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Estimating the optimal volumes of the cost function of cowpea crop in Al-Hawija district for the 2023 production season

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Abstract

The research aimed to estimate the optimal sizes for both production and areas planted with cowpea crop in Al-Hawija district for the 2023 production season for a random sample that included 25 farms out of the total farms in the study area. The cost function was estimated in its cubic form to pass the statistical, standard and economic tests using the statistical program (SPSS25). The results of the estimated model showed that the optimal size of production reached (1.914) tons/dunum and the optimal areas of the crop reached (2.359) dunums, which is larger than the actual sizes in the research sample. The same applies to the value of the total revenue and profit, which amounted to (3829856) and (3829712) thousand dinars, respectively. The economic efficiency of the cultivated areas reached about 55% and the production quantity reached about 62%. This percentage is somewhat low due to the tendency of farmers to cultivate more profitable crops. The research recommended the necessity of motivating farmers in how to use resources optimally and the possibility of using Modern techniques in agriculture through the use of improved seeds with high productivity and disease resistance, as well as modern irrigation techniques to reduce waste in the amount of water used, thus enabling the possibility of reaching the optimal volumes and achieving levels of economic efficiency by activating the advisory role in this regard and holding advisory seminars.

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تقدير الحجوم المثلى لدالة تكاليف محصول اللوبيا في قضاء الحويجة للموسم الانتاجي 2023

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الملخص العربي:

هدف البحث الى تقدير الحجوم المثلى لكل من الانتاج والمساحات المزروعة بمحصول اللوبيا في قضاء الحويجة للموسم الانتاجي 2023 لعينة عشوائية شملت 25 مزرعة من اجمالي مزارع منطقة الدراسة وتم تقدير دالة التكاليف بصيغتها التكعيبية لاجتيازها الاختبارات الاحصائية والقياسية والاقتصادية وباستخدام البرنامج الاحصائي (SPSS25) وقد اظهرت نتائج النموذج المقدر بان الحجم الامثل للانتاج قد بلغ (1.914) طن/دونم وبلغت المساحات المثلى للمحصول (2.359) دونم وهي اكبر من الحجوم الفعلية في عينة البحث وكذلك الحال بالنسبة لقيمة الايراد الكلي والربح فقد بلغ (3829856)، (3829712) الف دينار على التوالي، وبلغت الكفاءة الاقتصادية للمساحات المزروعة حوالي 55% ولكمية الانتاج حوالي 62% وتعد هذه النسبة منخفظة الى حدٍ ما نتيجة لاتجاه المزارعين الى زراعة المحاصيل الاكثر ربحية واوصى البحث بضرورة تحفيز المزارعين في كيفية استخدام الموارد استخداماً امثل وامكانية استخدام التقنات الحديثة في الزراعة من خلال استخدام البذور المحسنة ذات الانتاجية العالية والمقاومة للامراض وكذلك تقنات الري الحديثة للحد من الهدر في كمية استخدام المياه وبذلك امكانية الوصول الى الحجوم المثلى وتحقيق مستويات الكفاءة الاقتصادية من خلال تفعيل الدور الارشادي بهذا الخصوص واقامة الندوات الارشادية.

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الكلمات المفتاحية: الحجوم المثلى، دالة التكاليف، محصول اللوبيا.

INTRODUCTION:

The cowpea crop is one of the most important food legume crops and is a summer crop in Iraq. It is grown for its green pods and is rich in carbohydrates, proteins and minerals. It contains 20-30% protein and is considered an ancient crop and Central Africa is likely to be its main home. (Mahjoub and Fawzi, 2020: 213) Since the cowpea crop is one of the favorite crops for the tastes of the Iraqi consumer, it is necessary to study the optimal behavior for its cultivation and determine the optimal sizes of them, as the concept of optimization currently plays an important role in economic analysis. Optimization works as an indicator of the appropriate behavior of the farmer in making sound economic decisions. Studying the determination of the optimal size of production and area will achieve economic efficiency. (Al-Sayed, 2018: 139)

IMPORTANCE OF THE RESEARCH:

The importance of this research comes from the main topic of the research, as farmers of the cowpea crop lack how to reach the optimal sizes in terms of the use of production resources as well as the optimal exploitation of the cultivated areas and thus reach the optimal size of the final production.

