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YIELD AND LAND EQUIVALENT RATIO OF INTERCROPPING MAIZE WITH EGYPTIAN COTTON

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A B S T R A C T

Mixed cropping is a system of agriculture that involves planting two or more crops simultaneously in the same field. A two year study was conducted at Giza Agric. Exp. & Res. Sta., Fac. of Agric., Cairo Univ., Egypt, during 2011 and 2012 summer seasons to increase yields of maize and cotton, as well as, famer's benefit. Mixed intercropping pattern (120 cm ridge width) was used in this study for growing both crops, maize plants were distributed in four plants per hill spacing at 70 cm of middle of ridge after one month of growing cotton, whereas, cotton plants were sown in both sides of 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, defoliation of maize at 100 days from sowing maize and harvesting maize for silage at 90 days age) were used under intercropping and solid plantings. A split-split plot arrangement in randomized complete block design was used. Cropping systems were distributed at main plots, whereas, cotton varieties and maize treatments were allotted in sub and sub – sub plots, respectively. For cotton plants under intercropping, shading of adjacent maize plants affected negatively number of open bolls per plant, seed cotton yields per plant and per ha. Cotton cultivar Giza 80 had higher values of number of open bolls per plant, seed cotton yields per plant and per ha in a comparison with the other. Harvested maize plants for silage caused significant increments in number of open bolls/plant, seed cotton yields per plant and ha by 7.69, 13.36 and 11.97 percent, respectively, as compared with intercropped cotton plants with harvested maize plants for grains. The studied cotton traits were affected by the interaction between cropping systems and maize treatments only. Intercropping maize with cotton decreased number of ears per plant, grain yields per plant and per ha as compared with recommended solid planting of maize. Intercropping decreased grain yields caused significant reduction in grain yield per ha by about 22.13% as compared with recommended solid planting of maize. Intercropping maize with cotton increased LER as compared to solid plantings of both crops. LER ranged from 1.45 to 1.98 with an average of 1.69. Net return of intercropping maize with cotton was varied between treatments from 475 to 936 € per ha as compared with recommended solid planting cotton (212 €).

Keywords: *Intercropping, Maize, Cotton cultivars, Silage, Competitive relationships, Financial return .*

INTRODUCTION

Egyptian farmers are developing different crop production systems to increase productivity and sustainability since ancient times. The feed shortage peak is at summer season where some Egyptian farmers have to use maize (*Zea mays* L.) as fodder or defoliation of maize for animal feeding and grains. Cutting three upper leaves of maize plant affects total grain and 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 , 2000). 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). Variations in intercropping are based on the timing of sowing and harvesting, and the degree of mixing/separation of the crops. Since lower leaves may be located under shadow in maize intercropping (they have small role in increasing grain weight) so they can be used in intercropping (Borras and Salfer, 2004). Shading of maize plants reduced photosynthetic capacity of cotton in mixed intercrop pattern (Metwally , 2012), but leaves of Egyptian cotton (*Gossypium barbadense*) 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.

In other words, the leaves 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. Unfortunately, the cultivated area of cotton plants in Egypt decreased from about 447 thousand ha in 1982 to 136 thousand ha in 2012 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 grains in the Egyptian market is intensively increasing where maize cultivated area reached about 802 thousand ha in 2012 (EAS, 2013). In view of the previous, intercropping patterns, cotton cultivars and maize harvest period may have impact on the amount of intercepted sunlight radiation by intercropped cotton plants. So, the objective of this work was to maximize productivity of intercropping cotton and maize, as well as, famer's benefit.

MATERIALS AND METHODS

A two year study was conducted at Giza Agricultural Experiments and Research Station, 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 increase yields of maize and cotton, as well as, famer's benefit. The experiment included six treatments which were the combinations among intercropping, cotton cultivars and maize treatments in addition to two solid cotton plantings). Mixed intercropping pattern was 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 grains were planted in the middle of the ridge and grown in four plants/hill distanced at 70 cm apart. 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 2 plants/hill 20 cm apart) and it is recommended, solid 2 (pure stand of cotton conducted as that of intercropping pattern). 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 cultivars Giza 80 and Giza 86 (long staple, over 1.25 inches), as well as, one maize variety single cross 30k08 (S.C. 30k08) were used. Table (1) shows some varietal differences of the two Egyptian cotton cultivars.

