The Standard Estimation of Production Cost Functions for Tomato Crop in Al-Diwaniyah Governorate for the Agricultural Season (2023-2024)

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Abstract

The research aims to conduct a standard estimation of the production cost functions for the tomato crop in Al-Diwaniyah Governorate, based on a case study of the production situation of the tomato crop at the level of the governorate's center and districts. The research relied on the descriptive economic analysis approach to describe and interpret the most important economic variables associated with tomato production and employed quantitative economic analysis methods to determine the key economic variables affecting tomato production in the study area.

Moreover, the research estimated the production cost functions of the tomato crop in its various forms to determine the optimal production level and the profit-maximizing level. The analysis was based on field data collected during the summer, winter, and spring agricultural seasons of 2024 through a questionnaire targeting a random sample of 120 farmers, ensuring each individual in the population had an equal chance of being selected. The study identified the main independent factors affecting tomato production as follows: (cultivated area, manual labor, machinery wages, cost of improved seeds, cost of organic fertilizers, cost of chemical fertilizers, cost of pesticides, and miscellaneous expenses). The results of the study showed that the three seasons achieved productive and economic efficiency in tomato production. The estimated models were found to be free of multicollinearity problems based on Frisch test. Furthermore, the coefficients of the independent variables were significant at the 5% level based on the t-test, and the overall model was significant at the 1% level based on model testing, indicating the positive impact of all independent variables across all seasons. The study recommends the necessity of enhancing the productive and economic efficiency of tomato farmers within the study sample by applying and training farmers in modern technological methods, providing them with knowledge to increase their expertise, supplying improved crop seeds, and encouraging the use of soil mechanical analysis. It also advocates for integrated pest management systems to eliminate pests and insects affecting the crop, thereby improving productive efficiency and achieving the optimal production level and maximum profit level.

Keywords: Productive Efficiency, Profit-Maximizing Level, Production Costs.

Introduction

The **Tomato crop** is considered one of the most important vegetable crops, rich in salts and vitamins essential for human nutritional needs (6) ,(18)Tomatoes contain key elements such as fiber, Vitamin A, Vitamin C, and potassium. Tomatoes contribute 20% of the daily requirement for Vitamin A in a diet based on 2000 calories, and their share in daily Vitamin C needs is 26%. Lycopene, a dominant antioxidant naturally found in tomatoes, is beneficial in preventing the growth of various types of cancer (2). Tomatoes are consumed fresh or processed, serving as a primary food for many people and contributing significantly to vegetable exports (3).

Tomatoes are cultivated in four growing seasons: early summer season, regular summer season, spring season, and winter season, in addition to cultivation in greenhouses. This type of farming significantly increases the supply of vegetables and alleviates shortages during the winter season. Through the application of this technology, vegetables are available in the market earlier compared to traditionally grown vegetables in open fields. This contributes to extending the availability of vegetables in markets. Fresh and processed tomatoes hold great economic importance as they are not only a source of household income but also create employment opportunities, enabling small farmers to participate in the market (11).

At the international level, vegetables are commercially produced using plastic mulching techniques within tunnels covered by polyethylene sheets. The benefits of plastic mulching include reducing weed growth, increasing water use efficiency by the plant, improving production quality, and enabling early harvests. The area dedicated to vegetable production using plastic tunnels has expanded, introducing this technology as a new innovation. The use of plastic mulching combined with plant residues and synthetic materials is considered a modern method for achieving higher profits from vegetable production. Compared to traditional open-field farming, out-of-season vegetables reach markets 7 to 14 days earlier. The yield of these vegetables is also 2 to 3 times greater compared to traditional methods (13). A study conducted in Ethiopia also showed that small farmers were more interested in tomato production than other vegetable crops due to its multiple harvests and high profit per unit area (5).

