Determining the optimal size of production and measuring the specialized efficiency in grape production farms in Diyala Governorate - Iraq for the season 2021

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ABSTRACT

In this research, an economic analysis it conducted for a sample of orchards producing grapes in Diyala Governorate - Iraq for the production season 2020-2021. Through a questionnaire conducted with (141) producers. The research aimed to measure the specialized efficiency of productive factors and to know the optimal combination that achieves optimal production. By estimating the multivariate production function. It included (X_1) nitrogen fertilizer, (X_2) phosphate fertilizer, (X_3) animal manure, (X_4) number of irrigation hours per dunum, (X_5) the number of labor hours per dunum, (X_6) the amount of control pesticide. In addition, (X_7) the number of renewed trees per dunum as independent factors, while productivity (Y) was a dependent factor, the optimal quantities of the productive factors included in the estimated model it reached, including the optimal productivity, which amounted to (4734.5) K.G. / dunum. Which is achieved by adopting the optimal combination of production factors consisting of (141) K.G. of urea fertilizer, (99) K.G. Of phosphate fertilizer, (4098) K.G. Of animal manure, (6) irrigation hours / dunums, (11) working hours / dunums, as well as (6) liters / dunums of control pesticide, and (44) renovated trees / dunums, and with the approval of the budget constraint of (553) thousand dinars / dunums. It recommended applying the optimal combination of the productive factors to achieve the optimal size of dunum productivity, as well as to educate the producers in order to achieve the specialized efficiency of the productive factors.

تحديد الحجم الأمثل للإنتاج وقياس الكفاءة التخصصية في مزارع انتاج العنب في محافظة ديالى – العراق للموسم 2021

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الخلاصة

تم في هذا البحث تحليل اقتصادي لعينة من بساتين انتاج محصول العنب في محافظة ديالى – العراق للموسم الإنتاجي 2020 – 2021، من خلال استبيان اجري مع (141) منتج، استهدف البحث قياس الكفاءة التخصصية للعوامل الإنتاجية ومعرفة التوليفة المثلى التي تحقق الإنتاج الأمثل بواسطة تقدير دالة الإنتاج متعددة المتغيرات تضمنت (X₁) السماد النيتروجيني، (X₂) السماد الفوسفاتي، (X₃) السماد الحيواني، (X₄) عدد ساعات الري للدونم، (X₅) عدد ساعات العمل بالدونم، (X₆) كمية مبيد المكافحة، و(X₇) عدد الأشجار المجددة بالدونم كعوامل مستقلة، بينما كانت الإنتاجية (Y) عاملاً تابعاً، تم التوصل للكميات المثلى للعناصر الإنتاجية المتضمنة بالنموذج المقدر ومنها تم التوصل للإنتاجية المثلى التي بلغت (4734.5) كغم/دونم، والتي تتحقق باعتماد التوليفة المثلى من عوامل الإنتاج المكونة من (141) كغم من سماد اليوريا، و(99) كغم من السماد الفوسفاتي و (4098) كغم من السماد الحيواني، و (6) ساعة ري/ دونم، و(11) ساعة عمل/ دونم، وكذلك (6) لتر/ دونم من مبيد المكافحة، و (44) شجرة مجددة/ دونم، وباعتماد قيد الميزانية البالغ (553) ألف دينار/ دونم، تمت التوصية بضرورة تطبيق التوليفة المثلى للعناصر الإنتاجية لتحقيق الحجم الأمثل لإنتاجية الدونم وكذلك توعية المنتجين بهدف تحقيق الكفاءة التخصصية للعناصر الإنتاجية.

الكلمات المفتاحية: محصول العنب، دالة الإنتاج، الكفاءة التخصصية، قيد الميزانية.

INTRODUCTION

Grape fruits belong to the genus *Vitis*, the family *Vitaceae*, the grape family, it includes seventy types of grapes, foremost of which are Eurasian grapes, and it considered one of the most widespread types of grapes in terms of the number of varieties worldwide especially in the Middle East and Europe. The most important of these varieties are (Al-Halwani, the Seedless variety, and the Perlite variety), and there are some other varieties that have a limited spread. (Al-Bitar. 2015:314) There are many varieties of grapes spread in Iraq, the most famous of these varieties (Al-Halwani variety, Amiri variety, Kamali variety, and the French variety). There are other varieties spread in the orchards producing the grape crop, which it produced in a limited manner, such as (Alriyasii variety). The number of fruit trees for the grape crop in 2020 in Diyala Governorate reached (381792) trees. Of the total number of fruit trees in Iraq, amounting to (11613783), fruit grapes are spread more concentrated in the governorates of Salah al-Din, Diyala, Babylon, Baghdad, and Najaf. In 2019, Iraq's production of grapes reached (420466) tons, of which in Salah al-Din Governorate (292235) tons, which ranked first. Then it is followed by Diyala Governorate, as its production amounted to (85445) tons of the total production of Iraq, then followed by Najaf Governorate, as its production amounted to (18170) tons. While Iraq's production reached (858177) tons of grapes in 2020, Among them, the production of Diyala Governorate amounted to (82096) tons of the total production of Iraq, and it came in second ranked after Salah al-Din Governorate, which occupied the first ranked, as its production amounted to (294609) tons of the total production of Iraq in 2020. (Central Agency for Statistics and Information Technology. 2020) .

It is clear that the total production of the crop is low in Diyala Governorate, despite its distinction in the production of grapes. The decrease in production means a decrease in the productivity of a dunum in addition to the rise in the prices of production inputs, which leads to a rise in variable production costs. This is the focus of the research problem. That can contribute to finding a solution to it through this research. The study aims to know the actual use of the combination of

productive factors, and then estimate the multivariate production function to know the optimal combination of productive factors that achieve optimal production, and then calculate the specialized efficiency.

