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The productive economic efficiency of lemongrass in Fayoum governorate in Egypt

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Abstract:

The objective of this study was to determine the different factors affecting the production of lemongrass in Fayoum governorate, also to show its economic efficiency indicators through the use of production and cost functions to determine the minimal and maximal size of the profit.

The study was mainly relied on field data which were randomly collected from 40 producers of lemongrass in Fayoum and Ibshaway centers, in Fayoum Governorate, during 2020/2021 cropping season. That in addition to the data published in statistical bulletins from government agencies.

Results showed: 1) production functions found that, amounts of nitrogen fertilizer, biocides and of human work man / working day had a direct effect on the production amount of lemongrass , i.e. by increasing 1 % of the used quantity of each them, the production of lemongrass crop was increased by about %, 0.390 0.040 % ,0.499% respectively. 2) total elasticity was about0.929 , showing the dominance of the relationship of decreasing returns to scale , i.e. by increasing the quantity of inputs by 1 %, the amount of production increased by 0.929 % (less than the correct one) . This indicated that production is economic in the second productive stage, as total production increases at a decreasing rate for any addition of these inputs. 3) the Optimum volume of Production to minimize costs to scale was estimated at about 13.69 tons / feddan , while the phase of maximizing returns to scale was estimated at about 29 tons / feddan, which was not reached by any producer. This indicates farmers producing lemongrass still have an opportunity to increase their production to maximize their profits, through the vertical expansion of crop production .4) elasticity of costs amounted to about 1.49 . Thus, production was in the stage of economic production, and that productivity can be increased by about 10 % by increasing costs 14.9% under the current production level. This indicated the possibility of increasing production by adding units of different production elements . 5) efficiency measures confirmed that the feddan net return in the study sample was about 29128.6 pounds, the rate of return to costs of lemongrass in the study sample was about 1.76 pounds, the profitability of the pound spent was about 2.75 pounds, and the cost of the unit produced in the study sample was about 1075.8 pounds. The study recommended paying attention to the productive factors affecting production, namely nitrogen fertilizer, the amount of bio-pesticides, and trained human labor by making extension fields with educational courses for producers to improve their production and increasing the exported quantity of lemongrass.

Keywords: Lemongrass, Fayoum Governorate, production function, Cost Function, economic efficiency.

1- Introduction:

Recently, cultivation of medicinal and aromatic plants has been taken great importance in Egypt, because of their economic return. Many Economical Studies of the most important Egyptian aromatic plants had been done from many years ago, e.g. El Sawalhy, 1977 and Ahmed, 1980. Some studies were interested on their production economics (Shehata, 1988, Mousa, 1992, Ahmed, 2005), others on economic stabilization and exporting (Ghanem, 1998 Shabbara & Taha 2007), their manufacturing (Rayadh, L., 2002, El-Hawari 2006) their productive efficiency (Hassan et al, 2014) or on comparative economics of production and marketing between some aromatic plants in both Egypt and India (Shabbara et al 2017, Shabbara et al, 2019).

Many of these studies were done on Anise, Caraway , Coriander, Cumin, Fennel, Peppermint and Spearmint, rarely on Calendula ,Chamomile , Marjoram and Rosemary but there is no serious economic study on Lemongrass.

Lemongrass (*Cymbopogon citratus*) is considered one of the important medicinal and aromatic plants. It is a perennial medicinal plant belonging to family Geramineae, which is distributed worldwide especially in tropical and subtropical areas of Africa, Asia, and America (Akhila, 2010, Francisco et al ,2011, Chanthal et al., 2012)

The growing demand for lemongrass is stimulated by its therapeutic benefits. Lemongrass is rich in fiber, proteins and a high percentage of various antioxidants. This type of herb is a good source of many important minerals and vitamins, such as Vitamin A, Vitamin C. and Folic acid. Also, it contains many minerals as potassium, magnesium, phosphorus, manganese, zinc and iron. The main effective compounds of lemongrass are citral and essential oil (Carlson et al., 2001, Schaneberg and Khan 2002). Its oil

contains the basic component, citral up to 85%, and myrcene, citronellal, citronellol, linalool and geraniol. Citral is used as a raw material for the production of ionone, vitamin A and beta-carotene (Carlson et al, 2001).