However, at times, tomato overproduction results in market surplus, causing distress sales and reduced profits for farmers. Many factors significantly influence profit margins in tomato cultivation and marketing. Factors that affect tomato profit at the wholesale level include formal education level, labor costs for wholesale activities, purchase prices, transportation costs, and selling prices (19). Al-Diwaniyah Governorate is one of the most important regions for tomato cultivation due to its vast agricultural areas. Moreover, tomatoes grow in various types of soils, from sandy to heavy clay. Sandy soils are preferred when the goal is early production or a short growing season, while heavy soils are favored when the goal is a safe crop free from harmful pesticides for human health (1). In recent years, Al-Diwaniyah Governorate has made intensive efforts to improve tomato productivity by developing farming systems and enhancing crop management practices.

Research Problem

The Iraqi economy is currently facing severe economic crises, leading to a decline in foreign currency reserves and an increase in the trade and budget deficits. To address these challenges, it is essential to explore various economic sectors for potential solutions. The agricultural sector is one of the most productive economic sectors and can be relied upon to generate foreign currency and alleviate the trade balance burden. Tomatoes are one of the key agricultural export commodities that can contribute to achieving the desired economic goals for Iraq. Increasing tomato production serves three primary purposes: achieving self-sufficiency to meet the population's needs, creating new job opportunities in the manufacturing sector, and enhancing exports. Therefore, it is necessary to study and analyse the economic resources used in tomato production, estimate the optimal production level and the profit-maximizing level, and compare them with actual production. This analysis will help policymakers devise agricultural production strategies by addressing knowledge gaps, increasing tomato production, and meeting human consumption demands.

Research Objectives

The study aims to perform a standard estimation of the production cost functions for tomato crops in Al-Diwaniyah Governorate by analyzing the production conditions of tomatoes in the governorate's center and districts. The objectives include:

- Estimating productivity and economic efficiency indicators associated with tomato production in the study area to assess whether tomato cultivation generates profits.

- Standard estimation of economic variables affecting tomato production by evaluating the efficiency of utilizing shared economic resources in tomato farming and determining the relative impact of each resource.
- Estimating production cost functions for tomatoes to determine the optimal production level and the profit-maximizing level, and comparing them with actual production to assist agricultural policymakers in formulating plans and programs to increase tomato production and address cultivation challenges.

Research Methodology

The study employed descriptive economic analysis to describe and interpret the key economic variables related to tomato production. It also utilized quantitative economic analysis methods eviews10and spss25, such as variance analysis and the least significant difference test, to determine whether significant differences exist between the tomato growing seasons. Additionally, multiple regression analysis was used to measure the primary economic variables influencing tomato production in the study area. Various forms of production cost functions for tomatoes were estimated and compared based on theoretical economic principles.

Data Sources

The study relied on a questionnaire collected during the summer, spring, and winter agricultural seasons of 2024 through personal interviews with a random sample of 120 farmers in Al-Diwaniyah Governorate and its districts. The sample was drawn from approximately 50% of the governorate's center and districts and distributed equally across the seasons. Forty farms were selected for summer cultivation, representing about 2.34% of all farms, another 40 for winter cultivation, representing about 9.46%, and 40 for spring cultivation, representing about 14.13%. The sample was selected randomly to ensure each individual had an equal chance of being included.

Results and discussion

First: Testing the Significance of Differences in Economic Variables Affecting Tomato Production in the Study Area

An analysis of variance (ANOVA) was conducted to examine the differences between the economic variables affecting tomato production in the study area. This analysis was based on production theory assumptions, previous studies in this field, and the nature of the data. The economic variables analyzed include:

- Average production
- Net returns
- Production cost

Using one-way ANOVA, the study tested the null hypothesis, which assumes no significant differences between the economic variables affecting tomato production in Al-Diwaniyah Governorate across the cultivation seasons.

The results revealed significant differences at the 0.01 level among the economic variables influencing tomato production, leading to the rejection of the null hypothesis. This finding necessitated further analysis at the individual cultivation season level.

