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RESPONSE OF GROUNDNUT TO INTERCROPPING WITH SOME SESAME VARIETIES UNDER DEFERENT PLANT DENSITY

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Abou-Kerisha[1], M.A.; R.A. Gadallah[1] and E.E.A. Mohamdain[1]
1- Crop Intensification Research Department, Field Crop Research Institute Agricultural Research Center, Giza, Egypt

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ABSTRACT

Two field trials were carried out at Shandaweel Research Station (Sohag governorate) during 2005 and 2006 summer seasons to investigate the response of groundnut to intercropping with three sesame varieties under different plant densities in relation to yield and yield component of both crops. A split plot design with three replicates was used. The main plots were devoted to sesame varieties (Shandaweel 3, Toshka 1 and Giza 32) while the sub plots were devoted for plant densities (100%, 67% and 50% representing three hill spacing of sesame i.e. 20, 30 and 40 cm. respectively). The groundnut (the main crop) was grown on all ridges at a normal plant density. The data obtained indicate that all studied traits of groundnut were decreased when intercropping with sesame varieties as compared with solid crops. This reduction was higher when intercropped with sesame cv Giza 32 than with the other sesame varieties. Yield and yield components of groundnut were also significantly affected by the plant densities of sesame varieties. The yield of groundnut when intercropped with low sesame density (50%) exceeded that with high density of sesame (100%) by 31.66, 27.51 and 29.53 % in the first, the second and the combined of the two seasons respectively. The results also indicated that yields of all sesame varieties were decreased under intercropping condition. Sesame Giza 32 variety surpassed the other varieties (Shandaweel 3 and Toshka 1) in plant height, number of branches, number of capsules / plant, seed yield / plant and seed yield / fad. The high plant density (100%) recorded the highest sesame seed yield / fad. where the increase was 46.93 and 13.50 % in the first season, 2.46 and 8.71% in the second season and 25.86 and 11.19% in the combined data over the low and medium density treatments, respectively. The response equations of pod yield / fad. of groundnut was linear with each decrease of sesame planting density and with higher magnitude under Toshka 1 than under the other to sesame varieties. The treatment of groundnut with Toshka 1 under low density had higher land equivalent ratio (LER) (1.41), intercropping advantage (IA) (582.8) and monetary advantage index (MAI) (1666.85). The treatment of groundnut with Giza 32 under low density had higher actual yield loss (AYL) (+1.245). It could be concluded that intercropping groundnut with Toshka 1 under medium density had favoured the growth and yield of both crops.

INTRODUCTION

Groundnut and sesame are of the major oil seed crops in the world as well as in Egypt. These crops are grown not only for oil production but also for fresh human consumption or for export. Intercropping oil seed crops are an avenue of approach to increase the net return of the land in desert areas through increasing land use efficiency by intercropping system.

Several investigations reported that number of pods per plant was found to be the most important trait as contributor to yield in groundnut. It had a positive relationship with yield per plant, but it had a negative correlation with 100-pod weight while, 100-pod weight had positive correlation with 100-seed weight. **(Salame *et al* 1981). El-Mihi *et al* (1990)** found that intercropping sesame with groundnut had positive effect on land equivalent ratio which was more than one. Aggressivity value in general was positive for sesame whereas

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groundnut was the dominated. **Gabr (1999)** found that groundnut intercropped with sesame at 1:1 row ratio produced lower yield than its pure stand with various combinations. Groundnut pod yield was the highest when grown at 100% plant densities whereas seed yield was the highest at 50% of recommended plant densities. Therefore LER was the highest when groundnut and sesame were intercropped at 1:1 row ratio with 100% and 50% plant densities groundnut and sesame respectively. **Sarkar and Sanyal (2000)** noted that an intercropped of groundnut with sesame was found most beneficial compared to sole stand sesame. Sesame + groundnut under 3:2 row proportion gave the maximum sesame- equivalent yield (947 kg/ ha), land equivalent ratio (1.31), product of relative crowding coefficient (K 3.87), monetary advantage (Rs, 2.913 / ha) net returns (Rs, 5.321 / ha) income equivalent ratio (1.21) and also indicated a modest competitive ratio (0.86: 1.16) and aggressivity factor ($\pm$ 0.37). **Badran (2002)** found that groundnut was dominant intercrop component while sesame was the dominated one under the studied intercropping system, with the exception of early planting of sesame followed by planting groundnut. **Toaima *et al* (2004)** found that growth, yield components and total yield of peanut and sesame were significantly affected by intercropping patterns. Intercropping sesame and peanut in 2:2 patterns produced the highest yield for peanut and sesame, compared with the other intercropping patterns. **Bhatti *et al* (2006)** reported that the sesame grown in association with different grain legumes i.e. mungbean, mash bean, soybean and cowpea) appeared to be a dominant crop as indicated by its higher values of relative crowding coefficient, competitive ratio and positive sign of aggressivity.

