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Research Article

Economic and Productive Efficiency of Spearmint Crop in Fayoum Governorate in Egypt

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Abstract

Spearmint production in Egypt did not reach the expected value. The research aims to identify the available economic possibilities for the production and marketing, the productive and economic efficiency and cost functions of the spearmint crop, for the study sample, in Fayoum governorate in Egypt. A study on a sample of 50 spearmint producers from Fayoum and Ibshewia Markazes in Fayoum Governorate, had been done during 2019/2020. It was shown from production functions, in the linear and logarithmic form and using the stepwise regression, that the most important factors affecting production were; automated labor, which was a good trend for the use of modern technologies, the trained skilled workers in the cultivation of spearmint and finally the element of nitrogen fertilizer. It was shown also that, the total production flexibility reached 1.133 which means that there was an opportunity for producers to improve and increase their production. The cost functions showed the optimal size of spearmint production was 17 tons and that of production maximization profit for the spearmint crop was 34 tons. The efficiency measures showed that, the feddan net return of spearmint was 32304 pounds, the net return on the variable costs was 2.49 pound and the net return on total costs was 1.35, which confirmed the importance of investing in spearmint cultivation. The study recommended increasing the area cultivated from the spearmint to increase Egyptian exports and improve the Egyptian agricultural trade balance.

Keywords: Counselling; Spearmint; Fayoum governorate; Production function; Cost function; Economic efficiency.

Introduction

The Sustainable Agricultural Development Strategy 2030 (Ministry of Agriculture and Land Reclamation, 2009) clarified that, one of the most important obstacles facing Egyptian agricultural exports was the limited amount of what was exported compared to the large production capacities. It declared also that traditional crops represented the largest proportion of exports, while crops that enjoy competitive advantages within global markets, such as medicinal and aromatic plants, were ignoring. These crops are considered as nontraditional plants having many uses either as herbal form or by extracting active substances and using them in the pharmaceutical, food, perfumery and cosmetics industries (Baser, 1993). Spearmint is an aromatic herbal plant used widely in cosmetic, confectionary, chewing gum, food, toothpaste, pharmaceutical industries and for essential

oil productions. It is an important herb used fresh and dried for folk medicine such as stimulant and carminative. The essential oil is extracted from freshly harvested mint leaves or from dried leaves via distillation process. The essential oil obtained has been shown to possess antibacterial, antifungal, antiviral, insecticidal and antioxidant properties (Singh and Aggarwal, 2013). The Egyptian mint has a good reputation in the Europe and USA. Germany, Uk and Spain are the major markets. (Shabbara et al., 2019).

The economic importance of medicinal and aromatic plants depends on the relative relationship between the economic return (the local return or the return from foreign exchange earnings in agricultural exports) of these plants compared to the economic return from alternative crops or those in competition with them on the land unit. This confirms the economic feasibility of agricultural investment in the field of aromatic medicinal plants, which averaged about 69.8 thousand feddan of cultivated area, increased to about 81.7 thousand feddan in (2017-2019) (Ministry of Agriculture and Land Reclamation, 2009) by increasing the interest of organic cultivation.

The cultivated area of Spearmint in Egypt was about 4.1 thousand feddan, producing about 68 thousand tons. It was cultivated at about 1.36 thousand feddan having a feddan productivity of about 23.35 tons/ feddan, while the total production was about 31.3 thousand tons for the period (2017-2019) in Fayoum governorate, which occupied the first place among the governorates in Egypt in spearmint production (Ministry of Agriculture and Land Reclamation, 2009).

Despite of the appropriateness of the climatic conditions, the validity and diversity of the Egyptian soil, the abundance of skillful labor and availability of expertise among producers, there is a shortage of produced spearmint from the expected production. Thus, the research aims to identify the economic possibilities available for the production and marketing of spearmint by studying the productive and economic efficiency through the production and cost functions of the spearmint crop for the study sample in Fayoum governorate and to reach measures of the economic efficiency of the spearmint.

Methodology

The study was mainly based on field data which were randomly collected from 50 producers of spearmint in the two most important spearmint-growing Markazes; Fayoum and Ibshewai Markazes, from the village of Manshaet Abd-Allah in Fayoum Markaz and Abu Jinshu village in Ibshewia in Fayoum Governorate in Egypt, during 2019/2020 cropping season. That in addition to, unpublished and published data found in statistical bulletins from government agencies, such as the Ministry of Agriculture.

