Statistical Estimation of Production and Costs Functions of Cucumber Crop under greenhouse system: A Field Study

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ABSTRACT

This research aims in general to study the estimation of the functions of production costs as they reflect the relationship between total costs and actual production, through which it is possible to derive the most important economic indicators that reflect the extent to which agricultural production units achieve economic efficiency in their use of productive resources involved in the production process, as well as the extent to which these units achieve maximization of profits for the agricultural product. The study of production costs and the associated important indicators, whether at the level of the production unit or at the national level, can be used to draw and analyze price policies and help agricultural producers in making their own production decisions, which would encourage producers to continue or expand the production process or stop production.

In addition to determining the volume of production that achieves most of the profits and then achieve economic efficiency from the use of productive elements.

Keywords: Costs Functions, Production Functions, Economic Efficiency, Optimal Volume of Production.

INTRODUCTION

Egyptian agriculture faces several basic problems that limit its fulfillment of what is required by local needs or the development of exports to meet the ongoing deficit in the trade balance. The most important of these problems are limited water and land resources, low acreage productivity, as well as the incompatibility of production and harvest seasons related mainly to the climate with appropriate export periods that are characterized by intense competition in international markets.

Therefore, the Ministry of Agriculture and Land Reclamation has recently moved towards implementing a national project to establish 100,000 greenhouses on an area of 100,000 acres, with the aim of establishing integrated agricultural development communities and superior quality of locally fresh products, as well as maximizing the use of land and water units, providing new job opportunities in the targeted reclamation areas, and increasing export rates of agricultural products to support the national economy.

Greenhouses are of great importance as a good way to use modern techniques and patterns in agriculture , in order to achieve a high economic return by increasing production and shortening the unit of the area used for agriculture and producing high-quality agricultural crops free of pollutants in good quantities and qualities in the off-season, as well as providing the quantities of water used in agriculture, where protected crops consume from 60-70% of the quantities of water consumed by traditional(open) agriculture.

Accordingly, the importance of protected agriculture is highlighted as a possible means of developing agricultural production in light of those existing determinants, and it also comes at the forefront of technologies to face many problems, as the limited agricultural and water land resources in addition to the increasing local demand for food as a result of the steady growth in the population led to the need to search for non-traditional means in order to increase the supply of food crops.

Depending on the agricultural development strategy until 2030, which seeks to make better use of limited resources, whether water or land, protected agriculture is at the forefront of solutions, means and technologies to confront this.

The expansion of the use of greenhouses is one of the tools of technology used in vertical agricultural expansion to develop production , which is the basis of the state's strategy to develop agriculture to bridge the food gap and confront the huge population increase, as well as obtaining a product free of diseases and pests and then has a high competitiveness, whether locally or internationally, by taking advantage of its high capacity to increase production and provide additional units of land and water resources, as well as overcoming the problem of seasonal unemployment and then facing the seasonality of prices and the seasonality of income for agricultural workers and producers, as well as benefiting

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from modern technologies such as organic agriculture and tissue agriculture and others that enable access to good exportable varieties with the required specifications globally and appropriate export periods to face global competition..

RESEARCH PROBLEM

The Egyptian agricultural sector faces great challenges in fulfilling its role, in terms of providing food and clothing to members of society, as well as providing an appropriate amount of foreign currency necessary to finance economic and social development plans. It is also faced with some other problems and challenges, including: the lack of seasonality of production and harvesting with optimal periods for export, limited water resources, continuous population increase, and the relative stability of the cultivated area, which limits horizontal expansion and makes vertical expansion one of the necessary means for the development of agricultural production in light of these existing determinants.

Despite the importance of protected agriculture in general and its ability to increase agricultural production and meet local needs of most vegetable crops according to different strategies, in addition to its role in raising the productive efficiency of the land and irrigation water units, and overcoming the seasonality of employment and production compared to open agriculture, the spread of greenhouses in Egypt still faces legislative and financing difficulties and high prices of production supplies in the first place.

RESEARCH OBJECTIVE

The research aims in general to identify the role of greenhouses in raising the efficiency of the use of some agricultural resources in Egypt, providing vegetable crops throughout the year, achieving local sufficiency and raising export rates by achieving the following sub-goals:

- Statistical estimation of the production functions and costs of the cucumber crop inside the greenhouses in the study sample in Dakahlia Governorate.
- Identify the production, marketing and financing problems facing the spread of greenhouses in the field study sample.

METHODOLOGY DATA SOURCES

The research used descriptive and quantitative statistical analysis methods, and the statistical estimation of production functions and costs of the most important vegetable crops under study was also made.

To achieve the objectives of the study, it relied mainly on preliminary data for a field sample deliberately selected from vegetable farmers in greenhouses in Dakahlia Governorate, collected through a questionnaire prepared specifically for this purpose. 90 questionnaire forms were prepared for the cucumber crop, and included the data necessary to conduct the study for the agricultural season 2021/2022.

The research also relied on secondary data issued by the Economic Affairs Sector of the Ministry of Agriculture and Land Reclamation, the Horticultural Research Institute of the Agricultural Research Center, the Academy of Scientific Research and Technology, scientific theses from various universities and scientific research centers, and the International Information Network (Internet).

DISCUSSION OF RESULTS

This part of the study was concerned with the statistical estimation of the production functions and costs of the cucumber crop for the study sample, in order to discuss the extent of compatibility with the use of agricultural resources in the production of agricultural crops. This chapter includes estimating the production functions and cost items at the greenhouse level separately in the study sample in the governorate.

