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Determining the optimal combination of production factors in pomegranate production farms in Diyala Province-Iraq: An analytical study for the season 2022

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Optimal combination. Production function. Pomegranate crop. Cost function.

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Abstract: This study aimed to analyze the reality of pomegranate production in Diyala Governorate - Iraq for the season 2022 using the Cobb-Douglas function model, with the aim of achieving optimization in production through the Lagrange method. The production function it estimated for a sample of pomegranate orchards, the function included production, as a dependent factor and each of labor, capital, and area are independent factors. The optimal combination of productive factors that achieve the optimal production volume reached (6.985) tons / hectare in the short-run. The total cost function was also estimated, including the optimal production volume in the long- run, which reduces costs, reaching (30.8) tons / hectare, which is achieved by exploiting the optimal area of the orchard, which amounted to (32.667) hectare. While the long-run profit-maximizing production reached (21.077) tons/hectare, it was recommended to use the optimal combination of production factors that have been reached, which achieve optimal production that reduces costs, and then increase the areas planted with pomegranate trees in the long-run in the study region.

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تحديد التوليفة المثلى لموارد الإنتاج في مزارع انتاج الرمان في محافظة ديالى – العراق: دراسة تحليلية للموسم 2022

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المستخلص

استهدفت الدراسة تحليل واقع انتاج الرمان في محافظة ديالى – العراق للموسم 2022 باستخدام انموذج دالة كوب- دوجلاس، وبهدف تحقيق الأمثلية بالإنتاج من خلال طريقة لاكرانج، تم تقدير دالة الإنتاج لعينة بساتين فاكهة الرمان، تضمنت الدالة الإنتاج عاملاً تابعاً وكل من العمل ورأس المال والمساحة عوامل مستقلة، وتم التوصل للتوليفة المثلى من العناصر الإنتاجية التي تحقق حجم الإنتاج الأمثل إذ بلغ (6.985) طن/هكتار بالمدى القصير. كما تم تقدير دالة التكاليف الكلية ومنها تم التوصل لحجم الإنتاج الامثل بالمدى الطويل والذي يخفض التكاليف إذ بلغ (30.8) طن/ هكتار والذي يتحقق باستغلال المساحة المثلى للبستان والتي بلغت (32.667) هكتار، بينما بلغ الإنتاج المعظم للربح بالمدى الطويل (21.077) طن/ هكتار، تمت التوصية بضرورة استخدام التوليفة المثلى من العناصر الانتاجية التي تم التوصل اليها والتي تحقق الإنتاج الأمثل المدني للتكاليف وثم زيادة المساحات المزروعة بأشجار الرمان بالمدى الطويل في منطقة الدراسة.

الكلمات المفتاحية: التوليفة المثلى، دالة الإنتاج، محصول الرمان، دالة التكاليف، العراق.

1. Introduction:

The importance of investing in the cultivation of fruit trees it highlighted by exporting some fruits to areas that do not have suitable production conditions, such as bananas and citrus fruits, where they are consumed in region other than the region where they were produced. Fruit trees are also associated with food industries, such as preserving fruits by freezing and making juices. Fruits also have a high nutritional value when consumed. (Al-Bitar, 2015: 5) Diyala Governorate is one of the fruit-producing governorates of Iraq. The area planted with fruit trees in Diyala Governorate is (33173) thousand hectares, of which (3527) hectares it planted with pomegranate trees, the number of pomegranate trees reached (2.813.694) productive trees. The amount of pomegranate fruit production in Diyala Governorate for the year 2022 (132.767) thousand tons, with a contribution rate of (59.5%) of the total fruits produced in the governorate. (Central Organization for Agricultural Statistics. 2022) The average cost per hectare of pomegranate orchards in Diyala governorate for the 2019 season was (446 dollar), while in the 2021 season it amounted to (514 dollar) due to the high prices of productive inputs. (Diyala Agriculture Directorate. 2021. Department of Planning) Orchards producing pomegranate fruits it considered profitable projects that help diversify and increase farm income

