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Effect of sesame-tomatoes intercropping systems under different dates of sesame on improving productivity of crops

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ABSTRACT

Field experiment was conducted at Sids Horticulture Research Station, in Beni-Suif Governorate in 2018 and 2019 summer seasons to study the effect of intercropping sesame (Shandaweel-3) with hybrid tomato (Nema 1400) in three intercropping patterns 100% tomato + (50%, 33% and 25% sesame) in addition solid planting of both crops under three sowing dates for sesame was also studied the effect on plant growth, yield attributes and yield of both crops. The experiment was implemented in a split plots design with three replications. The main plots were devoted to the previous three intercropping dates, whereas, the sub-plots were allocated to the intercropping patterns of sesame with tomato. Results indicated that intercropping patterns increased all growth characteristics and yield of tomato compared with solid planting. The yield and its components were significantly affected by different intercropping patterns in both crops. The highest tomato yields (26.033, and 27.303ton fed.$^{-1}$) in the first and second seasons, respectively, were obtained when sesame was planted before tomato by 15 days for tomato with 50% from density (CS_1) pattern. However, the highest yield of sesame (2.83 and 3.60 ardab per fed.$^{-1}$) in the first and second seasons, respectively, was obtained when sesame plants were grown before tomato by 15 days and 50% from total density, whereas, the lowest value was recorded at CS_3 pattern (1.52 and 1.82ardab fed.$^{-1}$), respectively. Maximum values of total land equivalent ratio (LER) (1.62 and 1.63), were observed with CS_1in both seasons, respectively. The data indicated that tomato was dominating in the first date when sesame planting before tomato by 15 days. The total or net return showed that intercropping sesame with tomato by 50% from total density were higher (LE. 41954 and 44706) compared to solid tomato (LE.32108 and 33296) or solid sesame planting (LE. 5161 and 7991). Therefore, it is recommended to grow sesame before tomatoes by 15 days, at a distance of 10 cm between gores and one plant in the grove (with a density of 50% of the total density of sesame) to obtain the highest productivity of tomato crops and the highest economic return to farmers.

Keywords: tomato, sesame planting density, Intercropping, Land equivalent ratio (LER), Aggressivity (A), Total return, Net return.

INTRODUCTION

Tomato (*Solanumlycopersicum*) is consider one of the most important vegetable crops cultivated in Egyptian, where its anual consumption is about 9.8 million tons. The average productivity is 17 ton/fed. The cultivated tomatoes area in 2017 was 395.571faddan spread over three growing seasons as follows 168878 faddan in the Winter season, 197607 faddan in summer and 29086 faddans in autumn (Bulletin of The Agricultural Statistics 2017). It was documented air and soil temperatura in fluences flowering and fruit setting in tomato by during autumn and Winter seasons in Middle and Upper Egypt. The climate in Middle and Upper Egypt is very hot in the summer with drycondition. Therefore, providing natural protection from hot weather by intercropping sesame (*sesamumindicum*) with tomato is frequently used. In Egypt, the early and late summer tomato market is from the open field planting during May up to August. During this period, temperature can exceed 35°C under field condition resulting in either non- uniform growth and por fruit yield or even completely failure of tomato cropping in a great part of the cultivated area. (Pressman *et al.,*2002).

Intercropping tomato with other field crops is suggested to be implemented to lower production cost, maximize land utilization and raise farmers' income. Additional advantages could be obtained from associated intercropping system through higher monetary return and more stable income compared to mono-crop cultures. Therefore, investigation were conducted on protect tomato plants by intercropping some field crops with it. Abd El-Aal and Zohry (2003) indicated that intercropping maize with summer tomato gained more benef it. They found that the marketable yield of tomato has increased as a result of maize shadow, besides aving water and increasing land use productivity per unit area. Abd El-Aal and Zohry (2004) reported that faba vean intercropping with tomato system maximized irrigation wáter utilization through saving 31% compared to solid treatment, in addition to an increase in fruit yield and marketable fruits yield of tomato. Saeed et al.(2007) found that, during reproductive development, high temperature causes significant increase in flower drop and significant reduction in fruit set and that severely decrease fruit yield. Ibrahim et al. (2010) intercropped tomato with faba bean and obtained high tomato yield of 20.19 ton/fed, whereas solid tomato attained 14.80 ton/fed, with higher total income and máximum value of total land equivalent ratio (2.21), area time equivalent ratio (1.94) under cultivation of faba bean variety Giza 843 on fourrows on both sides of tomato beds.Ibrahim et al., (2011) reported that intercropping wheat cv. Giza 168 with tomato in November 15 attained higher yield (22.28) ton fed^{-1}, compared with 12.75 ton fed-1

obtained from solid tomato. Under that system higher land equivalent ratio (2.66), total income and net return were obtained. Abd El-Hady*et al.* (2013) showed that the increasing in yield components might due to wide distance between plants under intercropping condition. (Hussain*et al.*, 2008; Mohamed *et al.*, 2013; Abd El-Gaid*et al.,*2014) reported that intercropping tomato with other crops increased productivity, land equivalent ratio, and total income tan tomato solid crop. Abd El-Zaher et al. (2013) found that of intercropped wheat with tomato showed yield advantage compared with solid planting. Maximum value of land equivalent ratio was 2.25 and 2.21, total income and net return were obtained with four wheat rows with adding 50% mineral nitrogen fertilizer and 50% of organic fertilizer (Moussa*et al.,*2013).

