STUDIES ON SUNFLOWER-TOMATO INTERCROPPING

M. M. Kestha, and **M. G. El-Baz**, Oil Crops Research Section, Field Crops Research Institute, ARC, Giza, Egypt
E-mail: maatykeshta2@hotmail.com

Abstract

Two field experiments were conducted during the 2001 and 2002 seasons to study the possibility of sunflower 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 subplots were devoted to two tomato populations of 12,000 and 24,000 plants/fad (Fad=faddan=200 m. sq.=0.42 ha). Results indicated that sunflower–tomato cropping has some good advantages. The highest yields of tomatoes (20.3 tons/fad) and sunflower (980 g/fad) were obtained when high plant populations of sunflower were cropped with tomato at the flowering stage. This pattern also resulted in the highest land equivalent ratio (LER) of 2.10, while the early cropping recorded the lowest yield in crops (900 kg of tomatoes and 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 the 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 fruit; b) increase the land use by producing sunflower seed without significant reduction of tomato yield; c) compensate for any possible loss which could face tomato growers, e.g., disease or market price decline. Advantages of some intercropping systems have been mentioned by some investigators.

Ujjinaiah et al. (1991) and Umrani et al. (1987) reported that sunflower (*Helianthus annuus L.*), pigeonpea *(Cajanus cajan* L.*)* 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-mungbean intercropping systems gave the highest (1.38) land equivalent ratio, followed by sunflower-mashbean 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 the groundnut-sunflower intercropping system (Koppalkar and Sheelavantar, 1990). Iqbal (1987) reported that an alternate single row 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 ratios in all the intercropping patterns. Sheik Mohammad et al. (1993) found that groundnut–sunflower intercropping in alternate rows (2-2 or 3-2*)* increased the total yield more than the sole crops and that increasing the sunflower population from 23,616 to 107,959 plants/ha gave the best results.

The aim of this investigation was to study sunflower–tomato relay cropping to recognize the best time and population of sunflower cropping and to evaluate the possible benefits in yield and quality.

Materials and Methods

Two field experiments were conducted during the 2001 and 2002 seasons at El–Serw Agricultural Research Station. Tomato seeds (Castle Rock) were sown in the nursery and were transplanted about 6 weeks later on ridges 15 cm apart. Sunflower (Vidoc hybrid) was sown on tomato ridges in hills 30 cm apart and thinned to one plant/hill at 15 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 solid at the time of tomato transplanting (So); 3) sunflower sown with tomatoes at transplanting time (S1); 4) sunflower sown during flowering time of tomatoes (S2); and 5) sunflower sown at fruiting stage of tomatoes (S3). The subplots were devoted to two sunflower populations: 1) sowing sunflower on one side of the ridge (12,000 plants/fad); and 2) sowing sunflower on both sides of the ridge (24,000 plants/fad). Each subplot (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 % P2O5) during land preparation, 120 kg nitrogen in the form of ammonium nitrate (33 % N) in three equal doses (at transplanting, 3 weeks after and 5 weeks after transplanting) and potassium sulphate (48 %) at the rate of 24 kg/fad during land preparation. Solid sunflower received 45, 15 and 15 kg/fad of NPK.

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

	2001		2002	
Date	planting	** harvesting	planting	harvesting
Tomato *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

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

The land equivalent ratio (LER) was estimated using the equation of Willey and Rao, 1980a,b: Land Equivalent Ratio (LER) = La+ Lb= Ya/Sa+ Yb/Sb, where La and Lb are the LERs for the individual crops and Ya and Yb are the individual crop yields in single crops.

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

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

The data obtained were subject 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

Tomatoes. The percentage of damaged tomato fruits was markedly affected by sunflower population. The high sunflower population, 24,000 plants/fad, reduced the percentage of damaged tomato fruits (Table 2). Time of sunflower cropping also had a significant effect on damaged tomato fruits. 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. This means that earlier sunflower cropping provides a higher amount of shade during tomato fruiting and hence reduces fruit damage caused by sun scorch.

Table 2. Damaged tomato fruits (%) as affected by sun scorch under sunflower cropping.

Season	2001			2002		
Planting methods	One side	Two sides	mean	One side	Two sides	Mean
Solid tomato, 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	**			*		

Fruit Yield. Data presented in Table 3 showed that tomato fruit yield was significantly affected by the time of sunflower cropping. The first cropping (S1) resulted in marked reduction in tomato yield compared with the solid planting, while cropping in both seasons resulted in the lower population in the first season compared with the solid planting. It is worth mentioning that there was no significant difference between the yield of the solid planting and that of S3 in the first season.