Average quantity used of production elements and physical output of the cultivated cucumber crop at the level of the area categories:

The results of the questionnaire, which are shown in Table (1), indicated that the average productivity per 100 m2 of greenhouses planted with the cucumber crop in the study sample was about 2.66 tons / 100 m2. The third category (350m and above) came as the highest average productivity, which was estimated at about3.13 tons / 100 m2. The first category (200 m2– less than 250 m2) was the lowest productivity, which was estimated at 2.18 tons / 100 m2. It was used to produce the cucumber crop in the three categories. Physical quantities of production elements were the number of seedlings necessary for agriculture (seedling / greenhouse), the number of human work units for the crop (hour / greenhouse), the number of automated work units for the crop (hour / greenhouse), the amount of municipal fertilizer used (cubic meter/ greenhouse), the amount of nitrogen fertilizer (effective unit/ greenhouse), the amount of phosphate fertilizer (effective unit/ greenhouse), the amount of urea fertilizer (effective unit/ greenhouse), the amount of pesticides (liter / greenhouse), the amount of irrigation water (m3 / greenhouse).

The average results of the questionnaire came as follows for each category , the first category is the number of seedlings needed for planting 787 (seedlings/ greenhouse), the number of human labor units 271 (hours / greenhouse), the number of automated work units 91 (hours / greenhouse), the amount of municipal fertilizer used was about 15 (cubic meters/ greenhouse), the amount of nitrogen fertilizer 44 kg (effective unit/ greenhouse), the amount of phosphate fertilizer 43 kg (effective unit/ greenhouse), the amount of urea fertilizer 35 kg (effective unit/ greenhouse), the amount of pesticides 3 (liters / greenhouse), the amount of irrigation water 133 (m3 / greenhouse).

The average results of the questionnaire for the second category were the number of seedlings needed for planting 899 (seedling / greenhouse), the number of human work units 320 (hour / greenhouse), the number of automated work units 120 (hour / greenhouse), the amount of municipal fertilizer used was about 25 (cubic meters/ greenhouse), the amount of nitrogen fertilizer 59 kg (effective unit/ greenhouse), the amount of phosphate fertilizer 60 kg (effective unit/ greenhouse), the amount of urea fertilizer 49 kg (effective unit/ greenhouse), the amount of pesticides 4 (liter / greenhouse), the amount of irrigation water 180 (m3 / greenhouse).

The average results of the questionnaire for the third category were the number of seedlings needed for planting 1202(seedling / greenhouse), the number of human work units 711 (hour / greenhouse), the number of automated work units 278 (hour / greenhouse), the amount of municipal fertilizer used was about 29 (cubic meters/ greenhouse), the amount of nitrogen fertilizer 99 kg (effective unit/ greenhouse), the amount of phosphate fertilizer 98 kg (effective unit/ greenhouse), the amount of urea fertilizer 71 kg (effective unit/ greenhouse), the amount of pesticides 6 (liter / greenhouse), the amount of irrigation water 218 (m3 / greenhouse).

The average results of the questionnaire for the three categories were the number of seedlings needed for planting 931(seedling / greenhouse), the number of human labor units 434 (hour / greenhouse), the number of automated labor units 163 (hour / greenhouse), the amount of municipal fertilizer used was about 23 (cubic meters/ greenhouse), the amount of nitrogen fertilizer 67 kg (effective unit/ greenhouse), the amount of phosphate fertilizer 67 kg (effective unit/ greenhouse), the amount of urea fertilizer 52 kg (effective unit/ greenhouse), the amount of pesticides 4 (liter / greenhouse), the amount of irrigation water 177 (m3 / greenhouse).

Statistical Estimation of Production Functions of Cucumber Crop:

Using the statistical estimation of the agricultural production functions of the cucumber crop at the level of one greenhouse, with the aim of identifying the productive and economic efficiency of the use of resources or productive elements used in the production of cucumbers in the field study sample, by estimating the total output function and then deriving the partial and total elasticities and deriving the marginal output and average output functions according to each variable production element in the production function under study, and then comparing the value of the marginal output of each variable production element with the unit price of this same production element or the cost of its alternative opportunity, in order to identify the economic efficiency of using additional units of this production element.

Table 1. Quantities of production elements used in the production of cucumber crop at the level of study categories

Statement		First category	Second category	Third category	Average of categories
Area (m^2)	S	240	280	380	300
Number of seedlings	x1	787	899	1202	963
Number of human labor hours	x2	271	320	711	434
Number of automated labor hours	x3	91	120	278	163
Amount of organic fertilizer	x4	15	25	29	23
Azote	x5	44	59	99	67
Phosphate	x6	43	60	98	67
Urea	x7	35	49	71	52
Amount of pesticides	x8	3	4	6	4
Amount of irrigation water	x9	133	180	218	177
Yield		6	8	12	9
Productivity per 100 m^2	-	2.18	2.65	3.14	2.66

Source: collected and calculated from questionnaire in Agricultural season 2021-2022.