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if the available resources it optimally utilized. (Bachhav, 2020) concluded in a study he conducted on orchards producing pomegranate crops in Maharashtra - India, through a questionnaire conducted Conducting it with (62) producers of pomegranate fruits, the researcher aimed to know the amount of profits achieved from orchards producing pomegranates. The researcher concluded that fruit production is one of the economically profitable projects, as he found that the average profits for the studied sample were (3213.32) dollars / hectare during the year. In addition, modern technologies have a role in reducing production costs and increasing the profits achieved. This is evident from the results reached by (Abu Naga and Sukkar. 2022) in a study conducted in the Maghra Oasis region - Egypt. Where he concluded that the use of solar panels as a substitute for the fuel used to operate irrigation pumps leads to a reduction in variable production costs in addition to reducing the effort in performing farm operations and thus increasing the annual profits from selling the pomegranate crop. (Al-Saif, etall.2022) in a study aimed at knowing the effect of chemical fertilization by spraying on pomegranate trees in the Alexandria region - Egypt, that spraying potassium and calcium achieves high quality fruits as it reduces fruit cracking and increases the size of the fruit and the amount of sugar and water content in the fruit. Because of the high prices of production inputs, production costs rise, which leads to lower profits and thus the lack of incentive for producers to develop production in quantity and quality. As proved by (Al Tamimi, 2019), when an economic study was conducted on orange farms in Diyala Governorate - Iraq for the 2018 season, and he concluded that Variable costs constituted the largest percentage of the total production costs, and the rise in variable production costs resulted from the rise in prices in the input markets. Low-cost organic fertilizers are also a factor in the development of the amount of production. As their effectiveness it been proven according to a study conducted by (Hamad and Kafish. 2015) in Anbar Governorate – Iraq. As he concluded that organic fertilizers (horse manure and poultry waste) showed significant in their use of pomegranate trees, as it led using this fertilizer to increase the size of the fruits compared to an experiment without fertilization at the same site. Climate factors and the quality of irrigation water are also a factor in poor production, which causes a lack of economic profits and its effect appears during the year on trees and fruits. As (Al-Masoudi and Al-Kinani. 2016) concluded that the lack of rationing and regulation of irrigation water and the effect of high sun temperature are among the reasons for the deterioration of production fruits in Karbala Governorate - Iraq.

Due to the lack of economic studies on the reality of pomegranate production in Diyala Province, this research study came to contribute to solutions to the problem of high prices of productive inputs. In addition, previous studies did not deal with determining the optimal quantities of production factors, but only analyzed the proportional relationship between production and productive factors. This research aims to determine the optimal combination of the main productive factors (labor, capital, and farm area) by analyzing the reality of production and production costs of pomegranate farms in Diyala Province. The main factors of production it determined by the estimated function to achieve the allocative efficiency of the main production factors to avoid waste of productive resources and thus reduce production costs. The research it based on the hypothesis that achieving the optimal combination of available productive resources achieves optimal production in pomegranate orchards in the study area for the purpose of reducing production costs and thus achieving technical efficiency. The research it organized into three parts: the first part is the introduction to the research and the previous studies that it conducted on the subject of the research in addition to the research problem and its objective. The second part is the conceptual framework that clarifies the economic rules on which the research depends in applying the practical part. In addition, the third part is the practical part.

2. **Conceptual Framework:** The conceptual framework shows the independent variables in the production function (Cobb-Douglas) and the dependent variable, in addition to the variables included in the estimated total costs function of pomegranate orchards in the study region.

2-1. Formulation of the Production function Cobb-Douglas: The Cobb-Douglas production function is homogeneous of the first degree, as well as easily estimated after including the main production factors, which are labor, capital, and farm area. (Al-Afandi, 2012: 227) The characteristics of the Cobb-Douglas function show the possibility of estimating and extracting the optimal volumes of production and production factors. (Debertin. 2012: 172) The function model consists of the following variables:

$$Y = A\,L^{b1}\,K^{b2}\,N^{b3}$$

It is the labor (L) measured by the number of hours per hectare, the invested capital (K) measured by the unit (dollars/hectare), the farm area (N)

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measured by the unit (hectare), and the dependent variable is the production (tons/hectare), as well as (b1, b2, b3) are the productive elasticities of labor, capital, and area, respectively.

2-2. Determining the optimal quantities of the productive factors: The optimal quantities of the productive factors can it found by applying the Lagrange formula. Which includes the production function in exponential form and the budget constraint equation, by using the Lagrange multiplier to link the two equations, and after determining the level of the average total cost per hectare, as follows: (Al-Hayali, 2014: 169)

$C = WL + rK + aN$ Cost equation

$WL + rK + aN - C^{\circ}$ budget constraint

$Z = \left(A\, L^{b1}\, K^{b2} N^{b3}\right) + \lambda\,(WL + rK + aN - C^{\circ})$ Lagrange function

The units of equations (P_Y) define the price of production measured in (dollars / ton), and (W) labor wages measured in dollars, as well as (r) the interest rate on capital (dollars), while (C°) is the budget constraint for the factors of production (labor, capital, and area). Then the necessary condition it applied by finding the first partial differentiation for each productive factors, and by adopting the actual prices of the productive factors on the farm, the optimal sizes of the productive factors can be reached, and then the optimal volume of production is found. (Nicholson & Snyder 2008: 39)

2-3. Formulation of the total cost function model: Production costs are the sum of what the farm incurs in return for purchasing the inputs that it used in the production process. (Al-Hasnawi 2011: 133) Production costs are divided in the short- run into fixed costs, which are not related to the volume of production and are borne by the producer, whether produced or not, and variable costs associated with the volume of production that increase with its increase and decrease with its decrease. (Qitf and Khalil, 2004: 199) Production costs are a determining factor for the behavior of the producer for a specific budget level based on the price level in the input markets, and based on that, the production decision it made. (Jehle & Reny, 2011: 135) Accordingly, the cost function can it formulated in the simplified form:

