PRODUCTIVITY AND FIBER TECHNOLOGICAL PROPERTIES OF TWO EGYPTIAN COTTON VARIETIES UNDER SOLID AND INTERCROPPING CULTURES

By

ABDULSAMAD HASHIM NOAMAN
B.Sc. Agric. Sci. (Horticulture), Fac. Agric., Baghdad Univ., Iraq., 1989
M.Sc. Agric. Sci. (Agronomy), Fac. Agric., Anbar Univ., Iraq., 2001

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APPROVAL COMMITTEE

Dr. SAAD HASSAN ABOUKHADRAH……..……..………..……
Professor of Agronomy, Fac. Agric., Kafr El-Sheikh University

Dr. MAZHAR MOHAMED FAWZY ABDALLA……....…..……
Professor of Agronomy, Fac. Agric., Cairo University

Dr. SAYED AHMED SAFINA...………...
Assistant Professor of Agronomy, Fac. Agric., Cairo University

Dr. ABD EL-ALIM ABD EL-RAHMAN METWALLY…....
Professor of Agronomy, Fac. Agric., Cairo University

Date: 16 / 9 / 2014

SUPERVISION SHEET

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SUPERVISION COMMITTEE

Dr. ABD EL-ALIM ABD EL-RAHMAN METWALLY
Professor of Agronomy, Fac. Agric., Cairo University

Dr. SAYED AHMED SAFINA
Assistant Professor of Agronomy, Fac. Agric., Cairo University

Name of Candidate: Abdulsamad Hashim Noaman **Degree:** Ph.D.
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Supervisors: Dr. Abd El-Alim Abd El-Rahaman Metwally
Dr. Sayed Ahmed Safina
Department: Agronomy **Branch:**
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ABSTRACT

Two field experiments were conducted at Giza Agric. Exp. & Res. Sta., Fac. of Agric., Cairo Univ., Giza governorate, Egypt, during 2011 and 2012 summer seasons to study the productivity and fiber quality of two Egyptian cotton varieties under solid and mixed cultures, as well as, farmer's benefit. Mixed intercropping pattern (120 cm ridge width) was used in this study for growing both crops, maize plants were growing in four plants per hill at 70 cm spacing of middle of ridge after one month of growing cotton, whereas, cotton plants were sown in both sides of the ridge by growing two plants per hill distanced at 20 cm apart, in addition to recommended solid plantings of both crops. Two Egyptian cotton varieties (Giza 80 and Giza 86), as well as, one maize variety (S.C. 30k08) were used. Three maize treatments were used under intercropping and solid plantings. A split split plot design in randomized complete block arrangement was used. The most important results could be summarized as follow: There are gradual and consistent increases in seed cotton yields per plant and per feddan under solid cotton plantings in comparisons with mixed pattern. Cotton variety Giza 80 had higher values of seed cotton yields per plant and per feddan in comparison with the other variety. Harvested maize plants for green fodder caused significant increment in seed cotton yields per plant and per feddan as compared with intercropped cotton plants with harvested maize plants for grains. Cotton cultivar Giza 86 had higher fiber parameters than the other under intercropping and solid cultures. Fiber properties were not affected significantly by cropping cultures. Recommended maize solid planting had the highest grain yields per plant and per feddan as compared with the other cropping systems. Grain yields per plant and per feddan were not affected by cotton varieties and maize treatments. Land equivalent ratio (LER) ranged from 1.45 to 1.98 with an average of 1.69. Net return of intercropping maize with cotton varied between maize treatments from 4079 to 7578 L.E. per feddan as compared with recommended solid planting of cotton (1798 L.E.).

Key words: Intercropping, maize, cotton, fiber properties, LER, farmer's benefit

DEDICATION

I dedicate this work to my great country Iraq, country of the civilization and the knowledge, Castle of Lions and Kaaba of the glory and the immortality

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Special deep appreciation is given to my father, my mother, my wife, my son, my brothers and sisters.

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INTRODUCTION

The increase of production and productivity of the smallholders, through cultivation of cash and food crops, have been one of the great priorities in Egypt last years, because the current production system of the agriculture sector has been unable to answer the demand in terms of food and income sources. Cotton (*Gossypium* spp.) is the most important fiber crop in the world; the lint is used to make processed cotton, which is woven into fabrics, either alone or combined with other fibers. The seeds contain acceptable percentage of edible oil and the residual cake is rich in proteins and used for cattle feed. The seed shells can be used as raw fodder for animals as straw, or as fuel. The indeterminate growth habit of cotton plants makes them very responsive to changes in the environment and management. Seed cotton yield and fiber qualities may be significantly altered by a number of agronomic practices.

Leaves of cotton remain perpendicular, or mostly so to the impinging sunlight. Cotton cultivar could play an important factor to escape from shading effects of maize plants of different species where there were significant differences between cotton cultivars in some traits of growth, yield and its attributes under intercropping conditions. Cultivar selection accounts for 75% of fiber length variation, whereas 51% micronaire variation is attributed to weather and management with only 25% determined by genetics (Meredith, 1986). Cotton quality data obtained from the Mississippi River valley delta region for twentythree years showed that inferior quality (staple length and micronaire) is highly correlated with the introduction of new cultivars (Barnes and Herndon, 1997).

Unfortunately, the cultivated area of cotton (*Gossypium barbadense* L.) plants in Egypt decreased from about one million feddan in 1982 to 323 thousand feddan in 2012 (Egyptian Bulletin of statistical Cost production and Net Return, 2013) as a result of increased production cost and lower net return as compared with other summer crops, i.e. maize, rice, …etc. On the other hand, the demand for the maize (*Zea mays* L.) grains in the Egyptian market is intensively increasing where maize cultivated area reached about one million and 900 thousand feddan in 2012. However, the feed shortage is during high summer season where some Egyptian farmers have to use maize as fodder or stripping leaves of maize for animal feeding and consequently the degree of maize yield reduction is directly proportional to the percentage of leaf area destroyed. Cutting three upper leaves of maize plant affects total grain dry matter (Imam, 1997), but forage maize has become a major constituent of ruminant rations in recent years, where its inclusion in dairy cow diets improves forage intake, increases animal performance and reduces production costs (Anil *et al*., 2000).

Egyptian farmers are developing different crop production systems to increase productivity and sustainability since ancient times. Plants in intercrops grow differently from plants in single crops, due to inter-specific plant interactions, but adaptive plant physiological responses to competition in mixed stands have not been studied in detail. Intercropping is the best way to keep the area of cotton without significant change in crop structure. Consequently, crop species in intercropping pattern must be carefully chosen to minimize competition and enhance the efficient use of water, light and nutrients (Sayed Galal *et al*., 1983). Accordingly, intercropping is recommended to increase total agriculture products in Egypt from 50 years ago (Metwally, 1999). Plant growth may be limited either because of lack of sufficient light, water, and nutrients in the environment or because of competition for these resources from other plants (Friday and Fownes, 2001). On the other hand, although shading of maize plants reduced photosynthetic capacity of cotton in mixed intercrop pattern (Metwally *et al*., 2012), but leaves of Egyptian cotton are tracking the light throughout the day; this is because the cotton plant leaves are arranged in the form of helix, which encourages cotton on the reception of light. Variations in intercropping are based on the timing of sowing and harvesting both crops, and the degree of mixing/separation of the crops.

In view of the previous, intercropping patterns, cotton varieties and the purpose of maize production may have impact on the amount of intercepted sunlight radiation by intercropped cotton plants. So, the objective of this work was to evaluate the productivity and fiber quality of two Egyptian cotton varieties under intercropping with maize and solid cultures, as well as, farmer's benefit.

REVIEW OF LITERATURE

Agriculture is the basic activity by which humans live and survive on the earth. The agricultural sector still faces structural weakness and at present only 3.5% of Egypt’s land qualifies as agricultural land. Agriculture is practiced on an area of about 8.0 million feddan (about 3.5 million ha), including recently reclaimed lands (Abdelhakam, 2005). At this juncture, it is important to identify the shortcomings and constraints associated with the Egyptian agriculture, review the initiatives taken by the state to address the issues and suggest suitable options to adopt to realize sustainable agriculture and rural development.

Sustainable agriculture is more efficient in the use of resources such as soil and water, and is in balance with the environment conditions. It must be ecologically appropriate, economically justified and socially desirable. The Egyptian farmers look to other crops with high profitability like maize, and this is one of the main reasons that led to the intercropping maize with cotton. So, the literature of this study will be divided as follows:

1. A brief overview on

a. Some important cotton problems

For many centuries, agriculture has remained one of the major sectors of the Egyptian economy. Egyptian cotton produces a natural vegetable fiber that is used in the manufacturing of cloth. It is preferred around the world because it is long fiber cotton that makes it softer and stronger at the same time. No doubt, industrialization continues to depend largely on agricultural production. Import restrictions to safeguard the competitiveness of Egyptian cotton are not in place and clothing factories have favored imported textiles and fabrics over local merchandise because of their lower prices. Moreover, Egyptian factories are currently unequipped to manufacture anything but short-staple cotton and there are lacks in a clear agricultural strategy that links local and international market demand to Egyptian agriculture situation.

The most pressing problem facing Egypt's cotton crop is dwindling land areas on which it is grown. The reason behind the decrease in cotton land area is that farmers are no longer interested in the crop because of inconsistent pricing policies. Egyptian cotton continues to face several challenges which have led to an obvious deterioration in its status on the international market. Farmers cannot face the challenges of international markets and the sudden changes in prices. Farmers are increasingly losing interest in cotton production because of high input costs and because it is sensitive to international economic downturn as a result of its forward linkages with the textile industry.

On the other hand, the feeding system is considered one of these problems that affect the productivity of cotton at the national level in summer season. It is considered one of the key factors which play an important role in animal development and improvement (El-Nahrawy, 2008). Egypt depends mainly on Egyptian clover (berseem) in the winter season. Consequently, there is a balance between dairy cattle and crop production and that is an excellent example of an integrated production system in the winter season where green fodder crops and agricultural residues provide the feed for animals, while there is imbalance between dairy cattle and crop production in the summer season where amount of green fodder yields is low during this period, especially the cotton crop remains more than 6 months in the field.

b. Some important maize advantages

The growth of some crops and varieties, which require long hours of daylight to reach maturity, is also limited by the invariable day lengths of the tropics. Solar radiation, which is critical to plant growth, and whose intensity is controlled by the angle of the sun, day length, and cloudiness, is lower in winter and higher in summer in temperate zones. For smallholder farmers with limited production capacity, finding enough feed in the summer months to maintain good meat and milk production is always a problem in Egypt.

Maize has a high photosynthesis efficiency which is made possible by the specialized anatomical and biochemical features that enable a so-called "C_4"photosynthesis. As a C_4 plant, maize responds well to both high temperatures and intense sunlight. Maize has a wider range of uses. These include human food, industrial processed food production of starch and used as green forage or silage to feed animals. The major reason maize has spread so widely is its ability to produce high yields of grain under a wide variety of climatic conditions. Most maize grain produced is used as animal feed; in less developed countries it is, however, also a staple food. Green forage demand for rapidly expanding livestock industry is increasing day by day. Maize plant as a whole is an important forage for many dairy and beef animals.

On the other hand, grain filling is strongly dependent on photosynthetic activity after anthesis. Stripping leaves can affect the maturity of maize. A much earlier study by Stickler and Pauli (1961) compared varying stripping leaves intensity applied at different growth stages. Hicks *et al.* (1977) showed that stripping leaves before tasseling resulted in increased ear moisture at harvest and delayed maturity, while stripping leaves following tasseling hastened maturity. Also, Johnson (1978) reported that early stripping leaves at the five-leaf stage delayed silking and pollination. However, optimum yield and quality of maize forage has been reported shortly after 50% kernel milkline (Wiersma *et al*., 1993).

Stripping leaves, in optimum conditions, has been shown to reduce crop yield, and yield reduction is greatest if leaf removal coincide with the pollination stage (Rajewski and Fracncis, 1991; Board, 2004 and Yang and Midmore, 2004). Harvesting three leaves 20 days after sowing (growth stage 2) and no stripping leaves treatments on sorghum plant recorded the highest values for vegetative dry matter, leaf area and seed weight. Stripping leaves treatments had no effect on plant height and stem diameter of the sorghum plant. Therefore, based on the findings farmers are urged to guard against late stripping leaves on the development of the sorghum plant since this will impact negatively on the yields and to some extent compromise the plant growth with regard to leaf area and vegetative dry matter (Legwaila *et al.,* 2013).

Also, silage is considered the better way to conserve forage crops. Silage is very palatable to livestock and can be fed at any time. Maize is commonly fed to livestock as fodder stover or silage (Christopher *et al*., 1966). The feeding of maize fodder is popular in the semi-arid, as well as, in areas where maize often fails to reach the stage of mature grain. The stalks of the crop at this stage are more palatable and higher in protein than other stages (John and Warren, 1967).When maize is grown for silage it is harvested 2–3 weeks earlier than maize harvested for grain. However, Pain (1978) reported that since maize is the most suitable crop to be grown for silage in temperate countries, forage maize become one of the most important feed stuff for ruminants specially cattle (Rouanet, 1987).

2. Importance of intercropping

It is clear that Egyptian cotton as the strategic crop is under stress and the farming sector needs to make certain changes and adjustments in the Egyptian production systems. One of the key strategies in the agricultural production systems is intercropping. It has been increasingly investigated in recent years because of the enhanced interest in sustainable practices. Row intercropping, mixed intercropping, strip intercropping and relay intercropping are most important systems of intercropping. Intercropping system is a type of mixed cropping and defined as the agricultural practice of cultivating Kassam, 1976 and Sanchez, 1976).

This system leads to increase in level of biological diversity over much of the farm and productivity per unit area which leads to lower cost of production and higher profits without any increase in the use of water duty for these farms. Some Egyptian researchers have designed a method for assessing intercrop performance as compared to pure stand yields (Sayed Galal *et al*., 1979 and Sayed Galal and Metwally, 1982). The features of an intercropping system differ with soil, local climate, economic situation and preferences of the local community (Steiner, 1982). Individual crop yields sometimes could decrease because of a lack of knowledge about cultural practices or because of environmental limitations (Brown *et al.*, 1985). Accordingly, intercropping culture acts as an insurance against failure of crop in abnormal year. One important reason intercropping is popular in the developing world is that it is more stable than monocropping (Horwith, 1985).

3. The basic components of a successful intercropping pattern

Farmers practice intercropping with a wide array of crops, consisting ordinarily of a major crop and other insignificant crops, however, it is pertinent that the selection of compatible crops be given priority as this depends on their growth habit, land, light, water and fertilizer utilization (Thayamini and Brintha, 2010). The choice of crop combination is key to successful intercropping (Ijoyah and Fanen, 2012). Incompatibility factors such as planting density, root system and nutrient competition need to be considered (Ijoyah and Jimba, 2012).

Success of an intercropping pattern depends on the ability of the second crop to become established under the canopy of the first crop in variable midsummer conditions. Selecting a second crop as a cereal crop to replace some cotton ridges under solid cotton cultures is a critical task where competition of C_3 plants as cotton for environmental resources is less than C_4 plants as maize under an intercropping pattern. Plants which grow together frequently compete primarily for solar radiation. In this case, spatial arrangement of intercropping pattern, sowing and maturity dates of both crops and maize plant density per unit area could be playing an important role to minimize the adverse effects on intercropped cotton plants in different ways.

a. Spatial arrangement

The literatures indicated variable results in response to different intercropping patterns (Sayed Galal *et al.*, 1979 and 1983). Efficient use of solar energy for photosynthesis is important for plant growth and survival, especially in low light environments which caused by using any intercropping pattern. Penetrated light intensity through intercrops is potentially influenced by spatial arrangement of intercropping patterns. Cotton plants can grow between maize hills on the same rows, interplanted on separate rows or interplanted on the same rows. There are at least two basic spatial arrangements used in intercropping maize with cotton plants in Egypt. Most practical patterns are variations of the following:

• Row intercropping, it is commonly observed that there was a decrease in intercropped seed cotton yield per unit area as compared with solid culture of cotton (Kamel *et al.*, 1990; Mohamed and Salwau, 1994 and Metwally *et al*., 2012).

• Mixed intercropping, it is a newly released pattern used by Metwally *et al*. (2012) which produced the highest yield of maize and cotton as compared with alternating ridges.

b. Sowing and maturity dates

Selection of intercrop is one the basis of duration of crop growth and development. Variations in intercropping are based on the timing of sowing and harvesting, and the degree of mixing/separation of the crops. The period between planting cotton and some cereals, *i.e*., sorghum or maize plants may have important role for increasing intercropped seed cotton per unit area. Fryrear (1981) mentioned that the sorghum plants sown on 15^{th} June reduced cotton yields by 22 – 38 %, while, the sorghum plants sown on 15^{th} July did not reduce cotton yields as compared with solid culture of cotton plants. Also, planting cotton with maize plants in the same date increased the adverse effect of intercropping pattern as compared with other date, *i.e*. maize was sown after cotton planting three weeks later (Abo-El Nour, 1989 and Metwally *et al*., 2012).

Planting intercrops that feature staggered maturity dates or development periods takes advantage of variations in peak resource demands for nutrients, water and sunlight. Having one crop mature before its companion crop lessens the competition between the two crops. Competition for light should be low among the component crops. The biggest complementary effects and biggest yield advantages occur when the component crops have different growing periods so make their major demands on resources at different times (Ofori and Stern, 1987).

c. Maize plant density

Increasing maize plant density results in enhanced crowding stress for all plants of the same or different species within an intercropping pattern. Plant population and row width affected the relative amount of light energy which was absorbed by both plants and soil. When the component crops are present in approximately equal densities, production is often determined by the more aggressive crop, usually the cereal. Most crops become more competitive, however, as their proportional contribution to total intercrop density increases (Willey and Osiru, 1972). Hence, the plant architecture is a commonly used strategy to allow one member of the intercropped plants to capture sunlight that would not otherwise be available to the other. Total system light interception is determined by crop geometry and foliage architecture (Trenbath, 1983). The transformed material from the third leaf under the maize is reported from 1 to 66 percent, 20 days after flowering (Anderew and Petersn, 1984). Consequently, cutting leaves with low intensity and at the end of growth cycle does not develop meaningful reduction in aggregation of dry matter (Tilaoun, 1993). Maize number and row number was not affected by any treatment but the time of cutting leaves have effects on grain number per row (Allison, 1995).

Accordingly, maize canopy architecture (spatial distribution of shoot organs) plays an important role in the amount of sunlight radiation that is intercepted by cotton plant under intercropping pattern, and light proved as a critical competition factor in intercropping culture (Abd El-Aal and Mohamed 1988; Kamel *et al*., 1990; Abdel-Malak *et al*., 1991 and Metwally *et al*., 2012). It is expected that resulting efficiency due to these activities affects disadvantages resulting from cutting some leaves and retrieves its yield, therefore leads to dual application of more maize, for instance determining the role of top and down leaves which mirror their feedback to shadow and competition, can lead to investigation of intercropping with other plants.

Increased maize plant density, as well as, decreasing distance between hills of maize plants resulted in adverse effects on growth and yield of cotton plants but the appropriate distribution for maize plants per unit area under intercropping conditions may minimize such effects. Spatial distribution of plants and their growth habits apparently tended to reduce the expected differences in net radiation. In intercropping between high and low canopy crops is to improve light interception and hence yields of the shorter crops requires that they be planted between sufficiently wider rows of the taller one (Seran and Brintha, 2010).

In general, it could be concluded that high maize population densities led to serious reduction in number of open bolls per plant and seed cotton yield per plant under intercropping pattern, where Kamel *et al*. (1990) showed that average number of total bolls per plant, seed cotton yield per plant and per fad, as well as, lint percentage were increased as maize plant densities decreased in intercropping combinations, while, number of open bolls per plant and seed index were not affected. Moreover, Sahid *et al.* (1990) grew cotton plants at 40 000, 60 000 and 80 000 plants/ha, as well as, maize between the cotton rows at 25 cm spacing in the row. They reported that seed cotton yields were 0.96, 0.93 and 0.89 t per ha at populations of 40 000, 60 000 and 80 000 plants per ha, respectively. Furthermore, Mohamed and Salwau (1994) grew cotton in hills 20 cm apart under an intercropping pattern with maize spaced 30, 60 or 90 cm apart, as well as, given 70, 95 or 120 kg N per fad. They indicated that the highest seed cotton yield was obtained by sowing maize plants at 60 cm between hills and supplying with 120 kg N per fad in both seasons, but this system reduced seed cotton yields by 8 and 31% as compared with sole-cropped cotton in 1990 and 1991, respectively.

However, Azevedo *et al.* (1997) intercropped cotton plants at a density of 2 500, 5 000 or 10 000 plants per ha with maize variety BR 106 at densities of 5 000, 10 000 or 20 000 plants/ha. They mentioned that increasing the density of maize plants reduced significantly yield of cotton. Also, Azevedo *et al.* (2000) investigated the effects of plant population on yield, its components and agronomic efficiency of perennial cotton (*Gossypium hirsutum*) and maize (*Zea mays*) intercrops. They showed that yield of perennial cotton was decreased with increasing maize population, but maize plant population did not affect cotton fiber qualities. Moreover, Metwally *et al.* (2009a) revealed that number of open bolls/plant, seed cotton yield (*Gossypium barbadense)* per plant and per fad were decreased by decreasing distance between maize hills from 70 to 35 cm., whereas, boll weight was not affected.