Sesame 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 to compete with sunflower the as major crop in most cultivated areas. Considerable interest has been shown in growing sesame 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 sesame seed without significant reduction of tomato yield; c) compensate for any posible loss which could face tomato growers, e.g., disease or market price decline. Advantages of some intercropping systems have been mentioned by some investigators. The interaction between sowing date and cultivar affected significantly seed yield and its attributes, namely number of capsules/plant, plant height, seed weight/plant (Ali and Jan, 2014). Ultimately, higher yield can be achieved through suitable cultivars and optimum sowing date. Bhardwaj et al. (2014) indicated that earlier sowing date resulted in significantly higher seed yield by about 56%. Tahir et al. (2012), and Hamza and Abd El-Salam (2015). Showed that the early sowing date as an optimum date for higher yield and its attributes compared to late sowing date in sesame. Toaima et al (2004) and Haruna (2013). Reported that the merits of intercropping sesame with ground nut have been well documented by several investigators such as Öztürk O, ŞamanO.(2012) mentioned that increasing plant population density increased seed yield per ha. Abdel-Galil and Abdel-Ghany (2014) noticed that intercropping sesame with ground nutis more profitable to farmers tan ground nut sole planting. Pretty and Bharucha (2014)reported that"the combination of the terms 'sustainable' and 'intensification' is an attempt to indicate that desirable outcomes around both more food and improved environmental goods and services could be achieved by a variety of means".Chongdar et al. (2015) and Hamza and Abd El-Salam (2015)reported that planting Shandaweel-3 cultivar in 15th March was the effective pattern for promoting capsules number and weight/plant, sedes weight/plant and biological seeds and oil yields/fed. As wall as the interaction between sowing dates and varieties was also highly significant. Salem, Emad M.M. (2016) noticed that early sowing date (15thMarch) with Shandaweel-3 cultivar and adding 100 kg S/fed could be recommended for increasing sesame yield and its components. Because sesame is a short duration crop, it has the potential to enhance cropping systems intensification and diversification (Oyeogbe et al. 2015). Khan et al (2017) reported that máximum productivity and economic return was obtained when intercropping groundnut with sesame. Land equivalent ratio,equivalent yields, relative yields values and economic return were found highest under cultivated three rows of ground nut in between twop air rows of sesame. Amira A. El- Mehy and Mohamed (2018) reported that inter cropping maize hybrid TWC 324 with tomato and spraying with YE2, protected tomato plants during late summer from negative effect of high temperature and increased setting percentage and marketabl eyield as well as productivity of unitarea and net return. The objective of this research was to determine the most profitable sesame intercropping pattern with tomato and the best sowing date for sesame to attain máximum land usage.

MATERIALS AND METHODS

Field experiment was carried out to evaluate three intercropping system of tomato with sesame under three different sesame sowing dates. These experiments were conducted at Sids Agricultural Research Station, Bani-Suif Governorate, Egypt during 2018 and 2019 growing seasons. The experiment was laid out in split plot design with three replication, where sesame sowing dates was in the main plots and the intercropping arrangement treatments were in the sub plots. Sesame sowing dates were 20th April, 5th May and 20th May. Intercropping treatments were as follows:

-50% sesame (CS_1): sesame was sown on other sides of tomato bed (one plant/hill at 10 cm apart resulted in 35000 plant/fed).
-33% sesame (CS_2): sesame was sown on other sides of tomato bed (one plant/hill at 15 cm apart resulted in 23333 plant/fed).
-25% sesame (CS_3): sesame was sown on other sides of tomato bed (one plant/hill at 20 cm apart resulted in 175000 plant/fed).

Solid planting of tomato and sesame implemented in each replication to determine the competitive relationships, yield advantage of both crops and net income fed^{-1}.

The chemical and physical analysis of the experimental soil at a depth of 0-30cm is shown in **Table (1)**

Table 1. Chemical and Physical analysis of the experimental soil at 0-30cm depth during 2018 and 2019 seasons.

Depth (0-30 cm)	Growing Season	
	First Season	Second Season
Textural class	Clay	Clay
Chemical analysis		
pH	7.9	7.8
Available N ppm	45.0	37.0
Available P ppm	12.5	11.0
Available K ppm	202.5	203.8
EC. dSm-1(at 25°C)	0.53	0.66
OM%	1.20	1.57
Physical analysis		
Sand%	16.30	16.35
Silt%	33.80	33.45
Clay%	49.90	50.20

Tomato cultivar hybrid Nema 1400 was transplanted at 30cm apart between plants in the middle of beds (120 cm width) on 5th May in the two successive seasons, while harvest of the fruit began on the end of July and lasted until the end of September. Sesame cultivar was Shandaweel 3.

