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AGRONOMY AND SOILS

Effect of Intercropping Corn on Egyptian Cotton Characters

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ABSTRACT

Two experiments were conducted at Gemmeiza Agric. Exp. and Res. Station, A.R.C., El-Gharbia Governorate, Egypt, during 2006 and 2007 summer seasons to study the effects of intercropping corn with cotton on seed cotton yield and its components. Intercropping patterns included alternating ridges between cotton and corn at 2:1 and 3:1, respectively, (60 cm per ridge), a mixed intercropping pattern (120 cm per ridge) for growing the two crops, and two additional solid planting patterns of cotton. Intercropping corn with cotton resulted in lower values for number of open bolls plant^{-1}, seed cotton yield plant^{-1} and seed cotton yield acre^{-1} as compared with recommended solid planting of cotton. Alternating ridges between cotton and corn in a 3:1 ratio had higher values for number of open bolls plant^{-1} , seed cotton yield plant^{-1} , grain yield plant^{-1} and lint percentage as compared with the other intercropping patterns. Mixed intercropping pattern gave the highest yields for both crops. Seed cotton yield in intercropping patterns was affected by intercepted light on cotton plants through adjacent corn plants and the ratio of occupied cotton plants in the intercropping area. Cotton fiber properties were not affected significantly by any of the different cropping systems, corn varieties or their distributions. Seed yield of intercropped cotton reached 80.45 % of that obtained from recommended solid planting of cotton in addition to 2.90 ton acre^{-1} of corn grains. Intercropping corn with cotton increased total and net returns as compared with recommended solid planting of cotton. Mixed intercropping pattern gave the highest financial return value when using high population densities of both crops and distributing the corn plants at a wide distance between hills.

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Maximizing agricultural resource use through intensification of agricultural systems is an important way to achieve greater production and income per unit area per year. Intercropping is an important practice to increase the total yield per unit area. This system is used in many parts of the world, especially in regions where the small farmer intensively utilizes a limited land area (Francis, 1986) and is recommended as a method to increase total agriculture production in Egypt (Metwally, 1999). Two crops of significance to Egyptian agriculture are cotton and corn. Cotton (*Gossypium* spp.) has been used for manufacturing clothes for at least 8000 years. It is the most important fiber crop in the world and its lint is used to make processed cotton, which is woven into fabrics, either alone or combined with other fibers. The seeds contain a high percentage of edible oil and the residual cake is rich in proteins and used as cattle feed. Unfortunately, the cultivated area of cotton plants in Egypt has decreased from about approximately 429 thousand hectares in 1982 to 232 thousand hectares in 2007 (Egyptian Agricultural Statistics, 2007) as a result of increased production cost and lower net return as compared with other summer crops, i.e. corn, rice, etc. Conversely, the demand for the corn grains in the Egyptian market has been increasing and the corn cultivated area reached about 650 thousand hectares in 2007.

The merits of intercropping cotton with other plants have been documented by several workers in some countries. Cotton plants have been intercropped with sorghum and *Setaria* (pigeon pea) in India (Aiyer, 1949), with corn or sorghum in West Africa (Baker, 1979), with corn in North East Brazil (Rao, 1984) and with corn in Egypt (Mohamed et al., 1986; Kamel et al., 1990 and Abdel-Malak et al., 1991). Wide distance between corn hills resulted in more light intercepted by both crops in intercropping cultures than that of narrow distance between hills (Metwally et al., 2003; 2005a and b). Indeed, corn canopy architecture plays an important role in the amount of sunlight radiation intercepted by other crops sown in an intercropping pattern. Studies have revealed that the reduction of light intensity caused by the shading due to corn plants reduces the photosynthetic capacity of a second crop in an intercrop pattern (Sayed Galal and Metwally, 1982; Abd El-Aal and Mohamed, 1988; Kamel et al., 1990; Abdel-Malak et al., 1991 and Shafik, 1995). In view of the previous, intercropping patterns, corn varieties and plant population densities may have an impact on the amount of intercepted sunlight radiation by intercropped cotton plants. The objective of this work was to study the effect of intercropping corn on cotton plants and seed cotton yield.

MATERIALS AND METHODS

Two field experiments were conducted at the Gemmeiza Agricultural Experiments and Research Station, Agricultural Research Center (A.R.C.), El-Gharbia Governorate, during the 2006 and 2007 summer seasons. Two corn varieties, single cross 30k09 (kindly provided by Pioneer – Egypt Company) and three way cross 310 (kindly provided by Corn Res. Dept., F.C.R.I., A.R.C., Ministry of Egyptian Agriculture and Soil Reclaimed), were used. The Egyptian cotton variety used was Giza 89, a long staple cotton (kindly provided by Cotton Res. Inst., A.R.C.). Egyptian clover (berseem) was the preceeding winter crop in both seasons. The experiment soil texture was clay. Normal cultural practices for growing cotton and corn were used as recommended in the area. Cotton seeds were sown on 24th and 30thMarch at 2006 and 2007, respectively, while corn was sown three weeks later. Cotton was thinned to 2 plants per hill at 20 cm between hills in all treatments.