Table 1. Some varietal differences of the two Egyptian cotton cultivars

Cotton cultivars	Giza 80	Giza 86
Pedigree	Crossing between Giza 66 x Giza 73	Crossing 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 by Cotton Research Institute, F.C.R.I., A.R.C., Giza, Egypt

Plants of maize treatments were harvested for silage at 80 days from maize sowing, defoliation of maize plants (under ear leaf) at 100 days from maize sowing and harvesting maize plants for grains at 115 days from maize age. The experimental soil texture was clay and Egyptian clover (berseem) was the preceding winter crop in both seasons. Normal cultural practices for growing cotton were used as those of recommended in the area. Cotton seeds were sown on 24 and 30th March at 2011 and 2012, respectively, while maize grains were sown three weeks later.

A split-split plot arrangement in randomized complete block design with three replications was used. Cropping systems (mixed intercropping and solid plantings) were randomly assigned to the main plots, cotton cultivars 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 in solid 1; but (mixed and solid 2 patterns, three ridges were 5.0 m long and 1.2 m wide). The plot area was 18 m^2.

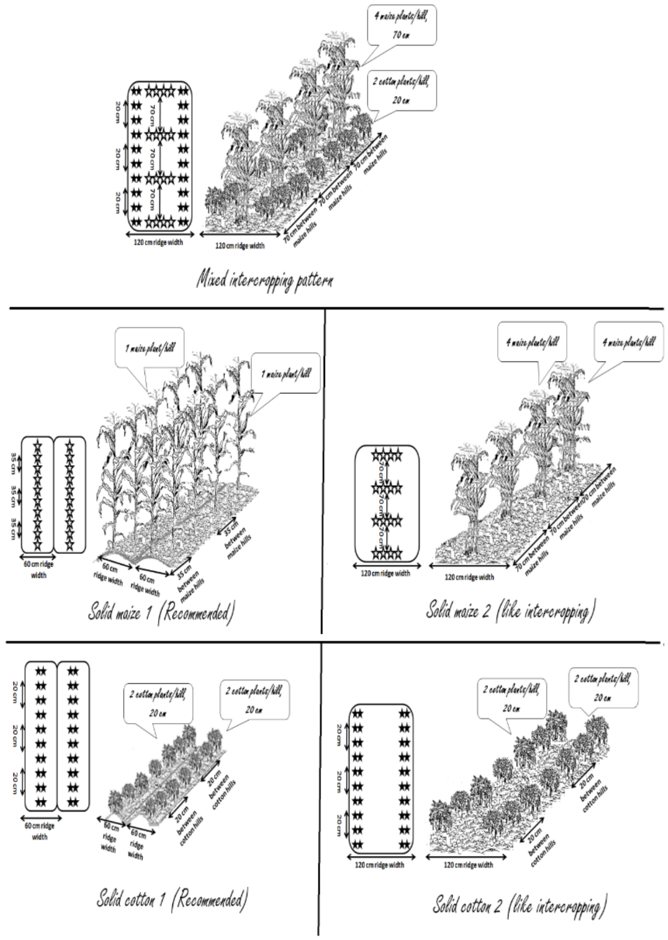

Figure 1. Solid and mixed intercropping patterns of maize and cotton

Cotton traits

At harvest, numbers of total and open bolls per plant and seed cotton yield per plant (g) were recorded on ten guarded plants. Seed cotton yield per ha (ton) was measured by ginning all cotton plants from the plot area.

Maize traits

At harvest, number of ears/plant (prolificacy), grain yields per plant (g) was measured on ten maize plants. Grain and silage yields per ha were measured by harvesting all maize plants from the plot area.