The plot size was 42 m^2 including 5 beds of 1.2m width and 7m length. All cultural practices followed for tomato and sesame in the area were done as recommended. Air temperature was obtained from a nearby weather station during the two growing seasons and presented in **Table (2).**

Table 2. Monthly average of maximum (max) and minimum(min) air temperatures(°C) at the experimental site in 2018 and 2019 seasons.

	2018		2019	
	Max.°C	Mini.°C	Max. °C	Mini.°C
April	28.41	12.94	30.68	14.44
May	34.45	18.10	35.71	19.24
Jun.	37.42	20.24	38.07	22.56
Jul.	38.14	22.81	39.68	23.02
August	37.69	22.80	38.11	23.23
Sept.	35.32	20.52	37.76	20.91

Data recorded in the study:

Tomato:

Ten tomato plants were selected randomly in each plot 65 days after transplanting to measure: plant height (cm) and number of branches/plant, fruit weight (g), number of fruits/plant, weight of fruits (kg)/plant were estimated at the third picking, and total yield ton/fed i.e., weight of all picking up to the end of the experiment.

Sesame:

At maturity, ten sesame plants were taken randomly from each plot to determine: plant height, number of branches/plant, number of capsules/plant, capsule length, weight of 1000- seed(g), seed yield/plant (g) and seed yield/fed (ardab). One ardab = 120Kg.

Seed yield were determined per the experimental plot (42m^2) and consequently yield fed^{-1} (4200m^2) was calculated.

Analysis of variance for the obtained results in each growing season was comducted. The measured variables were analyzed by ANOVA using MSTAT statistical package (Freed, 1991). Mean comparisons were performed using the least significant differences (L.S.D) test with a significance level of 5% (Gomez and Gomez, 1984).

B) Competitive relationships:

1. Land equivalent ratio (LER) :

LER defined as the ratio of area needed under sole 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 (tomato)

Y_{bb} = Pure stand yield of crop b (sesame)

Y_{ab} = Intercrop yield of crop a (tomato)

Y_{ba} = Intercrop yield of crop b (sesame)

2. Aggressivity (A).

Aggressivity value was calculated by the formula proposed by **Mc- Gilichrist (1965).**

$$A_{ab} = \frac{Y_{ab}}{Y_{aa} \times Z_{ab}} - \frac{Y_{ba}}{Y_{bb} \times Z_{ba}}$$

Where: A_{ab} = Aggressivity value for the components "a".

Y_{aa} is pure stand yield of crop a, Y_{bb} is pure stand yield of crop b, Y_{ab} is mixture yield of a (when combined with b) and Y_{ba} yield of b (when combined with a).

$Z_{ab}$is sown proportion of species a (in a mixture with b) and Z_{ba} is sown

D. Farmer's benefit:

Total cost and net return of intercropping systems as compared to recommended sole planting of tomato were determined as follows:

1. Total return of intercropping cultures = Price of tomato yield + price of sesame yield (Egyptian Pound). To calculate the total return, the average of tomato and sesame prices presented according to the **Bulletin of The Agricultural Statistics (2017) part (2).** It is supposed that all other practices for tomato and sesame plants for all treatments are constant.

2. Net return per fadden = Total return – (fixed cost of tomato + variable costs of sesame according to intercropping pattern).

3. The average of prices of main products are L.E. 1715 and 1912 for ton of tomato and for ardab of sesame (one ardab = 120Kg seeds), respectively in 2017season.

4. Total costs L.E./fed.8812 and 5106 for solid tomato and sesame, respectively.

5. Total costs of intercropped sesame with tomato = total costs of (tomato + sesame).

6. Costs of intercrop sesame: L.E/fed. 791&528and 396for 50,33 and 25% density plants, respectively.

RESULTS

Tomato:

Effect of sowing date of sesame on tomato performance:

Data in **Table (3)** indicated that. The greatest tomato yield per feddan was obtained when sesame was sown on 20nd April in both seasons (before planting tomato by 15 days). Tomato yield was 24.661 and 25.619 ton/fedin the first and second season respectively. Tomato yield/fed decreased by 5.62 and 13.27% when sesame was sown on 5th May and 20nd May respectively, in the first and second season the reduction estimated by 9.898 and 20.5% for the respective sowing dates.

Table 3. Effect of sowing dates of sesame on growth, yield and its components of tomato in 2018 and 2019 seasons.