$TRC = P^{\circ}.X + FC$

Where (TRC) it the total cost of purchasing the productive resource, (P°) is the market price of the resource, (FC) is the fixed costs, and (X) is the quantity of the productive resource. The cost function takes the cubic form, which it characterized by ease of analysis. Accordingly, the short-term function model is in the following mathematical form: (Al-Hayali, 2014: 25)

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$$SRTC = b_0 + b_1 Q + b_2 Q^2 + b_3 Q^3 + Ui$$

Then the variable (A) that represents the area of the orchard it added, as the derivation of the production function in the long - run it done by deleting the parameter (b_0) that represents the fixed costs. Thus, the function is subject to long-run conditions as all production costs are variable, so that the final formula for the total costs function is as follows:

$$LRTC = b_1 Y - b_2 Q^2 + b_3 Q^3 + b_4\, QA + b_5 A^2 + Ui$$

2.4. Calculation of economies of scale achieved: The profit-maximizing condition in a perfectly competitive market it met by bringing the producer into equilibrium at the lowest point of the long-run average total cost curve (LRATC). (Al-Afandi: 250) This can it achieved by adopting the profit function and then performing partial differentiation with respect to production (Q) to find the profit-maximizing production volume. (Al-Hayali: 118) The ratio of economies of scale it measured quantitatively through the following relationship: (Mclemore, Dan L. etall.1983: 79-83)

$$ECON. = \frac{LRATC_m - LRATC_i}{LRATC_m - LRATC_o} * 100$$

Since:

$LRATC_m$ = the level of costs for the lowest level of production achieved.

$LRATC_i$ = expected level of costs at scale of production (i)

$LRATC_o$ = expected level of costs for optimal production volume.

The achieved economies of scale can it supported by finding cost elasticity that explains the response of production to the limits of added costs due to the expansion of the size of the farm and through the following relationship: (Debertin, 2012. P.166)

$$Elasticity = \frac{\Delta LRATC}{\Delta Y} * \frac{Y}{LRATC}$$

Since:

ΔLRATC = amount of change in the long-run average total cost curve.

ΔY = amount of change in the level of production achieved in the long - run.

LRATC = the expected long-run average total cost level.

Y = the level of production achieved in the long - run.

3. Results and Discussion:

3-1. Research region and data sources: The basic data on production, costs and labor were obtained through a questionnaire conducted in an interview with (41) pomegranate farmers in Diyala Governorate - Iraq for the 2022 production season. Secondary data it obtained from the Directorate of

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Agricultural Statistics in Diyala Governorate and the Directorate of Agriculture in Diyala Governorate. Data tabulation it analyzed using (Excel) and then analyzed using (Eviews.10).

3-2. Statistical analysis of the estimated production function (Cobb - Douglas): The semi-logarithmic formula it adopted in estimating the Cobb-Douglas production function shown in Table (1). The function passed the statistical tests and was identical to the economic logic. It is evident from Table (1) the significance of the estimated production function parameters.

Table (1) shows the significance of the estimated production function parameters. The value of the coefficient of determination (R^2) also shows that (18%) of the changes in production were the result of the combination of production factors included in the quantitative analysis. While the remaining percentage (19%) is subject to other factors that are not subject to for quantitative measurement, the (F) test also proved the significance of the function as a whole.

3-2-1. Autocorrelation test of the estimated production function: Table (1) shows the absence of the autocorrelation problem through the value of (D-W) test, as it is located in the hypothesis acceptance region (4 - DU > D-W > DU), and thus the (H_0) hypothesis can be accepted, and the estimated function is as follows:

Table (1): the estimated production function of the research sample

Variables	Parameters	t - value	Significant
Output (Y)	0.818964866544	2.839873	%5
L	0.161784441264	4.175870	%5
K	0.0415057571003	1.475815	%10
N	0.0459116664544	2.372759	%5
Econometrics & Statistical test			
R^2	0.813667		-----
D - W test	1.942088		%5
F - test	53.85652		%5

$$Ln(Y) = 0.818 + 0.161\ Ln\ (L) + 0.0415\ Ln\ (K) + 0.0459\ Ln\ (N)$$

It is clear from Table (1) that there is a direct proportional relationship between the production factors included in the estimated function, as an increase in labor by (1%) leads to an increase in the quantity of production by (0.161) units. Increasing the capital by (1%) leads to an increase in production by (0.0415) units of the total output. Therefore, increasing the area of the orchard by (1%) leads to an increase in the quantity of production by (0.0459) units of the total production.