The experiment included 14 treatments as follows: (three intercropping and two solid plantings), two corn varieties and two distributions of corn plants (two plants/hill at 35 cm hill spacing and four plants/hill at 70 cm hill spacing).

The treatments are illustrated in Figure 1 as follows:

1. Two cotton ridges alternating with one ridge of corn cv. S.C.30k09 by planting two corn plants/hill at 35 cm hill spacing resulting in 46,900 plants of cotton and 13,333 corn plants acre-1 (designated as 2:1 pattern).
2. Two cotton ridges alternating with one ridge of corn cv. S.C.30k09 by planting four corn plants/hill at 70 cm hill spacing resulting in 46,900 plants of cotton and 13,333 corn plants acre-1 (designated as 2:1 pattern).

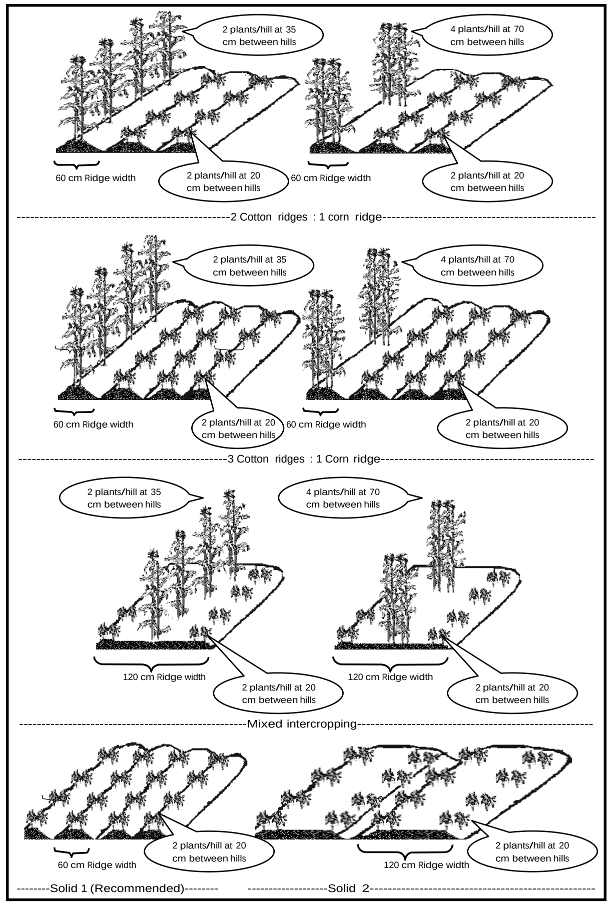

Fig.1. Cropping patterns of intercropping corn with cotton and solid plantings.

3. Two cotton ridges alternating with one ridge of corn cv. T.W.C.310 by planting two corn plants/hill at 35 cm hill spacing resulting in 46,900 plants of cotton and 13,333 corn plants acre-1 (designated as 2:1 pattern).
4. Two cotton ridges alternating with one ridge of corn cv. T.W.C.310 by planting four corn plants/hill at 70 cm hill spacing resulting in 46,900 plants of cotton and 13,333 corn plants acre-1 (designated as 2:1 pattern).
5. Three cotton ridges alternating with one ridge of corn cv. S.C.30k09 by planting two corn plants/hill at 35 cm hill spacing resulting in 52,500 plants of cotton and 10,000 corn plants/acre-1 (designated as 3:1 pattern).
6. Three cotton ridges alternating with one ridge of corn cv. S.C.30k09 by planting four corn plants/hill at 70 cm hill spacing resulting in 52,500 plants of cotton and 10,000 corn plants acre-1 (designated as 3:1 pattern).
7. Three cotton ridges alternating with one ridge of corn cv. T.W.C.310 by planting two corn

plants/hill at 35 cm hill spacing resulting in 52,500 plants of cotton and 10,000 corn plants acre-1 (designated as 3:1 pattern).

8. Three cotton ridges alternating with one ridge of corn cv. T.W.C.310 by planting four corn 5plants/hill at 70 cm hill spacing resulting in 52,500 plants of cotton and 10,000 corn plants acre-1 (designated as 3:1 pattern).
9. Mixed intercropping pattern, cotton was planted at the two sides of ridge (120 cm width) resulted in 70,000 plants acre^{-1}, whereas, corn cv. S.C.30k09 was planted in the middle of the ridge resulted in 20,000 plants acre^{-1} by planting two corn plants/hill at 35 cm hill spacing.
10. Mixed intercropping pattern, cotton was planted at the two sides of ridge (120 cm width) resulted in 70,000 plants acre^{-1}, whereas, corn cv. S.C.30k09 was planted in the middle of the ridge resulted in 20,000 plants acre^{-1} by planting four corn plants/hill at 70 cm hill spacing.
11. Mixed intercropping pattern, cotton was planted at the two sides of ridge (120 cm width) resulted in 70,000 plants acre^{-1}, whereas, corn cv. T.W.C.310 was planted in the middle of the ridge resulted in 20,000 plants acre^{-1} by planting two corn plants/hill at 35 cm hill spacing.
12. Mixed intercropping pattern, cotton was planted at the two sides of ridge (120 cm width) resulted in 70,000 plants acre^{-1}, whereas, corn cv. T.W.C.310 was planted in the middle of the ridge resulted in 20,000 plants acre^{-1} by planting four corn plants/hill at 70 cm hill spacing.
13. Solid 1: Pure stand of cotton ridges was conducted by planting at one side of the ridge (60 cm width). Cotton was thinned to two plants/hill at distance of 20 cm between hills resulting in 70,000 plants acre^{-1}. This system is the recommended one.
14. Solid 2: Pure stand of cotton was conducted by planting both sides of the ridge (120 cm width). Cotton was thinned to two plants/hill at a distance of 20 cm between hills resulting in 70,000 plants acre^{-1}.