RESERCH HYPOTHESIS:

The research it based on the hypothesis that there is an irregular use of the available production requirements, and this led to a decrease in the productivity of a dunum in the orchards of the grape crop. Achieving optimal production is possible through achieving the optimal combination of the available productive factors by adopting the prices of production inputs during the research season.

MATERIALS AND METHODS:

1 - Questionnaire form, analysis programs (Excel) and (Eviews 10).

2- The production function is multivariate, from which the aim function is derived as follows:

The production function model consists of variables, which are factors of production, as well as parameters, which are elasticities of production factors, as follows: (Al-Hayali, 2014: 17)

$$\ln Y = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7$$

Since $(\ln Y)$ = productivity, $(X_1 - X_7)$ = quantities of factors of production, and $(b_1 - b_7)$ = elasticities of productive factors.

The objective function can it formed through the estimated production function after converting it to the exponential formula and linking it to the budget constraint equation, which consists of the prices of factors of production contributing to the productive process and using the Lagrange multiplier. And depending on the prices of productive inputs, as follows: (Nicholson & Snyder. 2008: 37-39)

$$\mathbf{C^° - X_1 r_1 - X_2\, r_2 - X_3 r_3 - X_4 r_4 - X_5 r_5 - X_6 r_6 - X_7 r_7 = 0 \quad \textbf{\textit{budget constraint}}}$$

As: (C) = average cost, $(X_1 - X_7)$ = quantities of factors of production, and $(r_1 - r_7)$ = factor prices

To form the aim function, the production function it converted from its logarithmic form to its exponential form:

$$Y = b_0\ X_1^{b1} X_2^{b2}\ X_3^{b3}\ X_4^{b4}\ X_5^{b5}\ X_6^{b6}\ X_7^{b7}$$

Therefore, the aim function is:

$$L = b_0\ X_1^{b1} X_2^{b2}\ X_3^{b3}\ X_4^{b4}\ X_5^{b5}\ X_6^{b6}\ X_7^{b7}$$
$$+ \lambda \left(C^° - X_1 r_1 - X_2\, r_2 - X_3 r_3 - X_4 r_4 - X_5 r_5 - X_6 r_6 - X_7 r_7 \right)$$

Note that (λ) = Lagrange multiplier, and to achieve maximization of production, the partial differentiation of all productive factors is found to achieve the condition of applying the law of diminishing returns and then achieve the optimal combination. (Al-Afandi. 2012: 232)

RESULTS AND DISCUSSION

The structure of production costs for the research sample for the production season 2021:

Costs are the sum of what the farm incurs in return for obtaining the productive resources that it used in the production process. In the orchards of grape production, the farmer needs a group of factors that affect the trees for the formation and ripening of the fruits, and therefore the formation of the fruits depends on the efficiency of using a group of factors that the producer intervenes in synthesizing. The items of production costs in the research sample included fixed and variable costs, as follows:

Variable Production Cost Items:

It includes the production costs spent during the production period as variable costs related to the volume of production achieved. The items of variable costs for the research orchards sample included the following:

1 - The cost of nitrogen fertilizer: The questionnaire showed that some of the sample producers got this fertilizer from free markets, and another part got it at the price subsidized by the state.

2- The cost of superphosphate fertilizer: Some farmers used triple superphosphate fertilizer in limited quantities, as its prices were high, whether from the state or free markets.

3 - The cost of manure fertilizer: All the farmers who interviewed during the questionnaire used organic fertilizer, as organic fertilizer it purchased from fermentation sites in large farms or from livestock breeding places in the study region.

4- The cost of seasonal hired labor: This item included the costs of family and rented labor during the production period, which begins in January, when trees begin to grow, and ends in August. This labor includes orchard service operations. labor wages ranged from (15-25) thousand Iraqi dinars for each worker who works (6) hours during the day, whether it was rented work or family work during the production period, and the sample farmers did not use mechanical work inside the orchards producing grapes, according to the questionnaire.

5 - The cost of maintaining the irrigation channels and the orchids road: It included the costs of periodic cleaning of the irrigation channels for connecting water flows from the source to the trees, which are the main channels of the orchids, in addition to cleaning and maintaining the service road inside the orchids.

6 - The cost of maintenance of irrigation pumps: These costs it related to the increase or decrease in the number of operating hours of the irrigation pump.

7 - The cost of fuel and operating oils for the pump: It included the costs of the irrigation pump fuel and operating oils. This item it considered to have high costs due to the high fuel prices.

8- The cost of electricity taxes: It included the taxes paid by the sample farmers for the use of irrigation pumps powered by electricity.

9 - Irrigation cost: It includes irrigation costs during the production period, as intensive irrigation begins, which directly affects the fruits, from March to July, according to weather conditions and temperatures. As for the remaining period, it is the dormant period of trees, and irrigation it less.

10 - Shed maintenance costs: The prevailing system for planting grape trees in the research region is the system of planting on trellises, which it called (shed). This shed consists of wooden poles called (pegs) fixed to the ground, thick metal wires, and a thin metal wire mesh that is square or rectangular in shape, and these wires have a certain degree of tension. Some wires it exposed to cutting due to use, as well as the wooden pegs are subject to breakage over time, so they it replaced on an annual basis.

11- Pesticide costs: Control costs included the costs of purchasing the control pesticide used in grape orchards during the studied production season.

Fixed cost items:

Fixed costs include expenses incurred by the producer whether production is achieved or not, meaning that it is not related to the volume of production. According to the questionnaire within the limits of the research region, the fixed costs of production included the following items:

1- Land rent allowance: Rental allowance for the area of the orchard land it calculated based on the prevailing wages in the study area and based on the contract data approved in the Diyala Agriculture Directorate - Land Rental Department.