The effect of plant population of sesame on yield and yield components had been reported by several workers. Seed yield per unit area increased with increasing population density from 80.000 to 160.000 plants / ha beyond this density it becomes counter productive. **(Delgado and Yamonos, 1975).** Also, **Channabasavanna and Setty (1992)** found that seed yields of two sesame varieties were significantly higher with 666,666 plants / ha compared with 222,222 plants / ha. due the increase in the capsules / m^2 though the number of branches / plant and capsules / plant were higher in the low density. Morever, **Chimanshette and Dhoble (1992)** reported that the plant density of 222,000 plants / ha (45 cm ×100 m) recorded significantly higher seed yield (364 kg/ ha) than lower plant densities. The seed yield decreased significantly with the decrease in plant density from 222,000 to 111,000 plant density of both sesame varieties. Furthermore, **Ghungarde *et al* (1992)** and **Dhoble *et al* (1993)** showed that sesame seed yield / plant was higher at lower plant density where it was curvilinearly decreased with an increase in plant density, but the seed yield /ha was however, increased asymptotically. They added that the competition- freeness index declined with increase in plant density. **Ghosh and Patra (1994)** showed that high plant density (333,000 /ha) recorded higher seed yield and greater harvest index and higher oil yield than the low plant densities. It also paid high net return along with high return / rupee invested. **El-Serogy *et al* (1997)** showed that the B.35 sesame variety surpassed Giza 32 in plant height and first capsule height, while Giza 32 surpassed B.35 in number of capsules/ plant and seed weight / plant, 1000-seed weight and seed yield / fad. The highest values for number of capsules / plant, seed yield/ plant and 1000-seed weight were recorded from plants sown on ridges 70cm. apart with 10cm. between hills while the highest seed yield / fad was produced by growing sesame plants on ridges 50 × 10 cm. on one side or 60 × 20 cm. on the two sides of ridges. **Ghosh (2004)** found that LER was higher there is also significant economic benefit expressed with higher MAL values when grown groundnut with cereal fodder intercropping systems. **Sherif Sahar *et al* (2005)** found that the number of pods / plant, pods weight / plant, 100 seed weight and pods yield / fad of groundnut were increased when intercropped with maize grown plants at 100cm. apart than when maize plants were oriented at 50cm. **El-Sawy *et al* (2006)** showed that intercropping system of 100% peanut +25% sunflower gave the highest significant values for yield and yield components of both crops. While intercropping system of 100% peanut + 100% sunflower produced higher land equivalent ratio (1.67). **Rahnama and Bakhshandedh (2006)** found significant effect on the yield components due to an increase in sesame row-spacing. They indicated that the increase in plant spacing from 5 to 20 cm. caused a decrease in stem height but caused an increase in stem diameter and pod number per plant. **Abd El–Zaher *et al* (2007)** recorded that intercropping systems of 100% peanut + 33% maize gave the highest total yield, followed by 100% peanut + 50% maize, whereas the lowest value was obtained with 100% peanut + 67% maize intercropping.

MATERIALS AND METHODS

Two field trails were carried out at Shandaweel Agric. Res. Sta., Sohag governorate (Upper Egypt) during the summer 2005 and 2006 seasons. The objective of this study was to investigate the response of groundnut to intercropping with three sesame grown varieties under different plant densities in relation to yield and yield components of both crops. The groundnut (the main crop) was grown on all ridges at (normal density).

A split plot design with three replicates was used. The main plots were devoted to three sesame varieties i.e. Shandaweel 3, Toshka 1 and Giza 32 whereas the sub plots were allocated for three hill spacing of sesame which were 20, 30 and 40cm. The area of each sub plot was $24m^2$ (6m. wide×4m. long), consisting of ten ridges. Groundnut was grown on one side of all ridges in one plant / hill 10cm. apart (70,000 plant / fad) and sesame was planted on the other side of ridges with two plants / hill in **(Table 1)**.

Pure stand for groundnut and sesame was included for comparison. Groundnut was sown in the first week of May while sesame was sown in third week of May during the two seasons. During seedbed preparation, 30 kg P_2O_2 / fad in the form of calcium superphosphate (15.5% P_2O_5) was added. Nitrogen fertilizer was used at the rate of 30 kg N / fad for groundnut and 15 kg / fad for sesame in the form of ammonium sulfate (20.5 / N) in two equal doses. The first dose was added after thinning and the second at one month later. Potassium fertilizer was added at the rate of 50 kg / fad for groundnut and 25 kg / fad for sesame in one dose with the first dose of nitrogen in the form of potassium sulfate (48% K_2O).

Harvesting took place in the first week and the later week of Sep. for sesame and groundnut respectively in both seasons. At harvest, samples of ten plants each were taken from each sub plot and the following data were recorded on growth and yield components of the two component crops.

Sesame data: Plant height (cm.), number of branches / plant, number of capsules / plant, seed index (g), seed yield / plant (g) and seed yield / fad. (ardab = 120 kg.).

Groundnut data: Plant height (cm.), number of pods/ plant, seed index (g), pod yield / plant (g) and pod yield / fad. (ardab = 75 kg.).

Competitive relationships

1. Land equivalent ratio (LER)

LER is determined as the sum of the fractions of the yield of intercrops relative to their sole crop yields **(Willey and Osiru 1972).** Land equivalent ratio LER was determined according to the following formula:

$$LER = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where: Yaa is pure stand yield of species a, Ybb is pure stand yield of species b, Yab is mixture yield of a (when combined with b) and Yba yield of b (when combined with a).

2. Aggressivity (Agg)

This was proposed by **Mc–Gillchrist (1960)** and was determined according to the following formula.

$$Aab = \frac{yab}{yaa \times zab} - \frac{yba}{ybb \times zba}$$

An aggressivity value of zero indicates that the component crops are equally competitive. For any other situation both crops will have the same numerical value, but, the sign of the dominate crop will be positive and the dominated negative. The greater the numerical value of (Agg), the bigger the difference in competitive abilities and the bigger the difference between actual and expected yields.

3. Competitive ratio (CR) was calculated by following the formula as advocated by **Willey and Rao (1980)**

$$CR = CRa + CRb \quad CRa = \left\{\left(\frac{LERa}{LERb}\right) \times \left(\frac{Zba}{Zab}\right)\right\},$$

Where: LERa and LERb represent relative yield of a and b intercrops, respectively. Since the CR values of the two crops will in fact be reciprocals of each other.

CRa , CRb are the competitive ratio for intercrop where Zab representing the sown proportion of intercrop a (sesame) in combination with b (groundnut) and Zba the sown proportion of intercrop b (groundnut) in combination with a (sesame).

Table 1 . Plant populations of both groundnut and sesame in different rectangular ties system

Treatment	Rectangularity		Population / fad.	
	Groundnut	Sesame	Groundnut	Sesame
Sole	60 ×10 cm	60 ×20 cm	70.000	70.000
Plant density in the intercrop				
S_1		60 ×20 cm	70.000	70.000 (100%)
S_2		60 ×30 cm	70.000	46.666 (67%)
S_3		60 ×40 cm	70.000	35.000 (50%)

4. Actual yield loss (AYL) was calculated as according to **(Banik, 1996)** as follows:

$$AYL = AYLa + AYLb = \left[\left\{\frac{(Yab/Zab)}{(Yaa/Zaa)}\right\} - 1\right] + \left[\left\{\frac{(Yba/Zba)}{(Ybb/Zbb}\right\} - 1\right].$$

Where: AYLa and AYLb are the partial yield loss of intercrop sesame and groundnut respectively.

