Scientific Research Publishing

Open Journal of Applied Sciences, 2022, 12, 855-864
https://www.scirp.org/journal/ojapps
ISSN Online: 2165-3925
ISSN Print: 2165-3917

Estimating the Efficiency of Summer Tomatoes Production: A Case Study in Borg El-Arab Area, Egypt

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How to cite this paper: El-Khalifa, Z.S., Ayoub, A. and Zahran, H.F. (2022) Estimating the Efficiency of Summer Tomatoes Production: A Case Study in Borg El-Arab Area, Egypt. *Open Journal of Applied Sciences*, **12**, 855-864.
https://doi.org/10.4236/ojapps.2022.126058

Received: May 15, 2022
Accepted: June 4, 2022
Published: June 7, 2022

Abstract

Tomatoes are one of the most popular and widely consumed vegetable crops worldwide. Egypt is characterized by its tomatoes production, whether for domestic use or export. Summer tomato farmers' income has recently been reduced due to high production costs, particularly in new lands. As a result, the purpose of this research is to evaluate the economic efficiency of the elements used in summer tomato production in the Borg El-Arab area of Egypt as a new land. According to the findings, the summer tomato crop produced a reasonable profit for small-holding farmers in the study area. However, the elements are being used excessively in the production process, particularly seeds and fertilizers, resulting in increased production costs and failure to achieve economic efficiency of the elements used in the study area.

Keywords

Economic Efficiency, Summer Tomatoes, Production Costs, Economic Indicators, Borg El-Arab Area, New Lands

1. Introduction

Vegetable crops aid in the provision of food and nutrition to people. Vegetables are rapidly growing and could meet the needs of consumers in a short period of time [1] [2]. In Egypt, vegetable crops are planted in three seasons: summer, winter and nili, with cultivated areas of approximately 898, 848 and 122 thousand feddan in 2019/2020, respectively [3].

Tomatoes are one of the most popular and widely consumed vegetable crops

worldwide due to their high nutritive value from vitamin and mineral contents [4] [5]. A tomato is composed of 95% water, 4% carbohydrates and less than 1% fat and protein [6]. Tomatoes fruits, whether fresh, cooked or processed, contain lycopene and anti-oxidant that may help protect against carcinogenic substances [7] [8].

Egypt is characterized by its tomatoes production, whether for domestic use or export. It has been produced about 6.81 million tons, representing 33.3% of total vegetable production, which is approximately 20.44 million tons in 2019/2020 [3]. Tomatoes have also captured the attention of farmers with small or large land holdings due to high income and rising tomatoes fruits prices.

In Egypt, new lands are reclaimed lands that have contributed to an increase in agricultural production, amounting to approximately 3.4 million feddans in 2020. Summer tomatoes grow in warm and temperate zones. The cultivation areas of summer tomatoes in new lands reached approximately 123 thousand feddans, representing approximately 62.4% of total summer tomatoes cultivation areas, which is estimated to be approximately 197 thousand feddans in 2020 [3]. In addition, production costs are important in determining net revenue and aid in determining optimal production level, in order to expand crop cultivation or shift to other crop cultivation [9].

Recently, summer tomatoes farmers' income has been reduced as a result of high production costs, particularly in new lands with low soil fertility, as a result of overuse of inputs, which reflects inefficiency in allocating economic resources optimally. As a result, Borg El-Arab area in Alexandria Governorate was chosen for this study as a new land to estimate the efficiency of elements used to produce summer tomatoes in season 2020/2021.

Furthermore, summer tomatoes were selected because they have the largest cultivated area of summer vegetable crops in the governorate of Alexandria, with 41.5 thousand feddans, representing 65.8% of the total cultivated summer vegetables area in Alexandria, which is approximately 63 thousand feddans in season 2019/2020 [3].

The study's objectives were as follows:

1) To define the current status of Egyptian summer tomatoes production during the period (2005/2006-2019/2020).

2) To assess the production costs, revenue and some economic indicators of summer tomatoes in the study area.

3) To estimate the economic efficiency of the elements used in summer tomatoes production in the study area.

2. Data and Methods

2.1. Data Source & Study Area

This study is relied on both published and unpublished data from the Egyptian Ministry of Agriculture and Land Reclamation data (Agricultural Statistics Bulletin 2005/2006-2019/2020) and Alexandria directorate of agriculture, statistics

department records (2019/2020). In addition, primary data was gathered from summer tomato farmers in Borg El-Arab area of Alexandria Governorate, Egypt. Borg El-Arab is 60 kilometers west of Alexandria and about 7 kilometers from the Mediterranean coast via the Alexandria-Matrouh Road. It covers 47.5 thousand feddan.

The study area was chosen because it represents the largest cultivated area with summer tomatoes in new lands, Alexandria Governorate, with cultivated area reaching approximately 18.3 thousand feddan representing 52% of the total cultivated area with summer tomatoes in Alexandria in season 2019/2020 [10].