The multiple regression method was used in the dual logarithmic image to select the most important explained independent variables most influential in the amount of total output per acre (Q) that was studied as the determinants of the productivity of the acre of the crop under study in the greenhouses covered by the field study. It was used in estimating the production functions of the study sample in the form of (Cobb-Douglas), including seven independent variables:

$$Q = \alpha \cdot X_1^{\beta_1} \cdot X_2^{\beta_2} \cdot X_3^{\beta_3} \cdot X_4^{\beta_4} \cdot X_5^{\beta_5} \cdot X_6^{\beta_6} ... X_9^{\beta_9}$$

Whereas:

- Q = Total greenhouse production of cucumber crop (tons/greenhouse).
- X1 = Number of seedlings required for planting (seedlings/greenhouse).
- X2 = Number of labor units for the crop (hours/greenhouse).
- X3 = Number of machine units for the crop (hours/greenhouse).
- X4 = Quantity of organic fertilizer used (cubic meters/greenhouse).
- X5 = Quantity of nitrogen fertilizer (effective units/greenhouse).
- X6 = Quantity of phosphate fertilizer (effective units/greenhouse).
- X7 = Quantity of urea fertilizer (effective units/greenhouse).
- X8 = Quantity of pesticides (liters/greenhouse).
- X9 = Quantity of irrigation water (m3/greenhouse).
- β = Production elasticity for each production factor in the function.
- α = Constant amount of total greenhouse output.

First: Statistical estimation of the production functions of the cucumber crop in the total sample of the field study:

The production function parameters of the cucumber crop were estimated from the study sample data according to the model estimated in the form of (Cobb - Douglas) converted to the double logarithmic form to simplify the estimation of the derivatives of the function and its ease of interpretation, by entering all the production elements affecting the total greenhouse output of the cucumber crop through the previous model:

(1) The production function of the cucumber crop in the study sample:

The production elements with a positive moral impact on the production of the cucumber crop in the study sample were determined through the estimated model of the total output function of the greenhouse of the cucumber crop using multiple regression in the double logarithmic image, which is shown by the following equation:

Equation

LnQ =2.12+ 0.7 Ln X1+0.65 Ln X2 + .087 Ln X3 +.141 Ln X4+.052 Ln X9

(7.6) (3.4)* (5.6) ** (3.3) * (2.7) ***

$$F = 211 \qquad \bar{R}^2 = 0.88$$

It was found from the total output function (Q) that the most important productive elements with a significant impact on the total output of the greenhouse of the cucumber crop are the number of seedlings, human labor, mechanical labor, the amount of municipal fertilizer and the amount of irrigation water. By estimating the production elasticities of these elements, it was found that the production elasticity of the number of seedlings, human labor, mechanical labor, the amount of municipal fertilizer and the amount of irrigation water amounted to about 0.7,0.65, 0.87, 1.41 and0.52, respectively, indicating that the increase in the amount used of elements by 10% leads to an increase in the production of the greenhouse of cucumber by7%, 6.5%, 8.7%, 141%, and 5.2%, respectively. The significance of these results was statistically proven at a significant level (0.01).

Overall Productivity Resilience (E.P.) was estimated this means that the increase in these production elements by the estimated function by 10% leads to an increase in the total output of the greenhouse of the option by about 41.5%, and this shows that the increase in the amount of the total output of the greenhouse is less than the increase in the amount of production elements used, which means an increase in the return to capacity because the flexibility of production is greater than the correct one.

The adjusted determination coefficient ($\bar{R}^2$) was about 0.88, which indicates that those independent variables explained by the estimated function are responsible for about 88% of the total changes in the total greenhouse output of the cucumber crop, and the value (F) indicates the statistical significance of the estimated function at a significant level (0.01).

Table 2. Economic efficiency indicators for the use of production elements used in the option production function in the study sample

Statement	Production Factors (Inputs) in the Total Output Function				
	Number of Seedlings kg	Human Labor	Mechanical Labor	Amount of Organic Fertilizer	Amount of Irrigation Water
	X1	X2	X3	X4	X9
Average Amount of Production	963	434	163	23	177
Average Total Output	9				
Production Elasticity of Production Factor (E.X.)	0.6	0.77	0.9	1.4	0.5
Total Production Elasticity (E.P.)	4.15				
Average Output (A.P.) (ton/acre)	0.008	0.018	0.049	0.348	0.045
Marginal Product (M.P.)	0.006	0.012	0.043	0.49	0.024
Value of Marginal Product	36.1	74.3	264.7	3040.7	145.7
Price of Production Factor Unit	2.5	16	92	410	34
Economic Efficiency (E.E.)	14.4	4.6	2.9	7.4	4.3

* Price of a unit of main product (price of a ton of cucumbers) = 6200 pounds.
* Average product (A.P.) = Average total output of the greenhouse ÷ Average quantity of production factor for the greenhouse.
* Marginal product (M.P.) = Elasticity of production of the production factor (E.X.) × Average product (A.P.).
* Value of marginal product (V.M.P.) = Marginal product (M.P.) × Price of a unit of main product (PQ).
* Economic efficiency (E.E.) = Value of marginal product (V.M.P.) ÷ Price of a unit of production factor (PX).
Source: Collected and calculated from the results of the study questionnaire.)

The marginal output and the average output for each production element were estimated in the estimated total output function of the cucumber crop in the study sample, as it was found from Table (2) that the marginal output (M.P.) From the crop of cucumbers for the number of seedlings, human labor, mechanical labor, the amount of municipal fertilizer and the amount of irrigation water, it was estimated at about 0.006, 0.012, 0.043, 0.490, 0.024 tons/greenhouse for those productive elements, respectively. The value of the marginal output (V.M.P) for those productive elements was estimated at about 36.1, 74.3, 264.7, 3040.7, and 135.7 pounds/greenhouse, respectively. While the average unit price of the number of seedlings was about2.5 pounds /per seedling, the average wage of the human labor unit was about 16 pounds/ hour, the average price of the automated labor unit was about 92 pounds / hour, the average price of municipal fertilizer was about 410 pounds /m3, and the average cost of irrigation water was about 34 pounds/ m3.