2 - The cost of shed depreciation: Depreciation it calculated according to the law of the annual depreciation premium by subtracting the value of the rubble from the cost of the original, divided by the assumed age of the shed. (Al-Kalidar and Al-Dabash. 2018: 175), and the age of the shed, in addition to the fixed assets, was estimated at seven years, as its work efficiency decreases.

3 - **The cost of the depreciation of the irrigation channels and the orchard road**: It includes the cost of the annual depreciation of the irrigation canals that it used to deliver irrigation water from the source to the trees. With the extension of the main irrigation canal, there is a road with a width of (3-4) meters used for the passage of agricultural machinery.

4 - **The cost of the depreciation of the orchard fence:** It included the calculation of the annual depreciation premium of the orchard fence. Through the questionnaire, it became clear that a fence consisting of metal beams and concrete stakes surrounded some of the orchards. On the other hand, a concrete fence, and the annual extinction premium it calculated according to the type of fence.

5- Fixed human labor costs Fixed human labor costs: fixed labor included it planting new grape seedlings instead of dead trees, in addition to the cost of irrigation during the hibernation period. These expenses it considered fixed labor.

6- Tree consumption costs: It means that the default period for trees has passed since planting until the season of low production, as the tree's productivity decreases after that period and becomes economically unfeasible, so it uprooted and replaced with new seedlings. (Ahmed and Ibrahim. 2010: 142) This item of costs it added to the fixed costs, because regenerated trees do not bear fruit until three years after them it planted.

7- The interest rate on capital: The interest rate on capital was determined (10%) of the total capital invested in the productive season, which included expenses spent on purchasing production requirements, orchard service operations, and farm asset maintenance operations. According to the Agricultural Cooperative Bank in the search region. (The Agricultural Cooperative Bank. 2021)

The structure of production costs per dunum in the research sample for the 2020-2021 season:

It means the expenses incurred by the producer in exchange for the use of production factors, whether they are production requirements or orchard service operations, which are as in Table (1):

Table (1) shows that the average variable production costs constituted the largest part of the total production costs, reaching (59.07%) of the total average production costs per dunum. As for the fixed production costs, they constituted (41.03%) of the total costs.

Table (1) The structure of production costs and the percentage of contribution to the research sample

Costs type	Production cost items		The average cost thousand dinars / dunum	Relative importance%
Average variable production costs	The cost of nitrogen fertilizer		23.000	4.16
	The cost of phosphate fertilizer		51.000	9.22
	The cost of organic fertilizer		15.000	2.71
	The cost of pesticides		12.000	2.17
	Wage labor	Family labor	32.000	5.79
		hired labor	80.000	14.47
	The cost of cleaning the irrigation canals		2.000	0.36
	The cost of maintaining irrigation pumps		6.000	1.08
	Cost of fuel and oils		31.000	5.61
	The cost of electricity taxes		2.000	0.36
	Irrigation cost		67.000	12.12
	Shed maintenance cost		6.000	1.08
Total average variable production costs			327.000	% 59.07
Average fixed production costs	Shed depreciation cost		32.000	5.79
	The cost of renting the land of the orchard		15.000	2.71
	The cost of depreciation of irrigation canals and the orchard road		27.000	4.88
	The cost of the depreciation of the orchard fence		26.000	4.70
	Irrigation pump depreciation cost		12.000	2.17
	Fixed labor cost		29.000	5.24
	The cost of trees depreciation		41.000	7.41
	Interest rate on capital (10%)		44.000	7.96
Total average fixed production costs			**226.000**	**% 41.03**
Average total production costs per dunum			**553.000**	**%100**

Reference / calculated by the researcher based on the questionnaire.

Estimation of the multivariable production function model:

A multivariable function needs to satisfy the necessary condition in order to reach its maximum, which means that the function has reached its settling point. (Al-Hayali. 2014: 130) The study of the single productive season of fruit crops requires taking into account the determination of the productive factors that directly affect the achievement of production. Therefore, the productive factors have named and included in the function model in short-run conditions. The model variables included the productive factors affecting the production of the grape crop, which can quantitatively measure as independent variables. As for production, it was a dependent factor as follows:

Y = production quantity of grapes (kg / dunum)

X_1 = quantity of nitrogenous chemical fertilizer (kg/dunum)

X_2 = quantity of superphosphate fertilizer (kg/dunum)

X_3 = quantity of organic fertilizer - livestock manure (kg / dunum)

X_4 = number of irrigation hours / hour / irrigation / dunum

X_5 = number of human labor hours / hour / dunum

X_6 = quantity of pesticide/liter/dunum for each control time

X_7 = number of renewed trees / tree / dunum

The double logarithmic formula was more consistent with the logic of economic theory than the other formulas (the semi-logarithmic formula, the linear formula, and the inverted semi-logarithmic formula) in terms of the signs and the values of the parameters of the productive factors that were included in the estimated model. The analysis it carried out using (The Ordinary Least Squares method), as it gives the best-unbiased linear estimate by adopting the statistical analysis program (Eviews 10), as follows:

$Ln(Y) = 1.705 + 0.2401\ Ln(X_1) + 0.246\ Ln(X_2) + 0.267\ Ln(X_3) + 0.0701\ Ln(X_4) + 0.26003\ Ln(X_5) + 0.09430\ Ln(X_6) + 0.344\ Ln(X_7)$

Table (2) Parameters of the multivariate production function estimated for the orchards of the research sample for the season 2020-2021