In view of the previous presentation, a successful intercropping pattern mostly depends on some basic points to maximize production and minimize competition between the maize and cotton plants under intercropping conditions such as spatial arrangement of intercropping pattern, sowing and maturity dates of both crops and maize plant density per unit area which have the greatest positive impact on the ability of cotton crop to become established under maize canopy.

4. Intercropping maize with cotton

Performance of maize and cotton plants under different intercropping patterns is a potential "biological efficiency" built into these patterns either cotton plants between maize hills on the same rows or interplanted on separate rows. Disadvantage of intercropping as compared with sole crops may be occurred (Crookston and Hill, 1979 and West and Griffith, 1992). Obviously, complementary should exist between the component crops under intercropping culture. The choice of compactable crops depends on the plant growth habit, land, light, and water and fertilizer utilization (Brintha and Seran, 2009). To maximize production and minimize competition between cotton and maize plants, the two crops under intercropping conditions need to be studied as follow:

a. Maize plant

Intercropping is a common practice in some countries of the world despite the recommendation that the cash crop be planted in pure stand for maximum benefits. However, cereal plants like maize can be harvested at optimal phase of development and are efficiently used by livestock under intercropping conditions. Maize with its large number of cultivars and different maturity periods has wider range of tolerance to different environmental conditions (Purseglove, 1972). Direct and indirect effects of mutual shading in an intercropping system on forage quality, morphological development and forage yield have been reported. These differences may have resulted from species variation, length of shading period, change in leaf-to-stem ratio or environmental conditions (Buxton and Fales, 1993). There are two factors that affect yield in relation to incident radiation in an intercropping system, the total amount of light intercepted and the efficiency with which intercepted light is converted to dry matter (Keating and Carberry 1993).

Munro (1958) showed that there was a decrease in grain yield per unit area of intercropped maize with cotton than planting it alone, where, the grain yield was 1877.5 and 2904 lb per acre, respectively, for the two cropping systems (mixed and sole cropping). However, Abd El-Aal and Mohamed (1988) intercropped maize with cotton plants in two patterns (1:1 and 1:2 alternating ridges, respectively), as well as, solid cultures of maize and cotton plants. The results indicated that intercropping maize with cotton had no significant effect on shelling percentage, while, ear weight, 100-kernel weight and grain yield per feddan were affected significantly in two seasons. Also, they added that number of ears per plant was increased slightly by intercropping maize with cotton without significant differences in two seasons.

Madiwalar *et al.* (1989) studied the effect of applying 100 or 150% of the recommended NPK rate (80 kg N + 40 kg P_2O_5 + 40 kg K_2O/ha) to cotton variety 170 CO-2 and 0, 50, 100 or 150% of the recommended NPK rate (40 + 20 + 20 kg/ha) to maize grown in an intercropped stand with one crop on each side of a 75 cm flat ridge on seed cotton and maize yields. They demonstrated that maize grown in pure stands with 100% recommended NPK rate gave maize grain yield of 2.68 t per ha, but in intercropped stands, maize yield was 2.17-2.68 t/ha.

Daware *et al.* (2004) intercropped cotton with black gram, soybean, cowpea, sateria at 1:1 ratio, pigeon pea at 6:1 ratio, and sorghum and maize at 2:1 ratio, respectively. They revealed that among intercrops, maize recorded the highest yield. In addition, Khan and Abdul Khaliq (2004) studied performance of different summer fodders as intercrops in cotton plants. Cotton plants were planted in 80 cm space single rows and 120 cm spaced double row strips, while, maize, sorghum, ricebean and cowpea fodders were intercropped in the space between 80 cm apart single rows, as well as, 120 cm spaced double row strips of cotton. They detected that the maize intercropped at 120 cm spaced double row strips of cotton produced significantly higher fodder yield (+22.77 %) than that grown in 80 cm spaced single rows of cotton. However, intercropped maize in double row strips gave significantly lower yield than that obtained from the sole crop.

Abo-El Nour (1989) showed that intercropping maize with cotton plants had no significant effects on ear weight and 100-kernel weight in both experiments, while, grain yield per plant was increased under intercropping pattern as compared with maize in solid culture. On the other hand, Umrani and Pharande (1979) detected that sorghum grain yield per unit area was reduced by 18% by intercropping sorghum with cotton as compared with sorghum alone, but cotton plant had no significant effects on fodder production. Also, Ghaly *et al.* (1988) intercropped maize with cotton plants in two patterns (1:1 and 1:2 alternating ridges, respectively), as well as, solid cultures of maize and cotton plants. They indicated that solid culture of maize plants produced higher grain yield/unit area as compared with intercropped maize with cotton plants. Furthermore, Hosny *et al.* (1989) showed that height of first ear of number ears per plant were not affected significantly by intercropping maize with cotton plants.

On the other hand, Abdel-Malak *et al.* (1991) intercropped maize with cotton plants in two systems, *i.e*. planting one ridge of cotton plants on both sides alternating with one ridge of maize and planting two ridges of cotton plants on both sides alternating with one ridge of maize, as well as, solid cultures of maize and cotton plants. They found that grain yield per unit area was decreased significantly by intercropping maize with cotton plants. While, Metwally *et al.* (2009a) found that the highest intercropped maize grain yield per plant was obtained by growing three cotton ridges alternating with one maize ridge (3:1) as compared with the other cropping systems, whereas, solid planting of maize gave the highest grain yield per feddan.

b. Cotton plant

The relationships among cotton lint yield and its components are complex. The components are influenced by genetic and environmental variation and by the interaction between both. The primary lint yield components that contribute to lint yield like of bolls per unit area, seeds per boll and lint per seed (Worley *et al.*, 1974). Lint, seed and seed cotton biomass are closely related to the number of bolls per unit area (Wells and Meredith 1984).

There are a number of external factors which cause the physiological shedding of buds and bolls of cotton plant such as intercropping which plays an important role in the levels of shading intensity on cotton plant during growth and development stages. Shading promotes shedding of reproductive organs in cotton (Eaton and Ergle, 1954). Also, Munro (1958) mentioned that there was a decrease in intercropped seed cotton yield per unit area as compared with growing cotton alone, where, seed yield of cotton was reached 618.5 and 956 lb per acre for mixed and sole cropping, respectively. Moreover, Madiwalar *et al.* (1989) showed that cotton plants were grown in pure stands with 100% recommended NPK rate gave seed cotton yield of 1.99 t per ha, but in intercropped stands with maize, seed cotton yield reached 0.94 - 1.28 t/ha.

In another study, Ghaly *et al.* (1988) demonstrated that intercropping maize with cotton plants had no significant effect on number of open bolls per plant, boll weight, seed cotton yield per plant, seed index and lint percentage. In addition, Abo-El Nour (1989) detected that number of open bolls per plant, seed cotton yield per plant and per fad were reduced seriously by intercropping maize with cotton plants, but boll weight, seed index and lint percentage were not affected by intercropping patterns. However, Kamel *et al.* (1990) showed that number of total bolls per plant, seed cotton yield per plant and per fad, as well as, lint percentage were affected significantly by intercropping patterns, while, number of open bolls per plant and seed index were not affected.

However, Memon and Malik (1980) observed that the highest seed cotton yield per unit area was obtained by growing cotton plants alone (611.13 lb per acre), while, intercropped seed cotton yield was reduced to 208 – 307 lb per acre. On the other hand, Khan *et al.* (2001) studied the effect of different intercropping patterns on yield and its components of cotton (*G. hirsutum*). Cotton plants were sown in 2 patterns, *i.e*. 80 cm space single rows and 120 cm space 2-row strips. Mung bean, mashbean, soybeans, sesame, maize, sorghum, cowpea and ricebean plants were intercropped in space between the cotton rows/strips, the next day after sowing of cotton. They demonstrated that planting patterns had no significant effect on seed cotton yield per unit area, but intercropping patterns affected significantly seed cotton yield. Moreover, Metwally *et al*. (2009b) in Egypt concluded that seed cotton yield per plant and per feddan were affected significantly by cropping systems, where, solid cultures of cotton gave higher seed cotton yield per plant and per fad than intercropping cultures.

However, Mohamed *et al*. (1986) reported that number of open bolls per plant and seed cotton yield per plant were increased significantly by intercropping maize with cotton plants, but plant height and lint percentage were not affected. Higher seed cotton yield per fed was obtained under intercropping pattern 1:1 (one ridge of maize alternating with one ridge of cotton sown on both sides). Also, Hosny *et al*. (1989) showed that number of open bolls per plant was not affected by intercropping maize with cotton plants, except seed cotton yield per fed. On the other hand, Abdel-Malak *et al.* (1991) indicated that number of open bolls per plant, seed cotton yield per plant and per fed were decreased significantly by intercropping maize with cotton plants, while, lint percentage and seed index were not affected.

5. Differences of cotton varieties

Egypt's year round moderate climate is perfect for cotton plantation and gives it a superior quality. Egypt produces three different categories of cotton (extra long staple, long staple, medium and short staple cotton). Egyptian cotton is of the highest quality and well renowned for its long fiber and thin yarn. Longer fibers enhance the quality of yarn, and the thin yarn allows higher thread counts per square inches. Another factor that contributes to the unique quality of Egyptian cotton is that it is hand-picked, which reduces the stress on the fibers and preserves the cotton far better than mechanical picking.

As a result, the sheets made from Egyptian cotton are soft, strong and durable.

Variation in the growth habit and maturity of cotton (*Gossypium barbadense* L.) varieties is a complicating factor in cultivar testing. Cotton cultivar selection, a key management component in any cropping system, is even more critical in ultra-narrow row cotton production. Most common cause of low productivity is the cultivation of inferior varieties (Masood *et al*., 1992). Theoretically, each variety has an optimum management system that is different from other varieties. In a study of eight transgenic cultivars, yields for cotton planted in ultra-narrow rows were higher than conventional row spacings (Witten and Cothren, 2000). Seed cotton yield, lint yield, and gin turnout were different among row spacings and cultivars (Jones, 2001).

Cotton varieties could play an important factor to escape other plants of the same species (intra-specific competition) or integrate with different species (inter-specific competition) from some difficult intercropping conditions. Thus, such varieties may possess different mechanisms to tolerate the intercropping conditions. The efficient use of basic resources in the cropping system depends partly on the inherent efficiency of the individual crops that make up the system and partly on complementary effect between the crops (Willey and Reddy, 1981).

Also, fiber strength is largely determined by genotype such that cultivars with the highest strength tend to produce longer cellulose molecules providing fewer break points in the lint and greater cross linkages between fibers (Jordan, 2001). However, Bryant *et al*. (2003) found that yields (in 3 of the 5 site-yr), were not statistically different for most or all of the cotton cultivars tested. On the other hand, cotton growth and maturity are altered by cultivars, seasonal management and environmental conditions (Gwathmey and Craig, 2003).

Early maturing cotton cultivars allow timely removal from the field (Faircloth, 2007). Moreover, Musa and Mustafa (2012) recorded that significant differences for boll weight and high significant differences were also recorded for weight of lint per boll, seed cotton yield, plant height and number of bolls per plant among ten Egyptian cotton cultivars and experimental lines. No significant differences were observed among genotypes for seed index, number of seeds per boll and weight of seed cotton per boll. The results indicated that 94-B-2 experimental line had an average seed cotton yield advantage of 19% over Barakat-90, with fiber length of 35.1, micronaire value of 3.7 and fiber strength of 37.5 better than Barakat-90. It gave 52% of its yield in the first pick compared to 44% for Barakat-90.

6. Cotton fiber technology

Understanding the biological properties of cotton fiber is critical to improving fiber quality. Cotton fiber quality depends on cotton fiber properties which grown under different light intensities. Cotton fibers are elongated epidermal cells initiated on seed ovules. Development consists of four phases of growth: initiation, primary elongation, secondary wall formation and maturation (DeLanghe, 1986). These stages are influenced by environmental, genetic, physiological and biochemical factors and the combination of various fiber quality properties contribute to the overall economic value (Bradow and Davidonis, 2000).

Cotton classification, or classing, is the process of describing the quality of cotton in terms of such properties as grade, staple length and micronaire. Classification is essential to the cotton pricing systems and is required for high-level quality control in textile production. In the past the classing of grade and staple was done by hand and eye. Cotton is an indeterminate plant, vegetative development continues during formation of reproductive structures. Cotton fiber yield is the product of the number of bolls produced, the dry weight of each boll, and dry weight percentage of fiber contained within each boll.

Environmental factors have a significant impact on the fiber technology traits. High temperatures can increase rates of metabolic processes and cause more rapid fiber development; shortening the time between fertilization and boll opening (Ehlig, 1986), while cool temperatures can delay fiber initiation and early elongation (Haigler *et al.*, 1991). In addition, improved light resources have been shown to increase fiber yield through boll number per plant (Pettigrew, 1994). Consequently, shading, and the associated reduction in assimilate supply, reduces fiber yield and quality (Pettigrew, 1996). Reduced light (63%) significantly decreased photosynthesis and carbohydrate concentrations in leaves and bolls, resulting in increased fruit abscission and decreased fiber quality (Zhao and Oosterhuis, 1998).

Accordingly, selecting this crop as C_3 plants to intercrop between C_4 plants on the same ridge is a critical task where competition of C_3 plants as cotton for environmental resources especially solar radiation is less than C_4 plants as maize but ridge width and early harvested maize plants could be playing an important role to minimize the adverse effects of mixed intercropping pattern. Leaves of *Gossypium barbadense* “track” the light throughout the day. The various ways of plants interact with light as affected by both the environment and neighboring vegetation and results in reflected, reradiated, scattered, and direct sunlight. Sensing mechanisms include both red/far-red (phytochrome) and blue (cryptochrome and phototropin) absorbing pigments.

Several studies demonstrated that intercropping maize with cotton plants had no significant effects on cotton fiber properties (Abd El-Aal and Mohamed, 1988; Ghaly, 1988; Mohamed and Salwau, 1994 and Metwally *et al*., 2012). Now, all cotton quality characteristics are measured by instruments. The high-volume instrument (HVI) system was developed to objectively measure important fiber properties. The HVI classification system currently consists of instrument measurements of fiber length, strength, length uniformity, micronaire and color, as well as the presence of extraneous matter (trash). Since 1991, 100% of the US crop is graded by the HVI system. Neps may also be considered for applications where visual appearance is important. Several fiber properties are important to the mill and many are affected by how the gin is operated. These fiber properties are:

a. Cleanness

Cleaning involves the removal of both moisture and trash, but it also means the loss of some marketable fiber.

b. Length

Cotton fiber length is an important component of quality as defined by the textile industry. Cotton fiber length varies genetically and any sample of cotton fiber shows an array, or distribution, of fiber length. *Gossypium barbadense* plants typically produce longer fiber than *Gossypium hirsutum* plants. There may be a relationship between the amount of indole 3 acetic acid (IAA) present during primary elongation and final fiber length (Clement *et al.*, 2012). Moreover, environmental factors can influence the final fiber length. The HVI reports fiber length as the mean length of the longer half of the fibers in the sample (the upper-half-mean, length) in hundredths of an inch. Three length properties are important: (1) staple length or the average length of the longer half of the fiber; (2) the percentage by weight of the fibers shorter than half an inch, referred to as short fiber content (SFC); and (3) length uniformity index (UI) or the average fiber length as a percentage of staple length.

c. Smoothness

Rough preparation refers to the appearance of cotton and causes increased waste to be produced during textile processing.

d. Color

The color is important to mills in the dyeing of fabric. Storage with high moisture content (whether in a module or in a trailer) will reduce the brightness of the cotton. Color grade is assigned by the classer's visual observation with the aid of instrumentation that measures brightness, Rd, and yellowness, +b, of the sample.

e. Maturity

Fiber maturity is related to the amount of cellulose deposited during boll development. Cellulose is the element of the fiber that is dyed in the textile process and the more cellulose present, the better dye uptake. Micronaire or mic is an airflow measurement of fiber fineness. It is performed on a weighed test specimen, which is compressed to a specific volume in a chamber. Air is forced through the specimen and the resistance to the airflow is measured. When fiber is fine or thin-walled, less air passes and low micronaire is indicated. When fiber is thick or very trashy, air passes through the plug easily and high micronaire is indicated. Producing a very trashy sample is therefore the only way for gin operation to affect micronaire. Low micronaire is usually a predictor of low dye uptake and high micronaire is a sign of good dye uptake but very high micronaire causes reduced yarn strength.

f. Strength

Strength is another quality resulting from breeding, and gin operation has little effect on it. Fiber length, fiber strength and micronaire all contribute to spinnability and yarn strength (May, 1999). Cotton can be made weak by over drying, thus worsening both the loss of staple and the creation of short fibers during ginning and cleaning. Humidification can improve strength but not staple loss. The HVI system measures fiber strength by clamping a bundle of fibers, with 1/8 inch between the two sets of jaws, and measuring the force required to break the fibers. Results are reported as grams per tex or grams per denier. A “tex” is a unit equal to the weight in grams of 1,000 meters of fiber. Therefore, the strength reported is the force in grams required to break a bundle of fibers one tex unit in size.

g. Contamination

Fiber contamination is a serous and expensive problem for the mills. Grass and bark enters the system during the harvesting and field storage process. Once this material gets ground up, it can resemble fibers and is difficult to separate from the cotton. Moreover, foreign fibers or other contaminates can enter into the cotton during harvesting, field storage and ginning.

Moreover, there is a “nep” which is a small knot of tangled fibers, often caused biologically or by mechanical processing. Neps can detract from the visual appearance of fabrics by causing white specks. Neps can be measured with the Zellweger Uster Advanced Fiber Information System (AFIS) nep tester and are reported as total neps per gram of cotton and mean nep diameter in millimeters. Nep formation during processing can be minimized through the use of appropriate equipment and settings.

7. Land equivalent ratio

Land equivalent ratio (LER) is the indicator for successful intercropping pattern. LER is most commonly used to make intercrop versus sole crop comparisons, and is defined as the relative land area under sole crops that is required to produce yields equivalent to intercrops. So, it is expected that high values of LER will be obtained by using suitable pattern of intercropping, intercropping-tolerant cotton varieties with maize plants and adopting the best agricultural practices for the production of the matching pairs of both species.

Hosny *et al.* (1989) found that LER exceeded one in two systems of intercropping maize and cotton plants. In addition, Kamel *et al.* (1990) reported that intercropping maize with cotton gave significant advantages in land use under all applied patterns. However, Azevedo *et al*. (1999) intercropped cotton plants at densities of 2 500, 5 000 or 10 000 plants/ha with cowpeas (*Vigna unguiculata*) cv. EMEPA 1 or BR 106 maize variety at densities of 5 000, 10 000 or 20 000 plants/ha. They showed that all the intercrops gave higher land use efficiencies than sole crops. In maize intercrops, the highest land use efficiency was obtained with the highest cotton and lowest maize density. Also, Azevedo *et al.* (2000) investigated the effects of plant population on yield, its components and agronomic efficiency of perennial cotton (*Gossypium hirsutum*) and maize (*Zea mays*) intercrops. They indicated that the highest land equivalent ratios were recorded from systems where perennial cotton grown at a density of 10 000 plants/ha was combined with maize at any tested population level (5 000, 10 000 and 20 000 plants/ha). Martin *et al*. (1990) found that land equivalent ratios "based on DM weight" were ranged from 0.97 to 1.11 in dwarf maize intercrops, from 1.16 to 1.23 in tall intercrops in

1985, from 1.11 to 1.12 in dwarf maize intercrops and from 1.04 to 1.23 in tall intercrops in 1986.

However, Mohamed and Salwau (1994) mentioned that the highest land equivalent ratio (LER) was obtained by intercropping maize between cotton rows (30 cm apart). While, Bezerra Neto and Robichaux (1996) grew cotton cv. Deltapine 20 in single rows alternating with single rows of alternating *Vigna unguiculata* cv. CB 46 and maize variety cv. Pioneer 3183 SX, or double rows alternating with a row each of the other 2 crops, or single or double rows alternating with single or double rows, respectively, containing alternate plants of the other 2 crops. *V. unguiculata* and maize were grown at densities of 20 000, 30 000, 40 000 or 50 000 plants/ha. Land equivalent ratio for yield was highest when single rows of cotton alternated with single rows of the other species, the efficiency being increased at higher densities of the food crops, when the relative contribution of maize was highest.

Khan *et al.* (2001) grew cotton (*Gossypium hirsutum*) cv. NIAB 78 at 80-cm space single rows and 120-cm space double row strips (40/120 cm) in Faisalabad, Pakistan. The next day, after sowing of cotton, mung bean, mashbean (*Vigna mungo*), soybean (*Glycine max*), sesame, maize, sorghum, cowpea and ricebean (*Vigna umbellata*) were intercropped in space between the cotton rows/strips. LER values were greater than one in all the intercropping systems except cotton + sesame at 80-cm single rows of cotton indicated the yield advantage of intercropping over sole cropping of cotton. However, Metwally *et al.*

(2009 and 2012) reported that intercropping increased LER as compared with recommended solid plantings of maize and cotton, where, it was ranged from 1.09 to 1.62 with average of 1.32 according to intercropping patterns. Mixed intercropping pattern of maize and cotton gave increases of LERs over those obtained by intercropping maize with cotton in alternating ridges (2:1 and 3:1). They added that S.C.30K09 maize variety gave high LERs than those obtained by T.W.C.310 maize variety. Distributing the high density of intercropped maize plants at a wide distance between hills (4 plants/hill at 70 cm apart) resulted in increased relative yields of both crops and LERs as compared with narrow distance between hills of maize plants (2 plants/hill at 35 cm apart) according to light interception on leaves of cotton and maize.