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3-2-2. Testing the Variance Heteroscedasticity Problem: Because the study relied on cross-sectional data for a community with varying characteristics, it confirmed that the model was free from the problem of heteroscedasticity of variance by conducting the (ARCH) test, and the results were as shown in Table (2):

Table (2): (ARCH) test to detect the problem of heteroscedasticity of variance in the estimated Cobb-Douglas production function for the research sample

Heteroscedasticity Test: ARCH				
F-statistic	0.007112	Prob. F (1,38)		0.9332
Obs*R-squared	0.007485	Prob. Chi-Square (1)		0.9311
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 02/13/23 Time: 09:53				
Sample (adjusted): 2 41				
Included observations: 40 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.001093	0.000279	3.916789	0.0004
RESID^2(-1)	0.013006	0.154224	0.084335	0.9332
R-squared	0.000187	Mean dependent var		0.001108
Adjusted R-squared	-0.026124	S.D. dependent var		0.001348
S.E. of regression	0.001365	Akaike info criterion		-10.30630
Sum squared resid	7.08E-05	Schwarz criterion		-10.22185
Log likelihood	208.1260	Hannan-Quinn criter.		-10.27577
F-statistic	0.007112	Durbin-Watson stat		1.916106
Prob(F-statistic)	0.933233			

Where the value of (Prob. Chi-Square) was (0.8374), which is greater than (0.05), the problem of heteroscedasticity of variance in the estimated function is absent. (Al-Sawaei. 2011. p. 128)

3-3. Determine the optimal combination of production factors: The optimal production volume can it found by forming the Lagrange function, as it formed from the estimated production function after converting it to the exponential formula and the (budget constraint) equation as follows:

$Ln(Y) = 0.818 + 0.161\ Ln\ (L) + 0.0415\ Ln\ (K) + 0.0459\ Ln\ (N)$

Converting the estimated production function into exponential form:

$Y = 2.268\ L^{0.161}\ K^{0.0415}\ N^{0.0459}$ ... (1)

The budget constraint is as follows:

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$W_L + r_k + a_N - \mathbf{C}^{\circ} = 0$

The prices of the inputs included in the estimated function model are:

W = average wage for labor = 15 dollar /hour

r = interest rate on capital = 0.10 dollar

a = Average land rent = 48 dollar /hectare

$\mathbf{C}^{\circ}$ = average total production costs = 531 dollar / hectare.

When replacing the prices of production factors and the average cost of a hectare and equating the equation to zero, it becomes:

$15(\mathrm{L}) + 0.10\ (\mathrm{K}) + 48(\mathrm{N}) - \mathbf{531} = 0 \ldots (2)$

By Using the Lagrange multiplier (λ) to connect the estimated production function and the budget constraint, we get the Lagrange equation:

$$\mathbf{Z} = \left(2.268\ \mathrm{L}^{0.161}\ \mathrm{K}^{0.0415}\ \mathrm{N}^{0.0459}\right) + \boldsymbol{\lambda}(15(\mathrm{L}) + 0.10\ (\mathrm{K}) + 48(\mathrm{N}) - \mathbf{531}) = 0 \ldots . (3)$$

Then applying the necessary condition by finding the partial differential with respect to labor, capital, area, and the Lagrange multiplier:

$$\frac{\partial \mathbf{Z}}{\partial \mathbf{L}} = \left(\mathbf{2.268\ L^{0.161}\ K^{0.0415}\ N^{0.0459}}\right) + \boldsymbol{\lambda}(\mathbf{15(L) + 0.10(K) + 48(N) - 531}) = \mathbf{0}$$

$$= (2.268)(0.161)\mathrm{L}^{-0.839}\ \mathrm{K}^{0.0415}\ \mathrm{N}^{0.0459} - \lambda 15 = 0$$

$$= (0.365148)\mathrm{L}^{-0.0.839}\ \mathrm{K}^{0.0415}\ \mathrm{N}^{0.0459} / \ 15 = \lambda$$

$$= (0.0243432)\mathrm{L}^{-0.0.839}\ \mathrm{K}^{0.0415}\ \mathrm{N}^{0.0459} = \lambda \ldots \ldots (4)$$

$$\frac{\partial \mathbf{Z}}{\partial \mathbf{K}} = \left(\mathbf{2.268\ L^{0.161}\ K^{0.0415}\ N^{0.0459}}\right) + \boldsymbol{\lambda}(\mathbf{15(L) + 0.10(K) + 48(N) - 531}) = \mathbf{0}$$

$$= (2.268)(0.0415)\mathrm{L}^{0.161}\ \mathrm{K}^{-0.958}\ \mathrm{N}^{0.0459} - \lambda 0.10 = 0$$

$$= (0.094122)\mathrm{L}^{0.161}\ \mathrm{K}^{-0.958}\ \mathrm{N}^{0.0459} / \ 0.10 = \lambda$$