As shown in Table (2-15), the average output (A.P.) of the cucumber crop for the number of seedlings, human labor, mechanical labor, the amount of municipal fertilizer and the amount of irrigation water was estimated at about0.008, 0.018, 0.049, 0.348, 0.045 tons/greenhouse for those productive elements, respectively.

The economic efficiency of the use of productive elements was estimated in the estimation function. The economic efficiency index is calculated by dividing the value of the marginal output (V.M.P) of each productive element by (÷) the price of the unit of this productive element (PX). Table (2) shows that the value of the economic efficiency index for the number of seedlings, human labor, mechanical labor, the amount of municipal fertilizer and the amount of irrigation water was found to be greater than the correct one, which reflects a high level of economic efficiency for the use of these productive elements, as it was found that the value of the marginal output of the productive element is higher than the price of the unit of productive elements.

(2) Cucumber crop production function in the first category:

The production elements with a positive moral impact on the production of the cucumber crop for the first category of the study sample were determined through the estimated model of the total output function of the greenhouse of the cucumber crop using multiple regression) in the double logarithmic image, which is shown by the following equation:

Equation

$$LnQ = 1.33 + 0.24\ Ln\ X_1 + 0.18\ Ln\ X_5 + .017\ Ln\ X_6 + .037\ Ln\ X_8 + 0.01\ Ln\ X_9$$

(3.2)** (3.2)* (2.4) * (7.3) ** (3.4) **

F= 167 $\bar{R}^2 = 0.90$

It was found from the total output function (Q) that the most important productive elements with a significant impact on the total output of the greenhouse from the cucumber crop are the number of seedlings, nitrogen fertilizer, phosphate fertilizer, the amount of pesticides and the amount of irrigation water, and by estimating the production elasticities of those elements, it was found that the production elasticity of the number of seedlings, nitrogen fertilizer, phosphate fertilizer, the amount of pesticides and the amount of irrigation water amounted to about0.24,0.18 , 0.17, 0.37,0.01 , respectively, indicating that the increase in the amount used of elements by 10% leads to an increase in the production of the greenhouse from cucumber by 2.4% , 1.8% ,1.7%, 3.7%,0.1%, respectively, and the significance of these results was statistically proven at a significant level (0.01).

Overall Productivity Resilience (E.P.) was estimated this means that the increase of these production elements by the estimated function by 10% leads to an increase in the total output of the greenhouse of the option by about 9.7%. This shows that production takes place in the second stage of production (the economic stage), as the percentage of increase in the total output of the greenhouse is greater than the percentage of increase in the amount of production elements used, which means a decrease in the return of capacity because the flexibility of production is less than the correct one.

The adjusted determination coefficient ($\bar{R}^2$) reached about 0.90, which indicates that those independent variables explained by the estimated function are responsible for about 90% of the total changes in the total greenhouse output of the first category of the option crop, and the value (F) indicates the statistical significance of the estimated function at a significant level (0.01).

The marginal output and the average output for each production element were estimated in the estimated total output function of the cucumber crop in the study sample, as it was found from Table (3) that the marginal output (M.P.) of the cucumber crop for each of the number of seedlings, nitrogen fertilizer, phosphate fertilizer, the amount of pesticides and the amount of irrigation water, it was estimated at about 0.002, 0.025, 0.024, 0.740, 0.0005 tons/greenhouse for those productive elements, respectively. The value of the marginal output (V.M.P) for those productive elements was estimated at about 11.3, 152.2, 147.1, 4588, 2.8 pounds/greenhouse, respectively.

Table 3. Economic efficiency indicators for the use of production elements used in the option production function in the study sample in the first category

Statement	Production Factors (Inputs) in the Total Output Function				
	Number of seedlings kg	Amount of Azote fertilizer	Amount of Phosphate fertilizer	Amount of Pesticides	Amount of Irrigation Water
	X1	X5	X6	X8	X9
Average Amount of Production Factor	787	44	43	3	133
Average Total Output			6		
Production Elasticity of Production Factor (E.X.)	0.24	0.18	0.17	0.37	0.01
Total Production Elasticity (E.P.)			0.97		
Average Output (A.P.) (ton/acre)	0.008	0.136	0.14	2	0.045
Marginal Product (M.P.) (ton/acre)	0.002	0.025	0.024	0.74	0.0005
Value of Marginal Product (V.M.P.) (LE)	11.3	152.2	147.1	4588	2.8
Price of Production Factor Unit (PX) (LE)	2.5	12.9	16.5	320	34
Economic Efficiency (E.E.)	4.5	11.8	8.9	14.3	0.1

* Price of a unit of main product (price of a ton of cucumbers) = 6200 pounds.
* Average product (A.P.) = Average total output of the greenhouse ÷ Average quantity of production factor for the greenhouse.
* Marginal product (M.P.) = Elasticity of production of the production factor (E.X.) × Average product (A.P.).
* Value of marginal product (V.M.P.) = Marginal product (M.P.) × Price of a unit of main product (PQ).
* Economic efficiency (E.E.) = Value of marginal product (V.M.P.) ÷ Price of a unit of production factor (PX).
Source: Collected and calculated from the results of the study questionnaire.

While the average price per unit of seedling number was about 2.5pounds /per seedling, the average price per unit of nitrogen fertilizer was about 12.9 pounds /effective unit, the average price per unit of phosphate fertilizer was about 16.5pounds /effective unit, the average value of pesticides was about 320 pounds/liter, and the average cost per cubic meter of irrigation water was about 34 pounds.

