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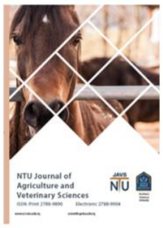

Distributional Efficiency and Optimality of Production Resources for Yellow Corn in Nineveh Province: A Case Study of Ba'aj District for the 2023 Fall Season

1st Waleed Ismail ibrahim hamo[1] , 2nd Zwaid Fathi Abd[2]
1,2. University of Mosul, College of Agriculture and Forestry

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Corresponding author:
Waleed Ismail ibrahim hamo
College of Agriculture and Forestry
University of Mosul, Mosul, Iraq
Email:
Waleed.23agp13@student.uomosul.edu.iq

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A B S T R A C T

This research aimed to estimate the distribution efficiency and optimality of productive resources for yellow corn (autumn crop) in Nineveh Governorate, specifically in Al-Ba'aj district, for the 2023 production season. A random sample of 75 farmers was selected, and data related to production and productive resources were collected, including (cultivated area (x1), seed quantity (x2), fertilizers (x3), human labor (x4), machinery (x5), and irrigation hours (x6)). Using quantitative analysis methods and some mathematical indicators, the production function and distribution efficiency were estimated. The double logarithmic function was chosen as the best model to represent the relationship between the studied variables.The analysis results indicated that the distribution efficiency for some productive resources (x4, x3, x2) was less than one, meaning that the added cost exceeds the added return, indicating waste in resource use and the need to reduce the use of these productive resources. In contrast, the distribution efficiency for resources (x6, x5) was greater than one, meaning that the added return exceeds the added cost, which necessitates increased use of these economic resources.The quantities of productive resources required to achieve the optimal production size per dunam were (6.176, 85.105, 3.308, 2.118, 12.84) for resources (x6, x5, x4, x3, x2) respectively, which exceed the actual quantities used. The study recommended supporting farmers to achieve optimal production utilization through the optimal use of productive resources in the production of yellow corn in the studied farms.

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1. Introduction

Cereal crops hold significant economic importance due to their various food and industrial uses. They are the primary source of food in many regions worldwide and play a crucial role in various food industries, as well as serving as livestock feed. Additionally, they contribute to national income and absorb a substantial portion of agricultural labor.
Yellow corn is one of the strategic cereal crops in most countries, ranking third globally after wheat and barley. In 2021, the global cultivated area reached 205.87 million hectares, with an output of 1,210.24 million tons and a productivity of 5,878.64 kg per hectare. In Iraq, yellow corn ranks fourth in economic importance after wheat, barley, and rice, with a cultivated area of 374.4 thousand hectares, a production of 325.9 thousand tons, and a productivity of 1,148.8 kg per dunam. This crop serves dual purposes, acting as a food source in many countries when blended with wheat flour. It is utilized in the production of pasta and serves as a nutritional source for animal husbandry, with starch and oil extracted for human consumption. FAO, 2023.

Importance of the Research

The importance of this research lies in the economic significance of yellow corn as a raw material in many food industries, particularly in starch and oil production. Approximately 40% of corn grains are used in concentrated feed for poultry and livestock, while the leaves are utilized as animal fodder. Furthermore, corn is a vital source of income for many families and supports a considerable number of agricultural workers.This research also highlights the efficiency of utilizing productive resources in corn production. Economic efficiency is a key indicator in shaping production and pricing policies by demonstrating the contributions of economic resources to production and determining the optimal use of these resources. By assessing the potential to achieve economic efficiency, this study serves as a tool for measuring the performance of production units and reallocating resources to ensure their efficient use, thereby achieving overall economic efficiency.