Table 1: summarizes the key economic variables influencing tomato production in Al-Diwaniyah Governorate during the 2023-2024 agricultural season:

Table 1. Economic Variables Affecting Tomato Crop Production in Al-Diwaniyah Governorate for the Agricultural Season (2023-2024):

Economic Variables	Unit	Calculated F-Value
Average Production	Ton	111.99**
Net Returns	Thousand IQD	31.53**
Production Costs	Thousand IQD	106.93**

****Significance at 1% Level**

-Source: Results derived based on the questionnaire.

The production of tomatoes was also analyzed for each cultivation season individually. A comparative analysis was conducted between the averages of production, net returns, and production costs for tomato production using the Least Significant Difference (LSD) test. The analysis revealed significant differences among these averages, necessitating a separate analysis for each cultivation season (summer, spring, winter), as shown in Table (2):

Table 2. Results of the Least Significant Difference (LSD) Test Comparing Economic Variables Affecting Tomato Production and Its Cultivation Seasons in Al-Diwaniyah Governorate for 2024

Economic Factors	Season	Summer	Winter	Spring
Average Production	Summer	-	-0.11	3.58*
	Winter	0.11	-	3.69*
	Spring	-3.58*	-3.69*	-
Net Returns	Summer	-	-345.22*	621.00*
	Winter	345.23*	-	-966.23*
	Spring	-621.00*	-966.23*	-
Production Costs	Summer	-	899.15*	688.75*
	Winter	-899*	-	-210.40*
	Spring	-688.75*	210.40*	-

***Significance at 5% Level**

-Source: Results derived based on the questionnaire.

Second: Economic Indicators of Productive and Economic Efficiency Associated with Tomato Production

Based on the data in Table ،3 the extent of achieving economic profits for tomato production is determined as follows:

Table 3. Indicators of Productive Efficiency Associated with Tomato Production in Al-Diwaniyah Governorate for 2024

Economic and Productive Indicators	Unit	Summer Season		Winter Season		Spring Season	
		Value	CV%	Value	CV%	Value	CV%
Average cultivated area	Dunam	3.90	61.03	3.68	50.82	2.29	45.85
Average productivity	Ton	12.49	11.45	12.59	11.83	8.91	7.74
Average human labor productivity	Kg/1,000 dinars	14.00	5.00	15.00	6.67	12.00	1.67
Average machinery labor productivity	Kg/ 1,000 dinars	21.00	4.76	30.00	3.33	33.00	2.60
Average seed productivity	Kg/ 1,000 dinars	54.00	3.70	27.00	1.48	39.00	1.79
Average organic fertilizer productivity	Kg/ 1,000 dinars	57.00	7.02	45.00	2.22	70.00	14.29
Average chemical fertilizer productivity	Kg/ 1,000 dinars	28.00	3.57	20.00	35.00	16.00	0.63
Average pesticide productivity	Kg/ 1,000 dinars	33.00	1.21	59.00	1.69	49.00	6.12
Net Return	1,000 dinars	3941.7	14.54	4289.30	16.31	3320.70	9.23
Net return per ton	1,000 dinars	314.4	3.36	338.47	4.81	372.98	1.59
Added value	1,000 dinars	6433.4	10.52	653.90	11.89	5351.10	7.24
Relative profitability	%	128.6	3.90	135.08	7.34	140.45	1.03
Revenue-to-cost ratio	-	1.96	3.06	2.03	4.93	1.99	1.51
Rate of return dinars invested	%	0.96	6.25	1.03	9.1	0.99	3.03

-Source: Calculated based on the questionnaire form.

1. **Productivity:** The highest productivity of the crop was achieved in the winter season, followed by the summer season, and finally the spring season. The productivity levels were 12.59، 12.49، and 8.91 tons/donum for each respective season.

2. **Manual Labor:** The highest productivity of manual labor used in tomato production was achieved in the winter season, followed by the summer season, and finally the spring season. The productivity levels were 15، 14، and 12 kg per thousand IQD respectively.

3. Mechanical Labor: The highest productivity of mechanical labor used in tomato production was achieved in the spring season, followed by the winter season, and finally the summer season. The productivity levels were 33، 30، and 21 kg per thousand IQD respectively

4. **Improved Seed Productivity:** The highest productivity of improved seeds for crop production was achieved in the summer season, followed by the spring season, and finally the winter season, with 54, 30, and 27 kg per 1,000 dinars, respectively.