RESEARCH PROBLEM:

The research problem focuses on the low cultivated areas of the bean crop, the low production of the dunum yield, and the failure to achieve economic efficiency due to the high production costs and the low return from this crop compared to the competition of other major crops. Therefore, it was necessary to study this topic in order to reach results that would contribute to finding appropriate solutions to address this problem for the bean crop in the study area.

OBJECTIVE OF THE RESEARCH:

The research aims to study:

(1) Estimating the long-term cost function of the cowpea crop in Al-Hawija district.

(2) Estimating the optimal production size that minimizes costs and maximizes profit from the cowpea crop in Al-Hawija district.

(3) Estimating the optimal size of the areas planted with cowpea crop in Al-Hawija district.

(4) Estimating the economic efficiency of the areas and production of cowpea crop in the study area.

DATA SOURCES:

The cross-sectional data were obtained by designing a questionnaire using the random sampling method for field farms. 25 questionnaires were collected, all of which were entered into the research plan.

THEORETICAL FRAMEWORK:

Cost function: It means the relationship between the amount spent by the producer in exchange for obtaining the production resources used in producing a certain product, and the amount of this product, i.e.: The cost function is nothing but an expression of production costs as a function of the amount of the product, and cost functions are divided according to their relationship to time into**:**

Short _ run cost faction

Long _ run cost faction

By short run we mean the period that allows the producer to change the amount of production by changing the variable production resources, but it is not long enough to change the size of the unit, i.e. the period that does not allow the amount of fixed costs to change, while the long run is the period that allows the producer to change the amount of production and the size of the production unit, i.e. the period that allows the amount of fixed and variable costs to change, and therefore all the costs that the producer bears in this period are variable costs. (324: 2012 Nicholson & Snyder,)

Types of cost functions: (Cary, 2017: 121)

Total cost functions take different forms, which are:

Linear function $TC = a + BY$

Quadratic function Y^2 $TC = a + BY \_ B_2$

Cupic function $TC = a + B Y \_ B_2Y^2 + B_3 Y^3$

The Optimum Size of Farm

The optimal production volume is determined to know the optimal behavior of the farm manager or farmer; this is based on the cost functions that can be obtained from the cross-sectional data at the farm level. The optimal production quantity (Q) is the one where the average cost curve is at its lowest level, and therefore the optimal production volume is defined as the volume that achieves the greatest savings in capacity or the lowest possible cost or the highest net return per unit of production, and the appropriate criterion for this is the extent to which economic efficiency increases with increasing volume, i.e. the extent to which the average cost curve decreases with increasing volume, which requires obtaining the variable costs (VC) from the total costs (TC). (VC) was divided by the output volume (Q) to obtain the average variable cost (AVC) and reach the minimum limit of (AVC) by taking its first derivative and applying the necessary condition for the minimum limit at which economic efficiency is achieved, and at this point the optimal production volume is (Al-Jazaerli, 2018: 197)

THE OPTIMUM SIZE OF FARM:

The level of production at which the average total costs are as low as possible is the production that determines the optimal size of the project in the long run. At this size, marginal costs are equal to average total costs, and the share of the production unit in average costs is as low as possible. At this level of production, the efficiency of production factors is as high as possible. The optimal size can also be defined as the size that achieves the greatest savings in capacity or the lowest possible cost or the highest net return per unit of production. The variation in determining the optimal size of the farm is due to differences in the nature of agriculture, environmental conditions, the level of technology adopted in agriculture, the degree of risk and uncertainty, the nature of possession, and the level of inflation. (Al-Saadani, 2013: 36) To obtain the optimal sizes for both production and area, the long-term cost function can be derived by adopting the short-term cost functions in the following general formula: (Davied . 2019: 276)

$$SRTC = b0 + b_1Q - b_2Q^2 + b_3Q^3 - b_4QA + b_5A^2 + Ui \quad \ldots\ldots (1)$$

$Q, A > 0$

Where:

TC = represents total costs (thousand dinars).

Q = represents the total production quantity for each farm (kg).

A = represents the area or size of the farm (dunums).

bi = represents the regression coefficients.

Ui = represents the random variable.

By excluding the fixed term b0, which represents fixed costs, the long-run cost function becomes:

$$LRTC = b_1Q + b_2Q^2 - b_3Q^3 + b_4QA - b_5A^2 - Ui = 0 \ldots\ldots\ldots (2)$$

By writing equation (2) in its implicit form, where TC is an implicit function of Q, A.