Dependent Variable: LN(Y)				
Method: Least Squares				
Date: 02/19/23 Time: 07:56				
Sample: 1 141				
Included observations: 141				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.705491	0.077184	22.09634	0.0000
LN(X1)	0.240143	0.068500	3.505742	0.0006
LN(X2)	0.246999	0.098377	2.510740	0.0132
LN(X3)	0.267937	0.095525	2.804899	0.0058
LN(X4)	0.070131	0.034451	2.035709	0.0438
LN(X5)	0.260033	0.101839	2.553368	0.0118
LN(X6)	0.094301	0.065316	1.443758	0.1512
LN(X7)	0.344219	0.104834	3.283473	0.0013
R-squared	0.871530	Mean dependent var		2.290957
Adjusted R-squared	0.864768	S.D. dependent var		0.090449
S.E. of regression	0.033262	Akaike info criterion		-3.913766
Sum squared resid	0.147142	Schwarz criterion		-3.746461
Log likelihood	283.9205	Hannan-Quinn criter.		-3.845779
F-statistic	128.8940	Durbin-Watson stat		1.862379
Prob(F-statistic)	0.000000			

Economic and econometric analysis of the multivariate production function of the grape crop:

After conducting the statistical analysis, it became clear that the function corresponds to the logic of economic theory and the laws of econometric. The results of the statistical analysis were as follows:

Statistical analysis

The (t) test shows the percentage of confidence in the estimated model parameters, and the level at which the calculated (t) value is significant represents the possible measurement error. (Atiyah. 2004: 197) Based on this rule, the statistical analysis through this test in Table (2) shows the significance of the independent variables (X_1, X_2, X_3, X_4, X_5, and X_7) of the production function estimated at a significant level (0.05). While the analysis showed the significance of the variable (X_6) at the level of (0.10), with a positive effect on production. The variable (X_7), which represents the number of renewed trees per dunum, had a positive effect on production.

Standard analysis:

The statistical analysis proved that there is no autocorrelation problem between the residuals through the Durbin-Watson test. As its value reached (1.862) at the level of significance (0.05), where its value is located in the region of accepting the null hypothesis, as (2 > D-W > DU) at the number of variables (K = 7), which proves the absence of the problem of autocorrelation between residuals. The statistical analysis also proved the overall significance of the function estimated through the value of (F) test calculated as it reached (128.894) at the level of significance (0.05), degrees of freedom (K = 7), and number of sample observations (N = 141). Because the study it based on cross-sectional data, the estimated function must tested free from the problem of heteroscedasticity of random errors that appear in the cross-sectional data. Therefore, the Park test it carried out, which included conducting multiple regression of the logarithm square with the least squares residual as a dependent factor, with the logarithm of each independent factors separately as an independent factor, and the results were as follows:

1- Logarithm squared by least squares residuals with logarithm of factor (X_1):

$\text{Log} (ei)^2 = -8.61409986041 + 0.416701489438 \text{Log}(X_1)$

$t = (-3.221991) \quad (0.279748) \quad R^2 = (0.000563) \; F = (0.078259)$

2- Logarithm squared by least squares residuals with logarithm of factor (X_2):

$\text{Log} (ei)^2 = -8.58318839589 + 0.408153516527 \text{Log}(X_2)$

$t = (-3.212356) \; (0.268218) \qquad R^2 = (0.000517) \; F = (0.071941)$

3- Logarithm squared by least squares residuals with logarithm of factor (X_3):

$\text{Log} (ei)^2 = -9.24457667774 + 0.66725464377 \text{Log}(X_3)$

$t = (-2.425785) \; (0.361476) \qquad R^2 = (0.000939) \; F = (0.130665)$

4- Logarithm squared by least squares residuals with logarithm of factor (X_4):

$\text{Log} (ei)^2 = -9.67693008662 + 1.1398426023 \text{Log}(X_4)$

$t = (-4.180255) \; (0.790490) \qquad R^2 = (0.004475) \; F = (0.624875)$

5- Logarithm squared by least squares residuals with logarithm of factor (X_5):

$\text{Log} (ei)^2 = -9.24695103771 + 0.860300722437 \text{Log}(X_5)$
$t = -2.656052) \; (0.396815) \qquad R^2 = (0.001132) \; F = (0.157462)$

6 - Logarithm squared by least squares residuals with logarithm of factor (X_6):

Log $(ei)^2$ = -9.13041769644 + 0.738175423941 Log(X_6)
t = (-3.390921) R^2 = (0.001598) F = (0.222445)

7 - Logarithm squared by least squares residuals with logarithm of factor (X_7):

Log $(ei)^2$ = -8.43063912419 + 0.295297002836 Log(X_7)
t = (-2.152488) (0.142699) R^2 = (0.000146) F = (0.020363)

The results of the analysis show the insignificance of the independent variable of the functions estimated through the value of the (t) test, as well as through the calculated (F) value showing the insignificance of the function as a whole, and this means that there is no problem of instability of variance heteroscedasticity.

Determination coefficient (R^2): The statistical analysis showed through the value of the determination coefficient (R^2) that 87% of the changes in production it caused by the productive factors included in the estimated function. As for the remaining 13%, it is due to other factors that affected production and were not subject to quantitative measurement.

Economic analysis: The optimal behavior of the product in the research sample:

The optimal size of production can be determined by determining the optimal quantities of the productive factors contributing to the production process by conducting a set of mathematical operations that lead us to the optimal sizes of the productive factors, which reflect the ability of the producer to achieve the optimal combination. Thus, this combination of production factors can adopted to achieve maximization of production and by adopting a certain level of production costs, which it called (budget constraint). This requires performing multiple mathematical operations through which a tool called the Lagrange multiplier it used. (Al-Hayali 2014: 142) Then form a model consisting of the estimated production function after converting it to the exponential formula and linking it with the (budget constraint) and using the Lagrange multiplier to form (the Lagrange function). In addition, this multiplier has an economic value equal to one. (Nicholson & Snyder 2008: 39) As for the prices of the productive factors, they were determined based on the prices adopted by the farmer in purchasing the production inputs, which are as shown in Table (3):

Table (3) Prices and quantities of factors of production actually used in the research sample.