8. Farmer's benefit

Conventional method of planting cotton in closely-spaced single rows does not permit convenient intercropping of maize. On the other hand, market prices usually determine the length of the maize season; most growers agree that early yields provide the highest profits per unit area.

Intercropping system aims to increase farmer's financial return by raising biological efficiency per unit area in limited time. Subiyakto *et al.* (1990) studied that the effect of intercropping cotton with maize (one cotton ridge alternating with one maize ridge, two cotton ridges alternating with one maize ridge, three cotton ridges alternating with two maize ridges and cotton only) as well as, control in cotton, the results revealed that intercropping pattern 3 cotton:2 maize gave the greatest return as compared with the other treatments.

However, Metwally *et al.* (2009a) reported that intercropping cotton with maize increased total and net returns as compared with recommended solid planting of cotton. Intercropping culture increased total and net returns by about 25.2 and 32.8 %, respectively, as compared with recommended solid planting of cotton. The net return of intercropping maize with cotton varied between treatments from £uro 243.12 and 603.87 per acre as compared with recommended solid planting of cotton (£uro 301.75). Mixed intercropping pattern gave the highest financial value when using high population densities of both crops and distributing the maize plants at a wide distance between hills (4 plants/hill at 70 cm apart). The financial return showed that the mixed intercropping pattern has higher values than alternating ridges (2:1 and 3:1).

MATERIALS AND METHODS

Two field experiments were conducted at Giza Agricultural Experiments and Research Station, Faculty of Agriculture, Cairo University, Giza governorate (Lat. 30°00′30″ N, Long. 31°12′43″ E, 26 m a.s.l), Egypt, during 2011 and 2012 summer seasons to evaluate the productivity and fiber technology of two Egyptian cotton varieties under intercropping and solid cultures, as well as, farmer's benefit. The experiment included sixteen treatments which were the combinations among intercropping, cotton (*Gossypium barbadense*) varieties and maize (*Zea mays* L.) treatments in addition to solid plantings of both crops). The intercropping pattern was mixed pattern designated by planting cotton seeds on both sides of wide ridge (120 cm width) and thinned to two plants/hill distanced at 20 cm apart, whereas, maize plants were sown in the middle of the ridge and distributed in four plants/hill distanced at 70 cm apart.

Two solid plantings of maize were designated as solid 1 (recommended maize; conducted by sowing maize grains on row/ridge and distributed in one plant/hill distanced at 30 cm apart, 60 cm width). Solid 2 : pure stand of maize conducted by growing maize plants in the middle of the wide ridge and distributed in four plants/hill distanced at 70 cm apart, 120 cm width (like mixed pattern). Two solid plantings of cotton were designated as solid 1 (pure stand of cotton ridges) conducted by sowing one row / ridge, 60 cm width and its

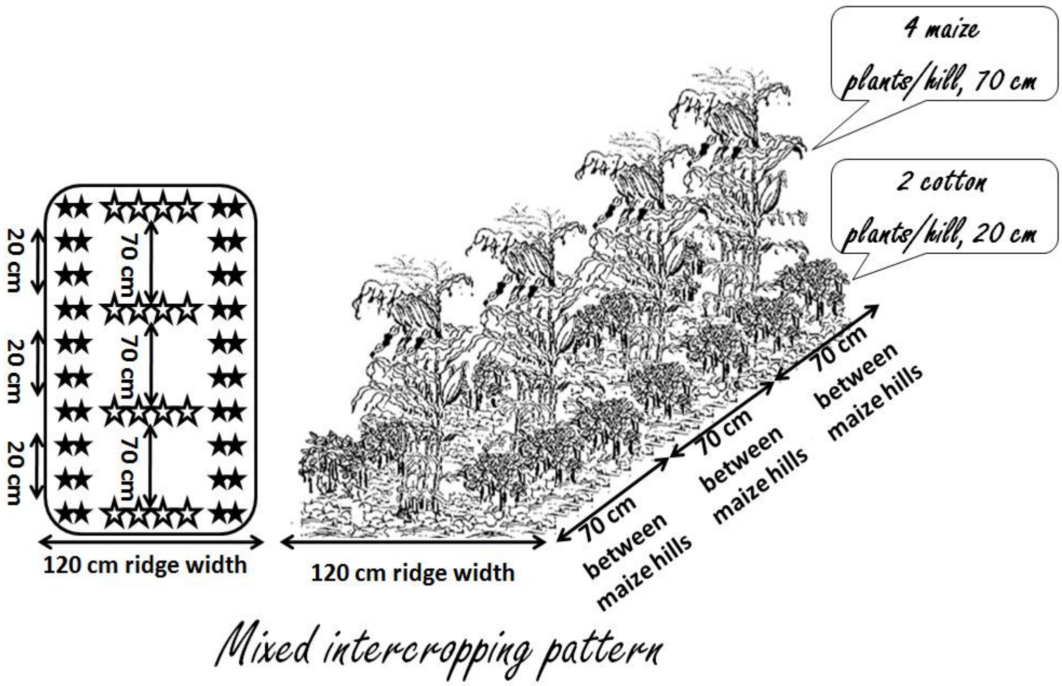

Figure 1. Mixed intercropping pattern.

recommended culture, solid 2 (pure stand of cotton conducted by sowing cotton seeds in two rows/wide ridge, 120 cm width).

Solid plantings of maize 1 and 2 were used to compare the performance of maize plants under mixed intercropping pattern. Also, solid plantings of cotton 1 and 2 were used to compare the performance of cotton plants under mixed intercropping pattern (Figure 1). The Egyptian cotton varieties Giza 80 and Giza 86 (long staple, over 1.25 inches) from Cotton Research Institute (C.R.I), A.R.C, Giza, Egypt. as well as, one maize variety single cross 30K08 (S.C. 30K08) were used from Pioneer Company. Table (1) shows some varietal differences of the two Egyptian cotton varieties.

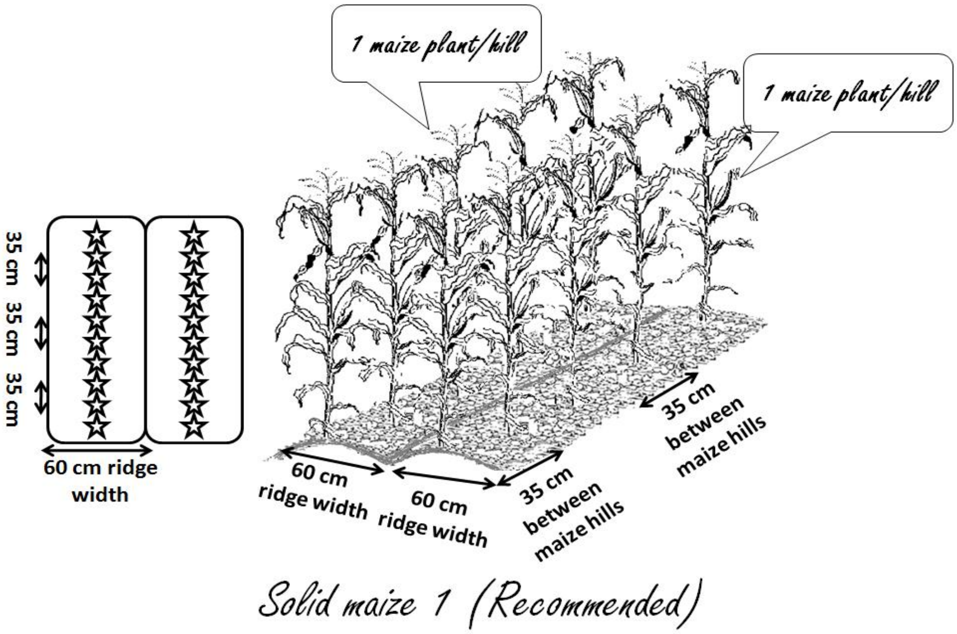

Figure 2. Solid maize 1 (Recommended).

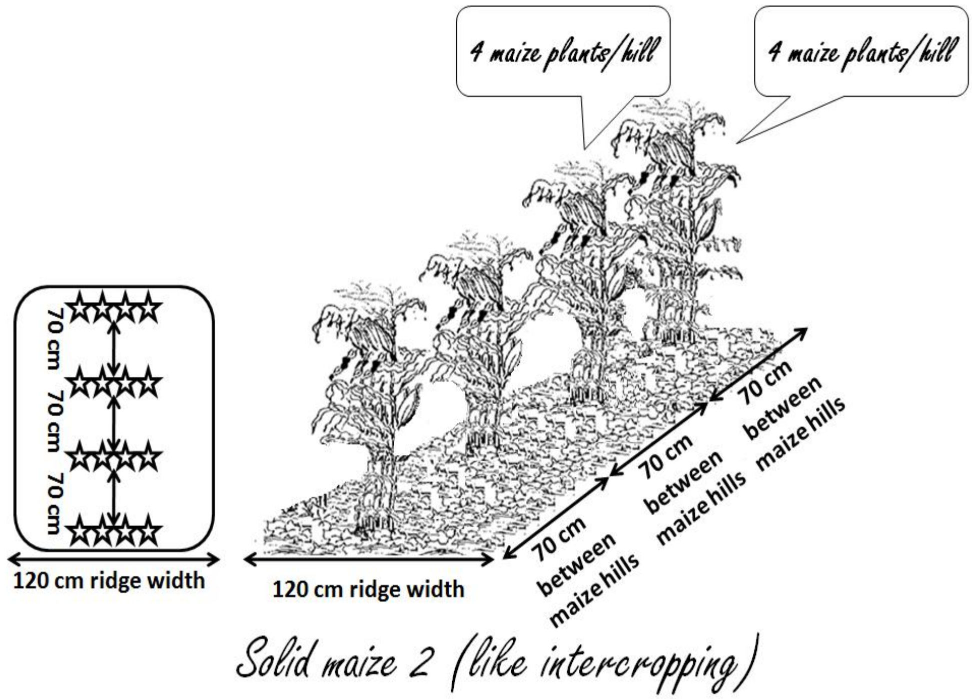

Figure 3. Solid maize 2 (like intercropping).

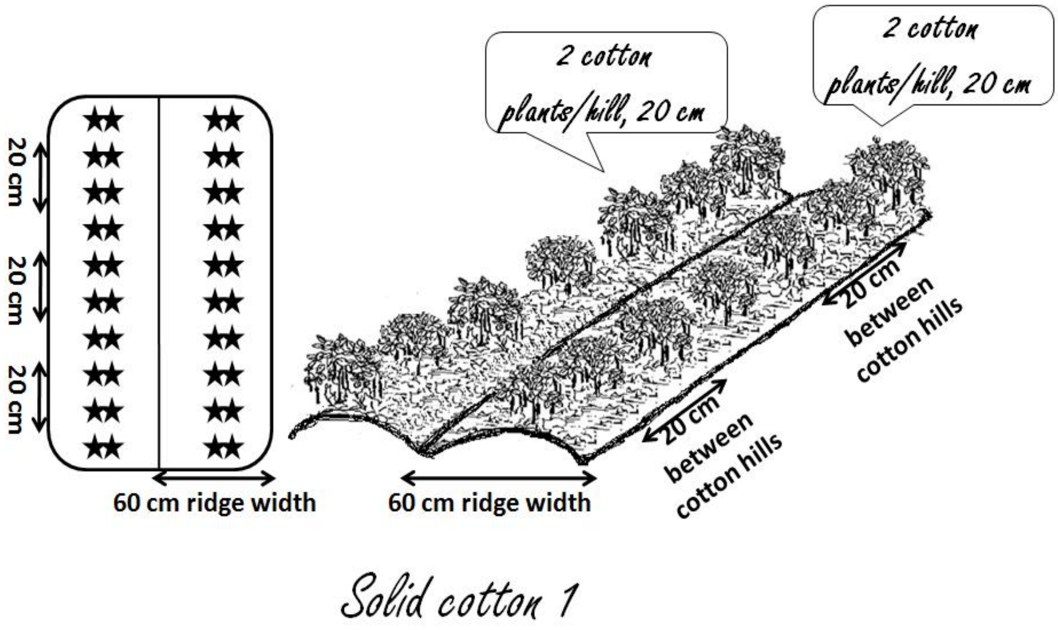

Figure 4. Solid cotton 1.

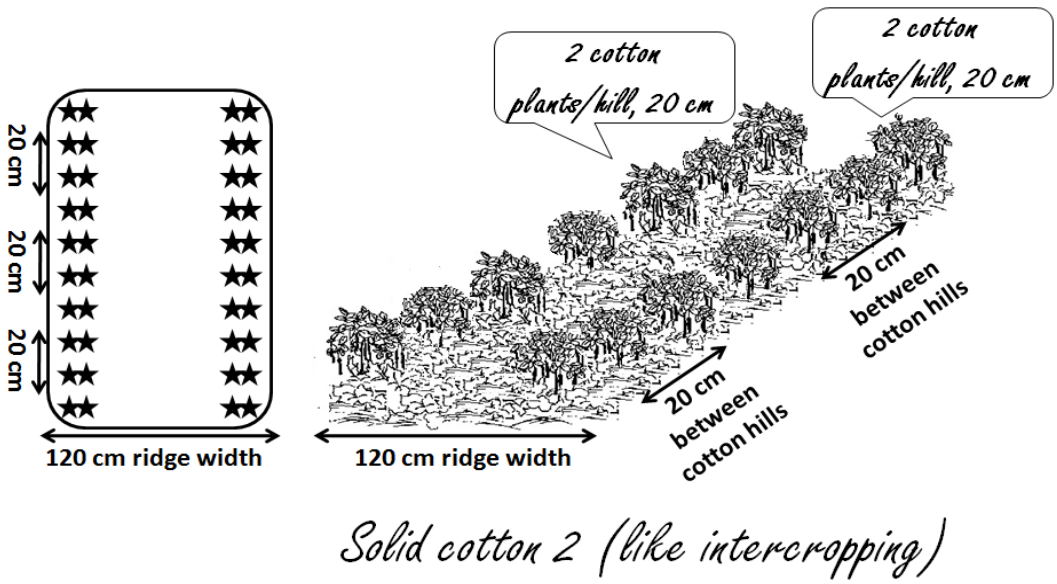

Figure 5. Solid cotton 2 (like intercropping).

Maize plants under (solid 1 and 2) and under intercropping with cotton were harvested for green fodder (silage) at 85 days from maize sowing, stripping leaves of plants (under ear leaf) at 100 days from maize sowing and harvesting maize plants for grains at 120 days from maize sowing.

A split split plot design in randomized complete block arrangement with three replications was used. Cropping systems (mixed intercropping and solid plantings) were randomly assigned to the main plots, cotton varieties were arranged in sub-plots and maize treatments were arranged in sub sub-plots. Each sub sub-plot consisted of 6 ridges, each ridge was 5.0 m long and 0.6 m wide (except mixed and solid patterns, each ridge was 5.0 m long and 1.2 m wide). The plot area was 18 m^2.

Table 1. Some varietal characteristics of the two Egyptian cotton varieties.

Cotton varieties	**Giza 80**	**Giza 86**
Pedigree	Cross between Giza 66 x Giza 73	Cross between Giza 75 x Giza 81
Country of origin	Egypt	Egypt
Class – growing areas	Middle of Egypt	Middle and North of Delta
The 1st node of sympodial branch	8	7
Plant height	Medium	Tall
Leaf size	Medium	Large
Size of boll casings	Large (3/4 of boll size)	medium

*** These data were obtained from Cotton Research Institute, C.R.I., A.R.C., Giza, Egypt.**

The experimental soil texture was clay and Egyptian clover (berseem) (*Trifolium alexandrinum*) was the preceding winter crop in both seasons. Normal cultural practices for growing cotton were used as recommended in the area. Nitrogen fertilizer was applied by 120 Kg N/feddan for both crops under intercropping pattern and solid maize, but solid cotton had fertilized by recommended dose. Cotton seeds were sown at 24 and 30th March of 2011 and 2012, respectively, while maize grains were sown three weeks later.

Cotton traits

At 120 days from cotton sowing, light intensity measurements were recorded between cotton plants. Light intensity inside each canopy was measured by Lux – meter apparatus at 12 A.M. O'clock as follows:

1. Light intensity at middle of the plant (lux).
2. Light intensity at bottom of the plant at 20 cm from the soil surface (lux).

Values of light intensity were transformed as a percentage from full sun light (100%), measured above cotton plants under recommended solid culture (solid 1 cotton) .

At harvest, the following traits were measured on ten guarded plants chosen randomly from each plot:

1. Number of total bolls per plant.
2. Number of open bolls per plant.
3. Boll weight (g).
4. Seed index :weight of 100 seeds (g).

5. Seed cotton yield per plant (g).
6. Seed cotton yield per feddan (kentar) was measured by ginning all cotton plants from the plot area. (kentar =157.5 Kg).
7. Lint (%).

Cotton fiber technology traits

1. Fiber length parameters:
   a. Upper half mean 'UHM' (mm).
   b. Uniformity ratio (%)
2. Fiber bundle tensile:
   a. Strength (g/tex).
   b. Elongation (%).
3. Fineness traits: Micronaire reading (Mic. reading)
4. Color:
   a. Reflectance 'RD' (%).
   b. Yellowness +b.

The fiber properties were measured using High Volume Instrument (HVI) according to A.S.T.M. (2003) by Cotton Technology Research Division, Cotton Research Institute, Agricultural Research Center, Giza, Egypt. Fiber length parameters were determined as upper half mean (U.H.M) and uniformity ratio (%). Fiber elongation (%) was measured. Also, fiber fineness was expressed as Micronaire instrument reading, measured by (HVI). Color – reflectance RD (%) was measured.

Maize traits

At harvest, the following traits were measured on twelve guarded plants chosen randomly from each plot:

1. Plant height (cm).
2. Prolificacy (number of ears/plant).
3. Grain weight/ear (g).
4. Shelling (%).
5. 100 – grain weight (g).
6. Harvest index (HI) (%).
7. Grain yield per plant (g).
8. Grain yield per feddan (ardab) was measured by harvesting all maize plants from the plot area and adjusted maize grains at 15.5% moisture.
9. Green fodder yield per feddan (ton) was measured by harvesting all maize plants from the plot area at 85 days from maize sowing and estimated total fresh weight of maize plants per feddan.

Competitive relationships

Land equivalent ratio (LER)

LER defined as the ratio of area needed under solid cropping to one of intercropping at the same management level to produce an equivalent yield (Mead and Willey, 1980). It is calculated as follows:

$$LER = (Y_{ab} / Y_{aa}) + (Y_{ba} / Y_{bb})$$

Where Y_{aa} = Pure stand yield of crop a (maize) Y_{bb} = Pure stand yield of crop b (cotton)

Y_{ab} = Intercrop yield of crop a (maize) Y_{ba} = Intercrop yield of crop b (cotton)

Financial return

Farmer's benefit was calculated by determining the total costs and net return of intercropping culture as compared to recommended solid planting of cotton according to Metwally *et al*. (2009a)

1.Total return

Total return = Price of maize yield (L.E.) + price of cotton yield (L.E.). To calculate the total return, the average of the maize grains and cotton seeds prices presented by Egyptian Bulletin of Statistical Cost Production and Net Return (2013) was used.

2.Net return

Net return = Total return – (fixed cost of cotton + variable costs of both crops according to intercropping pattern) according to Metwally *et al.* (2009b).

Statistical analysis

Analysis of variance of the obtained data of each season was performed. The homogeneity test was conducted on error mean squares and accordingly, the combined analysis of the two experimental seasons was carried out. The measured variables were analyzed by ANOVA using MSTATC statistical package (Freed, 1991). Mean comparisons were done using least significant differences (L.S.D) method at 5 % level of probability to compare differences between the means (Snedecor and Cochran, 1988).

RESULTS AND DISCUSSION

Three factors were used in this study, *i.e.* cropping systems, cotton varieties and maize treatments to study intercropping maize with two Egyptian cotton varieties. Traits of solid and intercropped cotton will be presented in the first part followed by those of solid and intercropped maize in the second part followed by those of fiber cotton technology in the third part followed by those of competitive relationships in the fourth part and finally farmer's benefit in the last part.

1. Cotton traits

Significance of mean squares of variation sources for each of light intensity within cotton plants at 120 days from cotton sowing, and cotton traits across 2011 and 2012 seasons, are presented in Table 2. There was no significant effects of years and the interaction between years and other factors on light penetration within cotton plants and other traits (Table 2). Light intensity at middle and bottom of the plant at 120 days from cotton sowing, number of open bolls per plant, boll weight, seed cotton yield per plant and per feddan, lint percentage and 100 – seed weight were affected significantly by cropping systems, whereas, total number of bolls per plant was not affected. Light intensity at middle and bottom of the plant at 120 days age, number of open bolls per plant, boll weight, seed cotton yields per plant and per feddan were affected significantly by cotton varieties, whereas, total

Table 2. Significance of variation sources as obtained from the combined analysis of the two seasons for some cotton traits as affected by two growing seasons, cropping systems, cotton varieties, maize treatments and their interactions.