As shown in Table (3), the average output (A.P.) of the cucumber crop for both the number of seedlings, nitrogen fertilizer, phosphate fertilizer, the amount of pesticides and the amount of irrigation water was estimated at0.006, 0.136, 0.140,2,000, 0.045 tons/greenhouse for those productive elements, respectively.

The economic efficiency of the use of the productive elements was estimated in terms of the estimated value. The economic efficiency index is calculated by dividing the value of the marginal output (V.M.P) of each productive element by (÷) the price of the unit of this productive element (PX). Table (3) shows that the value of the economic efficiency index for each of the number of seedlings, nitrogen fertilizer, phosphate fertilizer and the amount of pesticides was found to be greater than the correct one, which reflects a high level of economic efficiency for the use of these productive elements, as it was found that the value of the marginal output of the productive element is higher than the price of the unit of the productive elements and the least efficient of them is the amount of irrigation water.

(3) Cucumber crop production functions in the second category:

The production elements with a positive moral impact on the production of the cucumber crop for the second category of the study sample were determined through the estimated model of the total output function of the greenhouse of the cucumber crop using multiple regression in the double logarithmic image, which is shown by the following equation:

Equation

$$LnQ = 1.65 + 0.38\, Ln\, X_1 + 0.27\, Ln\, X_2 + .037\, Ln\, X_6 + .021\, Ln\, X_7$$

(2.9)* (76.2)* (2.43) * (2.03) *

$$F = 89.12 \qquad \bar{R}^2 = 0.67$$

It was found from the total output function (Q) that the most important production elements with a significant impact on the total output of the greenhouse from the cucumber crop are the number of seedlings, the number of human working hours, phosphate fertilizer and the amount of urea fertilizer, and by estimating the production elasticities of those elements, it was found that the production elasticity of the number of seedlings, the number of human working hours, phosphate fertilizer and the amount of urea fertilizer amounted to about0.38 , 0.27, 0.37, 0.21, respectively, indicating that the increase in the amount used of elements by 10% leads to an increase in the production of the greenhouse from cucumber by 3.8%, 2.7% , 3.7%, and 2.1%, respectively. The significance of these results was statistically proven at a significant level (0.01).

Overall Productivity Resilience (E.P.) was estimated this means that the increase of these production elements by the estimated function by 10% leads to an increase in the total output of the greenhouse of the option by about 12.3%. This shows that production takes place in the initial stage of production, as the increase in the amount of the total output of the greenhouse is less than the increase in the amount of production elements used, which means an increase in the return to capacity because the flexibility of production is greater than the correct one.

The adjusted determination coefficient ($\bar{R}^2$) was about 0.67, which indicates that those independent variables explained by the estimated function are responsible for about 67% of the total changes in the total greenhouse output of the second category of the option crop, and the value (F) indicates the statistical significance of the estimated function at a significant level (0.01).

The marginal output and the average output for each production element were estimated in the estimated total output function of the cucumber crop in the study sample, as it was found from Table (4) that the marginal output (M.P.) of the cucumber crop for each of the number of seedlings, the number of human working hours, phosphate fertilizer and the amount of urea fertilizer, it was estimated at 0.003,0.007, 0.049, 0.034 tons/greenhouse for those productive elements, respectively. The value of the marginal output (V.M.P) for those productive elements was estimated at about 21, 41.9, 305.9, and 212.6 pounds/greenhouse, respectively.

The average unit price of seedlings was about2.2 pounds /per seedling, the average unit price of human labor was about 16 pounds /working hour/ day, the average unit price of phosphate fertilizer was about 17 pounds /effective units, and the average unit price of urea fertilizer was about 22 pounds /effective units.

Table 4. Economic efficiency indicators for the use of production elements used in the option production function for the second category of the study sample

Statement	Production Factors (Inputs) in the Total Output Function			
	Number of seedlings kg	Human Labor	Phosphate fertilizer	Urea fertilizer
	X1	X2	X6	X7
Average Amount of Production Factor	899	320	60	49
Average Total Output		8		
Production Elasticity of Production Factor (E.X.)	0.38	0.27	0.37	0.21
Total Production Elasticity (E.P.)		1.23		
Average Output (A.P.) (ton/acre)	0.009	0.025	0.133	0.163
Marginal Product (M.P.) (ton/acre)	0.003	0.007	0.049	0.034
Value of Marginal Product (V.M.P.) (LE)	21	41.9	305.9	212.6
Price of Production Factor Unit (PX) (LE)	2.2	16	17	22
Economic Efficiency (E.E.)	9.5	2.6	18	9.7

* Price of a unit of main product (price of a ton of cucumbers) = 6200 pounds.
* Average product (A.P.) = Average total output of the greenhouse ÷ Average quantity of production factor for the greenhouse.
* Marginal product (M.P.) = Elasticity of production of the production factor (E.X.) × Average product (A.P.).
* Value of marginal product (V.M.P.) = Marginal product (M.P.) × Price of a unit of main product (PQ).
* Economic efficiency (E.E.) = Value of marginal product (V.M.P.) ÷ Price of a unit of production factor (PX).
Source: Collected and calculated from the results of the study questionnaire.

As shown in Table (4), the average output (A.P.) of the cucumber crop for both the number of seedlings and the number of human working hours, phosphate fertilizer and the amount of urea fertilizer was estimated at about 0.009, 0.025, 0.133, 0.163 tons/greenhouse for those productive elements, respectively.