Sowing Dates	Plant height (cm)	Number of branches /plant	Number of fruits/ plant	Weight of fruit (gm)	Weight of fruits/ plant (Kg)	yield/ fed. (ton)
2018						
20nd April	61.78	3.34	44.64	92.22	4.11	24.661
5th May	61.04	3.53	40.85	80.67	3.65	23.348
20nd May	60.29	3.02	33.19	68.33	3.19	21.771
L.S.D0.05	NS	NS	6.33	10.37	0.58	1.40
Tomato Solid						**23.860**
2019						
20nd April	68.96	3.76	49.18	97.78	4.59	25.619
5th May	65.16	3.69	44.233	87.89	3.80	23.312
20nd May	60.56	3.44	40.46	77.44	3.11	21.259
L.S.D 0.05	NS	NS	5.17	9.21	0.41	2.19
Tomato Solid						**24.553**

Effect of intercropping patterns:-

Data in **(Table 4).** Indicated that Cropping system CS_1 had the highest values of all characterse.i.plant height No. of branches/plant, No. of fruits/plant, weight of fruit, weight of fruits/plant and yield/fed. in both seasons as compared to the others patterns. Whereas, the increasing of total yield/fed of tomato were 24.999 and 25.857 ton/fed. in the first and second season respectively.

Table 4. Effect of intercropping patterns of sesame on growth, yield and its components of tomato in 2018 and 2019 seasons.

Intercropping Patterns (Tomato 100%)		Plant height (cm)	No. of branches /plant	No. of fruits/ plant	Weight of fruit (gm)	Weight of fruits/ plant (Kg)	yield/ fed. (ton)
2018							
+ Sesame %	50	62.98	3.56	44.43	91.11	4.41	24.999
	33	61.02	3.23	38.59	80.00	3.57	23.300
	25	59.11	3.11	35.66	70.11	2.99	21.481
L.S.D0.05		5.50	0.32	6.28	5.52	0.53	2.20
Solid							**23.860**
2019							
+ Sesame %	50	71.07	3.80	49.68	97.89	4.67	25.857
	33	68.18	3.67	43.78	86.89	3.70	23.130
	25	56.42	3.40	40.41	77.44	3.12	21.259
L.S.D 0.05		5.73	0.34	5.42	5.24	0.47	1.54
Solid							**24.553**

Effect of interaction between intercropping dates and intercropping patterns:

Results presented in **Table (5)** showed that intercropping pattern of (100 % tomato+ 50% sesame) recorded the highest values for all tomato characters when planting the sesame before tomato by 15 days and planting on 10 cm between hills in all characters of tomato, whereas gives 26.033, and 27.303 ton/fed. for total yield/fed. in the first and second seasons respectively. On the other side, the lowest value was showed under 100 % tomato + 25 % sesame pattern when planting sesame on 20cm between hills after tomato by 15 days in both seasons, whereas it gives 18.733 and 20.600 ton/fed. for total yield/fed.

Table 5. Effect of interaction between intercropping dates and intercropping patterns on grows, yield and its components for tomato in 2018 and 2019 seasons.

Intercropping Dates	IntercroppingPatterns (100% Tomato)		Plant height (cm)	No. of branches /plant	No. of fruits/ plant	Weight of fruit (gm)	Weight of fruits/ plant (Kg)	yield/ fed. (ton)
2018								
20nd April	**+ Sesame %**	50	63.67	3.53	48.32	100.00	4.79	26.033
		33	61.67	3.30	44.69	93.33	4.17	25.017
		25	60.00	3.20	40.91	83.33	3.37	22.933
5th May	**+ Sesame %**	50	62.80	3.93	45.85	95.00	4.18	25.380
		33	61.27	3.40	38.47	78.33	3.30	23.753
		25	59.07	3.27	38.23	68.67	2.94	20.910
20nd May	**+ Sesame %**	50	62.47	3.20	3913	78.33	3.70	23.583
		33	60.13	3.00	32.60	68.33	3.22	21.120
		25	58.27	2.87	27.85	58.33	2.65	18.733
L.S.D0.05			9.52	0.55	10.88	9.57	0.92	3.80
Solid tomato								**23.860**

2019								
20nd April	**+ Sesame %**	50	75.27	3.87	54.07	105.00	5.29	27.303
		33	71.33	3.80	50.47	98.33	4.62	25.877
		25	60.27	3.60	43.00	90.00	3.84	23.677
5th May	**+ Sesame %**	50	70.60	3.80	49.23	101.67	4.79	26.177
		33	67.67	3.73	42.00	85.00	3.52	22.393
		25	57.20	3.53	41.47	75.00	3.09	21.367
20nd May	**+ Sesame %**	50	67.33	3.73	45.73	87.00	3.94	24.090
		33	62.53	3.53	38.87	77.33	2.96	21.130
		25	51.80	3.07	36.77	67.33	2.44	20.600
L.S.D 0.05			9.83	0.59	9.38	9.08	0.82	2.66
Solid								**24.553**

B- Sesame:

Effect of sowing dates:

Data in (Table 6).indicated that the increase in seed yield for plant and faddan when planting sesame before tomato by 15 days over that received the planting after tomato by 15 days was to 2.46 and 3.36% in the first and second season respectively. But compared to the planting the sesame in the same date of planting tomato was increased 1.40 and 1.72% in both seasons respectively.