$$= (0.94122)\mathrm{L}^{0.161}\ \mathrm{K}^{-0.958}\ \mathrm{N}^{0.0459} = \lambda \ldots \ldots (5)$$

$$\frac{\partial \mathbf{Z}}{\partial \mathbf{N}} = \left(\mathbf{2.268\ L^{0.161}\ K^{0.0415}\ N^{0.0459}}\right) + \boldsymbol{\lambda}(\mathbf{15(L) + 0.10(K) + 48(N) - 531}) = \mathbf{0}$$

$$= (2.268)(0.0459)\mathrm{L}^{0.161}\ \mathrm{K}^{0.0415}\ \mathrm{N}^{-0.954} - \lambda 48 = 0$$

$$= (0.1041012)\mathrm{L}^{0.161}\ \mathrm{K}^{0.0415}\ \mathrm{N}^{-0.954} / \ 48 = \lambda$$

$$= (0.002168775)\mathrm{L}^{0.161}\ \mathrm{K}^{0.0415}\ \mathrm{N}^{-0.954} = \lambda \ldots \ldots (6)$$

$$\frac{\partial Z}{\partial \lambda} = (20\mathrm{L} - 0.10\mathrm{K} - 12\mathrm{N} - 477) = 0 \ldots . (7)$$

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By dividing equation (4) by equation (5), it is possible to find the value of the variable (L) in terms of the variable (K), as follows:

$$\frac{(0.0243432)L^{-0.0.839}\ K^{0.0415}\ N^{0.0459}}{(0.94122)L^{0.161}\ K^{-0.958}\ N^{0.0459}} = \frac{\lambda}{\lambda}$$

$$L = 0.0258634538\ K - - - (8)$$

Then divide equation (6) by equation (5) to find the value of variable (N) in terms of variable (K), as follows:

$$\frac{(0.002168775)L^{0.161}\ K^{0.0415}\ N^{-0.954}}{(0.94122)L^{0.161}\ K^{-0.958}\ N^{0.0459}} = \frac{\lambda}{\lambda}$$

$$N = 0.00230421686\ K - - - (9)$$

The value of the optimal size of the capital (K) it found, the values of equations (8) and (9) it replaced by the budget constraint equation (Equation 7) as follows:

$=(15L - 0.10K - 48N - 531)$

$= 15(0.0258634538\ K) – 0.10\ K – 48\ (0.00230421686\ K) = 531$

$= 0.387951807\ K– 0.10K – 0.1106024092\ K= 531$

$0.1773493978\ K = 591$

$$K = \frac{531}{0.1773493978} = 2994\ \ \textit{Dollar / Hectar}$$

The value of (K) it substituted by equation (7) and equation (8) to find the optimal sizes for the labor factor (L) and the area factor (N), as follows:

$L = 0.0258634538\ (2994) = 77.4\ \ \textit{work hour/hectare}$

$N = 0.00230421686\ (2994) = 6.898\ \ \textit{Hectar}$

Then the optimal volume of production it found, the optimal quantities of labor, capital and area it compensated by the estimated production function:

$Y = 2.268\ \ L^{0.161}\ K^{0.0415}\ N^{0.0459}$

$Y = 2.268\ \ (77.4\ )^{0.161}\ (2994)^{0.0415}\ (6.898)^{0.0459}$

$Y = 2.268\ \ (2.014)(1.394)(1.097) = 6.985\ \ \textit{Ton / Hectar}$

3-3-1. Comparison of the optimal combination with the combination actually used in the research sample: By comparing the optimal combination of production factors with the combination of factors actually used, it becomes clear that there is a difference between the volumes of production achieved using the same level of production costs, which means that there is inefficiency in the production process.

Table (3): Comparison of the optimal combination with the actual combination of production elements in the research sample

production factors	**The optimum combination/ hectare**	**The combination actually used/hectare**
Labor	77.4 working hours	67.5 working hours
Capital	2994 dollar	2290 dollar
Area	6.898 hectare	4.3 Hectare
achieved production	6.985 Ton	4.2 Ton

Reference/researcher based on the questionnaire& the estimated production function.

3-4. Production Cost Structure: Table (4) shows that the variable costs per hectare constituted the largest percentage of the total costs, amounting to (52.72%), including work wages, which constituted (19.40%), then fixed costs, which constituted (47.28%), Including the interest rate on capital, which constituted (43.13%).

