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Soybean supply response functions in Egypt

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Abstract: The research aimed to study ways to increase soybean production in Egypt because of its many benefits, the most important of which is to contribute to reducing the nutritional gap from vegetable oils in Egypt, and because of the economic importance of soybeans, as it is an essential component of poultry feed, and enters into many food industries that are accepted by the consumer. The research was based on data published in Egyptian government agencies and some specialized websites. To reach the main objective of the research, some statistical methods were used that fit the available data, and the response functions of the soybean crop supply with other competing oil crops and with competing summer crops in the agricultural cycle were estimated. Among the most important research results: the average area planted with soybeans during the period (2000 - 2020) was about 24 thousand feddans with an annual growth rate of 5.78%, and the average total production during the same period was 38.24 thousand tons with an annual growth rate of 6%. The rate of self-sufficiency of vegetable oils (produced from local and imported oils) during the study period was 30.2%. The self-sufficiency rate of soybean oil (including the product from domestic seeds and imported seeds) was 39.26%. By estimating the response functions of the soybean crop supply using one variable with the area slowed down, it was found that the response of the cultivated area of soybeans during the period (2000-2020) is directly proportional to the area slowed down a year with both the farm price per ton, the productivity per feddan in tons, the cost per ton of rice for the previous year, and the price ratio between soybeans and tomatoes in LE/ton, each separately. The area planted with soybeans is inversely proportional to the cost ratio between soybeans and corn in LE per ton by slowing down, the cost ratio between soybeans and rice in LE per ton by slowing down, the price ratio between soybeans and tomatoes in LE/ton for the previous year, the price ratio between soybeans and corn in LE/ton for the previous year, and the price ratio between soybeans and tomatoes in LE/ton for the previous year. The first equation shows the response of farmers to both the farm price and productivity of soybeans, and in the second shows their response to the price ratios between soybeans and corn, and in the third shows their response to the costs of a ton of corn, and in the fourth was the response to both the ratio of costs between a ton of soybeans yield per ton of sunflower and net yield per ton of corn, In the seventh, both the ratio of the costs of a ton of soybeans to the costs of a ton of rice and the ratio of the costs of a ton of soybeans to a ton of tomatoes were answered. By studying the means of increasing the planted area of soybeans, it turned out that the best ones are loading on the Levantine corn in the summer in the ancient lands of Egypt – good fertility and drainage – and it may be possible to further increase the production of the soybean crop compared to those values in 2020.

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Introduction:

Soybeans are one of the important economic crops in Egypt that contribute to the high growth of the national economy in general, which is considered a necessary need to increase production in order to cover local consumption, (website of the Egypt agricultural channel,2022) soybeans are one of the main important crops that enter into the use of many different purposes, including edible oil and thus contribute to reducing the nutritional gap from liquid vegetable oils in Egypt, which reached 199 thousand tons in 2020, as well as soybeans enter into the production of poultry feed, which is an essential component in these feeds – 1.80 million tons of the soybean crop was used as animal food by 39.10% of the amount available for consumption, which amounted to 4.6 million tons (Egyptian Ministry of Agriculture, Food balance bulletin, 2020), in addition, soybeans are used for many multiple purposes, as it is used in food and is included in the bakery industry in addition to wheat flour and others.

The cultivation of soybeans needs fertile soil, it belongs to legumes, and there is the cultivation of soybean varieties in fertile, well-drained lands with few weeds and yellow lands, and it can be grown in calcareous and sandy lands while avoiding cultivation in Saline, uneven or poorly drained lands or using irrigation water with high salinity and not repeating the cultivation of soybeans on the same plot of land annually so as not to help spread diseases (Egyptian Ministry of Agriculture, guidelines bulletin for soybeans, 2005). Despite this and the great economic importance of the soybean crop, Egypt suffers from a large agricultural gap and Egypt imports more than 90% of its annual consumption needs from it. The Egyptian state has moved to expand the cultivation of the soybean crop within the summer crops by including the crop in contractual agriculture to ensure an appropriate profit for the farmer.

Research problem:

The decrease in the cultivated area of the soybean crop and thus the decrease in local production from it, despite the great economic importance of the crop due to the high production costs and the stability of the productivity of the Feddan and thus the low yield per unit area. Although research efforts have found the possibility of reducing costs by about 25%, increasing the productivity of the Feddan by about 30% and achieving a high net per feddan by planting new high-yielding varieties resistant to cotton leaf worm and do not need spraying with pesticides, which saves about 20% of costs, reduces environmental pollution and increases the number of beneficial insects, but the planted area is still low because soybeans compete with many profitable summer crops such as rice.

Research objectives:

The research aimed to study how to increase soybean crop production in Egypt to contribute to reducing the oil gap in Egypt, by studying the development of soybean crop production during the period (2000-2020), and studying the development of the consumption situation of oils in general and soybean oil in particular in Egypt during the same period, and studying the response functions of soybean crop supply using the Nerlove model, for other competing oil crops, as well as for competing summer crops in the agricultural cycle. Methodology and Data sources: the research method relied on the use of descriptive and quantitative methods in analyzing the available data using some criteria of dispersion and centralization such as the arithmetic mean and the coefficient of determination and others. Some delayed distribution models have been used to analyze the supply response of crops such as Nerlove, Fisher and Solo, and calculate the supply elasticity in both the long and short term, and the full response coefficient by focusing on the use of the Nerlove model in the supply response of soybeans for other competing oil crops and for other summer crops in their linear and logarithmic dual image.

The research was based on secondary data published in the bulletins of the Economic Affairs Sector of the Egyptian Ministry of Agriculture and land reclamation and some specialized websites in the field of research.

Theoretical framework:

Supply response function:

It refers to the description of a dynamic, moving relationship between the quantity offered of a particular commodity and its price in light of the change of other factors affecting supply, which means that it is a long-term relationship. In general, the concept of the supply response function refers to the influence of some other factors - other than price - that lead to the response of farmers by increasing or decreasing the planted area of the crop, such as the farm price of competing crops, the net yield of the crop and competing crops for the same agricultural cycle, as well as the production costs of the crop and competing crops, on which farmers rely in their price forecasts. In general, the response of producers to reduce or increase the cultivated area depends on their expectations of prices, as the expected prices depend not only on the prices of the previous year but on a series of previous prices, and also include the yield of the crop and competing crops on the same agricultural patch in the same agricultural loop, and also on the productivity of the previous crop, and on the costs of the crop and competing crops, and these factors directly affect the decisions of producers to reduce or increase the cultivated area of the studied crop or competing crops.

Display response models:

It can be estimated using some models with a distributed time gap through some delay periods (slowing down) for the variable listed in the model, and this shows that farmers make their farm decisions are usually influenced by some variable, the most important of which is the farm price of the crop in the previous year. Thus, the supply response function of any crop can be estimated from the per-feddan productivity, the farm price, the per-feddan costs and the per-feddan yield of the crop itself with a delay period of one year or more. The most important of these models-which were mentioned in the research-are:

(1) Fisher Model: It assumes that the cultivated area is strongly influenced by farm prices in three previous periods, therefore it takes into account the arithmetic average of the farm price in three previous periods. It takes the following form:

$Y_t = a + b_1 x_{1(t-1)} + b_2 x_{2(t-1)} + \ldots\ldots\ldots\ldots + b_n x_{n(t-n)} + U$

Where the:

Y_t = the sown area of the crop in the current year.

