Competitive Relationship for Intercropped Maize and Sesame Under Different Both Intercropping Systems and Sowing Patterns

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ABSTRACT
Two field experiments were conducted at the experimental farm, Faculty of Agriculture, Damanhour, Alexandria University during 2004 and 2005 summer seasons, to study the competitive relationship for maize/sesame intercropping by different systems and sowing patterns. Maize cultivar Three Way Cross 310 and sesame variety Giza 32 were sown on April 20th and May 20th, solely or intercropped together simultaneously or in sequences under three systems i.e. the same ridges, as well as alternative ridges (1:1) and (2:2). A split-plot experimental design, with four replications was used. The three intercropping systems occupied the main plots, while the eight sowing pattern treatments were arranged in the sub-plots. The data obtained showed that maize was the dominant intercrop component, while sesame was the dominated one under the three studied intercropping systems. The values of Land Equivalent Ratio (LER) and Relative Crowding Coefficient (RCC) were more than one for all studied intercropping treatments, indicating that a considerable yield advantage was obtained. The values of (LER) were 1.38 and 1.37 in the first and second seasons, respectively, indicating that the productivity of the cultivated unit area increased by 37.5%, averaged over both seasons, when intercropping both crops together compared with sole sowing of both crops

INTRODUCTION
As far as we know, all the previous studies under tropical and warm temperature regions indicated that intercropping culture increased land use efficiency (LUE) (Pendlton et al., 1963; Wahua and Miller, 1978; Sayed Galal et al., 1983; Moursi et al., 1983; Badran, 1988 and 1994; Gomaa et al., 1995; Metwally, 1999; Abdel-Aal et al., 2000; Badran, 2002; Metwalley et al., 2003 and 2005 and Abo-Kerisha et al., 2008).

The intercropping crops compete for different below and above soil environmental factors. It is expected that two crops of wide different needs for the ecological conditions might result in an increase in the total combined yields. This is fully indicated when maize, tall plants, are intercropped with short sesame plants. There can be a situation where a given crop will actually grow better in the presence of another crop than as a sole crop. But, usually a yield advantage occurs because companion crops differ in their use of growth resources in such a way that when they

are grown in combination. Thus, they are able to compensate each other and so make better overall use of resources than they were grown separately.

A few available reports revealed that intercropping sesame with groundnut under Egyptian conditions increased LER from 28 up to 91% increment in yields compared with the solid plantings of both crops (El-Gamel et al., 1990; El-Mihi et al., 1990; Gabr et al., 1993; Gomaa et al., 1995; Gabr, 1998 and Badran, 2002).

On the other hand, El-Gamel et al., (1990), showed that aggressivity values were, in general, positive for sesame. El-Mihi et al., (1990) reported that interplanted sesame on the top of the ridge was more aggressive than when grown on the other side of groundnut ridges. Gabr et al., (1993) stated that aggressively was slight under (1:1), (1:2), (2:1) and (2:2) alternate ridges of sesame/groundnut intercropping systems. Badran, (2002) indicated that sesame was dominant in some treatments but dominated under other studied intercropping treatments.

The present research work was designed in order to obtain more information on the degree of competition relationship in terms of Land Equivalent Ratio (LER), Aggressivity (A) Relative Crowding Coefficient (RCC) for intercropped maize/sesame under newly cultivated sandy soil conditions by different systems and sowing patterns using seed yields.

MATERIALS AND METHODS

Two field experiments were conducted at El-Boustan experimental farm Faculty of Agriculture at Damanhour, Alexandria University during the two successive summer seasons, 2004 and 2005. The main objective was studying the effect of different intercropping systems for maize and sesame intercropped by both different intercropping systems and sowing patterns on a competitive relationship using seed yields.

Each experiment included 24 treatments which were the combinations of three intercropping systems and eight different sowing patterns. The three studied intercropping systems were: the same ridges, as well as alternate ridges (1:1) and (2:2) while, the sowing patterns were combinations of April 20th and May 20th sowing dates, for both maize and sesame as follows:

1. Maize and sesame were simultaneously sown on the same day, on April 20th (M_1S_1).
2. The two crops were simultaneously sown on the same day, on May 20th (M_2S_2).
3. Early sowing of maize, on April 20th, followed by sowing of sesame on May 20th (M_1S_2).
4. Early sowing of sesame, on April 20th, followed by sowing of maize on May 20th (M_2S_1).