During the 2020/2021 season, primary data was collected through a field survey in the study area. Data on production costs, revenue and yield were collected from a random sample of 41 tomato farmers from a total of 400 summer tomatoes production farms in agricultural administration in Borg El-Arab area. This means that the sample demonstrates approximately 10% of the study community. They are all small holdings of 5 feddans or less.

2.2. Methods

In order to meet the study's objectives, the descriptive analysis of summer tomato elements in new lands, including means, maximum, minimum, relative importance and growth functions. Also, a description of production costs and their relative importance in the study area, as well as some economic indicators of summer tomatoes in the study area used to determine total efficiency are as follows:

1) Net Revenue = total cost − total revenue.

2) Revenue over variable cost (gross margin/faddan) = total revenue − variable costs.

3) Revenue over total cost = total revenue/total cost.

4) Net return over invested pound = net Revenue/total cost.

Furthermore, quantitative analysis was performed to estimate the summer tomatoes production function and its derivatives using the OLS method in order to assess the economic efficiency of the elements used in summer tomatoes production in the study area. Following that, this study applies some standard tests to ensure data accuracy, such as the Jarko-Bera [11], White test and LM Test [12].

Economic efficiency denotes the relationship between a variable's marginal production value and marginal cost. Furthermore, production function denotes the relationship between independent variables (X_n) and dependent variables (P_t) [13].

The production function has the normal form of an exponential function (1) and the best form of summer tomatoes production function was logarithmic in the study area, as shown on Equation (2):

$$P = \alpha X_1^{\beta 1} X_2^{\beta 2} \ldots X_K^{\beta K} \tag{1}$$

$$\ln P_t = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \cdots + \beta_K \ln X_K + \cdots \varepsilon_t \tag{2}$$

where:

$\ln P_t$ = the production of summer tomatoes at time *t*.

$\ln X_{1,2,\ldots,K}$ = the production elements of summer tomatoes.

α = the intercept term.

$\beta_{1,2,\ldots,K}$ = the parameters of independent variables.

ε_t = the random error.

Economic Efficiency (EE) is used to determine whether the production elements of summer tomatoes crop in the study area are being used optimally or not. By estimating the following derivatives:

1) Average product = Yield/number of units from variables.

2) Marginal product value = Marginal product × farm price.

3) EE = Marginal product value/Price of variables.

Where:

If EE > 1, this indicates that economic efficiency has not been achieved and that more elements must be added.

If EE < 1, this indicates that economic efficiency has not been achieved and that elements must be reduced.

But when EE = 1, this indicates that the elements are being used to its maximum capabilities.

3. Results and Discussion

3.1. Current Status of Egyptian Summer Tomatoes Production

Table 1 and Table 2 represent a descriptive analysis of summer tomatoes development in new lands and Egypt during the period from 2005/2006 to 2019/2020. Summer tomatoes cultivated areas in Egypt were approximately 0.24 million feddans, down from 0.285 million feddan in 2008/2009 to 0.197 million feddans in 2019/2020, a decline of nearly 1.4% over the study period. As a result, Egypt's summer tomato production fell from 4.2 million tons in 2008/2009 to 3.2 million tons in 2017/2018. Whereas the yield has increased slightly by around 0.7% from 14.5 in 2007/2008 to 16.3 ton/feddans in 2019/2020.

While the cultivated areas of summer tomatoes in new lands were around

Table 1. Descriptive analysis of summer tomatoes during 2005/2006-2019/2020.

	Variables	Mean	Maximum	Minimum	Std. Deviation	% from total area	% from total production
Egypt	Cultivated area (1000 Fed)	242	285	197	26.8		
	Production (1000 ton)	3773	4234	3218	362		
	Yield (ton/Fed)	15.62	16.33	14.48	0.55		
New lands	Cultivated area (1000 Fed)	134.8	180.2	84.59	25.1	55.67	
	Production (1000 ton)	2014	2698	1101	475		53.38
	Yield (ton/Fed)	14.82	15.95	12.28	1.25		

Source: Data analyses using SPSS.25.

Table 2. Growth functions of summer tomatoes during 2005/2006-2019/2020.

Variables		Equation	R^2	F	*t*	Growth Rate %
Egypt	Cultivated area	$\hat{Y}_t = e^{5.6-0.014X_t}$	0.32	5.99*	−2.4*	−1.4
	Production	$\hat{Y}_t = e^{8.3-0.001X_t}$	0.12	1.8	−1.3	−0.1
	Yield	$\hat{Y}_t = e^{2.7+0.007X_t}$	0.68	27.9***	5.3***	0.7
New lands	Cultivated area	$\hat{Y}_t = e^{4.7+0.015X_t}$	0.11	1.6	1.2	1.5
	Production	$\hat{Y}_t = e^{7.3+0.028X_t}$	0.23	3.9	1.9	2.8
	Yield	$\hat{Y}_t = e^{2.6+0.014X_t}$	0.47	11.7*	3.4*	1.4

Notes: $\hat{Y}$ dependent variable; X_t time by years. (***) Statistically significant difference at 0.001; (*) Statistically significant difference at 0.05; Source: Data analyses using SPSS.25.