Problem Statement

One of the key methods for assessing how closely farmers approach or deviate from the efficient use of productive resources is through the distribution efficiency of the resources employed. Despite the economic importance of yellow corn and the focus on its cultivation, production and productivity remain below optimal levels. This situation hinders achieving distribution efficiency and the optimal production size close to global production levels, necessitating the use of advisory resources and staff to ensure the optimal use of economic resources, particularly the limited irrigation water.This research is based on the hypothesis that there is variability in the efficiency of resource use among yellow corn farmers in Al-Ba'aj district during the 2023 production season (autumn crop), which reflects on the distribution efficiency of the crop. Consequently, farmers have been unable to achieve optimal resource use and production efficiency due to either excess or deficit in the quantity of resources used in the sampled farms. The study aims to determine the optimal behavior of farmers in the sample by estimating the efficiency of input utilization, thereby identifying the optimal use of productive resources for yellow corn during the 2023 production season (autumn crop). It also seeks to estimate the distribution efficiency of inputs in the sampled farms throughout the same production season.

2. Materials and Methods

To achieve the research objectives, we employed two analytical approaches. The first was descriptive analysis, relying on previous studies and economic theory concepts related to the relationships between productive resources and final output.The second approach was quantitative analysis to evaluate the practical results of the research. This involved using multiple regression analysis and the ordinary least squares method to estimate the production function of the crop through various well-known forms, selecting the best representation of the relationship between productive resources and final output based on certain statistical, econometric, and economic indicators. Additionally, we estimated the optimal quantities of productive resources used in the production process via the production function and cost constraints, as well as calculated the distribution efficiency of the resources using the statistical software EViews.
The research relied on cross-sectional data obtained from official sources through a questionnaire and personal interviews with a random sample of yellow corn farmers for the 2023 production season . The sample comprised approximately 75 farmers, representing about 30% of the research population in Al-Ba'aj district, which includes a total of 251 farmers and encompasses several villages in the area.
Distributive efficiency is one of the types of economic efficiency, in addition to technical efficiency, and expresses the farm's ability to obtain the optimal allocation of economic resources. Taking into account its prices among the available economic options (6) (Shabib, 2005: 106), and distributive efficiency is an important indicator for the producer to know his efficiency in using the resources used in the production process. Economic theory assumes that distributive efficiency is complete based on marginal conditions for maximizing profits, which requires that the value of the marginal product of each resource be Value

Marginal. Product (VMP) equals the marginal cost of each resource Marginal Foctor Cost (MFC).(7) (Al -Najafi, 1986, 390) The farmer is more efficient in using resources when the value of the value of the border product is approaching each resource to the marginal cost per resource than the correct one and this means that the use of production resources is done in the optimal way, and when the ratio is greater than the correct one in the sense that the return is The additive exceeds the added cost, and this requires the use of more economic resources, which leads to an increase in profits until the value of the border product is equal to the resource cost of the resource. (8) (HASAN, 2008.19-32), and when the ratio is equal to zero and the supplier price and the output is fixed and due to the live product is zero and this is urged at the point where production is in the event of glorification and is at the end of the second stage of the production stages, and when the percentage is negative Production is in the third stage of the production stages, and the border product is negative (9) (Debertin, 2012,83) and the border product curve is below the horizontal axis. Distribution efficiency is calculated according to the seller style in two ways, the first: (10) (NMADU and Other, 2014,134-146).

AE = VMP / MFC

VMP = MP $*P_y$

MFC = P_X

The second method uses the following formula: (Ahmed and other ,2015, 26-31)

AE =VMP / MFC

VMP = MP $*P_y$

MFC = P_X

MP = B_i * AP

AP = G(Y) / G(X)

MP = B_i *G(Y) / G(X)

MFC = P_X

AE = Distribution Efficiency, VMP = Value of Marginal Product, MFC = Marginal Factor Cost = Price of the Resource.

PY, PX = Price of the production factor and price of the output, respectively

Bi = Coefficient of the production factor

AP = Average Product of the resource

G(X), G(Y) = Geometric mean of the resource and the output, respectively.