Table 3. Tomato fruit yield (kg/fad) as affected by sunflower cropping.

Season	2001			2002		
Planting methods	One side	Two sides	mean	One side	Two sides	Mean
Solid tomato, T	19683		19683	15387		15387
- S_1	2727		1852	2800		1890
- S_2	19150		19725	17866		17223
- S_3	19383		19608	16393		16263
F-Test	**		**	**		**
LSD(0.05)	597		932	414		1008
Mean	15237	15198	15217	13112	12270	12691
F-Test	**			**		

S1, S2 and S3 were sunflower cropping at transplanting, flowering and fruiting of tomatoes, respectively

Sunflower population also significantly affected tomato yield in early cropping. Tomato fruit yield reduction was greater in the higher population than the lower one, but in later cropping (S2) and (S3) tomato yield was significantly affected in each stage expect in (S2) of the first season.

Sunflower. Table 4 indicated that sunflower plant height was significantly affected by planted populations. It increased with increasing population density. Also time of cropping markedly affected sunflower plant height. This was true in both seasons. Maximum plant height (220.0 and 201.8 cm in the first and second seasons, respectively) was obtained with solid planting of sunflower (So) on both sides of ridges. Such conditions could also increase the competitive ratio of sunflower as shown in Table 6. This result agreed with that of Sheik Mohammed et al. (1993).

Table 4. Sunflower plant height as affected by cropping.

Season	2001			2002		
Planting methods	One side	Two sides	mean	One side	Two sides	Mean
Solid tomato, T	203.3	220.0	211.7	198.0	201.8	199.8
- S_1	191.7	196.7	194.2	190.5	197.0	193.8
- S_2	185.0	190.0	187.5	177.1	180.1	178.2
- S_3	183.3	181.7	182.5	180.2	176.0	178.1
F-Test	*		*	*		*
LSD(0.05)	5.2		7.5	6.1		4.0
Mean	190.8	197.1	194.0	186.4	188.7	187.5
F-Test	*			*		

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 climate conditions during each stage. Plant population 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 when sunflower was sown at the lowest population density at the S2 or S3 stages of tomatoes.

Table 5. Days to sunflower flowering.

Season	2001			2002		
Planting methods	One side	Two sides	mean	One side	Two sides	Mean
Solid tomato, T	64.3	63.3	63.8	65.0		65.7
- S_1	62.0	62.3	62.2	63.0		63.7
- S_2	59.0	61.7	60.3	62.5		63.0
- S_3	65.0	62.0	63.5	62.3		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	NS			NS		

Seed Yield. Table 6 shows that seed yield was significantly affected by either plant population or time of cropping. Cropping sunflower during tomato transplanting (S1) recorded the lowest seed yield, but it increased again when sunflower relayed at flowering (S2) or at fruiting (S3) stages and it surpassed the yield of solid crop in the first season. It means that sunflower wasn't affected by tomato plants when cropped at a late stage. The crop increased also by increasing sunflower plant population from 12,000 to 24,000 plants/fad. This result is in agreement with that obtained by Sheik Mohammad et al. (1993) who found that cropping groundnut with sunflower increased the yield more than the sole crops when plant population increased from 23,000 to 107,000 plants/ha. Iqbal (1987) stated that the yield of both crops increased 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 planting did not induce significant effects on seed oil content.

Table 6. Sunflower seed yield (kg/fad).

Season / Planting methods	1996			1997		
	One side	Two sides	mean	One side	Two sides	Mean
Solid tomato, T	820	1233	1027	667	1080	838
- S_1	570	797	683	417	660	558
- S_2	648	1270	934	633	1023	843
- S_3	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 content.

Season / Planting methods	2001			2002		
	One side	Two sides	mean	One side	Two sides	Mean
Solid tomato, T	44.2	44.2	44.2	45.1	44.9	45.0
- S_1	43.5	43.4	43.4	44.5	44.3	44.4
- S_2	43.8	43.8	43.8	44.3	44.4	44.4
- S_3	43.2	43.4	43.3	43.8	43.7	43.7
F-Test	NS		NS	NS		NS
LSD(0.05)	---		--	--		---
Mean	43.7	43.7	43.7	44.2	44.3	44.3
F-Test	NS			NS		

Land Equivalent Ratio (LER). The LER shows the benefit of intercropping if the actual estimate is above unity, indicating a yield advantage in the yield mixture. Data in Table 8 shows that sowing sunflower during tomato transplanting (S1) reduced the LER below one, while sowing sunflower in high populations during tomato flowering (S2) and fruiting (S3) stages caused significant advantages of LER (206, 230) and (211.90) in the first and the second seasons, respectively. This means that seed yield of sunflower intercropped with tomatoes was extra yield and was obtained without significant reduction compared with the solid planting, while this ratio decreased in the lower population. These results are in agreement with those obtained by Koppalkar and Sheelavantar (1990) who reported that the highest LER (1.61) was obtained in groundnut-sunflower intercropping. Similar results were also reported by Iqbal (1987) and Ahmed and Rashid (1996) who intercropped sunflower with soybean (1.38).

