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Impact of Intercropping System on Egyptian Food Security and Balance of Trade

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Abstract : Food shortage is one of the major problems which faces Egypt due to the limited cultivable land area and the growing increase in population. By applying intercropping as one of the agricultural intensification systems , Both descriptive and quantitative statistical methods have been applied, The research aims to investigate the possibility of intercropping some of the major crops with other crops that cultivate the same time period, The core objective is to estimate the volume of production that can be attained from the intercropped plants in the main Governorates which are cultivate the two intercropped plants , and the consequent reduction in deficit in Egypt's Balance of Trade.

Returns expected from intercropping some plants: Production Quantity of intercropping of wheat, soybeans, maize, broad beans and tomatoes are 746.3, 225.38, 4451.5, 207.9, 28.78 (Thousand tons) respectively, and the decline percentage in the imports quantity are 10.9%, 42.9%, 92.0%, 66 %, 106.6%, and the imports value is decreased for wheat, soybeans, maize and broad beans can be reduced by 3.827, 0.587, 1.94 and 0.177 billion US$, respectively. In addition to tomato exports which generate increased around 70.94 million US$(surplus). Total revenue obtained from the intercropping of these plants is around 6.441 billion US$, From what proceeded, the following can be concluded It is important to adopt intercropping as one of the main farming methods used to raise production per plot of agricultural land. It is highly recommended to raise farmers' awareness about the importance of intercropping wheat with cotton.

Key words: Balance of Trade - Food Security- Intercropping.

Introduction

Food shortage is one of the major problems Egypt faces due to the limited cultivable land area and the growing increase in population, which jointly resulted in difficulties to provide the population's food needs despite adopting modern agricultural methods to attain the highest possible yields from agricultural crops to meet the increasing demand for food. Therefore, turning towards adopting intensification is believed imperative in the light of the continuously changing variables that are becoming harder year over year. It is worth mentioning that intensification aims to achieve optimum use of all available resources that can be used to attain the highest possible productivity per unit of land area, which can be achieved by applying intercropping as one of the agricultural intensification systems [1].

Intercropping is defined as the cultivation of two or more crops simultaneously in the same field. It also means growing quick-maturing vegetables between widely spaced, longer-term crops to make efficient use of the cultivated land area. However, it might lead to some competition between the intercropped plants during all or part of the season. Therefore it is very important to carefully select the plants to be intercropped with the

main crop so that their environmental needs do not contradict with the needs of the main crop. There are several methods of intercropping, some of them include intercropping some crops with maize, intercropping soybeans with maize, tomatoes with maize, relay intercropping of potatoes with maize, intercropping peanuts with maize, sorghum with maize, cowpeas with maize, wheat with cotton, and wheat with tomatoes , Harmony between the conducted agricultural operations is one of the necessary conditions for intercropping in order to achieve the hoped for agronomic advantages per unit of cultivated land area [2].

Research Problem

In the light of the currently existing limited agricultural land area, it is very difficult to increase the areas planted with strategic and main crops like wheat, broad beans, soybeans, and maize, the demand for which has been increasing, leading to a widening gap between production and consumption.

Methodology and Sources of Data

Both descriptive and quantitative statistical methods have been applied to achieve the research objectives, the methodology is Applying the proposed intercropping system in the main Governorates which are cultivate the two intercropped plants as (Kafr el-Sheikh - Behira -Bny Suef - Fayoum – Al sharkeia - Al Gharbia - Dakahlia) Governorates to increase the production and decrease the gap between production and consumption, Data used have been collected from the Bulletin of Agricultural Economics and Statistics published by the Ministry of Agriculture and Land Reclamation, Egyptian Food Balance Sheet, the Central Agency for Public Mobilization and Statistics, in addition to some electronic websites and published researches.

Research Objective

The research aims to investigate the possibility of intercropping some of the major crops with other crops that share the same time period, require the same agricultural operations, and do not contradict in terms of nutrition needs. The core objective is to estimate the volume of production that can be attained from the intercropped plants in main Governorates growing the two intercropped plants, and the consequent reduction in deficit in Egypt's Balance of Trade.