Moreover, each of the two crops were solely planted at each of the two assigned planting dates. This resulted in four other sole-cropping treatments, i.e., sole maize planting on April 20th (M_1), sole sesame planting on Aril 20th (S_1), sole maize planting on May 20th (M_2) and sole sesame planting on May 20th (S_2). A spilt-plot design with four replicates was used. The intercropping systems were assigned to the main plots, while the sowing patterns were randomly distributed in the sub-plots. The experimental unit consisted of eight ridges spaced 60 cm apart and three meters long. The maize cultivar Three Way Cross 310 (TWC 310) and sesame variety Giza 32 (G32) were used in the two seasons. Sesame seeds were mixed with sand during sowing for better seed distribution.

Regarding the same ridge intercropping system, maize grains were sown on the northern side of the ridge, while sesame seeds occupied the southern side but in the two other intercropping systems, both crops were sown on both sides of the ridges.

The plant population/ha of maize and sesame were about 41666 and 222,222, respectively. The two respective plant populations were maintained through thinning maize seedlings to one plant/hill spaced 40 cm apart and sesame in two plants/hill spaced 15 cm apart. Both nitrogen fertilizer as ammonium sulphate (20.6% N) and potassium fertilizer, as potassium sulphate (48% K_2O) were side- dressed at two equal doses at rates of 216 and 115.5 kg/ha., respectively. Half of the amount was added at the first irrigation and the rest was applied at the second irrigation in both sole-cropping and simultaneous intercropping. For the sequential intercropping treatments, in which the two crops were sown at two different dates, the first application of both nitrogen and potassium fertilizers was added at sowing irrigation of the latest planted crop, while the second dose was applied at the subsequent irrigation. In addition, phosphorous fertilizer in the form of ordinary supper phosphate (15.5% P_2O_5) was broadcasted during soil preparation, at a rate of 74 kg P_2O_5/ha. All other cultural

practices, recommended for El-Boustan region, were applied for both crops.

The following three competitive relationships were determined:
1- **Land Equivalent ratio (LER):** It is the ratio of area needed under monoculture to that of intercropping at the same management level to produce an equivalent yield according to Mead and Willey (1980). It was calculated as follows:
LER $= RYm + RYs$
$RYm = Yim/Ymm.$
$RYs = Yis/Yss$

Where: RYm = Relative yield of maize.
RYs = Relative yield of sesame.
Yim = Intercrop yield of maize.
Yis = Intercrop yield of sesame.
Ymm = Solid crop yield of maize.
Yss = Solid crop yield of sesame.

2- **Aggressivity (A):** It was calculated according to McGilchrist's (1965) equation, as follows:
$Acm = (Yim/Ymm)$ (Yis/Yss)
$Acs = (Yis/Yss) - (Yim/Ymm)$

Where: Acm and Acs are the aggressivity values for maize and sesame, respectively.

3- **Relative Crowding Coefficient (RCC):** It was calculated, for maize (RCCm) and sesame (RCCs) according to the equation, as described by Willey and Osera (1979).

$RCCm = Yim/(Ymm - Yim)$
$RCCs = Yis/ (Yss - Yis)$

Where: RCCm and RCCs are the relative crowding coefficient of maize and
sesame, respectively.

In the present investigation, the grain yield of solid maize sown on May 20th and the seed yield of solid sesame sown on April 20th were used

,as control, to calculate Relative Yield of maize (RYm) and sesame (RYs) in both studied seasons.

It should be noted that during both seasons, maize was considered as the main while sesame was the secondary crop. Two orthogonal comparisons were carried out for intercropping systems. i.e., (C_1): the same ridge of intercropping system vs alternating ridge systems and (C_2); (1:1) alternate ridges of intercropping system vs (2:2) alternate ridges of intercropping system.