Table (4): Structure of average production costs for the research sample

Type of production costs	**Average production cost items / hectare**	**average cost (dollar/ hectare)**	**Relative importance**	**Relative importance (AVC) (AFC)**
average variable costs/hectare	The cost of renting the land	48	% 9.04	52.72%
	The cost of chemical fertilizers	53	% 9.98	
	The cost of organic fertilizer	16	% 3.01	
	The cost of pesticides	20	% 3.77	
	Work wage costs	103	% 19.40	
	The cost of cleaning the irrigation canals	4	% 0.75	
	The cost of maintaining irrigation pumps	4	% 0.75	
	Cost of fuel and oils	11	% 2.07	
	irrigation cost	18	% 3.39	
	farm fence maintenance cost	3	% 0.56	
Total average variable costs		280	----	
Average fixed costs/ hectare	The cost of depreciation of irrigation canals	3	% 0.56	47.28%
	The cost of the depreciation of the farm fence	2	% 0.38	
	Irrigation pump depreciation cost	2	% 0.38	
	Fixed labor costs	15	% 2.82	
	Capital interest rate(0.10)	229	% 43.13	
Total average fixed costs		251	-----	
Average total costs dollar /hectare		531	% 100	% 100

Reference: researcher based on the questionnaire.

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3-5. Statistical analysis of the estimated total costs function: Table (5) shows that the estimated costs function passed the statistical tests through the value of (t) calculated, and the non-significance of the variable (Q^3), as it shows the inability of the specific production costs to achieve this level of production. The analysis also proved the significance of the function through the test value (F). For a significant level of 0.05, degrees of freedom (K=5), and the number of sample (N = 41). Table (5) also shows through the value of the coefficient of determination (R^2) that production it affected by the costs spent by (91%), and the remaining percentage (9 %) did not appear to be affected by the analysis.

3-5-1. Autocorrelation test of the estimated cost function: The statistical analysis in Table (5) showed the absence of the autocorrelation problem through the test value (D-W) as it is (4 - DU > D-W > DU). Thus, the (H_0) hypothesis can accepted.

Table (5): the function of estimated costs of orchards of the research sample

Variables & Tests	Parameters	t - Value	Significant
b_0	473.784908618	1.762796	%5
b_1Q	298.077455174	3.114750	%5
b_2Q^2	- 26.7186808677	-2.122468	%5
b_3Q^3	0.0987941769782	0.382385	-----
AQ	38.9158146808	2.207887	%5
A^2	- 18.3514543638	-1.664061	%10
Standard & Statistical test			
R^2	0.913264		-----
D - W test	1.849084		%5
F - test	73.70466		%5

Both production and area are implicit functions of costs, so the estimated cost's function can it written in the following implicit form:

$$V = TC - 473.784 - 298.077\ Q + 26.718\ Q^2 - 0.098794176\ Q^3 - 38.915\ AQ + 18.351\ A^2$$

Then the first partial differential it found for the area of the orchard (A):

$$\frac{\partial V}{\partial A} = -38.915\ \ Q\ +\ 36.702A$$

$$A = \frac{38.915}{36.702} Q$$

$$A = 1.060296441Q \dots \dots .. (10)$$

By substituting the value of equation (10) into the original cost function and excluding the fixed term, we get the long-run cost function as follows:

$LRTC = 298.077\ Q - 26.718\ Q^2 + 0.0987941769782\ Q^3 + 38.915\ Q\ (1.060296\ Q) - 18.351\ (1.060296\ Q)^2$

$LRTC = 298.077\ Q - 26.718\ Q^2 + 0.0987941769\ Q^3 + 41.261\ Q^2 – 20.630\ Q^2$

Adding the (Y^2) terms, we get:

$LRTC = 298.077\ Q – 6.0877\ Q^2 + 0.0987941769\ Q^3$

The long-run total cost function.

3-5-2. Testing the Heteroscedasticity of Variance Problem for the Estimated Production Costs Function: To ensure that the estimated model is free from the problem of heteroscedasticity of variance, the (ARCH) test was performed, as the results are shown in Table (6), as the value of (Prob. Chi-Square) was greater than (0.05). and thus, the existence of the problem of heteroscedasticity of variance is negated and the hypothesis is accepted. (H_0).

Table (6): Test to detect the problem of heteroscedasticity of variance in the estimated cost function model for the research sample

Heteroscedasticity Test: ARCH				
F-statistic	0.037088	Prob. F(1,38)		0.8483
Obs*R-squared	0.039002	Prob. Chi-Square (1)		0.8434
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 02/11/23 Time: 11:52				
Sample (adjusted): 2 41				
Included observations: 40 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	115484.3	28709.27	4.022545	0.0003
RESID^2(-1)	0.031288	0.162466	0.192583	0.8483
R-squared	0.000975	Mean dependent var		119055.8
Adjusted R-squared	-0.025315	S.D. dependent var		136885.0
S.E. of regression	138606.8	Akaike info criterion		26.56538
Sum squared resid	7.30E+11	Schwarz criterion		26.64982
Log likelihood	-529.3075	Hannan-Quinn criter.		26.59591
F-statistic	0.037088	Durbin-Watson stat		2.001596
Prob(F-statistic)	0.848311			

3-6. Determining the optimal quantities of production and area in the long-run: To determine the optimal volume of production in the long - run, it is possible to find the average total cost in the long - run by dividing the long-run total costs equation by production (Q):

$$LRTC = 298.077\ Q - 6.0877\ Q^2 + 0.0987941769782\ Q^3$$

$$\frac{LRTC}{Y} = \frac{298.077\ Q - 6.0877\ Q^2 + 0.09879417697\ Q^3}{Q}$$

$$LRATC = 298.077\ - 6.0877\ Q + 0.0987941769782\ Q^2$$

Long-run average total costs equation.