S.O.V.	df	Percentage of light intensity at		Number of bolls/plant		Boll weight	Seed cotton yield /plant	Seed cotton yield/ feddan	Lint percent	100 – seed weight
		Middle of the plant	Bottom of the plant	total	open					
Years (Y)	**1**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Cropping systems(S)	**2**	**	**	N.S.	**	**	**	**	**	**
Y x S	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Cotton varieties (V)	**1**	**	**	N.S.	**	**	**	**	N.S.	N.S.
Y x V	**1**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S x V	**2**	N.S.	N.S.	**	**	**	N.S.	N.S.	N.S.	**
Y x S x V	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Maize treatments (T)	**2**	**	**	**	**	**	**	**	N.S.	**
Y x T	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S x T	**4**	**	**	**	**	**	**	**	N.S.	**
V x T	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S x T	**4**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x V x T	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S x V x T	**4**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S x V x T	**4**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

**** = significant, N.S. = non-significant**

number of bolls per plant, lint percentage and 100 – seed weight were not affected.

Light intensity at middle and bottom of the plant at 120 days from cotton sowing, numbers of total and open bolls per plant, boll weight, seed cotton yields per plant and per feddan and 100 – seed weight were affected significantly by maize treatments, whereas, lint percentage was not affected.

The interaction between cropping systems and cotton varieties affected significantly numbers of total and open bolls/plant, boll weight and 100 – weight, whereas, the interaction between cropping systems and maize treatments affected significantly light intensity at middle and bottom of the plant at 120 days age, numbers of total and open bolls/plant, boll weight, seed cotton yields per plant and per feddan and 100 – seed weight. All the studied cotton parameters were not affected by each of seasonal effects, cotton varieties, maize treatments and other interactions.

a. Intercepted light intensity within cotton plants

Intercepted light intensity within cotton plants at 120 days age was affected significantly by the cropping systems (Table 3). There were gradual and consistent increases in light intensity within cotton plants under solid cotton plantings in a comparison with mixed pattern. Under intercropping conditions, light intensity at middle and bottom of the plant were decreased by 5.88 and 16.07% as compared with recommended solid planting of cotton (solid 1), 7.09 and 18.96% in comparison with solid planting of cotton (solid cotton 2), respectively.

Table 3. Effect of cropping systems, cotton varieties, maize treatments and their interactions on intercepted light intensity within cotton plants, numbers of total and open bolls/plant, boll weight, combined data across 2011 and 2012 seasons.

Cropping systems	Maize Treatments	Percentages of light intensity at middle of the plant			Percentages of light intensity at bottom of the plant			Total number of bolls/plant			Number of open bolls/plant			Boll weight (g)		
		Cotton varieties		Mean	Cotton varieties		Mean	Cotton varieties		Mean	Cotton varieties		Mean	Cotton varieties		Mean
		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86	
Intercropping culture	M_1	14.1	13.6	13.8	4.1	3.7	3.9	18.1	19.9	19.0	8.0	7.7	7.8	2.4	2.4	2.4
	M_2	14.8	14.1	14.4	5.3	4.8	5.0	19.2	20.1	19.6	8.1	7.7	7.9	2.5	2.6	2.5
	M_3	15.5	14.7	15.1	5.8	5.2	5.5	19.3	19.9	19.6	8.7	8.0	8.4	2.5	2.6	2.5
Average of intercropping		14.8	14.1	14.4	5.0	4.5	4.7	18.9	20.0	19.4	8.2	7.8	8.0	2.5	2.5	2.5
Solid 1		15.7	15.0	15.3	5.9	5.4	5.6	20.1	19.1	19.6	9.2	8.1	8.6	2.5	2.7	2.6
Solid 2		15.8	15.2	15.5	6.1	5.5	5.8	19.6	19.6	19.6	8.8	8.3	8.5	2.6	2.7	2.6
General mean of cotton varieties		15.4	14.7	15.0	5.6	5.1	5.3	19.5	19.5	19.5	8.7	8.0	8.3	2.5	2.6	2.5
LSD $_{0.05}$ for:																
Cropping systems (S)				0.5			0.1			N.S.			0.98			0.02
Cotton varieties (V)				**			**			N.S.			**			**
Maize treatments (T)				0.3			0.4			0.15			0.98			0.02
S x V				N.S.			N.S.			0.22			0.13			0.03
S x T				0.2			0.4			0.27			0.17			0.04
V x T				N.S.			N.S.			N.S.			N.S.			N.S.
S x V x T				N.S.			N.S.			N.S.			N.S.			N.S.

**** = significant, N.S. = non-significant, M_1: Harvested maize plants for grains, M_2: Stripping leaves of maize plants and M_3: Green fodder for silage.**

It is clear that shading of adjacent maize plants affected negatively light intensity between cotton plants. These results are in parallel with those obtained by Metwally *et al.* (2012) who showed that there was a reduction in light intensity at the middle and bottom of cotton plants, at 100 and 130 days age, by 31.6, 39.1, 40.9 and 55.1 %, respectively, as compared with those of the recommended solid planting (solid 1). These results are in agreement with those reported by Safina *et al.* (2014).

With respect to the two cotton varieties, cotton varieties differed significantly for intercepted light intensity within cotton plants at 120 days age (Table 3). Cotton variety Giza 80 had higher values of intercepted light intensity within cotton plants in comparison with the other variety. Cotton variety Giza 86 had 4.5 and 8.9 percent reduction in light intensity at middle and bottom of the plant, respectively, than those of variety Giza 80. These results may be due to low plant height cotton variety Giza 80 and some morphological characters which reflected positively on receiving solar radiation and consequently the final yield (Table 3). Differing cotton leaf shapes with varying lobing cause large alterations in the structure of the plant canopy and its ability to intercept light (Wells and Meredith, 1986) These results are in agreement with those reported by Safina *et al.* (2014).

In regard to maize treatments, intercepted light intensity within cotton plant at 120 days from cotton sowing was affected significantly by maize treatments (Table 3) . Harvested maize plants for silage caused significant increment in light intensity at middle and bottom of the plant by 9.4 and 41.0 percent, respectively, as compared with intercropped cotton plants with harvested maize plants for grains. Also, stripping leaves of maize plant caused significant increment in light intensity at middle and bottom of the plant by 4.3 and 28.2 percent, respectively, in comparison with intercropped cotton plants with harvested maize plants for grains. These results are in agreement with those reported by Safina *et al.* (2014).

Intercepted light intensity within cotton plants was not affected significantly by interaction between the two cotton varieties and cropping systems (Table 3). These data show that each of these two factors act independently on intercepted light intensity within cotton plants meaning that cotton varieties responded similarly to cropping systems. These results are in agreement with those reported by Safina *et al.* (2014).

Intercepted light intensity within cotton plants was not affected significantly by the interaction between the two cotton varieties and maize treatments (Table 3).

Intercepted light intensity within cotton plants was not affected significantly by the interaction between cropping systems, the two cotton varieties and maize treatments (Table 3). The data show that each of these factors act independently on intercepted light intensity within cotton plants meaning that cotton varieties responded similarly to cropping systems and maize treatments. These results are in agreement with those reported by Safina *et al.* (2014).

b. Total number of bolls per plant

Total number of bolls per plant was not affected significantly by the cropping systems (Table 3). These data may be due to translocation rate of photosynthates from leaves to storage organs of cotton plants during the early stages of cotton growth and development was similar under the cropping systems. These results are in agreement with those reported by Safina *et al.* (2014).

With respect to the two cotton varieties, cotton varieties did not differed significantly for total number of bolls per plant (Table 3). These data may be due to translocation rate of photosynthates from leaves to storage organs of cotton plant did not differ between the two cotton varieties especially during the early stages of cotton growth and development. These results are in agreement with those reported by Safina *et al.* (2014).

In regard to maize treatments, total number of bolls per plant was affected significantly by maize treatments (Table 3). Harvested maize plants for forage or stripping leaves caused significant increments in total number of bolls per plant than those of intercropped cotton plants with harvested maize plants for grains.

It is clear that total number of bolls per plant was increased steadily either after harvested maize plants for silage or after stripping leaves of maize plants as compared with intercropped cotton plants with harvested maize plants for grains. Sunlight is required by cotton plants to produce photosynthates and consequently if the production of photosynthates cannot supply the demand then the plant stops retaining young bolls (Hake *et al*., 1996). The results data may be attributed to maize treatments that caused significant increment in light intensity at middle and bottom of the cotton plant and thereafter more rates in translocation of photosynthates from leaves to storage organs of cotton plant either at 100 or 120 days than 140 days from cotton sowing, where the carbohydrate balance of reproductive tissues strongly influences reproductive success in cotton (Zhao *et al*., 2005 and Snider *et al*., 2009). These results are in agreement with those reported by Safina *et al.* (2014).

Total number of bolls per plant was affected significantly by the interaction between the two cotton varieties and cropping systems (Table 3). Cotton variety Giza 80 fluctuated more under cropping systems than Giza 86 (Table 3). Variety Giza 80 recorded the highest number of total bolls per plant under recommended solid culture (solid cotton 1), whereas, the lowest number of total bolls per plant was obtained by intercropping cotton variety Giza 86 with harvested maize plants for grains. These results are in agreement with those reported by Safina *et al.* (2014).

Total number of bolls per plant was not affected significantly by interaction between cotton varieties and maize treatments (Table 3), as well as, cropping systems and maize treatments.

Total number of total bolls per plant was not affected significantly by the interaction between cropping systems, cotton varieties and maize treatments (Table 3). These data show that each of these two factors act independently on number of total bolls per plant meaning that cotton varieties responded similarly to cropping systems and maize treatments. These results are in agreement with those reported by Safina *et al*. (2014).

c. Number of open bolls per plant

Number of open bolls per plant was affected significantly by the cropping systems (Table 3). There are gradual and consistent increases in number of open bolls per plant under solid cotton plantings in comparison with mixed pattern. It is clear that shading of adjacent maize plants affected negatively number of open bolls/plant. Under intercropping conditions, number of open bolls per plant was decreased by 6.9 and 5.8% as compared with recommended solid planting (solid 1) and solid planting (solid 2), respectively.

Obviously, light transmission within cotton canopy was reduced by growing four maize plants per hill at 70 cm between hills under mixed stand in comparison with solid cotton plantings and consequently shading of adjacent maize plants caused significant reduction in number of open bolls per plant as compared with solid plantings of cotton. Plant dry matter production often shows a positive correlation with the amount of intercepted radiation by crops in intercropping system (Sivakumar and Virmani, 1980) and sole cropping (Kiniry *et al*., 1989). These results are similar to those reported by Metwally *et al*. (2012) who mentioned that the number of open bolls per plant was severely reduced under mixed intercropping pattern than alternating ridges. These results are in agreement with those reported by Safina *et al.* (2014).

With respect to cotton varieties, they differed significantly in number of open bolls per plant (Table 3). Cotton variety Giza 80 had higher values of number of open bolls per plant in comparison with cotton variety Giza 86 (8.0 percent reduction in number of open bolls per plant than the other variety). These results may be due to cotton variety Giza 80 having some morphological characters which reflected positively on receiving solar radiation and consequently the final yield (Table 1). These results are in agreement with those reported by Safina *et al.* (2014).

In regard to maize treatments, number of open bolls per plant was affected significantly by maize treatments (Table 3). Harvested maize plants for silage caused significant increment in number of open bolls per plant by 7.6 percent as compared with intercropped cotton plants with harvested maize plants for grains. Also, stripping leaves of maize plant at 100 days from maize sowing caused significant increment in number of open bolls per plant by 1.2 percent in comparison with intercropped cotton plants with harvested maize plants for grains.

It is important to mention that boll opening is a process under the control of hormones. Ethylene is primarily responsible for triggering the process of boll opening. Ethylene is the active ingredient in such crop management compounds as Prep. High auxin produced by the developing seeds counters the action of ethylene and prevents premature opening, but as the boll reaches maturity, auxin level drops and ethylene increases (Oosterhuis *et al*., 1994). It is clear that harvested maize plants at 85 days from maize sowing for green fodder (about one month before harvesting maize plants for grains), as well as, stripping leaves formed favorable environmental conditions, especially, increasing light intensity which was more available to cotton plants during boll formation and maturation, where radiation intercepted by the crop canopy is directly correlated to dry matter accumulation (Gonias *et al*., 2012). These results are in agreement with those reported by Safina *et al*. (2014).

Number of open bolls per plant was affected significantly by the interaction between cotton varieties and cropping systems (Table 3).

Cotton variety Giza 80 recorded the highest number of open bolls per plant under recommended solid planting of cotton (solid cotton 1), whereas, the lowest number of open bolls per plant was obtained by intercropping cotton variety Giza 86 with harvested maize plants for grains. These results are in agreement with those reported by Safina *et al*. (2014).

Number of open bolls per plant was not affected significantly by the interaction between cotton varieties and maize treatments (Table 3). These data show that each of these two factors act independently on number of open bolls per plant meaning that cotton varieties responded similarly to maize treatments. These results are in agreement with those reported by Safina *et al*. (2014).

Also, number of open bolls per plant was not affected significantly by the interaction between cropping systems, cotton varieties and maize treatments (Table 3). These data show that each of these two factors act independently on number of open bolls per plant meaning that cotton varieties responded similarly to cropping systems and maize treatments. These results are in agreement with those reported by Safina *et al.* (2014).

d. Boll weight

Boll weight was affected significantly by the cropping systems (Table 3). There are gradual and consistent increases in boll weight under solid cotton plantings in a comparison with intercropping. It is clear that shading of adjacent maize plants affected negatively boll weight. Boll weight of intercropped cotton plant with maize was decreased by 3.8% as compared with recommended solid planting of cotton (solid 1) or (solid 2) planting.

These data show that solid plantings of cotton intercepted normal solar radiation which led to producing normal boll weight than mixed pattern. Accumulation of dry matter by a crop is directly dependent upon the amount of radiation intercepted by the crop canopy (Monteith, 1977). These results are in agreement with those reported by Safina *et al.* (2014).

With respect to cotton varieties, they differed significantly for boll weight (Table 3). Cotton variety Giza 80 had lower values of boll weight in a comparison with the other. Cotton variety Giza 80 had 3.8 percent reduction in boll weight than that of Giza 86. Boll weight played an apposite role to number of open bolls per plant (Table 3). These results are in agreement with those reported by (Zelitch, 1982) and Safina *et al.* (2014).

In regard to maize treatments, boll weight was affected significantly by maize treatments (Table 3). Harvested maize plants for silage caused significant increment in boll weight by 4.1 percent as compared with intercropped cotton plants with harvested maize plants for grains. These results are in agreement with those reported by Safina *et al.* (2014).

Boll weight was affected significantly by the interaction between cotton varieties and cropping systems (Table 3). Cotton variety Giza 86 recorded the highest boll weight under recommended solid planting of cotton (solid 1), whereas, the lowest boll weight was obtained by intercropping cotton variety Giza 80 with harvested maize plants for grains. These results are in agreement with those reported by Safina *et al.* (2014).

Boll weight was not affected significantly by interaction between cotton varieties and maize treatments (Table 3). These data show that each of these two factors act independently on boll weight meaning that cotton varieties responded similarly to maize treatments. These results are in agreement with those reported by Safina *et al.* (2014).

Boll weight was not affected significantly by the interaction between cropping systems, cotton varieties and maize treatments (Table 3). These data show that each of these two factors act independently on boll weight meaning that cotton varieties responded similarly to cropping systems and maize treatments. These results are in agreement with those reported by Safina *et al.* (2014).

e. Seed cotton yield per plant

Seed cotton yield per plant was affected significantly by the cropping systems (Table 4). There are gradual and consistent increases in seed cotton yield per plant under solid cotton plantings in a comparison with mixed pattern. In general, seed cotton yield per plant may be attributed to total open bolls per plant and boll weight it is clear that shading of adjacent maize plants under mixed stand affected negatively seed cotton yield per plant. Under intercropping conditions, seed cotton yield per plant was decreased by 10.3 and 11.1% as compared with recommended solid planting of cotton (solid 1) and (solid 2) planting, respectively. Reduced light significantly decreased photosynthesis and carbohydrate concentrations in leaves and bolls, resulting in increased fruit abscission and decreased yield and fiber quality (Zhao and Oosterhuis, 1998). These results are similar to those reported by Kamel *et al.* (1990), Khan *et al*. (2001) and Metwally *et al*., (2012) who demonstrated that seed cotton yield per plant was reduced significantly by intercropping patterns.

With respect to cotton varieties, they differed significantly for seed cotton yield per plant (Table 4). Cotton variety Giza 80 had higher values of seed cotton yield per plant in comparison with the other variety. Cotton variety Giza 86 had 3.6 percent reduction in seed cotton yield per plant than that of Giza 80 cultivar. These results may be due to cotton variety Giza 80 have some morphological characters

Table 4. Effect of cropping systems, cotton varieties, maize treatments and their interactions on seed cotton yields per plant and per feddan, lint percent and 100 – seed weight, combined data across 2011 and 2012 seasons.

Cropping systems	Maize Treatments	Seed cotton yield/ plant (g)			Seed cotton yield/ feddan (kentar)			Lint (%)			100 – seed weight (g)		
		Cotton varieties		Mean	Cotton varieties		Mean	Cotton varieties		Mean	Cotton varieties		Mean
		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86	
	M_1	18.9	18.5	18.7	5.17	5.09	5.13	36.2	34.7	35.5	10.2	9.6	9.9
Intercropping	**M_2**	20.0	19.9	20.0	5.38	5.28	5.33	35.5	34.7	35.0	9.9	9.3	9.6
culture	**M_3**	21.8	20.7	21.2	5.97	5.49	5.73	35.3	36.3	35.8	9.4	9.3	9.4
Average of intercropping		20.2	19.7	20.0	5.50	5.28	5.39	35.7	35.2	35.4	9.9	9.4	9.6
Solid 1		22.8	21.9	22.3	6.69	5.78	6.23	36.6	36.9	36.8	9.4	9.5	9.4
Solid 2		23.0	22.0	22.5	6.69	5.89	6.29	36.9	37.0	37.0	9.7	9.9	9.8
General mean of cotton varieties		22.0	21.2	21.6	6.29	5.68	5.98	36.4	36.4	36.4	9.6	9.6	9.6
LSD $_{0.05}$ for:													
Cropping systems (S)				0.18			0.21			0.44			0.09
Cotton varieties (V)				**			**			N.S.			N.S.
Maize treatments (T)				0.18			0.21			N.S.			0.09
S x V				N.S.			N.S.			N.S.			0.13
S x T				0.32			0.34			N.S.			0.16
V x T				N.S.			N.S.			N.S.			N.S.
S x V x T				N.S.			N.S.			N.S.			N.S.

**** = significant, N.S. = non-significant, M_1: Harvested maize plants for grains, M_2: Stripping leaves of maize plants and M_3: Green fodder for silage.**

which reflected positively on receiving solar radiation and consequently the final yield (Table 1). Plant productivity is more closely related to measurements of canopy photosynthesis than to measurements of single leaf photosynthesis (Zelitch, 1982).

In regard to maize treatments, seed cotton yield per plant was affected significantly by maize treatments (Table 4). Harvested maize Plants for green fodder (silage) at 85 days from maize sowing caused significant increment in seed cotton yield per plant by 13.3 percent as compared with intercropped cotton plants with harvested maize plants for grains. Also, stripping leaves of maize plant at 100 days age caused significant increment in seed cotton yield per plant by 6.9 percent in comparison with intercropped cotton plants with harvested maize plants for grains.

It is clear that harvested maize plants (green fodder for silage) at 85 days from maize sowing (about three months before ginning cotton) induced favorable environmental conditions especially light intensity which was more available to cotton plants during boll formation and maturation. Also, stripping leaves of adjacent maize plants caused an increase of light intensity between cotton plants during boll formation and maturation (Metwally *et al*., 2012). These results are in agreement with those reported by Safina *et al.* (2014).

Seed cotton yield per plant was not affected significantly by the interaction between cotton varieties and cropping systems (Table 4). These data show that each of these two factors act independently on seed cotton yield per plant, meaning that cotton varieties responded similarly to cropping systems. These results are in agreement with those reported by Safina *et al.* (2014).

Seed cotton yield per plant was not affected significantly by the interaction between cotton varieties and maize treatments (Table 4). These data show that each of these two factors act independently on seed cotton yield per plant, meaning that cotton varieties responded similarly to maize treatments. These results are in agreement with those reported by Safina *et al.* (2014).

Also, seed cotton yield per plant was not affected significantly by the interaction between cropping systems, cotton varieties and maize treatments (Table 4). These data show that each of these two factors act independently on seed cotton yield per plant meaning that cotton varieties responded similarly to cropping systems and maize treatments. These results are in agreement with those reported by Safina *et al.* (2014).

f. Seed cotton yield per feddan

Seed cotton yield per feddan was affected significantly by the cropping systems (Table 4). There are gradual and consistent increases in seed cotton yield per feddan under solid cotton plantings in comparison with all intercrops. It is clear that shading of adjacent maize plants affected negatively seed cotton yield per feddan. Under intercropping conditions, seed cotton yield per feddan was decreased by 13.4 and 14.3% as compared with recommended solid planting of cotton (solid 1) and (solid 2) planting, respectively. It is important to mention that the wide distance between maize hills (70 cm) under mixed intercropping pattern had a positive effect on productivity of intercropped cotton plants with maize. Number of cotton plants and seed cotton yield per plant were integrated together for producing the highest seed cotton yield under mixed pattern (Metwally *et al*., 2012). These results generally agree with those obtained by Munro (1958), Grimes (1963), Memon and Malik (1980), Madiwalar *et al.* (1989), Kamel *et al.* (1990), Abdel-Malak *et al*. (1991) and Metwally *et al*. (2012) who showed that seed cotton yield per feddan was reduced significantly by intercropping as compared with the solid culture of cotton.