$x_{1\,(t-1)\,(t-2)\,(t-3)}$ = the arithmetic average of the farm price for the previous three years.

(2) Nerlove Model: It assumes that the cultivated area is affected not only by previous farm prices but also by the cultivated area in the previous year. Nerlove has developed a partial modification model, which is based on the fact that the area desired to be cultivated is not equal to the actual area, and therefore the function in the final image takes the following form:

$$Y_t = a + b_1 x_{1(t-1)} + b_2 Y_{(t-1)}$$

Where the:

Y_t = area of the crop in the current year.

$x_{1\,(t-1)}$ = farm price of the crop in the previous year.

$Y_{(t-1)}$ = area of the crop in the previous year.

(3) Solo Model: Solo relied in his model on the fact that the independent variable that affect the dependent variable are numerous , and using the laws of compatibility, It arrived at its model, so the function takes the following form:

$$Y_t = a + b_1 x_{1(t-1)} + b_2 Y_{(t-1)} + b_3 Y_{(t-2)}$$

Where the:

Y_t = sown area of the crop in the current year.

$x_{1\,(t-1)}$ = farm price of the crop in the previous year.

$Y_{(t-1)}$ = sown area of the crop in the previous year.

$Y_{(t-2)}$ = sown area of the crop with a delay of two years.

Annual response coefficient (partial adjustment coefficient): Through this coefficient, the degree of responsiveness to variable that can affect the farmer's response in the range to expansion or contraction in the cultivation of the crop under study is estimated, which ranges from zero to the correct one. And is equal to (1 - the slope coefficient of the area with a slowing period of a year.

Full response period (Year): It is the period of time required to achieve the full response of the farmer starting from the year after planting.

Results and Discussion:

Soybean production in Egypt:

1- Development of soybean crop production in Egypt during the period (2000 – 2020):

In table (1) it is clear that the average area planted with soybean crop during the study period amounted to 24.05 thousand feddans, and the standard deviation was 8.38, and the annual growth rate was 5.78%. The average productivity per feddan during the same period was 1.33 tons/feddan, its standard deviation was 0.12, and the annual growth rate was 0.24%. The average total production during the same period was 38.24 thousand tons, its standard deviation was 10.51, and the annual growth rate was 6.04% .

Table (1): Production status of soybean crop in Egypt during the period (2000-2020).

Statement	During the period (2000 - 2020)		
	Average period	standard deviation	Growth rate (%)
Cultivated area (thousand feddans)	24.05	8.38	5.78
Productivity per feddan (ton/feddan)	1.33	0.12	0.24
Total output (thousand tons)	38.24	10.51	6.04

Source: Ministry of Agriculture and land reclamation, economic affairs sector, agricultural yield statistics bulletin, miscellaneous issues

2- Soybean production in Egypt in the year "2020:

The area planted with soybeans in Egypt reached 29.95 thousand feddans, and the productivity per feddan reached 1.204 tons/feddan, and the total production reached 36 thousand tons, in 2020.

The Consumer situation of liquid vegetable oils in Egypt:

Vegetable oils are extracted from several crops, the most important of which are soybeans, sunflower, sesame, peanuts, cottonseed and others. And in this part of the research the Consumer situation of vegetable oils in general and soybean oil in particular was studied. This is as follows:

1- Development of the consumption situation of liquid vegetable oils in Egypt during the period (2000 – 2020): In Table (2) it is clear that the average domestic production of vegetable oils during the period (2000 – 2020) amounted to 209.5 thousand tons, and the standard deviation of 79.49, and the annual growth rate reached 7%. The national average consumption per thousand tons during the same period was 694.14 thousand feddans, and its standard deviation was 251.95, and the annual growth rate was 4%. The average nutritional gap of vegetable oils over the same period was 485.10 thousand tons, and its standard deviation was 203.25, and the annual growth rate was 3%. The average self-sufficiency rate during the same period was 30.23%. The average per capita of vegetable oil during the same period was

8.25 kg/ year, its standard deviation was 2.18, and the annual growth rate was 2%.

2- Consumption situation of soybean oil in Egypt:

The oil is extracted from soybeans with an extraction rate of about 20%, and the rest is included in the composition of feed. In this research, the focus is on studying the consumption situation of soybean oil in Egypt. From Table (2) it is clear that the average domestic production of soybean oil during the period (2000 – 2020) amounted to 117.38 thousand tons, and its standard deviation reached 82.34, and the annual growth rate reached 16%. The average national consumption per thousand tons during the same period was 368.14 thousand feddanss, and its standard deviation was 0.12, and the annual growth rate was 0.24%. The average nutritional gap of soybean oil over the same period was 150.76 thousand tons, and its standard deviation was 141.04, and the annual growth rate was 4%. The average rate of self-sufficiency during the same period was 39.26%. The average per capita soybean oil during the same period was 3.28 kg/year, its standard deviation was 1.44, and the annual growth rate was 2%.

Table (2): Consumption situation of liquid vegetable oils and soybean oil in Egypt during the period (2000-2020).

	Statement	During the period (2000 - 2020)		
		Average period	Standard deviation	Growth rate (%)
Consumer situation of liquid vegetable oils	Domestic production(1) (thousand tons)	209.05	79.49	7
	National consumption (thousand tons)	694.14	251.95	4
	Food gap (thousand tons)	-485.10	203.25	3
	Self-sufficiency rate (%)	30.23	-	-
	Average per capita (kg/year)	8.25	2.18	2
Consumer situation of soybean oil	Domestic production(2) (thousand tons)	117.38	82.34	16
	National consumption (thousand tons)	368.14	141.04	4
	Food gap (thousand tons)	-150.76	110.11	-1
	Self-sufficiency rate (%)	39.26	-	-
	Average per capita (kg/year)	3.28	1.44	2

(1),(2) It includes the production of domestic seeds and imported seeds.

Source: Ministry of Agriculture and land reclamation, Economic Affairs Sector, food balance bulletin, miscellaneous issues.

3- Consumption situation of vegetable oils and soybean oil in 2020:

- **Vegetable oils:**

Production of vegetable oils from local seeds reached 81 thousand tons and the national consumption reached 2032 thousand tons, thus the food gap reached 1951 thousand tons, and the self-sufficiency rate reached 4%. The production of vegetable oils from imported seeds amounted to 413 thousand tons, the gap of which amounted to 1619 thousand tons, and the self-sufficiency rate reached 20.3%. Thus, the domestic production of vegetable oils – including produced from local seeds and imported seeds – amounted to 494 thousand tons, the food gap amounted to 1538 thousand tons, the self-sufficiency rate of which was 24.3%.

- **Soybeans oil:**

Soybean oil productio**n** reached 409 thousand tons, and national consumption reached 608 thousand tons. The nutritional gap of soybean oil amounted to 199 thousand tons, the self-sufficiency rate of soybean oil reached 67.3%, and the average per capita soybean oil reached 6 kg/year.