Factors contributing to production	Average unit price	The average amount used/ dunum	The average cost of dunum
Nitrogen fertilizer	(0.650) thousand dinars / kg	(36) K.g	(23) thousand dinars
Superphosphate fertilizer	(0.950) thousand dinars / kg	(54) K.g	(51) thousand dinars
Organic manure	(0.025) dinars / kg	(2160) K.g	(54) thousand dinars
Hours of hired human labor	(6) thousand dinars / hour	(16) hours	(112) thousand dinars
irrigation costs	(4) thousand dinars / hour	(7) hours/once irrigation	(28) thousand dinars
pesticide	(6) thousand dinars / liter	(2) liters	(12) thousand dinars
Fuel and oil costs	----------	----------	(31) thousand dinars
Shed maintenance	----------	----------	(6) thousand dinars
Electric irrigation pump taxes	----------	----------	(2) thousand dinars
Cleaning irrigation channels	----------	----------	(2) thousand dinars
Maintenance of irrigation pumps	----------	----------	(6) thousand dinars
Total average variable costs		(327) thousand dinars	
Total average fixed costs		(226) thousand dinars	
The total average cost of an acre		(553) thousand dinars	

Source / calculated by the researcher based on the questionnaire

Converting the estimated production function from logarithmic form to exponential form:

$$Y = 5.504 \, X_1^{0.240} \, X_2^{0.246} \, X_3^{0.267} \, X_4^{0.0701} X_5^{0.260} \, X_6^{0.0943} \, X_7^{0.344} \dots\dots \quad (1)$$

The cost equation that consists of factor prices is:

$$C = P_{X1} + P_{X2} + P_{X3} + P_{X4} + P_{X5} + P_{X6} + P_{X7}$$

When setting a constraint on production costs and setting it equal to zero, we get the budget constraint:

$$X_1 P_{X1} + X_2 P_{X2} + X_3 P_{X3} + X_4 P_{X4} + X_5 P_{X5} + X_6 P_{X6} + X_7 P_{X7} - C^\circ = 0$$

As the budget constraint and prices of production factors included in the estimated function are:

C° = average total costs = 493 thousand dinars / dunum.

P_{X1} = average price of chemical fertilizer = 0.650 thousand dinars / kg

P_{X2} = average price of triple superphosphate fertilizer = 0.950 thousand dinars / kg

P_{X3} = average price of organic manure = 0.025 thousand dinars / kg

P_{X4} = average price per hour of irrigation = 4 thousand dinars / dunum.

P_{X5} = average cost of seasonal rented labor = 6 thousand dinars / hour.

P_{X6} = the average price of the control pesticide = 6 thousand dinars / liter.

P_{X7} = average cost of tree renewal = 3 thousand dinars / tree.

Substituting the prices of production factors into the cost equation, we get the budget constraint:

$0.650X_1 + 0.950\ X_2 + 0.025X_3 + 4\ X_4 + 6X_5 + 6\ X_6 + 3\ X_7 - 553 = 0\ldots\ldots (2)$

Using the multiplier, a Lagrange function it formed to connect equation (2) with equation (1) to obtain the Lagrange function:

$L = 5.504\ X_1^{0.240} X_2^{0.246} X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344} + \lambda\ 0.650X_1 + 0.950\ X_2 + 0.025X_3 + 4\ X_4 + 6X_5 + 6\ X_6 + 3\ X_7 - 553 = 0\ \ldots.. (3)$

Equation (3): Aim function**.**

To find the optimal quantity for one of the production factors, the first partial differential is found for that factor with the imposition of the stability of the other factors, which is a condition for the application of the law of diminishing returns in the short-run, as follows: (Al-Afandi. 2012: 232)

$\frac{\partial L}{\partial X_1} = (5.504)(0.240)X_1^{0.240-1} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344} - \lambda 0.650 = 0$

$= 1.32096\ X_1^{-0.760} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344} / 0.650\lambda = 0$

$= 2.032246154\ X_1^{0.240-1} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344} = \lambda \ldots. (4)$

$\frac{\partial L}{\partial X_2} = (5.504)(0.246)X_1^{0.240} X_2^{0.246-1}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344} - \lambda 0.950 = 0$

$= 1.353984\ X_1^{0.240} X_2^{-0.754}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344} / 0.950\lambda = 0$

$= 1.425246316\ X_1^{0.240} X_2^{-0.754}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344} = \lambda \ldots. (5)$

$\frac{\partial L}{\partial X_3} = (5.504)(0.267)X_1^{0.240} X_2^{0.246}X_3^{0.267-1} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344} - \lambda 0.025 = 0$

$= 1.469568\ X_1^{0.240} X_2^{0.246}X_3^{-0.733} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344} / 0.025\lambda = 0$

$= 58.78272\ X_1^{0.240} X_2^{0.246}X_3^{-0.733} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344} = \lambda \ldots. (6)$

$\frac{\partial L}{\partial X_4} = (5.504)(0.0701)X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701-1} X_5^{0.260} X_6^{0.0943} X_7^{0.344} - \lambda 4 = 0$

$= 0.3858304\ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{-0.929} X_5^{0.260} X_6^{0.0943} X_7^{0.344} / 4\lambda = 0$

$= 0.0964576\ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{-0.929} X_5^{0.260} X_6^{0.0943} X_7^{0.344} = \lambda \ldots (7)$

$\frac{\partial L}{\partial X_5} = (5.504)(0.260)X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260-1} X_6^{0.0943} X_7^{0.344} - \lambda 9 = 0$

$= 1.43104\ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{-0.740}X_6^{0.0943} X_7^{0.344} / 6\lambda = 0$

$= 0.15900444\ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{-0.740}X_6^{0.0943} X_7^{0.344}\ \lambda \ldots. (8)$