Lemongrass oil is widely used in folk medicine as anti-sweating, antihypertensive, as well as using for stomach pain, headache, joints, ampagogy and rheumatism (Rao& Jamir 1982). Studies have also shown that this herb has great effects for cases of renal colic and help urinary duct stones get out (Locksley et al, 1982). It is promoted to contribute in the treatment of anemia and certain skin infections, improve digestive health and lower cholesterol. It regulates blood sugar levels and protect against obesity (Praditvarn & Sambhandharaksa 1950).

The lemongrass oil has an anesthetic effect on intestinal worms. In recent research it has been shown to lower blood pressure in rats. In a small, randomized, controlled trial, an infusion made from lemongrass was used as an inexpensive remedy for the treatment of oral thrush in HIV/AIDS patients. Laboratory studies have shown cytoprotective, antioxidant, and anti-inflammatory properties (Gagan et al., 2011)

This oil is included in the manufacture of soaps and aromatic odors and is used in deodorants and some cosmetics as well as pesticides, to reduce its unacceptable smell. Its oil is important in expelling mosquitoes. In addition, it is added to some food products and used for cooking, as well as distillate residues can be used as feed for livestock or in the paper industry.(Gagan et al., 2011).

Fayoum governorate in Egypt, is the first in cultivating lemongrass, where about 204.75 feddans were being cultivated, with an average productivity about 15.14 tons per feddan, while the governorate's production was about 3152.5 tons for the average period 2010-2018 (Economics Publications , 2019).

Although Lemongrass is considered one of the most important economic and export crops in Egypt, it did not find sufficient attention for improving the productive efficiency of producers or find interest about the input productive elements affecting production. This led to a lack of clarity in the economic and productive efficiency of lemongrass producers.

Thus, this research aims to determine the different factors affecting the production of lemongrass to show the productive and economic efficiency of the producers through the use of production and cost functions. Also, to determine the minimal and maximal size of the profit, showing economic efficiency indicators.

2- Data Sources and Methodology:

The study was mainly relied on field data **which were** randomly **collected from 40 producers of lemongrass in** Fayoum and Ibshawai centers, in Fayoum Governorate, in Egypt

(fig.1), during 2020/2021 cropping season. That in addition to **the data published in statistical bulletins** from government agencies, such as the Ministry of Agriculture.

The study was based on using statistical and economic methods as simple linear regression, multiple regression and stepwise regression. Cost function was specified and estimated in various functional forms. Average cost function and marginal cost function were calculated. Also, some analysis had been done to assess the economic efficiency of lemongrass production.