The economic efficiency of the use of productive elements was estimated in terms of the estimated value. The economic efficiency index is calculated by dividing the value of the marginal output (V.M.P) of each productive element by (÷) the price of the unit of this productive element (PX). Table (2-19) shows that the value of the economic efficiency index for the number of seedlings, the number of human working hours, phosphate fertilizer and the amount of urea fertilizer was found to be greater than the correct one, which reflects a high level of economic efficiency for the use of these productive elements, as it was found that the value of the marginal output of the productive element is higher than the price of the unit of productive elements.

(4) Cucumber crop production functions in **the third category:**

The production elements with a positive moral impact on the production of the cucumber crop for the third category of the study sample were determined through the estimated model of the total output function of the greenhouse of the cucumber crop using the multi-phase (gradual) regression in the double logarithmic image, which is shown by the following equation:

Equation

$$LnQ = 1.5 + 0.43\ Ln\ X_1 + 0.52\ Ln\ X_3 + 0.23\ Ln\ X_9$$

$$(3.1)^{*} \quad (5.6)^{**} \quad (2.2)^{*}$$

$$F = 101.1 \qquad \bar{R}^2 = 0.77$$

It was found from the total output function (Q) that the most important production elements with a significant impact on the total output of the greenhouse from the cucumber crop are the number of seedlings, the number of automatic working hours and the amount of irrigation water. It was found that the production flexibility of the number of seedlings, the number of automatic working hours and the amount of irrigation water amounted to about 0.43,0.52 and 0.23 respectively, which indicates that the increase in the amount used of elements by 10% leads to an increase in the production of the greenhouse from cucumbers by 4.3%, 5.2% and 2.3% respectively. The significance of these results was statistically proven at a significant level (0.01).

Overall Productivity Resilience (E.P.) was estimated this means that the increase of these production elements by the estimated function by 10% leads to an increase in the total output of the greenhouse of the option by about 11.8%. This shows that production takes place in the initial stage of production, as the increase in the amount of the total output of the greenhouse is less than the increase in the amount of production elements used, which means an increase in the return to capacity because the flexibility of production is greater than the correct one.

The adjusted determination coefficient ($\bar{R}^2$) was about 0.77, which indicates that those independent variables explained by the estimated function are responsible for about 77% of the total changes in the total greenhouse output of the third category of the option crop, and the value (F) indicates the statistical significance of the estimated function at a significant level (0.01).

The marginal output and the average output for each production element were estimated in the estimated total output function of the cucumber crop in the study sample, as it was found from Table (5) that the marginal output (M.P.) of the cucumber crop for both the number of seedlings and the number of hours of automatic work and the amount of irrigation water , it was estimated at about 0.0004, 0.002, 0.005 tons/greenhouse for those productive elements, respectively, and the value of the marginal output (V.M.P) for those productive elements was estimated at about2.6, 13.7,7.7 pounds/greenhouse, respectively.

While the average unit price of the number of seedlings was about2.2 pounds /per seedling, the average unit price of automatic work was about 99 pounds / hour, and the average cost of a cubic meter of irrigation water was about 34 pounds.

As shown in Table (5), the average output (A.P.) of the cucumber crop for both the number of seedlings and the number of hours of automatic work and the amount of irrigation water was estimated at0.001, 0.004, 0.005 tons/greenhouse for those productive elements, respectively.

The economic efficiency of the use of productive elements was estimated in the estimation function. The economic efficiency index is calculated by dividing the value of the marginal output (V.M.P) of each productive element by (÷) the price of the unit of this productive element (PX). Table (2-21) shows that the value of the economic efficiency index for each of the number of seedlings, the number of hours of automatic work and the amount of irrigation water was found to be greater than the correct one, which reflects a rise in the level of economic efficiency for the use of these productive elements, as it was found that the value of the marginal output of the productive element is higher than the price of the unit of productive elements.

Table 5. Economic efficiency indicators for the use of production elements used in the option production function in the study sample

Statement	Production Factors (Inputs) in the Total Output Function		
	Number of seedlings	Mechanical Labor	Amount of Irrigation Water
	X1	X3	X9
Average Amount of Production Factor	1202	278	218
Average Total Output		12	
Production Elasticity of Production Factor (E.X.)	0.43	0.52	0.23
Total Production Elasticity (E.P.)		1.18	
Average Output (A.P.) (ton/acre)	0.001	0.004	0.005
Marginal Product (M.P.) (ton/acre)	0.0004	0.002	0.001
Value of Marginal Product (V.M.P.) (LE)	2.6	13.7	7.7
Price of Production Factor Unit (PX) (LE)	2.2	92	34
Economic Efficiency (E.E.)	1.2	1.1	1.2

* Price of a unit of main product (price of a ton of cucumbers) = 6200 pounds.
* Average product (A.P.) = Average total output of the greenhouse ÷ Average quantity of production factor for the greenhouse.
* Marginal product (M.P.) = Elasticity of production of the production factor (E.X.) × Average product (A.P.).
* Value of marginal product (V.M.P.) = Marginal product (M.P.) × Price of a unit of main product (PQ).
* Economic efficiency (E.E.) = Value of marginal product (V.M.P.) ÷ Price of a unit of production factor (PX).
Source: Collected and calculated from the results of the study questionnaire.