With respect to the Land Equivalent Ratio (LER) trait, five orthogonal comparisons were done among the eight treatments of sowing patterns, i.e., solid planting vs intercropping (C_3), solid plantings in April vs May, (C_4), maize solid plantings in April vs May (C_5) sesame solid plantings in April vs May (C_6) and among intercropping sequences of maize and sesame (C_7). On the other hand, another five orthogonal comparisons were also done for the interaction among the intercropping systems(I) and C_3, C_4, C_5, C_6 and C_7 as shown in Table (2).

Regarding Relative Yields for maize (RYm) and sesame (RYs), three orthogonal comparisons were performed among the six treatments of sowing patterns and another three orthogonal for their interactions with intercropping systems as shown in Table (1).

Data were statistically analyzed according to Steel and Torrie (1980).

RESULTS AND DISCUSSION
1- Advantage of intercropping
1-a) Relative Yields of maize (RYm):
The same ridge of intercropping system vs. the alternating ridges of intercropping systems (C_1) data in Tables (1 and 3) revealed that intercropped maize with sesame on the same ridge system (side of ridge for each crop) insignificantly and significantly increased RYm in the first and second seasons, respectively. This may be attributed to the smaller area occupied by maize plants under alternating ridges systems as compared with the same ridge of intercropping system (50% reduction in the area). Our results are in agreement with those obtained by Sayed Galal et al. (1983), Badran (1988), Metwally (1999) and Metwally et al. (2005).

The results summarized in Table (3) showed that (2:2) alternating ridges system insignificantly reduced RYm during both seasons, by about

6.29%, averaged the two seasons, as compared with the (1:1) alternating ridges system. This result may be attributed to the distribution of maize plants under (1:1) alternating ridges which gave more relative light penetrated and intercepted as compared with the other studied system i.e., (2:2) alternating ridges.

Maize solid plantings vs intercropped with sesame (C_3), as shown in Table (3), indicated significant increase in RYm of solid planting in both seasons compared with intercropping culture. This result might be mainly attributed to more area actually planted by solid maize (100%) than intercropping plantings (66.7%). These findings were parallel with those obtained by Sayed Galal et al. (1983), Metwally (1999), Badran (2002) and Metwally et al. (2005).

Concerning to the fifth comparison (C_5), it is clearly evident from the results presented in Tables (1 and 3) that the early solid planting of maize on April 20th significantly and highly significantly decreased RYm, by about (13.23%) compared with th 3 late sole plantings on May 20th, over both seasons. These results were supported by Badran (1988).

Regarding to intercropping maize with sesame by sequences of sowing dates (C_7), it was clear from Table (3) that the lower means for RYm were: 0.65 and 0.68 were obtained from the two intercropping treatments (M_2S_1) and (M_1S_2) in the first and second seasons, respectively.

1-b) Relative Yield of sesame (RYs):

The data presented in Tables (1 and 3) revealed that the RYs were not significantly affected by the three intercropping systems in both seasons. With respect to the third comparison (C_3), solid vs intercropped plantings of sesame, the data showed that intercropping sesame with maize significantly decreased the RYs by about 33.51% as an average of both seasons compared with the sole plantings, Table (3). April vs May plantings of sole sesame (C_6) the data in Tables (1 and 3) indicated that early solid planting on April 20th highly significantly increased the RYs by about 15.92%, averaged both seasons, compared with the late solid plantings on May 20th. Concerning the effect of intercropping sesame with maize in sequences by the two sowing dates i.e., April 20th and May 20th (C_7), it was evident that interpolating sesame early on April 20th, at the same time with maize (M_1S_1) gave the higher values of RYs (0.72 and 0.68) in the first and second season respectively, followed by the (M_2S_1) treatment where sesame was intercropped early on April 20th one month

before sowing of maize (Table 3). This indicated that the relative sowing date of the two interplanted species played an important role in determining the magnitude of competition between the two crops throughout the growing period.