Cultivation under Intercropping:

Before cultivation, the field area must be divided into raised beds, usually 90-120 cm wide, with 4-5 rows arranged 15-cm apart on top of each bed where wheat is sown first during November. In March, after weeding, cotton is sown on the two ridges of each bed, at 25 to 30-cm distance between the rows. The last irrigation of wheat shall be the first for cotton, after which wheat is harvested and left on top of the beds until dry and transferred out of the field. Irrigation during wind blows should be avoided in order to avoid plant dormancy.

Wheat should be harvested after full maturity. The best harvesting time is before sunset or early morning to avoid deseeding or breaking of wheat spikes, and to maintain the emerging cotton seedlings during May until finishing wheat harvesting at the beginning of May in Upper Egypt, and at Mid-May in Lowe Egypt. Cotton picking, which starts in September, is one of the most important agricultural operations that affect cotton rank and quality standards. Therefore, picking should be conducted twice [3].

Results :

First: Intercropping Wheat with Some Crops:

1. Intercropping Cotton with Wheat

Besides considered major strategic agricultural crops, wheat and cotton are two of the main crops grown during the winter and summers seasons. This is due to the fact that cotton ranks first in terms of Egyptian exports of field crops, whereas wheat is one of the most important winter crops grown for food consumption but unfortunately production volume does not cover domestic consumption. That is why the Government of Egypt strives to curb the food gap in wheat by implementing several programs that aim to raise wheat production, either through vertical or horizontal expansions.

Intercropping wheat with cotton is regarded important due to many reasons; the following are some of them:

- Raising productivity of food crops grown during the winter season (i.e., wheat) without disrupting the implemented cropping pattern by sowing cotton seeds under wheat on two sides of the ridge in hills.
- Raising productivity per unit of land area.
- Raising and distributing economic return all year round, and evading dependency on one crop.
- Evading infestation of cotton bolls with spinal and pink worms by early cultivation.
- Minimizing the risk of cotton infestation with leafminers, cutworm, aphids and thrips.

The following are the results of intercropping cotton with wheat:

Wheat is usually planted over 65% of the cotton area, in which case wheat production per unit area is equivalent to 65% of the Wheat alone cultivated area. Accordingly, results presented in Table (1) indicate that total wheat production at the level of main Governorates in which the two crops are grown amounted to 472.3 thousand tons, which covers only part of the imports. As such, wheat produced under this method is worth 3066 million US$ based on the import prices of 2014.

2. Intercropping of Wheat with Winter Tomatoes

Winter tomato is a very important vegetable crop that generates high economic revenue. It grows well in most of the Egyptian Governorates. And due to the limited natural resources available for agricultural crops, namely land and water, in addition to the high cost of production inputs like labor (human and mechanical), fertilizers, pesticides, etc., some modern agricultural policies aim to utilize such resources in cultivating more than one crop in the same time by intercropping some crops with the main crops. Such method leads to increasing the cropped area and saving some production resources for growing other crops [3].

The following part presents results of studying the economic impacts of intercropping wheat with winter tomatoes over 97611 feddans in Old Lands, [4] Table (1). Under this system, wheat is intercropped over the whole area, where tomatoes are grown over raised beds, whilst wheat is grown at the two sides of each bed. As a result wheat yield per feddan in each Governorate equals productivity in that Governorate multiplied by the area under winter tomatoes in the corresponding wheat production Governorate. Accordingly, total wheat production obtained from intercropping with tomatoes amounted to 274 thousand tons, which covers of total wheat imports about 761 million US$ from the burden on the balance of trade, which is the saved value of wheat imports based on 2014 price [5].

Based on the achieved results, the following recommendations are offered:

1. Raising farmers' awareness about the importance of intercropping wheat with cotton, especially in fertile Old Lands.
2. Expansion in conducting experiments on wheat intercropping with winter tomatoes for successive years in order to evaluate the economic efficiency of this cultivation system.
3. Expansion in conducting studies on crop cultivation under intercropping in order to come up with effective recommendations that help in raising crop production at the national level.