Yab representing the yield of intercrop a (sesame) in combination with b (groundnut), Yba the yield of intercrop b (groundnut) in combination with a (sesame).

5. Intercropping advantage (I A) was calculated using the following formula **(Banik *et al* 2000):**

IA sesame = **AYL** sesame × **Price** sesame

IA groundnut = **AYL** groundnut × **Price** groundnut

The market price of average the two seasons for sesame and groundnut were 600 LE / ardab and 400 LE / ardab respectively.

6. Monetary advantage index (MAI): suggests that the economic assessment should be in terms of the value of land saved; this could probably be most assessed on the basis of the rentable value of this land. MAI was calculated according to the formula, suggested by **Willey (1979).**

$$MAI = \frac{Value\ of\ combined\ intercrops \times LER - 1}{LER}$$

The data for each experiment were then analyzed by MSTATC software for comparison of the mean values and the two seasons by LSD test at the 5% level. Response equations were calculated according to **Snedecor and Cochran (1988)** or explained by **Abdul-Galil *et al* (2000 b).**

RESULTS AND DISCUSSION

I- Groundnut response

1. Sesame varietals differences effect

Data presented in **Table (2)** showed that sesame varieties had significant effects on growth, yield and yield components of groundnut (the main crop) in both seasons and the combined data of both seasons. Data indicated that plant height and number of branches / plant of groundnut were decreased when intercropped with any sesame variety as compared by solid but with more adverse effect with cv Giza 32 compared with those intercropped by the other two varieties. These results were true in both seasons. Yield and yield components were also significantly decreased by sesame varieties. These decreases were high with cv Giza 32 the combined data. The reduction due to intercropping with cv Shandaweel 3 was 31.28 % for number of pods / plant, 5.06 % for seed index, 55.46 % for pods yield / plant and 40.55 % for pods yield / fad as compared with the solid the combined of the two seasons. This reduction with cv Toshka 1 was 32.14% for number of pods/ plant, 11.82% for seed index, 60.82% for pods yield / plant and 34.76% for pods yield / fad. While when intercropping with cv Giza 32 was 35.89% for number of pods / plant, 12.43 % for seed index 66.15 % for pod yield / plant and 49.71 % for pod yield / fad. on the same order. Based on these results, it seemed that yield and yield components of groundnut were truely affected by sesame varieties. The more branched sesame variety Giza 32 with latter plants more shading to might have had caused groundnut intercrop which resulted in substantially reduced yield and yield components due to a low amount of light intercepted. It could be

Table 2. Effect of sesame varieties on yield and yield components of groundnut in the two seasons and their combined data

Varieties	Plant height (cm.)	No. of branches / plant	No. of pods / plant	Seed index (g)	Pod yield / plant (g)	Pod yield / fad (ardab)
First season						
A_1 Shandaweel 3	49.91	9.33	26.95	74.05	34.56	6.97
A_2 Toshka 1	47.73	10.29	26.64	68.71	28.44	7.29
A_3 Giza 32	46.60	8.20	24.53	68.08	22.89	5.72
LSD	1.63	1.49	0.34	2.75	1.22	0.18
C.V.	2.59	1.23	1.01	2.99	3.26	2.01
Solid first season	56.67	12.80	42.20	78.97	73.00	10.92
Second season						
A_1 Shandaweel 3	49.42	10.18	32.38	73.82	36.56	7.19
A_2 Toshka 1	49.40	11.22	31.93	68.53	34.11	8.25
A_3 Giza 32	46.00	9.42	30.80	67.99	31.14	6.25
LSD	1.51	0.74	1.11	3.40	1.06	0.34
C.V.	2.64	5.52	2.68	3.71	2.38	3.58
Solid second season	61.00	13.33	44.13	76.73	86.67	12.90
Combined data of the two seasons						
A_1 Shandaweel 3	49.66	9.76	29.66	73.94	35.56	7.08
A_2 Toshka 1	48.57	10.76	29.29	68.62	31.28	7.77
A_3 Giza 32	46.30	8.81	27.67	68.20	27.02	5.99
LSD	0.92	0.31	0.48	1.19	0.67	0.16
C.V.	2.48	4.18	2.18	2.20	2.79	2.95
Solid combined seasons	58.83	13.00	43.16	77.85	79.83	11.91

concluded that the shorter and less branched sesame varieties (Shandaweel 3 and Toshka 1) were more pertinent for intercropping with groundnut. Similar results were obtained by **Gabr (1999).**

2. Effect of sesame planting density

Data in **Table (3)** showed that sesame planting density had a significant effect on all traits of groundnut in both seasons and their combined. With each increase in hill spacing and hence the decrease of sesame planting density there was a consistent significant increase in all growth and yield attributes of groundnut. Therefore the pod yield per plant and per fad. were progressively increased. It seemed that narrowing the distance between sesame plants to 20 cm. diminished light penetration to groundnut plants and hence might have had decreased their photosynthesis which in turn, decrease the amount of photosynthates available for growth and development. The yield of groundnut when shaded with low sesame plant density (50%) exceeded that with high dense sesame population (100% plant density) by 31.66, 27.51 and 29.53 % in the first, the second and the combined data of the two seasons, respectively. These data are in agreement with obtained by **Toaima *et al* (2004), Sherif Sahar *et al* (2005) and Abd El-Zaher *et al* (2007).**

3. Effect of the interaction

The interaction effects of sesame varieties and sesame planting densities on growth, yield and yield components of groundnut were significant in some traits i.e. number of branches / plant in the first season and combined data, number of pods / plant in the second season and the combined data, seed index in the combined data and pod yield per plant and per fad. in both seasons and the combined data, **(Table 4)**. It is evident from **Table (4)** that groundnut pod yield / fad. and its components

Table 3. Effect of planting density sesame on yield and yield components of groundnut in the two seasons and their combined data