The research relied on descriptive and quantitative analysis. It used some different measures such as relative importance, averages, simple regression analysis and stepwise regression, in more than one mathematical form, such as linear and double logarithmic form, to find out which form was consistent with economic and statistical logic (El Shayal, 1982).

To measure the impact of different production inputs on the Spearmint crop production function in the study sample, the multi linear regression and double logarithmic multi regression models were used. That in addition of stepwise linear regression and stepwise logistic regression models, which means the use of the “Cobb- Douglas” production function.

This function is easy for estimating its features, as they turn into linear form by taking the logarithms at their marginal, and the function gives directly the production flexibilities to each productive element, as flexibility indicates the extent to which the change in production responds to the change in production elements. In addition, the function illustrates the features of the Diminishing returns law.

The function of production of spearmint was estimated in its physical form and by studying the most important factors affecting the production of spearmint. Multi-regression model at linear and logarithmic forms was used and then stepwise multi regression model was used of to identify the most influential factors on spearmint production. Also, the correlation matrix was required to identify the relationship between each of these productive elements and production. It was made between the production of each farmers, of the study sample, and the different production factors. Basing on results of the estimates, some production inputs were excluded when examining stepwise multi regression model.

Description of the mathematical model used

The output (dependent variable) was expressed in the production function in its physical form. Also, all the variables were expressed in their physical forms which were supposed to affect the dependent variable. From the statistical and economic point of view, Cobb-Douglass double logarithmic form was the best form. Therefore, the production function takes one of the following mathematical forms:

Estimation of the regression model in the multilinear form:

$Yi = \alpha + \beta1\ X1i + \beta2\ X2i + \beta3\ X3i + \beta4\ X4i + \beta5\ X5i + \beta6\ X6i + \beta7\ X7i + \beta8\ X8i$

Estimation of the regression model in the double logarithmic form:

$\log Yi = \alpha + \beta1 \log X1i + \beta2 \log X2i + \beta3 \log X3i + \beta4 \log X4i + \beta5 \log X5i + \beta6 \log X6i + \beta7 \log X7i + \beta8 \log X8i$

Where;

(Yi) = Estimated value of the amount of production (tons/feddan) per observation.

(Y1i) = Number of seedlings (thousand seedlings/ feddan) per observation.

(Y2i) = Amount of municipal fertilizer (m3/feddan) per observation.

(Y3i) = The amount of automated work (working hour) per observation.

(Y4i) = Amount of human labor (man/working day) per observation.

(Y5i) = The quantity of added effective nitrogen fertilizer (unit/feddan) per observation.

(Y6i) = The quantity of added effective phosphate fertilizers (unit/feddan) per observation.

(Y7i) = The quantity of foliar fertilizers (liters/feddan) per observation.

(Y8i) = The quantity of sulfur (kg/feddan) per observation.

$\beta1$, $\beta2$, ..., $\beta7$ estimated function parameters,

i = 1,2,…… .no. of observations.

Results and Discussion

About twenty year ago, an economic study showed that there had been a fluctuation in the area under cultivation and the total production of medical and aromatic crops, but their net return exceeds the competing crops (Abdel- Aal, 2000). Studying the general trend of the area cultivated by medical and aromatic plants in the Arab Republic of Egypt (table 1),

an annual statistical significance of total area of these plants was shown to be increased at the level of 0.05, which amounted to about 938 feddan.

Table 1. Equations of the general trend of the area of medical and aromatic plants and the area and production of spearmint through (2019-2000).

Indicators	Equation	R^2	Average	change rate%
Total area of medicinal and aromatic plants (feddan)	$\hat{Y}_i = 46507 + 938x_i$ (2.4)*	0.25	56360	1.7
Organic area of medicinal and aromatic plants (feddan)	$\hat{Y}_i = 14191 + 5110x_i$ (11.7)**	0.88	39467	12.9
Cultivated area of Spearmint (feddan)	$\hat{Y}_i = 1462 + 168.9x_i$ (4.8)**	0.56	3236	5.2
Feddan productivity (tons/feddan)	$\hat{Y}_i = 0.448 + 1.14x_i$ (0.75)**	0.75	12.4	9.2
Total production of Spearmint (tons)	$\hat{Y}_i = 10666 + 5465x_i$ (3.8)**	0.73	46714	11.7

Where $\hat{Y}i$ is the value of the Dependent variable.

