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STUDIES ON SUNFLOWER-TOMATOES RELAY CROPPING

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Abstract

Two field experiments were conducted at El-Serw Agricultural Research Station in North Delta, Egypt, during 1996 and 1997 seasons to study the possibility of sunflower relay cropping on transplanted tomatoes. A split plot design with four replications was used. The main plots were devoted to the time of sunflower cropping e.g., at transplanting (S1), flowering (S2), and fruiting (S3) stages of tomatoes. The sub plots were devoted to sunflower populations (12000 and 24000 plants/fad*).

Results indicated that sunflower-tomatoes relay cropping has some good advantages. The highest yield of tomatoes (20.3 tons/fad) + sunflower (980 kg/fad) were obtained when the high plant population of sunflower was relayed in the highest land equivalent ratio LER (2.10). While, the early cropping relay (S1) recorded the lowest yield in both crops (0.9 ton of tomatoes + 798 kg of sunflower/fad), the lowest LER (0.64) and the highest sunflower competitive ratio (11.8).

INTRODUCTION

Sunflower has become an important oil crop in Egypt and it could help in reducing the great shortage in local edible oil production, but it is still difficult for sunflower to compete with the major crops in most cultivated areas. Considerable interest has been shown in growing sunflower with tomatoes during summer season. The benefits of this cropping pattern are: a) provide shade for tomatoes to prevent sun scorch which causes white spots on the surface of the frult, b) increase the land use by producing sunflower seed without significant reduction of tomatoes yield, c) compensate for any possible loss which could face tomatoes crop growers e.g. diseases or market price decline. Advantages of some intercropping systems have been mentioned by some investigators. Ujjinaiah et al., (1991) and Urmani et al., (1987) reported that sunflower (*Helianthus annus* L.) pigeonpea (*Cajianus cajan*) gave higher value for land equivalent ratio than the single cropping of the component crops. Ahmed and Rashid (1996) found that sunflower-soybean and sunflower-mungbeen in-

tercropping systems gave the highest (1.38) land equivalent ratio, followed by sunflower-mashbeen intercropping system (1.34) and the three intercropping systems gave higher combined yield than single cropping of the component crops. The highest land equivalent ratio of 1.61 was obtained in groundnut-sunflower intercropping system (Koppalkar and Sheelavantar, (1990). Iqbal (1987) reported that alternate single rows pattern of groundnut-sunflower cropping gave 36,05% yield advantage compared with single cropping of component crops. He also concluded that lentil (Lens culinaris L.) showed higher values of competitive ratio in all intercropping in alternate rows (2-2 or 3-2) increased the total yield than the sole crops and that increasing sunflower population from 23,616 to 107,959 plants/ha. gave the best results.

The aim of this investigation is to study sunflower-tomatoes relay cropping to recognize the best time and best population of sunflower for relaying and evaluate the possible benefits in yield and quality.

Fad = faddan = 4200 m2 = 0.42 ha.

MATERIALS AND METHODS

Two field experiments were conducted during 1996 and 1997 seasons at El-Serow Agriculture Research Station. Tomatoes seed (Castle rock) were sown in nursery and were transplanted about 6 weeks later on ridges 15 cm apart. Sunflower (Vidoc hybrid) was sown on tomatoes ridges in hills 30 cm apart and thinned to one plant/hill at 20 days after sowing. Table (1) shows planting and harvesting dates of both crops.

A split plot design with four replications was used. The main plots were devoted to the following sowing treatments:

1. Transplanted solid tomatoes (T).
2. Sunflower sown solid at the time of tomatoes transplanting (S0).
3. Sunflower sown with tomatoes at transplanting time (S1).
4. Sunflower sown during flowering time of tomatoes (S2).
5. Sunflower sown at fruiting stage of tomatoes (S3).

The sub plots were devoted to two sunflower populations:

1. Sowing sunflower on one side of the ridge (12000 plants/fad).
2. Sowing sunflower on both sides of the ridge (24000 plants/fad).

Each sub plot (experimental unit) contained 5 ridges x 120 cm width x 6 m length NPK fertilizers were added as recommended i.e. 100 kg Calcium superphosphate (15.5% P_2O_5) during land preparation, 120 kg nitrogen in the form of ammonium nitrate (33%N) in three equal doses (at transplanting, after 3 weeks and after 5 weeks of transplanting) and potassium sulphate (48% K_2O) in the rate of 24 kg/fad during land preparation. Solid sunflower received 45,15 and 15kg/fad of NPK.

Estimated characters:

The yield of the two inner ridges was determined for each crop and a sample of five plants were taken at random from each crop to estimate the following characters, i.e. percentage of tomatoes fruits dameged by sun scorch and days to flowering, plant height (cm), seed oil content of sunflower.

$$\text{The land equivalent ratio (LER)} = La + Lb = \frac{Ya}{Sa} + \frac{Yb}{Sb}$$

Where : La and Lb are the LERs for the individual crops, Ya and Yb are the individual crop yields in single crops.