Statistical estimation of soybean yield response function models:

1- Characterization of the economic and productive variable of the soybean crop used to estimate the response functions:

Table (3) shows that the average annual area planted during the period from (2000-2020) amounted to 24.05 thousand feddans with a growth rate of 5.8%, while the rest of the variable were identified by slowing down the explanatory variable, some in the absolute picture and some in the relative picture of many summer crops competing for the soybean crop in the same agricultural cycle, whether oil crops or others, and according to the simple correlation matrix, the most the remaining variable were deleted because of the linear duplication problem between them and the other variable.

2- Statistical estimation of the supply response functions for the soybean crop:

The supply response functions for the soybean crop in Egypt were estimated during the period (2000-2020) using Fisher, Nerlove and solo models to illustrate the method of each model separately in

the linear form, and many attempts were made for variable in their absolute and relative form, and it turned out that the best model is the multiple regression model in its linear and double logarithmic form to reach a more logical estimate from a statistical and economic point of view, and some proposed attempts were also made for multiple regression in the linear picture of the soybean crop supply response. The study relied in its interpretation of the results on the moral of the model on the one hand, and its consistency with economic logic on the other**.**

Table (3): description of the economic explanatory variable used in estimating the supply response of the soybean crop in Egypt during the period (2000-2020).

Variants	Average period	Growth rate (%)
area planted with soybeans (thousand feddans)	24.05	5.8%
Soybean feddanage (thousand feddans)	23.43	2.6%
Farm price of soybeans slow down (LE/ton)	2946.05	8.7%
Productivity per feddan of soybeans slow down (tons/feddan)	1.32	0.5%
Cost per ton for soybeans (LE)	2212.01	12.6%
Net yield of soybeans (LE / ton)	931.91	24.7%
Cost per ton of corn (LE)	1084.25	12.1%
cost of a ton of sunflower (LE)	1851.03	11.3%
Net yield per tonne of corn (EGP)	585.77	6.8%
Net yield of sunflower ton (EGP)	723.63	16.7%
Percentage of calories between a ton of soybeans and a ton of corn (%)	1.73	0.3%
Caloric ratio between a ton of soybeans and a ton of sunflower (%)	1.00	-1.6%
The ratio of the cost of a ton of soybeans to the cost of a ton of corn (%)	2.00	0.4%
The ratio of the cost of a ton of soybeans to the cost of sunflower (%)	1.13	1.1%
The ratio of net yield per ton of soybeans to net yield per ton of corn (%)	1.34	16.7%
The ratio of net yield per ton of soybeans and net yield per ton of sunflower (%)	1.27	6.8%
The price ratio between a ton of corn, a ton of soybeans (%)	0.59	-0.3%
The cost of a ton of rice (%)	756.60	9.5%
The calorie ratio between soybeans and tomatoes (%)	2.95	2.0%
The ratio of the cost of a ton of soybeans to the cost of a ton of rice (%)	2.69	2.8%
The ratio of the cost of a ton of soybeans to the cost of a ton of tomatoes (%)	8.13	6.8%
The ratio of net yield of tomato ton to net yield of soy (%)	1.46	-14.2%

Source: 1-Ministry of Agriculture and land reclamation, Economic Affairs Sector, Bulletin of Agricultural Statistics, Miscellaneous numbers. 2-Ministry of Agriculture and land reclamation, Economic Affairs Sector, cost and net return statistics bulletin, miscellaneous numbers**.**

Some delayed distribution models have been used to analyze the supply response of the soybean crop, namely the Nerlove, Fisher, and solo models. This is as follows:

The results in Table (4) indicate the response function of the soybean crop supply using the Nerlove model, which shows the response of the farmer to the farm price in the previous year, as increasing it by one LE results in increasing the planted area of the crop in the next year by 3 feddans, assuming the constancy of other factors fixed at a certain level. The results also show that the flexibility of the supply response in the short and long term has reached about 0.367, 0.41, respectively, and this shows that the increase in the farm price by 10% leads to an increase in the cultivated area by 3.6%, 4.1%, respectively, and the annual response coefficient as well as the time period required to achieve a full response in farms reached about 0.89, 1.13 years, respectively, starting from the year following planting. The morale of the model as a whole was also fixed at a morale level of 1%, which is indicated in (F), where it reached 15.52.

As for the Fisher model, it is clear from the same previous table that the most important factors affecting the cultivated area in the current year are the arithmetic average of the farm price for a three-year delay period, since its increase by one LE entails an increase in the cultivated area of the crop in the next year by 4 feddans, assuming that other factors are constant at a certain level, and the significance of the model as a whole is fixed at a significant level of 1%, which is explained in (F) and the value of the determination coefficient is about 64 which means that about 45% of the changes in the cultivated area

in the current year are due to the price and the rest are due to other factors that have not been studied.

Finally, the solo model, where his study shows that one of the most important factors affecting the current cultivated area of the crop is the farm price and the cultivated area with a one-year delay period and the cultivated area with a two-year delay period, as it turns out that there is a direct relationship between the current area and the previous cultivated area with a one-year delay period, and this is consistent with economic logic, while there is an inverse relationship between the current area and the previous cultivated area with a two-year delay period, and this is not consistent with economic logic there is also a direct relationship between the increase in the current area and the farm price in the previous year, and this is also consistent with the economic logic, as the short-term flexibility has reached And the long period is about 0.49, 0.57, which means that an increase in the farm price by 10% leads to an increase in the cultivated area by 4.9%, 5.7%, respectively, and the annual response coefficient is about 0.86 years, as well as the time period required to achieve a full response for farms is about 1.16 years starting from the year after planting. The significance of the model as a whole was fixed at a significance level of 1%, which is indicated in (F), and the value of the determination coefficient reached about 54%.

Table (4) estimating the supply response in the linear image of the soybean crop in different models in Egypt during the period (2000-2020).

Model name	Equations	R2	F	Full response period	annual response factor	long-term flexibility	short-term flexibility
Nerlove for linear image	$Y1 = 12.83 + 0.003X_{(t-1)}+0.113Y_{(t-1)}$ (2.5)* (0.5)	0.64	7.6**	0.367	0.41	0.89	1.13
Fisher linear pictures	$Y1 = 14.28 + 0.004\ X_{(t-1,t-2,t-3)}$(3.9)**	0.45	15.52**	-	-	-	-
Solo for linear image	$Y1=17.32+0.004X_{(t-1)}+0.14Y_{(t-1)}–0.29Y_{(t-2)}$ (3.04)*(0.61) (-1.75)*	0.54	6.69**	0.49	0.57	0.86	1.6

**Significant at 0.01 * significant at 0.05

Annual response coefficient (λ) = 1 - Area regression coefficient with a one-year deceleration period.

Full response period = 1/ λ, $X_{(t-1,t-2,t-3)}$:The average price for three years slows down,

$X_{(t-1)}$: the price slows down a year, $Y_{(t-1)}$: Area deceleration year, $Y_{(t-2)}$: area deceleration two years

Source: 1-Ministry of Agriculture and land reclamation, Economic Affairs Sector, Bulletin of Agricultural Statistics, Miscellaneous numbers. 2- Ministry of Agriculture and land reclamation, Economic Affairs Sector, cost and net return statistics bulletin, miscellaneous numbers.