Xi is the value of the time independent variable during the period (2000-2019).

i = (1, 2, 3… 20).

Source: Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Economics Bulletins, miscellaneous issues

It represented about 1.7% of the average area cultivated from medical and aromatic plants of about 56360 feddan and the coefficient of determination showed that 25% of the changes in the area under cultivation were due to the time factor and the rest was due to another factor (Equation 1). While, there was an annual increase for the organically cultivated medicinal and aromatic plant area by about 5110 feddan (second equation). It represented about 12.9% of the average of the whole organically cultivated area (about 39467 feddan) at the study period (2000-2019). Also, the cultivated area of spearmint (at national level) showed an annual increase by 168.9 feddan (third equation), representing about 5.2 % of the average cultivated spearmint area (about 3236 feddan) at the study period and the determination coefficient was 0.56. As for feddan productivity of spearmint, the fourth equation showed an annual increase of about 1.14 tons, representing about 9.2% of the average feddan productivity of spearmint, which was about 12.4 tons, and the determination coefficient was about 0.75. The fifth equation showed a statistically significant annual increase in the amount produced from spearmint, which amounts to about 5464.6 tons, representing about 11.7% of the average amount produced from spearmint (about 46,714 tons) and the determination coefficient was about 0.72. The results were coincided with those recorded by (Othman, 2021).

The production function for spearmint crop

The production function for spearmint crop in the study sample in Fayoum Governorate in 2019/2020 was shown in table (2) in its linear and logarithmic form. At these forms, the production was the dependent factor while the group of independent factors were; amount of seedlings (thousand seedlings/ feddan), amount of municipal fertilizer

(m3/feddan), amount of automated work (working hour), amount of human labor (man/working day), the quantity of added effective nitrogen fertilizer (unit/feddan), the quantity of added effective phosphate fertilizers (unit/feddan), the quantity of foliar fertilizers (liters/feddan) and the quantity of sulfur (kg/feddan).

Table 2. The function of Spearmint production with stepwise regression in linear and logarithmic forms for the study sample in 2019/2020.

Mathematical form	The equation	R^2	F
Linear	$Y = 6.9 + 0.714\ X_3 + 0.026\ X_4 + -0.116 X_5$	0.82	29.9
	(7.1)** (5.1)** (3.1)**		
Double logarithmic	$Ln\ Y = 1.25 + 0.797\ Ln\ X_3 + 0.155\ Ln\ X_4 + 0.250\ Ln\ X_5$	0.83	30.4
	(7.5)** (5.5)** (2.9)**		

Where:

Y: the average produced quantity (tons / feddan)

X3: Automatic work (hours/feddan)

X4: The human labor per man/working day.

X5: the amount of phosphate fertilizer in active units

** Level of significance at 0.01 * Level of significance at 0.05 - not significant

Source: Study sample data for spearmint farmers in Fayoum province for agricultural season 2019/2020

To select the best form, from the statistical and economic point of view, correlation matrix, multi regression, stepwise regression models, estimating function by linear and logarithmic forms were used. Then, the logarithmic form was shown to be the best. Therefore, it was found that the most independent variable affecting the spearmint production was the amount of automated work, as by increasing 1% of the amount of automated work 0.797% of spearmint production will be increased. While it was found that, increasing the amount of human work by 1% led to an increase of spearmint production by o.155% and increasing units of phosphate fertilizer by 1% led to increase the amount of spearmint production by 0.250%. It was shown also that, Production flexibility was about 1.133 and 83% of the changes in production were attributed to the previous factors where the determination coefficient factor was 0.83. The results showed the significance of the model was confirmed as calculated (F) value was estimated at about 30.4 which was greater than its tabulated value.

