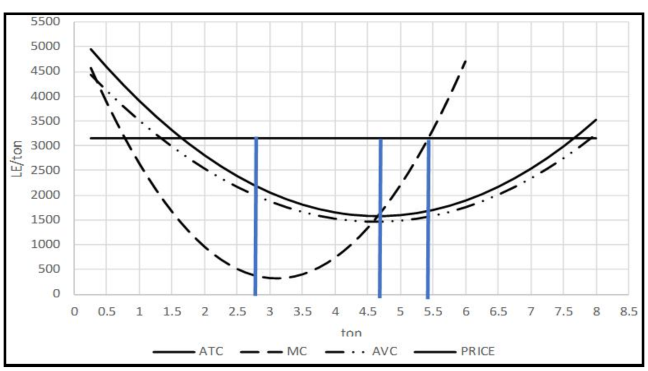

Fig. 3: The average production functions of rice crop in the salt-affected land (Equations 5, 6, 7 and the rice field primary data, 2019).

Total Cost Function

The total production cost function of rice can be estimated as a cubic function, equation no. 8 and Fig. 4.

$TC_c = 561 + 4790.5\ Q\ (5.7)^{**} - 1440.7\ Q^2\ (-2.7)^{**} + 155.8\ Q^3\ (1.9)^{*}$ (8)

$R\backslash^2 = 0.29$ F- ratio = 16.5

Where:

TC_c = the total production cost of rice in LE/feddan

Q = the quantity produced from rice in ton/feddan

The previous total production cost function and Fig. 4 indicate that: (i) all estimated parameters and the model are statistically significant. (ii) the variation in the rice yield (Q) explain 29% of the variation in total production costs. (iii) the rice farmers will maximize their profits by producing about 5.43 ton per feddan where the slopes of total cost curve and total return curve are equal. (iv) the total production costs of rice at the maximum profit level is estimated at 9032 LE/feddan. (v) the average total returns of rice farmers is estimated at 17072 LE/feddan and then the average net profit is estimated at 8040 LE/feddan.

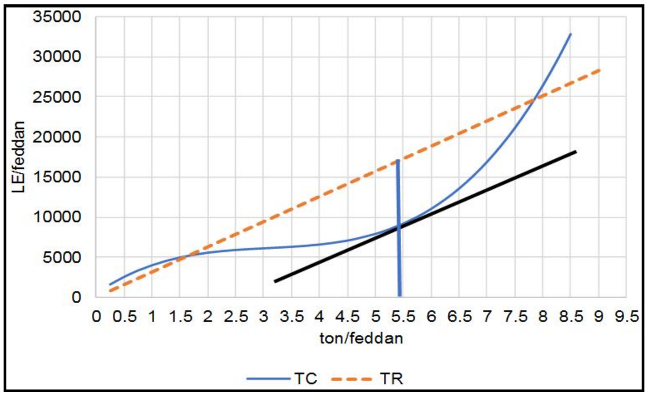

Fig. 4: The total production function of rice crop in the salt-affected land (Equation 8 and the rice field primary data, 2019).

Income Forgone

The steps of calculation of income forgone for rice farmers in the salt-affected land are presented in table 4. The results in the table show the following indicators: (i) the actual, optimal and maximizing-profit quantities produced of rice are estimated at 2.81 ton/feddan, 4.65 ton/feddan and 5.43 ton/feddan, respectively. The average farmgate price of rice is estimated at 3144 LE/ton.

Thus, the total returns for rice farmers at the actual, optimal and maximizing-profit levels are estimated at 8835 LE/feddan, 14620 LE/feddan and 17072 LE/feddan, respectively. (ii) the average production costs at the actual, optimal and maximizing-profit production levels of rice are 2173 LE/ton, 1581 LE/ton and 1663 LE/ton, respectively. Therefore, the total costs at the at the actual, optimal and maximizing-profit production levels of rice are 6106 LE/feddan, 7352 LE/feddan and 9030 LE/feddan, respectively. (iii) the profit at the actual, optimal and maximizing-profit production levels of rice are 2729 LE/feddan, 7268 LE/feddan and 8042 LE/feddan, respectively. Consequently, the income forgone for rice farmers at the optimal and maximizing-profit production levels are 4539 LE/feddan and 5313 LE/feddan, respectively.