Competitive ratio was computed using the formula of Willey and Rao 1980:

$$\text{Competitive ratio} = \frac{\text{LER of crop (a)}}{\text{LER of crop (b)}}$$

Table 1. Dates of tomatoes and sunflower planting and harvesting.

	1996		1997	
date	Planting	**Harvesting	Planting	harvesting
Tomatoes* T	12/3	10/8	5/3	7/8
Sunflower S_1	22/4	20/7	13/4	10/7
Sunflower S_2	7/6	2/9	25/5	23/8
Sunflower S_3	30/6	28/9	19/6	20/9

Tomatoes* were tras planted on S1 ++ harvisting tomatoes means the end of tomatoes picking.

Obtained data were subjected to statistical analysis as shown by Gomez and Gomez (1984). The treatment means were compared using the least significant difference (LSD) procedure.

RESULTS AND DISCUSSION

A: Tomatoes:

Damaged fruits: The percentage of damaged tomato fruits was markedly affected by sunflower population. The high sunflower population (24000 plants/fad) reduced the percentage of damaged tomatoes fruits (Table 2). Time of sunflower cropping also had a significant effect on damaged tomatoes fruits. The early cropping (S1) reduced the percentage of damaged fruits, while it increased in (S2). There were further increases in (S3) but still lower than the solid planting of tomatoes. It means that earlier sunflower cropping provides higher amount of shade during tomatoes fruiting and hence reduce damaged fruits caused by sun scorch.

Table 2. Damaged tomato fruit (%) as affected by sun scorch under sunflower relay cropping during 1996 and 1997 seasons.

Season	1996			1997		
Planting methods	One side	Two sides	Mean	One side	Two sides	Mean
-Solid Tomatoes, T	31.3	31.3	31.3	30.4	28.4	29.4
- S1	4.0	5.0	4.5	5.8	6.8	6.3
- S2	15.7	9.3	12.5	12.9	13.2	13.0
- S3	22.7	17.3	20.0	18.7	20.4	19.5
F.Test	*		**	**		**
LSD (0.05)	2.4		4.3	2.3		3.8
Mean	18.4	15.8	17.1	17.0	17.2	17.1
F.Test	**			*		

Frulit yield: data presented in Table (3) show that tomatoes fruit yield was significantly affected by the time of sunflower cropping. The first cropping (S1) resulted in marked reduction in tomatoes yield compared with the solid planting, while relaying sunflower during tomatoes flowering stage (S2) resulted in significant increase in fruit yield in both seasons, except the lower population in the first season compared with the solid planting. It is worthy to mention that there was no significant difference between the yield of the solid planting and that of (S3) in the first season. Sunflower population also significantly affected tomatoes yield in the early cropping. Tomatoes fruit yield reduction was greater in the higher population than the lower one, but in later cropping (S2) and (S3) tomatoes yield was not significantly affected in each stage except in (S2) of the first season.

B. Sunflower:

Plant height: Data presented in Table (4) indicate that sunflower plant height

Table 3. Tomato fruit yield (kg/fad) as affected by sunflower relay cropping during 1996 and 1997 seasons.

Season	1996			1997		
Planting methods	One side	Two sides	Mean	One side	Two sides	Mean
Time of relaying						
-Solid Tomatoes, T	19683	19683	19683	15387	15387	15387
- S1	2727	977	1852	2800	980	1890
- S2	19150	20300	19725	17866	16580	17223
- S3	19383	19833	19608	16393	16133	16263
F.Test	**		**	**		**
LSD (0.05)	597		932	414		1008
Mean	15237	15198	15217	13112	12270	12691
F.Test	**			**		

S_1, S_2 and S_3 = Cropping sunflower with tomatoes at the time of transplanting, flowering and fruiting of tomatoes, respectively.

Table 4. Sunflower plant height (cm) as affected by relay cropping during 1996 and 1997 seasons.

Season	1996			1997		
Planting methods	One side	Two sides	Mean	One side	Two sides	Mean
Time of relaying:						
-Solid sunf, S_0	203.3	220.0	211.7	198.0	201.8	199.8
- S1	191.7	196.7	194.2	190.5	197.0	193.8
- S2	185.0	190.0	187.5	177.1	180.1	178.2
- S3	183.3	181.7	182.5	180.2	176.0	178.1
F.Test	*		*	*		*
LSD (0.05)	5.2		4.5	6.1		4.0
Mean	190.8	197.1	194.0	186.4	188.7	187.5
F.Test	*			*		

S_1, S_2 and S_3 = Cropping sunflower with tomatoes at the time of transplanting, flowering and fruiting of tomatoes, respectively.

was significantly affected by plant population. It was increased with increasing population density. Also, time of cropping markedly affected sunflower plant height. This was true in both seaasons.