Table 6. Average cost of production elements used in the production of cucumber crop in greenhouses and the net return and the return of the pound at the level of the categories of the study sample

	First category	Second category	Third category	Total Average (Sample)	%
Seedling Cost	1762	1900	2600	2087	4.7
Labor Cost	3221	5870	9899	6330	14.2
Machinery Cost	8293	10670	23120	14028	31.5
Organic Fertilizer Cost	6043	9987	12690	9573	21.5
Azote Fertilizer Cost	765	876	1260	967	2.2
Phosphate Fertilizer Cost	850	1010	1555	1138	2.6
Urea Fertilizer Cost	805	990	1550	1115	2.5
Pesticides Cost	2740	3670	4790	3733	8.4
Irrigation Water Cost	4765	5460	6290	5505	12.4
Total Variable Costs	29244	40433	63754	44477	100
Total Fixed Costs	1300	2030	3563	2298	
Rent	550	1100	1600	1083	
Price per Kg	6200	6200	6200	6200	
Revenue	32760	45000	69950	49237	
Net Profit	2216	2537	2633	2462	
Return per LE Spent on Variable Costs	0.073	0.06	0.039	0.053	

Source: collected and calculated from questionnaire in Agricultural season 2021-2022.

Cucumber Crop Cost Analysis

The average cost of the production elements used in the production of the cucumber crop in greenhouses and the net return and the return of the pound at the level of the study sample categories:

The data in Table (6) indicate that the cost of automatic work represented the highest cost within the production costs of the crop of cucumbers grown in greenhouses in the study sample, as it was estimated at 31.5% of the total variable costs in the sample , followed by the cost of municipal fertilizer at 21.5% of the total variable costs in the sample, followed by the cost of human labor at 14.2% of the total variable costs in the sample, followed by the cost of irrigation water at 12.4% of the total variable costs in the sample , followed by the cost of purchasing pesticides at 8.4% of the total variable costs in the sample, followed by the cost of purchasing seedlings at 4.7% of the total variable costs in the sample. As for chemical fertilizers, they were the lowest cost in the sample cost items, as the table data indicate that the average net return amounted to 2216 pounds for the first category, 2537 pounds for the second category, 2633 pounds for the third category, where the first category of the area achieved 200- less than 250m2, a return on variable costs of about 0.073 pounds.

Second: Statistical Estimation of the Cost Functions of the Cucumber Crop in the Field Study Sample

Cost Functions for the Total Sample

By estimating the parameters of the total cost function (T.C) for the production of the cucumber crop in the study sample in the quadratic and cubic form using the data of the study sample, it was found that the best estimated images are the function in the cubic form shown by Equation (1):

$$\mathbf{T.C = 5669.3\,Q - 141.2\,Q^2 + 6.1\,Q^3} \quad \leftarrow (1)$$
$$(2.9)^{**} \quad (-6.1)^{**} \quad (3.1)^{*}$$
$$R^2 = 0.78 \qquad F = 180.5$$

Where:
T.C: Total production costs (pounds) for the production of the option in the study sample.
Q: Actual total output (tons).
* *Significant at 1% significance level.

The total costs function (T.C) for producing the cucumber crop in the study sample shows that the total output (Q) is responsible for about 78% of the total changes in the total costs of the cucumber crop.

The average cost function (A.C) was estimated by dividing the derivative total cost function (T.Ci) by the volume of production (Q), thus obtaining equation (2):

A.C = 5669.3 – 141.2 Q + 6.1 Q^2 ← (2)

The marginal cost function (M.C) was also estimated by calculating the derivative total cost function (T.Ci) referred to in Equation (1) and obtaining the marginal cost function shown in Equation (3):

M.C = 5449.4 – 282.4 Q+ 18.3 Q2 ← (3)

It turns out that the optimal production volume that reduces costs for the production of cucumbers for the second category of the study sample amounted to about 8 tons, which is achieved at the minimum end of the average costs or is achieved when the marginal costs (M.C) are equal to the average costs (A.C), and the average total production volume of the greenhouse in the study sample reached about 9 tons, which is greater than the optimal production volume. As for the volume of economic production that maximizes profit, it reached about6.9 tons, which is achieved when the marginal costs (M.C) are equal to the marginal revenue (M.R), which is equal to the unit price of the final product (PQ) in the full competition market, and to find the flexibility of production costs (E.C.) the marginal costs (M.C) are divided by the average costs (A.C), where the marginal costs amounted to about 4482.1 pounds and the average costs amounted to about 23422.1 pounds, and the flexibility of production costs was estimated at about0.22 , which indicates that the production of the option for the second category of the study sample is at the stage of increasing the return to capacity, because the flexibility of the cost function is a reflection of the flexibility of the production function.

4- Cost function of the third category of the study sample

By estimating the parameters of the total cost function (T.C) to produce the cucumber crop for the third category of the study sample in the quadratic and cubic form using the data of the study sample, it was found that the best estimated images are the function in the quadratic form shown by Equation (1):

T.C = 13211.1 + 9454.2 Q – 161.2Q^2 ← (1)
(2.5) * (2.6)* (-4.1)**
R^2= **0.69** F= **77.45**

Where:

T.C = Total production costs (pounds) for the production of the option in the study sample.

Q = Actual total output (tons).

**Significant at 1% significance level.

The total costs function (T.C) for producing the cucumber crop in the study sample shows that the total output (Q) is responsible for about 69% of the total changes in the total costs of the third category of cucumber crop.