0.135 million feddans, up from 0.085 million feddan in 2005/2006 to 0.18 million feddans in 2014/2015. As a result, over the study period, production increased from 1.1 million tons in 2005/2006 to 2.7 million tons in 2014/2015. While production fell during the remainder of the study period, reaching 1.9 million tons in 2019/2020. In addition, the summer tomatoes yield was around 14.8 ton/feddan, up from 12.3 ton/feddan in 2008/2009 to 16 ton/feddan in 2010/2011, a 1.4% increase. While the yield value fluctuated between high and low until the end of the study period. In addition, there are various factors that contribute to crop yield reductions, such as low soil fertility, insufficient water and overuse of fertilizers and pesticides. This is a consistent with Noonari *et al.* [7] which reported that low production is due to poor soil, insufficient canal water, insect pests and inadequate extension services in Pakistan. Moreover, Khanal *et al.* [14] reported that high and low temperatures, as well as differences between day and night temperatures, may have an effect on the quality of tomatoes.

Despite, summer tomatoes are one of Egyptian most essential vegetables. During the study period, the cultivated area and production of summer tomatoes decreased. Furthermore, the results show that new lands are suitable for growing summer tomatoes, with unstable yield during the study period. This could have a negative impact on summer tomato farmers' ability to achieve a remunerative net return. Furthermore, Kassem *et al.* [1] reported that there is a decrease in the income of summer tomato farmers in Egypt due to inefficient use of agricultural economic resources used in summer tomato production.

3.2. Assessing the Production Costs, Revenue and Some Economic Indicators of Summer Tomatoes in the Study Area

Production costs represent all inputs used in the production process as well as fixed costs during the summer tomatoes production period in the study area. The percentage contribution of each input to the total cost was also calculated in the season 2020/2021.

Table 3 shows that in the study area, farmers cultivated an average of 2.11 feddans of summer tomatoes. Farmers spent an average of L.E. 5.26 thousand

Table 3. Average summer tomatoes production costs and revenue in the study area in season 2020/2021.

Inputs (L.E./Fed)	**Value**	**%**
Land Preparation	1482	3.734
Seeds	8684	21.88
Manure	2549	6.422
Fertilizers	6946	17.50
Pesticides	6724	16.94
Labor wages	3429	8.639
Irrigation	4618	11.64
Variable costs	34,432	86.75
Fixed costs	5259	13.25
Total cost	39,691	100.0
Farm price (L.E./ton)	3393	-
Yield (ton/Fed)	32.9	-
Cultivated area (Fed)	2.11	
Revenue (L.E./Fed)	111,154	-

Source: Primary data.

per feddan on fixed costs, which were represented in land rent. In addition, L.E. 34.4 thousand was spent on variable costs, which included seeds, manure, fertilizers, pesticides, labor wages, land preparation and irrigation. Fixed and variable costs represent approximately 13.3% and 86.7% of total costs, respectively, amounting to approximately L.E. 39.7 thousand per feddan. In addition, seeds, fertilizers and pesticides were high compared to other costs in the study area.

This indicates that increasing production costs may result in lower income, particularly for small-holding farmers. Noonari *et al.* [7] discovered that high production costs could be traced back to the use of cutting-edge technology by studying the economic effects of tomato production in Pakistan. Also, Keskin *et al.* [4] confirmed that the most important costs element is labor force because increasing labor force productivity is important in the sustainability and competitiveness of tomatoes production. While, Kushwaha *et al.* [15] confirmed that the main constraints of tomatoes production in India were the high cost of quality seed, a lack of labor, and expensive irrigation.

Table 4 shows that some economic indicators were used to determine the profitability and efficiency of summer tomatoes farms in the study area, where summer tomatoes' farmers earned an average of L.E. 71.5 thousand per feddan. This is due to a high average yield of approximately 32.9 tons/fed. Moreover, the summer tomatoes crop in the study area was sold for about L.E. 3.4 thousand per ton. Furthermore, the gross margin per feddan of summer tomatoes was increased by L.E.76.8 thousand/Fed. In addition, the revenue over total cost ratio

Table 4. Some economic indicators of summer tomatoes crop in study area in season 2020/2021.

Indicators	Value
Net Revenue (L.E./Fed)	71,463
Revenue over variable cost (L.E./Fed)	76,722
Revenue over total cost ratio	2.8
Return per invested pound (L.E./Fed)	1.8

Source: The authors' calculations.

was around 2.8, indicating that summer tomatoes farms in the study area are efficient. Return per invested pound also indicates that increasing the profitability of the pound spent on the production process by approximately L.E.1.8 per feddan.