$\frac{\partial L}{\partial X_6} = (5.504)(0.0943)X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943-1} X_7^{0.344} - \lambda 6 = 0$

$= 0.5190272\ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{-0.905} X_7^{0.344} / 6\lambda = 0$

$= 0.086504533\ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{-0.905} X_7^{0.344} = \lambda \ldots. (9)$

$$\frac{\partial L}{\partial X_7} = (5.504)(0.344)X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344-1} - \lambda 3 = 0$$

$$= 1.893376 \ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{-0.656} / 3\lambda = 0$$

$$= 0.631125333 \ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{-0.656} = \lambda \dots (10)$$

$$\frac{\partial L}{\partial \lambda} = (\ 0.650X_1 + 0.950 \ X_2 +0.025X_3 +6 \ X_4 +9X_5 +6 \ X_6 +3 \ X_7 - 553 = 0) \dots (11)$$

To find the value of the factor (X_1), equation (4) it divided by equation (10). As we find the value of the factor (X_1) in terms of the factor (X_7), and since the Lagrange multiplier (λ) has a value of one, it is possible, in short, to find the value of (X_1), as well as with the factors other productivity as follows:

$$\frac{2.032246154 \ X_1^{0.240-1} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344}}{0.631125333 \ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{-0.656}} = \frac{\lambda}{\lambda}$$

$$X_1 = 3.22003578 \ X_7 \dots \dots (12)$$

Also, to find the value of the factor (X_2) by dividing equation (5) by equation (10):

$$\frac{1.425246316 \ X_1^{0.240} X_2^{-0.754}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344}}{0.631125333 \ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{-0.656}} = \frac{\lambda}{\lambda}$$

$$X_2 = 2.25826193 \ X_7 \dots \dots (13)$$

To find the value of the factor (X_3), equation (6) it divided by equation (10):

$$\frac{58.78272 \ X_1^{0.240} X_2^{0.246}X_3^{-0.733} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344}}{0.631125333 \ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{-0.656}} = \frac{\lambda}{\lambda}$$

$$X_3 = 93.139534 \ X_7 \dots \dots (14)$$

We find the value of factor (X_4) by dividing equation (7) by equation (10):

$$\frac{0.0964576 \ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{-0.929} X_5^{0.260} X_6^{0.0943} X_7^{0.344}}{0.631125333 \ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{-0.656}} = \frac{\lambda}{\lambda}$$

$$X_4 = 0.1528343024 \ X_7 \dots \dots (15)$$

Then we find the value of the factor (X_5) by dividing equation (8) by equation (10):

$$\frac{0.15900444 \ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{-0.740}X_6^{0.0943} X_7^{0.344}}{0.631125333 \ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{-0.656}} = \frac{\lambda}{\lambda}$$

$$X_5 = 0.2519379775 \ X_7 \dots \dots (16)$$

We also find the value of the factor (X_6) by dividing equation (9) by equation (10):

$$\frac{0.086504533 \ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{-0.905} X_7^{0.344}}{0.631125333 \ X_1^{0.240} X_2^{0.246}X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{-0.656}} = \frac{\lambda}{\lambda}$$

$$X_6 = 0.13706395303 \ X_7 \dots \dots (17)$$

To find the value of (X_7), we substitute equations (12) (13) (14) (15) (16) (17) into equation (11), as follows:

$$= 0.650(3.22003\ X_7) + 0.950(2.2582\ X_7) + 0.025(93.139\ X_7) + 4(0.1528343\ X_7) \\ + 6(0.251937\ X_7) + 6(0.13706395\ X_7) + 3(\ X_7) - 553$$

$$= (2.093023) + (2.145348) + (2.32848\ X_7) + (0.611337202) + (1.511627) \\ + (0.82238371\ X_7) + (3\ X_7) - 553\ = 0$$

$$0.2273048\ X_3 = 553$$

$$X_7 = \frac{553}{12.512198912} = 44\quad tree/dunum$$

The number of trees that can renewed per dunum within the specified budget constraint.

Then we substitute the value of (X_7) into equation (12) to find the value of (X_1):

$$X_1 = 3.22003578\ (44) = 141\ Kg/dunum$$

The optimal quantity of nitrogen fertilizer for the research sample.

To find the value of (X_2), we substitute the value of the factor (X_7) into equation (13), as follows:

$$X_2 = 2.25826193\ (44) = 99\ K.g/dunum$$

The optimal amount of superphosphate fertilizer in the research sample.

In order to find the optimal size for the factor (X_3), the value of (X_7) it substituted by equation (14):

$$X_3 = 93.139534\ (44) = 4098\quad Kg/dunum$$

The optimal amount of organic fertilizer in the research sample.

Then we substitute the value of (X_7) into equation (15) to find the optimal size for the factor (X_4):

$$X_4 = 0.1528343024\ (44) = 6\quad hour/dunum/\ once\ irrigation$$

The optimal size for the number of irrigation hours per dunum.

So by substituting the value of (X_7) into equation (16) to find the optimal size for the factor (X_5):

$$X_5 = 0.2519379775\ (44) = 11\quad Labor\ hour/dunum/day$$

The optimal size for the number of labor hours per dunum.

In order to find the optimal size of the control pesticide, the amount of factor (X_7) it substituted by equation (17):

$$X_6 = 0.13706395303(44) = 6\quad liters/dunum$$

The optimal size of the control pesticide in the research sample.