Days to flowering: Data in Table (5) revealed that days from sowing to flowering increased as sunflower was sown early (S1) and late (S3). This change probably is due to the climatic conditions during each stage. Plant poplulation density did not induce marked effects in plant duration. However, the interaction between sowing date and plant population density of sunflower induced significant effects on sunflower duration. The shortest plant duration was noticed with sowing sunflower at the lowest population density at S2 or S3 stages of tomatoes.

Seed yield: Table (6) Shows that seed yield was significantly affected by either plant population or time of cropping. Data revealed that cropping sunflower during tomatoes transplanting (S1) recorded the lowest seed yield, but seed yield increased again when sunflower relayed at flowering (S2) or fruiting (S3) stages of tomatoes and it surpassed the yield of the solid crop in the first season. It means that sunflower was not effected by tomatoes plants when cropped at late stages. The crop increased also by increasing sunflower plant population from 12000 to 24000 plants/fad. This results is in good agreement with that obtained by Sheik Mohammad et al (19933) who found that cropping groundnut with sunflower increased the total yield than sole crops when plant population increased from 23000 to 107000 plants/ha. Iqpal (1987) stated that the total yield of both crops increased with about 36%, compared with the single cropping.

Seed oil content: Data listed in Table (7) revealed that there were no significant effects due to plant population and timing of sunflower cropping. This was true in the two seasons of experimentation. The interaction between sunflower population density and time of its planting did not induce significant effects on seed oil content.

Land equivalent ratio (L.E.R.): The L.E.R. reflects the benefit from intercropping if the actual estimate is above unity, indicating a yield advantage in the yield mixture. Data in Table (8) show that sowing sunflower during tomatoes transplanting (S1) reduced the LER below one, while sowing sunflower in high population during tomatoes flowering (S2) and fruiting (S3) stages caused significant advantages of L.E.R. (2.06, 2.30) and (2.1, 1.90) in the first and the second seasons, respectively. This means that seed yield of sunflower intercropped with tomatoes was an extra yield and obtained without significant reduction, compared with the solid

planting, while this ratio was decreased in the low population. These results are in agreement with those obtained by Koppakar and Sheelavantar (1990) who reported that the highest LER (1.61) was obtained in groundnut-sunflower intercropping. Similar results also were reported by Iqpal (1987) and Ahmad (1996) when intercropped sunflower with soybean (1.38).

Competitive ratio

Competitive ratio is an important way to show the behavior and the degree with which any crop competes with another when intercropped. Data presented in Table (9) show that sunflower was a strong competitor when intercropped early with tomatoes (S1), while competitive ratio of sunflower was 5 and 3.6 when sown on one side of ridge in both seasons., the ratio increased when it was sown on both sides to 11.8 and 10.2 in the first and second seasons, respectively. On the other hand, when relaying sunflower during flowering or fruiting stages of tomatoes, competitive ratio of sunflower decreased sharply to be less than one, while it was around one in tomatoes. These data explained the great reduction of tomatoes and sunflower yields in S1 stage. This is probably due to the high requirement of both crops to light and nutrients in the same time, and show that the fast vegetative growth and plant height (194 cm) of sunflower in short time (63 days) prevented tomatoes from getting its requirement at the early stage. In S2 and S3 tomatoes plants were established and both crops did not compete each other, thus, the values of competitive ratio of both crops were close together. Similar observations were reported by Iqbal (1987) who showed that lentil showed higher values of competitive ratio when intercropped with soybean and also by Ahmed (1996) who found that sunflower exhibited the highest competitive ratio (2.14) by alternate rows mashbeen.

It could be concluded that sunflower-tomatoes relay cropping appeared advantageous and gave the higher yield of both crops and the highest LER when sunflower was sown on both sides sowing with high sunflower population, decreased yield of both crops and increased competivtive ratio of sunflower.

Table 5. Days to sunflower flowering as affected by relay cropping during 1996 and 1997 seasons.

Season	1996			1997		
Planting methods	One side	Two sides	Mean	One side	Two sides	Mean
Time of relaying						
Solid sunf., S_0	64.3	63.3	63.8	65.0	66.3	65.7
- S1	62.0	62.3	62.2	63.0	66.4	63.7
- S2	59.0	61.7	60.3	62.5	64.5	63.0
- S3	65.0	62.0	63.5	62.3	63.1	62.7
F.Test	**		*	**		*
LSD (0.05)	1.8		2.0	1.6		2.0
Mean	62.6	62.3	62.4	63.2	64.6	63.9
F.Test	N.S			N.S		

Table 6. Sunflower seed yield (kg/fad) under relay cropping during 1996 and 1997 seasons.