Then by applying the necessary condition to reduce costs by deriving, the production variable (Q), to find the optimal volume of production that reduces costs in the long - run, as follows:

$$\frac{\partial\ LRATC}{\partial Q} = 6.0877 + 0.197588353950 = 0$$

$$Q = \frac{6.0877}{0.19758835395} = 30.8100\ \text{Ton/ Hectar}$$

The optimal volume of production that helps to reduce costs in the long - run.

The volume of production, which lowers costs in the long - run, it compensated by equation (10) to find the value of variable (A), as follows:

$$A = 1.060296441\ (30.8100\ ) = 32.667\ \text{Hectar}$$

The optimal area that achieves production that reduces costs.

3-6-1. Long-Run Producer Equilibrium: The volume of production at the point of long-run producer equilibrium can it found by applying the condition (MC = MR) as follows:

So: MC = marginal costs, MR = marginal returns

$$\pi = TR - LRATC$$

$$\pi = P.(Q) - 298.077\ - 6.0877\ Q + 0.0987941769782\ Q^2$$

By substituting the average price of the production of (300 dollars/ ton), we get:

$$\pi = 300\ Q - 298.077\ - 6.0877\ Q + 0.0987941769782\ Q^2$$

Then applying the balance condition:

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$$\pi = \frac{\partial TR}{\partial Q} = \frac{\partial \text{LRATC}}{\partial Q}$$

$$\pi = MR - \text{MC} = 0$$

$$\pi = 300 - 298.077 - 6.0877 + 0.19758835395 \text{ Q} = 0$$

$$\pi = 300 - 304.164 + 0.19758835395 \text{ Q} = 0$$

$$-4.1647 + 0.19758835395 \text{ Q} = 0$$

$$0.19758835395 \text{ Q} = 4.1647$$

$$\text{Q} = \frac{4.1647}{0.19758835395} = 21.0776 \text{ Ton/ Hectar}$$

The profit maximizing production at the producer's equilibrium point.

3-7. Achieved economies of scale: Table (7) shows that pomegranate producers in the research sample can achieve the volume of production at the equilibrium point of (21) tons, and at this volume the percentage of economies of scale achieved is equal to (100%) and the cost elasticity is equal to zero. Increasing production after the equilibrium point leads to higher production costs and lower economic efficiency.

Table: (7): economies of scale achieved for the research sample orchards

Production levels tons/hectare	The average total cost dollar /hectare	economies of scale %	Cost elasticity
1.8	287	42%	---
10	247	74%	-0.197
15	229	88%	-0.235
17	223	92%	-0.228
20.5	214	99%	-0.248
21	214	100%	0.000
45	224	92%	0.083
50	241	78 %	0.705
55	262	62%	0.881

Source: researcher depending on questionnaire and estimated cost function

* Note that the lowest average cost in the sample orchards was (342) dollars for the lowest level of production, which was (2.8) tons/ha.

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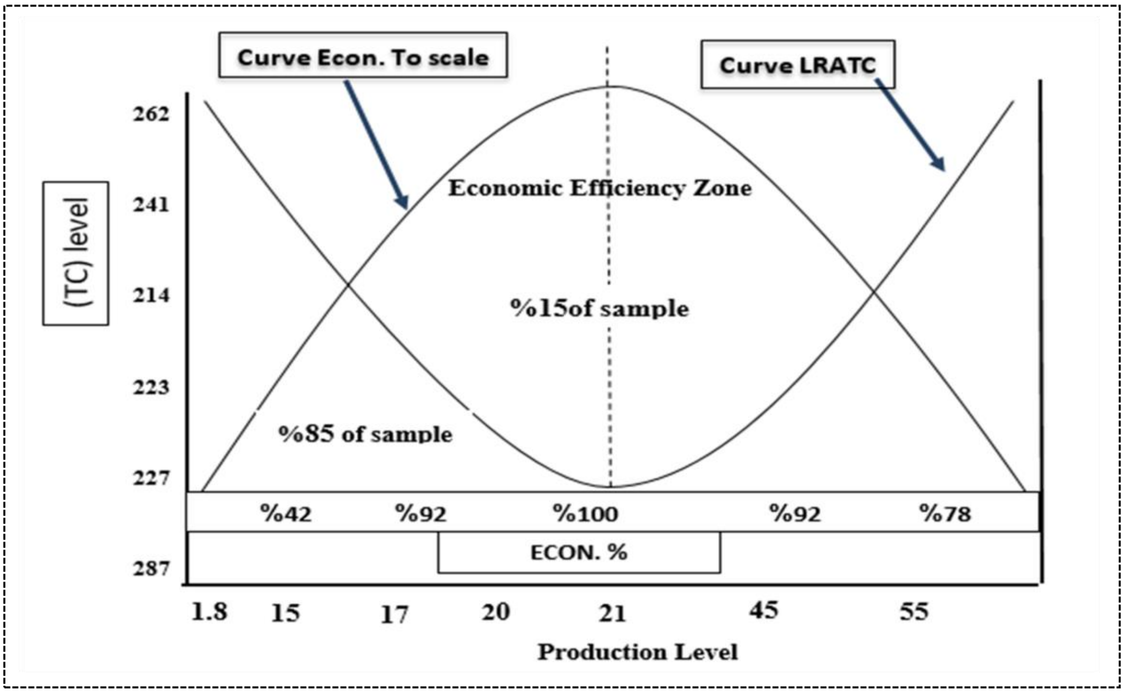