This indicates that the summer tomatoes crop generated a reasonable profit for small-holding farmers in the study area. This is a consistent with Hasan and Bai [16] which reported that tomatoes production is highly profitable, although farmers faced some issues, such as low vegetable prices and a lack of cold storage facilities in Bangladesh. On the other hand, Prasad *et al.* [6] reported that large tomatoes growers are getting a higher yield and small tomatoes farms are not economically viable in India.

3.3. Estimating the Economic Efficiency of the Elements Used in Summer Tomatoes Production in the Study Area

It may be determined whether the production elements are being used optimally by estimating the efficiency or not. This could be accomplished by employing a production function which aids in the selection of various production factors as well as understanding how to determine which elements have productive and economic efficiencies Shafei *et al.* [13]. After determining the most influential elements on summer tomatoes production using stepwise regression, the production function was estimated. Also, the elements of production function have normality distribution, homogeneity and no autocorrelation.

The most influential elements were land preparation (X_1), seeds (X_2), fertilizers (X_3), pesticides (X_4), labor wages (X_5) and irrigation (X_7) in the study area.

The best form of summer tomatoes production function was logarithmic, as shown in the following equation:

$$\ln P_t = 0.28 + 0.638\ln X_1 - 0.082\ln X_2 + 0.109\ln X_3 + 0.349\ln X_4 + 0.052\ln X_5 + 0.559\ln X_7$$
$$(30.4)^{***} \quad (-4.1)^{***} \quad (7.01)^{***} \quad (8.9)^{***} \quad (3.22)^{***} \quad (6.98)^{***}$$

Previous equation demonstrates the productivity elasticity of land preparation (X_1), fertilizers (X_3), pesticides (X_4), labor wages (X_5) and irrigation (X_7) were positive and less than one. This indicates that these elements are in the second or economic stage of the production. It is vital to stop adding more elements to the production process at this point. Whereas the productivity elasticity of seeds (X_2)

Table 5. Economic efficiency of summer tomato in the study area.

Derivatives	Elements					
	X_1	X_2	X_3	X_4	X_5	X_7
Elasticity	0.638	−0.082	0.109	0.349	0.052	0.559
Average products	0.022	3.80	1.32	0.049	0.968	0.01
Marginal products	0.014	−0.311	0.144	0.017	0.050	0.01
Marginal product values	47.50	−1055	489	57.68	169.6	33.93
Price of variables	1482	8684	2549	6946	3429	4618
Economic efficiency	**0.03**	**−0.12**	**0.19**	**0.01**	**0.05**	**0.01**

Source: Calculated from production function and Table 3.

was negative. This demonstrates that this element is at the third stage of production, indicating that it should be reduced to return to the second stage.

Table 5 shows that economic efficiency was less than one of land preparation (X_1), fertilizers (X_3), pesticides (X_4), labor wages (X_5) and irrigation (X_7). Marginal product values by about L.E. 47.50, 489, 57.68, 169.6 and 33.93, respectively of these elements were less than their price by about 1482, 2549, 6946, 3429 and 4618, respectively. This indicates that these elements are being used excessively and that they should be reduced in the production process. Furthermore, because the seeds coefficient is negative, it is not possible to achieve economic efficiency in their use and element concentration should be lowered to reach the second stage of production.

Notes that there is overuse of elements in the study area, this could be due to low soil fertility—causing farmers to add more items, particularly fertilizers. This means that fertilizer application is significant for summer tomatoes production, particularly in arid and semiarid regions such as Egyptian new lands. This is a consistent with the findings of Al-Amri; Iqbal *et al.* [5] [17] which found that fertilizer application is one of the most important factors in achieving a profitable tomatoes yield, especially in arid and semiarid regions. Also, Mitra and Yunus [9] confirmed that farmers in Bangladesh should reduce their input use in order to reduce input costs and increase tomatoes productivity. Furthermore, Mohammed and Dulaimi [8] refer that the optimal size of the farm is one of the most important factors in increasing the farmer's profitability and plays a significant role in increasing the economic efficiency of using production elements.

4. Conclusion

The main objective of this study was to evaluate the economic efficiency of the elements used in the production of summer tomatoes in the Borg El-Arab area of Alexandria Governorate, Egypt. Summer tomatoes are a short-season crop with a high yield and the small-holding farmers in the study area gained a reasonable profit. However, farmers should reduce the overuse of elements in the

production process. So, summer tomatoes farmers should be aware of the need to rationalize elements in order to avoid future production cost increases. Additionally, more training and extension may help to alleviate this problem.

Acknowledgements

Authors acknowledge SRTA-City for achieving this work.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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