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 (2009)

Total return

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

Net return

Net return = Total return – (fixed cost of cotton + variable costs of both crops according to intercropping pattern). Analysis of variance of the obtained results of each season was performed. The measured variables were analyzed by ANOVA using MSTATC statistical package (Freed, 1991). Data for the 2 years was tested for homogeneity using F-test test of homogeneity and it was found to be homogeneous so the data were combined for analysis. 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

1.Cotton plants

a.Cropping Systems

Number of open bolls per plant, seed cotton yields per plant and per ha were affected significantly by the cropping systems, whereas, number of total bolls/plant was not affected (Table 2). There are gradual and consistent increases ($P \leq 0.05$) in number of open bolls per plant, seed cotton yields per plant and per ha under solid cotton plantings in comparison with all intercrops. It is clear that shading of adjacent maize plants affected negatively in number of open bolls per plant, seed cotton yields per plant and per ha. They were decreased by 6.97 and 5.88%, 10.31 and 11.11%, 13.67 and 14.40% as compared with solid 1 and 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. Plant dry matter production often shows a positive correlation with the amount of intercepted radiation by crops in intercropping and solid cropping system (Sivakumar and Virmani, 1980 and Kiniry , 1989), where the carbohydrate balance of reproductive tissues strongly influences reproductive success in cotton (Zhao , 2005 and Snider , 2009) and consequently radiation intercepted by the crop canopy is directly correlated to dry matter accumulation (Gonias , 2012), where, there were significant reductions in seed cotton yield and open bolls per plant under this pattern (Metwally , 2012).

Obviously, spatial arrangements of mixed stand did not encourage cotton plant for well growth and consequently abnormal environmental conditions were performed to the plant during bolls formation. Accordingly, spatial arrangement has an important influence on the degree of competition between crops (Addo-Quaye , 2011). It could be concluded that the actual planted area with cotton plants under mixed intercropping pattern (100 % of the unit area) played an important role in seed cotton yield per ha, where, number of cotton plants and seed cotton yield per plant under mixed stand were integrated together for producing final seed cotton yield per unit area.

b.Cotton Cultivars

Cotton cultivars were differed significantly for number of open bolls per plant, seed cotton yields per plant and per ha, whereas, number of total bolls per plant was not differed between cotton varieties (Table 2). Cotton cultivar Giza 80 had higher values ($P \leq 0.05$) of number of open bolls per plant, seed cotton yields per plant and per ha in a comparison than cultivars. These results may be due to cotton cultivar Giza 80 have some morphological characters which reflected positively on receiving solar radiation and consequently the final yield (Table 1).

Table 2. Effect of cropping systems, cotton cultivars, maize treatments and their interactions on number of open bolls/plant, seed cotton yields per plant and per ha, combined data across 2011 and 2012 seasons

		Number of open bolls/plant			Seed cotton yield/plant (g)			Seed cotton yield/ha (ton)		
	Maize treatments	Cotton varieties		Mean	Cotton varieties		Mean	Cotton varieties		Mean
Cropping systems		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86	
Intercropping culture	M_1	8.0	7.7	7.8	18.9	18.5	18.7	1.94	1.91	1.92
	M_2	8.1	7.7	7.9	20.0	19.9	20.0	2.02	1.98	2.00
	M_3	8.7	8.0	8.4	21.8	20.7	21.2	2.24	2.06	2.15
Average of intercropping		8.2	7.8	8.0	20.2	19.7	20.0	2.06	1.98	2.02
Solid 1		9.2	8.1	8.6	22.8	21.9	22.3	2.51	2.17	2.34
Solid 2		8.8	8.3	8.5	23.0	22.0	22.5	2.51	2.21	2.36
General mean of cotton varieties		8.7	8.0	8.3	22.0	21.2	21.6	2.36	2.13	2.24
$LSD_{0.05}$ for:										
Cropping systems (S)				0.98			0.18			0.08
Cotton varieties (V)				*			**			*
Maize treatments (T)				0.98			0.18			0.08
S x V				0.13			N.S.			N.S.
S x T				0.17			0.32			0.13
V x T				N.S.			N.S.			N.S.
S x V x T				N.S.			N.S.			N.S.

**, *, N.S = Significant at 1 and 5 % probability levels and non-significant, respectively, M1: Harvested maize plants for grains, M2: Defoliation of maize plants and M3: Green fodder for silage.

It is clear that there were a relationship between interception solar radiation and canopy of cotton cultivar. 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 1 and solid 2, respectively. Obviously, shading of adjacent maize plants resulted in lower adverse effects on cotton cultivar Giza 86 than the other one 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 Karademir (2010) who found that there is significant negative correlation between fiber length and seed cotton yield and lint yield.

a.Maize Treatments

Harvested maize plants for silage caused significant increment ($P \leq 0.05$) in number of open bolls/plant, seed cotton yields per plant and ha by 7.69, 13.36 and 11.97 percent, respectively, as compared with intercropped cotton plants with harvested maize plants for grains (Table 2).