In order to find the optimal volume of production, the optimal quantities of productive factors it substituted by equation (1), as follows:

$$Y = 5.504\ X_1^{\mathbf{0.240}}\ X_2^{0.246}\ X_3^{0.267}\ X_4^{0.0701} X_5^{0.260}\ X_6^{0.0943}\ X_7^{0.344}$$

$$Y = 5.504\ (141)^{0.240}(99)^{0.246}(4098\ )^{0.267}(6)^{0.0701}\ (11)^{0.260}\ (6)^{0.0943}\ (44)^{0.344}$$

$$Y = 5.504(3.279)(3.096)(9.216)(1.133)(1.865)(1.184)(3.675)$$

$$= (5.504)\quad (860.206)$$

$$Y = \ 4734.5\quad K.g\ /\ dunum$$

Optimal production volume by achieving the optimal combination of productive factors in the research sample.

Comparing the optimal behavior with the actual behavior of the product in the research sample:

The economic analysis of the research sample showed that there is a difference in the quantities used of all productive factors in different proportions, and by adopting the same level of costs, which are as in Table (4):

Table (4) Actual and optimal product behavior in the research sample for 2021 season

inputs and outputs	optimal behavior/ dunum	actual behavior/ dunum
Nitrogen fertilizer (X_1)	(141) K.g.	(36) K.g.
Phosphate fertilizer (X_2)	(99) K.g.	(54) K.g.
Animal manure(X_3)	(4098) K.g.	(2160) K.g.
Irrigations hours (X_4)	(6) hours/ once	(7) hours/ once
Number of labor hours (X_5)	(11) hours / day	(16) hours / day
Pesticide (X_6)	(6)liters	(2)liters
Number of renewed trees (X_7)	(44) trees	(13) trees
achieved production	(4734.5) kg /dunum	(4060) kg

Source/researcher based on the questionnaire and the estimated production function.

Table (4) shows that the sample farmers did not achieve the optimal state by exploiting production factors through the difference between the optimal combination that it reached and the actual combination. This means that there is a lack of efficiency in managing the production process.

Comparison of optimal fertilizer quantities with recommended quantities:

The quantities of organic and chemical fertilizers and the plant's need for them related to the degree of soil fertility and the plant's need for these elements. The quantities of optimal fertilizers that have reached must compared with the quantities of fertilizers recommended by the Ministry of Agriculture. Which depends on the average age of the tree and the extent of the plant's need for fertilizer. As for the optimal quantities that reached, they depended on the budget constraint that the farmer determines for the production process. Table (5) shows the optimal quantities of fertilizers that found in the research and the quantities of recommended fertilizers.

Table (5) Quantities of fertilizers (optimal, recommended, and actually used) in the research sample for the season 2020-2021

The number of trees per dunum		Nitrogen fertilizer kg / dunum			Phosphate fertilizer kg / dunum			Organic fertilizer kg / dunum		
Typical	Actual	optimum	recommended	Actual	optimum	recommended	Actual	optimum	recommended	Actual
200	155	141	110	36	99	75	54	4098	1400	2160

Source / researcher based on the questionnaire, Table (4), Agricultural Extension Bulletin.

Table (5) shows that there is a difference between the quantities of fertilizer recommended by the Ministry of Agriculture and the optimal quantities that have been reached this difference is normal as a result of the difference in the standard adopted in determining quantities. The research relied on a specific cost level to reach the optimal quantities, while the recommended quantities are determined depending on the average age of the trees and soil fertility.

Achieving technical and economic efficiency in the production process:

Calculating the Economic Derivatives of the Estimated Production Function:

Calculating the marginal, average, and total product of one of the productive factors requires the application of the law of diminishing returns. Which provides for fixing the productive factors that contribute to the production process at their arithmetic average, and that one of these factors remains subject to change by increase or decrease to know its effect on the total production of the farm. Moreover, since the marginal product equals the change in the total product, therefore, the marginal product, the average product, and the total product of the variable productive factor can it calculated by adopting the estimated production function and the following relationships: (Al-Afandi, 2012: 232)

$$Y = 5.504 \, X_1^{0.240} X_2^{0.246} X_3^{0.267} X_4^{0.0701} X_5^{0.260} X_6^{0.0943} X_7^{0.344}$$

$$Y = (X_i)^{bi}(X_n)^{bn} = Valum$$

$$MP_{Xi} = \frac{\partial Y}{\partial X_i} = Valum$$

$$AP_{Xi} = \frac{Y}{X_i} = Valum$$

The quantities of productive factors fixed at the arithmetic mean are as follows:

$\overline{X_1}$ = 36 k. g / dunum of Nitrogenous fertilizer

$\overline{X_2}$ = 54 k. g / dunum of Superphosphate fertilizer

$\overline{X_3}$ = 2160 kg / dunum of organic fertilizer

$\overline{X_4}$ = 7 hours / dunum of irrigation hours

$\overline{X_5}$ = 16 hours / dunum, the number of hours of rented labor

$\overline{X_6}$ = 2 liters / dunum of pesticide

$\overline{X_7}$ = 13 trees/dunum, the number of trees renewed during the season

Depending on the economic derivatives of the production function, the law of diminishing returns it applied to the productive factors included in the estimated production function, and the results were as shown in Table (6):

Table (6) Total product, average product, and marginal product of the productive factors included in the production function estimated in the research sample

production factors	TP (K.g)	AP (K.g)	MP (K.g)
X_1	1374.9	38.1	9.1
X_2	1373	25.4	6.2
X_3	1349.9	0.624	0.166
X_4	1394.2	199.5	11.1
X_5	1375.7	85.9	24.3
X_6	1428.5	714.6	66.7
X_7	1347.3	103.6	35.6

Source/researcher based on the estimated production function and the TP, MP and AP laws.

Table (6) shows the total production and the average product, the marginal product of the production factors included in the estimated function. Through these outputs, it is clear the effect of each production factor on the productivity of a dunum in the orchards of the research sample.