Solid plantings of cotton (solid 1 and solid 2) were used to compare the performance of cotton plants under intercropping patterns.

A split split plot design in randomized complete block arrangement with three replications was used. Cropping systems (intercropping and solid) were randomly assigned to the main plots, corn varieties were allotted in sub-plots and the distributions of corn plants were devoted to sub sub-plots. Each sub sub-plot consisted of 12 ridges; each ridge was 5 m long, 60 cm wide (except mixed patterns, where each ridge was 5 m long, 120 cm wide). The plot area was 36 m^2. Light intensity measurements were recorded between cotton plants at 100 and 130 days from cotton sowing dates. Light intensity inside each canopy was measured using a Lux-meter apparatus at 12 a.m. o'clock as follows: 1) Light intensity at the middle of the plant (lux) and 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 light intensity measured above cotton plants, *i.e.* outside the plant population.

At maturity, plant height (cm), position of first fruiting node (No.), number of open bolls plant^{-1} , boll weight (g), seed cotton yield plant^{-1} (g), and grain yield plant^{-1} (g) was recorded from individual plants. Seed cotton yield acre^{-1} (ton) and grain yield acre^{-1} (ton) were measured by harvesting all cotton and corn plants per plot. Lint percentage (%) and seed index (g) were measured by sampling ten cotton plants. Chemical compositions of crude protein and oil content were analyzed according to A.O.A.C. (1995) methods. Crude protein content was calculated by multiplying total nitrogen by 6.25 (Sadasivam and Manickam, 1996). The fiber properties were measured using High Volume Instrument (HVI) methods according to A.S.T.M. (2003) by the Cotton Technology Res. Division, Cotton Res. Inst., A.R.C., Giza, Egypt. Fiber length parameters determined were upper half mean [UHM] (mm), uniformity ratio (%), fiber elongation (%), and micronaire (MIC).

Farmer's benefit was calculated by determining the total cost and net return of intercropping culture as compared to recommended solid planting of cotton according to Metwally et al. (2005b, 2009): Total return of intercropping cultures = price of maize yield + price of cotton yield (€uro). To calculate the total return, the average of the maize grains and cotton seeds prices presented by Egyptian Agricultural Statistics (2007) was used. Net return acre^{-1} = total return – (fixed cost of cotton + variable costs of both crops according to intercropping patterns). The homogeneity test was conducted of 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.

RESULTS AND DISCUSSION

Significance of Mean Squares of Different Sources of Variation. Intercepted light intensity within the cotton canopy, cotton plant height, position of first fruiting node, number of open bolls plant^{-1}, seed cotton and grain yields plant^{-1} and acre^{-1} were affected significantly by cropping systems (S), corn varieties (V) and distributions of corn plants (D). Not affected were boll weight, seed index, seed oil and protein content, as well as fiber characters. Seed cotton yield plant^{-1} was affected significantly by the interaction between cropping systems and corn varieties (S x V), while lint percentage was affected significantly by cropping systems (S) only. Seasonal effects and the interactions were not significant (Tables 1 and 2).

Cropping Systems. Solid planting patterns had higher values than intercropping patters for intercepted light intensity in the cotton plant canopy, number of open bolls plant^{-1}, seed cotton yield plant^{-1} and acre^{-1}, as well as lint percentage. Intercropping patterns had higher values than solid plantings for plant height and position of first fruiting node (Tables 3 and 4). The reduction in light intensity at the middle and bottom of cotton plant, at 100 and 130 days age, were 31.6, 39.1, 40.9 and 55.1 %, respectively, as compared with the recommended solid planting of cotton (Solid 1). It is clear that intercropping patterns caused a significant reduction in light interception through adjacent corn plants and produced taller cotton plants. These results are similar to those reported by Metwally et al. (2009) who reported that a mixed intercropping pattern had the lowest light intensity as compared with alternating intercropping ridges.