Season	1996			1997		
Planting methods	One side	Two sides	Mean	One side	Two sides	Mean
Time of relaying						
Solid sunfl., S_0	820	1233	1027	667	1080	838
- S1	570	797	683	417	660	558
- S2	648	1270	934	633	1023	843
- S3	763	1350	1082	573	920	747
F.Test	*		**	*		**
LSD (0.05)	128		102	90		71
Mean	700	1163	931	573	921	747
F.Test	**			**		

Table 7. Sunflower seed oil (%) as affected by relay cropping during 1996 and 1997 seasons.

Season	1996			1997		
Planting methods	One side	Two sides	Mean	One side	Two sides	Mean
Time of relaying						
-Solid sunf., S_0	44.2	44.2	44.2	45.1	44.9	45.0
- S1	43.5	43.4	43.4	44.5	44.3	44.4
- S2	43.8	43.8	43.8	44.3	44.4	44.4
- S3	43.2	43.4	43.3	43.8	43.7	43.7
F.Test	N.S		N.s	N.S		N.S
LSD (0.05)	---		---	---		---
Mean	43.7	43.7	43.7	44.2	44.3	44.3
F.Test	N.S			N.S		

S_1, S_2 and S_3 = Cropping sunflower with tomatoes at the time of transplanting, flowering and fruiting of tomatoes, respectively.

Table 8. Land equivalent ratio (LER) of tomatoes and sunflower as affected by relay cropping during 1996 and 1997 seasons.

Season	1996			1997		
Planting Methods	One side	Two sides	Mean	One side	Two sides	Mean
Time of relaying						
- S1	0.84	0.64	0.74	0.84	0.67	0.75
- S2	1.76	2.06	1.91	2.11	2.30	2.21
- S3	1.91	2.10	2.01	1.93	1.90	1.92
Mean	1.50	1.60	1.55	1.63	1.62	1.63
F.Test	*		**	*		**
LSD (0.05)	0.4		0.3	0.3		0.2
Mean	1.50	1.60	1.55	1.63	1.62	1.63
F.Test	N.S			N.S		

S_1, S_2 and S_3 = Cropping sunflower with tomatoes at the time of transplanting, flowering and fruiting of tomatoes, respectively.

Table 9. Competitive ratio of tomatoes yield (a) and sunflower yield (b) as affected by relay cropping in 1996 and 1997 seasons.

Season	1996						1997					
Planting method	one side		two sides		Mean		one side		two sides		Mean	
Time of relaying	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(a)	(a)	(b)	(a)	(b)
-S1	0.20	5.00	0.08	11.8	0.14	8.40	0.27	3.66	0.09	10.2	0.18	6.93
-S2	1.23	0.81	1.00	1.00	1.12	0.95	1.22	0.82	1.14	0.88	1.18	0.86
-S3	1.05	0.95	0.93	1.08	0.99	1.02	1.24	0.80	1.24	0.81	1.24	0.81
F. Test	**	**	**	**	**	**	**	**	**	**	**	**
L.S.D. (0.05)	0.11	0.21	0.11	0.21	0.10	0.2	0.08	0.18	0.08	0.19	0.08	0.18
Mean	0.83	2.25	0.67	4.63	0.75	3.44	0.91	1.76	0.82	3.95	0.86	2.86

$_1$, S_2 and S_3 = Cropping sunflower with tomatoes at the time of transplanting, flowering and fruiting of tomatoes, respectively.

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دراسات علي مواعيد زراعة عباد الشمس علي الطماطم في زراعات متداخلة

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أقيمت تجربتان حقليتان في محطة البحوث الزراعية بالسرو – شمال الدلتا خلال الموسمين ١٩٩٦ / ١٩٩٧ لدراسة انسب ميعاد لزراعة عباد الشمس كمحصول متداخل بعد شتل الطماطم، وكان التصميم المستخدم هو القطع المنشقة مرة واحدة – شغلت القطع الرئيسية بمواعيد زراعة عباد الشمس وهي : عند شتل الطماطم، عند بدء تزهير الطماطم وعند بدء اثمار الطماطم.

أما القطع المنشقة فكانت كثافتين نباتيتين وهما : (١٢) ألف ، (٢٤) ألف نبات للفدان. وأوضحت النتائج امكانية زراعة عباد الشمس علي الطماطم وأن أعلا محصول من الطماطم (٢٠,٣ طن للفدان) بالاضافة إلي ٩٨٠ كجم من بذرة عباد الشمس تم الحصول عليها من زراعة عباد الشمس بكثافة (٢٤) ألف نبات علي جانبي مصاطب الطماطم في مرحلة بداية تزهير الطماطم. كما أعطت هذه المعاملة أعلا معدل استفادة الأرض (٢,١) بخلاف المعاملات الأخري التي أعطت أقل محصولا وأقل معدل استفادة من الأرض بالاضافة الي أعلا معدل منافسة من عباد الشمس للطماطم.