With respect to cotton varieties, they were differed significantly for seed cotton yield per feddan (Table 4). Cotton variety Giza 80 had higher values of seed cotton yield per feddan in comparison with Giza 86. Overall treatments, cotton variety Giza 86 had 9.6 percent reduction in seed cotton yield per feddan than that of Giza 80 cultivar. These results may be due to cotton variety Giza 80 having some morphological characters which reflected positively on receiving solar radiation and consequently the final yield (Table 1). These results are in agreement with those reported by Safina *et al.* (2014).

In regard to maize treatments, seed cotton yield per feddan was affected significantly by maize treatments (Table 4). Harvested maize plants for green fodder caused significant increment in seed cotton yield per feddan by 11.6 percent as compared with intercropped cotton plants with harvested maize plants for grains. These results are in agreement with those reported by Safina *et al.* (2014).

Seed cotton yield per feddan was not affected significantly by interaction between cotton varieties and cropping systems (Table 4). These data show that each of these two factors act independently on seed cotton yield per feddan meaning that cotton varieties responded similarly to cropping systems. These results are in agreement with those reported by Safina *et al.* (2014).

Seed cotton yield per feddan was not affected significantly by the interaction between cotton varieties and maize treatments (Table 4). Although the interaction was not significant but the rate of increment in seed cotton yield of Giza 80 with M3 (green fodder for silage) treatment was higher than that Giza 86. These results are in agreement with those reported by Safina *et al.* (2014).

Seed cotton yield per feddan was not affected significantly by the interaction between cropping systems, cotton varieties and maize treatments (Table 4). Also, cotton variety Giza 80 had higher seed cotton yield under mixed intercropping with maize M3 (green fodder for silage) than that of Giza 86 under recommended solid culture. These results are in agreement with those reported by Safina *et al.* (2014).

g. Lint percent

Lint percent was affected significantly by the cropping systems (Table 4). There are gradual and consistent increases in lint percent under solid cotton plantings in a comparison with mixed pattern. It is clear that shading of adjacent maize plants affected negatively lint percent of intercropped cotton plant with maize. Under intercropping conditions, lint percent was decreased by 3.8 and 4.3% as compared with recommended solid planting of cotton (solid 1) and (solid 2), respectively.

It is important to mention that mixed stand resulted in unfavorable conditions for cotton growth and little dry matter accumulation in different parts of cotton organs during different periods of cotton growth as compared with solid cotton plantings, where close relationship have been described between light interception and lint yield (Heitholt *et al*., 1992). These results are in parallel with those obtained by Metwally *et al.* (2012) who found that solid plantings of cotton gave higher values of lint percentage than intercropping patterns. These results are in agreement with those reported by Safina *et al.* (2014).

With respect to cotton varieties, cotton varieties did not differed significantly for lint percent (Table 4). These results are in agreement with those reported by Safina *et al.* (2014).

In regard to maize treatments, lint percent was not affected significantly by maize treatments (Table 4). These results are in agreement with those reported by Safina *et al.* (2014).

Lint percent was not affected significantly by interaction between the two cotton varieties and cropping systems, as well as, the interaction between cotton varieties and maize treatments (Table 4). These data show that each of these factors act independently on lint percent meaning that cotton varieties responded similarly to cropping systems. These results are in agreement with those reported by Safina *et al.* (2014).

Also, lint percent was not affected significantly by the interaction between cropping systems, cotton varieties and maize treatments (Table 4). Although the order interaction was not significantly; but lint percentage of Giza 86 varied from 34.7% under intercropping (M2) to 37% in solid culture (solid 2) the corresponding values were 35.5% to 36.9% for Giza 80 these data indicate that lint percentage is sensitive to light intensity especially more with varieties like Giza 86. These results are in agreement with those reported by Safina *et al.* (2014).

h. Seed index: 100 - seed weight

Seed index was affected significantly by the cropping systems (Table 4). There is no consistent trend in 100 - seed weight under solid cotton plantings in comparison with mixed pattern. These results are in agreement with those reported by Safina *et al.* (2014).

With respect to cotton varieties, they did not differ significantly for 100 - seed weight (Table 4). These results are in agreement with those reported by Safina *et al.* (2014).

In regard to maize treatments, 100 - seed weight was affected significantly by maize treatments (Table 4). Harvested maize plants for green fodder caused significant reduction in 100 - seed weight by 5.0 percent as compared with intercropped cotton plants with harvested maize plants for grains. Also, stripping leaves maize plants at 100 days age caused significant reduction of 100 - seed weight by 3.0 percent in comparison with intercropped cotton plants with harvested maize plants for grains. It is important to repert that seed index is one component of lint percent; this is demonstrated by a highly significant negative correlation between seed index and lint percent (Clement *et al*., 2012).

Seed index was affected significantly by interaction between cotton varieties and cropping systems (Table 4). Cotton variety Giza 80 fluctuated more than Giza 86 under cropping systems. These results are in agreement with those reported by Safina *et al.* (2014).

Seed index was not affected significantly by the interaction between cotton varieties and maize treatments (Table 4). The data show that each of these two factors act independently on 100 - seed weight meaning that cotton varieties responded similarly to maize treatments. These results are in agreement with those reported by Safina *et al.* (2014).

Also, seed index was not affected significantly by the interaction between cropping systems, cotton varieties and maize treatments (Table 4). These data show that each of these two factors act independently. These results are in agreement with those reported by Safina *et al.* (2014).

2. Fiber technology traits of cotton

Significance of mean squares of variation sources for each of fiber length parameters (upper half mean and uniformity index), fiber strength and elongation, micronaire reading and color reflectance in combined data across 2011 and 2012 seasons, were affected significantly by cotton varieties. Cotton fiber technology traits were not affected by each of seasonal effects, maize treatments and their interactions (Table 5).

a. Cropping systems

Fiber quality traits were not affected significantly by the cropping systems (Table 5 and 6). These data reveal that environmental factors did not influence fiber quality traits (upper half mean, uniformity index, fiber strength and elongation, micronaire reading and color – reflectance). The data revealed that wide space between maize hills at distance 70 cm apart formed a good chance for intercropped cotton with maize plants to intercept reasonable amount of solar radiation under mixed pattern (Metwally *et al.*, 2012) during fiber formation and consequently fiber yield and quality were not affected by mixed pattern (see also Pettigrew, 1996). Similar results were obtained by Abd El-Aal and Mohamed (1988), Ghaly *et al.* (1988) and Metwally *et al*. (2012). These results are in agreement with those reported by Safina *et al.* (2014).

b. Cotton varieties

Cotton varieties differed significantly for fiber quality traits (Table 5 and 6). Cotton variety Giza 86 recorded the highest upper half mean and uniformity index, fiber strength and elongation and color – reflectance as compared with the other variety. These data may be due to the size of boll casings is larger (three quarters of boll size) in cotton cultivar Giza 80 than those of by cotton cultivar Giza 86 which affected negatively penetration of solar radian to the boll and lower fiber quality (Table 1).

Table 5. Significance of variation sources as obtained from the combined analysis of the two seasons for cotton fiber technology traits as affected by two growing seasons, cropping systems, cotton varieties, maize treatments and their interactions.

S.O.V.	df	Fiber length parameters Upper half mean	Uniformity index (%)	Fiber strength (g/tex)	Fiber elongation (%)	Mic. reading	Color – Reflectance RD%
Years (Y)	**1**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Cropping systems (S)	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Cotton varieties (V)	**1**	**	**	**	**	**	**
Y x V	**1**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S x V	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S x V	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Maize treatments (T)	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x T	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S x T	**4**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
V x T	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S x T	**4**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x V x T	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S x V x T	**4**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S x V x T	**4**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

**** = significant, N.S. = non-significant**

Table 6. Cotton fiber technology traits as affected by cropping systems, cotton varieties, maize treatments and their interactions, combined data across 2011 and 2012 seasons.

Cropping systems	Maize treatments	Fiber length parameters						Fiber strength (g/tex)		
		Upper half mean Cotton varieties		Mean	Uniformity index (%) Cotton varieties		Mean	Cotton varieties		Mean
		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86	
Intercropping culture	M_1	30.8	32.0	31.4	84.9	87.2	86.1	38.7	43.9	41.3
	M_2	31.1	32.5	31.8	85.1	86.8	85.9	39.6	44.8	42.2
	M_3	31.4	32.8	32.1	85.5	86.5	86.0	39.8	45.0	42.4
Average of intercropping		31.1	32.5	31.8	85.2	86.8	86.0	39.3	44.5	41.9
Solid 1		31.3	32.9	32.1	85.3	86.7	85.9	39.4	43.5	41.5
Solid 2		31.1	32.7	31.9	85.4	86.8	86.1	40.6	44.5	42.5
General mean of cotton varieties		31.2	32.7	31.9	85.3	86.8	86.0	39.8	44.2	42.0
LSD $_{0.05}$ for:										
Cropping systems (S)				N.S.			N.S.			N.S.
Cotton varieties (V)				**			**			**
Maize treatments (T)				N.S.			N.S.			N.S.
S x V				N.S.			N.S.			N.S.
S x T				N.S.			N.S.			N.S.
V x T				N.S.			N.S.			N.S.
S x V x T				N.S.			N.S.			N.S.

**** = significant, N.S. = non-significant, M_1: Harvested maize plants for grains, M_2: Stripping leaves of maize plants and M_3: Green fodder for silage.**

Table 6. Continued.

Cropping systems	Maize treatments	Fiber elongation (%)			Mic. reading			Color – Reflectance RD%		
		Cotton varieties		Mean	Cotton varieties		Mean	Cotton varieties		Mean
		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86	
Intercropping culture	M_1	7.3	7.5	7.4	4.7	3.5	4.1	64.7	73.3	69.0
	M_2	7.7	7.7	7.7	4.7	3.3	4.0	64.8	73.6	69.2
	M_3	7.8	7.5	7.7	4.7	3.4	4.0	65.4	73.3	69.3
Average of intercropping		7.6	7.6	7.6	4.7	3.4	4.0	65.0	73.4	69.2
Solid 1		7.6	7.7	7.7	4.8	3.4	4.1	64.8	75.1	70.0
Solid 2		7.6	7.7	7.6	4.5	3.6	4.1	65.3	75.3	70.3
General mean of cotton varieties		7.6	7.7	7.6	4.6	3.5	4.0	65.0	74.6	69.8
LSD $_{0.05}$ for:										
Cropping systems (S)				N.S.			N.S.			N.S.
Cotton varieties (V)				**			**			**
Maize treatments (T)				N.S.			N.S.			N.S.
S x V				N.S.			N.S.			N.S.
S x T				N.S.			N.S.			N.S.
V x T				N.S.			N.S.			N.S.
S x V x T				N.S.			N.S.			N.S.

** = significant, N.S. = non-significant, M_1: Harvested maize plants for grains, M_2: Stripping leaves of maize plants and M_3: Green fodder for silage.

Also, it seems that there is a negative correlation between seed yield cotton per unit area and fibers technologies traits because cotton cultivar 'Giza 80' recorded the highest seed cotton yield per ha but fiber technology traits were inferior, whereas, the inverse trend was recorded for the other cultivar 'Giza 86'. It is clear that there is a relationship between intercepted solar radiation and canopy of cotton cultivar which resulted in a positive or negative impact on fiber technology traits. Accordingly, productivity of shaded cotton cultivar Giza 80 per unit area was reduced by 17.92% in comparison with non-shaded treatment, whereas, this percentage reached 8.75 and 10.40% in the other cultivar (Giza 86) in comparison with solid cotton 1 and solid cotton 2, respectively. The elongation period is affected by environmental, as well as, genetic factors (Quisenberry and Kohel, 1975). Obviously, shading of adjacent maize plants resulted in lower adverse effects on cotton cultivar Giza 86 than the other variety and consequently cotton cultivar Giza 86 was more compatible for shading conditions than the other cultivar which explained natural behavior of cotton cultivar Giza 86 and Giza 80 growth and development under North and Middle of Egypt conditions, respectively.

Similar results were reported by Subhan *et al*. (2001) who observed that cotton fiber quality is mainly influenced by genotype of the cultivars but agronomic practices and environmental conditions are the secondary factors influencing fiber quality. Also, Bednarz *et al*., (2005) indicated that there were a number of factors influencing fiber quality, of which cultivar is of the greatest importance while agronomic practices are secondary. Accordingly, growth of cultivar Giza 80 is more compatible with the environmental conditions of South of Egypt in comparison with the other. Our variety results are supported by the findings of Bowman (2007) and Faircloth (2007) who reported that fiber strength was influenced by cotton cultivar. These data are parallel with those obtained by Karademir *et al.* (2010) who found that there is significant negative correlation between fiber length and seed cotton yield and lint yield, whereas, there is positive and significant correlation between fiber length and fiber strength. These results are in agreement with the results obtained by Cheng and Zhao (1991), Khan *et al*. (1991), Gomma (1995), Ulloa and Meredith (2000), Mei *et al.* (2004), Asif *et al.* (2008), Azhar and Naeem (2008) and Başal *et al*. (2009). These results are in agreement with those reported by Safina *et al.* (2014).

c. Maize treatments

In regard to maize treatments, fiber quality traits (upper half mean, uniformity index, fiber strength and elongation, micronaire reading and color – reflectance) were not affected significantly by maize treatments (Table 5 and 6). These results may be due to harvested maize (green fodder for silage), the stripping leaves of maize plants or harvested maize for grains (about 80, 65 or 50 days before ginning cotton plants, respectively) resulted in more intercepted light by intercropped cotton with maize plants during fiber formation and consequently fiber yield and quality were not affected by mixed pattern (Pettigrew, 1996). Similar results were obtained by Abd El-Aal and

Mohamed (1988), Ghaly *et al.* (1988) and Metwally *et al*. (2012). Although insignificant effects of cropping systems and maize treatments, but solid planting cotton had insignificant increases in each of fiber length and strength than those of intercropped treatments. Also, increasing light intensity during boll development caused insignificant increments in fiber length and strength (compare M3 and M1 treatment). These results are in agreement with those reported by Safina *et al.* (2014).

d. Response of cotton varieties to cropping systems

Fiber technology traits were not affected significantly by the interaction between cropping systems and cotton varieties (Table 5). But variety Giza 86 under solid plantings had higher fiber length than those of Giza 80, as compared with intercropping values. Also, variety Giza 86 was more affected by shading of intercropped maize than Giza 80. These results are in agreement with those reported by Safina *et al.* (2014).

e. Response of cotton varieties to maize treatments

Fiber technology traits were not affected significantly by the interaction between cotton varieties and maize treatments (Table 5). The data show that each of these two factors act independently on fiber technology traits. These results are in agreement with those reported by Safina *et al.* (2014).

f. Interaction among cropping systems, cotton varieties and maize treatments

Fiber technology traits were not affected significantly by the interaction between cropping systems, cotton varieties and maize treatments (Table 5). These data show that each of these two factors act independently on fiber technology traits meaning that cotton varieties responded similarly to cropping systems and/or maize treatments. These results are in agreement with those reported by Safina *et al.* (2014).

3. Maize traits

Significance of mean squares of variation sources for each of plant height, number of ears/plant (prolificacy), harvest index 'HI', grain weight/ear, shelling, 100 - grain weight, grain yields per plant and per feddan, as well as, green fodder for silage yield per feddan in combined data across 2011 and 2012 seasons, are presented in (Table 7).There were not significant effects of the two years on maize traits. Plant height, prolificacy, grain weight/ear, 100 - green weight, grain yields per plant and per feddan, as well as, green fodder for silage yield per feddan were affected significantly by cropping systems, whereas, shelling and harvest index (HI) were not affected. All the studied maize traits were not affected by each of seasonal effects, cotton varieties, maize treatments and their interactions.

Table 7. Significance of variation sources as obtained from the combined analysis of the two seasons for some maize traits at harvest as affected by two growing seasons, cropping systems, cotton varieties, maize treatments and their interactions.

S.O.V.	df	Plant height	Prolificacy	Harvest index(HI) %	Grain weight/ear	Shelling %	100 – grain weight	Grain yield/ plant	Grain yield /feddan	Green fodder yield /feddan
Years (Y)	**1**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Cropping systems (S)	**2**	**	**	N.S.	**	N.S.	**	**	**	**
Y x S	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Cotton varieties (V)	**1**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x V	**1**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S x V	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S x V	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Maize treatments (T)	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x T	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S x T	**4**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
V x T	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S x T	**4**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x V x T	**2**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S x V x T	**4**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S x V x T	**4**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

**** = significant, N.S. = non-significant**

a. Plant height

Plant height was affected significantly by cropping systems, whereas, it did not differ between mixed pattern and solid maize 2 (Table 8). Recommended maize solid planting (solid maize 1) had the tallest plants as compared with the other cropping systems.

Intercropping maize with cotton decreased plant height by 9.83% as compared with recommended maize solid planting (solid maize 1).

It is important to mention that although number of maize plants per hill varied between solid maize 1 and 2, however, number of maize plants per unit area did not differ. Growing four maize plants per hill may led to increase in intra-specific competition between the four maize plants than one plant inside the hill for environmental resources especially solar radiation under the cropping systems.

Obviously, four maize plants per hill under mixed pattern and solid maize 2 suffered from mutual shading than one plant per hill under recommended maize solid planting (solid maize 1). Mutual shading is known to increase the proportion of invisible radiation, which has a specific elongating effect upon plants (Chang, 1974), hence maize plants in the same canopy had leaves preferentially oriented perpendicular to the row when competition for light was intense (Girardin and Tollenaar, 1994). In addition, spatial arrangement of mixed pattern was identical for spatial arrangement of maize solid planting (solid maize 2) that lead to similarity in environmental conditions especially solar radiation between these patterns. Spatial

Table 8. Effect of cropping systems, cotton varieties, maize treatments and their interactions on plant height, prolificacy and harvest index, combined data across 2011 and 2012 seasons.

Cropping systems	Maize Treatments	Plant height (cm)			Prolificacy			Harvest index (%)		
		Cotton varieties		Mean	Cotton varieties		Mean	Cotton varieties		Mean
		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86	
Intercropping culture	M_1	159.7	161.6	160.6	0.85	0.89	0.87	51.5	49.9	50.7
	M_2	153.8	162.9	158.4	0.81	0.83	0.82	49.8	48.3	49.0
	M_3	--	--	--	--	--	--	--	--	--
Average of intercropping		156.8	162.3	159.5	0.83	0.86	0.84	50.6	49.1	49.8
Solid maize 1	M_1	175.6	175.6	175.6	0.94	0.94	0.94	47.4	47.4	47.4
	M_2	178.2	178.2	178.2	0.90	0.90	0.90	45.9	45.9	45.9
	M_3	--	--	--	--	--	--	--	--	--
	Mean	176.9	176.9	176.9	0.92	0.92	0.92	46.6	46.6	46.6
Solid maize 2	M_1	169.7	169.7	169.7	0.83	0.83	0.83	52.1	52.1	52.1
	M_2	165.4	165.4	165.4	0.83	0.83	0.83	49.8	49.8	49.8
	M_3	--	--	--	--	--	--	--	--	--
	Mean	167.5	167.5	167.5	0.83	0.83	0.83	50.9	50.9	50.9
General mean of Maize treatments	M_1	168.7	168.7	168.7	0.87	0.89	0.88	50.3	49.8	50.0
	M_2	167.3	167.3	167.3	0.85	0.85	0.85	48.5	48.0	48.2
	M_3	--	--	--	--	--	--	--	--	--
General mean of cotton varieties		167.1	168.9	168.0	0.86	0.87	0.86	49.3	48.8	49.0
$LSD_{0.05}$ for:										
Cropping systems (S)				1.58			0.05			N.S.
Cotton varieties (V)				N.S.			N.S.			N.S.
Maize treatments (T)				N.S.			N.S.			N.S.
S x V				N.S.			N.S.			N.S.
S x T				N.S.			N.S.			N.S.
V x T				N.S.			N.S.			N.S.
S x V x T				N.S.			N.S.			N.S.

N.S. = non-significant, M_1: Harvested maize plants for grains, M_2: Stripping leaves of maize plants and M_3: Green fodder for silage.

arrangement has an important influence on the degree of competition between crops (Addo-Quaye *et al*., 2011). Accordingly, row width and number of maize plants per hill play a major role in light transmission through maize plants among the cropping systems. These results are in agreement with those reported by Metwally *et al.* (2014).

Overall different cropping systems, plant height were not affected by the two cotton varieties (Table 8). It is known that maize is one of the C_4 plants and is immune for light saturation; therefore there was stability for intercropped maize plant with the two cotton varieties (Giza 80 and Giza 86) to have the same efficiency for capturing solar radiation and more photosynthesis rate during maize growth and development which enhanced length and number of internodes. The results reveal that there was vegetative vigor of maize plants (which respond well to intense sunlight as C_4 crop) more than cotton plants (C_3 photosynthesis which renders them less responsive to high light) that are expressing stability of maize plant height. These results are in agreement with those reported by Metwally *et al.* (2014).