Alternating ridges of intercropped pattern 3:1 had the highest values for intercepted light intensity on cotton plants at the two growth stages, number of open bolls plant^{-1}, seed cotton yield plant^{-1} and lint percentage as compared with the other intercropping patterns (Tables 3, 4 and 5). Advantage of the intercropping pattern 3:1 in light penetration over alternating ridges 2:1 and mixed intercropping pattern was due to spatial arrangement of this pattern which had the lowest number of corn plants per unit area (50% of recommended solid planting of corn). Although the number of open bolls plant^{-1} , seed cotton yield plant^{-1} and lint percentage were severely reduced under mixed intercropping pattern than other ones, this system produced the highest yield of both crops (3.61 ton acre^{-1} as a result of a combined 0.97 ton of seed cotton in addition to 2.64 ton of corn grains). This may be due to higher plant densities of both crops per unit area (100% of recommended solid plantings of both crops). It could be concluded that number of cotton plants and seed cotton yield plant^{-1} were integrated together for producing the highest seed cotton yield under intercropping cultures. These results are similar to those reported by Munro (1958), Grimes (1963), Memon and Malik (1980), Madiwalar et al. (1989), Kamel et al. (1990) and Abdel-Malak et al. (1991) whom showed that seed cotton yield acre^{-1} was reduced significantly by intercropping as compared with the sole culture of cotton. In addition, Kamel et al. (1990) and Khan et al. (2001) demonstrated that seed cotton yield plant^{-1} and acre^{-1} were reduced significantly by intercropping patterns. Boll weight was not affected by shading effects of adjacent corn plants (Table 4). It is clear that 100-seed weight in cotton is mainly dependent on the genetic constitution of the variety and is seldom affected by the cropping systems (Ghaly et al., 1988). Solid plantings of cotton had the highest values for seed cotton yield acre^{-1} as compared with intercropping patterns (Table 5). In other words, intercropping patterns decreased seed cotton yield acre^{-1} by 34.3 % as compared with recommended solid planting of cotton (solid 1). This may be due to shading effects of intercropped corn plants (Table 3).

Seed oil and protein contents, as well as, fiber technology traits were not affected by cropping systems (Table 6). These results may be due to the early time of harvesting and removal of corn plants (about 50 days) before harvesting cotton plants and consequently equal environmental conditions were available to cotton plants during boll formation and maturation. These results generally agree with those obtained by Memon and Malik (1980), Ghaly et al. (1988), Hosny et al. (1989) and Azevedo et al. (2000) who demonstrated that intercropping corn and cotton had no significant effect on fiber length, micronaire reading and elongation.

Corn Varieties. The corn variety S.C.30k09 is shorter in height (265.25 cm) than T.W.C.310 (297.91 cm). Intercropping short corn plants with cotton caused a significant increase in intercepted light on adjacent cotton plants (Table 3). Intercropping corn variety S.C.30k09 with cotton had lower adverse effects on number of open bolls plant^{-1} than the tallest variety (T.W.C.310) and consequently caused significant increase in number of bolls plant^{-1} (Table 4). Also, intercropping the tallest corn variety (T.W.C.310) had greater adverse effects on cotton seed yield plant^{-1} in mixed intercropping pattern than alternating ridges; this trend was paralleled with the percentage of intercepted light on cotton plants between patterns (Table 3). These results generally agreed with those obtained by Sayed Galal and Metwally (1982), Shafik (1995) and Metwally et al. (2003) who found that there were significant adverse effects among intercropped corn varieties on soybean plants.

Distributions of Corn Plants. Increasing the distance between corn hills from 35 to 70 cm caused a significant increase in intercepted light intensity by cotton plants, on number of open bolls plant^{-1}, and on seed cotton and grain yield both plant^{-1} and acre^{-1}. The reverse was true for plant height and position of first fruiting node (Tables 3, 4, and 5). A wide distance between hills of corn plants caused increases of 18.0, 7.3 and 10.5 % in the number of open bolls plant^{-1}, seed cotton yield plant^{-1} and acre^{-1} , respectively, as compared with the narrow distance. This may be due to more intercepted light from wide distance between hills of corn plants than narrow distance (Table 3). Other characters of cotton were not affected by distributions of intercropped corn plants (Table 4). It could be concluded that the wide distance of corn hills had a positive effect on productivity of intercropped cotton plants without any productivity reduction in the corn plants. These results are in a good line with those obtained by Kamel et al. (1990) and Metwally et al. (2005b).

All the studied characters of cotton plants were not affected significantly by the interactions among seasons, cropping systems, corn varieties and distributions of corn plants except seed cotton yield plant^{-1} which was affected significantly by the interaction between cropping systems and corn varieties (Table 4). The highest seed cotton yield plant^{-1} was obtained by intercropping corn variety S.C.30k09 in alternating ridges in a 3:1 pattern under wide distance between hills of corn plants. The lowest yield was obtained by intercropping the tallest corn variety (T.W.C.310) in mixed intercropping pattern. Seed cotton yield of intercropping cotton with corn was affected more by intercepted light on cotton plants by adjacent corn plants in mixed intercropping patterns with in those with defined corn plant distributions (Table 3). Data indicate that intercropping cotton with corn variety S.C.30k09 and distributed corn plants in wide distance (70 cm, 4 plants per hill) in mixed intercropping pattern gave the highest intercropped seed cotton yield (1.10 ton acre^{-1}) in addition to 2.91 ton acre^{-1} of corn grains,. This arrangement had the heaviest plant density per unit area for cotton (70,000 plants acre^{-1}) than the other intercropping patterns.