Density	Plant height (cm.)	No. of branches / plant	No. of pods / plant	Seed index (g)	Pod yield / plant (g)	Pod yield / fad (ardab)
First season						
S_1 (100%)	44.87	8.29	21.99	67.33	23.55	5.46
S_2 (67%)	48.02	9.02	25.24	69.78	29.00	6.54
S_3 (50%)	51.35	10.51	30.89	73.73	33.33	7.99
LSD	3.41	0.59	1.24	3.73	1.61	0.29
C.V.	6.92	6.17	4.62	5.17	5.46	4.30
Solid	56.67	12.80	42.20	78.97	73.00	10.92
Second season						
S_1 (100%)	45.82	9.14	26.78	67.17	28.81	6.14
S_2 (67%)	48.15	10.02	31.84	69.91	33.45	7.09
S_3 (50%)	50.84	11.67	36.49	73.27	39.55	8.47
LSD	2.81	0.50	0.80	4.24	1.11	0.20
C.V.	6.34	4.77	3.01	5.89	3.17	2.93
Solid	61.00	13.33	44.13	76.73	86.67	12.90
Combined data of the two seasons						
S_1 (100%)	45.35	8.71	24.39	67.25	26.18	5.80
S_2 (67%)	48.09	9.52	28.54	69.88	31.22	6.81
S_3 (50%)	51.10	11.09	33.69	73.67	36.44	8.23
LSD	2.09	0.37	0.75	1.09	0.92	0.17
C.V.	6.29	5.45	3.76	4.06	4.29	3.52
Solid	58.83	13.00	43.16	77.85	79.83	11.91

were significantly increased with the decrease of sesame planting density but with different magnitudes the increase of pod yield / fad. was more pronounced under Toshka 1 intercrop followed by shandeweel 3 which amounted to 52.3% in the former compared with 34.1% in the latter. This increase amounted to 39.1% under Giza 32. The differential response of groundnut pod yield / fad., which reflects the differential response of its yield components, clearly indicate that the three sesame varieties adversely affected the growth and yield of groundnut. This adverse effect varied with the variation of variety and its planting density. Generally, each decrease of sesame density was followed by a noticeable increase in groundnut pod yield / fad. However, Toshka 1 variety favoured the growth and hence pod yield / fad. of groundnut to a greater extent than Giza 32 where Shandaweel 3 variety had a moderate effect in this respect. The interaction between sesame varieties and their planting density followed the response of sesame seed yield / fad. to the increase of planting density **(Table 4)**. It was mentioned that Giza 32 was the least responsive to the decrease of density 100% to 50% where it showed greater compensation for the decrease of planting density through more branching. Therefore this cultivar showed more aggressivity against groundnut, where the decrease of its plants population did not yield as much increase in the groundnut pod yield / fad. as that observed under Toshka 1 or Shandaweel 3. According to this interaction, groundnut was more benefited from the decrease to plant population of Toshka 1 than of Giza 32 where Shandaweel 3 had a moderate effect in this respect.

The relationship between pod yield of groundnut and the planting density of sesame varieties represented a linear relation as indicated by the following equations and as illustrated in **Figure (1)**.

Table 4. Effect of the interaction between sesame varieties and planting density on yield and yield components of groundnut in the two seasons and their combined data

Varieties	Density	Plant height (cm.)	No. of branches / plant	No. of pods / plant	Seed index (g)	Pod yield / plant (g)	Pod yield / fad (ardab)
First season							
A_1 Shandaweel 3	S_1 (100%)	45.60	7.67	23.12	73.08	31.33	6.10
	S_2 (67%)	49.00	8.93	25.80	74.26	35.67	6.27
	S_3 (50%)	55.13	11.40	31.93	74.82	36.67	8.53
A_2 Toshka 1	S_1 (100%)	42.80	9.80	23.13	65.57	24.33	5.41
	S_2 (67%)	48.80	10.40	25.00	69.65	29.67	7.64
	S_3 (50%)	51.60	10.67	31.80	70.90	31.33	8.83
A_3 Giza 32	S_1 (100%)	46.20	7.40	19.73	63.33	15.00	4.87
	S_2 (67%)	46.27	7.73	24.93	65.43	21.67	5.70
	S_3 (50%)	47.33	9.47	28.93	75.48	32.00	6.60
LSD		NS	1.02	NS	NS	2.78	0.51
C.V.		-	6.17	4.62	-	5.46	4.30
Solid		56.67	12.80	42.20	78.97	73.00	10.92
Second season							
A_1 Shandaweel 3	S_1 (100%)	47.33	8.47	25.80	73.54	32.00	6.38
	S_2 (67%)	49.73	10.27	31.07	73.75	33.67	6.98
	S_3 (50%)	51.20	11.80	40.27	74.18	44.00	8.22
A_2 Toshka 1	S_1 (100%)	46.93	11.47	27.67	63.64	28.33	6.92
	S_2 (67%)	49.93	11.00	32.53	69.64	34.67	7.92
	S_3 (50%)	51.33	12.20	35.60	72.32	39.33	9.92
A_3 Giza 32	S_1 (100%)	43.20	8.47	26.87	64.33	26.10	5.11
	S_2 (67%)	44.80	8.80	31.93	66.34	32.00	6.37
	S_3 (50%)	50.00	11.00	33.60	73.31	35.33	7.28
LSD		NS	NS	1.70	NS	1.92	0.35
C.V.		-	4.77	3.01	-	3.17	2.93
Solid		61.00	13.33	44.13	76.73	86.67	12.90
Combined data of the two seasons							
A_1 Shandaweel 3	S_1 (100%)	46.47	8.12	24.46	73.31	31.67	6.24
	S_2 (67%)	49.37	9.60	28.43	74.01	34.67	6.63
	S_3 (50%)	53.17	11.60	36.10	74.50	40.33	8.37
A_2 Toshka 1	S_1 (100%)	44.87	10.13	25.40	64.61	26.33	6.16
	S_2 (67%)	49.37	10.70	28.77	69.65	32.17	7.78
	S_3 (50%)	51.47	11.44	33.70	71.61	35.33	9.38
A_3 Giza 32	S_1 (100%)	44.70	7.94	23.30	63.83	20.55	4.99
	S_2 (67%)	45.53	8.27	28.43	65.89	26.83	6.04
	S_3 (50%)	48.67	10.24	31.27	74.90	33.67	6.94
LSD		NS	0.64	1.29	3.40	1.66	0.29
C.V.		-	5.45	3.76	4.06	4.29	3.52
Solid		58.83	13.00	43.16	77.85	79.83	11.91

Figure (1)