Calculating the specialized efficiency of productive resources:

The efficient use of the productive factor it achieved when the last dinar spent has achieved another dinar added to the revenue, and this is possible when the ratio of the value of the marginal product of the productive factor to its marginal cost is equal to one. However, if it is less than one, then this means that the added cost exceeds the added return, and this means that there is waste in using the productive factor and it did not achieve specialized efficiency. In addition, if the ratio is greater than one, this means that more units of the productive factor can added to achieve additional profits. (Debertin 2012: 125) Based on this rule, the efficiency of using the productive resource can it calculated by finding the value of the marginal product for each resource. Then apply the ratio between the value of the marginal product of that resource with its marginal cost in order to reach the specialized efficiency of the productive factors used in the production process and by adopting the following relationships:

$$VMPP_{Xi} = Py.(MP_{Xi}) = \text{ The value of the resource's marginal product}$$

Since:

VMP$_{Xi}$ = the value of the resource's marginal product (Xi)

Py = average product price (average price of grapes) = 0.400 thousand dinars / K.g

Table (7) The value of the marginal product of the production factors included in the estimated function in the orchards of the research sample

production factors	MPxi (K.g)	Production price (thousand dinars / K.g)	VMPxi (thousand dinars)

X_1	9.1	0.400	3.6
X_2	6.2	0.400	2.4
X_3	0.166	0.400	0.266
X_4	11.1	0.400	4.6
X_5	24.3	0.400	9.7
X_6	66.7	0.400	26.6
X_7	35.6	0.400	6.6

Source/researcher based on Table (6) and the questionnaire.

Table (7) shows the marginal product values for each productive factor included in the estimated production function based on the average production price adopted by the farmers of the research sample. As it became clear through the questionnaire that the average price per kilogram of the grape crop amounted to (400 dinars). According to the (Debertin) formula, the specialized efficiency of the productive factors can it measured through the ratio of the value of the marginal product of the resource to the ratio of the value of the marginal cost, as follows:

$$r = \frac{VMP_{Xi}}{MFC_{Xi}}$$

Since:

r = the specialized efficiency of the productive factor.

VMP_{Xi} = marginal product value of the productive factor.

MFC_{Xi} = marginal factor cost.

Table (8) the specialized efficiency of production factors in the function estimated in the research sample.

S	productive factor	VMP_{Xi}	MFC_{Xi}	r
1	Nitrogen fertilizer (X_1)	3.6	0.650	5.5
2	Super Phosphate Fertilizer (X_2)	2.4	0.950	2.5
3	Animal manure (X_3)	0.266	0.025	10.6
4	Irrigation Hours (X_4)	4.6	4	1.1
5	Labor hours (X_5)	9.7	6	1.6
6	Pesticides (X_6)	26.6	6	4.4
7	Number of renewed trees (X_7)	6.6	3	2.2

Source/researcher based on the questionnaire and the estimated production function.

Table (8) shows that the specialized efficiency of all factors of production actually used was greater than one. According to Debertin formula, farmers need to redistribute productive factors to achieve specialist efficiency.

Calculating surplus and deficit using production factors:

The percentage of surplus and deficit of the productive factors in the orchards of the research sample can it calculated according to the following formula: (Sanusi and others, 2015. 1070 - 1075)

$$D = \frac{VMP - MFC}{VMP} * 100$$

Table (9) the percentage of surplus and deficit using factors of production in the research sample.

S	productive factor	(VMP_{Xi})	(MFC_{Xi})	Surplus or Deficit%
1	Nitrogen fertilizer (X_1)	3.600	0.650	%81

2	Super Phosphate Fertilizer (X_2)	2.400	0.950	%60
3	Animal manure (X_3)	0.266	0.025	%90
4	Irrigation Hours (X_4)	4.600	4.000	%13
5	Labor hours (X_5)	9.700	6.000	%38
6	Pesticides (X_6)	26.600	6.000	%77
7	Number of renewed trees (X_7)	6.600	3.000	%54

Source / researcher depending on the marginal product equations.

It is clear from Table (9) that there is a deficit in the use of some production resources from the optimal size, as the analysis shows that there is a deficit in the use of nitrogenous chemical fertilizers by (19%). As for the deficit percentage using phosphate fertilizer and animal manure, it is (40%) and (10%), respectively. The analysis also showed that there was a deficit for pesticides by (23%), while the deficit percentage for the number of renovated trees in dunums was (46%). As for the number of labor hours, the analysis showed that there is a surplus in the exploitation of this factor by (38%), as well as a surplus in the number of irrigation hours per dunum by (13%) over the optimal size.

CONCLUSION

The results of the research in the study of grape-producing orchards in Diyala governorate for the productive season 2021 proved the possibility of realizing the research hypothesis through the following the optimum productivity of (4734.7 K.g / dunum) can be achieved by adopting the optimal combination of production factors, which amounted to (141) K.g / dunum of nitrogen fertilizer, (99) K.g / dunum of phosphate fertilizer, (4098) K.g / dunum of animal manure, (6) irrigation hours / dunum, (11) working hours / dunum, (6) liters / dunum of pesticide. In addition (44) trees / dunums that can be renewed during the productive season, by approving the budget constraint of (553) thousand dinars / dunums. The specialized efficiency of the productive factors is greater than one, and this means that farmers need to redistribute the productive factors. From calculating the surplus and deficit of the productive factors. It became clear that there was a deficit using (both types of chemical fertilizers, animal manure, the control pesticide, and the number of renovated trees per dunum), as well as the existence of a surplus using the number of labor hours and the number of irrigation hours per dunum.

RECOMMENDATIONS

Based on the conclusions reached, the following can it recommended the application of the optimal combination of productive factors reached by the research in the research region, and the need for the state to support the prices of production requirements in the orchards producing the grape crop. Agricultural extension plays its role through extension seminars and training courses for grape producers with the aim of applying the results of scientific research. Supporting the price of output as an incentive for producers and organizing the marketing process by providing marketing services that lead to an increase in the quality of the crop.

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