Intercropping corn with cotton should be compared with solid planting of cotton under farmer's conditions (Solid 1). In general, intercropping corn with cotton increased total and net returns as compared to recommended solid planting of cotton. Over all the intercropping patterns, intercropping increased total and net returns by about 25.2 and 32.8 %, respectively, as compared with recommended solid planting of cotton (Solid 1). Net return of intercropping corn with cotton was varied between treatments from €uro 243.1 to 603.8 acre^{-1} as compared with recommended solid planting of cotton (€uro 301.7). Mixed intercropping pattern gave the highest financial return value when using high population densities of both crops and distributing the corn plants at a wide distance between hills (4 plants/hill at 70 cm).

The financial returns showed that the mixed intercropping pattern had the highest value over alternating ridges 2:1 and 3:1. It may be concluded that intercropping corn with Egyptian cotton is more profitable to farmers than solid cotton planting (Table 7). These findings are in parallel with those reported by Sayampol and Changsalak (1999) who grew table corn and baby corn (*Zea mays*) in the early rainy season with row spacing of 1.5 meters, and intercropped with one row of groundnut or sesame. The cotton varieties (IRCT413 and Si Samrong 60) were relay cropped one week before corn harvest. They showed that cropping systems with table corn gave more profit than that of the baby corn. Intercropping patterns, corn varieties, distributions of corn plants and other cultural practices such as fertilizers and irrigation should be further investigated to improve the efficiency of intercropping corn with cotton plants.

Table 1. Significance of variation sources as obtained from the combined analysis of the two seasons for some cotton traits at 100 and 130 days age as affected by two growing seasons, cropping systems, corn varieties, distributions of corn plants and their interactions.

Source of variation	df	Mean squares of percentages of light intensity at			
		100 days from cotton sowing		130 days from cotton sowing	
		Middle of the plant community	Bottom of the plant community	Middle of the plant community	Bottom of the plant community
Year (Y)	1	N.S.	N.S.	N.S.	N.S.
Cropping systems (S)	4	*	*	*	*
Y x S	4	N.S.	N.S.	N.S.	N.S.
Corn varieties (V)	1	*	*	*	*
Y x V	1	N.S.	N.S.	N.S.	N.S.
S x V	4	N.S.	N.S.	N.S.	N.S.
Y x S x V	4	N.S.	N.S.	N.S.	N.S.
Distributions of corn plants (D)	1	*	*	*	*
Y x D	1	N.S.	N.S.	N.S.	N.S.
S x D	4	N.S.	N.S.	N.S.	N.S.
V x D	1	N.S.	N.S.	N.S.	N.S.
Y x S x D	4	N.S.	N.S.	N.S.	N.S.
Y x V x D	1	N.S.	N.S.	N.S.	N.S.
S x V x D	4	N.S.	N.S.	N.S.	N.S.
Y x S x V x D	4	N.S.	N.S.	N.S.	N.S.

* = Significant at 5% level of probability N.S. = Non-significant

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

S.O.V.	df	Mean squares															
		Plant height	Position of first fruiting node	Number of open bolls plant^{-1}	Boll weight	Yield plant^{-1}		Yield acre^{-1}		Seed index	Lint	Seed content		Fiber length parameters		Fiber elonga-tion	Mic. reading
						Seed cotton	Grain	Seed cotton	Grain			Oil	Protein	Upper half mean	Uni-formity ratio		
Year (Y)	1	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Cropping systems (S)	4	*	*	*	N.S.	*	*	*	*	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S	4	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Maize 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.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S x V	4	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S x V	4	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Distributions of maize plants (D)	1	*	*	*	N.S.	*	*	*	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x D	1	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S x D	4	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
V x D	1	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S x D	4	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x V x D	1	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S x V x D	4	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Y x S x V x D	4	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

* = Significant at 5% level of probability N.S. = Non-significant

Table 3. Effect of cropping systems, corn varieties, distributions of corn plants and their interactions on light intensity on cotton plants after 100 and 130 days from cotton sowing, combined data across 2006 and 2007 seasons.