Second: Intercropping Some Crops with Maize

Maize is considered number one as the intercropped plant for several reasons, including:

1. The large area where maize is grown, which allows the application of a full intercropping plan.
2. The cultivation of maize on one side of the row gives a greater chance for better utilization per unit of land area due to the fact that it posses distinguished biological, morphological and physiological characteristics compared to other crops, which makes it able to compensate plant intensity, yield higher production under monoculture production, and convert light energy into dry matter [6].

Maize Cultivation Under Intercropping:

Maize is grown in all well-drained non-saline soils. It grows well in clay soil and clay loamy good texture soil, as well as sandy good fertilized soils. Land is prepared for cultivation by plowing twice orthogonally then planned at a rate of 10 lines in each two reeds. After that, the land is divided into strips so that the length of each strip is no longer than 7 meters. The rows are then connected to convertors to control the irrigation process. The most appropriate time for maize seeding starts from mid-May until Mid-Jun, where early cultivation leads to good growth of the maize plant, and reduces infestation with borers. Delay until after mid-Jun leads to obvious reduction in maize yield.

Advantages of Intercropping legumes with maize:

Bacterial Inoculation of Some Intercropped Plants; Leguminous crops intercropped with maize, like **Broad Beans**, soybeans, Green beans, peanuts and cowpeas, are treated individually, where N-fixing rhizobia bacteria supply plants with most of their needs from this ingredient, leading to reduction in nitrogen fertilization rates, higher yield, improved crop quality, higher protein content in the seeds, in addition to improved soil fertility and environmental protection. Therefore, it is considered an important agricultural operation. In case intercropped with soybeans, it is preferred to adopt dry seeding of maize in rows at the bottom third of the used ridge, in 30-40 cm distant holes[6].

1. Intercropping Soybeans with Maize

This method aims to increase soybeans area, yield per unit area, curbing the gap in oilseeds, increasing land utilization rate, and raising economic return. It is preferred to use short hybrid varieties of white and yellow maize.

As regards soybeans, it is preferred to use short, high yielding, disease resistance, early mature varieties like Giza 21, Giza 111, Giza 82, Giza 83 and Giza 35.

Soybeans should be seeded three weeks before maize. In case seeding time is delayed, soybeans should be planted with maize. It is preferred to grow soybeans under wet farming on the same irrigation used for maize. Soybeans seeding should not be delayed after the end of May and Jun, 15th, and Maize too [7].

There exist several methods for intercropping soybeans with maize, some of which are listed below:

1. The system (2 maize:2 soybeans) is used for short maize varieties.
2. The system (2 maize:3 soybeans or 2 maize:4 soybeans) is used for triple hybrid varieties.
3. Intercropping in the middle of raised beds.

System No. 1: (2 maize:2 soybeans)

This system is adopted to realize high yield from maize, and lower yield from soybeans (about 75% of maize and 55% of soybeans compared to monoculture).

Under this system, maize is grown on two lines interchangeably with soybeans. Dry seeding is used for cultivating maize in 40-cm distant holes on two lines, leaving two lines for soybeans. In order to ensure accurate distances, location of each hole is determined in the water course by putting a handful of ammonium sulfate fertilizer at 40-cm distance "the same distance as holes". Maize is then seeded using the hopper, where dust falling from the holes covers the fertilizer, ensuring that maize seeding in the two lines is done. The number of seeds is usually about 5-6 seeds per hole, where thinning of the two plants will be an ongoing process until harvesting. After that, the whole land area is intensively irrigated, including the two lines reserved for soybeans due to the fact that it is usually planted under wet farming. After appropriately dry, soybeans is seeded in two rows per lines using the hopper (one row on top of the ridge, and the second is on the slope of the ridge that is not facing the cultivated maize) so that dust can be transferred from the idle ridge to the used ridge to support maize sticks. Soybeans can be grown before maize in case there is enough time for planting the two crops. In this case the whole land area is intensively irrigated, and at the time of plowing soybeans is sown on the two assigned lines like previously described, whereas maize is seeded with the first or second irrigation of

soybeans using the previously described farming method, taking into consideration that seeding is never delayed after mid-Jun.

System No. 2: (2 maize : 4 soybeans)

In case the producer wishes to realize higher yield from soybeans and lower yield from maize (about 50% of maize and 85% of soybeans compared to monoculture system), maize is grown on two lines interchangeably with four lines of soybeans using the previously mentioned farming methods, except that the distance between holes is 40 cm. In addition, two plants must be left in the hole when thinning.