Also, defoliation maize plants at 100 days age caused significant increment in number of open bolls/plant, seed cotton yields per plant and per ha by 1.28, 6.95 and 4.16 percent, respectively, in comparison with intercropped cotton plants with harvested maize plants for grains. Accumulation of dry matter by a crop is directly dependent upon the amount of radiation intercepted by the crop canopy (Monteith, 1977). These results may be due to removal maize plants as silage (one month) before harvesting maize plants for grains or defoliation of maize plants before two weeks from harvesting maize plants for grains create favorable environmental conditions especially light intensity which was more available to cotton plants during boll formation and maturation (Safina , 2014). These results are in a good line with those obtained by Metwally (2012) who reported that the early time of harvesting and removal maize plants (about 50 days) before picking seed cotton led to subject cotton plants to environmental conditions which were available during boll formation and maturation.

b.Cotton Cultivars Response to Cropping Systems

Numbers of total and open bolls per plant were affected significantly by the interaction between cropping systems and cotton cultivars, whereas, seed cotton yields per plant and per ha were not affected (Table 2). Cotton cultivar Giza 80 had higher value ($P \leq 0.05$) of open bolls per plant under solid 1.

c.Cropping Systems Response to Maize Treatments

Numbers of total and open bolls per plant, seed cotton yields per plant and per ha were affected significantly by the interaction between cropping systems and maize treatments (Table 2). Cotton plants which grown with harvested maize for silage recorded higher values ($P \leq 0.05$) of each of open bolls per plant, seed cotton yields per plant and per ha, whereas, the reverse trend for these traits was true when cotton plants grown with harvested maize plants for grains.

d.Cotton Cultivars Response to Maize Treatments

Numbers of open bolls per plant, seed cotton yields per plant and per ha were not affected significantly by the interaction between cotton cultivars and maize treatments (Table 2).

e.Interaction among Cropping Systems, Cotton Cultivars and Maize Treatments

Numbers of total and open bolls per plant, seed cotton yields per plant and per ha were not affected significantly by the interaction between cotton cultivars and maize treatments (Table 2).

1.Maize plants

a.Cropping Systems

Intercropping maize with cotton resulted in significant reduction ($P \leq 0.05$) in prolificacy grain yields per plant and per ha (Table 3). From the other view, all the studied maize traits were not differed significantly between mixed stand and solid maize 2. These data may be due to four maize plants per hill suffered from mutual shading than one plant per hill. 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. Maize plants in the same canopy had leaves preferentially oriented perpendicular to the row when competition for light was intense (Girardin and Tollenaar, 1994). As a result of mixed intercropping pattern, number of ears per plant, grain yields per plant and per ha were decreased by 8.69, 12.07 and 22.13 percent as compared with solid maize planting recommended (Solid 1), whereas, grain yield of maize and its attributes were not differed between mixed stand and solid maize 2. Obviously, row width played a major role in light transmission through maize plants and thus a maximum benefit of natural environmental resources. Obviously, crop yielding ability per unit area under mixed intercropping conditions can be enhanced by maintaining the optimum number of intercropped plants to maximize the total light interception by the canopies.

Growing maize with cotton resulted in significant increment in silage yield per ha by 6.02 and 1.84 percent in comparison with recommended solid maize planting (solid maize 1) and solid maize 2, respectively. It is clear that spatial arrangement of mixed stand was largely similar to solid maize 2 than solid maize 1 and it was responsible for increasing silage yield per ha considering the stability of the number of maize plants per unit area. These results are in accordance with those obtained by Khan and Abdul Khaliq (2004) who showed that intercropped maize at 120 cm spaced double row strips of cotton produced significantly higher fodder yield than that grown in 80 cm spaced single rows of cotton

b.Cotton Cultivars and maize treatments

Had no significant effects on intercropped maize characters. Also, the interactions among cropping systems, cotton cultivars and maize treatments did not affect maize characters (Table 3). It is clear that each of these factors act independently ($P > 0.05$) on all the studied maize traits.