Cropping systems	Distributions of corn plants	Percentages of light intensity at											
		100 days from cotton sowing (100d)						130 days from cotton sowing (130d)					
		Middle of the plant			Bottom of the plant			Middle of the plant			Bottom of the plant		
		S.C.30k09	T.W.C.310	Mean	S.C.30k09	T.W.C.310	Mean	S.C.30k09	T.W.C.310	Mean	S.C.30k09	T.W.C.310	Mean
I. Intercropping patterns A. 2 cotton: 1 corn	2 Plants/hill	9.76	7.96	8.86	4.32	2.63	3.47	5.83	3.47	4.65	1.44	0.62	1.03
	4 Plants/hill	11.46	9.66	10.56	5.36	3.56	4.46	8.47	5.60	7.03	2.10	1.48	1.79
	Mean	10.61	8.81	9.71	4.84	3.09	3.96	7.15	4.53	5.84	1.77	1.05	1.41
B. 3 cotton: 1 corn	2 Plants/hill	11.95	8.17	10.06	5.72	4.20	4.96	6.76	4.73	5.74	2.21	1.62	1.91
	4 Plants/hill	12.89	11.73	12.31	6.09	5.60	5.84	8.95	6.99	7.97	2.87	2.29	2.58
	Mean	12.42	9.95	11.18	5.90	4.90	5.40	7.85	5.86	6.85	2.54	1.95	2.24
C. Mixed intercropping	2 Plants/hill	8.92	5.31	7.11	3.54	2.32	2.93	4.68	2.96	3.82	1.06	0.35	0.70
	4 Plants/hill	10.45	7.69	9.07	4.38	2.97	3.67	7.76	4.34	6.05	1.84	0.88	1.36
	Mean	9.68	6.50	8.09	3.96	2.64	3.30	6.22	3.65	4.93	1.45	0.61	1.03
Average of intercropping	2 Plants/hill	10.21	7.14	8.67	4.52	3.05	3.78	5.75	3.72	4.73	1.57	0.86	1.21
	4 Plants/hill	11.60	9.69	10.64	5.27	4.04	4.65	8.39	5.64	7.01	2.27	1.55	1.91
	Mean	10.90	8.41	9.65	4.89	3.54	4.21	7.07	4.68	5.87	1.92	1.20	1.56
II. Solid patterns A. Solid 1 (Recommended)	Mean		14.12			7.13			9.65			3.48	
B. Solid 2	Mean		13.44			6.74			9.26			3.28	
L.S.D. 0.05 Cropping systems	(S)		1.24			0.59			0.88			0.37	
L.S.D. 0.05 Corn varieties	(V)		1.05			0.43			0.62			0.24	
L.S.D. 0.05 Distributions of corn plants	(D)		0.92			0.39			0.53			0.18	

Table 4. Effect of cropping systems, corn varieties, distributions of corn plants and their interactions on plant height, position of first fruiting node, number of open bolls plant^{-1}, boll weight, seed cotton and grain yields plant^{-1}, combined data across 2006 and 2007 seasons.

Cropping systems	Distributions of corn plants	Plant height (cm)			Position of first fruiting node (No.)			Number of open bolls plant^{-1}			Boll weight (gm)			Seed cotton yield plant^{-1}			Grain yield plant^{-1}		
		V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
I. Intercropping patterns A. 2 cotton: 1 corn	2 Plants/hill	161.8	175.9	168.8	8.7	9.5	9.1	8.00	6.58	7.29	2.52	2.79	2.65	18.97	16.98	17.97	225.12	174.53	199.82
	4 Plants/hill	155.0	169.2	162.1	7.9	8.7	8.3	9.25	8.00	8.62	2.81	2.42	2.61	20.14	18.36	19.25	258.93	215.08	237.00
	Mean	158.4	172.5	165.5	8.3	9.1	8.7	8.62	7.29	7.95	2.66	2.60	2.63	19.55	17.67	18.61	242.02	194.80	218.41
B. 3 cotton : 1 corn	2 Plants/hill	144.6	162.4	153.5	8.3	9.0	8.6	9.16	7.58	8.37	2.22	2.89	2.55	19.77	18.30	19.03	252.30	229.03	240.66
	4 Plants/hill	138.1	153.7	145.9	7.4	8.1	7.7	10.33	9.00	9.66	2.32	3.34	2.83	21.02	19.56	20.29	281.52	245.61	263.56
	Mean	141.4	158.0	149.7	7.8	8.5	8.2	9.74	8.29	9.01	2.27	3.11	2.69	20.39	18.93	19.66	266.91	237.32	252.11
C. Mixed intercropping	2 Plants/hill	168.0	182.7	175.4	9.1	10.0	9.6	7.08	5.41	6.24	2.44	2.98	2.71	16.05	13.00	14.52	196.41	169.85	183.13
	4 Plants/hill	162.0	174.9	168.4	8.3	9.2	8.8	8.41	6.75	7.58	2.26	2.89	2.57	17.22	14.37	15.79	211.69	195.52	203.60
	Mean	165.0	178.8	171.9	8.7	9.6	9.2	7.74	6.08	6.91	2.35	2.93	2.64	16.63	13.68	15.15	204.05	182.68	193.36
Average of intercropping	2 Plants/hill	158.1	173.6	165.9	8.7	9.5	9.1	8.08	6.52	7.30	2.39	2.88	2.63	18.26	16.09	17.17	224.61	191.13	207.87
	4 Plants/hill	151.7	165.9	158.8	7.9	8.7	8.3	9.33	7.91	8.62	2.46	2.88	2.67	19.46	17.43	18.44	250.71	218.73	234.72
	Mean	154.9	169.8	162.3	8.3	9.1	8.7	8.70	7.21	7.96	2.42	2.88	2.65	18.86	16.76	17.81	237.66	204.93	221.29
II. Solid patterns A. Solid 1 (Recommended)	Mean		132.5			6.7			10.75			2.06			21.75			---	
B. Solid 2	Mean		135.0			6.8			10.41			2.07			21.43			---	
L.S.D. 0.05 Cropping systems	(S)		12.31			0.50			0.92			N.S.			1.02			26.15	
L.S.D. 0.05 Corn varieties	(V)		4.42			0.31			0.68			N.S.			0.89			15.61	
L.S.D. 0.05 Distributions of corn plants	(D)		3.77			0.26			0.52			N.S.			0.85			8.96	
L.S.D. 0.05 S x V			N.S.			N.S.			N.S.			N.S.			1.04			N.S.	
V1: S.C.30k09																			
V2: T.W.C.310																			