5. **Organic Fertilizer Productivity:** The highest crop productivity was achieved in the spring season, followed by the summer season, and finally the winter season, with 70, 57, and 45 kg per 1,000 dinars, respectively.

6. **Chemical Fertilizer Productivity:** The highest crop productivity was achieved in the summer season, followed by the winter season, and finally the spring season, with 28, 20, and 16 kg per 1,000 dinars, respectively.

7. **Pesticide Productivity:** The highest crop productivity was achieved in the winter season, followed by the spring season, and finally the summer season, with 59, 49, and 33 kg per 1,000 dinars, respectively.

8. **Net Return:** The highest net return was achieved in the winter season, followed by the summer season, and finally the spring season, with 4289.3, 3941.7, and 3320.7 kg per 1,000 dinars, respectively.

9. **Net Return per Ton:** The highest net return per ton was achieved in the spring season, followed by the winter season, and finally the summer season, with 372.96, 338.47, and 314.43 kg per 1,000 dinars, respectively.

10. **Added Value:** The highest added value was achieved in the spring season, followed by the summer season, and finally the winter season, with 70, 57, and 45 kg per 1,000 dinars, respectively.

11. **Relative Profitability:** The highest relative profitability was achieved in the spring season, followed by the summer season, and finally the winter season, with 70, 57, and 45 kg per 1,000 dinars, respectively.

12. **Revenue-to-Cost Ratio:** The highest revenue-to-cost ratio was achieved in the spring season, followed by the summer season, and finally the winter season, with 70, 57, and 45 kg per 1,000 dinars, respectively.

13. **Rate of Return on the Invested Dinar:** The rate of return on the invested dinar for growing the tomato crop for the sample in the winter, spring, and summer seasons was about 1.03, 0.99, and 0.96%, respectively. Thus, the highest return on the invested dinar was achieved in the winter season, followed by the spring season, and finally the summer season.

It is clear from the above that all three seasons achieved productive and economic efficiency in tomato crop production. The values of the coefficient of variation indicate that there are no significant differences in productivity for the economic variables used in tomato production for the research sample within each agricultural season.

The important economic variables that affect the production of the tomato crop (tons per dunam) are as follows:

- **X1:** Area cultivated (tons)
- **X2:** Human labor (dinars per ton)
- **X3:** Machinery labor costs (dinars per ton)
- **X4:** Cost of improved seeds (dinars per ton)
- **X5:** Cost of organic fertilizer (dinars per ton)
- **X6:** Cost of chemical fertilizer (dinars per ton)
- **X7:** Cost of pesticides (dinars per ton)
- **X8:** Miscellaneous expenses (includes expenses for soil preparation for planting, road paving, social insurance, machinery, etc.)

The effect of these economic variables on crop production for the research sample was studied using multiple regression analysis with various mathematical models, and the one that matches economic and statistical theory was selected (10).

2.1Standard Estimation of the Economic Variables Affecting Crop Production in the Summer Season:

Through estimating the standard relationship between the economic variables affecting the crop and its production, it was found that the best matching model according to the theory and statistical model, tested by the significance of t and f tests, is the **Double Logarithmic Model**, which is expressed by the following equation(1):

$$Ln\, y = -1.94 + 0.03lnx1 + 0.16lnx3 + 0{,}09lnx4 + 0.06lnx5 + 0.19lnx6 + 0.15lnx7 + 0.08lnx8$$

(7.07) ** (4.35) ** (2.83) ** (2.12) * (5.41) ** (3.48) ** (3.80)**

$R^{\backslash 2}$=0.825 F=10307.03

**It means that it is significant at the 5% level.
*It means that it is significant at the 1% level.
-The values in parentheses indicate the calculated (T) value.