V = LRTC – $b_1Q + b_2Q^2 - b_3Q^3 + b_4QA - b_5A^2$ - Ui = 0 …. (3)

By taking the first derivative of the implicit function in terms of area (A) and setting it equal to zero, we get: (manar and zanzal,2021 :152)

$$\frac{\partial v}{\partial A} = b_4Q - 2b_5A = 0 \text{ ----------------------------(4)}$$

$$A = \frac{1}{2}\frac{b_4}{b_5}Q \text{ ---(5)}$$

If A is obtained in terms of Q.

By substituting the value of A in the original function (2), we get the long-run cost function:

$$LRTC = b_1Q - b_2Q^2 + b_3Q^3 - b_4Q\left(\frac{b_4}{2b_5}Q\right) + b_5\left(\frac{b_4Q}{2b_5}\right)^2 + U$$

$$= b_1Q - b_2Q^2 + b_3Q^3 - \frac{b^2{}_4Q^2}{2b_5} + \frac{b_5b^2{}_4Q^2}{4b^2{}_5}$$

$$= b_1Q - b_2Q^2 + b_3Q^3 - \frac{b^2{}_4Q^2}{2b_5} + \frac{b^2{}_4Q^2}{4b_5}$$

$$= b_1Q - b_2Q^2 + b_3Q^3 - \left(\frac{1}{2}\right)\frac{b^2{}_4Q^2}{b_5} + \left(\frac{1}{4}\right)\frac{b^2{}_4Q^2}{b_5}$$

$$= b_1Q - b_2Q^2 + b_3Q^3 - \frac{1}{4}\frac{b^2{}_4}{b_5}Q^2$$

$$= b_1Q + b_2Q^2 - \left(\frac{1}{4}\right)\frac{b^2{}_4}{b_5})Q^2 + b_3Q^3$$

Adding the terms of Q2 gives:

$$= b_1Q - (b_2 - \frac{1}{4}\frac{b^2{}_4}{b_5})Q^2 + b_3Q^3$$

The final formula for the long-run total cost function is as follows:

$$LRTC = \pi Q - \pi_2Q^2 + \pi_3Q^3 \text{ when } \pi_2 = -(b_2 - \frac{1}{4}\frac{b^2 4}{b_5}$$

$LRTC = b_1Q - b_2Q^2 + b_3Q^3$ long run total cost function

RESULTS AND DISCUSSION:

Estimating the long-term total cost function of the cowpea crop in the study sample for the production season (2023):

Using the least squares (OLS) method, the short-term total cost function of the cowpea crop was estimated for the study sample and it was found to be consistent with economic logic and passed the statistical and standard tests as follows:

$$SRTC = 365.865 + 143.533Q - 0.000002135Q^2 + 0.00000021104Q^3 - 0.00111AQ + 0.00045A^2$$

Table (1) Total cost function of cowpea crop in the short term

Independent variables	Estimated parameters	Statistical parameters
Q	143.533 *(3.021)	R^2 = 0.76
Q^2	- 0.000002135 *(- 4.309)	R^{-2} =0.71
Q^3	0.00000021104 *(2.971)	F = 15.475
AQ	- 0.00111 *(-916.1)	D.W = 1.890
A^2	0.00045 *(3.983)	* = t(0.05)

Source: Calculated using SPSS 25 based on questionnaire data.

When writing the function in its implicit form, we get:

$$V = C - 143.533Q + 0.000002135Q^2 - 0.00000021104Q^3 + 0.00111AQ - 0.00045A^2$$

By taking its first partial derivative with respect to the cultivated area (A) and setting it equal to zero, we get:

$$\frac{\partial V}{\partial A} = 0.00111\,Q - 0.0009\,A = 0$$

$A = 1.233\,Q$

By substituting the value of A in the original function and adding the terms of Q2, we obtain the cost function for the bean crop in the long run:

$LRTC = 143.533\,Q - 0.0008081\,Q^2 + 0.00000021104\,Q^3$

Long-run cost function of cowpea crop

Statistical analysis:

After ensuring the validity of the estimates of the parameters of the estimated models for the bean crop from the economic point of view, which were consistent with the economic theory in terms of indication and supporting the fact that the shape of the total cost curve is convex and thus the shape of the average total cost curve takes the shape of the letter (U), the role of statistical criteria comes, as the estimated parameters were statistically significant according to the (t) test and at a significance level of (5%). To demonstrate the quality of the fit of the estimated regression line, the significance of the estimated functions as a whole was proven at a statistical level of (5%) and based on the F test, which amounted to (15.475). The coefficient of determination showed that (76%) of the changes in total costs were caused by the change in the total yield of the bean crop and that (24%) of the remaining changes did not appear in the model and their effect was absorbed by the random variable.