1- c) Land Equivalent Ratio (LER):-

The analysis of variance showed that LER was insignificantly affected by the studied intercropping systems in both seasons Table (2). Regarding to the solid plantings vs intercropping plantings (C_3), data indicated that intercropping was significantly superior over the solid plantings in both seasons as shown in the Table (3). The values of LER for intercropping were greater than one (1.375), averaged of both seasons Table (3). This means that, about 38% of land area was needed more under monoculture plantings for both crops i.e, maize and sesame, to produce the same combined intercrop yields obtained from intercropping both crops together. With respect to the intercropping sequences by sowing dates (C_7), the highest LER value (1.46) averaged both seasons, was obtained when maize was intercropped with sesame by sowing both crops simultaneously on May 20th (M_2S_2). On the other hand the lowest LER value (1.15) averaged both seasons was obtained when maize intercropped with sesame by sowing maize one month before sesame (M_1S_2) treatment Table (3). This results are in agreement with those obtained by Badran (1988) , EL–Gamel et al., (1990), El–Mihi et al (1990); Gabr et al, (1993); Badran, (1994); Gomaa et al., (1995), Badran, (2002) and Metwally et al, (2005).

2) Aggressivity (A):-

Data in Table (4) represent the values of the aggressivity for maize and sesame crops as affected by different intercropping systems and sowing patterns in 2004 and 2005 seasons. It was evident from Table (4) that the three studied intercropping systems were statistically similar in both seasons. It is clear that maize was more aggressive under the same ridge intercropping system compared with the two other studied intercropping systems i.e., (1:1) and (2:2) alternating ridges. The data, also, revealed that the aggressivity value of sesame was positive, while that of maize was negative, when the two crops were intercropped by sowing pattern (M_2S_1) in the first season. This means that the sesame crop was the dominant intercrop component, while maize was the dominated one under this sowing pattern. Such results were expected since sowing sesame early in April 20th, one month before maize, might have given the sesame plants a

better chance for growing compared with maize plants. Our results are in accordance with those reported by, EL-Gamel *et al* (1990), EL-Mihi *et al.* (1990) and Badran (2002).

3) Relative Crowding Coefficient (RCC):-

Relative Crowding Coefficient (RCC) was not significantly affected by the studied intercropping systems in both studied seasons as shown in Table (5). It was clear that the same ridge of intercropping system produced the higher values of RCC (4.93 and 5.11) for maize in the first and second season, respectively, compared with other studied intercropping systems i.e., (1:1) and (2:2) alternating ridges. The (2:2) alternating ridges of intercropping system gave the highest values of RCC for sesame in both seasons. It was evident that intercropped maize with sesame by, when sowing both crops at the same time early in April 20th (M_1S_1) produced the higher values of the product RCC for sesame in both seasons. On the other hand, sowing both crops simultaneously late in May 20th (M_2S_2) produced the higher value of the product RCC for maize in both seasons. This means that ir .ercropping of both crops early in April 20th or late in May 20th on the same day was more effective in increasing the RCC for sesame and maize, respectively. Again, RCC of either maize or sesame exceeded the unity for both studied factors i.e., intercropping systems and sowing patterns, in both sea ions, indicated that the land use efficiency was increased by intercropping maize with sesame under any of the studied systems compared with the monoculture of each. The present results were in agreement with those obtained by Gabr *et al* (1993); Gabr (1998) and Badran (2002).

Table 1 : Means squares of Relative Yields for maize (RYm) and sesame (RYs) intercropped in 2004 and 2005 seasons.

Sources of variations	d.f	RYm		RYs	
		2004	2005	2004	2005
Replications	3	0.0400	0.0370	0.333	0.052
Intercropping systems (I)	2	0.0500	0.1390*	0.058	0.028
C_1: The same ridges vs alternating ridges	1	0.0760	0.2460*	0.111	0.046
C_2 (1:1) vs (2:2) alternating ridges	1	0.0240	0.0310	0.005	0.009
Error "a"	6	0.0270	0.0240	0.114	0.037
Sowing patterns (S)	5	0.1590**	0.0900**	0.377**	0.368**
+ C_3	1	0.3030**	0.1730**	1.529**	1.531**
+ + C_4	1	0.1150*	0.0680**	0.167**	0.155**
+ + + C_5	3	0.1260**	0.0700**	0.063**	0.052**
I X S	10	0.0030	0.0030	0.005	0.003
I X C_3	2	0.0005	0.0005	0.008	0.006
I X C_4	2	0.0015	0.0003	0.003	0.002
I X C_5	6	0.0042	0.0050	0.005	0.002
Error "b"	45	0.0180	0.0090	0.010	0.006
C.V%		16.77	11.86	13.70	10.91

* and ** are significant at 5% and 1% levels , respectively.