Figure (1) Curve of the average total costs and the curve of economies of scale achieved for the research sample.

Figure (1) shows that the largest difference between the average total cost curve in the long - run and the economies of scale curve achieves economic efficiency in the production process, and only (15%) of the pomegranate fruit orchards sample producers were able to work within the economic efficiency area. As for the remaining percentage (85%), they work below that area and were unable to achieve the optimal volume of production because of the low efficiency of managing the production process optimally due to the dispersal of the producer’s efforts over an area that exceeds the available capabilities and thus the occurrence of economic losses. (Debertin, 2012: 158)

4. Conclusions:

1. There is a difference between the optimal combination that has been reached and the combination actually used of production factors, which is the reason for the decrease in the amount of production, as the average actual production was (4.2 tons / hectare), while the optimal production volume was (6.985 tons / hectare) using the same level costs in the short - run.
2. The pomegranate producers in the study area could not achieve economic efficiency by exploiting the available budget, as the average actual production costs were (531 dollars/hectare), while the average estimated costs that achieve the optimal size of production were (214 dollars/hectare).

5. Recommendations: Based on the conclusions reached, the following can it recommended:

1. The need to use the optimal combination of productive factors (labor, capital, and area) in the orchards of pomegranate production in the study region to achieve the optimal size that maximizes profits.
2. Increasing the areas planted with pomegranate trees in the study region in order to increase production and thus increase returns in the long - run.
3. Activating policies to support the prices of production inputs, especially imported ones, as they cause higher production costs.
4. Activating the role of agricultural extension in communicating scientific research recommendations to farmers and applying them practically in pomegranate farms.
5. Stimulating pomegranate producers in the study area by limiting the import of this fruit.

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Appendix (1): Questionnaire Form:

Questionnaire: Determining the optimal combination of production resources in pomegranate production farms in Diyala Governorate - Iraq (An analytical study for the season 2022)

First: General Data:

1- Form number (----) 2- District (-----) 3- Age of farmer (---)

4- Academic Achievement (----) 5- Academic Specialization (----)

6- Number of farm family members working on the farm (--------)

7- Number of years of experience (----------) 8- The total area of the farm (------)

9- The number of trees producing the farm (------)

10- The age of the trees (-----) 11- The number of renovated trees on the farm (----)

Second: investment costs		
Statement	**Cost / dinars**	**annual depreciation cost**
Land rent / per hectare		
farm fence cost		
The cost of irrigation schedules		
The cost of constructing the farm road		
Cost and year of purchasing an irrigation pump		
Total invested capital		
interest rate on capital		

Third: Prices of production requirements			
Statement	**Amount/kg, l/ha**	**Price / liter, kg**	**Total cost**
Phosphate fertilizer			
Urea fertilizer			
animal manure			
Insecticides			
weed killers			
Fungicides			

Fourth: the costs of the rented work				
type of employment	**The number of working days on the farm**	**Number of working hours/day**	**Worker's wages / day**	**Total cost**
Pruning and hoeing				
Soil preparation				
composting				
control				
other				
the total				

Fifth: fixed work costs				
type of employment	**The number of working days on the farm**	**Number of working hours/day**	**Worker's wages/day**	**Total cost**
Tree renewal				
irrigation				
guard				
Periodic control				
the total				

Sixth: variable costs		
type of employment	**Cost / dinar**	**the details**
Irrigation schedule cleaning costs		
Tree renewal costs		
fuel costs		
Electricity tax		
Irrigation pump maintenance costs		
The cost of irrigation		
the total		

Seventh: production and harvest	
items	**the details**
amount of household consumption	
The total quantity of the crop sold	
Reaping costs	
The amount of damaged fruits	