STANDARD ANALYSIS:

In order for the model to be acceptable and reliable in explaining the phenomenon studied, it is necessary to conduct the necessary standard tests related to the standard problems, which are:

THE PROBLEM OF AUTOCORRELATION OF THE RANDOM VARIABLE:

The problem of autocorrelation between random residuals occurs when the random residuals are related to each other, meaning the existence of a correlation between the successive random error values, which violates one of the assumptions of random error, which explains that random errors related to the sample items are not related, and when this assumption is violated, the problem of autocorrelation will occur and its effect will be on the results of the regression analysis, so the tests give less accurate results than those that appear in the absence of it, and the cross-sectional data are less exposed to this problem. (Al-Adhari, 2010: 99). This problem is revealed by the Durbin-Watson test, as it is suitable for testing the presence of first-degree autocorrelation (Attia, 2004: 448), which showed the absence of the problem of autocorrelation in this estimated model because the value of (D.W) was in the region of accepting the null hypothesis, i.e. D.W equals (1.890), and from the D.W table for a 5% significance level and degrees of freedom (5), we find that D.W lies between:

1.83 < 1.890 < 2.17 That is du < D.W < 4 – du

From this we conclude that there is no positive or negative autocorrelation for the first-degree random variable.

MULTICOLLINEARITY PROBLEM:

This problem occurs if there is a linear relationship between two or more independent variables in the regression model, which hinders the isolation of their individual effects on the dependent variable (Al-Adhari, 2010: 89). However, the model fulfilled the assumption of the absence of a multilinear relationship between the independent variables (Multicollinearity), because the model is non-linear in that the variables Q2 (the square of the result), Q3 (the cube of the result) are significantly related to the variable Q, but the relationship is non-linear (Gujarati, 2015:).

HETEROSKEDASTICITY PROBLEM:

The third assumption related to the random variable ui is that the probability distribution of the variable ui remains constant for all values of the independent variable, i.e. the variance for each ui remains constant for all values of the independent variable, and this is expressed in the following formula:

Var (u) = E [(ui – E(ui)²] = E (ui)² = δ² u constant

One of the consequences of this problem is that the estimated parameters lose their efficiency, and therefore the tests become inaccurate or inappropriate, and the predictions based on this basis are less reliable than other predictions on methods that are free from the problem of heterogeneity instability (Attia, 2000: 439). Given that the study relies on cross-sectional data, in which this phenomenon may be more prevalent than time series data, it must be detected (Attia, 2005: 449).

There are tests to detect the presence of the problem of heterogeneity instability, namely the Spearman and Goldfield tests, the Kleiser test, and the Park test. The Park test was adopted, which includes estimating the square error regression equation as a dependent variable and the result as an independent variable according to the following formula:

$\text{Log}\,(ei)^2 = a + b\text{Log}\,(Q)$

The relationship estimated by the logarithmic formula for the bean yield was as follows:

$$log\ e_i^2 = 4.015 + 0.059\ logQ$$

T = (0.297) (0.013)

R^2 = 0.023 F= 0.035 D.W= 2.983

Since the estimated function is not significant below the 5% significance level according to the F test, and the calculated t value for the slope of the error regression coefficients is less than the tabular t value at the 5% significance level, this indicates that there is no problem of instability of variance homogeneity.

ECONOMIC ANALYSIS:

It includes the practical importance of the long-term cost function represented by calculating and estimating the optimal volumes of production and cultivated areas for the civilian bean crop for costs, marginal costs, cost elasticity and the function coefficient.