Table 5. Effect of cropping systems, corn varieties, distributions of corn plants and their interactions on seed cotton and grain yields acre^{-1}, lint percentage and seed index, combined data across 2006 and 2007 seasons.

Cropping systems	Distributions of corn plants	Seed cotton yield (ton acre^{-1})			Grain yield (ton acre^{-1})			Lint (%)			Seed index (g)		
		V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
I. Intercropping patterns A. 2 cotton: 1 corn	2 Plants/hill	0.80	0.69	0.74	2.28	1.94	2.11	35.24	34.71	34.97	10.51	10.35	10.43
	4 Plants/hill	0.89	0.78	0.83	2.46	2.05	2.25	35.91	35.02	35.46	10.56	10.38	10.47
	Mean	0.84	0.73	0.78	2.38	2.00	2.18	35.57	34.86	35.21	10.53	10.36	10.44
B. 3 cotton : 1 corn	2 Plants/hill	0.97	0.83	0.90	1.76	1.44	1.61	36.81	36.38	36.59	10.70	10.55	10.62
	4 Plants/hill	1.07	0.91	0.99	1.93	1.61	1.76	37.10	36.72	36.91	10.73	10.63	10.68
	Mean	1.02	0.87	0.94	1.84	1.52	1.68	36.95	36.55	36.75	10.71	10.59	10.65
C. Mixed intercropping	2 Plants/hill	1.00	0.85	0.92	2.78	2.32	2.54	33.81	33.48	33.64	10.48	10.30	10.39
	4 Plants/hill	1.10	0.94	1.02	2.91	2.54	2.73	33.97	33.78	33.87	10.50	10.36	10.43
	Mean	1.05	0.89	0.97	2.84	2.43	2.64	33.89	33.63	33.76	10.49	10.33	10.41
Average of intercropping	2 Plants/hill	0.92	0.79	0.85	2.28	1.90	2.08	35.28	34.85	35.06	10.56	10.40	10.48
	4 Plants/hill	1.02	0.87	0.94	2.43	2.07	2.25	35.66	35.17	35.41	10.59	10.45	10.52
	Mean	0.97	0.83	0.90	2.35	1.98	2.17	35.47	35.01	35.24	10.57	10.42	10.50
II. Solid patterns A. Solid 1 (Recommended)	Mean		1.37			---			37.73			10.85	
B. Solid 2	Mean		1.29			---			37.48			10.76	
L.S.D. 0.05 Cropping systems	(S)		0.09			0.15			2.88			N.S.	
L.S.D. 0.05 Corn varieties	(V)		0.06			0.10			N.S.			N.S.	
L.S.D. 0.05 Distributions of corn plants	(D)		0.04			0.09			N.S.			N.S.	
V1: S.C.30k09													
V2: T.W.C.310													

Table 6. Effect of cropping systems, corn varieties, distributions of corn plants and their interactions on seed contents and fiber technology characters, combined data across 2006 and 2007 seasons.