Previous Studies on Economic Efficiency Many researchers have examined economic efficiency, including distribution efficiency and the optimal use of productive resources. Here are a few notable studies that highlight the variables studied, methodologies used, and the findings reached.11. Mohammad (2008): This study, titled "Estimating Economic Efficiency and Constraints in Yellow Corn Production in Northern Bangladesh," aimed to measure both technical and economic efficiency in yellow corn production. It also evaluated the profits of corn farmers and calculated growth rates for production, area, and productivity. The study used a random sample of 100 farmers, all of whom employed hybrid seeds for planting. The average productivity was 6.35 tons per hectare in the Dinajpur area and 6.18 tons per hectare in the Panchagarh area. The production functions for both regions showed significant parameters for seeds, urea fertilizer, irrigation frequency, and human labor hours at the 5% and 1% levels, except for the marginal product (MP), which was not significant. The coefficient of determination was 0.84 for Dinajpur and 0.79 for Panchagarh. Key constraints mentioned by farmers included high seed prices, low output prices, and the unavailability of fertilizers at the necessary planting time. The researcher recommended establishing a regulated market system to expand yellow corn production in the study areas. 12. Zalkuwi et al. (2010): In their research titled "Economic Efficiency Analysis of Yellow Corn Production in the Ganye Local Government Area of Adamawa State, Nigeria," the study sought to determine the cost efficiency of farmers in the area and assess the profits and economies of scale for yellow corn farmers. Using a random sample of 200 farmers, the results showed that the total revenue, net income, and return on investment were 57,052.97 N/ha, 30,239.78 N/ha, and 1.13 N/ha, respectively. The results also indicated that production elasticity was greater than one, signifying increasing returns to scale. The estimation of the random cost function showed that the variability parameters were significant at the 5% level, and the estimated parameters for fertilizers, pesticides, seeds, and hired labor were positive and significant at the 1% level. The average cost efficiency was found to be 1.04. These studies provide insights into the factors affecting economic efficiency in yellow corn production and highlight the importance of resource allocation and market conditions.Previous Studies on Economic Efficiency of Yellow Corn Production 13.Ngabitsinze (2014): In the study titled "Economic Efficiency of Yellow Corn Production in Rwanda, Huye District," the researcher employed a stochastic frontier cost function. A sample of 65 yellow corn farmers was collected during the study period (2012-2013). The research aimed to determine the cost efficiency of farmers, profitability, and economies of scale in corn cultivation. The findings indicated that yellow corn production was unprofitable and that there were economies of scale. The study recommended developing better agricultural plans for the future to increase production and profits, as well as intensifying efforts to educate farmers through training courses to enhance crop efficiency. 14. Al-Samarrai and Mohammed (2017): This research focused on the optimal behavior of yellow corn producers in Salah al-Din Governorate for the 2017 production season. The study aimed to estimate the production function of the crop and identify the optimal quantities for maximizing profits. Using the ordinary least squares method and testing various production function forms, the double logarithmic function was selected as the best model based on statistical and econometric criteria. Key findings revealed that the maximum profit production volume was 6,449 kg per dunam, with an optimal area of 79.85 dunams, and capital maximized for profit was 114,730 dinars, with labor of 7.4 man-days. The study concluded that investing in corn cultivation yields substantial returns. 15. jiad (2021): This study examined the factors influencing yellow corn production in Salah al-Din Governorate, specifically in the Al-Dur district, using stochastic frontier analysis for the 2021 agricultural season. The research aimed to identify the factors affecting corn production, and data were collected from a sample of 112 farmers using a questionnaire. The analysis estimated technical efficiency, revealing that the average technical efficiency for the sample was 66%. All resources used in production (area, pesticides, fertilizers) had a positive impact on output, while variables such as seeds, human labor, and water quantity negatively affected production. The study indicated that land area had the most significant effect on production, followed by fertilizer quantity. Recommendations included enhancing the experience of those involved in corn cultivation and reallocating productive inputs to ensure optimal use and reduce waste in quantities utilized. These studies collectively provide valuable insights into the factors affecting economic efficiency in yellow corn production, emphasizing the importance of resource management and agricultural practices.