Table 6. Effect of sowing dates of sesame on growth, yield and its components of sesame in 2018 and 2019 seasons.

Intercropping Dates	Plant height (cm)	No. of branches/ plant	No. of capsules/ plant	Length of capsule (cm)	Weight of 1000 seed (gm)	Seed yield/ plant (gm)	Seed yield/fed. (ardab)
2018							
20th April	155.55	2.80	86.00	2.77	5.31	15.14	2.53
5th May	148.44	2.22	70.26	2.69	4.71	12.93	2.22
20th May	120.11	2.13	62.29	2.61	4.53	12.44	2.02
L.S.D0.05	24.29	NS	13.43	NS	0.23	2.30	0.34
2019							
20th April	171.67	3.00	114.88	3.85	5.54	15.52	3.07
5th May	164.44	2.49	95.33	3.51	4.89	13.16	2.62
20th May	137.67	2.35	92.52	3.33	4.75	13.03	2.27
L.S.D 0.05	25.28	NS	19.79	NS	0.22	2.14	0.48

2- Effect of intercropping patterns of sesame on the on growth, yield and its components of sesame in 2018 and 2019 seasons:

Results in **Table (7)** observed that the average no. of branches/plant, length of capsule, weight of 1000 seed and seed yield/plant were increased with the least sesame densities (25%) and gradually decreased with increasing plant density up to 50% in the intercrop in the first and second season. Seed yield per fed. inversely behaved to yield components traits, the 50% density of sesame treatment significantly out- yielded the 33% and 25% treatments. The increase in yield of 50% density treatment over the 33% and 25%treatmentswere estimated to 6.72%, 25.69% in the first season and 17.93%, 31.76% in the second season respectively.

Table 7. Effect of intercropping patterns of sesame on growth, yield and its components of sesame in 2018 and 2019 seasons.

Intercropping Patterns (Tomato 100 %)		Plant height (cm)	No. of branches/ plant	No. of capsules/ plant	Length of capsule (cm)	Weight of 1000 seed (gm)	Seed yield/ plant (gm)	Seed yield/fed. (ardab)
2018								
+ Sesame %	50	149.44	2.04	56.44	2.33	4.21	11.73	2.53
	33	142.67	2.44	73.81	2.71	4.82	13.46	2.36
	25	132.00	2.67	88.29	3.03	5.53	15.31	1.88
L.S.D0.05		9.85	0.25	7.62	0.36	0.25	1.19	0.33
Sesame Solid								**5.37**
2019								
+ Sesame %	50	165.00	2.29	89.18	3.21	4.64	12.45	3.18
	33	159.44	2.64	98.66	3.51	4.90	13.62	2.61
	25	149.45	2.91	114.82	3.96	5.65	15.65	2.17
L.S.D 0.05		10.08	0.23	13.72	0.30	0.27	1.33	0.26
Sesame Solid								**6.85**

Although, the total yield is considered a reliable index of yield component traits, but sesame population density within each treatment have to be taken into consideration. These results agreed with those observed by**Ibrahim et al.(2010).**

3- Effect of interaction between intercropping dates and intercropping patterns. The interaction revealed that the highest values for seed yield per fed. was obtained in **Table (8)** when planting the seed sesame before planting of tomato by 15 days with 50% plant density of sesame,(2.83 and 3.60 ardab/fed. in both season respectively), whereas, the lowest yield was showed when planting seed of sesame after tomato by 15 days with 25% plant density of sesame,(1.52 and 1.82 ardab/fed. in both season respectively), .

Table 8. Effect of interaction between intercropping dates and intercropping patterns of sesame on growth, yield and its components of sesame in 2018 and 2019 seasons.