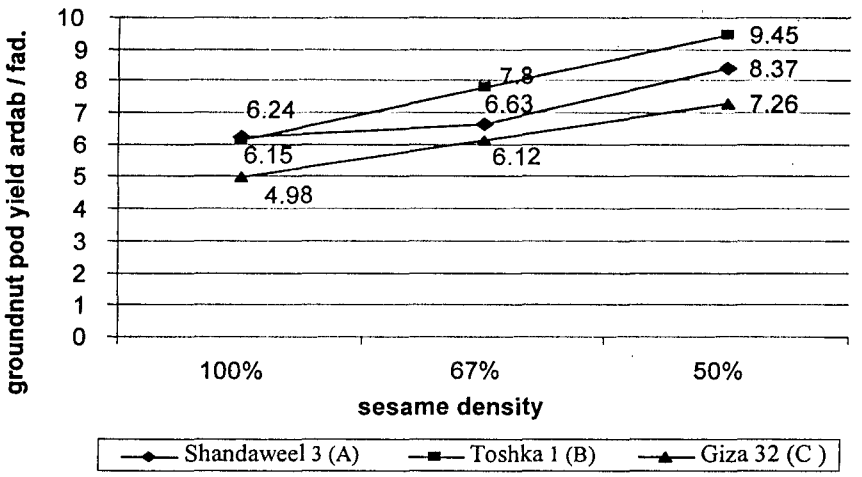

Figure 1. Relation between the pod yield of groundnut and planting density of sesame

Y Shandaweel 3 (A) = 6.24 – 0.29 X +0.68 X²
Y Toshka 1 (B) = 6.15 + 1.65 X
Y Giza 32 (C) = 4.98 + 1.14 X

Where: X = estimated 100% = zero, 67 %= 1 and 50 %= 2 planting density of sesame.

It is evident that the response equations of pod yield / fad. of groundnut was linear with each decrease of sesame planting density and with higher magnitude under Toshka 1 than under the other to sesame varieties.

II- Sesame

1. Varietal differences

Data in **Table (5)** showed significant differences in all traits except seed index in both seasons and the combined data of the two seasons. Data indicated that growth traits yield and yield component of the three sesame varieties were decreased under intercropping conditions in both seasons and the combined of the two seasons. The reduction in Shandaweel 3, Toshka 1 and Giza 32 varieties were 9.04, 2.71 and 9.04 % for plant height 6.94, 3.69 and 7.73 % for number of branches / plant 0.63, 7.04 and 14.93 % for number of capsules / plant 2.77, 1.88 and 7.36 % for seed index 9.61, 5.30 and 1.87 % for seed yield / plant and 34.74, 27.54 and 15.48% for seed yield / fad of their solids in the combined data of the two seasons. Giza 32 variety surpassed the other verities (Shandaweel 3 and Toshka 1) in plant height, number of branches and capsules / plant, seed yield / plant and seed yield / fad, while Toshka 1 had the highest value of seed index only. These results hold fairly true in the second season and the combined data of the two seasons. The lowest values of those traits were observed with Shandaweel 3 variety with few exceptions **(Table 5)**. Differences between the three sesame varieties may be attributed to their genetic differences and interaction between the genetically make-up and the environmental conditions. Similar conclusion was reported by **El-Serogy *et al* (1997) and Rahnama and Bakhshandeh (2006).**

2. Effect of planting density

Data in **Table (6)** revealed that sesame density had significant effect on all traits except seed index in both seasons. The highest values of sesame plants reached its maximum when sesame was planted at 50% density, whereas at 100% density recorded minimum values. The same trend could be detected for the average number of branches / plant. These results were true in both seasons and the combined data. Yield components of sesame i.e number of capsules / plant, seed index and seed yield / plant were superior when planted at 50% density followed by those planted at 67% density. It is clear that yield component traits were increased consistently and regularly with increasing sesame density. The highest plant density (100%) recorded the highest seed yield / fad and

Table 5. Effect of sesame varieties on yield and yield components in the two seasons and their combined data

Varieties	Plant height (cm)	No. of branches / plant	No. of capsules / plant	Seed index (g)	Seed yield / plant (g)	Seed yield / fad (ardab)
First season						
A_1 Shandaweel 3	98.00	1.96	108.44	4.49	11.91	3.34
A_2 Toshka 1	103.09	2.05	106.42	4.64	12.11	3.87
A_3 Giza 32	123.46	4.13	135.55	4.47	14.75	4.42
LSD	3.42	0.093	6.58	NS	0.29	0.14
C.V.	2.42	2.61	4.30	2.79	1.71	2.71
Solid A_1	104.00	1.5	109.80	4.60	12.87	5.72
Solid A_2	104.00	1.6	114.40	4.63	12.13	5.80
Solid A_3	134.33	2.33	171.20	4.90	15.13	5.70
Second season						
A_1 Shandaweel 3	98.84	2.05	108.87	4.62	15.22	3.75
A_2 Toshka 1	100.91	2.15	109.07	4.77	16.11	4.39
A_3 Giza 32	123.96	4.22	163.74	4.60	16.78	5.30
LSD	3.56	0.10	2.90	NS	0.399	0.25
C.V.	2.52	2.76	1.74	3.12	1.90	4.24
Solid A_1	112.33	1.7	108.93	4.77	16.67	5.16
Solid A_2	105.67	1.8	117.40	4.97	16.67	5.60
Solid A_3	138.67	2.73	180.60	4.87	17.00	5.80
Combined data of the two seasons						
A_1 Shandaweel 3	98.42	2.01	108.68	4.56	13.35	3.55
A_2 Toshka 1	102.00	2.09	107.74	4.71	14.11	4.13
A_3 Giza 32	123.71	4.18	149.64	4.53	15.77	4.86
LSD	2.05	0.002	2.99	0.103	0.18	0.12
C.V.	2.46	2.86	3.18	2.92	1.64	3.63
Solid A_1	108.20	1.6	109.37	4.69	14.77	5.44
Solid A_2	104.84	1.7	115.90	4.80	14.90	5.70
Solid A_3	136.00	2.53	175.90	4.89	16.07	5.75

was significantly superior to those of medium and low plant densities in both seasons and the combined data of the two seasons. The seed yield / fad of high plant density was 46.93 and 13.50% in the first season, 2.46 and 8.71% in the second season and 25.86 and 11.19% in the combined data over low and medium plant densities, respectively. These results revealed that under low plants density the increases in number of branches and capsules / plant, seed index and seed yield / plant, could not compensate the yield loss because of less population and vice versa under high density. These results are in agreement with those obtained by **El-Serogy *et al* (1997), Ghungarde *et al* (1992), Chimanshette and Dhoble (1992), Ghosh and Patra (1994) and Rahnama and Bakhshandeh (2006).**