Table 8. Land equivalent ratio (LER) of tomatoes and sunflower as affected by cropping.

Season Planting methods	2001			2002		
	One side	Two sides	mean	One side	Two sides	Mean
Solid tomato, T	0.48	0.64	0.74	0.84	0.67	0.75
- S=	1.67	2.06	1.91	2.11	2.30	2.21
- S=	1.91	2.10	2.01	1.93	1.90	1.92
- S=	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		

Competitive Ratio. Competitive ratio is an important way to show the behavior and the degree to which any crop competes with another when intercropped. Table 9 shows that sunflower was a strong competitor when intercropped early with tomatoes (S1) while the 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 cropping sunflower during flowering or fruiting stages of tomatoes, the competitive ratio of sunflower decreased to less than one, while it was near one in tomatoes. These data explained the great reduction of tomato and sunflower yields in the S1 stage. This is probably due to the high requirement of both crops for light and nutrients at the same time, and shows that the fast vegetative growth and plant height (194 cm) of sunflower in a short time (63 days) prevented tomatoes from getting their requirements at the early stage. In S2 and S3, tomato plants were established and both crops did not compete with 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 soybeans and also by Ahmed and Rashid (1996) who found that sunflower exhibited the highest competitive ratio (2.14) by alternate rows of mashbean.

Table 9. Competitive ratio of tomato yield (a) and sunflower yield (b).

Season Planting methods	2001						2002					
	One side		Two sides		Mean		One side		Two sides		Mean	
Solid tomato, T	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
- S_1	0.20	5.00	0.08	11.8	0.14	9.40	0.27	3.66	0.09	10.2	0.18	6.93
- S2	1.23	0.51	1.00	1.00	1.12	0.95	1.22	0.92	1.14	0.88	0.18	0.86
- S_3	1.05	0.55	0.93	1.08	0.99	1.02	1.24	0.80	1.24	0.81	1.24	0.81
F-Test	**	**	**	**	**	**	**	**	**	**	**	**
LSD(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	1.73	092	3.95	0.86	2.86

S1= S2 and S_3 = cropping sunflower with tomatoes at transplanting, flowering and fruiting stages, respectively.

Conclusions

It could be concluded that sunflower–tomatoes cropping appeared advantageous and gave the higher yield of both crops and the highest LER when sunflower was sown on both sides of ridges during flowering or fruiting stage of tomato, while early sunflower sowing with high sunflower population decreased yield of both crops and increased competitive ratio of sunflower.

References

Ahmed, R. and Rashid, I. 1996. Sunflower–legumes intercropping systems under rained conditions; competition and yield advantage. Mahashtra. J. Agric., 13(1):119–120.

Gomez K.A. and Gomez, A. A. 1984. Statistical procedures for agricultural research John Wiley and Sons, Inc, New York.

Iqbal, M. 1987. Studies on gram–lentil intercropping relationship under different geometrical patterns. M. Sc. (hons.) Agro. Thesis .Univ. Agric., Faisalabad.

Koppalkar, B, .G. and Sheelavantar, M.N. 1990. Studies on oilseed production potential of groundnut and sunflower intercropping systems during summer conditions. Farming Systems. 6(1-2):1-7.

Sheik Mohammad, K. and Reddy, A., Putman, D.H 1993. Evaluation of planting pattern and density effects on sunflower: groundnut sole and intercrop system in a systematic fan design.

Ujjinaiah, U.S., Rajasheker , B. G., Venugopal, N. and Seenapa, K. 1991. Sunflower-pigeon pea intercropping . J. Oilseeds Res. 8(1):72-78.

Umrani, N.K., Patil, C.B. and Chavan, K.B. 1987. Effect of row proportion on sunflower and pigeonpea intercropping. Ind J. Agric. Sci. 57(7):468- 471.

Willey R. and Rao, R. 1980a. A competitive ratio for quantifying competition between intercropping. Exp. Agric. 16(1):117-125.

Willey, R.W. and Rao, B. M. 1980b. A competitive ratio for quantifying competition and yield advantage. Field Crop Abst. 32(1):1-10.