System No. 3

This system is adopted in North Egypt(in Disouk of Kafr ElShiekh Governorate and Qattor of Gharbia Governorate)Under this system, soybean is grown on90-cm wide raised beds. After the first or second irrigation of soybeans, maize is seeded in the two ridges,in50-cm distant holes in the middle of the bed, leaving two plants in each hole. Planting should never be delayed after mid-Jun[7].

Application of Intercropping Models of Soybeans with Summer Maize

Table (1)is presents the results of intercropping soybeans with summer maize in the main Governorates producing the two crops under the first intercropping system. Area under summer maize amounted to some 1223.352 thousand feddans, [(4)] on which soybeans is intercropped. Total achievable production amounted to 885.437 thousand tons in case monoculture, where total production under intercropping is estimated at 225.38 thousand tons ,The percentage increase of about 55% compared to monoculture system production, by using the same region and yield. this production covers a part of the imports volume about 586.7 million US$ based on 2014 data [5].

In case the second intercropping system is applied, where soybeans production accounts for 85% of the quantity produced under monoculture system, soybeans produce is estimated to reach 568.403 thousand tons, which covers the whole imports volume of soybeans saves ranges about560- 660 million US$. However, maize production is expected to account for 50% of the quantity produced under monoculture system. Therefore, other methods should be explored to provide the difference, estimated at 2668.9 thousand tons in Old Lands. The domestic production of maize in Egypt reached about 51% from the total consumption. In 2014, it reached about 3.32 million tons and the imports' amount reached about 4.80 million tons at the same year by imports' value that amounted about 1940 million dollar [8].

2. Intercropping Tomatoes with Maize

The program of intercropping maize with tomatoes aims to promote the production of summer vegetables without negatively affecting the area under field crops grown in the summer cropping pattern, in addition to increasing yield per unit area and economic return, reducing environmental pollution, resisting weeds (through cultivation without services and higher plant intensity), besides rationalizing irrigation water use, fertilization, and service operations, which eventually reduces production costs.

Under this system tomato is grown on the same bed at a rate of 100% relative to normal intensity, whilst maize is intercropped at a rate of 60-70%. Summer tomato is grown during late March until late April. Early mature, high yielding, disease resistant hybrid varieties must be selected for cultivation. Maize is planted 1-1.5 months after planting tomatoes. Tomato must be properly irrigated before planting maize. After the end of harvesting season maize should be irrigated as per the technical recommendations each 15-12 days. Tomatoes must be picked when starting to get colored such that the level of maturity is appropriate for domestic marketing or exports. Maize matures after 100-120 days from the day of planting, according to variety and planting time. After maturity, cobs are harvested, peeled and transferred for drying.

Table (1) is presents the potentials of intercropping summer tomato with summer maize on areas in the Governorates where the two crops are grown together. It is clear that maize planted area amounted to 1592.3 thousand feddans in Old Lands, [(4)] yielding 26630 thousand tons of tomatoes. However, in case tomato is intercropped with maize in New Lands, tomato production reached around 2153.8 thousand tons from an area of 396.7 thousand feddans, which is a total tomato production reached 28784 thousand tons, a quantity that can

be destined for exports at a price of 766 US$ per ton [(5)] to raise Egyptian exports of tomatoes and earn hard currency.

Maize grown under this system yields only 70% from the same area, whilst tomato yields 100%, just like it is grown under monoculture system. and maize produced is estimated at 3736.5 thousand tons. But when Tomato areas can also be saved for growing maize in order to raise maize production thus cut maize imports. In this case, maize produced is estimated at 715 thousand tons (in case of area under summer tomato is estimated at 238.4 thousand feddans, and assuming that average yield is about 3 tons/feddan).

Third: Intercropping Broad Beans with Tomatoes

The Government of Egypt is seeking to achieve self-sufficiency in broad beans during the next five years by increasing production to more than half a ton per Currently annum, production obtained from the grown crop covers only 30% of the population's consumption needs in Egypt, whereas the remaining 70% is covered by imports. Although most of the quantity imported from western countries is mainly "horse been" variety, which is a type of beans grown for feeding horses and animals not humans, importers seek to import this variety due to its cheap price, where it is sold for LE 4/kg compared to LE 8/kg of the domestic varieties [9].