3. Effect of the interaction

The interaction effects of sesame varieties and plant density on growth, yield and yield components were significant in all trait of sesame except

Table 6. Effect of sesame density on yield and yield components of sesame in the two seasons and their combined data

Density	Plant height (cm.)	No. of branches / plant	No. of capsules / plant	Seed index (g)	Seed yield / plant (g)	Seed yield / fad (ardab)
First season						
S_1 (100%)	96.76	1.86	105.36	4.31	11.29	4.54
S_2 (67%)	106.80	2.88	120.84	4.55	12.60	4.00
S_3 (50%)	120.75	3.40	124.22	4.73	14.89	3.09
LSD	5.31	0.065	8.18	NS	0.444	0.16
C.V.	4.78	2.33	6.81	8.86	3.34	4.00
Solid A_1	104.00	1.5	109.80	4.2	12.87	5.72
Solid A_2	104.00	1.6	94.4	4.63	12.13	5.80
Solid A_3	134.33	2.33	171.2	4.90	15.13	5.70
Second season						
S_1 (100%)	96.91	1.97	123.16	4.50	14.11	4.99
S_2 (67%)	107.02	2.97	126.38	4.68	15.78	4.59
S_3 (50%)	119.78	3.49	132.13	4.81	18.22	4.87
LSD	6.51	0.056	5.48	NS	4.84	0.23
C.V.	5.88	1.95	4.20	7.29	2.94	5.04
Solid A_1	112.33	1.7	108.73	4.47	16.67	5.16
Solid A_2	105.67	1.8	97.4	4.97	16.67	5.60
Solid A_3	138.67	2.73	180.6	4.87	17.00	5.80
Combined data of the two seasons						
S_1 (100%)	96.84	1.91	114.26	4.41	12.70	4.77
S_2 (67%)	106.24	2.92	123.63	4.62	14.19	4.29
S_3 (50%)	120.39	3.44	128.18	4.77	16.33	3.79
LSD	3.98	0.038	4.66	0.26	0.31	0.13
C.V.	5.35	1.98	5.55	8.08	3.15	4.66
Solid A_1	108.20	1.6	109.27	4.34	14.77	5.44
Solid A_2	104.84	1.7	95.9	4.80	14.90	5.70
Solid A_3	136.00	2.53	175.9	4.89	16.07	5.75

number of capsules / plant in the second season and seed index in the both seasons and the combined data (**Table 7**). Plant height of sesame reached maximum values in Giza 32 variety when planted at 50% density, whereas the minimum values were observed with Shandaweel 3 and 100% plant density. Same trend could be detected for average number of branches, capsules / plant and seed yield / plant as influenced by plants density. The maximum values of seed index were recorded by Toshka 1 when planted at 50% density, while the lowest value by Shandaweel 3 when planted at 100% density in both seasons and the combined data. Maximum value of seed yield / fad was recorded by Giza 32 variety when planted at 100% density, whereas the minimum values was recorded by Shandaweel 3 in the first season and Toshka 1 in the second season when planted at 50% density. Doubling the planting density decreased plant height and branching in the three varieties but with different magnitudes. Giza 32 was the most sensitive regarding plant height, but the least sensitive regarding branching. This varietals response was judged through the percentage decrease in height and branching averages due to doubling the planting density. Regarding seed yield / fad. Giza 32 was the least responsive the planting density whereas Toshka 1 most responsive. The percentage increase in seed yield / fad. amounted to 15.2% and 68.9% respectively.

The relationship between seed yield of sesame varieties and planting density is represented by the following equation for each sesame variety in **Figure (2).**

Table 7. Effect of interaction between sesame varieties and planting density on yield and yield components of sesame in the two seasons and their combined data

Varieties	Density	Plant height (cm.)	No. of branches / plant	No. of capsules / plant	Seed index (g)	Seed yield / plant (g)	Seed yield / fad (ardab)
First season							
A_1 Shandaweel 3	S_1 (100%)	90.67	1.20	105.47	4.20	10.20	3.75
	S_2 (67%)	95.40	2.17	106.73	4.53	11.87	3.65
	S_3 (50%)	107.93	2.50	113.13	4.73	13.67	2.62
A_2 Toshka 1	S_1 (100%)	94.93	1.27	104.87	4.40	11.67	4.88
	S_2 (67%)	105.00	2.27	106.87	4.73	12.00	4.13
	S_3 (50%)	109.33	2.60	107.53	4.80	12.67	2.59
A_3 Giza 32	S_1 (100%)	104.67	3.10	105.73	4.33	12.00	4.99
	S_2 (67%)	120.0	4.20	148.93	4.40	13.93	4.21
	S_3 (50%)	145.73	5.10	152.00	4.67	18.33	4.05
LSD		9.20	0.113	14.17	NS	0.769	0.28
C.V.		4.78	2.33	6.18	8.86	3.34	4.00
Solid A_1		104.00	1.5	109.80	4.2	12.87	5.72
Solid A_2		104.00	1.6	94.4	4.63	12.13	5.80
Solid A_3		134.33	2.33	171.2	4.90	15.13	5.70
Second season							
A_1 Shandaweel 3	S_1 (100%)	94.00	1.30	105.00	4.37	12.67	4.28
	S_2 (67%)	97.53	2.27	107.47	4.63	15.67	3.75
	S_3 (50%)	105.00	2.60	114.13	4.87	17.33	3.21
A_2 Toshka 1	S_1 (100%)	90.07	1.40	106.80	4.60	15.00	5.21
	S_2 (67%)	105.67	2.37	109.00	4.80	16.00	4.59
	S_3 (50%)	107.00	2.67	111.40	4.90	17.33	3.38
A_3 Giza 32	S_1 (100%)	106.67	3.20	157.67	4.53	14.67	5.47
	S_2 (67%)	117.87	4.27	162.67	4.60	15.67	5.42
	S_3 (50%)	147.33	5.20	170.87	4.67	20.00	5.02
LSD		11.28	0.097	NS	NS	0.838	0.402
C.V.		5.88	1.95	4.20	7.29	2.94	5.04
Solid A_1		112.33	1.7	108.73	4.47	16.67	5.16
Solid A_2		105.67	1.8	97.4	4.97	16.67	5.60
Solid A_3		138.67	2.73	180.6	4.87	17.00	5.80
Combined data of the two seasons							
A_1 Shandaweel 3	S_1 (100%)	92.34	1.25	105.24	4.28	11.44	4.02
	S_2 (67%)	94.47	2.22	107.17	4.58	13.77	3.70
	S_3 (50%)	106.47	2.55	113.63	4.80	14.83	2.92
A_2 Toshka 1	S_1 (100%)	92.50	1.33	105.84	4.50	13.33	5.05
	S_2 (67%)	105.33	2.32	107.93	4.77	14.00	4.36
	S_3 (50%)	108.17	2.63	109.47	4.85	15.00	2.99
A_3 Giza 32	S_1 (100%)	105.67	3.15	131.70	4.43	13.33	5.23
	S_2 (67%)	118.93	4.23	155.80	4.50	14.80	4.32
	S_3 (50%)	146.53	5.15	161.44	4.67	19.17	4.54
LSD		6.90	0.065	8.08	NS	0.54	0.23
C.V.		5.35	1.98	5.55	8.08	3.15	4.66
Solid A_1		108.20	1.6	109.27	4.34	14.77	5.44
Solid A_2		104.84	1.7	95.9	4.80	14.90	5.70
Solid A_3		136.00	2.53	175.9	4.89	16.07	5.75