3. Results and Discussion

3-1 Measuring the Distribution Efficiency of Productive Resources Used in Yellow Corn Production for the 2023 Autumn Season Distribution.

efficiency reflects the producers' effectiveness in utilizing their productive resources. To calculate the distribution efficiency of the resources used in yellow corn production in the sampled farms, it is essential to determine the parameters of the resources utilized.To obtain these parameters, the production function was estimated using multiple regression analysis based on the ordinary least squares (OLS) method across various formulations. The double logarithmic function was selected as the best representation of the relationship between the quantity of corn produced and the productive resources employed, relying on statistical, econometric, and economic indicators. This is illustrated in the following equation:

$LnY = 97.27 + 0.102LnX_1 + 0.154LnX_2 + 0.192LnX_3 + 0.110LnX_4 + 0.229LnX_5 + 0.213LnX_6$ ……. Production Function Equation

Y = Production of yellow corn (kg)

X1 = Area planted (dunam)

X2 = Quantity of seeds (kg)

X3 = Quantity of fertilizers (kg)

X4 = Human labor (man/day)

X5 = Mechanical labor (hours)

X6 = Irrigation water (hours)

The geometric mean of production and the resources used in producing yellow corn in the farms sampled for this study was calculated based on the results of the questionnaire analysis, as shown in Table (1):

Table 1. Geometric Mean of Production and Productive Resources for Yellow Corn in Sampled Farms.

Geometric Mean	Element
20975.015	Production of Corn (kg)
123.831	Seed Quantity (kg)
1648.46	Fertilizer Quantity (kg)
76.719	Human Labor (man/day)
30.298	Mechanical Labor (hours)
177.656	Irrigation Water (hours)

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

Source: Calculated by the Researcher Based on Questionnaire Data

1.The distribution efficiency of the seed resource used per dunam is calculated as follows:

A- Calculating Average Production (AP)

The average production (AP) of the seed resource is calculated by dividing the geometric mean of yellow corn production by the geometric mean of the quantity of seeds, using the following formula:

$AP = \frac{G(Y)}{G(X)}$

$AP = \frac{20975.015}{123.831}$

AP = 169.383

B- Calculating Marginal Product (MP) The marginal product of the seed resource is calculated by multiplying the average production by the elasticity of production for the seed resource (the regression coefficient):

MP = Bi * AP

MP = **0.**154 * 169.383

MP = 26.085

C- Calculating Value of Marginal Product (VMP) The value of the marginal product of the seed resource is calculated by multiplying the marginal product by the price of the yellow corn output (the actual price per kilogram at which producers sold their production in the study area). The average price per kilogram of yellow corn is 0.350 thousand dinars/kg, which means the value of the marginal product of human labor is 9.13 thousand dinars, calculated as follows:

VMP = MP*Py

VMP = 26.085 * 0.350

VMP = 9.13

D- Calculating Marginal Factor Cost (MFC) The marginal factor cost represents the price of the seed resource, which is about 0.350 thousand dinars/kg, as shown in the following formula:

MFC = P_x = 0.350

E- Calculating Distribution Efficiency After completing the above steps, we apply the following formula to calculate the distribution efficiency:

AE or r = $\frac{VMP_{xi}}{MFC_{xi}}$

AE or r = $\frac{9.13}{10.5}$ = 0.869

Conclusion The distribution efficiency of the seed resource is 0.869, indicating a reasonable efficiency in the use of seed resources for yellow corn production.

2. Distribution Efficiency of Chemical Fertilizer Resource

A. Calculating Average Production (AP) The average production (AP) for the chemical fertilizer resource is calculated as follows:

AP = $\frac{G(Y)}{G(X)}$

AP = $\frac{20975.015}{1648.46}$

AP = 12.724

B. Calculating Marginal Product (MP)The marginal product of the chemical fertilizer resource is calculated using the formula:

MP = Bi * AP

MP = **0.**192 * 12.724

MP = 2.443

C. Calculating Value of Marginal Product (VMP) The value of the marginal product of the chemical fertilizer resource is calculated as follows:

VMP = MP*Py

VMP = 2.443 * 0.350

VMP = 0.855

D. Calculating Marginal Factor Cost (MFC) The marginal factor cost represents the price of the chemical fertilizer, which is about 0.950 thousand dinars/kg:

MFC = P_x = 0.950

E. Calculating Distribution Efficiency The distribution efficiency of the fertilizer resource is calculated using the following formula:

AE or r = $\frac{VMP_{xi}}{MFC_{xi}}$

AE or r = $\frac{0.855}{0.950}$ = 0.9

Conclusion. The distribution efficiency of the chemical fertilizer resource is 0.9, indicating a good level of efficiency in the use of fertilizer resources for yellow corn production.