Therefore the National goal is how raise the broad beans planted area to 370 thousand feddans in order to reach a production volume of 540 thousand tons over the next five years, which is the quantity required for achieving self-sufficiency in broad beans in Egypt.

Studies proved that per capita consumption of broad beans in Egypt is estimated at 6kg/annum. The policy makers are focus on crop intensification by intercropping broad beans with sugar cane plantation in Upper Egypt, and with tomatoes in Fayoum Governorate, and with sugar beet too, in addition to finding new areas for cultivating broad beans without encroaching the areas devoted to wheat cultivation.

Results of Studying the Intercropping of Broad Beans with Winter Tomatoes

The study aims to assess the impact of intercropping broad beans with tomatoes at some of the Governorates in which the two crops are grown. It is clear from Table (1) that tomato planted areas in Old and New Lands are estimated at 97.6 and 69.4 thousand feddan, respectively. [(4)] The intercropping of broad beans with winter tomatoes resulted in yielding 207.9 thousand tons covering 66% of the imported quantity, estimated at 313 thousand tons in 2014, [(9)] saving around 17.7 million US$ for the Balance of Trade, thanks to intercropping with winter tomatoes only. It is worth noting that several studies proved the success of intercropping broad beans with tomatoes. Moreover, applying this system protects tomatoes from frost, leading to higher production due to warming, in addition to obtaining a better quality of the produced tomatoes.

Based on the studies conducted by the Agricultural Research Center, the current study highly recommends planting disease-resistant varieties like Sakha 1, Sakha 2, Sakha 3, Sakha 4, improved Giza 3, Giza 716, and other varieties that stand broomrape like Giza 843, Mist 1, Mist 3, and drought tolerant varieties like Nubaria 1, Nubaria 2 and Nubaria 3 [7].

Discussion :

Expected Returns from Intercropping Some Plants:

Studying the relative importance of foreign agricultural trade clear that average value of trade over the period 2009-2014 amounted to 9613.28 million US$ [10]**.**

Table (1) is indicates the returns expected from intercropping some plants. as the values of wheat, soybeans and maize imports can be reduced by 3.827, 0.587 and 1.94 billion US$, respectively. In addition, increased tomato exports can generate around 70.94 million US$. As such total revenue obtained from the intercropping of these plants is around 6.441 billion US$, in addition to the previously mentioned 17.7 million US$ saved from cutting broad beans imports due to intercropping with winter tomatoes in some Governorates.

Table (1) Cultivated area, The expected Production Quantity of intercropping, Egypt's imports and exports of the most important food commodities in 2014.

Crop	Cultivated area of Main Crops (Thousand fedden)	imports quantity (Thousand tons)	Expected Production Quantity of intercropping (Thousand tons)	%The decline percentage in the imports quantity	value of savings as a result of intercropping (million dollars)	Direction of trade
Wheat	3555.50	6821	746.3	10.9	3827	imports
Soybean	1223.352	525	225.38	42.9	586.7	imports
Maize	2947.302	4840.8	4451.5	92.0	1940	imports
Tomato	1988.597	27	28.784	(Surplus) 106.6	70.49	exports
Broad bean	1670.36	313	207.9	66.4	17.7	imports
Total Revenue					6441.89	

Source: Central Agency for Public Mobilization and Statistics - Food Balance Bulletin Arab Republic of Egypt in 2013.

From what proceeded, the following can be concluded:

- It is important to adopt intercropping as one of the main farming methods used to raise production per plot of agricultural land, and to save some of the agricultural inputs used to grow the two intercropped plants, by raising awareness about the role plays through agricultural extension services.
- It is highly recommended to raise farmers' awareness about the importance of intercropping wheat with cotton, especially in fertile Old Lands.
- It is recommended to expand the experiments and evaluation of intercropping wheat with winter tomatoes over successive years in order to identify the economic efficiency of adopting this method.
- It is recommended to conduct studies on intercropped plantations in order to reach effective recommendations that help in raising production from plants grown under this system at the national level.

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