Table 4: The actual, optimal and maximizing-profit productions, costs and returns for rice farmers, 2019.

Maximizing profit production level	Optimal production level	Actual production level	Unit	Item
5.43	4.65	2.81	ton/feddan	Production
3144	3144	3144	LE/ton	farmgate price
17071.92	14619.6	8834.64	LE/feddan	total return
1663	1581	2173	LE/ton	Average cost
9030.09	7351.65	6106.13	LE/feddan	total costs
8041.83	7267.95	2728.51	LE/feddan	Profit/feddan
5313.32	4539.44		LE/feddan	income forgone

Source: Figures 3, 4 and the rice field primary data, 2019.

The Impact of Technological Changes on the Average Production Costs Levels

As mentioned above the rice farmers in the salt-affected land reveal that the improved varieties increase yield by 25%. The average total cost functions and the average variable cost of improved rice varieties, *i.e.*, broad grain varieties, (ATC\ and AVC\) can be estimated as a quadratic function, equations no. (9) and (10), respectively.

$$ATC\backslash = 5348.4\ (6.3)^{**} - 1294.9\ Q\ (-3.03)^{**} + 111.29\ Q^2\ (2.1)^{*} \qquad (9)$$

$R\backslash^2 = 0.35$ F ratio = 21.37

$$AVC\backslash = 4790.5\ (5.7)^{**} - 1152.5\ Q\ (-2.7)^{**} + 99.7\ Q^2\ (1.9)^{*} \qquad (10)$$

$R\backslash^2 = 0.29$ F ratio = 16.51

The marginal cost function of improved rice varieties ($MC\backslash_c$) can be derived from the previous equation (9) as follows, equation no. (11):

$$MC\backslash = 5348.4 - 2589.9\ Q + 333.9\ Q^2 \qquad (11)$$

The average total cost and marginal cost functions of old varieties (equations 5,6 and 7) and the average total cost and marginal cost functions of improved varieties (equations 9, 10 and 11) are presented in Fig. 5. The results can be concluded from the figure are: (i) 25% increase in the yield of rice because of improved varieties cultivation leads to: (i) obvious moving the average total cost, average variable and marginal cost functions to the right. (ii) all the three function have been relatively shift down. Therefore, the production levels which minimize the total costs and maximize the profits of rice farmers have been moved to the right. (ii) The minimum points of averages costs and the maximum points of profits move obviously to right. The optimal production level of cost has been moved from 4.65 ton/feddan for long grain varieties to 5.7 ton/feddan for broad grain varieties. In addition, the maximize-profit level has been moved from 5.43 ton/feddan for the long grain varieties to 6.74 ton/feddan for the broad grain varieties.

Impacts of agricultural problems on the rice yield

The farms in the salt affected land suffer from four main agricultural problems. These problems are various levels of salinity and grand water, shortage of irrigation water in summer and continuous shortage of irrigation water at the tail of irrigation channels. The impacts of the four main problems on the yield of rice have been investigated and estimated in this part of the