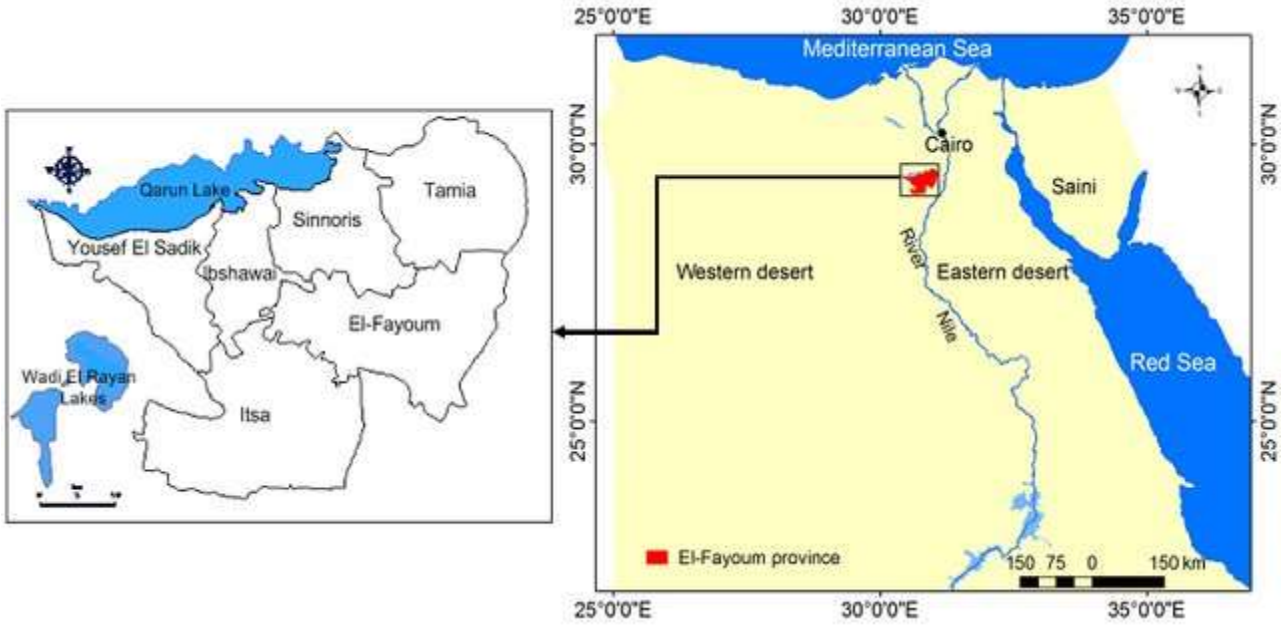

Fig. (1) Location of El Fayoum Governorate in Egypt map (right), the administrative boundaries of El Fayoum Governorate (left).

3- Results and Discussion:

3-1 The development of area and production of lemongrass in Fayoum Governorate

By studying the development of the cultivated area of lemongrass in Fayoum Governorate, it showed the statistically significant annual increase (Table 1), which was estimated at 47.9 and represented about 23.4 % of the average area (about 204.75 fedden). It showed also the coefficient of determination was 0.56 , while (F) value was estimated at 8.7 for the period (2010- 2018).

The development of total production of lemongrass in Fayoum governorate showed statistically significant annual increase (Table 1) estimated at 725.6 tons, representing about 23% of the average production of lemongrass in Fayoum governorate (about 3152.5 tons). It showed also the coefficient of determination (R^2) was 0.52 while (F) value was estimated at 7.72 for the period (2010-2018).

Table 1: General trend equations of the area and production of lemongrass in Fayoum governorate, during the period (2010-2018).

Equation no.	Variable	Equation	R^2	Annual changing rate
1	area of lemongrass (Fadden)	$\hat{Y}i = 34.9 + 47.9Xi$ * (2.9)	0.56	23.4
2	production of lemongrass (Ten)	$\hat{Y}i = 475.2 + 725.6\ Xi$ * (2.7)	0.52	23.0

$\hat{Y}i$: the estimated value of the dependent variable

Xi : the element of time as an independent variable since i (1, 2, 3, 4 ..... 1 0 .)

** Significant at the level of 1%. * Significant at the level of 5%.

Source: Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Economics Publications (2019)

3-1-1 Factors affecting production:

The relationship between the production of lemongrass and affecting factors was studied. If we consider the lemongrass production quantity (ton) was the dependent variable (Y) , all production factors were independent variables (Xi). Such factors were; the amount of seedlings (thousand seedlings) X_1 , the amount of manure fertilizer (m^3) X_2 , the amount of nitrogen fertilizer (unit) X_3 , the amount of phosphate fertilizer (unit) X_4 , the amount of potassium fertilizer (unit) X_5 , the quantity of biocides (package) X_6 , quantity of human labor (man / working day) X_7 , the amount of mechanical labor (hour) X_8 .

To show the most important factors affecting the quantity of lemongrass production, the double logarithmic form was used. The linear and double logarithmic functions and Multiple Regression Analysis, then the Stepwise Regression Analysis were estimated to obtain the best form and the results of which were consistent with the economic and statistical logic. It became clear from the results that the double logarithmic form was the best.