Plant height was not affected by maize treatments (Table 8). Differences in plant height had insignificant effects among maize treatments. Obviously, plant height was not affected by stripping leaves of maize except ear leaf at 100 days from maize sowing, where, plant height is strongly associated with the flowering date, both morphologically and ontogenetically, because internode formation stops at floral initiation, which means that earlier flowering maize is usually shorter (Troyer and Larkins, 1985). These results are in agreement with those reported by Metwally *et al.* (2014).

All the interactions among cropping systems, the two cotton varieties and maize treatments did not affect plant height significantly (Table 8). It is clear that each of these factors act independently on plant height. These results are in agreement with those reported by Metwally *et al.* (2014).

b. Prolificacy (number of ears per plant)

Number of ears per plant was affected significantly by the cropping systems whereas, it was not differed between mixed pattern and solid maize 2 (Table 8). Recommended maize solid planting (solid maize 1) had the highest values of number of ears per plant as compared with the other cropping systems. Intercropping maize with cotton resulted in significant reduction in number of ears per plant by 10.6% as compared with recommended maize solid planting (solid maize 1).

These data may be due to crop yielding ability of maize plant was decreased by increasing number of maize plants per hill from one to four plants under mixed pattern and solid maize 2 than solid maize 1. Growing four maize plants per hill may led to increase in intra-specific competition between four maize plants, than one plant inside the hill for environmental resources especially solar radiation under the cropping systems. Conversely, growing one maize plant per hill benefited from the available environmental resources under recommended maize solid planting (solid maize 1) than the other patterns (mixed pattern and solid maize 2). Decreasing row spacing at equal plant density promotes more equidistant plant spacing, theoretically reducing plant-to-plant competition, while improving plant resource capture and utilization (Andrade *et al*., 2002 and Barbieri *et al*., 2008), where, the yield reduction of maize was more when intercropped in paired row system than normal row system (Alom *et al*., 2010). These results are in agreement with those reported by Metwally *et al.* (2014).

Overall different cropping systems, prolificacy was not affected by the two cotton varieties (Table 8). It is clear that number of ears per plant was not altered by cotton varieties and consequently there was negative effect on photosynthesis process during different periods of maize growth and development. The flowering stage, which includes pollination, is the most critical period in the development of the maize plant and grain production occurs between pollination and maturity.

The results revealed that there was vegetative vigour of maize plants (which respond well to intense sunlight as C_4 crop) more than cotton plants (C_3 photosynthesis which renders them less responsive to high light) that are expressing stability of number of ears per plant. These results are in agreement with those reported by Metwally *et al.* (2014).

Prolificacy was not affected by maize treatments (Table 8). It is clear that that the dry matter accumulation in different parts of maize plant was great enough during growth and development of maize plant to counterbalance stripping leaves of maize plant except ear leaf at 100 days from maize sowing.

On the other hand, green fodder for silage treatment did not reach to the milk stage and act independently at 85 days from maize sowing on number of ears per plant. The soluble carbohydrate in corn stalk tissue increased rapidly from tasseling to a maximum in milk stage and thereafter declined with maturity. Crude protein content declined steadily in corn leaves but changed very little in corn stalks from milk stage to final maturity (Johnson *et al*., 1966).

All the interactions among cropping systems, the two cotton varieties and maize treatments did not affect number of ears per plant (Table 8). It is clear that each of these factors act independently on number of ears per plant. These results are in agreement with those reported by Metwally *et al.* (2014).

c.Harvest index (HI)

Harvest index (HI) is an important trait associated with the increases in crop yields, where plant harvest index is the economic yield per total plant yield (Hay, 1995). HI was not affected by the cropping systems (Table 8). These data indicated that there was a constant rate for accumulating photosynthates between economic yield and the other constituents of biological yield during maize growth and development among the cropping systems.

Overall different cropping systems, HI was not affected by the two cotton varieties (Table 8).

Also, HI was not affected by maize treatments (Table 8). The data revealed that the different parts of maize plant were great enough to counterbalance stripping leaves of maize plant except ear leaf at 100 days from maize sowing, while, green fodder for silage treatment did not reach to the milk stage and act independently at 80 days from maize sowing on HI.

All the interactions among cropping systems, the two cotton varieties and maize treatments did not affect HI (Table 8). It is clear that each of these factors act independently on HI.

d. Grain weight per ear

Grain weight per ear was affected significantly by the cropping systems; whereas, it did not differ between mixed pattern and solid maize 2 (Table 9). Recommended maize planting (solid 1) had the highest values of grain weight per ear as compared with the other cropping systems. Intercropping maize with cotton resulted in significant reduction in grain weight per ear as compared with recommended maize solid planting. It is clear that one plant per hill may be maximizing the available environmental resources ;especially, solar radiation by the canopy under recommended maize solid planting and thereafter more rates of photosynthesis and growth in the whole plant expressed in an increase in grain weight per ear than those grown as four plants per hill under mixed pattern and solid maize 2.

Overall different cropping systems, grain weight per ear was not affected by the two cotton varieties (Table 9). These data revealed that

Table 9. Grain weight/ear, shelling percentage and 100 – grain weight as affected by cropping systems, two cotton varieties and maize treatments and their interaction (combined data across 2011 and 2012 seasons).

Cropping systems	Maize Treatments	Grain weight/ear (g) Cotton varieties		Mean	Shelling (%) Cotton varieties		Mean	100 – Grain weight (g) Cotton varieties		Mean
		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86	
Intercropping culture	M_1	147.5	144.3	145.9	87.8	87.5	87.6	29.5	29.2	29.3
	M_2	140.3	151.1	145.7	87.1	87.8	87.4	28.7	29.0	28.8
	M_3	--	--	--	--	--	--	--	--	--
Average of intercropping		143.9	147.7	145.8	87.4	87.6	87.5	29.1	29.1	29.1
Solid maize 1	M_1	162.7	162.7	162.7	87.4	87.4	87.4	32.5	32.2	32.3
	M_2	154.0	154.0	154.0	86.7	86.7	86.7	32.3	32.4	32.3
	M_3	--	--	--	--	--	--	--	--	--
	Mean	158.3	158.3	158.3	87.0	87.0	87.0	32.4	32.3	32.3
Solid maize 2	M_1	159.6	159.6	159.6	87.4	87.4	87.4	29.9	29.6	29.7
	M_2	140.7	140.7	140.7	87.1	87.1	87.1	29.5	29.5	29.5
	M_3	--	--	--	--	--	--	--	--	--
	Mean	150.1	150.1	150.1	87.2	87.2	87.2	29.7	29.5	29.6
General mean of maize treatments	M_1	156.6	155.5	156.0	87.5	87.4	87.4	30.6	30.3	30.4
	M_2	145.0	148.6	146.8	86.9	87.2	87.0	30.1	30.3	30.2
	M_3	--	--	--	--	--	--	--	--	--
General mean of cotton varieties		150.8	152.0	151.4	87.2	87.2	87.2	30.4	30.3	30.3
$LSD_{0.05}$ for:										
Cropping systems (S)				5.30			N.S.			1.30
Cotton varieties (V)				N.S.			N.S.			N.S.
Maize treatments (T)				N.S.			N.S.			N.S.
S x V				N.S.			N.S.			N.S.
S x T				N.S.			N.S.			N.S.
V x T				N.S.			N.S.			N.S.
S x V x T				N.S.			N.S.			N.S.

N.S. = non-significant, M_1: Harvested maize plants for grains, M_2: Stripping leaves of maize plants and M_3: Green fodder for silage.

translocation rate of photosynthates from leaves to storage organs of maize plant did not affected by the two cotton varieties. Obviously, there was vegetative vigour of maize plants (which respond well to intense sunlight as C_4 crop) more than cotton plants (C_3 photosynthesis which renders them less responsive to high light) that are expressing stability of grain weight per ear between the two cotton varieties.

Grain weight per ear was not affected by maize treatments (Table 9). These data indicate that maize treatments (stripping leaves of maize plant except ear leaf at 100 days from maize sowing and harvested maize plants for grains) did not permit more light penetration within plant canopy and hence constant rate of light utilization by this canopy. Almost, this may be led to equal amounts of photosynthates which were partitioned to the developing ears. On the other hand, green fodder for silage treatment did not reach to the milk stage and act independently at 80 days from maize sowing on grain weight per ear. Since the number of grain per ear is more in treatments where light penetration in canopy is more, and if significant leaves in reservoir filling are deleted in longer distances than pollination, more photosynthesis is resulted due to dedication of more assimilate to developed grains. Therefore the numbers of fertile grains are increasing per ear. Stripping leaves in tassel expression results in reduction of grain number per ear and simply, grain number per ear is one of the components of treatment which is affected meaningfully by stripping leaves treatment (Mangan *et al*., 2005).

All the interactions among cropping systems, the two cotton varieties and maize treatments did not affect grain weight per ear (Table 9). It is clear that each of these factors act independently on grain weight per ear.

e.Shelling

Shelling was not affected by the cropping systems (Table 9). These data reveal that grains and cobs were increased at constant rate under recommended maize solid planting. Cobs may be considered as temporary sink and the stored photosynthates were translocated to grains during their development. These results are in accordance with those reported by Abd El-Aal and Mohamed (1988) who found that intercropping maize with cotton had no significant effect on shelling percentage.

Overall different cropping systems, shelling was not affected by two cotton varieties (Table 9). These data reveal that there was vegetative vigour of maize plants (which respond well to intense sunlight as C_4 crop) more than cotton plants (C_3 photosynthesis which renders them less responsive to high light) that are expressing stability of shelling between the two cotton varieties.

Shelling was not affected by maize treatments (Table 9). These data reveal that the dry matter accumulation in different parts of maize plant was great enough during growth and development of maize plant to counterbalance stripping leaves all leaves of maize plant except ear leaf at 100 days from maize sowing, while, green fodder for silage treatment did not reach to the milk stage and act independently at 85 days from maize sowing on shelling. Grain number per ear was related to daily rate of plant photosynthesis at silking (Edmeades and Daynard 1979).

All the interactions among cropping systems, the two cotton varieties and maize treatments did not affect shelling (Table 4). It is clear that each of these factors act independently on shelling.

f. 100 - grain weight

100 - grain weight was affected significantly by the cropping systems, whereas, it was not differed between mixed pattern and solid maize 2 (Table 9). Recommended maize solid planting (solid maize 1) had the highest 100 - grain weight as compared with the other cropping systems. These data may be due to ability of one maize plant per hill under recommended maize solid planting (solid maize 1) to convert more solar energy to chemical energy and photosynthate metabolites translocated to the sink might owe much to 100 - grain weight than those grown mixed pattern and solid maize 2, where Zhang and Li (1987) reported that 100 - grain weight were increased under intercropping pattern but decreased in mixed rows as compared with solid corn. These results are in parallel with those obtained by Abd El-Aal and Mohamed (1988) who indicated that intercropping maize with cotton had significant effect on 100 - grain weight.

Overall different cropping systems, 100 - grain weight was not affected by two cotton varieties (Table 9). These data reveal that there was vegetative vigour of maize plants (which respond well to intense sunlight as C_4 crop) more than cotton plants (C_3 photosynthesis which renders them less responsive to high light) that are expressing stability of 100 - grain weight between the two cotton varieties. These results are in parallel with those obtained by Reddy and Daynard (1983) who showed that the grain weight achieved by maize kernels is largely genetically determined.

100 - grains weight was not affected by maize treatments (Table 9). Such results support the notion that grain weight is a product of the `sink capacity' of individual grains and the availability of assimilates to fill these sinks. Grain weight has been shown to vary with grain number per plant (Kiniry *et al*., 1990), particularly in response to changes in post-flowering source-sink ratio (Borras and Otegui, 2001). On the other hand, green fodder for silage treatments act independently at 85 days from maize sowing on 100 – grain weight.

All the interactions among cropping systems, the two cotton varieties and maize treatments did not affect 100 – grain weight (Table 9). It is clear that each of these factors act independently on 100 – grain weight.

g. Grain yield per plant

Grain yield per plant was affected significantly by the cropping systems, whereas, it was not differed between mixed stand and solid 2 (Table 10). Recommended maize solid planting (solid 1) had the highest grain yield per plant as compared with the other cropping systems. These data may be due to lower population density under solid 1 , as well as, high competition between maize plant per hill under

Table 10. Grain yield of maize per plant and feddan and green fodder as affected by cropping systems, cotton varieties, maize treatments and their interactions, combined data across 2011 and 2012 seasons.

Cropping systems	Maize Treatments	Grain yield/plant (g) Cotton varieties		Mean	Grain yield (ardab/fed.) Cotton varieties		Mean	Green fodder yield (ton/fed.) Cotton varieties		Mean
		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86	
Intercropping culture	M_1	145.8	154.9	150.4	16.87	18.22	17.54	--	--	--
	M_2	141.6	146.0	143.8	16.24	16.90	16.57	--	--	--
	M_3	--	--	--	--	--	--	23.53	22.89	23.21
Average of intercropping		143.7	150.5	147.1	16.55	17.56	17.05			
Solid maize 1	M_1	174.4	174.4	174.4	24.59	24.59	24.59	--	--	--
	M_2	160.1	160.1	160.1	22.07	22.07	22.57	--	--	--
	M_3	--	--	--	--	--	--	21.89	21.89	21.89
	Mean	167.3	167.3	167.3	23.83	23.33	23.33			
Solid maize 2	M_1	147.9	147.9	147.9	18.49	18.49	18.49	--	--	--
	M_2	141.4	141.4	141.4	16.99	16.99	16.99	--	--	--
	M_3	--	--	--	--	--	--	22.79	22.79	22.79
	Mean	144.7	144.7	144.7	17.74	17.74	17.74			
General mean of maize treatments	M_1	156.0	159.0	157.5	19.98	20.43	20.19	--	--	--
	M_2	147.7	149.1	148.4	18.43	18.65	18.53	--	--	--
	M_3	--	--	--	--	--	--			
General mean of cotton varieties		151.8	154.0	152.9	19.37	19.54	19.45	22.74	22.52	22.63
LSD $_{0.05}$ for:										
Cropping systems (S)				2.1			0.18			1.30
Cotton varieties (V)				N.S.			N.S.			N.S.
Maize treatments (T)				N.S.			N.S.			N.S.
S x V				N.S.			N.S.			N.S.
S x T				N.S.			N.S.			N.S.
V x T				N.S.			N.S.			N.S.
S x V x T				N.S.			N.S.			N.S.

N.S. = non-significant, M_1: Harvested maize plants for grains, M_2: Stripping leaves of maize plants and M_3: Green fodder for silage.

mixed and solid 2. Similar results were obtained by Metwally *et al*. (2009).

Overall different cropping systems, grain yield per plant was not affected by the two cotton varieties (Table 10). These data reveal that translocation rate of photosynthates from leaves to storage organs did not affect by the two cotton varieties. Clearly, there was vegetative vigour of maize plants (which respond well to intense sunlight as C_4 crop) more than cotton plants (C_3 photosynthesis which renders them less responsive to high light) that are expressing stability of grain yield between the two cotton varieties. These results are in agreement with those reported by Metwally *et al.* (2014).

Grain yield per plant was not affected by maize treatments (Table 10). These data indicate that the different parts of maize plant was great enough to counterbalance stripping leaves of maize under ear leaf at 100 days from maize sowing, while, green fodder for silage treatments did not reach to that stage and act independently at 85 days from maize sowing on grain yield per plant. These results are in agreement with those reported by Metwally *et al.* (2014).

All the interactions among cropping systems, the two cotton varieties and maize treatments did not affect grain yield per plant (Table 10). It is clear that each of these factors act independently on grain yield per plant. These results are in agreement with those reported by Safina *et al.* (2014).

h. Grain yield per feddan

Grain yield per feddan was affected significantly by the cropping systems; whereas, it did not differ between mixed pattern and solid maize 2 (Table 10). Recommended solid planting (solid 1) had the highest grain yield per feddan as compared with the other cropping systems. In other words, intercropping and solid 2 cultures decreased grain yield per feddan by about 22.16% as compared with recommended solid planting (solid 1). These data may be attributed to that four plants per hill under mixed pattern and solid 2 formed unfavorable environment in utilizing solar energy and converting it to chemical energy per unit area during the early stages than maize plant grown as one plant per hill under recommended maize solid planting. These results are in accordance with those reported by Munro (1958), Abd El-Aal and Mohamed (1988), Ghaly *et al.* (1988), Madiwalar *et al.* (1989), Abdel-Malak *et al.* (1991) and Metwally *et al.* (2009).

Overall different cropping systems, grain yield per feddan was not affected by the two cotton varieties (Table 10). These data reveal that there was vegetative vigor of maize plants (which respond well to intense sunlight as C_4 crop) more than cotton plants (C_3 photosynthesis which renders them less responsive to high light) that are expressing stability of grain yield per feddan between the two cotton varieties. These results are in agreement with those reported by Metwally *et al.* (2014).

Grain yield per feddan did not differ significantly by maize treatments (Table 10). These data shows that stripping leaves of maize plants under ear leaf at 100 days from maize sowing did not cause significant reduction in grain yield per feddan, cutting leaves with low intensity and at the end of growth cycle does not develop meaningful reduction in aggregation of dry matter (Tilaoun, 1993). Also, green fodder for silage treatment did not reach to the milk stage and act independently. These results are in agreement with those reported by Safina *et al.* (2014).

All the interactions among cropping systems, and the two cotton varieties and maize treatments did not affect grain yield per feddan (Table 10). It is clear that each of these factors act independently on grain yield per feddan. These results are in agreement with those reported by Safina *et al.* (2014).

i.Green fodder yield per feddan

Forage yield per feddan was affected significantly by the cropping systems, whereas it did not differ between mixed pattern and solid maize 2 (Table 10). Recommended maize solid planting (solid maize 1) had the lowest forage yield per feddan as compared with the other cropping systems. These results are in agreement with those reported by Metwally *et al.* (2014).

Overall different cropping systems, forage yield per feddan was not affected by the two cotton varieties (Table 10). These data reveal that there was vegetative vigour of maize plants as C_4 crop more than cotton plants (C_3) that are expressing stability of green fodder for silage yield per feddan between the two cotton varieties. These results are in agreement with those reported by Metwally *et al.* (2014).

All the interactions among cropping systems, the two cotton varieties did not affect on green fodder for silage yield per feddan (Table 10). It is clear that each of these factors act independently on green fodder for silage yield per feddan. These results are in agreement with those reported by Metwally *et al.* (2014).

4. Competitive relationships

The values of LERs were estimated by using data of recommended solid plantings of both crops. Relative yields of maize and cotton were affected significantly by cropping systems (Table 11 and Fig. 6). Relative yields of maize and cotton were higher by intercropping cotton with maize which harvested green fodder for silage than others. These increases may be due to removal maize plants as by about one month before harvesting maize plants for grains, and this create favorable environmental conditions especially light intensity which was more available to cotton plants during boll formation and maturation.

Overall different cropping systems, relative yield of cotton was affected by cotton varieties, whereas, relative yield of maize was not affected (Table 11 and Fig. 6). Intercropping maize plants with cotton variety Giza 86 had higher values for relative yields of cotton, as compared to relative yields of cotton which obtained by growing maize plants with cotton variety Giza 80.

Overall cropping systems (intercropping and solid plantings), relative yield of cotton was affected by maize treatments, as compared to relative yield of maize, and consequently land equivalent ratio (LER)

Table 11. Effect of cropping systems, cotton varieties, maize treatments and their interactions on relative yields, land equivalent ratio (LER) of both crops, combined data across 2011 and 2012 seasons.

Cropping systems	Maize Treatments	Relative yields						LER		
		L_{maize} Cotton varieties		Mean	L_{cotton} Cotton varieties		Mean	Cotton varieties		Mean
		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86	
Intercropping culture	M_1	0.68	0.74	0.71	0.77	0.88	0.82	1.45	1.62	1.53
	M_2	0.73	0.76	0.74	0.80	0.91	0.85	1.53	1.67	1.59
	M_3	1.07	1.04	1.05	0.89	0.94	0.91	1.96	1.98	1.97
Average of intercropping		0.82	0.84	0.83	0.82	0.91	0.86	1.64	1.75	1.69
Recommended solid planting		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$LSD_{0.05}$ for:										
Cropping systems (S)				**			**			**
Cotton varieties (V)				N.S.			**			N.S.
Maize treatments (T)				N.S.			0.03			0.12
S x V				N.S.			N.S.			N.S.
S x T				N.S.			N.S.			N.S.
V x T				N.S.			N.S.			N.S.
S x V x T				N.S.			N.S.			N.S.