Determining the optimal production size for the costs of the cowpea crop In order to calculate the optimal size that minimizes costs (economies of scale) in the production of the cowpea crop, it is necessary first to find the equation of the average total cost in the long run LRATC, since all production costs are variable costs in the long run. The average cost equation was derived from the equation of the total cost by dividing the latter by the volume of output Q. The equation of the average total cost in the long run for the cowpea crop was as follows:

$$LRATC = 143.533 - 0.0008081Q + 0.00000021104\ Q^2$$

In order to determine the optimal production volume that minimizes costs, the first necessary condition for minimizing the cost function must be applied, which is to take the first derivative of the average total cost function with respect to output and set it equal to zero, then solve the equation with respect to Q, so we get:

$$\frac{\partial LRATC}{\partial Q} = -\,0.008081 + 0.000000422\ Q = 0$$

$$Q = \frac{0.008081}{0.000000422} = 1914.928\ kg/donum$$

$$Q = 1.914\ Ton$$

The optimal size for producing cowpea crop that reduces costs and maximizes profits

Determining the optimal areas for the bean crop:

In order to obtain the optimal areas planted with the bean crop using the flood irrigation method in Al-Hawija District, we substitute the value of Q in the value of A and we get:

$A = 1.233\, Q$

$A = 1.666\,(1.914) = 2.359\ donum$

The optimal area that cowpea farmers should exploit to reach the optimal production size that reduces costs and maximizes profits

Determining the profit at the optimal size of the bean crop

To obtain the profit at the optimal size of bean crop production in Al-Hawija district, by substituting the optimal production quantity of the crop in the average cost function of the bean crop in the long run, we obtain the average costs in the long run, and by multiplying the optimal quantity of production by the price of the crop, we obtain the total revenue at the optimal size, and then after that, we subtract the average costs from the total revenue at the optimal size, we obtain the profit at the optimal size of the bean crop in Al-Hawija district, as shown in Table:(2)

Table (2): Average long-term costs, total revenue and profit for the cowpea crop at the optimum size

Average Total Cost (ATC) (thousand dinars)	Total Revenue (TR) (thousand dinars)	Profit π(thousand dinars)
143.531	3829856	3829712.469

Source: Calculated by the researcher based on the long-run average cost function.

It is clear from Table (2) that the average total costs in the long term amounted to (531,143) thousand dinars, and the total revenue at the optimal size amounted to about (3,829,856) thousand dinars, while the profit at the optimal size amounted to (3,829,712,469) thousand dinars, and it became clear that it exceeds the amount of profit at the actual size of the production of the bean crop in Al-Hawija district by an amount of (950,142) thousand dinars/dunum.

Table (3): Total costs, total revenue and profit at the actual and optimum size of the bean crop

Crop	Actual size					
	A. Cost (ATC) (1000)	Total R.(1000D)	Profit π (thousand dinars)	Average Total Cost (ATC) (thousand dinars)	Total Revenue (TR) (Thousand Dinars)	Profit π (thousand dinars)
Beans	250750	2400000	2149250	143.531	3829856	3829712.469

Source: Calculated by the researcher based on the questionnaire and the long-term average cost function.

Table (3) shows that the average total cost of the cowpea crop amounted to (250,750) thousand dinars, and the total revenue for the sample amounted to about (2,400,000) thousand dinars, while the profit for the sample amounted to (2,149,250) thousand dinars, while the average cost value at the optimal size amounted to about (143,531) thousand dinars, and the total revenue at the optimal size amounted to about (3,829,856) thousand dinars, while the profit at the optimal size amounted to (3,829,712.469) thousand dinars. It became clear that the average cost value at the optimal size is less than its value at the sample size by (-250,606.469) thousand dinars, while the value of both the total revenue and the profit at the optimal size of the study sample exceeds its value at the actual size by (1,429,856) thousand dinars for the total revenue and (1,680,462.469) thousand dinars for the profit. This means that cowpea farmers in the district of Al-Huwaija: Reaching the optimal production volume to achieve the best profit at the lowest possible cost. Table (4) shows that the optimum area size of

(2.359) dunums for the bean crop exceeds the actual area sizes of the areas planted with the study sample crop in Al-Hawija district, as bean farmers should expand their areas by (1.059) dunums. Also, the optimum production size came at a rate that exceeded the actual rate of the study sample crop, as the optimum production size reached (1.914) tons. Since the optimum production size exceeds the actual size, bean farmers in the study sample should increase their production by (0.714) tons.