Intercropping Dates	Intercropping Patterns (Tomato 100 %)		Plant height (cm)	No. of branches/plant	No. of capsules/ plant	Length of capsule (cm)	Weight of 1000seed (gm)	Seed yield/ plant (gm)	Seed yield/fed. (ardab)
2018									
20th April	**+ Sesame %**	50	167.33	2.27	74.11	2.43	4.29	12.83	2.83
		33	155.33	2.93	85.44	2.75	5.45	14.88	2.63
		25	144.00	3.20	98.44	3.14	6.19	17.70	2.13
5th May	**+ Sesame %**	50	154.33	1.93	50.22	2.37	4.21	11.52	2.42
		33	152.00	2.27	74.11	2.70	4.56	12.69	2.25
		25	139.00	2.47	86.44	3.03	5.37	14.59	2.00
20th May	**+ Sesame %**	50	126.67	1.93	45.00	2.20	4.12	10.85	2.33
		33	120.67	2.13	61.89	2.69	4.44	12.81	2.20
		25	113.00	2.33	79.99	2.93	5.04	13.65	1.52
L.S.D$_{0.05}$			17.05	NS	13.20	0.63	0.44	2.05	0.57
Sesame Solid								**13.10**	**5.37**
2019									
20th April	**+ Sesame %**	50	181.67	2.47	107.99	3.49	4.79	13.52	3.60
		33	171.67	3.13	108.22	3.78	5.53	15.18	2.99
		25	161.67	3.40	128.22	4.27	6.29	17.87	2.61
5th May	**+ Sesame %**	50	170.00	2.27	94.77	3.10	4.59	11.57	3.34
		33	168.33	2.47	107.45	3.48	4.61	12.82	2.40
		25	155.00	2.73	108.78	3.95	5.48	15.08	2.08
20th May	**+ Sesame %**	50	143.33	2.13	77.11	3.04	4.54	12.27	2.60
		33	138.33	2.33	82.44	3.27	4.55	12.85	2.45
		25	131.67	2.60	93.00	3.67	5.17	14.00	1.82
L.S.D $_{0.05}$			17.46	NS	23.76	0.52	0.64	2.30	0.45
Sesame Solid								**13.83**	**6.85**

Competitive relationships

1. Land equivalent ratio: (LER)

The data in **Table (9)** indicate that all the values of LER which obtained, in 2018 and 2019 seasons exceeded the unit. It ranged from 1.07 due to intercropping 25% of sesame with tomato to 1.62 due to intercropping 50% of sesame with tomato. The advantage of the highest LER by intercropping sesame with tomato over the others intercropping patterns.

The data in **Table (10).** show that. This main that tomato was the dominant intercrop whereas as sesame was the dominated when sesame planting before tomato by 15 days in both seasons. On the other hand the sesame were positive while values of tomato were negative whereas sesame was the dominant when sesame planting with or after the tomato by 15 days.

Table 9. Effect of intercropping patterns of sesame with tomato on competitive relationships, in 2018 and 2019 seasons.

Treatments			Relative yield (RY)		LER	Aggressivity(A)	
			Ry_t	Ry_s		tomato	sesame
2018							
20th April	**+ Sesame %**	50	1.09	0.53	1.62	+0.03	-0.03
		33	1.05	0.49	1.54	+0.07	-0.07
		25	0.96	0.40	1.36	+0.16	-0.16
5th May	**+ Sesame %**	50	1.06	0.45	1.51	-0.30	+0.30
		33	0.99	0.42	1.41	-0.28	+0.28
		25	0.88	0.37	1.25	-0.24	+0.24
20th May	**+ Sesame %**	50	0.99	0.43	1.42	-0.73	+0.73
		33	0.89	0.41	1.30	-0.75	+0.75
		25	0.79	0.28	1.07	-0.33	+0.33
2019							
20th April	**+ Sesame %**	50	1.11	0.52	1.63	+0.05	-0.05
		33	1.05	0.44	1.49	+0.17	-0.17
		25	0.96	0.38	1.34	+0.20	-0.20
5th May	**+ Sesame %**	50	1.07	0.49	1.56	-0.43	+0.43
		33	0.91	0.35	1.26	-0.15	+0.15
		25	0.87	0.30	1.17	-0.03	+0.03
20th May	**+ Sesame %**	50	0.98	0.38	1.36	-0.54	+0.54
		33	0.86	0.36	1.22	-0.58	+0.58
		25	0.84	0.27	1.11	-0.24	+0.24

D. Farmer's benefit:

The financial return of intercropped sesame with tomato as compared with solid planting of both crops tomato or sesame, (**Table 10**). In general, intercropping sesame increased total and net return by 8.32% and 6.85% in the first season as well as 6.78% and 5.50% in the

second season respectively, as compared with recommended solid tomato. The net return of intercropping sesame with tomato when planting in 20th April and varied between treatments from 50%, 33% to 25% plant density from L.E. 42118, 37732 to 34003respectively, in the first season and from L.E. 44870, 39685 to 36896 respectively, in the second season.

Table 10. Financial return as affected by cropping systems and their interactions in 2018 and 2019 seasons.