3. Distribution Efficiency of Human Labor Resource

A. Calculating Average Production (AP) The average production (AP) for the human labor resource is calculated as follows:

AP = $\frac{G(Y)}{G(X)}$

AP = $\frac{20975.015}{76.719}$

AP = 273.4

B. Calculating Marginal Product (MP) The marginal product of the human labor resource is calculated using the formula:

MP = Bi * AP

MP = **0.**110 * 273.4

MP = 30.074

C. Calculating Value of Marginal Product (VMP) The value of the marginal product of the human labor resource is calculated as follows:

VMP = MP*Py

VMP = 30.074 * 0.350

VMP = 10.526

D. Calculating Marginal Factor Cost (MFC) The marginal factor cost represents the price of human labor, which is approximately 14,000 dinars:

MFC = P_x = 14

E. Calculating Distribution Efficiency. The distribution efficiency of the human labor resource is calculated using the following formula:

AE or r = $\frac{VMP_{xi}}{MFC_{xi}}$

AE or r = $\frac{10.526}{14}$ = 0.751

The distribution efficiency of human labor is 0.751, indicating that there is room for improvement in the use of human labor resources.

4. Distribution Efficiency of Machinery Resource

A. Calculating Average Production (AP). The average production (AP) for the machinery resource is calculated as follows:

AP = $\frac{G(Y)}{G(X)}$

AP = $\frac{20975.015}{30.298}$

AP = 692.288

B. Calculating Marginal Product (MP). The marginal product of the machinery resource is calculated using the formula:

MP = Bi * AP

MP = 0.229 * 692.288

MP = 158.534

C. Calculating Value of Marginal Product (VMP).The value of the marginal product of the machinery resource is calculated as follows:

VMP = MP*Py

VMP = 158.534 * 0.350

VMP = 55.487

D. Calculating Marginal Factor Cost (MFC) .The marginal factor cost represents the price of machinery, which is approximately 45.5 thousand dinars:

MFC = P_x = 45.5

E. Calculating Distribution Efficiency.The distribution efficiency of the machinery resource is calculated using the following formula:

AE or r = $\frac{VMP_{xi}}{MFC_{xi}}$

AE or r = $\frac{55.487}{45.5}$ = 1.219

The distribution efficiency of machinery is 1.219, suggesting an optimal utilization of machinery resources in the production process.

6. Distribution Efficiency of Irrigation Water Resource

A. Calculating Average Production (AP) .The average production (AP) for the irrigation water resource is calculated as follows:

AP = $\frac{G(Y)}{G(X)}$

AP = $\frac{20975.015}{177.656}$

AP = 118.065

B. Calculating Marginal Product (MP). The marginal product of the irrigation water resource is calculated using the formula:

MP = Bi * AP
MP = **0.**213 * 118.065
MP = 25.148

C. Calculating Value of Marginal Product (VMP) . The value of the marginal product of the irrigation water resource is calculated as follows:

VMP = MP*Py
VMP = 25.148* 0.350
VMP = 8.802

D. Calculating Marginal Factor Cost (MFC).The marginal factor cost, representing the price of irrigation water, is approximately 7.3 thousand dinars:

MFC = P_x = 7.3

E. Calculating Distribution Efficiency.The distribution efficiency of the irrigation water resource is calculated using the following formula:

AE or r = $\frac{VMP_{xi}}{MFC_{xi}}$

AE or r = $\frac{8.802}{7.3}$ = 1.205

Table 2. Distribution Efficiency of Resources Used in Corn Production per Dunam in Sample Farms for the 2023 Autumn Season