Statistical estimation of the most important variable affecting the supply response function of the soybean crop in Egypt:

This part of the research deals with the statistical estimation of the most important variable of the response function of the width of the soy crop using one variable with the area slowed down in the linear and logarithmic images, and using several variable with the area slowed down during the period (2000-2020)

First: Statistical estimation using a single variable with the area in the linear image

1- Agricultural price:

Equation (1) in Table (5) shows the significance of the statistical model at the level of significance of 1%, in the linear form, and the determination coefficient shows that 46% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the model under study. The response of the planted area of the soybean crop in the current year is directly proportional to the farm price per ton by slowing down the soybean crop, and the flexibility of the response in both the short and long term to this variable was estimated at 0.367, 0.41 respectively, that is, an increase in the price of a ton of soybeans in the previous year by 10% leads to an increase in the area of the soybean crop in the current year by 3.67%, 4.1% respectively in both the short and long term. The annual response coefficient in the model in the supply response function was 0.89, and therefore the period required to achieve full response in the grower reached 1.13 years starting from the year after planting.

2- Productivity per feddan:

Equation (2) shows the significance of the statistical model at the level of significance of 1%, in the linear form, and the determination coefficient reached 57%, that is, 57% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model. The response of the planted area of the soybean crop in the current year is directly proportional to the per feddan productivity per ton by slowing down the soybean crop, and the flexibility of the response in both the short and long term to this variable was estimated at about 2.05, 1.81 respectively, that is, an increase in the per feddan productivity of soybeans in the previous year by 10% leads to an increase in the area of the soybean crop in the current year by 20.5%, 18.1% respectively in both the short and long term. The annual response coefficient in the model in the supply response function was 0.54, and therefore the period required to achieve full response in the grower reached 1.9 years starting from the year after planting.

3- The price ratio between soybeans and corn:

Equation (3) shows the significance of the statistical model at the level of significance of 1%, and the determination coefficient reached 45%, that is, 45% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model. These results showed that the response of the planted area of the soybean crop in the current year is directly proportional to the price ratio between soybeans and corn per ton by slowing down, and the elasticity of the response in both the short and long term to this variable was estimated at 0.978, 1.1 respectively, that is, an increase in the price ratio per ton of soybeans and corn in the previous year by 10% leads to an increase in the area of the soybean crop in the current year by 9.78%, 11% respectively in both the short and long term. The annual response coefficient in the model in the supply response function was 0.54, and therefore the period required to achieve full response in the grower reached 1.9 years starting from the year after planting.

4- The ratio of the cost of a ton of soybeans to a ton of corn cost:

Equation (4) shows the significance of the statistical model at the level of 1% significance, and the determination coefficient was about 33%, that is, 33% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model. And that the response of the planted area of the soybean crop in the current year is inversely proportional to the cost ratio between soybeans and corn per ton by slowing down, and the flexibility of the response in both the short and long term to this variable was estimated at -0.518 , -1.1 respectively, that is, an increase in the cost ratio between soybeans and corn per ton in the previous year by about 10% leads to a decrease in the area of the soybean crop in the current year by about -5.18%, -11% respectively in both the short and long term, and this is consistent with economic logic. The annual response coefficient in the model in the supply response function was 0.48, and therefore the period required to achieve full response in the grower reached 2.1 year starting from the year after planting.

5- Cost of a ton of rice:

Equation (5) shows the significance of the statistical model at the level of 1% significance, and the determination coefficient reached about 40%, that is, 40% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model. The response of the planted area of the soybean crop in the current year is directly proportional to the cost of a ton of rice for the previous year and this is consistent with economic logic, and the flexibility of the response in both the short and long term of this variable was estimated at 0.189, 0.24 respectively, that is, an increase in the cost of planting a ton of rice in the previous year by 10% leads to an increase in the area of the soybean crop in the current year by 1.89%, 2.4% respectively in both the short and long term. The annual response coefficient in the supply response model was about 0.77, so the period required to achieve a full response in the grower was about 1.3 years starting from the year after planting.

6- Ratio of the cost of a ton of soybeans to a ton of rice:

Equation (6) shows the significance of the statistical model at the level of 1% significance, and the determination coefficient reached about 30%, that is, 30% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model. The response of the planted area of the soybean crop in the current year is inversely proportional to the cost ratio between soybeans and rice per ton by slowing down, and the flexibility of the response in both the short and long term to this variable was estimated at -0.296, -0.8, respectively, that is, an increase in the cost ratio between a ton of soybeans and a ton of rice in the previous year by 10% leads to a decrease in the area of the soybean crop in the current year by -2.96%, -8%, respectively, in both the short and long term, and this is consistent with economic logic. The annual response coefficient

in the model in the supply response function was 0.37, and therefore the period required to achieve full response in the grower was 2.3 years starting from the year after planting.

7- The price ratio between a ton of soybeans and a ton of tomatoes:

Equation (7) shows the significance of the statistical model at the level of 1% significance, and the determination coefficient reached about 35%, that is, 35% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model. The response of the planted area of the soybean crop in the current year is directly proportional to the price ratio between soybeans and tomatoes for the previous year, and the flexibility of the response in both the short and long term of this variable was estimated at 0.466, 0.82 respectively, that is, an increase in the price ratio between soybeans and tomatoes per ton in the previous year by 10% leads to an increase in the area of the soybean crop in the current year by 4.67%, 8.2% respectively in both the short and long term. The annual response coefficient in the model in the supply response function was about 0.57, and the period required to achieve a full response in the grower was 1.7

Table (5): Statistical estimation of the most important variable affecting the response of the soybean crop supply in the linear picture in Egypt during the period from (2000-2020)

Equation	Influencing variable	**Equations**	R2	F	Arithmetic mean	short-term flexibility	long-term flexibility	annual response factor	Full response period
1	Farm price	**$Y1 = 12.83 + 0.003\ x_{(t-1)} + 0.113y_{(t-1)}$ (2.48)* (0.48)**	0.46	7.6**	2946	0.367	0.41	0.89	1.13
2	Productivity per feddan	**$Y1 = -37.6 + 37.3x_{(t-1)} + 0.53y_{(t-1)}$ (3.5)** (3.4)****	0.57	12**	1.32	2.05	1.81	0.54	1.9
3	The caloric ratio between soybeans and corn	**$Y1 = -10.3 + 13.6x_{(t-1)} + 0.46y_{(t-1)}$ (2.39)* (2.61)***	0.45	7.3**	1.73	0.978	1.1	0.48	2.1
4	The ratio of the cost of a ton of soybeans to the cost of a ton of corn	**$Y1 = 24.3 - 6.23x_{(t-1)} + 0.52y_{(t-1)}$ (-1.3) (2.7)***	0.33	4.5**	2	-0.518	-1.1	0.48	2.1
5	The cost of a ton of rice	**$Y1 = 13.9 + 0.006x_{(t-1)} + 0.23y_{(t-1)}$ (1.95)* (0.96)**	0.40	6**	756.6	0.189	0.24	0.77	1.3
6	The ratio of the cost of a ton of soybeans to a ton of rice	**$Y1 = 16.4 - 2.65x_{(t-1)} + 0.63y_{(t-1)}$ (-0.87) (2.7)***	0.30	3.9**	2.69	-0.296	-0.8	0.37	2.7
7	The calorie ratio between soybeans and tomatoes	**$Y1 = 0.32 + 3.8x_{(t-1)} + 0.43y_{(t-1)}$ (1.4) (2.1)***	0.35	4.8--	2.95	0.466	0.82	0.57	1.7
8	The calorie ratio between corn and soybeans	**$Y1 = 0.32 - 33.7x_{(t-1)} + 0.47y_{(t-1)}$ (-2.10)* (2.6)****	0.42	6.4**	0.59	-0.827	-1.6	0.53	1.9
9	The calorie ratio between tomatoes and soybeans	**$Y1 = 29.2 - 40.2x_{(t-1)} + 0.39y_{(t-1)}$ (-2.01)* (2.03)***	0.41	6.2**	0.35	-0.585	-0.96	0.61	1.6