The positive sign of the regression coefficients of the amount of nitrogen fertilizer (the effective unit) , the amount of biocides (package) and the amount of human work (man / working day), shown from table (2), indicated that they had a direct effect on the production quantity of lemongrass. It showed that, increasing the amount used of each of them by %1 , lead to increase the production yield of lemongrass by about 0.040 % , 0.390% , 0.499 % , respectively. This effect would be considered if we impose the stability of other factors affecting the quantity of production , which did not used by the optimum quantity to increase the production .

Table 2: Stepwise regression of lemongrass production using in the study sample through 2020-2021

Statement	Mathematical Image	Equation	R R^2	FF
forms of the production function of lemongrass	Linear	$\hat{Y}i = 2.7 + 0.430\ X_3 + 0.486\ X_6 + 0.077\ X_7$ **(3.1) ** (3.9) **(3.4)	00.78	42.8
	Logarithmic	$\ln \hat{Y}i = 11.2 + 0.040 \ln X_3 + 0.499 \ln X_6 + 0.390 \ln X_7$ **(3.33) ** (4.7) **(3.83)	00.79	44.3

where:

$\hat{Y}i$: The amount of production of lemongrass (ton)

X_3: The amount of nitrogen fertilizer (units)

X_6 : The amount of biocides (package)

X_7 : The amount of human labor (man /working day)

(**) significant at 0.01 level.

(*) significant at 0.05 level .

-The value between the brackets indicates the calculated value of "T"

source : collected and calculated from the study sample data of Fayoum Governorate in 2020/2021

It was shown also that, the rate of coefficient of determination (R^2) indicated that about 9.7% of changes in the amount of production of lemongrass were explained by the independent variables included in the model, and the (F) value was about 44.3 which means the significance of the used model . The study declared also that, the total elasticity, which was about 0.929 showed the dominance of the relationship of Decreasing Returns to Scale, i.e. increasing the quantity of these inputs by 1 % increases the amount of production by 0.929 %, "less than the correct one " which indicates that production in the second productive stage is economic, as total production increases at a decreasing rate of any addition of these inputs.

3-2 Cost functions of the study sample

To get the average costs and marginal costs from the total cost equation, it can be expressed as follows.

$TC = a + b_1 X + b_2 X^2$

$$AC = \frac{a}{x} + b_1 + b_2 X$$

$MC = b_1 + 2 b_2 X$

Whereas:

TC= Total costs of lemongrass (pound / feddan)

X = Feddan yield (kg / feddan)

AC= average costs (pound / feddan)

MC= Marginal costs (pound / feddan)

Studying the relationship between the production costs of lemongrass (pounds) and its produced quantity (ton), quadratic and cubism forms were used to choose the best economic and statistical forms. The first equation in Table (3) showed the relationship between the total costs and the produced quantity of lemongrass per ton , from which it became clear that the square form was the best. This equation showed also that there was a statistically confirmed direct relationship between each of the total costs and lemongrass production. It showed also that, the coefficient of determination value reached to 0.67, indicating that about 67 % of the changes occurring in the total costs were due to changes occurring in the production .

To determine the optimum production volume to minimize costs to scale, the average costs were equalized with marginal costs. The average cost function was derived by dividing the costs by the quantity produced. The optimal production volume was estimated at 13.69 tons / feddan, and the average feddan production of this crop is 15.47 tons / feddan. It was clear from data of the study sample that only fifteen farmers achieved this size.

Table 3: Cost functions of lemongrass in the study sample in Fayoum Governorate

Statement	Equation	R R^2	FF	Cost elasticity
The cost function of lemongrass in square form	$TC\ i = 13761.8 - 1083.7\ X\ i + 70.3\ X\ i^2$ (3.10)** (2.8)** (2.68)** $AC = -1\ 083.7 + 70.3\ X + 13761.8\ X^{-1}$ $MC = -1083.7 + 140.7\ X$	00.67	37	1.49

Where

TC i = Total cost of Lemongrass production

Xi_1 = The quantity of lemongrass production estimated per ton.