Figure (2)

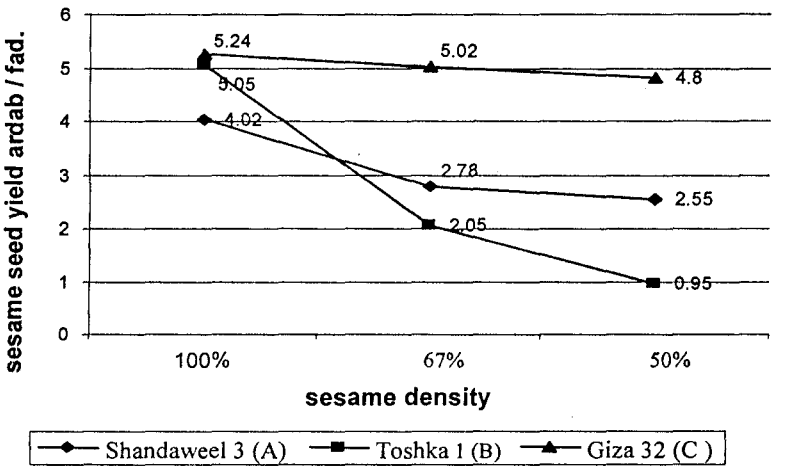

Figure 2 . Relation between seed yield of sesame and planting density

The relation between seed yield of sesame varieties and planting density which follows the equation.

$$Y\ Shandaweel\ 3\ (A) = 4.02 - 1.01\ X - 0.23\ X^2$$
$$Y\ Toshka\ 1\ (B) = 5.05 - 1071\ X - 0.34\ X^2$$
$$Y\ Giza\ 32\ (C) = 5.24 - 0.79\ X - 0.57\ X^2$$

Where: X = estimated 100% = Zero, 67% = 1 and 50% = 2 planting density.

According to the response of sesame seed yield varieties/fad. to the decrease to planting density from 100% to 50%, Toshka 1 was the most responsive, whereas, Giza 32 was the least responsive. This response amounted to 2.15 ardab / fad. for Toshka 1 compared with only 0.27 ardab / fad. for Giza 32. However Shandaweel 3 showed a moderate response which amounted to 1.11 ardab / fad.

This differential response, clearly indicates that Giza 32 with its high branches capsules, (2.53 branch / plant) could compensate for the decrease of plant population, whereas, Toshka 1 followed by Shandaweel 3 varieties, (1.7 and 1.6 / plant, respectively) could not as mach compensate for the decrease of population and hence were more responsive to the decrease to planting density.

III- Competitive relationships and yield advantages

1. Land Equivalent Ratio (LER)

Data in **Table (8)** indicated that land equivalent ratio LER showed considerable yield advantage resulting from intercropping groundnut with the three sesame varieties in the combined data of the two seasons. The results also revealed that intercropped groundnut with sesame varieties resulted in decreased yield of either crops. The results cleared that yields advantage of sesame and groundnut was affected by sesame varieties and planting density of sesame. The highest value of RYS (0.91) was recorded by Giza32 and the high sesame plant density whereas the lowest values (0.52) was recorded by Toshka 1 and the low plant density. While the highest value of RY_G (0.79) was recorded by intercropping with Toshka 1 and low plant density and the lowest values (0.42) were observed when intercropping with Giza 32 and high plant density.

Land equivalent ratio (LER) values were greater than one. It could be concluded that the actual productivity was higher than the expected productivity when groundnut was intercropped with different the sesame varieties and planting densities. The highest LER values (1.41) was observed due to intercropping groundnut with Toshka 1 cv

Table 8. Effect of sesame varieties and planting density on competitive relationships and monetary advantage index in the combined data of the two seasons