Allocative Efficiency (AE)	Marginal Cost of Resource (MFCxi) (in thousand dinars)	Marginal Product Value (VMPxi) (in thousand dinars)	Resource
0.869	10.5	9.13	Seed quantity
0.9	0.950	0.855	Fertilizer quantity
0.751	14	10.526	Hired human labor
1.219	45.5	55.487	Hired mechanic
1.205	7.3	8.802	Irrigation Water

This table summarizes the distribution efficiency of the various production resources used in corn farming in the sample farms during the 2023 autumn season.

3-2.Estimating Optimal Quantities of Production Resources Used in Corn Production in Sample Farms:

To estimate the optimal quantities of production resources, we convert the estimated production function from a logarithmic form to an exponential form:

$LnY = 43.209 + 0.102LnX_1 + 0.154LnX_2 + 0.192LnX_3 + 0.110LnX_4 + 0.229LnX_5 + 0.213LnX_6$—(5)

$Y = 319.047\ X_1^{0.102} X_2^{0.154} X_3^{0.192} X_4^{0.110} X_5^{0.229} X_6^{0.213}$ Production function --------- (1)

Cost Equation

Using the cost equation, which consists of the quantities of production resources multiplied by their prices:

$C = X1PX1 + X2PX2 + X3PX3 + X4PX4 + X5PX5 + X6PX$

By imposing a cost constraint and setting it to zero, we derive the constrained cost equation:

$C° - X1PX1 - X2PX2 - X3PX3 - X4PX4 - X5PX5 + X6PX6 = 0$

The constrained costs are the prices of the production resources included in the estimated function model:

° C = Average total costs: 421,000 dinars/dunum.
Px1 = Average price of land rent: 42.5 thousand dinars/dunum
Px2 = Average price of seeds: 10.5 thousand dinars/kg
Px3 = Average price of chemical fertilizer: 0.950 thousand dinars/kg
Px4 = Average price of hired labor: 14 thousand dinars/person/day
Px5 = Average price of hired machinery: 45.5 thousand dinars/hour
Px6 = Average cost of irrigation per hour: 7.3 thousand dinars/hour.

By substituting the prices of the production resources into the cost equation, we obtain the following cost constraint equation:

$421 – 42.5X_1 + 10.5X_2 + 0.950X_3 + 14X_4 + 45.5 X_5 + 7.3X_6$ Cost function ------ (2)

By imposing a cost constraint and setting it to zero, we derive the constrained cost equation:

421 - 42.5 X1 - 10.5 X2 - 0.950 X3 - 14 X4 - 45.5 X5 - 7.3 X6 = 0

sing the Lagrange Multiplier to Determine Optimal Quantities of Production ResourcesTo obtain the optimal quantities of the production resources, we need to form the objective function by linking Equation (1) with Equation (2). The objective function can be expressed as:

Z =$319.047X_1^{0.102}\,X_2^{0.154}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213}$ **+ λ (421** -42.5X_1 + 10.5X_2 +0.950X_3 + 14X_4 +45.5X_5 + 7.5X_6 **)....(3)**

Taking the first partial derivative of each input resource, we obtain:

$$\frac{\partial Z}{\partial X_1} = 32.542\,X_1^{-0.898}\,X_2^{0.154}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213} - \lambda 42.5 = 0$$

$$32.542\,X_1^{-0.898}\,X_2^{0.154}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213} = \lambda\,42.5 \text{ --------- } (4)$$

$$\frac{\partial Z}{\partial X_2} = 49.133\,X_2^{-0.846}\,X_1^{0.102}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213} - \lambda 10.5 = 0$$

$$49.133\,X_2^{-0.846}\,X_1^{0.102}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213} = \lambda 10.5 \text{ --------- } (5)$$

$$\frac{\partial Z}{\partial X_3} = 61.257X_3^{-0.808}\,X_1^{0.102}\,X_2^{0.154}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213} - \lambda 0.950 = 0$$