+ C_3 = Sole vs intercropped plantings.

+ + C_4 = April vs May plantings .

+ + + C_5 = Intercropped treatments by sequences of sowing dates.

Table 2: Mean squares of the Land Equivalent Ratio (LER) for maize and
sesame intercropping by different intercropping systems and
sowing patterns in 2004 and 2005 seasons.

Sources of variations	d.f	Season	
		2004	2005
Replications	3	0.276	0.131 *
Intercropping systems (I)	2	0.003	0.032
C_1- the same ridge vs. alternate ridges.	1	0.002	0.059
C_2- (1:1)vs. (2:2) alternate ridges	1	0.004	0.005
Error "a"	6	0.130	0.016
Sowing patterns (S)	7	0.853 **	0.884 **
C_3- Solid plantings vs. intercropping.	1	5.222 **	5.496 *
C_4- Solid plantings in (April vs. May)	1	0.002	0.009
C_5- Solid maize plantings in (April vs. May)	1	0.115 *	0.068 *
C_6- Solid sesame plantings in (April vs. May)	1	0.167 **	0.155 **
C_7- Intercropping sequences of sowing dates	3	0.156 **	0.153 **
I x S	14	0.009	0.006
I x C_3	2	0.0080	0.0005
I x C_4	2	0.0005	0.0015
I x C_5	2	0.0015	0.0005
I x C_6	2	0.0025	0.0020
I x C_7	6	0.0172	0.0135
Error "b"	63	0.021	0.010
C . V %		12.60	8.85

* and ** are significant at 5% and 1% levels , respectively

Table 3: Means of Relative Yields of maize (RYm), sesame (RYs) and Land Equivalent Ratio (LER) as affected by different intercropping systems and sowing patterns in 2004 and 2005 seasons.

Season	Trait	Intercropping Systems								Sowing Patterns								Mean
		The same ridges vs alternate ridges (C₁)		(1:1) vs (2:2) alternate ridges (C₂)		Solid plantings vs. intercropping (C₃)		Solid plantings in (April vs May) (C₄)		Maize solid plantings in (April vs May), C₅		Sesame solid plantings in (April vs May), C₆		Intercropping sequences of sowing dates (C₇)				
		The same ridge	Alternating ridges	(1:1) alternate ridges	(2:2) alternate ridges	Solid plantings	Inter-cropping	Solid planting in April	Solid planting in May	M₁	M₂	S₁	S₂	M₁S₁	M₁S₂	M₂S₁	M₂S₂	
2004	RYm	(1)(0.85)a	0.78 a	0.80a	0.75a	0.89a	0 75b	--	--	0.82b	0.96a	--	--	0.75b	0.73b	0.65c	0.89a	0 2
	RYs	0.68 a	0.76a	0.75a	0.77a	0.94a	0.63b	--	--	--	--	1 02a	0.86b	0.72a	0.55d	0 65b	0 60c	0 7
	LER	1.14 a	1.15a	1.16a	1.14a	0.92b	1.38a	0.92a	0.91a	--	--	--	--	1.46a	1.28b	1.29b	1 49a	1 1
2005	RYm	0.89 a	0.76b	0.79a	0.74a	0.87a	0 77 b	--	--	0.82b	0.93a	--	--	0.74c	0.68d	0 80b	0 85a	0 8
	RYs	0.69 a	0.72a	0.71a	0.73a	0.91a	0.60b	--	--	--	--	0.99a	0.83b	0.68a	0 53d	0 62b	0 58c	0 7
	LER	1.17 a	1.11a	1.12a	1.10a	0 89b	1 37a	0.91a	0.88a	--	--	--	--	1.42a	1.20b	1 42a	1 43a	1 1

(1) Means followed by the same letter within each row, for each comparison, are not significantly different 0.05 level.

Table 4: Aggressively values for yields of maize (Acm) and Sesame (Acs) as affected by different intercropping systems and sowing patterns in 2004 and 2005 seasons.