Table 3. Effect of cropping systems, cotton cultivars, maize treatments and their interactions on prolificacy, grain yields per plant and per ha and silage/ha, combined data across 2011 and 2012 seasons

Cropping systems	Maize treatments	Prolificacy			Grain yield/plant (g)			Grain yield/ha (ton)			Green fodder yield/ha (ton)		
		Cotton cultivars		Mean	Cotton cultivars		Mean	Cotton cultivars		Mean	Cotton cultivars		Mean
		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86		Giza 80	Giza 86	
Intercropping culture	M_1	0.85	0.89	0.87	145.8	154.9	150.4	7.29	7.74	7.51	--	--	--
	M_2	0.81	0.83	0.82	141.6	146.0	143.8	7.08	7.30	7.19	--	--	--
	M_3	--	--	--	--	--	--	--	--	--	56.02	54.50	55.26
Average of intercropping		0.83	0.86	0.84	143.7	150.5	147.1	7.18	7.52	7.35			
Solid maize 1	M_1	0.94	0.94	0.94	174.4	174.4	174.4	9.86	9.86	9.86	--	--	--
(recommended)	M_2	0.90	0.90	0.90	160.1	160.1	160.1	9.02	9.02	9.02	--	--	--
	M_3	--	--	--	--	--	--	--	--	--	52.12	52.12	52.12
	Mean	0.92	0.92	0.92	167.3	167.3	167.3	9.44	9.44	9.44			
Solid maize 2	M_1	0.83	0.83	0.83	147.9	147.9	147.9	7.83	7.83	7.83	--	--	--
	M_2	0.83	0.83	0.83	141.4	141.4	141.4	7.33	7.33	7.33	--	--	--
	M_3	--	--	--	--	--	--	--	--	--	54.26	54.26	54.26
	Mean	0.83	0.83	0.83	144.7	144.7	144.7	7.58	7.58	7.58			
General mean of maize treatments	M_1	0.87	0.89	0.88	156.0	159.0	157.5	8.32	8.47	8.39	--	--	--
	M_2	0.85	0.85	0.85	147.7	149.1	148.4	7.81	7.88	7.84	--	--	--
	M_3	--	--	--	--	--	--	--	--	--			
General mean of cotton varieties		0.86	0.87	0.86	151.8	154.0	152.9	8.06	8.17	8.11	54.13	53.62	53.87
L.S.D. at 0.05 for :													
Cropping systems (S)				0.05			2.1			0.18			1.30
Cotton varieties (V)				N.S.			N.S.			N.S.			N.S.
Maize treatments (T)				N.S.			N.S.			N.S.			N.S.
S x V				N.S.			N.S.			N.S.			N.S.
S x T				N.S.			N.S.			N.S.			N.S.
V x T				N.S.			N.S.			N.S.			N.S.
S x V x T				N.S.			N.S.			N.S.			N.S.

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

1.Land equivalent ratio (LER)

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 4 and Fig. 2). Relative yields of maize and cotton were higher by intercropping cotton with maize which harvested for silage than others. These results may be due to removal maize plants as silage (one month) before harvesting maize plants for grains 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 cultivars, whereas, relative yield of maize was not affected (Table 4 and Fig. 2). Intercropping maize plants with cotton cultivar Giza 86 had higher value for relative yield of cotton, whereas, lower relative yield of cotton was obtained by growing maize plants with cotton cultivar Giza 80.

Overall cropping systems (intercropping and solid plantings), relative yield of cotton was affected by maize treatments, whereas, relative yield of maize was not affected (Table 4 and Fig. 2). These data indicated that maize treatments responded similarly ($P > 0.05$) to maize varieties under intercropping pattern. Relative yields of maize and cotton were not affected by all the interactions (Table 4 and Fig. 2).

Table 4. Effect of cropping systems, cotton cultivars, 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 L_{maize} Cotton cultivars Giza 80	Giza 86	Mean	L_{cotton} Cotton cultivars Giza 80	Giza 86	Mean	LER Cotton cultivars Giza 80	Giza 86	Mean
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 plantings		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L.S.D. at 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: Defoliation of maize plants and M_3: Green fodder for silage.

In general, intercropping maize with cotton increased LER as compared to solid plantings of both crops (Table 4 and Fig. 2). It ranged from 1.50 (by intercropping cotton cultivar Giza 80 with maize which harvested for grains) to 1.98 (by intercropping cotton cultivar Giza 86 with maize which harvested for silage) with an average of 1.69. The advantage of the highest LER by intercropping cotton cultivar Giza 86 with maize which harvested for silage over the others could be due to the early time for removal maize plants from cotton fields which led to minimize adverse effects of intercropping maize on intercropped cotton plants especially cotton cultivar 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 (2009) who reported that the relative yield total of maize and cotton was greater in intercropping than solid, and the highest LER (1.61) were obtained in intercropping culture.