From the estimated model, it was found that the model is free from the problem of multicollinearity based on the Frisch Test. Additionally, the coefficients of the independent variables were found to be significant at the 5% level based on the t-test, and the model itself was significant at the 1% level based on the F-test. Therefore, all independent variables have a positive effect, as changes in these variables may lead to a relative change in crop production for the summer season in the same direction. It is estimated that the change is approximately 0.765, meaning that if the costs of these variables increase by 1% beyond the level of current usage, it could lead to a 7.65% increase in crop production for the summer season in the research sample.

The adjusted coefficient of determination was estimated at 0.82, which means that the independent variables included in the model explain about 82% of the variations in crop production. Based on the estimated partial standardized regression coefficients, the variables were ranked according to their relative importance in influencing crop production. The variable "miscellaneous expenses" ranked first in terms of its impact on tomato crop production, with a partial standardized regression coefficient of 0.189. This was followed by the pesticide variable (0.174), the cost of chemical fertilizer (0.171), the cultivated area (0.168), machinery labor costs (0.111), the cost of improved seeds (0.108), and finally, the organic fertilizer variable (0.092).

2.2 Standard Estimation of Economic Variables Affecting Tomato Crop Production in the Winter Season:

The standard relationship between tomato crop production in the winter season and the key economic variables affecting it was estimated. It was found that the best model, based on the statistical logic of the model and the significance of both the t-test and F-test, is the Double Logarithmic Model, which is expressed by the following equation (2):

$$Ln\, y = -4.53 + 0.03lnx1 + 0.42lnx2 + 0.22lnx3 + 0{,}17lnx4 + 0.15lnx5 + 0.11lnx7 + 0.07lnx8$$

(7.59) ** (3.13) ** (4.04) ** (3.02) * (4.86) ** (2.63) ** (2.02)**

$R^{\backslash 2}$=0.807 F= 7594.00

The results of Equation 2 indicate that the model is free from the problem of multicollinearity based on the F-test. As for the independent variables, they were significant at the 5% level based on the t-test, and the overall model was significant at the 1% level based on the F-test.

The independent variables for the research sample had a positive effect, meaning that changes in these variables lead to a relative change in crop production in the winter season in the same direction. It is estimated at approximately 0.765, meaning that an increase in the costs of these variables by 1% beyond the level of usage could lead to an 11.7% increase in crop production during the winter season. The adjusted coefficient of determination is estimated at about 80%, which means that the independent variables not included in the model explain about 20% of the variation in crop production. Among the variables, "machinery labor costs" ranked first in its impact on crop production, with a partial standardized regression coefficient of approximately 0.176, followed by "human labor" at 0.175. This was followed by "organic fertilizer" at 0.156, "cost of improved seeds" at 0.154, "cultivated area" at 0.149, "miscellaneous expenses" at 0.10, and finally "cost of pesticides" at 0.092.

2.3 Standard Estimation of Key Economic Variables Affecting Tomato Crop Production in the Spring Season: The standard relationship between tomato crop production in the spring season and the key economic variables affecting it was estimated. It was found that the best model, based on the statistical logic of the model and the significance of both the t-test and F-test, is the Double Logarithmic Model, which is expressed by the following equation (3):

$$lny = -2.14 + 0.03lnx1 + 0.23lnx2 + +0{,}08lnx4 + 0.09lnx5 + 0.19lnx6 + 0.12lnx8$$

(7.78) ** (3.07) ** (3.18) ** (6.93) * (3.99) ** (3.79) **

$R^{\backslash 2} = 0.841$ F=4749.07

Equation 3 indicates that the model is free from the problem of multicollinearity based on the F-test. As for the independent variables, they were significant at the 5% level based on the t-test, and the overall model was significant at the 1% level based on the F-test. The independent variables for the research sample had a positive effect, meaning that changes in these variables lead to a relative change in crop production in the spring season in the same direction. It is estimated at approximately 0.765, meaning that an increase in the costs of these variables by 1% beyond the level of usage could lead to a 7.46% increase in crop production during the spring season. The adjusted coefficient of determination is estimated at about 0.84, which means that the independent variables not included in the model explain about 16% of the variation in crop production. Among the variables, "machinery labor costs" ranked first in its impact on crop production, with a partial standardized regression coefficient of approximately 0.216, followed by "human labor" at 0.211. This was followed by "organic fertilizer" at 0.188, "cost of improved seeds" at 0.181, "cultivated area" at 0.149, "miscellaneous expenses" at 0.139, and finally "cost of pesticides" at 0.079. Technical efficiency reflects the ability of the production unit to achieve maximum production capacity using available inputs without wasting these resources (7).