AC= average costs per pound / Fadden

MC= Marginal costs per pound / Fadden

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 : Computed from the questionnaire forms for the sample of the study in Fayoum Governorate in 2020/2021

Also, to maximize profits, i.e. to obtain the maximum volume of profits, the marginal cost function was equating with the farm price per ton of lemongrass (about 3000 pounds/ton). Thus, it was estimated at about 29 tons / feddan, which was not reached by any producer. This indicated that crop farmers still have an opportunity to increase their production to maximize their profits, through the vertical expansion in the production of the crop. Calculating the flexibility of costs, it turned out that it amounted to about 1.49. This indicated that production was at the stage of economic level, and that productivity can be increased by about 10%, as costs increases by % 14.9 , at the current production level. This indicated the possibility of increasing production by adding units of different production elements .

3-3 Efficiency Concepts:

Efficiency involves two basic concepts:

1) Productive Efficiency :

Productive efficiency means obtaining the maximum possible production from the same amount of available productive resources or obtaining the same amount of production using a lesser amount of available resources . It means to learn how to make ideal blend of the using productive resources regardless of the price relationship. The production efficiency is considered to be part of economic efficiency.

2) Economic Efficiency :

Economic efficiency means achieving the greatest amount of return in relation to the cost of certain resources, or obtaining the same return with a lesser amount than the cost of the combination of previous resources. So, economic efficiency is a relative concept that expresses the ratio between the total value of outputs and the total value of inputs.

3-3-1 Measures of production and economic efficiency:

There are many measures of production and economic efficiency to infer the efficiency of the production process in the sample of the study, and measure the profitability of the agricultural activity. Therefore, this study relied on the most important of those measures, which are represented in the following:

First : Feddan net revenue.

The net revenue per unit area depends on the prices of the requirements of the production process , the prices of the final and secondary products of the crop , in addition to the average productivity of the unit area . It is the result of subtracting the total revenue from the total costs . This measure is considered one of the comprehensive measures of economic efficiency, as it is useful in knowing the difference in the revenue and proceeds from different crops . It was found from table (4) that the feddan net revenue of lemongrass in the study sample was about 29128.6 pounds.

Second: The rate of return to costs.

It is the ratio between the value of production to the cost of the production elements used in the production process. This measure is considered one of the comprehensive measures of production efficiency, as it measures the efficiency of all production elements (fixed and variable). It was found from table (4) that the rate of return to costs of lemongrass in the study sample was about 1.76 pounds.

Third : profitability of the pound spent.

This measure refers to the economic efficiency of variable productive elements only. It shows the amount of revenue generated from the use of farm assets in the production process. The higher the value of this measure indicates an increase in net revenue for the costs. The profitability of the pound spent is calculated by dividing the net feddan revenue by crop production (variable) costs. This measure shows the return on the pound spent in the production

process, and the increase in the value of this measure reflects the higher profitability of the pound spent and the availability of economic efficiency in production . It was found from table (4) that the profitability of the pound spent on lemongrass in the study sample was about 2.75 pounds.

Fourth : **Producing unit cost**

The cost of the unit produced is calculated by dividing the total costs by the average feddan production of the crop. This measure is useful in identifying the cost of the unit produced from the crop. This measure shows the extent to which production is related to costs and confirms that the producer is always rational, looking for the highest production at the lowest possible costs. The cost of the unit produced for lemongrass in the study sample was about 1075.8 pounds (Table 4).

Table 4: Measures of economic efficiency and productivity of lemongrass in the study sample in Fayoum Governorate in 2020/2021.

Statement	variable costs (pound)	total costs (pound)	total revenue (pound)	net revenue (pound)	Return /Costs	profitability of the pound spent	cost/ ton
value	10575.2	16575.2	45703.8	29128.6	1.76	2.75	1075.8

Source : collected and calculated from the data of the study sample in Fayoum Governorate in 2020/2021.

4- Recommendation:

Paying attention to the productive factors affecting production, namely: nitrogen fertilizer, the amount of bio-pesticides, and trained human labor by making extension fields with educational courses for producers to improve their production and thus increasing the exported quantity of lemongrass.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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