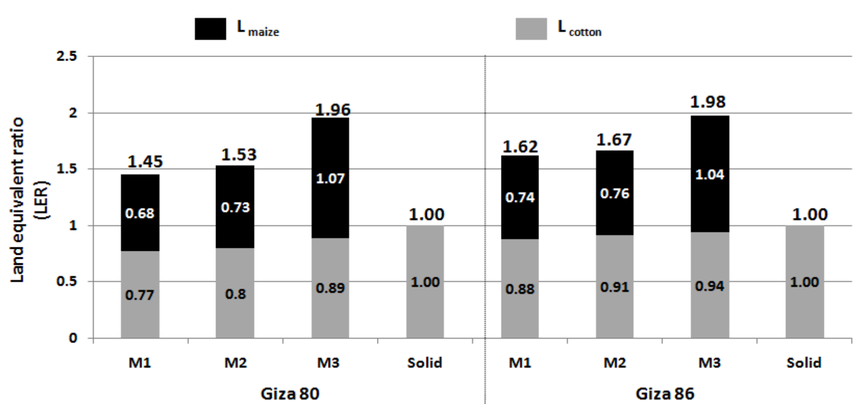

Figure 2. Relative yields of maize and cotton and land equivalent ratio (LER) as affected by cropping systems, cotton cultivars and maize treatments combined data across 2011 and 2012 seasons. M_1: Harvested maize plants for grains, M_2: Defoliation of maize plants and M_3: Green fodder for silage

1.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 113.3 and 364.7 per cent, respectively, as compared with solid planting of cotton (Table 5). Net return of intercropping maize with cotton was varied between treatments from 475 € to 936 € per ha as compared with solid planting of cotton (212 €). Intercropping cotton variety Giza 80 with maize which harvested for silage 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 (1990) who revealed 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 , 1999). Also, Metwally (2009 and 2012) 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.

Table 5. Financial return as affected by cropping systems, cotton cultivars, maize treatments and their interactions, combined data across 2011 and 2012 seasons

Cropping systems	Maize treatments	Financial return (EUR), € Maize Cotton cultivars Giza 80	Giza 86	Mean	Cotton Cotton cultivars Giza 80	Giza 86	Mean	Total Cotton cultivars Giza 80	Giza 86	Mean	Net return Cotton cultivars Giza 80	Giza 86	Mean
Intercropping culture	M_1	531	649	625	711	700	705	1312	1349	1331	516	506	511
	M_2	579	602	591	740	726	733	1319	1328	1324	475	485	480
	M_3	883	859	871	821	755	788	1704	1614	1659	936	847	892
Average of intercropping		688	704	696	757	727	742	1445	1430	1438	643	612	627
Recommended solid maize planting				876	--		--						366
Recommended solid cotton planting		--		--	920	795	857				274	149	212

M_1: Harvested maize plants for grains. M_2: Defoliation of maize plants. M_3: Green fodder for silage. Prices of main products are: Ton of silage = 38 € (market price), Ton of maize grains = 255 € and Ton of seed cotton = 873 € . Intercropping maize with cotton increased variable costs by about 873 € over than those of solid cotton planting it ranged between 113 € (M3) and 199 € (M2).

CONCLUSION

Results obtained from competitive relationship (LER) showed a significant advantage from mixed intercropping for exploiting the resources of the environment as compared to solid cropping which attributed to better economics and land use efficiency. Intercropping maize with cotton increased net return by 364.74% in a comparison with solid planting of cotton. Silage treatment gave the highest financial value by intercropping maize with cotton cultivar Giza 80 as compared with other maize treatments.

REFERENCES

Addo-Quaye AA, Darkwa AA and Ocloo GK. 2011. Growth analysis of component crop in maize - soybean crops in maize - soybean intercropping system as affected by time of planting and spatial arrangement. ARPN J. Agric. and Biological Sci., 6 (6): 34-44.

Anil L, Park J and Phipps RH. 2000. The potential of forage-maize intercrops in ruminant nutrition. Animal Feed Sci. and Technology, 85: 157-164.