** Significant at 0.01, * significant at 0.05, annual response coefficient (λ) = 1 - Area regression coefficient with a one-year deceleration period،

Full response period = $1/\lambda$, Short - term flexibility (η_s) = β_X (x / y), long-term flexibility (η_L) = η / λ

X_{t-1}: year independent variable slow down, $Y_{(t-1)}$: Area slow down a year,

the average current area of soybean crop = 24.05 thousand feddans

Source: 1-Ministry of Agriculture and land reclamation, Economic Affairs Sector, Bulletin of Agricultural Statistics, Miscellaneous numbers. 2-Ministry of Agriculture and land reclamation, Economic Affairs Sector, cost and net return statistics bulletin, miscellaneous numbers.

8- The price ratio between corn and soybeans:

Equation (8) shows the significance of the statistical model at the level of 1% significance, and the determination coefficient was about 42%, that is, 42% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the model under study. The response of the planted area of the soybean crop in the current year is inversely proportional to the price ratio between corn and soybeans for the previous year, and the flexibility of the response in both the short and long term to this variable was estimated at -0.827, -1.6 respectively, that is, an increase in the price ratio between corn and soybeans per ton in the previous year by 10% leads to a decrease in the area of the soybean crop in the current year by -8.27%, -16% respectively in both the short and long term. The annual response coefficient in the model of the supply response function was 0.53, so the period required to achieve a full response in the farmer was about 1.9 years starting from the year after planting.

9- The caloric ratio between tomatoes and soybeans:

Equation (9) shows the significance of the statistical model at the level of 1% significance, and the determination coefficient was about 41%, that is, 41% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model. The response of the planted area of the soybean crop in the current year is inversely proportional to the price ratio between soybean tomatoes of the previous year, and the flexibility of the response in both the short and long term of this variable was estimated at -0.585, -0.96 respectively, that is, an increase in the price ratio between tomatoes and soybeans per ton in the previous year by 10% leads to a decrease in the area of the soybean crop in the current year by -5.85%, -9.6% respectively in both the short and long term. The annual response coefficient in the model in the supply response function was about 0.61, and therefore the period required to achieve a full response in the grower was about 1.6 years starting from the year after planting.

Second: Statistical estimation using a single variable with the area in the logarithmic image:

1- Agricultural price:

The results of Equation (1) with Table (6) show the significance of the statistical model at the level of significance of 1%, and the determination coefficient indicated that 55% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model, and shows the response of the cultivated area of the soybean crop in the current year to the agricultural price per ton by slowing down the soybean crop as it is directly proportional to it, and the response elasticity reached 0.054, i.e. by increasing the price per ton an increase of 10% from soybeans in the previous year leads to an increase in the area of the soybean crop in the current year by 0.54%. The annual response coefficient in the model for the supply response function was 0.95, so the period required to achieve a full response in the grower was about 1.1 years starting from the year after planting.

2- Productivity per feddan:

Equation (2) in Table (6) shows the significance of the statistical model at the level of significance of 1%, and the determination coefficient indicated that 63% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model, and also shows the response of the cultivated area of the soybean crop in the current year with the per feddan productivity per ton by slowing down the soybean crop as it is directly proportional to it, and the response elasticity reached 0.53, i.e. by increasing the per feddan productivity a 10% increase in the tonnage of soybeans in the previous year leads to an increase in the area of the soybean crop in the current year by 5.3%. The annual response coefficient in the model for the supply response function was 0.47, so the period required to achieve a full response in the grower was about 2.13 years starting from the year after planting.

3- The caloric ratio between soybeans and corn:

The results of Equation (3) of Table (6) show the significance of the statistical model at the level of significance of 1%, and the determination coefficient indicated that 45% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model, and it also shows the response of the cultivated area of the soybean crop in the current year with the price ratio between soybeans and corn per ton by slowing down the soybean crop as it is directly proportional to it, and the response elasticity reached 0.53, i.e. by increasing the price ratio the difference between soybeans and corn per ton of soybeans in the previous year by 10% leads to an increase in the area of the soybean crop in the current year by 5.3%. The annual response coefficient in the model for the supply response function was 0.47, so the period required to achieve a full response in the grower was about 2.13 years starting from the year after planting.

4- The ratio of the cost of a ton of soybeans to the cost of a ton of corn:

The results of Equation (4) with Table (6) show the significance of the statistical model at the level of significance of 1%, and the determination coefficient indicated that 43% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model, and the model also showed the response of the cultivated area of the soybean crop in the current year to the ratio of the cost of a ton of soybeans to the cost of corn to a ton with a slowdown as it is inversely proportional to it, and the elasticity of the response reached 0.56, that is, by increasing the ratio of the cost of a ton of soybeans to the cost of corn in the previous year by 10% leads to a decrease in the area of the soybean crop in the current year by 5.6%. The annual response coefficient in the model for the supply response function was about 0.44, and therefore the period required to achieve a full response in the grower was about 2.3 years starting from the year after planting.

5- The cost of a ton of rice:

The results of Equation (5) with Table (6) show the significance of the statistical model at the level of significance of 1%, and the determination coefficient indicated that 48% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the model under study, and the model showed the response of the cultivated area of the soybean crop in the current year to the cost of a ton of rice by slowing down the soybean crop as it is directly proportional to it, and the elasticity of the response reached 0.47, i.e. an increase in the cost of a ton of rice in the previous year by 10% leads to an increase in the area of the soybean crop in the current year by 2.2%. The annual response coefficient in the model for the supply response function was about 0.78, and therefore the period required to achieve a full response in the farmer was about 1.15 years starting from the year after planting.

Table (6): Statistical estimation of the most important variable affecting the response of the soybean crop in the linear picture in Egypt during the period from (2000-2020).