Table (4) Actual and ideal production volumes and areas planted with bean crops

Crop	Actual size (1) of the area (acre)	Optimum size (2) for area (acre)	Efficiency % 2/1	Actual production volume (1) (tons)	Optimum size(2) for production (tons)	Efficiency % 2/1
Beans	1.3	2.359	%55	1.200	1.914	%62

Source: Calculated by the researcher based on the questionnaire data.

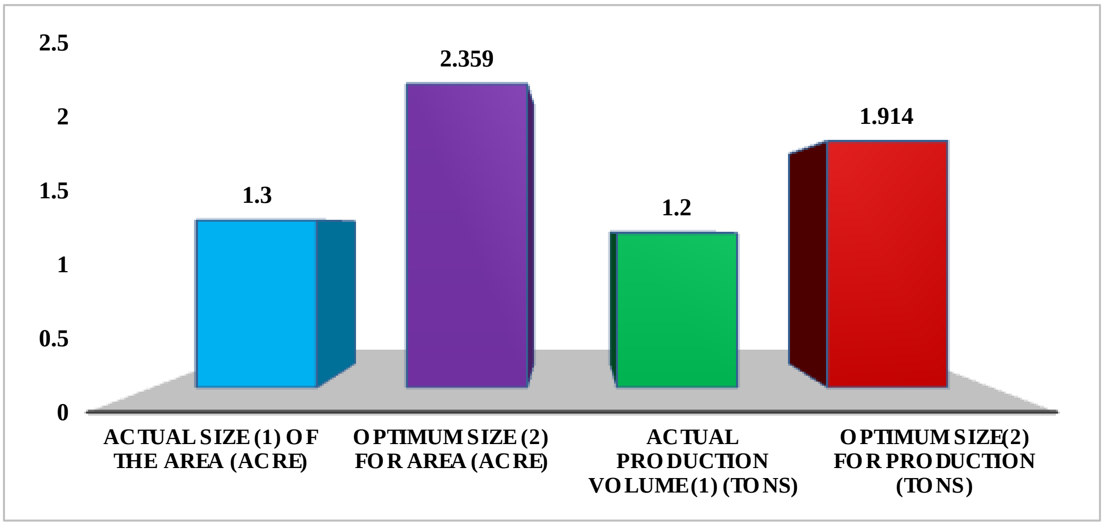

Figure (1) Actual and ideal production volumes and areas planted with bean crops in the study sample Source: According to Excel program based on Table(4)

CONCLUSIONS AND RECOMMENDATIONS:

CONCLUSIONS:

Based on the results reached in this study, the most important conclusions reached can be summarized, including the following:

1-It was shown from the results of the questionnaire form and the results of the quantitative analysis of the functions of the cost of the bean crop that the average costs in the long run at the optimal size exceeded the average costs of the actual size in the study sample by a difference of (-250606.469) thousand dinars.

2- It became clear that the total revenue at the optimal size is greater than at the actual size of the study sample by a difference of (1429856) thousand dinars.

3- The total profits obtained by bean farmers in the study sample at the optimal size exceed the total profits at the actual size by a method and by an amount of (1680462.469) thousand dinars.

4- The economic efficiency of the areas planted with cowpea crop at the actual and optimal size in the study sample reached 55%, while the economic efficiency of production at the actual and optimal size reached 62%. We conclude from this that farmers reaching the optimal sizes gives more profits than the actual sizes and at the lowest possible costs, and that the percentage of achieving economic efficiency is somewhat low in planting cowpea crop in Al-Hawija district.

RECOMMENDATIONS:

In light of the results reached, the study recommends the following:

(1) The necessity of motivating farmers in how to use resources optimally and the possibility of using modern technologies in agriculture through the use of improved seeds with high productivity and resistance to diseases as well as modern irrigation techniques to reduce waste in the amount of water used and thus the possibility of reaching the optimal volumes and achieving levels of economic efficiency by activating the advisory role in this regard and holding advisory seminars.

(2) Activating the role of pricing policy in Iraq by controlling the prices of inputs as well as the final product until it reaches the consumer, which encourages farmers to increase their production of this crop.

(3) Activating the role of government support in providing production requirements of improved varieties at appropriate prices to support and encourage farmers to grow such crops.

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