Borras L and Salfer GA. 2004. Seed dry weight Response to source–sink manipulation in wheat, maize and soybean. Field Crops Res., 86: 131-146.

Egyptian Agricultural Statistics. 2013. Study of important indicators of the agricultural statistics. Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Vol.2, Egypt.

Freed RD. 1991. MSTATC Microcomputer Statistical Program. Michigan State Univ., East Lansing, Michigan, USA.

Friday JB and Fownes JH. 2001. A simulation model for hedgerow light interception and growth. Agric. and Forest Meteorology, 108: 29-43.

Girardin P and Tollenaar M. 1994. Effects of intraspecific interference on maize leaf azimuth. Crop Sci., 34: 151-155.

Gonias ED, Oosterhuis DM, Bibi AC and Purcell LC. 2012. Estimating light interception by cotton using a digital imaging technique. American J. Experimental Agric., 2 (1):1-8.

Imam Y. 1997. Effect of defoliation on patterns of dry matter accumulation and yield of maize view. Abstracts of Iranian Congress of Agron. and Plant Breeding, Karaj.

Karademir E, Karademir C, Ekinci R and Gencer O. 2010. Relationship between Yield, Fiber Length and other Fiber-Related Traits in Advanced Cotton Strains. Not. Bot. Hort. Agrobot. Cluj, 38 (3): 111 – 116.

Khan MB and Abdul Khaliq A. 2004. Studies on intercropping summer fodders in cotton. J. Res. Sci., 15 (3): 325 – 331.

Kiniry JR, Jones CA, O'Toole JC, Blanchet R, Cabelguenne M and Spanel DA. 1989. Radiation-use efficiency in biomass accumulation prior to grain-filling for five grain-crop species. Field Crops Research, 20: 51-64.

Mead R and Willey RW. 1980. The concept of a "land equivalent ratio" and advantages in yields from intercropping. Exp. Agric., 16: 217-228.

Metwally AA, Shafik MM, Sherief MN and Abdel-Wahab TI. 2009. Possibility of intercropping maize with Egyptian cotton. The 4th Conf., Recent Technologies in Agric., 3-5 Nov., Cairo Univ., 2: 270-284, Egypt.

Metwally AA, Shafik MM, Sherief MN and Abdel-Wahab TI. 2012. Effect of intercropping corn on Egyptian cotton characters. J. Cotton Sci., 16 (4): 210–219, U.S.A.

Monteith JL. 1977. Climate and efficiency of crop production in Britain. Phil. Trans. R. Soc. London, B., 281: 277-294.

Rao VP. 1991. A study on intercropping of cotton with grain legumes under rainfed conditions. J. Res. APAU., 19: 73-74.

Saeed M, Shahid MRM, Jabar A, Ullah E and Khan MB. 1999. Agroeconomic assessment of different cotton-based i-9nter-relay cropping systems in two geometrical patterns. Int. J. Agri. Bio., 4: 234-237.

Safina SA, Noaman AH and Metwally AA. 2014. Productivity and Fiber Quality of Two Egyptian Cotton Cultivars Under Solid and Intercropping Cultures With Maize. Intl J Agri Crop Sci., 7 (11): 778-785.

Sivakumar MVK and Virmani SM. 1980. Growth and resource use of maize, pigeonpea and maize/pigeonpea intercrop in an operational research watershed. Experimental Agriculture, 16: 377-386.

Snedecor GW and Cochran WG. 1988. Statistical Methods 7th Ed. Iowa State Univ., Press, Iowa, Ames, U.S.A

Snider JL, Oosterhuis DM, Skulman BW and Kawakami EM. 2009. Heat stress-induced limitations to reproductive success in Gossypium hirsutum. Physiol. Plant, 137: 125- 138.

Subiyakto D, Soebandrijo H and Sahid M. 1990. The effect of intercropping cotton with maize on Helicoverpa armigera (Hubner) pada kapas. Pemberitaan-Penelitian-Tanaman-Industri, 16 (2): 65–69.

Zhao D, Reddy KR, Kakani VG, Koti S and Gao W. 2005. Physiological causes of cotton fruit abscission under conditions of high temperature and enhanced ultraviolet-B radiation. Physiol. Plant, 124: 189-199.