	Influencing variable	Equations	F	R^2	1- λ full	λ Annu	1/ λ Flexibil
1	Farm price	$lnY1 = -0.44 + \mathbf{0.}43\ lnx_{(t-1)}+0.054\ lny_{(t-1)}$	11.2^{*}	0.55	0.05	0.95	1.1
2	Productivity per	$lnY1 = 0.8\mathbf{9} + 2.20\ lnx_{(t-1)}+0.53\ lny_{(t-1)}$	15.3^{*}	0.63	0.53	0.47	2.13
3	The caloric ratio between soybeans	$lnY1=1.05+0.\mathbf{8}3lnx_{(t-1)}+0.53lny_{(t-1)}$(1.9)**(2.96)**	7.5^{**}	0.45	0.53	0.47	2.13
4	The ratio of the cost of a ton of soybeans to the	$lnY1=1.84–0.67lnx_{(t-1)}+0.56lny_{(t-1)}$(-1.63)(3.12)**	6.8^{**}	0.43	0.56	0.44	2.3
5	The cost of a ton	$lnY1 = 0.59 + 0.29\ lnx_{(t-1)}+0.22\ lny_{(t-1)}$	8.3^{**}	0.48	0.22	0.78	1.15
6	The ratio of the cost of a ton of	$lnY1=1.31–0.28lnx_{(t-1)}+0.67lny_{(t-1)}$(-0.77)(3.1)**	5.2^{**}	0.37	0.67	0.33	3.03
7	The calorie ratio between soybeans	$lnY1=1.1+0.59lnx_{(t-1)}+0.46lny_{(t-1)}$(1.8) (2.39)**	7.2^{**}	0.45	0.46	0.54	1.8
8	The calorie ratio between corn and	$lnY1=1.05–0.82lnx_{(t-1)}+0.53lny_{(t-1)}$(-1.9)*(2.9)**	7.5^{**}	0.45	0.53	0.47	2.13
9	The calorie ratio between tomatoes	$lnY1=1.08–0.59lnx_{(t-1)}+0.46lny_{(t-1)}$(-1.8) (2.4)*	7.2^{**}	0.46	0.46	0.54	1.8

** Significant at 0.01, * significant at 0.05

Annual response coefficient (λ) = 1 - the area regression coefficient with a one-year deceleration period,

Full response period = 1 / λ , ln $x_{(t-1)}$: independent variable slow down year, ln $Y_{(t-1)}$: The area is a year slower

Elasticity in the logarithmic function = (1 – λ), and it is the coefficient of slope of the area variable slowing down.

Source: 1-Ministry of Agriculture and land reclamation, Economic Affairs Sector, Bulletin of Agricultural Statistics, Miscellaneous numbers. 2-Ministry of Agriculture and land reclamation, Economic Affairs Sector, cost and net return statistics bulletin, miscellaneous numbers.

6- The ratio of the cost of a ton of soybeans to a ton of rice:

The results of equation (6) with Table (6) show the significance of the statistical model at the level of 1% significance, and the determination coefficient indicated that 37% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory

variable of the model under study, and the model showed the response of the cultivated area of the soybean crop in the current year with the ratio of the cost of a ton of soybeans to a ton of rice an increase in the ratio of the cost of a ton of soybeans to a ton of rice in the previous year by 10% leads to a decrease in the area of the soybean crop in the current year by 6.7%. The annual response coefficient in the model for the supply response function was about 0.33, So the period required to achieve a full response in the farmer was about 3.03 years starting from the year after planting.

7- The price ratio between soybeans and tomatoes:

The results of equation (7) of Table (6) show the significance of the statistical model at the level of the significance of 1%, and the determination coefficient indicated that 45% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the model under study, and the model also showed the response of the cultivated area of the soybean crop in the current year the price ratio between soybeans and tomatoes slows down as it is directly proportional to it, and the response elasticity reached 0.46, i.e. by increasing the percentage of the price difference between soybeans and tomatoes in the previous year by 10% leads to an increase in the area of the soybean crop in the current year by 4.6%. The annual response coefficient in the model for the supply response function was about 0.54, and therefore the period required to achieve a full response in the farmer was about 1.8 years starting from the year after planting.

8- The calorie ratio between corn and soybeans:

The results of equation (8) with Table (6) show the significance of the statistical model at the level of significance of 1%, in the logarithmic image and the determination coefficient indicate that 45% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model, and the model also showed the response of the cultivated area of the soybean crop in the current year, the price ratio between corn and soybeans per ton slows down as it is inversely proportional to it, and the response elasticity reached 0.53, i.e. by increasing the percentage of the price difference between corn and soybeans in the previous year by 10% leads to a decrease in the area of the soybean crop in the current year by 5.3%. The annual response coefficient in the model for the supply response function was about 0.47, and therefore the period required to achieve a full response in the farmer was about 2.13 years starting from the year after planting.

9- The calorie ratio between tomatoes and soybeans:

The results of equation (9) of Table (6) show the significance of the statistical model at the level of significance of 1%, in the logarithmic image and the determination coefficient indicate that 46% of the changes that occurred in the cultivated area of the soybean crop during the study period are due to the change in the explanatory variable of the studied model, and the response of the cultivated area of the soybean crop in the current year reached the caloric ratio between tomatoes and soybeans with a slowdown as it is inversely proportional to it, and the elasticity of the response reached 0.46, i.e. an increase in the caloric ratio between tomatoes and soybeans and soybeans in the previous year by 10% lead to a decrease in the area of the soybean crop in the current year by 4.6%. The annual response coefficient in the model for the supply response function was about 0.54, so the period required to achieve a full response in the grower was about 1.8 years starting from the year after planting.

Third: Statistical estimation of the soybean crop supply response using several independent variable

The results of Table (7) indicate the statistical estimation of the response of the soybean crop supply using several independent variable with the area slowing down in Egypt during the period from (2000-2020) through several different models, some in the absolute picture and some in the relative picture, such as Area, price, productivity, net yield of soybeans, as well as the price ratio, ton costs, cost ratio, net yield, net yield ratio of linear models to obtain the best logical results from a statistical and economic point of view.

- Equation (1) in the table shows the response of the farmer to both the farm price and the productivity per feddan of soybeans, where the significance of the model was established at 1%, and the determination coefficient indicated that about 70.2% of the change in the area of soybeans is due to the change in the variable explained in the equation, and that the rest of the changes are due to other non-measured factors, the results showed that by increasing the farm price of soybeans by one LE, the area increases by only 2 feddans with the assumption that other factors are constant at a certain level, and that by increasing the productivity per feddan by one ton, the area increases by 46.9 thousand feddans assuming the constancy of other factors at a certain level, and the response coefficient reached The annual period is 0.76 years, while the time period for

achieving a full response for farms is about 1.29 years starting from the year after planting.