Thirdly: Estimation of Production Cost Functions for Tomato Crops in the Research Sample:

Production cost functions are used to measure the relationship between two variables: total costs and production quantity, assuming the stability of other influencing factors. The mathematical model used in this research can be expressed as follows(14):

TC = d(Q)
Where:
TC: Total costs of producing tomatoes (in Dinar/Dunum) as the dependent variable.
Q: Quantity of tomato production (in tons) as the independent variable.
The mathematical equations were estimated using both quadratic and cubic forms, and the appropriate mathematical model was chosen based on statistical and economic criteria. The research concluded that the cost functions of the third degree are as follows:

$$TC = a_1 + a_2q + a_3q^2 + a_4q^3$$

Where:
TC: Estimated value of production costs for the crop.
Q: Quantity of tomato production for observation farms i.
a_1, a_2, a_3, a_4: Coefficients of the estimated function.

3.1- Statistical Estimation of the Production Cost Function for Tomatoes in the Summer Season

The coefficients of the production cost function for tomatoes in the summer season were estimated for the research sample. From an economic and statistical perspective, the production cost function of the third degree was deemed most appropriate. The signs of the coefficients aligned with the logic of economic theory, and there was a low degree of correlation among q, q^2, q^3, as well as a reduction in the standard errors of the estimated coefficients compared to other forms. The statistical function was found to be significant at the 5% level. As for the R^2 coefficient of determination, it was approximately 0.762, meaning that about 76.2% of the changes in the production costs of tomatoes can be explained by the variables related to per-dunum production of the crop. The remaining changes are due to other factors.

$$TC = 2341.64 + 538.14q - 21.18q^2 + 0.1q^3 \ldots\ldots\ldots\ldots\ldots(1)$$

(-2.06) * (5.89) ** (2.16)*
$R^2=0.762$ F=63.38**

The marginal cost(MC) and average cost(AC) functions were derived from Equation (1) in the following form(9):

$$MC=538.14 - 42.36q + 2.13q^2 \ldots\ldots\ldots\ldots(A)$$

$$AC = 2341.64/q + 538.14 - 21.18q + 0.71q^2 \ldots\ldots\ldots..(B)$$

By equating marginal costs (MC) and average costs (AC) (MC = AC), or by using the first derivative of average variable costs and equating it to zero (d(A.V.C)/dq = 0), it was found that the optimal production volume for tomato crops that minimizes costs is approximately 14.875 tons per dunum. When compared to the actual production volume for the research sample, which is approximately 12.49 tons per dunum, it was evident that tomato farmers in the summer season did not achieve the optimal production level.

Additionally, by equating the marginal costs with the price per ton of the crop for the research sample during the summer season, which is 640 dinars, the optimal production volume that maximizes profit was determined to be approximately 17.03 tons per dunum.

To estimate the net return for both the cost-minimizing production level and the profit-maximizing production level, and to evaluate technical efficiency—which reflects the appropriate selection of the production function among those actually used by the producer—the following equations were applied:

π = p q –TC ………….. (C)

Where:
π: Net return
q: Quantity of production
P: Price per ton of the crop (in dinars)
TC: Production costs

The net return from the crop at the optimal production level was approximately 5468 dinars, which is 1526.3 dinars higher than the net return at the actual production level. Meanwhile, the net return at the profit-maximizing production level was approximately 6847 dinars, which is 2905 dinars higher than the net return at the actual production level.