**** = significant, N.S. = non-significant, M_1: Harvested maize plants for grains, M_2: Stripping leaves of maize plants and M_3: Green fodder for silage**

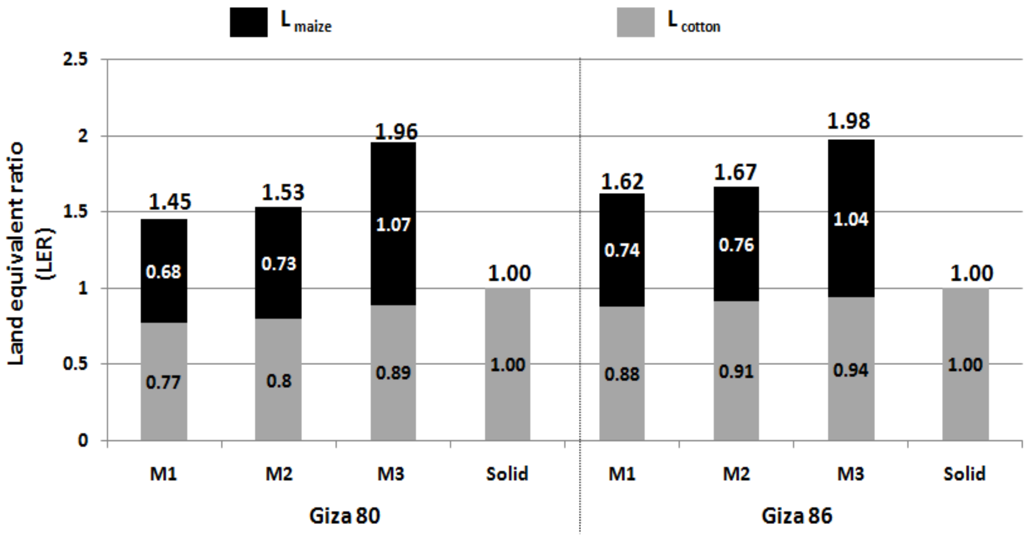

Figure 6. Relative yields of maize and cotton and land equivalent ratio (LER) as affected by cropping systems, cotton varieties, maize treatments and their interactions, combined data across 2011 and 2012 seasons.

was increasing by intercropping culture when maize was used as a green fodder crop or silage (Table 11 and Fig. 6). These data indicated that maize treatments responded similarly to cotton varieties under intercropping pattern. Relative yields of maize and cotton were not affected by all the interactions (Table 11 and Fig. 6).

In general, intercropping maize with cotton increased LER as compared to solid plantings of both crops LER was 1.69; by as increasing around 69% under intercropping than those of solid ones (Table 11 and Fig. 6). It ranged from 1.45 (by intercropping cotton variety Giza 80 with maize which harvested for grains) to 1.98 (by intercropping cotton variety Giza 86 with maize which harvested for green fodder green with an average of 1.69. The advantage of the highest LER by intercropping cotton variety Giza 86 with maize which harvested for green fodder over the others could be due to the early time for removal maize plants from cotton fields which led to minimize adverse effects of intercropped maize on adjacent cotton plants, especially, cotton variety Giza 86 which had small size of boll casings and consequently receiving more solar radiation than the other cotton cultivar. These results are in accordance with those obtained by Metwally *et al.* (2009) who reported that the relative yield total of maize and cotton was greater in intercropping than monoculture, and the highest LER (1.61) were obtained in intercropping. Also, these results are in parallel with those obtained by Hosny *et al.* (1989), Kamel *et al*. (1990), Azevedo *et al*. (1999 and 2000). Similar results were obtained by Metwally *et al*. (2014).

LER was not differed between cotton varieties (Table 11 and Fig. 6). LER varied significantly between maize treatments. Maize harvested for silage had higher LERs than those obtained by stripping leaves of maize plants or maize harvested for grains. These results may be due to removal maize plants as silage (one month) before harvesting maize plants for grains and created favorable environmental conditions, especially, light intensity which was more available to cotton plants during boll formation and maturation. LER was not affected by all the interactions. Similar results were obtained by Safina *et al*. (2014)

5. Farmer's benefit

Magnitude of such agro-economic advantages depends upon the type of intercrop (Rao, 1991). Mixed intercropping pattern increased total and net returns by about 167 and 274 per cent, respectively, as compared with recommended solid planting of cotton (Table 12, Figures 7 and 8). Net return of intercropping maize with cotton was varied between maize treatments from 4079 to 7578 L.E. per feddan as compared with recommended solid planting of cotton (1798 L.E.).

Intercropping cotton variety Giza 80 with maize which harvested for green fodder gave the highest financial value when using high population densities of both crops and distributing maize plants at a wide distance between hills (70 cm). The study suggested that intercropping cotton with maize plants is more profitable to farmers than solid planting of cotton provided farmers use suitable intercropping pattern.

These findings are parallel with those obtained by Subiyakto *et al.* (1990) who reported that intercropping pattern 3 cotton : 2 maize gave the greatest return as compared with the other treatments.

Different cotton based intercropping systems have been reported to increase farm income by 30 - 40% (Saeed *et al*., 1999). Also, Metwally *et al.* (2009) mentioned that mixed intercropping pattern gave the highest financial value when using high population densities of both crops and distributing the maize plants at a wide distance between hills (four maize plants per hill at 70 cm apart). They added that intercropping maize with cotton increased total and net returns by 25.2 and 32.8%, respectively, as compared with recommended solid planting of cotton. Similar results were obtained by Safina *et al*. (2014).

Table 12. Financial return per feddan as affected by cropping systems, cotton varieties, maize treatments and their interactions, combined data across 2011 and 2012 seasons.

Cropping systems	Maize Treatments	Financial return (L.E) Maize Cotton varieties			Cotton Cotton varieties			Total Cotton varieties			Net return Cotton varieties		
		Giza 80	Giza 86	Mean	Giza 80	Giza 86	Mean	Giza 80	Giza 86	Mean	Giza 80	Giza 86	Mean
Intercropping culture	M_1	5111	5520	5315	6043	5950	5996	11154	11470	11312	4389	4299	4344
	M_2	4920	5120	5020	6289	6172	6230	11209	11292	11250	4038	4121	4079
	M_3	7506	7301	7403	6978	6417	6697	14484	13718	14101	7960	7197	7578
Average of intercropping		5845	5980	5912	6436	6179	6307	12281	12159	12221	5462	5205	5333
Recommended solid maize planting				7450	--		--						3110
Recommended solid cotton planting		--		--	7820	6756	7288				2330	1266	1798

M_1: Harvested maize plants for grains. **M_2: Stripping leaves of maize plants.** **M_3: Green fodder for silage.**

Prices of main products are those of 2011: Ton of green fodder = 319 L.E. (market price) **Ardab of maize grains = 303 L.E.**

Kentar of seed cotton = 1169 L.E.

Intercropping maize with cotton increased variable costs by about 1428 L.E over than those of solid cotton planting it ranged between 962 L.E (M3) and 1689 L.E (M2).

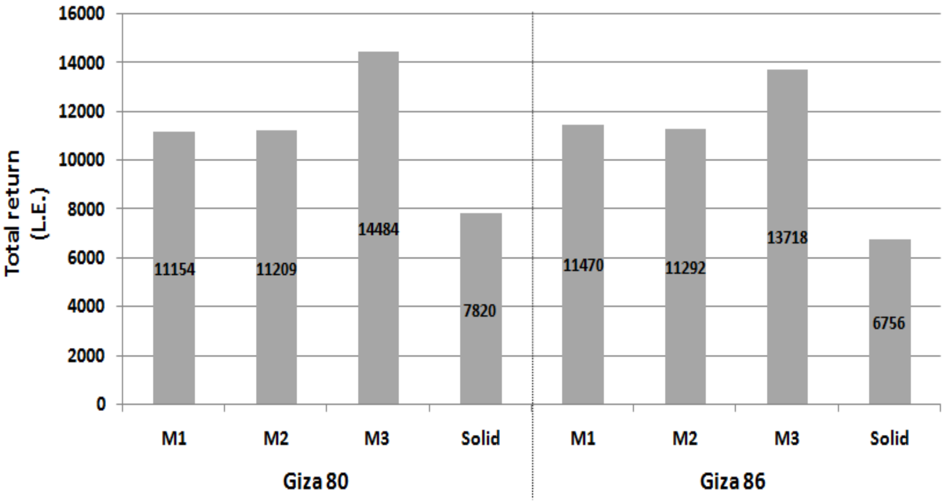

Figure 7. Total return as affected by cropping systems, cotton varieties, maize treatments and their interactions, combined data across 2011 and 2012 seasons.

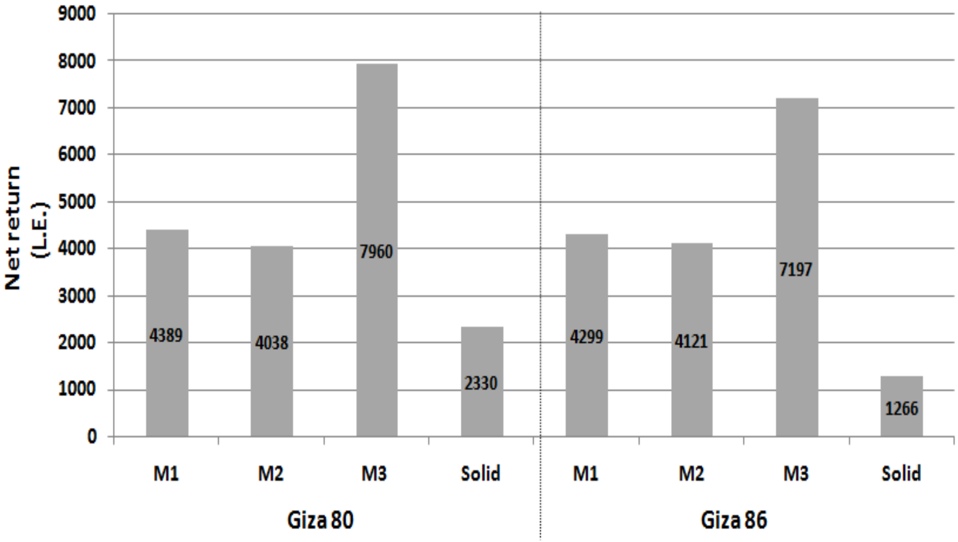

Figure 8. Net return as affected by cropping systems, cotton varieties, maize treatments and their interactions, combined data across 2011 and 2012 seasons.

SUMMARY

Two field experiments were conducted at Giza Agric. Exp. and Res. Sta., Fac. of Agric., Cairo Univ., Giza governorate, Egypt, during 2011 and 2012 at summer seasons to evaluate productivity and fiber technology of two Egyption cultivars under intercropping and solid culture, as well as, land use famer's benefit. Mixed intercropping pattern (120 cm ridge width) was used in this study for growing both crops, maize plants were sown in four plants per hill spacing at 70 cm of middle of ridge after one month from seeding, whereas, cotton plants were sown in both sides of the ridges by growing two plants per hill distanced at 20 cm apart, in addition to solid plantings of both crops. Two Egyptian cotton varieties Giza 80 and Giza 86, as well as, one maize variety S.C. 30K08 were used. Three maize treatments (harvesting maize for grains after 120 days). M2 stripping leaves maize at 100 days ago and harvesting maize for green fodder M3 were used under intercropping and solid plantings. A split split plot design in randomized complete block arrangement was used.

The results can be summarized as follows:

Cotton traits

1. There are consistent increases in light intensity within cotton plants under solid cotton plantings in comparison with mixed pattern.
2. Cotton variety Giza 80 had higher values of intercepted light intensity within cotton plants in a comparison with variety Giza 86.

3. Harvested maize plants for green fodder (after 85 days age M3) caused significant increment in light intensity at middle and bottom of cotton plant by 9.4 and 41.0 percent, respectively, as compared with intercropped cotton plants with harvested maize plants for grains (M1).
4. Intercepted light intensity within cotton plants was not affected significantly by interaction between cotton varieties and cropping systems.
5. Intercepted light intensity within cotton plants was not affected significantly by interaction between cotton varieties and maize treatments.
6. Intercepted light intensity within cotton plants was not affected significantly by the interaction between cropping systems, cotton varieties and maize treatments.
7. Number of total bolls per plant was not affected significantly by the cropping systems or cotton varieties.
8. Harvested maize plants for green fodder (M3) caused significant increment in number of total bolls per plant by 3.1 percent as compared with intercropped cotton plants with harvested maize plants for grains.
9. Cotton variety Giza 80 recorded the highest number of total bolls per plant under recommended solid culture (solid cotton 1), whereas, the lowest number of total bolls per plant was obtained by intercropping cotton variety Giza 86 with harvested maize plants for grains.
10. Cotton plants which grown with harvested maize for green fodder recorded the highest number of total bolls per plant in a comparison with those grown with harvested maize for grains.
11. Number of total bolls per plant was not affected significantly by each of the interactions between cotton varieties and maize

treatments, and the interaction between ropping systems, cotton varieties and maize treatments.

12. There are gradual and consistent increases in number of open bolls per plant under solid cotton plantings in a comparison with mixed pattern.
13. Cotton variety Giza 80 had higher values of number of open bolls per plant in comparison with the other.
14. Harvested maize plants for green fodder caused significant increment in number of open bolls per plant by 7.6 percent as compared with intercropped cotton plants with harvested maize plants for grains.
15. Cotton variety Giza 80 recorded the highest number of open bolls per plant under recommended solid planting of cotton (solid cotton 1), whereas, the lowest number of open bolls per plant was obtained by intercropping cotton variety Giza 86 with harvested maize plants for grains.
16. Cotton plants which grown with harvested maize for green fodder recorded the highest number of open bolls per plant in a comparison with those intercropped with harvested maize plants for grains.
17. Number of open bolls per plant was not affected significantly by the interaction between cropping systems, cotton varieties and maize treatments.
18. There are gradual and consistent increases in boll weight under solid cotton plantings in a comparison with mixed pattern.
19. Cotton variety Giza 80 had lower values of boll weight in a comparison with the other.
20. Harvested maize plants for green fodder caused significant increment in boll weight by 4.1 percent as compared with intercropped cotton plants with harvested maize plants for grains.

21. There are gradual and consistent increases in seed cotton yield per plant under solid cotton plantings in a comparison with mixed cropping pattern.
22. Overall cropping systems, cotton variety Giza 80 had higher values of seed cotton yield per plant in comparison with variety Giza 80.
23. Harvested intercropped maize plants early for green fodder caused significant increment in seed cotton yield per plant by 13.3 percent as compared with intercropped cotton plants when maize harvested latter for grains.
24. Seed cotton yield per plant was not affected significantly by the interactions between cropping systems, cotton varieties and maize treatments.
25. There are gradual and consistent increases in seed cotton yield per feddan under solid cotton plantings in comparison with mixed cropping pattern.
26. Cotton variety Giza 80 had higher values of seed cotton yield per feddan in comparison with variety Giza 86.
27. Harvested maize plants for green fodder caused significant increment in seed cotton yield per feddan by 11.6 percent as compared with intercropped cotton plants with harvested maize plants for grains.
28. Seed cotton yield per feddan was not affected significantly by interaction between cotton varieties and cropping systems.
29. Seed cotton yield per feddan was not affected significantly by the interactions between cropping systems, cotton varieties and maize treatments.
30. There are gradual and consistent increases in lint percent under solid cotton plantings in comparison with mixed pattern.
31. Lint percent was not deferred significantly by each of maize treatments, cotton varieties and their interactions.

32. Lint percent was not affected significantly by the interaction between cropping systems, cotton varieties and maize treatments.

Fiber technology

1. Fiber length parameter were not affected significantly by the cropping systems and maize treatments.
2. Cotton variety Giza 86 had higher values of upper half mean and uniformity index than the other.
3. Fiber length parameters were not affected significantly by all the interactions.
4. Fiber strength was not affected significantly by the cropping systems or intercropped maize treatments
5. Cotton variety Giza 86 had higher fiber strength than that of Giza 80 under all treatments.
6. Fiber strength was not affected significantly by all the interactions between cropping systems, cotton varieties and maize treatments.
7. Fiber elongation was not affected significantly by the cropping systems or maize treatments.
8. Cotton variety Giza 86 had higher fiber elongation than the other.
9. Fiber elongation was not affected significantly by all the interactions.
10. Micronaire reading was not affected significantly by the cropping systems and maize treatments.
11. Cotton variety Giza 86 had lower micronaire reading than that of Giza 80.
12. Micronaire reading was not affected significantly by all the interactions.
13. Color– reflectance was not affected significantly by the cropping systems and maize treatment and the interactions.

14. Cotton variety Giza 86 had higher color – reflectance than the other.

Maize traits

1. Recommended maize solid planting (solid maize 1) had the tallest plants as compared with the other cropping systems.
2. Intercropping maize with cotton decreased plant height by 9.83% as compared with recommended maize solid planting (solid maize 1).
3. Plant height was not affected by each of cotton varieties, maize treatments, and the interactions among cropping systems, cotton varieties and maize treatments.
4. Recommended maize solid planting (solid maize 1) had the highest values of number of ears per plant as compared with the other cropping systems.
5. Intercropping maize with cotton resulted in significant reduction in number of ears per plant by 10.6% as compared with recommended maize solid planting (solid maize 1).
6. Prolificacy of maize plants was not affected by each of cotton varieties, maize treatments, and the interactions among cropping systems, cotton varieties and maize treatments.
7. HI was not affected by each of the cropping systems, cotton varieties, maize treatments, and the interactions among cropping systems, cotton varieties and maize treatments did not affect HI.
8. Intercropping maize with cotton resulted in significant reduction in grain weight per ear as compared with recommended maize solid planting (solid maize 1).
9. Grain weight per ear was not affected by each of cotton varieties, maize treatments and the interactions among cropping systems, cotton varieties and maize treatments.

10. Shelling percentage was not affected by each of the cropping systems, cotton varieties, maize treatments, and the interactions among cropping systems, cotton varieties and maize treatments.
11. Recommended maize solid planting (solid maize 1) had the highest 100 – grain weight as compared with the other cropping systems.
12. Grain weight was not affected by each of cotton varieties, maize treatments, and the interactions among cropping systems, cotton varieties and maize treatments.
13. Recommended maize solid planting (solid maize 1) had the highest grain yield per plant as compared with the other cropping systems.
14. Grain yield per plant was not affected by each of cotton varieties, maize treatments, and the interactions among cropping systems, cotton varieties and maize treatments.
15. Recommended maize solid planting (solid maize 1) had the highest grain yield per feddan as compared with the other cropping systems.
16. Grain yield per feddan was not affected by each of cotton varieties, maize treatments, and the interactions among cropping systems, cotton varieties and maize treatments.
17. Recommended maize solid planting (solid maize 1) had the highest green fodder yield per feddan as compared with the other cropping systems.
18. Green fodder yield per feddan was not affected by each of cotton varieties, maize treatments, and the interactions among cropping systems, cotton varieties and maize treatments.

Competitive relationships

1. LER ranged from 1.45 (by intercropping cotton variety Giza 80 with maize which harvested for grains) to 1.98 (by intercropping

cotton variety Giza 86 with maize which harvested for green fodder) with an average of 1.69.

2. LER was not affected by all the interactions.
3. Mixed intercropping pattern increased total and net returns by about 81.21 and 253.94 per cent, respectively, as compared with recommended solid planting of cotton (solid cotton 1).
4. Net return of intercropping maize with cotton was varied between treatments from 4079 to 7578 L.E. per feddan as compared with recommended solid planting of cotton (1798 L.E.).
5. Intercropping cotton variety Giza 80 with maize which harvested for green fodder gave the highest financial value when using high population densities of both crops and distributing maize plants at a wide distance between hills (70 cm).