$$61.257X_3^{-0.808}\,X_1^{0.102}\,X_2^{0.154}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213} = \lambda 0.950 \text{ --------- } (6)$$

$$\frac{\partial Z}{\partial X_4} = 35.095\,X_4^{-0.890}\,X_1^{0.102}\,X_2^{0.154}\,X_3^{0.192}\,X_5^{0.229}\,X_6^{0.213} - \lambda\,14 = 0$$

$$35.095\,X_4^{-0.890}\,X_1^{0.102}\,X_2^{0.154}\,X_3^{0.192}\,X_5^{0.229}\,X_6^{0.213} = \lambda\,14 \text{ --------- } (7)$$

$$\frac{\partial Z}{\partial X_5} = 73.061\,X_5^{-0.771}\,X_1^{0.102}\,X_2^{0.154}\,X_3^{0.192}\,X_4^{0.110}\,X_6^{0.213} - \lambda 45.5 = 0$$

$$73.061\,X_5^{-0.771}\,X_1^{0.102}\,X_2^{0.154}\,X_3^{0.192}\,X_4^{0.110}\,X_6^{0.213} = \lambda 45.5 \text{ --------- } (8)$$

$$\frac{\partial Z}{\partial X_6} = 67.957\,X_6^{-0.787}\,X_1^{0.102}\,X_2^{0.154}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229} - \lambda 7.3 = 0$$

$$67.957\,X_6^{-0.787}\,X_1^{0.102}\,X_2^{0.154}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229} = \lambda 7.3 \text{ --------- } (9)$$

To find the value of X1 in terms of X2, we divide equation (4) by equation (5), yielding the expression for X1 in terms of X2 as follows:

$$\frac{32.542\,X_1^{-0.898}\,X_2^{0.154}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213}}{49.133\,X_2^{-0.846}\,X_1^{0.102}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213}} = \frac{\lambda 42.5}{\lambda 10.5}$$

$$\Rightarrow \frac{32.542X_2}{49.133\,X_1} = \frac{\lambda 42.5}{\lambda 10.5}$$

$341.691X_2 = 2088.152X_1 \Rightarrow$

$X_1 = \frac{341.691}{2088.152}\,X_2 \Rightarrow X_1 = 0.1636\,X_2$ --------- (10)

To find the value of X3 in terms of X2, we divide equation (5) by equation (6), resulting in:

$$\frac{49.133\,X_2^{-0.846}\,X_1^{0.102}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213}}{61.257X_3^{-0.808}\,X_1^{0.102}\,X_2^{0.154}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213}} = \frac{\lambda 10.5}{\lambda 0.950}$$

$$\Rightarrow \frac{49.133X_3}{61.257X_2} = \frac{\lambda 10.5}{\lambda 0.950}$$

$46.676X_3 = 643.198\,X_2 \Rightarrow$

$X_3 = \frac{643.198}{46.676}\,X_2 \Rightarrow X_3 = 13.780\,X_2$ -------- (11)

To find the value of X4 in terms of X2, we divide equation (5) by equation (7), yielding:

$$\frac{49.133\,X_2^{-0.846}\,X_1^{0.102}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213}}{35.095\,X_4^{-0.890}\,X_1^{0.102}\,X_2^{0.154}\,X_3^{0.192}\,X_5^{0.229}\,X_6^{0.213}} = \frac{\lambda 10.5}{\lambda 14}$$

$$\Rightarrow \frac{49.133\,X_4}{35.095\,X_2} = \frac{\lambda 10.5}{\lambda 14}$$

$687.862X_4 = 368.497X_2 \Rightarrow$

$X_4 = \frac{368.497}{687.862}\,X_2 \Rightarrow X_4 = 0.5357X_2$ ----- (12)