Function of costs of producing spearmint in the study sample

After studying the relationship between the total costs and the amount produced from spearmint in the study sample by many forms, it became clear, as shown from table (3) that the square form was the best. That equation showed the direct confirmed statistically relationship between both the total costs and the production of spearmint in the studied sample in Fayoum governorate. The determination coefficient was shown to be 0.50, indicating that about 50% of the changes in total costs were due to changes in production. The average cost function was derived, by dividing the costs by the produced quantity, and the marginal cost function was also derived. Then, the optimum production size,

which reaching production cost to the minimum, was determined by equalized the average costs to the marginal costs, and it was estimated at 17.4 tons/feddan. While the average feddan production of this crop was about 22.5 tons, only ten farmers had achieved this size (as shown from results). In order to maximize profits, i.e. obtain the maximization size of profits, the marginal cost function must be equated with the farm price per ton of spearmint, which was estimated at about 2500 pounds. The production size for the maximization profit was calculating from the equation, and estimated to be about 34.7 tons/feddan. This indicates that crop farmers still have an opportunity to increase their production to maximize their profits through the vertical expansion of crop production. By calculating the flexibility of costs, it turned out that it amounted to about 0.925. This indicates that production was in the non-economic production stage, and that productivity can be increased by about 10% by increasing costs by an amount 9.2% in light of the current production level, which indicates the possibility of increasing production by adding units of different production elements. Also, it was shown that the calculated (F) value was 10.2, confirming the significance of the estimated model.

Table 3. Quadrant costs function of spearmint in the study sample in production season 2019/2020.

Equation	R^2	F	Cost elasticity
TC i =- 23661.5-+3941 X i -78.4 X i 2	0.50	10.2	0.923
(-3.10) ** (2.8)** (-2.5)**			
AC = 3941 - 1764 X – 1051.6X-1			
MC = 3941+156.8 X			

Where;

Tc i = Total cost of spearmint production

Xi1 = the quantity of spearmint production estimated per ton.

AC= average costs per pound / acre

MC= Marginal costs per pound / acre

i= 1, 2, 3, number of farmers in the area.

** Significant at the level of 0.01 * significant at the level of 0.05

Source: Study sample data for spearmint farmers in Fayoum province for agricultural season 2019/2020

Table 4. Measures of economic efficiency of the spearmint crop in the study sample.

Net return/ total costs	Net return/ variable costs	Net return	Total Revenue	Total costs	Variable costs
1.35	2.49	32304	65250	23946	16123

Source: Study sample data for spearmint crop for agricultural season 2019/2020

Measures of economic efficiency of spearmint crop

Total revenue Measurement

The total revenue expresses the monetary value of each of the main and secondary outputs. It depends on two main factors, namely feddan productivity and farm prices. Therefore, the changes that occur in any of them will have an impact on the total revenue. Table 4 showed an increase in the total revenue of spearmint, as it was estimated at about 65250 pounds / feddan.

Feddan profitability (net return / feddan) Measurement

The net return per unit area depends on the prices of the requirements and primary and secondary products of the crop, in addition to the average productivity of the unit area. It reflects the use of improved seeds, new technology, as well as provision of production requirements, or improvement in farm management. This measure can be calculated from the following equation:

Net return /feddan = total revenue - total costs

Extrapolating the data of table (4) showed the net return of spearmint producers was estimated at 32304 pounds / feddan.

Net return to variable production costs Measurement

This measure refers to the economic efficiency of the variable production elements only. It shows the amount of return achieved from the use of variable assets in the production process. It is measured by dividing the net return per feddan on the variable costs. It is often called the profitability of the pound spent, as the variable costs change with the change in production. It was amounted to about 2.49 pounds (table 4) at the studied spearmint sample.

Net return to total production costs Measurement

It is the result of dividing the feddan net return on feddan total costs, the higher the value of this measure, the higher the return on costs. An increase in return/costs for spearmint producers was shown at the study sample (table 4), estimated at about 1.35 pounds.

The results of the study showed the increasing interest in production and export of spearmint crop at the current period. Therefore, the value of instability factors is, in general, decreasing and spearmint producers are moving to export the high-value spearmint oil and achieve added value of the spearmint crop, in the direction of its manufacture. This is in comparable with the economic instability in the size of production and the number of exports of medical and aromatic plants, in general, during the period (1995-2008), where studying factor of production instability was estimated about 19.2 (Mohamed, 2003) and that of exports was about 40.8 which was agreed with results of Omar (2011).

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