3.2 Statistical Estimation of the Production Cost Function for Tomato Crops in the Winter Season

The coefficients of the production cost function for tomato crops in the winter season were estimated for the research sample. From both an economic and statistical perspective, the production cost function of the third degree was the most appropriate. The signs of the coefficients were consistent with economic theory, and there was a low degree of correlation between q, q^2, and q^3, as well as a reduction in the standard errors of the estimated coefficients compared to other forms. The statistical function was found to be significant at the 5% level.

The R^2 coefficient of determination was approximately 0.76, meaning that 76% of the changes in the production costs of tomatoes can be explained by the variables related to per-dunum production of the crop, while the remaining changes are due to other factors.

$$TC = 3418.71 + 667.21\ q - 12.18^2 + 0.42q^3 \ldots\ldots\ldots\ldots\ldots(2)$$
$$(-2.17)^{*} \quad (\ 2.14\ )^{*} \quad (\ 4.94)^{**}$$

$$R^{\backslash 2}=0.762 \qquad F=63.38^{**}$$

The marginal cost (MC) and average cost(AC) functions were derived from Equation (2) in the following form:

$MC=667.21 - 24.36q + 1.26q^2$ ………….(A)

$AC = 3418.71/q + 667.21 - 12.18q +0.42q^2$ ………..(B)

By equating marginal costs (MC) and average costs (AC) (MC = AC), or by using the first derivative of average variable costs and equating it to zero (d(A.V.C)/dq = 0), it was found that the optimal production volume for tomato crops that minimizes costs is approximately 14.310 tons per dunum. When compared to the actual production volume for the research sample, which is approximately 12.59 tons per dunum, it was evident that tomato farmers in the winter season did not achieve the optimal production level. Additionally, by equating the marginal costs with the price per ton of the crop for the research sample during the summer season, which is 670 dinars, the optimal production volume that maximizes profit was determined to be approximately 19.484 tons per dunum. To estimate the net return for both the cost-minimizing production level and the profit-maximizing production level, the following equations were applied:

$\pi = p\ q - TC$ ………….(C)

Where:

π: Net return

q: Quantity of production

P: Price per ton of the crop (Dinars)

TC: Production costs

The net return from the crop at the optimal production level was about 5434 dinars, which is 1144.7 dinars more than the net return at the actual production level. Additionally, the net return at the profit-maximizing production level was about 8901 dinars, which is 4614 dinars more than the net return at the actual production level.

3.3 Statistical Estimation of the Production Cost Function for Tomato Crop in the Spring Season:

The parameters of the production cost function for the tomato crop in the spring season were estimated for the research sample. From both an economic and statistical perspective, it was found that the cost function is of third-degree, and the signs were consistent with economic theory. Additionally, the correlation between q, q^2, and q^3 was low, and the standard errors of the estimated parameters were reduced compared to other models. The statistical significance of the function was confirmed at the 5% level. The $R^{\backslash 2}$ coefficient was approximately 0.771, which means that 77.1% of the changes in the production costs of the tomato crop can be explained by the variables related to the production per dunum, with the remaining changes being attributed to other factors.

$$TC = 2464.78 + 5023.79q - 797.15q^2 + 29.68q^3 \ldots\ldots\ldots\ldots\ldots(3)$$

$$(8.07)^{**} \qquad (-7.78)^{**} \quad (21.25)^{*}$$

$R^{\backslash 2}=0.771$ $\quad F=66.68^{**}$

The marginal cost (MC) and average cost(AC) functions were derived from Equation (3) in the following form:

$$MC=5023.79 - 1594.30q + 89.04q^2 \ldots\ldots\ldots\ldots(A)$$

$$AC = 2464.78/q + 5023.79 - 797.15q + 29.68q^2 \ldots\ldots\ldots\ldots(B)$$

By equating marginal costs and average costs (MC = AC) or using the first derivative of the average variable costs and equating it to zero (d A.V.C / d q = 0), it was found that the optimal production size for tomato crop that minimizes costs is 13.462 tons per dunum. When compared to the actual production in the research sample, which is 8.91 tons per dunum**,** it was found that tomato farmers in the spring season did not achieve the optimal production level. By equating the marginal cost with the price of a ton of the crop in the summer season research sample, which is 750 dinars, and to estimate the net return for both the optimal size and the profit-maximizing size, the following equations were used(12)(4).