To find the value of X5 in terms of X2, we divide equation (5) by equation (8), resulting in:

$$\frac{49.133\,X_2^{-0.846}\,X_1^{0.102}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213}}{73.061\,X_5^{-0.771}\,X_1^{0.102}\,X_2^{0.154}\,X_3^{0.192}\,X_4^{0.110}\,X_6^{0.213}} = \frac{\lambda 10.5}{\lambda 45.5}$$

$$\Rightarrow \frac{49.133\,X_5}{73.061\,X_2} = \frac{\lambda 10.5}{\lambda 45.5}$$

$2235.551X_5 = 767.140X_2 \Rightarrow$

$X_5 = \frac{767.140}{2235.551}\,X_2 \Rightarrow X_5 = 0.343X_2$ -------- (13)

To find the value of X6 in terms of X2, we divide equation (5) by equation (9), resulting in:

$$\frac{49.133\,X_2^{-0.846}\,X_1^{0.102}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229}\,X_6^{0.213}}{67.957\,X_6^{-0.787}\,X_1^{0.102}\,X_2^{0.154}\,X_3^{0.192}\,X_4^{0.110}\,X_5^{0.229}} = \frac{\lambda 10.5}{\lambda 7.3}$$

$$\Rightarrow \frac{49.133X_6}{67.957\,X_2} = \frac{\lambda 10.5}{\lambda 7.3}$$

$358.670X_6 = 713.548X_2 \Rightarrow$

$X_6 = \frac{713.548}{358.670}\,X_2 \Rightarrow X_6 = 1.989X_2$ --------- (14)

By substituting equation (15), which represents the value of X2, into equations (10, 11, 12, 13, and 14), we obtain the optimal quantities of resources (X1, X3, X4, X5, and X6) as follows:

X2 = 6.176: This is the optimal quantity of seeds for planting per donum.

Substituting equation (15) into equation (10):
X1 = 0.1636 * (6.176) = 1.010: This represents the cultivated area.

Substituting equation (15) into equation (11):
X3 = 13.780 * (6.176) = 85.105: This is the optimal quantity of chemical fertilizers per donum.

Substituting equation (15) into equation (12):
X4 = 0.5357 * (6.176) = 3.308: This indicates the optimal quantity of hired labor per donum.

Substituting equation (15) into equation (13):
X5 = 0.343 * (6.176) = 2.118: This is the optimal number of hours of mechanized labor per donum.

Substituting equation (15) into equation (14):
X6 = 1.989 * (6.176) = 12.284: This represents the optimal number of hours of irrigation per donum.

After estimating the optimal quantities of production factors, it is now possible to estimate the optimal production volume by substituting the optimal quantities of the utilized resources into the production function as follows:

$Y = 319.047\ (1.010)^{0.102}\ (6.176)^{0.154}\ (85.102)^{0.192}\ (3.308)^{0.110}\ (2.118)^{0.229}\ (12.284)^{0.213}$

Y = 7.185*319.047=(2292.352) Kg

The optimal volume achieved through the use of the best combination of productive resources under the cost constraint.

Optimal Quantities for Production	Actual Quantities Used for Production	Production Elements
1.010	1	X1 - Cultivated Area (dunum)
6.176	5.25	X2 - Seeds (kg/dunum)
85.105	75.5	X3 - Fertilizer (kg/dunum)
3.308	2.2	X4 - Human Labor (worker/dunum)
2.118	2.5	X5 - Mechanical Labor (hours/dunum)
12.84	10.6	X6 - Irrigation (water) (hours/dunum)
2292.352	1724	Y - Productivity (kg/dunum)

Source: Researcher based on statistical analysis results (Eviews).

Conclusions:

Through the analysis of distributional efficiency and optimal resource use for yellow corn in the farms of the sample study, the researcher concluded that there is an excess in the use of certain resources, specifically for irrigation water and machinery, where the distributional efficiency exceeded one. In contrast, some resources, such as seeds, fertilizers, and labor, showed a deficiency in usage, with distributional efficiency values below one. This indicates inefficiencies in how farmers utilize production resources and achieve optimal production levels.

Recommendations :

The researcher recommends the need to adopt optimal quantities and utilize resources to achieve the optimal size, while avoiding waste and shortages in the use of production resources for yellow corn.

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