The average cost function (A.C) was estimated by dividing the derivative total cost function (T.Ci) by the volume of production (Q), thus obtaining equation (2):

A.C = 13211.1/Q + 9454.2- 161.2Q ← (2)

The marginal cost function (M.C) was also estimated by calculating the derivative total cost function (T.Ci) referred to in Equation (1) and obtaining the marginal cost function shown in Equation (3):

M.C = 9454.2– 322.4 Q ← (3)

It turns out that the optimal production volume that reduces costs for the production of cucumbers for the third category of the study sample amounted to about 9 tons, which is achieved at the minimum end of the average costs or is achieved when the marginal costs (M.C) are equal to the average costs (A.C), and the average total output volume of the greenhouse for the third category of the study sample has reached about 12 tons, which is greater than the optimal production volume. As for the volume of economic production that maximizes profit, it reached about 10.7 tons, which is achieved when the marginal costs (M.C) are equal to the marginal revenue (M.R), which is equal to the unit price of the final output (PQ) in the full competition market, and to find the flexibility of production costs (E.C.) The marginal costs (M.C) are divided by the average costs (A.C), where the marginal costs amounted to about 5820.1 pounds and the average costs amounted to about 8803 pounds , and the flexibility of production costs was estimated at about 0.71, which indicates that the production of the option for the third category of the study sample is at the stage of increasing the return to capacity, because the flexibility of the cost function is a reflection of the flexibility of the production function.

Productivity problems facing greenhouse farmers (cucumbers) in the study sample

Table (7) shows that the problem of the first rank was the rise in the prices of production inputs by about 15.79%of the total farmers of the sample, followed by the rise in the prices of fertilizers by about 15.20% , followed by the third, and the fourth, both traders or intermediaries control the price of the product ,the rise in pesticide prices by about 15.01%, 14.04%, respectively,

Table 7. Production problems or obstacles to protected agriculture in the study sample

م	Statement	Count	%	Ranking
1	High prices of production materials	81	15.79	1
2	High prices of fertilizers	78	15.2	2
3	Control of traders or intermediaries over the price of the product	77	15.01	3
4	High prices of pesticides	72	14.04	4
5	High prices of seedlings	67	13.06	5
6	Unavailability of production services	56	10.92	6
7	Shortage of fertilizers and difficulty in obtaining them	44	8.58	7
8	High labor costs and shortage of trained labor	38	7.41	8
	Total	513	100	

Source: Collected from the questionnaire.

Table 8. The most important proposed solutions to solve the productivity problems of protected agriculture in the study sample.

م	Statement	Number	%	Rank
1	Providing production supplies at reasonable prices	86	20.3	1
2	Providing markets close to production	81	19.1	2
3	Developing high-yielding varieties	77	18.2	3
4	Providing guaranteed pesticides for pest control	68	16	4
5	Providing advisory services	61	14.4	5
6	Knowledge and experience in greenhouse cultivation	51	12	6
	Total	517	100	

Source: Collected from the questionnaire.

followed by the rise in the prices of seedlings and the lack of production services by about13.06%, 10.92%, respectively, followed by the problem of the lack of fertilizers and the difficulty of obtaining them, the high labor costs and the lack of trained manpower by8.58%, 7.41%, respectively, of the total farmers of the sample.

Proposed solutions to solve the productivity problems of protected agriculture (cucumbers) in the study sample:

The data in Table (8) indicate that the proposed solutions to solve the problem of providing production supplies at reasonable prices came in first place with about 20.3%, followed by the proposed solution to solve the provision of markets close to production by about 19.1%, and came in third and fourth place for the proposed solutions to solve the problem of developing high-production varieties and providing guaranteed pesticides for postcentral by about 18.2% and 16.0%, respectively, of the total sample , followed by the solution of providing extension services, know-how and experience in cultivating the reserve by about 14.4% and12.0%, respectively.

CONCLUSION

1. Purchasing all the needs of the farmer from the production requirements at the beginning of the season to ensure that they are available throughout the year.
2. Educating farmers about the need to provide generators in sufficient numbers to be used in the event of power outages
3. Legislating and encouraging farmers to cultivate protected lands in the old lands, in addition to paying attention to the state of agriculture in the desert lands.
4. Solving the financing problems of farmers by facilitating procedures to obtain loans through the Agricultural Bank of Egypt with a minimum grace period of 5 years.

Contract farming with farmers who meet the quality specifications for export at prices satisfactory to farmers.

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الملخص العربي

التقدير الاحصائي لدوال الانتاج والتكاليف لمحصول الخيار تحت نظام الزراعة المحمية دراسة ميدانية

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يستهدف هذا البحث بشكل عام دراسة تقدير دوال تكاليف الإنتاج تحت نظام الزراعة المحمية (الصوب) بإعتبارها تعكس العلاقة بين التكاليف الكلية والانتاج الفعلي حيث يمكن من خلالها اشتقاق أهم المؤشرات الاقتصادية التي تعكس مدى ما تحققه الوحدات الإنتاجية الزراعية من كفاءة اقتصادية في استخدامها للموارد في العملية الإنتاجية وكذلك مدى ما تحققه هذه الوحدات من تعظيم أرباح المنتج الزراعي، كما تعد أيضًا دراسة التكاليف الإنتاجية وما يرتبط بها من مؤشرات هامة سواءعلى مستوى الوحدة الانتاجية او علي المستوى القومي، حيث يمكن الاستعانة بها في رسم وتحليل السياسات السعرية ومساعدة المنتجين الزراعيين في اتخاذ القرارات الإنتاجية الخاصة بهم، والتي من شأنها أن تشجع المنتجين علي الاستمرار و التوسع في العملية الإنتاجية أو التوقف عن الانتاج. علاوة علي تحديد حجم الإنتاج الذي يحقق معظمة الأرباح ومن ثم تحقيق الكفاءة الاقتصادية من استخدام الموارد الإنتاجية المختلفة.

الكلمات المفتاحية: دوال التكاليف ، دوال الانتاج ، الكفاءة الاقتصادية ،الحجم الامثل للانتاج .