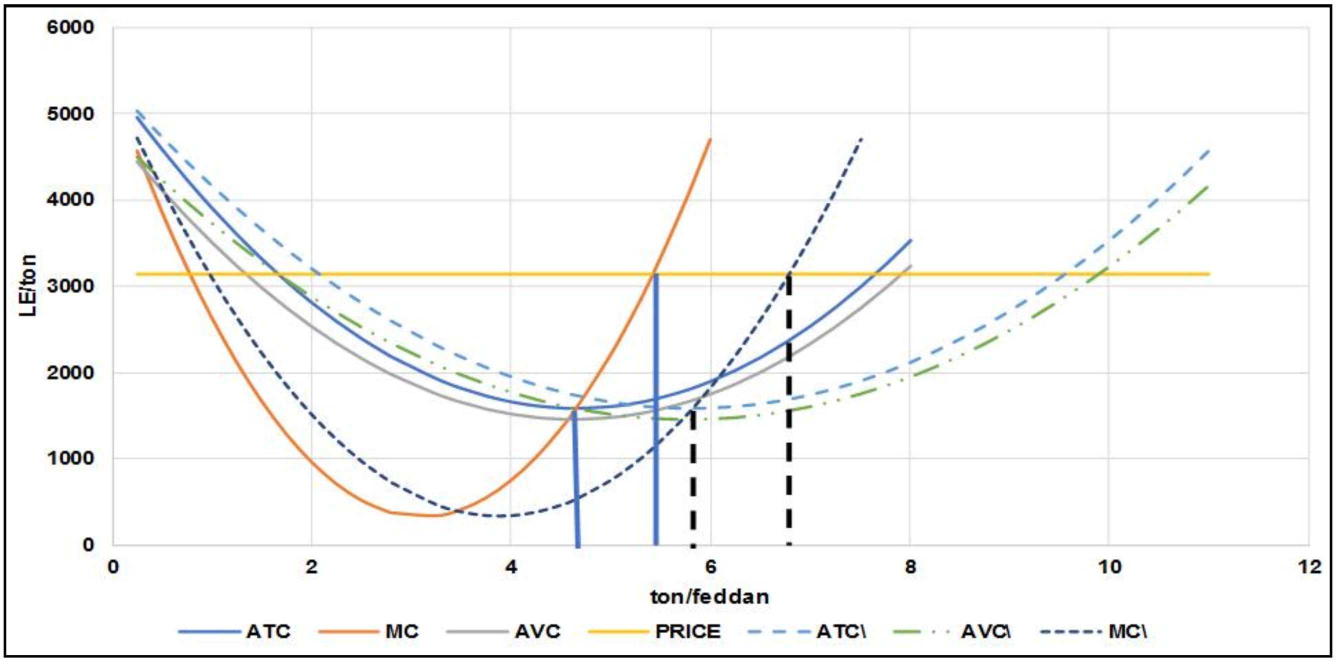

Fig. 5: The impacts of improved varieties on the averages total and marginal costs of rice crop in salt-affected land (Equations 7, 8 and the Rice field primary data, 2019).

study.

The impact of the salinity on the rice yield

The frequent of the respondents concerning the salinity levels……… in the studied rice farms are showed in table (5). Data in the table indicate that 25% and 21% of the rice farm suffers from weak and high levels of the salinity problems whereas 54% of the rice farms aren't suffers.

The relationship between the yield of rice and the intensity level of the salinity problem using the dummy variable model is estimated as follows:

Q = 3.184 (61.8)** - 0.588 weak (-6.4)** – 0.979 high (-10.3)** (12)

R^2 = 0.55 F ratio = 58.8 **

The results from the equation 12 shows that: (i) the estimated parameters and the dummy variable model are statistically significant. (ii) the variations of the intensity level of the salinity problem explain 55% of the variation of the rice yield in the rice farms. (iii) the rice yield in the farms does not suffer from the salinity is estimated at 3.184 ton /feddans whereas the rice yields have been decreased by 0.588 ton/feddan and 0.979 ton/feddan in the farms which suffers from weak and high levels of salinity, respectively.

The impact of the grand water on the rice yield

Data in table 5 indicate that 24% and 16% of the rice farm suffers from weak and high levels of the grand water problems whereas 59% of the rice farms aren't suffers.

The relationship between the yield of rice and the intensity level of the water table problem using the dummy variable model is estimated as follows:

Q = 3.119 (60.6)** - 0.536 weak (-5.6)** – 1.025 high (-9.2)** (13)

R^2 = 0.51 F ratio = 48.2 **

The results from the equation 13 shows that: (i) the estimated parameters and the dummy variable model are statistically significant. (ii) the variations of the intensity level of the water table problem explain 51% of the variation of the rice yield in the rice farms. (iii) the rice yield in the farms does not suffer from the water table problem is estimated at 3.119 ton /feddans whereas the rice yields have been decreased by 0.536 ton/feddan and 1.025 ton/feddan in the farms which suffers from weak

Table 5: The intensity of the main four problems in the rice farms, 2019.

Problem intensity	salinity level		grand water		shortage in irrigation water in summer		continuous shortage in irrigation water at the tail of channels	
	No	%	no	%	No	%	no	%
no problem	53	53.5%	59	60%	46	46%	38	38.4%
weak problem	25	25.3%	24	24%	29	29%	33	33.3%
high problem	21	21.2%	16	16%	24	24%	28	28.3%
Total	99	100%	99	100%	99	100%	99	100%

and high levels of water table problems, respectively.