- Equation (2) in the table shows the response of the farmer to the price ratio between a ton of soybeans and a ton of corn, where the significance of the model was fixed at 1%, and the determination coefficient indicated that about 46% of the change in the area of soybeans is due to the change in the variable explained in the equation, and that the rest of the changes are due to other non-measured factors, the results showed that by increasing the price ratio between a ton of soybeans and a ton of corn by one LE, the area of soybeans increases by 2.01 thousand feddans, assuming that other factors are constant at a certain level, which is consistent with economic logic, the annual response coefficient also reached 0.55 years, while the time period for achieving a full response has reached The farmer is about 1.81 years old starting from the year after planting.
- As for the results of Equation (3) in the table, the response of the farmer to the costs of a ton of corn is shown, where the significance of the model was fixed at 1%, and the determination coefficient indicated that about 45% of the change in the area of soybeans is due to the change in the variable explained in the equation, and that the rest of the changes are due to other non-measured factors, the results indicated that by increasing the costs of a ton of corn by one LE, the area of soybeans increases by 17 feddans with the assumption that other factors are constant at a certain level, which is consistent with economic logic, and the annual response coefficient reached 0.88 years, while the time period for achieving a full response for farms was about 1.14 years starting from the year after planting
- .Equation (4) in the table also shows the response of the farmer to both the ratio of the costs of a ton of soybeans to the costs of a ton of sunflower, and the ratio of the costs of a ton of soybeans to the costs of a ton of corn, where the significance of the model was fixed at 1%, and the determination coefficient indicated that about 43% of the change in the area of soybeans is due to the change in the variable described in the equation, and that the rest of the changes are due to other non-measured factors, the results showed that by increasing the ratio of the costs of a ton of soybeans to the costs of a ton of sunflower by one LE, the area of soybeans by 21.3 thousand feddans with the assumption that other factors are constant at a certain level, which differs with economic logic, and that with a low percentage of the costs of a ton of soybeans For the cost of a ton of corn by one LE, the area of soybeans increases by 10.5 thousand feddans assuming the constancy of other factors at a certain level, which is consistent with economic logic, and the annual response coefficient reached 0.65 years, while the time period to achieve a full response for farms reached about 1.53 years starting from the year after planting.

Table (7): Statistical estimation of soybean crop supply response using several independent variable with feddans slowing down in Egypt during the period (2000-2020)

		Equations	F	R2		
1	Area, price, productivity and net yield of soybeans	$Y1 = 48.4 + 0.002X_{1(t-1)} + 46.9X_{2(t-1)} - 0.002X_{3(t-1)} + 0.23Y_{(t-1)}$ (2.6)* (3.46)*(-1.6) (1.2)	9.4**	0.70	0.76	1.29
2	Price ratios	$Y1 = -4.9 - 6.2X_{4(t-1)} + 2.01X_{5(t-1)} + 0.44Y_{(t-1)}$ (-0.51)*(2.4)*(2.45)*	4.7**	0.46	0.55	1.81
3	Cost per ton	$Y_1 = 15.7 - 0.007X_{6(t-1)} + 0.017X_{7(t-1)} + 0.12Y_{(t-1)}$ (-1.49)*(1.9)*(0.47)*	4.6**	0.45	0.88	1.14
4	The ratio of costs per ton	$Y_1 = 12.9 + 21.3X_{8(t-1)} - 10.5X_{9(t-1)} + 0.34Y_{(t-1)}$ (1.9)* (-2.04)* (1.6)	4.2**	0.43	0.65	1.53
5	Net return ratio	$Y_1 = 15.8 - 2.8X_{10(t-1)} + 4.6X_{11(t-1)} + 0.23Y_{(t-1)}$ (-1.2)(3.33)** (1.26)	7.2**	0.56	0.76	1.61
6	Net Yield of oil crops	$Y_1 = 18.12 + 0.01X_{12(t-1)} - 0.01X_{13(t-1)} + 0.11Y_{(t-1)}$ (0.44)** (-2.6)*(0.65)	11*	0.67	0.88	1.14
7	The ratio of costs of competing crops	$Y1 = 28.1 - 9.4X_{14(t-1)} + 1.7X_{15(t-1)} + 0.29Y_{(t-1)}$(-2.8)*(3.03)** (1.3)	6.8**	0.55	0.71	1.41

Where the:

(X_1): farm price of soybean crop in LE (X_2): feddan productivity in tons/feddan,

(X_3): net yield per ton of soybeans in LE (X_4): the price ratio between a ton of soybeans and a ton of sunflower,
(X_5): the price ratio between a ton of soybeans and a ton of corn,
(X_6): the costs of a ton of sunflower, (X_7): the costs of a ton of corn,
(X_8): the ratio of the costs of a ton of soybeans to the costs of a ton of sunflower,
(X_9): the ratio of the costs of a ton of soybeans to the costs of a ton of corn,
(X_{10}): the ratio of the net yield per ton of soybeans to per ton of sunflower,
(X_{11}): the ratio of the net yield of a ton of soybeans to a ton of corn,
(X_{12}): the net yield of a ton of sunflower, (X_{13}): the net yield of a ton of corn,
(X_{14}): the ratio of the costs of a ton of soybeans to the costs of a ton of rice,
(X_{15}): the ratio of the costs of Soy for a ton of tomatoes
Source: 1-Ministry of Agriculture and land reclamation, Economic Affairs Sector, Bulletin of Agricultural Statistics, Miscellaneous numbers. 2-Ministry of Agriculture and land reclamation, Economic Affairs Sector, cost and net return statistics bulletin, miscellaneous numbers.

- As for the results of Equation (5) in the table to the farmer's response to the ratio of the net yield of a ton of soybeans to a ton of corn, where the significance of the model was fixed at 1%, and the determination coefficient indicated that about 56.1% of the change in the area of soybeans is due to the change in the variable explained in the equation, and that the rest of the changes are due to other non-measured factors, the results indicated that by increasing the ratio of the net yield of a ton of soybeans to a ton of corn by one LE, the area of soybeans increases by 4.6 thousand feddans, assuming that other factors are constant at a certain level, which is consistent with economic logic, the annual response coefficient also reached 0.76 years, while the time period for achieving a full response reached The farmer has about 1.31 years starting from the year after planting.
- Equation (6) in the table also shows the response of the farmer to both the net yield of a ton of sunflower and the net yield of a ton of corn, where the significance of the model was fixed at 1%, and the determination coefficient indicated that about 67.1% of the change in the soybean area is due to the change in the variable explained in the equation, and that the rest of the changes are due to other non-measured factors, the results showed that by increasing the net yield of a ton of sunflower by one LE, the soybean area increases by 10 feddans, assuming that other factors are constant at a certain level, which differs with economic logic, and that with a decrease in the net yield of a ton of corn by one LE, the area of soybeans increases by 10 feddans assuming constant factors The annual response coefficient reached 0.88 years, while the time period to achieve a full response for farms was about 1.14 years starting from the year after planting.
- Finally, as for the results of equation (7) in the table, the response of the farmer to both the ratio of the costs of a ton of soybeans to the costs of a ton of rice, and the ratio of the costs of a ton of soybeans to a ton of tomatoes, where the significance of the model was fixed at 1%, and the determination coefficient indicated that about 54.1% of the change in the area of soybeans is due to the change in the variable described in the equation, and that the rest of the changes are due to other non-measured factors, the results showed that by reducing the ratio of the costs of a ton of soybeans to the costs of a ton of rice by one LE, the area of soybeans increases by 9.4 a thousand feddans, assuming the constancy of other factors at a certain level, which is consistent with economic logic, and that by increasing the percentage of the cost of a ton of beans Soy costs a ton of tomatoes by one LE, the area of soybeans increases by 1.7 thousand feddans assuming the constancy of other factors at a certain level, which differs with economic logic, and the annual response coefficient reached 0.71 years, while the time period to achieve a full response for farms reached about 1.41 years starting from the year after planting.