Sources of variations	2004 season		2004 season	
	Acm	Acs	Acm	Acs
Intercropping systems (I)				
The same ridge intercropping	0.238	-0.238	0.300	-0.300
(1:1) alternating ridge of intercropping	0.107	-0.107	0.148	-0.148
(2:2) alternating ridge of inter-cropping	0.028	-0.028	0.048	-0.048
F-test	NS	NS	NS	NS
Sowing patterns (S):				
M_1S_1	0.028	-0.028	0.061	-0.061
M_1S_2	0.179	-0.179	0.148	-0.148
M_2S_1	-0.003	0.003	0.175	-0.175
M_2S_2	0.292	-0.292	0.276	-0.276
F-test	**	**	**	**
Interaction (IXS)	NS	NS	NS	NS

NS and **are not significant (P>0.05), significant at 1% level, respectively.

Table 5: Relative Crowding Coefficient (RCC) for maize and sesame as affected by different intercropping systems and sowing patterns in 2004 and 2005 seasons.

Sources of variations	RCC for maize		RCC for Sesame	
	2004	2005	2004	2005
Intercropping systems (I)				
The same ridge intercropping	4.93	5.11	1.31	1.32
(1:1) alternating ridge of intercropping	4.53	4.63	1.68	1.88
(2:2) alternating ridge of intercropping	3.02	2.91	7.12	2.26
F-test	NS	NS	NS	NS
Sowing patterns (S):				
M_1S_1	4.81	5.76	7.69	2.67
M_1S_2	2.36	2.01	1.44	1.21
M_2S_1	2.08	2.86	2.55	1.88
M_2S_2	7.41	8.12	1.81	1.54
F-test	NS	**	NS	**
Interaction (IXS)	NS	NS	NS	NS

NS and ** are not significant (P > 0.05), significant at 1% level, respectively.

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الملخص العربى

العلاقات التنافسية لمحصولي الذرة الشامية والسمسم المحملين مع بعض بنظم مختلفة من التحميل ومواعيد الزراعة

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أجريت تجربتان تحقليتان بمحطة البحوث الزراعية بكلية – الزراعية – بدمنهور – جامعة الإسكندرية خلال موسمي صيف (٢٠٠٤ & ٢٠٠٥) وذلك بهدف دراسة العلاقات التنافسية لمحصولي الذرة الشامية والسمسم المحملين مع بعض بنظم مختلفة من التحميل ومواعيد الزراعة. حيث تم زراعة كلا من الذرة الشامية (صنف فجر هجين ثلاثي ٣١٠) والسمسم (صنف جيزة ٣٢) منفردين ومحملين مع بعض بتتابعات من مواعيد الزراعة (٢٠ أبريل & ٢٠ مايو) تحت ثلاث نظم من التحميل كانت على سـفـس} التحميل بالخطوط المتبادلة (١:١) & (٢:٢) . وقد تم تنفيذ الدراسة في تصميم القطع المنشقة مرة واحدة بأربع تكررات حيث خصصت القطع الرئيسية لنظم التحميل بينما وزعت مواعيد الزراعة الثمانية عشوائيا على القطع الفرعية.

أظهرت النتائج أن الذرة الشامية هو المحصول السائد بينما كان السمسم هو المحصول المسود في كلا موسمي الدراسة حيث كانت قيم العدوانية موجبة للذرة الشامية وسالبة للسمسم؛ كما أكدت نتائج هذه الدراسة حدوث زيادة في معدل إنتاجية الأرض أي كفاءة معامل الحشد النسبي عن الوحدة وذلك بالنسبة لكل من نظم التحميل ومواعيد الزراعة على حد سواء بما يعنى زيادة الكفاءة الإنتاجية للأرض المنزرعة تحميلا بالمحصولين معا وذلك بأي توفيق من ميعادي زراعة المحصولين معا تحت أي نظام تحميل مقارنة بالزراعة لكليهما منفردة.

ترواح معدل كفاءة إنتاجية الأرض الزراعية تحت ظروف هذه الدراسة بين ١,٣٨ – ١,٣٧ فـي الموسم الأول والثاني على التوالي ، مما يؤكد على حدوث زيـادة محصولية تحققت بمقدارها ٣٧,٥٪ كمتوسط لموسمي الدراسة نتيجة تحميل السمسم مع (تحت ظروف الدراسة) مقارنة بزراعة أي من المحصولين بصورة منفردة.