Intercropping Dates	Intercropping Patterns (Tomato 100 %)		Yield/fed.		Financial return (L.E./fed.)				
			Tomato Ton	Sesame Ardab	Tomato yield	Sesame Yield	Total income	Total Cost	Net income
2018									
20th April	**+ Sesame %**	50	26.033	3.70	44647	7074	51721	9604	42117
		33	25.017	2.18	42904	4168	47072	9340	37732
		25	22.933	2.03	39330	3881	43211	9208	34003
Mean			24.661	2.64	42294	5041	47335	9384	37951
5th May	**+ Sesame %**	50	25.380	2.50	43527	4780	48307	9603	38704
		33	23.553	2.17	40393	4149	44542	9340	35202
		25	20.910	1.85	35861	3537	39398	9208	30190
Mean			23.281	2.17	39927	4155	44082	9384	34698
20th May	**+ Sesame %**	50	23.583	2.23	40445	4264	44709	9603	35106
		33	21.130	1.92	36238	3671	39909	9340	30569
		25	20.600	1.71	35329	3270	38599	9208	29391
Mean			21.77	1.95	37337	3735	41072	9384	31688
Mean of intercropping systems	+ Sesame %	50	24.999	2.81	42873	5373	48246	9603	38643
		33	23.233	2.09	39845	3996	43841	9340	34501
		25	21.481	1.86	368403	3563	40403	9208	31195
		Mean	23.238	2.25	39853	4311	44163	9384	34779
Tomato sole planting			**23.860**	-------	**40920**	-------	**40920**	**8812**	**32108**
Sesame sole planting			------	**5.37**	------	**10267**	-------	**5106**	**5161**
2019									
20th April	**+ Sesame %**	50	27.303	4.00	46825	7648	54473	9603	44870
		33	25.877	2.43	44379	4646	49025	9340	39685
		25	23.677	2.30	40606	4398	45004	9208	35796
Mean			25.619	2.91	43936	5565	49501	9384	40117
5th May	**+ Sesame %**	50	26.177	2.78	44894	5315	50209	9603	40606
		33	22.393	2.37	38404	4531	42935	9340	33595
		25	21.367	2.12	36644	4053	40697	9208	31489
Mean			23.312	2.42	39980	4634	44614	9384	35230
20th May	**+ Sesame %**	50	24.090	2.52	41314	4818	46132	9603	36529
		33	21.120	2.12	36221	4053	40274	9340	30934
		25	18.733	1.98	32127	3786	35913	9208	26705
Mean			21.314	2.21	36554	4219	40773	9384	31389
Mean of intercropping systems	**+ Sesame %**	50	25.857	3.10	44344	5927	50271	9603	40668
		33	23.130	2.31	39668	4410	44078	9340	34738
		25	21.259	2.13	36459	4079	40538	9208	31330
		Mean	23.415	2.53	40157	4805	44962	9384	35578
Tomato sole planting			24.553	-----	42108	-------	42108	8812	33296
Sesame sole planting			------	**6.85**	-------	**13097**	------	**5106**	**7991**

DISCUSSION

The sowing date of sesame had significant effect on yield components of tomato intercropped with sesame. These results may be due to the fact that the tomato plants were not affected by the high temperatures during the flowering and decade stages. These results were supported by those obtained by Ibrahim et al., (2010 and 2011).

Cropping systems significantly affected, plant height, No. of branches/plant, No. of fruits/plant, weight of fruit, weight of fruits/plant and total yield/fed. This results may be due to increasing of plant distance for intercropped sesame, which led to the shade of the plants and protect them from high temperature and not to drop the flowers and increase the nodes and consequently fruit yield was increased to a great extent. These results are consistent with Hussain *et al.*, 2008,Mohamed *et al.*, 2013, Degri et al., 2012;Degri et al., 2014 and Abd El-Zaher et al., (2013).

Plant height, No. of branches/plant, No. of fruits/plant, weight of fruit, weight of fruits/plant, and yield/fed. were significantly affected by the interaction between intercropping dates and intercropping patterns in both season**.** The data of both seasons indicated to night temperature during August and Sept. since soil temperature, the first season, were associated with lower degree, rather than the season, As a consequence the intercropping tomato yielded better under all respective sesame densities with all sowing dates. These results are in agreement with AbdEl-Hady *et al.* (2013) and Abd El-Gaid *et al.,* 2014). Plant height, no. of capsules/plant, weight of 1000seed, seed yield/plant and seed yield/fed. were significantly increased with sowing dates except no. of branches/plant it was not significantly and length of capsule in the first and second seasons.

Accordingly, the enhancements in sesame yields, yield components with early planting date may be due to that the plants had optimum vegetative growth, adequate photosynthetic activity and more assimilates than planting latter. This results cleared with those of Chongdar et al. (2015), Hamza and Abd El-Salam (2015) and Salem,Emad M.M.(2016)

The intercropping treatments had significant effects on plant height, no.of branches/plant, No. of capsules/plant, length of capsule, weight of 1000 seed, seed yield/plant and seed yield/fed. of sesame intercropped with tomato in both seasons. The above and

below ground competition between plants for solar radiation intercepted, water and nutrients from the soil might account much for the superiority of these traits when sesame density decreased to only 25%. The results are in agreement with those obtained by El Naim, et al (2010), Öztürk O, Şaman O.(2012) and Islam et al. (2016). Although, the total yield is considered a reliable index of yield component traits, but sesame population density within each treatment have to be taken into consideration. These results agreed with those observed by **Ibrahim et al. (2010).**