$\pi = p\ q - TC$ ………….(C)

Where:

π: Net return

q: Quantity of production

P: Price per ton of the crop (Dinars)

TC: Production costs

The net return from the crop at the optimal production level was about 6,733 dinars, which is 3,412.3 dinars higher than the net return at the actual production level. The net return at the profit-maximizing production level was about 7,639 dinars, which is 4,318 dinars higher than the net return at the actual production level.

forth: Economic Effects of Reaching the Optimal and Profit-Maximizing Production Levels for Tomato Farmers in the Diwaniya Governorate and its Districts

The results of the cost functions for the crop were estimated for the different agricultural seasons, and it was found that tomato farmers have not yet achieved the optimal and profit-maximizing production levels. To achieve these, it is necessary to improve the productivity and economic efficiency of the farmers in the research sample. This can be done through educating and training the farmers on modern technological methods, thereby reaching the optimal and profit-maximizing production levels. The economic effects of tomato farmers reaching the optimal and profit-maximizing production levels in the research sample for Diwaniya Governorate in 2024 on both production and profits are as follows (15)(8)(17):

-Increase in Production: According to the data in Table 4, reaching the optimal production level will lead to an increase in production by about 18.25 thousand tons compared to the actual production. Reaching the profit-maximizing production level will lead to an increase in production by about 36.89 thousand tons compared to the actual production.

- Increase in Profit: The data in Table 4 indicates that reaching the optimal production level will result in an increase in profit by about 9.16 million dinars compared to the actual profit. Reaching the profit-maximizing production level will result in an increase in profit by about 24.41 million dinars compared to the actual profit.

Table4. Economic Effects of Tomato Farmers Reaching the Optimal and Profit-Maximizing Production Levels for the Research Sample in Diwaniya Governorate for 2024.

Agricultural Season	Cultivated Area	Production (in thousand tons)			Net Return (in million dinars)		
	thousand tons	Actual	Optimal	Profit-Maximizing	Actual	Optimal	Profit-Maximizing
SUMMER	5.12	63.95	76.16	87.20	40.93	48.74	55.81
WINTER	1.27	16.00	18.17	24.74	10.72	12.17	16.58
SPRING	0.85	7.57	11.44	12.47	5.68	5.58	9.35
TOTAL	7.24	8.52	105.77	124.41	57.33	66.49	81.74

-Source: Ministry of Agriculture, Statistics Department Records, Unpublished Data for 2024.(16)
-Table No. 3 in the study.

Conclusions:

- The farmers in the research sample achieved efficiency in resource utilization, as indicated by the key calculated indicators of production and economic efficiency.
- The farmers in the research sample in the three seasons (winter, summer, and spring) failed to achieve the optimal and profit-maximizing production levels.
- Achieving the optimal production level for tomato farmers in the center of Al-Diwaniyah

Governorate and its districts would increase the crop's production by about 18.25 thousand tons compared to the actual production. Additionally, achieving the profit-maximizing production level would increase the crop's production by about 36.89 thousand tons compared to the actual production.

- Achieving the optimal production level for tomato farmers in the center of Al-Diwaniyah Governorate and its districts would increase the revenue from tomato production by about 9.16 million dinars compared to the actual revenue under the current production level. Moreover, achieving the profit-maximizing production level would increase the revenue from tomato production by about 24.41 million dinars compared to the actual revenue under the current production level.

Recommendations:

The research recommends the need to improve the production and economic efficiency of the farmers in the research sample by:

Implementing and training farmers on modern technological methods.

Providing them with the necessary knowledge to enhance their expertise.

Supplying improved seeds of the crop.

Encouraging the use of mechanical soil analysis.

Promoting the adoption of integrated pest management systems to eliminate pests and insects that affect the crop.

These measures aim to improve production efficiency and help farmers achieve the optimal production level and the profit-maximizing production level.

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