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الإنتاجية والخواص التكنولوجية لألياف صنفين من القطن المصري تحت ظروف الزراعة المنفردة والمحملة

رسالة مقدمة من

عبد الصمد هاشم نعمان
بكالوريوس العلوم الزراعية (البستنة)، كلية الزراعة، جامعة بغداد، العراق, ١٩٨٩م
ماجستير العلوم الزراعية (محاصيل)، كلية الزراعة، جامعة الأنبار، العراق, ٢٠٠١م

للحصول على درجة

دكتوراه الفلسفة

فى

العلوم الزراعية
(محاصيل)

قســم المحاصيــل
كلية الزراعــة
جامعة القاهرة
مــصــر

٢٠١٤

الإنتاجية والخواص التكنولوجية لألياف صنفين من القطن المصري تحت ظروف الزراعة المنفردة والمحملة

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مقدمة من

عبد الصمد هاشم نعمان
بكالوريوس العلوم الزراعية (البستنة)، كلية الزراعة، جامعة بغداد، العراق, ١٩٨٩م
ماجستير العلوم الزراعية (محاصيل)، كلية الزراعة، جامعة الأنبار، العراق, ٢٠٠١م

لجنة الحكم

دكتور / سعد حسن أبو خضرة ....
أستاذ المحاصيل، كلية الزراعة، جامعة كفر الشيخ

دكتور / مظهر محمد فوزي عبد الله ....
أستاذ المحاصيل، كلية الزراعة، جامعة القاهرة

دكتور / سيد أحمد سفينة ....
أستاذ مساعد المحاصيل، كلية الزراعة، جامعة القاهرة

دكتور / عبد العليم عبد الرحمن متولى ....
أستاذ المحاصيل، كلية الزراعة، جامعة القاهرة

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رسالة دكتوراه الفلسفة
فى العلوم الزراعية
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مقدمة من

عبد الصمد هاشم نعمان
بكالوريوس العلوم الزراعية (البستنة)، كلية الزراعة، جامعة بغداد، العراق, ١٩٨٩م
ماجستير العلوم الزراعية (محاصيل)، كلية الزراعة، جامعة الأنبار، العراق, ٢٠٠١م

لجنة الإشراف

دكتور / عبد العليم عبد الرحمن متولى
أستاذ المحاصيل، كلية الزراعة، جامعة القاهرة

دكتور / سيد أحمد سفينة
أستاذ مساعد المحاصيل، كلية الزراعة، جامعة القاهرة

اسم الطالب : عبد الصمد هاشم نعمان **الدرجة :** دكتوراه الفلسفة
عنوان الرسالة : الإنتاجية والخواص التكنولوجية لألياف صنفين من القطن المصري تحت ظروف الزراعة المنفردة والمحملة
المشرفون : دكتور: عبد العليم عبد الرحمن متولى
دكتور: سيد أحمد سفينة

قسم: المحاصيل **فرع:** **تاريخ منح الدرجة:** / / ٢٠١٤م

المستخلص العربى

أقيمت تجربتان حقليتان بمحطة البحوث والتجارب الزراعية بكلية الزراعة – جامعة القاهرة بالجيزة خلال موسمى الزراعة ٢٠١١-٢٠١٢ بهدف دراسة الأنتاجية والخواص التكنولوجية لألياف صنفين من القطن المصري زرعا تحت نظامي الزراعة المنفردة والزراعة المحملة مع الذرة الشامية, وكذلك دراسة أثر تحميل الذرة مع القطن في زيادة كفاءة استخدام الموارد الزراعية في زيادة الأنتاج والعائد للمزارع. أستخدم نظام التحميل المختلط (١٢٠ سم عرض الخط) لنمو المحصولين معا فى هذه الدراسة بحيث تمت زراعة أربعة نباتات من الذرة الشامية فى الجورة المسافة بين الجور ٧٠ سم بمنتصف المصطبة بعد شهر واحد من زراعة القطن والذى تمت زراعته على جانبى المصطبة بنباتين فى الجورة والمسافة بين الجور ٢٠ سم بالإضافة إلى الزراعة المنفردة لكلا من المحصولين. وكانت أصناف القطن المصرية جيزة ٨٠ وجيزة ٨٦ بينما كان صنف الذرة الشامية المستخدم هو هجين فردى ٣٠ ك ٨. أستخدمت ثلاث معاملات للذرة الشامية تحت نظم الزراعة المحملة والمنفردة بزراعة الذرة لانتاج الحبوب بدون أو بالتوريق الجزئي لأنتاج العلف . تم استخدام تصميم القطع المنشقة مرتين في توزيع القطاعات الكاملة العشوائية. أهم النتائج المتحصل عليها كما يلي: كانت هناك زيادة فى محصولى القطن الزهر للنبات وللفدان تحت نظم الزراعة المنفردة حوالي ١٥% بالمقارنة بنظام التحميل المختلط. تميز صنف القطن جيزة ٨٠ بزيادة حاصل القطن الزهر للنبات وللفدان عن الصنف الآخر جيزة ٨٦. نباتات القطن المحملة مع الذرة الشامية المحصودة بغرض انتاج العلف الأخضر أعطت زيادة فى محصولى القطن الزهر للنبات وللفدان بما يعادل انتاج القطن بالزراعة المنفردة الموصى بها. تفوق صنف القطن جيزة ٨٦ فى صفات التيلة عن الصنف الآخر تحت ظروف الزراعة المحملة والمنفردة. لم تتأثر صفات جودة تيلة القطن من حيث الطول والمتانة والنعومة بنظام التحميل. أعطت الزراعة المنفردة للذرة الشامية الموصى بها أعلى القيم لمحصولى الحبوب للنبات وللفدان مقارنة بنظم الزراعة الأخرى. محصولى حبوب النبات والفدان لم يتأثرا بصنفى القطن أو معاملات الذرة الشامية. تراوح معدل كفاءة إستغلال الأرض من ١,٤٥ إلى ١,٩٨ بمتوسط ١,٦٩. تراوح صافى الربح بتحميل الذرة الشامية مع القطن من ٤٠٧٩ إلى ٧٥٧٨ جنيه مصرى للفدان بالمقارنة بالزراعة المنفردة للقطن الموصى بها (١٧٩٨ جنيه مصرى)

الكلمات الدالة: القطن, الذرة الشامية, التحميل ، صفات التيلة، معدل كفاءة إستغلال الأرض، العائد الإقتصادى

الملخص العربى

الإنتاجية والخواص التكنولوجية لألياف صنفين من القطن المصري تحت ظروف الزراعة المنفردة والمحملة

أقيمت تجربتان حقليتان بمحطة البحوث والتجارب الزراعية بكلية الزراعة – جامعة القاهرة بالجيزة خلال موسمى الزراعة ٢٠١١ و ٢٠١٢م بهدف زيادة انتاجية محصولى صنفين من القطن في الزراعة المحملة مع الذرة الشامية وأثر ذلك على الصفات التكنولوجية للتيلة وكذلك على معدل استغلال الأرض وكذلك العائد النقدى للمزارع. أستخدم نظام التحميل المختلط (١٢٠ سم عرض المصطبة) لنمو المحصولين معا فى هذه الدراسة بحيث تمت زراعة أربعة نباتات من الذرة الشامية فى الجورة الواحدة والمسافة بين الجور ٧٠ سم بمنتصف المصطبه بعد شهر واحد من زراعة القطن والذى تمت زراعته على جانبى المصطبة بنباتين فى الجورة والمسافة بين الجور ٢٠ سم بالإضافة إلى الزراعة المنفردة لكلا المحصولين وكانت أصناف القطن المصرية المستخدمة فى الدراسة جيزة ٨٠ وجيزة ٨٦ بينما كان صنف الذرة الشامية المستخدم هو هجين فردى ٣٠ ك ٨. أستخدمت ثلاث معاملات للذرة الشامية (حصاد نباتات الذرة الشامية بغرض الحبوب M1، توريق الجزء السفلي من نباتات الذرة الشامية بعد ١٠٠ يوم من زراعته M2، حصاد نباتات الذرة الشامية بغرض العلف الأخضر بعد ٨٥ يوم لأنتاج السيلاج M3) تحت نظم الزراعة المحملة والمنفردة. تم استخدام تصميم القطع المنشقة مرتين في توزيع القطاعات الكاملة العشوائية.

نظم الزراعة:

الزراعة المحملة:

قطن محمل بالذرة الشامية , خطوط عرض ١٢٠ سم القطن على الجانبين ٢٠سم , ٢ نبات بالجورة. الذرة يزرع بعد شهر , ٤ نباتات بالجورة ٧٠سم بين الجور.

معاملات الذرة:

١- انتاج الحبوب , حصاد بعد ١٢٠ يوم M1.

٢- انتاج الحبوب مع التوريق الجزئي بعد ١٠٠ يوم لازالة الأوراق السفلية من الكوز الأصلي M2.

٣- العلف الأخضر للسيلاج حصاد الذرة بعد ٨٥ يوم من الزراعة M3.

الزراعة المنفردة:

١- قطن منفرد (solid 1 cotton) عرض الخطوط ٦٠سم , ٢ نبات بالجورة , ٢٠سم بين الجور الزراعة على جانب واحد.

٢- قطن منفرد (solid 2 cotton) عرض الخطوط ١٢٠سم , الزراعة على الجانبين ٢٠سم بين الجور , ٢نبات بالجورة. لقياس سلوك النباتات المحملة والمنفردة.

٣- ذرة منفرد موصى بزراعة solid 1 على خطوط ٦٠سم , ١ نبات /الجورة , ٣٠سم بين الجور عدد النباتات في الفدان حوالي ٢٠٠٠٠ نبات .

٤- ذرة منفرد للمقارنة مع الزراعة المحملة solid 2 على خطوط ١٢٠سم , ٤ نبات /جورة , ٧٠سم بين الجور, الجور في وسط الخط , لمقارنة سلوك النباتات المحملة بالمنفردة.

ويمكن تلخيص النتائج المتحصل عليها في النقاط التالية:

صفات القطن

١- لم تؤثر أصناف القطن على محصول العلف الأخضر(السيلاج) الفدان.

٢- زادت شدة الإضاءة المستقبلة بواسطة نباتات القطن تحت نظامى الزراعة المنفردة للقطن الموصى به بالمقارنة بنظام الزراعة المحملة.

٣- سجل صنف القطن جيزة ٨٠ أعلى القيم لشدة الإضاءة المستقبلة عن الصنف جيزة ٨٦.

٤- زادت شدة الأضاءة معنويا على نباتات القطن المحملة عندما حصدت نباتات الذرة للعلف (M3) في الإضاءة المستقبلة من منتصف نباتات القطن ومن أسفل نباتات القطن بـ ٩,٤ و ٤١,٠%، على الترتيب، بالمقارنة بنباتات القطن المحملة مع نباتات الذرة الشامية المحصودة بغرض الحبوب (M1).

٥- لم يتأثر عدد اللوز الكلى للنبات بنظم الزراعة (الزراعة المنفردة والزراعة المحملة).

٦- لم يختلف صنفى القطن فى عدد اللوز الكلى للنبات.

٧- أدى تحميل نباتات الذرة الشامية المحصودة بغرض انتاج العلف الأخضر M3 إلى زيادة معنوية فى عدد اللوز الكلى للنبات بـ ٣,١% بالمقارنة بنباتات القطن المحملة مع نباتات الذرة الشامية المحصودة بغرض الحبوب (M1).

٨- أعطى صنف القطن جيزة ٨٠ تحت نظام الزراعة المنفردة للقطن الموصى به (نظام الزراعة المنفردة للقطن ١) أعلى القيم لعدد اللوز الكلى للنبات، بينما تم الحصول على أقل القيم لعدد اللوز الكلى للنبات بتحميل صنف القطن جيزة ٨٦ مع نباتات الذرة الشامية المحصودة بغرض الحبوب.

٩- لم يؤثر التفاعل بين أصناف القطن ومعاملات الذرة الشامية على عدد اللوز الكلى للنبات.

١٠- زاد عدد اللوز المتفتح للنبات تحت نظامى الزراعة المنفردة للقطن بالمقارنة بنظام الزراعة المحملة.

١١- سجل صنف القطن جيزة ٨٠ أعلى القيم لعدد اللوز المتفتح للنبات عن الصنف (جيزة ٨٦).

١٢- أعطت نباتات القطن المحملة مع نباتات الذرة الشامية المحصودة بغرض السيلاج زيادة معنوية فى عدد اللوز المتفتح للنبات بـ ٧,٦ % بالمقارنة بنباتات القطن المحملة مع نباتات الذرة الشامية المحصودة بغرض الحبوب.

١٣- أعطى صنف القطن جيزة ٨٠ تحت نظام الزراعة المنفردة للقطن الموصى به (نظام الزراعة المنفردة للقطن ١) أعلى القيم لعدد اللوز المتفتح للنبات، بينما تم الحصول على أقل القيم لعدد اللوز المتفتح للنبات بتحميل صنف القطن جيزة ٨٦ مع نباتات الذرة الشامية المحصودة بغرض الحبوب.

١٤- لم يؤثر التفاعل بين نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على عدد اللوز المتفتح للنبات.

١٥- زاد وزن اللوزة تحت نظامى الزراعة المنفردة للقطن بالمقارنة بنظام الزراعة المحملة.

١٦- سجل صنف القطن جيزة ٨٠ أقل القيم لوزن اللوزة عن الصنف (جيزة ٨٦).

١٧- أدى تحميل نباتات الذرة الشامية المحصودة بغرض السيلاج إلى زيادة معنوية فى وزن اللوزة بـ ٤,١% بالمقارنة بنباتات القطن المحملة مع نباتات الذرة الشامية المحصودة بغرض الحبوب.

١٨- أعطى صنف القطن جيزة ٨٦ تحت نظام الزراعة المنفردة للقطن الموصى به (نظام الزراعة المنفردة للقطن ١) أعلى القيم لوزن اللوزة، بينما تم الحصول على أقل القيم لوزن اللوزة بتحميل صنف القطن جيزة ٨٠ مع نباتات الذرة الشامية المحصودة بغرض الحبوب.

١٩- زاد محصول القطن الزهر للنبات تحت نظامى الزراعة المنفردة للقطن بالمقارنة بنظام الزراعة المحملة.

٢٠- سجل صنف القطن جيزة ٨٠ أعلى القيم لمحصول القطن الزهر للنبات عن الصنف الآخر كمتوسط عام لجميع المعاملات.

٢١- أدى تحميل نباتات الذرة الشامية المحصودة بغرض السيلاج إلى زيادة معنوية فى محصول القطن الزهر للنبات بـ ١٣,٣% بالمقارنة بنباتات القطن المحملة مع نباتات الذرة الشامية المحصودة بغرض الحبوب.

٢٢- لم يؤثر التفاعل بين نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على محصول القطن الزهر للنبات.

٢٣- زاد محصول القطن الزهر للفدان معنويا تحت نظامى الزراعة المنفردة للقطن(solid 1 and solid 2) بالمقارنة بنظام الزراعة المحملة.

٢٤- سجل صنف القطن جيزة ٨٠ أعلى القيم لمحصول القطن الزهر للفدان عن الصنف جيزة ٨٦ في المتوسط العام.

٢٥- أدى تحميل نباتات الذرة الشامية المحصودة بغرض انتاج السيلاج(M3) إلى زيادة معنوية فى محصول القطن الزهر للفدان بـ ١١,٦% بالمقارنة بنباتات القطن المحملة مع نباتات الذرة الشامية المحصودة بغرض انتاج الحبوب (M1).

٢٦- لم يؤثر التفاعل بين نظم الزراعة وأصناف القطن على محصول القطن الزهر للفدان.

٢٧- سجلت نباتات القطن المحملة مع نباتات الذرة الشامية المحصودة بغرض السيلاج (M3) أعلى القيم لمحصول القطن الزهر للفدان بالمقارنة مع نباتات الذرة الشامية المحصودة بغرض الحبوب(M1) .

٢٨- لم يؤثر التفاعل بين أصناف القطن ومعاملات الذرة الشامية على محصول القطن الزهر للفدان.

٢٩- لم يؤثر التفاعل بين نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على محصول القطن الزهر للفدان.

٣٠- زادت نسبة تصافى الحليج تحت نظامى الزراعة المنفردة للقطن بالمقارنة بنظام الزراعة المحملة.

٣١- لم يختلف صنف القطن جيزة ٨٠ عن صنف القطن جيزة ٨٦ فى نسبة تصافى الحليج.

٣٢- لم تتأثر نسبة تصافى الحليج بمعاملات الذرة الشامية المحملة.

٣٣- لم يؤثر التفاعل بين كل من نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على نسبة تصافى الحليج.

٣٤- لم يكن هناك إتجاه ثابت لوزن المائة بذرة تحت نظم الزراعة المنفردة مقارنة بنظام الزراعة المحملة.

٣٥- لم يختلف صنف القطن جيزة ٨٠ عن صنف القطن جيزة ٨٦ فى وزن المائة بذرة.

٣٦- لم تختلف قياسات طول التيلة لنباتات القطن بنظام الزراعة المنفردة أو المحملة بشكل عام.

٣٧- تميز صنف القطن جيزة ٨٦ بطول التيلة مقارنة بصنف القطن الآخر جيزة ٨٠.

٣٨- لم تتأثر قياسات طول التيلة بمعاملات الذرة الشامية المحملة مع القطن.

٣٩- لم يؤثر درجات التفاعل بين نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على قياسات طول التيلة معنويا.

٤٠- لم تختلف متانة التيلة لنباتات القطن معنويا بنظم الزراعة المنفردة أو المحملة , كذلك معاملات الذرة المحملة.

٤١- تميز صنف القطن جيزة ٨٦ بمتانة التيلة مقارنة بصنف القطن الآخر جيزة ٨٠.

٤٢- لم يؤثر درجات التفاعل بين نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية معنويا على متانة التيلة.

٤٣- لم تختلف إستطالة التيلة لنباتات القطن معنويا بنظام الزراعة أو معاملات الذرة المحملة.

٤٤- تميز صنف القطن جيزة ٨٦ بإستطالة التيلة مقارنة بصنف القطن جيزة ٨٠.

٤٥- لم يؤثر درجات التفاعل بين نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على إستطالة التيلة معنويا.

٤٦- لم تختلف نعومة التيلة لنباتات القطن معنويا بنظام الزراعة أو معاملات الذرة المحملة.

٤٧- تميز صنف القطن جيزة ٨٠ بنعومة التيلة مقارنة بصنف القطن جيزة ٨٦.

٤٨- لم يؤثر مستويات التفاعل بين نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على نعومة التيلة معنويا.

٤٩- لم تختلف درجة إنعكاس لون التيلة لنباتات القطن بنظام الزراعة أو معاملات الذرة.

٥٠- تميز صنف القطن جيزة ٨٦ بدرجة إنعكاس لون التيلة مقارنة بصنف القطن جيزة ٨٠.

٥١- لم يؤثر درجات التفاعل بين كل من نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على درجة إنعكاس لون التيلة.

٥٢- تأثر المحصول النسبى للقطن بمعاملات الذرة الشامية فى حين لم يتأثر بها المحصول النسبى للذرة الشامية.

صفات الذرة

١- أدى تحميل الذرة الشامية مع القطن إلى نقص معنوى فى عدد كيزان الذرة الشامية بـ ١٠,٦% بالمقارنة بالزراعة المنفردة للذرة الشامية الموصى بها (نظام الزراعة المنفردة للذرة الشامية solid 1).

٢- لم تؤثر أصناف القطن على عدد كيزان الذرة الشامية.

٣- لم يتأثر عدد كيزان الذرة الشامية بمعاملات الذرة الشامية.

٤- لم تؤثر جميع التفاعلات بين نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على عدد كيزان الذرة الشامية.

٥- لم يتأثر دليل حصاد الذرة الشامية بنظم الزراعة أو أصناف القطن أو معاملات الذرة أو التفاعلات بينهم.

٦- أدى تحميل الذرة الشامية مع القطن إلى نقص معنوى فى وزن حبوب الكوز بالمقارنة بالزراعة المنفردة للذرة الشامية الموصى بها (نظام الزراعة المنفردة للذرة الشامية solid 1).

٧- لم تؤثر أصناف القطن على وزن حبوب الكوز كما لم تؤثر معاملات الذرة الشامية.

٨- لم تؤثر جميع التفاعلات بين نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على وزن حبوب الكوز.

٩- لم تتأثر نسبة التفريط بنظم الزراعة أو أصتاف القطن أو معاملات الذرة أو التفاعلات بين هذه العوامل التجريبية.

١٠- لم يتأثر وزن المائة حبة بمعاملات الذرة الشامية أو بأصناف القطن.

١١- لم تؤثر جميع التفاعلات بين نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على وزن المائة حبة.

١٢- أعطت الزراعة المنفردة للذرة الشامية الموصى بها (نظام الزراعة المنفردة للذرة الشامية solid 1) أعلى محصول حبوب للنبات بالمقارنة بنظام الزراعة المحملة بشكل عام.

١٣- لم تؤثر أصناف القطن على محصول حبوب النبات أو بمعاملات الذرة الشامية.

١٤- لم تؤثر جميع التفاعلات بين نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على محصول حبوب النبات.

١٥- أعطت الزراعة المنفردة للذرة الشامية الموصى بها (نظام الزراعة المنفردة للذرة الشامية solid 1) أعلى محصول حبوب للفدان بالمقارنة بنظم الزراعة الأخرى.

١٦- لم تؤثر أصناف القطن على محصول حبوب الفدان.

١٧- لم يتأثر محصول حبوب الفدان النبات بمعاملات الذرة الشامية.

١٨- لم تؤثر جميع التفاعلات بين نظم الزراعة وأصناف القطن ومعاملات الذرة الشامية على محصول حبوب الفدان.

١٩- أعطت الزراعة المنفردة للذرة الشامية الموصى بها (نظام الزراعة المنفردة للذرة الشامية ١) أعلى محصول علف أخضر(سيلاج) للفدان بالمقارنة بنظم الزراعة الأخرى.

٢٠- تأثر المحصول النسبى لكل من الذرة الشامية والقطن بنظم الزراعة.

٢١- أدى تحميل نباتات الذرة الشامية مع صنف القطن جيزة ٨٦ أعلى القيم للمحصول النسبى للقطن مقارنة بتحميل نباتات الذرة الشامية مع صنف القطن الآخر جيزة ٨٠.

العلاقات التنافسية والعائد النقدي:

١- تراوح معدل كفاءة إستغلال الأرض من ١,٤٥ (بتحميل صنف القطن جيزة ٨٠ مع نباتات الذرة الشامية المحصودة بغرض الحبوب) إلى ١,٩٨ (بتحميل صنف القطن جيزة ٨٦ مع نباتات الذرة المحصودة بغرض السيلاج) بمتوسط ١,٦٩.

٢- لم يختلف معدل كفاءة إستغلال الأرض بين صنفى القطن المستخدمين فى الدراسة.

٣- أعطت نباتات الذرة الشامية المزروعة بغرض العلف الأخضر (السيلاج) أعلى معدل كفاءة لإستغلال الأرض مقارنة بتوريق نباتات الذرة الشامية أو المزروعة بغرض الحبوب.

٤- لم يتأثر معدل كفاءة إستغلال الأرض بالتفاعلات المختلفة.

٥- تراوح صافى الربح بين المعاملات المختلفة تحت نظام التحميل المختلط من ٤٠٧٩ إلى ٧٥٧٨ جنيه مصرى للفدان بالمقارنة بالزراعة المنفرة للقطن الموصى بها (١٧٩٨ جنيه مصرى).

٦- أعطى تحميل صنف القطن جيزة ٨٠ مع نباتات الذرة المزروعة بغرض انتاج العلف الأخضر (السيلاج) أعلى قيمة إقتصادية وذلك بإستخدام الكثافات النباتية المرتفعة لكلا المحصولين مع توزيع ٤ نباتات ذرة شامية فى الجورة الواحدة والمسافة بين الجورة والأخرى ٧٠ سم.