Cropping systems	Distributions of corn plants	Seed oil content (%)			Seed protein content (%)			Fiber length parameters: Upper half mean			Fiber length parameters: Uniformity ratio (%)			Fiber elongation (%)			Micronaire reading		
		V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
I. Intercropping patterns A. 2 cotton: 1 corn	2 Plants/hill	22.05	21.91	21.98	24.65	24.88	24.76	32.28	32.03	32.15	84.08	83.98	84.03	10.05	9.91	9.98	4.05	3.95	4.00
	4 Plants/hill	22.21	22.06	22.13	24.50	24.71	24.60	32.40	32.11	32.25	84.43	84.31	84.37	10.21	10.05	10.13	4.18	4.01	4.09
	Mean	22.13	21.98	22.05	24.57	24.79	24.68	32.34	32.07	32.20	84.25	84.14	84.19	10.13	9.98	10.05	4.11	3.98	4.04
B. 3 cotton : 1 corn	2 Plants/hill	22.20	22.05	22.12	24.50	24.66	24.58	32.35	32.06	32.20	84.13	84.01	84.07	10.20	9.95	10.07	4.11	4.00	4.05
	4 Plants/hill	22.35	22.13	22.24	24.33	24.55	24.44	32.48	32.16	32.32	84.51	84.45	84.48	10.23	10.13	10.19	4.21	4.11	4.16
	Mean	22.27	22.09	22.18	24.41	24.60	24.50	32.41	32.11	32.26	84.36	84.23	84.29	10.21	10.04	10.12	4.16	4.05	4.10
C. Mixed intercropping	2 Plants/hill	21.93	21.75	21.84	25.03	25.33	25.18	32.21	31.88	32.04	84.06	83.90	83.98	10.01	9.90	9.95	4.00	3.93	3.96
	4 Plants/hill	22.11	21.90	22.00	24.88	25.15	25.01	32.36	32.01	32.18	84.30	84.25	84.27	10.15	10.00	10.07	4.13	4.00	4.06
	Mean	22.02	21.82	21.92	24.95	25.24	25.09	32.28	31.94	32.11	84.18	84.07	84.12	10.08	9.95	10.01	4.06	3.96	4.01
Average of intercropping	2 Plants/hill	22.06	21.90	21.98	24.72	24.95	24.83	32.28	31.99	32.13	84.09	83.96	84.02	10.08	9.92	10.00	4.05	3.96	4.00
	4 Plants/hill	22.22	22.03	22.12	24.57	24.80	24.68	32.41	32.09	32.25	84.41	84.33	84.37	10.19	10.06	10.12	4.17	4.04	4.10
	Mean	22.14	21.96	22.05	24.64	24.87	24.75	32.34	32.04	32.19	84.26	84.14	84.20	10.13	9.99	10.06	4.11	4.00	4.05
II. Solid patterns A. Solid 1 (Recommended planting)	Mean		22.56			24.20			32.56			84.49			10.25			4.24	
B. Solid 2	Mean		22.45			24.30			32.53			84.43			10.23			4.21	
V1: S.C.30k09																			
V2: T.W.C.310																			

Table 7. Financial return as affected by intercropping patterns, two corn varieties, distributions of corn plants and their interactions (combined data across 2006 and 2007 seasons).

Cropping systems	Distributions of corn plants	Financial return/acre (€uro)											
		Corn			Cotton			Total			Net		
		S.C.30k09	T.W.C.310	Mean	S.C.30k09	T.W.C.310	Mean	S.C.30k09	T.W.C.310	Mean	S.C.30k09	T.W.C.310	Mean
I. Intercropping patterns A. 2 cotton: 1 corn	2 Plants/hill	451.8	384.5	418.1	431.8	374.8	403.3	883.7	759.3	821.5	385.3	261.0	323.1
	4 Plants/hill	488.1	407.3	447.7	484.7	423.5	454.1	972.8	830.8	901.8	474.5	332.5	403.5
	Mean	470.0	395.8	432.8	458.2	399.1	428.6	928.2	795.1	861.6	429.8	296.7	363.2
B. 3 cotton : 1 corn	2 Plants/hill	348.8	286.3	317.6	522.5	444.5	483.5	871.3	730.8	801.1	383.6	243.1	313.3
	4 Plants/hill	382.2	318.5	350.3	570.2	492.2	531.2	952.5	810.7	881.6	464.7	323.0	393.8
	Mean	365.5	302.3	333.8	546.3	468.3	507.3	911.8	770.7	841.2	424.1	283.0	353.5
C. Mixed intercropping	2 Plants/hill	550.0	459.6	504.7	540.8	455.3	498.1	1090.8	915.0	1002.8	531.2	355.3	443.2
	4 Plants/hill	575.6	503.5	539.5	587.8	509.0	548.3	1163.5	1012.5	1088.0	603.8	452.8	528.3
	Mean	562.7	481.5	522.1	564.3	482.1	523.2	1127.1	963.7	1045.3	567.5	404.1	485.7
Average of intercropping	2 Plants/hill	450.2	376.7	413.5	498.3	424.8	461.6	948.6	801.7	875.1	433.3	286.5	359.8
	4 Plants/hill	482.0	409.7	445.8	547.6	474.8	511.2	1029.6	884.6	957.1	514.3	369.3	441.8
	Mean	466.1	393.2	429.6	523.0	449.8	486.3	989.1	843.1	916.1	473.8	327.8	400.8
II. Solid patterns Solid planting of cotton (Recommended)	Mean			---			731.3			731.3			301.7

- Prices of main products are that of 2007

€uro 197.3 / ton of corn

€uro 532.5 / ton of cotton

- Intercropping corn with cotton increased variable costs of intercropping culture from €uro 51.7 – 184.0 over those of solid planting according to intercropping patterns.

CONCLUSION

Intercropping corn with Egyptian cotton caused significant reductions in seed cotton yield and open bolls plant^{-1} without any adverse effects on lint characters. It is concluded that corn variety S.C.30k09 was most compatible with cotton under intercropping. In addition, 2.17 ton acre^{-1} of corn grains was gained by intercropping. However, intercropped seed cotton yield reached 80.45 % of solid planting. Therefore, farmers adopting intercropping pattern will have more income than those growing the two commodities in solid culture.

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