Increasing soybean production in Egypt:
The yield of the soybean crop can be increased by:

1- **Increasing the area planted with soybeans:** The reclamation project of one and a half million feddans is one of the leading projects in the field of agricultural development in Egypt to secure food, establish urban communities and create job opportunities for the youth sector (Egypt projects Map website). One of the most important objectives of this project is to increase the agricultural area, restructure the Egyptian countryside and expand the urban space to accommodate the natural increase in population

growth by creating integrated and modern urban communities, and planting crops that help bridge the food gap, which generates a huge financial return to the country. Thus, part of this area can be used to grow the soybean crop and reduce the food gap from it, thereby reducing the amount of imports from it.

2- **Loading the soybean crop with Levantine corn:** It is good to load the Levantine Durra with soybeans in fertile lands that are well drained, ventilated and free of salinity, where both Levantine corn and soybeans are grown. Loaded soybeans are planted with Levantine corn 2-3 weeks before the planting of Levantine corn, and soybeans are planted on the irrigation of the cultivation of Levantine corn. There are two loading systems (Ministry of Agriculture, Central Administration for agricultural extension, Bulletin of loading soybeans with Levantine corn, 2014), namely:

- **The First system (2 corn lines : 2 soybeans lines interchangeably):** It achieves a high productivity of corn and LEs than soybeans by approximately the equivalent (75% corn, 55% soybeans) compared to the single cultivation of both crops.
- **The second System (2 corn line : 4 soybeans line interchangeably):** It achieves a high productivity of soybeans and LEs than corn by approximately the equivalent (50% corn, 85% soybeans) compared to the single cultivation of both crops.

Applying the above to the current situation of the area planted with Levantine corn in Egyptian lands, it turned out that the area planted with Levantine corn in Egypt in 2020 amounted to 2.15 million feddans, and the average productivity per feddan was 3.300 tons/feddan, and the total production reached 36.06 thousand tons. The area planted with Levantine corn in the old lands (highly fertile, well ventilated and drainage) amounted to 1.89 million feddans, and the average productivity per feddan was 3.315 tons/feddan, and the total production reached 35.8 thousand tons.

From Table (8), it was conceived to load corn at the rates of 25%, 50%, 75% of the area planted with the Levantine corn crop in the summer in the ancient lands of Egypt-good fertility and drainage – and it was found that the production of the potential soybean crop was increased from its current equivalent, thus reducing the food gap and increasing both the rate of self-sufficiency and the amount of imports of soybeans compared to those values in 2020, as follows:

(A) In the case of the Loading System (2 corn line: 2 soybeans line):

- **When applying the loading system to (25%) of the area planted with Levantine corn:** It is expected that both the nutritional gap of soybeans in Egypt and the amount of imports from it will decrease by 6.86% and 7.37%, respectively, compared to their counterparts in 2020. It is expected that the self-sufficiency rate will increase to 7.59% compared to the same in 2020, which was 0.78%.

In Table (8): the possible economic variable of the soybean crop when following the systems of loading the soybean crop with Levantine corn in the ancient lands (good fertility) in Egypt and comparing them with the same in 2020.

Relative loading of soybeans with sorghum corn	The percentage of land on which beans were loaded with Levantine corn	Soybean production in 2020 (Thousand tons)(1)	Potential production of soybeans (in Thousand Tons)(2)	Total output (In Thousand Tons) (3)= (1)+(2)	Available for consumption of soybeans in 2020 (thousand tons) (4)	The nutritional gap of soybeans in 2020 (in Thousand Tons)	Possible nutritional gap (In Thousand Tons) (5)=(4)-(3)	Percentage change (%)	Soybean self-sufficiency rate in 2020 (%)	Potential self-sufficiency rate of soybeans (%)	The amount of soybean imports in 2020 (in Thousand Tons)	The amount of potential imports (in Thousand Tons)	Percentage change (%)
2 Sweet Corn : 2 soybeans	25%	36	313	349	4597	-4561	-4248	6.86	0.78	7.59	4561	4248	7.37
	50%		626	662			-3935	13.7		14.4		3935	15.
	75%		939	975			-3622	20.6		21.2		3622	25.9
2 Sweet Corn : 4 soybeans	25%		482	518			-4079	10.6		11.27		4079	11.8
	50%		965	1001			-3596	21.2		21.77		3596	26.8
	75%		1447	1384			-3114	31.7		32.26		3114	46.5

Source: 1-Ministry of Agriculture and land reclamation, Economic Affairs Sector, Bulletin of Agricultural Statistics, 2020.

2-Ministry of Agriculture and land reclamation, Economic Affairs Sector, food balance bulletin, 2020.

3-Ministry of Agriculture and land reclamation, central administration for agricultural extension, Bulletin of loading soybeans with Levantine corn, 2014.

- **The case of loading on (50%) of the area planted with Levantine corn:** It is expected that both the food gap of soybeans in Egypt and the amount of imports of it will decrease by 13.7% and 15.9%, respectively, compared to their counterparts in 2020. It is expected that the self-sufficiency rate will increase to 14.4% compared to the same in 2020, which amounted to 0.78%.
- **In the case of loading on (75%) of the area planted with Levantine corn:** It is expected that both the nutritional gap of soybeans in Egypt and the amount of imports from it will decrease by 20.6% and 25.9% each, respectively, compared to their counterparts in 2020. It is expected that the self-sufficiency rate will increase to 21.2% compared to the same in 2020, which amounted to 0.78%.

(B) In the case of the Loading System (2 corn line : 4 soybeans line):

- **In the case of loading on (25%) of the area planted with Levantine corn:** It is expected that both the nutritional gap of soybeans in Egypt and the amount of imports of it will decrease by 10.6% and 11.8% each, respectively, compared to their counterparts in 2020. It is expected that the self-sufficiency rate will increase to 11.27% compared to the same in 2020, which amounted to 0.78%.
- **In the case of loading on (50%) of the area planted with Levantine corn:** It is expected that both the nutritional gap of soybeans in Egypt and the amount of imports of it will decrease by 21.3% and 26.8%, respectively, compared to their counterparts in 2020. It is expected that the self-sufficiency rate will increase to 21.77% compared to the same in 2020, which was 0.78%.
- **In the case of loading on (75%) of the area planted with Levantine corn:** It is expected that both the food gap of soybeans in Egypt and the amount of imports of it will decrease by 31.7% and 46.5%, respectively, compared to their counterparts in 2020. It is expected that the self-sufficiency rate will increase to 32.26% compared to the same in 2020, which amounted to 0.78%.

Recommendations

1. It is recommended to increase awareness activities of the importance of the soybean crop in order to encourage and expand its cultivation horizontally and vertically, and the cultivation of new high-yielding varieties resistant to cotton paper worm, and do not need spraying with pesticides, which saves about 20% of costs, in addition to reducing environmental pollution.
2. Support the Projects Development Authority for projects to establish small presses to expand in those projects and work on their spread near the production sites.
3. When planting soybeans in the new lands, logistic zones can be established that include production and manufacturing rings as well as marketing to form an integrated system for the production, processing and marketing of extracted oils.
4. Continuing and expanding the application of contractual cultivation of the soybean crop at favorable prices - taking into account production costs - in order to ensure that farmers are encouraged to grow the crop.
5. Work on the application of loading systems with other agricultural crops, especially the Levantine corn crop, in order to benefit each other and to ensure the achievement of high productivity of soybeans.

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