Interaction effect between intercropping dates and patterns of sesame had significant effects on all characters for sesame in both seasons except no. of branches/plant in the two seasons. These results agreed with the results obtained by Abd El-Aal and Zohry (2004),Ibrahim et al.,(2010 and 2011), Tahir et al. (2012), Abd El-Hady *et al.* (2013), Abd El-Zaher et al., (2013), , and Hamza and Abd El-Salam (2015), Hussein and Azouz(2016) and Islam et al. (2016). In general, intercropping sesame with tomato increased LER as compared to sole sesame. . It is clear that plant population density of sesame and tomato played a major role in increasing productivity per unit area under intercropping planting where it reached 25 and 100 % of sole planting, respectively. Similar results were obtained by Khan, et al (2017) and Amira A. El-Mehy and Mohamed (2018). The aggressivity of sesame were negative while values of tomato were positive in CS_1 with all intercropping dates in both seasons. These results due to increasing the yield of tomato compared with the others dates for intercropping the sesame. This main that tomato was the dominated intercrop. These results were similar to those obtained by Ibrahim et al., (2010 and 2011), Upadhyay *et al*., (2010) and (WPTC,2011). The financial return of intercropped sesame with tomato as compared with solid planting of both crops tomato or sesame, According to the objective, intercropping sesame with tomato should be compared with solid planting of tomato under farmer· conditions. Similar results with Ibrahim et al., (2010 and 2011), Upadhyay *et al*., (2010) and (WPTC,2011) and Islam et al. (2016).

CONCLUSION

Finally, intercropping sesame with tomato gave the highest values of yield and its components and economic return (total income or net return) compared to sole planting for each tomato, or sesame. Therefore, it is recommended to grow sesame before tomatoes by 15 days, at a distance of 10 cm between plants and one plant in the hill(with a density of 50% of the total density of sesame) to obtain the highest productivity of tomato crops and the highest economic return to farmers**.**

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تأثير بعض نظم تحميل السمسم مع الطماطم تحت مواعيد زراعه مختلفة للسمسم على إنتاجية كلا المحصولين

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الملخص العربى

أقيمت تجربتان حقليتان فى محطة بحوث البساتين بسدس محافظة بنى سويف خلال عامى 2018 و 2019 بهدف دراسة تأثير تحميل السمسم (شندويل–3) على هجين الطماطم (نيما 1400) فى ثلاث نظم تحميل (100% طماطم + 50% سمسم ، 100% طماطم + 33% سمسم ، 100% طماطم + 25% سمسم) بلإضافه للزراعه المنفرده لكلا المحصولين تحت ثلاث مواعيد تحميل من السمسم وتأثيره على طول النبات والمحصول ومكوناته. تم إستخدام تصميم قطع منشقه مره واحده فى ثلاث مكررات حيث وضعت مواعيد التحميل للسمسم فى القطع الرئيسيه ونظم التحميل فى القطع الفرعيه واوضحت النتائج ان نظم التحميل ادت الى زيادة جميع صفات النمو والمحصول للطماطم مقارنة بالزراعه المنفرده كما تأثر المحصول ومكوناته لكلا المحصولين معنويا بنظم التحميل المختلفه وكانت اعلى القيم للمحصول (26,033 ، 27,303 طن/فدان) فى الموسم الأول والثانى على التوالى عند زراعة السمسم قبل الطماطم بـ 15 يوم و50% من الكثافه الكليه للسمسم و كانت اعلى قيم محصول السمسم (2,83 ، 3,60 اردب/فدان) فى كلا الموسمين على التوالى عند زراعة السمسم قبل الطماطم بـ 15 يوم وبكثافة 50% من الكثافه الكليه بينما اقل القيم (1.25، 1.82 اردب/فدان)سجلت عند زراعة السمسم بعد الطماطم بـ 15 يوم وبكثافة 25% من الكثافه الكليه. سجلت القيم العظمى لمعامل إستغلال الأرض (LER) (1,62 ، 1,63) عند زراعة السمسم قبل الطماطم بـ 15 يوم فى كلا الموسمين على التوالى وكذلك اوضحت النتائج ان الطماطم كانت سائده عند زراعة السمسم قبل الطماطم بـ 15 يوم. وايضا العائد الكلى وصافى العائد اعلى القيم عند التحميل بنفس الكثافه (41954، 44706 جنيه مقارنة بالطماطم المنفرده (32108، 33296 جنيه) او السمسم المنفرد (5161، 7991 جنيه)

وعلى ذلك يمكن التوصيه بتحميل السمسم مع الطماطم بزراعته قبل الطماطم بـ 15 يوم وبكثافه 50% من الكثافه الكليه للحصول على إنتاجيه واعلى صافى ربح من الطماطم .

الكلمات المفتاحية:طماطم،الكثافه النباتيه للسمسم،تحميل،معدل كفاءة إستغلال الأرض،العدوانيه،العائد الكلى،صافى العائد