The impact of the shortage in irrigation water in summer on the rice yield

Data in the table 5 indicate that 29% and 24% of the rice farm suffers from weak and high levels of the shortage in the irrigation water in summer season whereas 46% of the rice farms aren't suffers.

The relationship between the yield of rice and the intensity level of the shortage in the irrigation water during summer using the dummy variable model is estimated as follows:

Q = 3.182 (53.3)** - 0.503 weak (-5.2)** – 0.869 high (-8.5)** (14)

R^2 = 0.45 F ratio = 39.9 **

The results from the equation 14 shows that: (i) the estimated parameters and the dummy variable model are statistically significant. (ii) the variations of the shortage in irrigation water during the summer season explain 45% of the variation of the rice yield in the rice farms. (iii) the rice yield in the farms does not suffer from the shortage in irrigation water during the summer season is estimated at 3.182 ton /feddans whereas the rice yields have been decreased by 0.503 ton/feddan and 0.869 ton/feddan in the farms which suffers from weak and high levels of shortage in irrigation water in summer season, respectively.

The impact of the shortage in irrigation water at the tail of the irrigation channels on the rice yield

Data in the table 5 indicate that 33% and 28% of the rice farm suffers from weak and high levels of the shortage in the irrigation water at the tail of the irrigation channels whereas 38% of the rice farms aren't suffers.

The relationship between the yield of rice and the intensity level of the shortage in irrigation water at the tail of irrigation channels using the dummy variable model is estimated as follows:

Q = 3.216 (47.8)** - 0.450 weak (-4.6)** – 0.855 high (-8.3)** (15)

R^2 = 0.42 F ratio = 35.2 **

The results from the equation 15 shows that: (i) the estimated parameters and the dummy variable model are statistically significant. (ii) the variations of the intensity level of the shortage in irrigation water at the end of irrigation channels explain 42% of the variation of the rice yield in the rice farms. (iii) the rice yield in the farms does not suffer from the shortage in the irrigation water at the end of the irrigation channels is estimated at 3.216 ton /feddans whereas the rice yields have been decreased by 0.450 ton/feddan and 0.855 ton/feddan in the farms which suffers from weak and high levels of shortage in the irrigation water at the end of the irrigation channels, respectively.

Conclusions and Recommendation

The main results can be summarized as follows: (i) the relationship between the rice quantity produced and inputs used of seed, nitrogen, phosphorus fertilizers, human labor, mechanical work and irrigation water are positive, less than one and statistically significant. In addition, the returns to scale for rice production are increased. (ii) The rice isoquant curve for the improved varieties is higher than the rice isoquant curve for the old varieties. Consequently, the farmers can produce more output of rice under the same quantity used of irrigation water and nitrogen fertilizer using the improved varieties. (iii) the rice farmers will minimize their total costs by producing 4.65 ton per feddan where the slopes of total cost curve and marginal cost curve are equal. The total production cost of rice at the minimum level of costs is estimated at 1518 LE/ton and 7354 LE/feddan. (iv) the rice farmers will maximize their profit by producing 5.43 ton/feddan. The total production cost of rice at the maximum-profit level is estimated at 1481 LE/feddan and 8040 LE/feddan. (v) using the broad grain varieties by the farmers leads to: (i) obvious moving the average total cost, average variable and marginal cost functions to the right. (ii) all the three function have been relatively shifted down. Therefore, the production levels which minimize the total costs and maximize the profits of rice farmers have been moved to the right. (ii) The minimum points of averages costs and the maximum points of profits move obviously to right. The optimal production level of cost has been moved from 4.65 ton/feddan for long grain varieties to 5.7 ton/feddan for broad grain varieties. In addition, the maximize-profit level has been moved from 5.43 ton/ feddan for the long grain varieties to 6.74 ton/feddan for the broad grain varieties. The weak and high levels of salinity, water table, shortage in irrigation water during the summer season and shortage in irrigation water at the end of irrigation channels have statistically significantly decreasing effects.

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