variety	density	Relative yield			Agg		CR		AYL			IA			MAI
		RY (S)	RY (G)	Total LER	(S)	(G)	(S)	(G)	(S)	(G)	Total	(S)	(G)	Total	
A_1	S_1	0.74	0.52	1.26	+0.22	-0.22	1.42	0.70	-0.261	-0.478	-0.739	-156.6	-191.2	-347.8	1026.70
	S_2	0.68	0.61	1.29	+1.09	-1.09	1.67	0.60	+0.700	+0.010	+0.710	+420.0	+4.0	+424.0	1149.3
	S_3	0.54	0.70	1.24	+1.65	-1.65	1.54	0.65	+0.612	+0.054	+0.666	+367.2	+21.6	+388.8	909.86
Mean		0.65	0.61	1.26					+0.350	-0.138	+0.212	+210.2	-55.2	+155.0	1028.62
A_2	S_1	0.89	0.52	1.41	+0.37	-0.37	1.71	0.58	-0.114	-0.483	-0.597	-68.4	-193.2	-261.6	1598.75
	S_2	0.76	0.65	1.41	+1.06	-1.06	1.75	0.57	+0.912	+0.089	+1.001	+547.2	+35.6	+582.8	1666.85
	S_3	0.52	0.79	1.31	+1.61	-1.61	1.32	0.76	+0.311	+0.181	+0.492	+186.6	+72.4	+259.0	1314.40
Mean		0.72	0.65	1.37					+0.370	-0.071	+0.299	+221.8	-28.4	+208.4	1526.67
A_3	S_1	0.91	0.42	1.33	+0.49	-0.49	2.17	0.46	-0.096	-0.419	-0.509	-54.0	-167.6	-221.6	1273.23
	S_2	0.84	0.51	1.35	+1.16	-1.16	2.47	0.41	+1.096	-0.155	+0.941	+657.6	-62.0	+595.6	1374.77
	S_3	0.79	0.58	1.37	+1.71	-1.71	2.72	0.36	+1.371	-0.126	+1.245	+822.6	-50.4	+772.2	1364.00
Mean		0.84	0.50	1.35					+0.792	-0.233	+0.559	+475.4	-93.33	+381.83	1337.333
Mean over all	S_1	0.84	0.49	1.33			1.77	0.58	-0.155	-0.460	-0.615	-93.0	-184.00	-277.00	1183.093
	S_2	0.76	0.59	1.35			1.96	0.53	+0.903	-0.019	+0.884	+541.8	-7. 47	+534.33	1396.973
	S_3	0.62	0.69	1.31			1.86	0.59	+0.765	+0.036	+0.801	+458.8	+14.53	+473.33	1101.90

S_1 = sesame 100% S_2 = sesame 67% S_3 = sesame 50% A_1 = Shandaweel 3 A_2 = Toshka 1 A_3 = Giza 32

and with the high or medium planting density (100% and 67%), while the lowest values (1.24) was observed by cv Shandaweel 3 and low plant density. These results are in agreement with those obtained by **Toaima *et al* (2004) and El-Sawy *et al* (2006).**

2. Aggressivity (Ag)

Data on the aggressivity revealed that values of Ag for sesame were positive, whereas it was negative for groundnut. It means that sesame was the dominant and the groundnut was the dominated. Aggressivity values were increased with each decreased of sesame planting density **(Table 8).** Similar results were observed by **Gabr (1999) and Toaima *et al* (2004).**

3. Competitive ratio

Data on the competitive ratio to estimate the exact degree of competition indicate that sesame was more competition than groundnut under intercropping condition indicating the dominance of sesame whereas groundnut was dominated **(Table 8).** The results showed that degree of competition was affected by sesame density. Competition ratio of sesame was higher in the medium planting density (67%) and was reduced with low and high plant density. While competition ratio of groundnut was lowest when was intercropped with medium planting density of sesame and was increased in low and high density for Shandaweel 3 and Toshka 1 only.

4. Actual yield loss (AYL)

Similar trend to that of LER, Ag and CR was also observed for AYL **(Table 8).** In particular, AYL for the three sesame varieties was positive when intercropped with groundnut, which indicates a yield advantage for sesame, probably because of the positive effect of groundnut on sesame when grown in association while AYL_G was negative, which indicates a yield disadvantage to groundnut. Also, AYL_S under low and medium plant density were positive, which indicates yield advantage for sesame under low and medium plant density. While AYL_G under plant density were positive with low plant density only which indicated yield advantage for groundnut under low sesame density. The partial AYL of sesame was greater than the partial AYL of groundnut, it was due to sesame crop was the dominant and groundnut was dominated crop. Quantification of yield loss or gain due to association with different varieties and plant density could not be obtained through partial LER since partial AYL shows the yield loss or gain by its sign and as well as its value. Thus there was AYL for sesame ranged from -0.096 to 0.261 when using high plant density, indicating a yield loss from -9.6 to -26.1% compared with its sole crop. While AYL for groundnut ranged from -0.126 to –0.419 when intercropping with Giza 32 and indicating a yield loss of -12.6 to -41.9 %. Whereas, AYL for groundnut in low and medium density of Shandaweel 3 and Toshka 1 ranged from +0.010 to +0.181 to indicating increase in yield by +1.0 to +18.1% compared with its sole crop. Total AYL, also was positive when intercropping groundnut with low or medium sesame planting density, which indicates that this system was successful. Thus, there was a gain of 88.4% in medium density and 80.1% in low density increase in yield of system.

5. Intercropping advantage (IA)

The IA, which is an indicator of the economic feasibility of intercropping systems, indicated that some advantages systems were positive when using low or medium sesame planting density, which indicates that these intercropping systems had the highest economic advantage, whereas system of groundnut with high planting density of the three sesame varieties for Shandaweel 3 and Toahka 1 and with Giza 32, which had negative values, showed an economic disadvantage **(Table 8).** IA values of the three sesame varieties were positive, indication a yield advantage for sesame while IA for groundnut were negative, indicating a yield disadvantage for groundnut. IA total value was positive under medium and low densities which indicate that these intercropping systems had the highest economic advantage.

6. Monetary advantage index (MAI)

Similar trend to that of IA was observed for monetary advantage index (MAI). These values were positive when intercropping groundnut with the three sesame varieties under the three plant densities **(Table 8).** The highest MAI value (1666.85) was observed when groundnut was intercropped the medium planting density of Toshka 1 fallowed by Giza 32 (1374.77). The lowest value (909.86) was observed when it was intercropped under the low plant density of Shandaweel 3. These results clear that using Toshka 1 had the highest values of MAI (1598.75). Whereas Shandaweel 3 recorded the low values (909.86).

The results also showed that the medium plant density of sesame recorded the high value MAI (1396.973) which was reduced with the high and the low planting density. These findings are in agreement with the results of LER, Ag, CR and AYL. Similarly, **Ghosh (2004).**

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مجلة اتحاد الجامعات العربية
للعلـــــوم الزراعيـــــة
جامعة عين شمس ، القاهـرة
مجلد(١٦)، عدد (٢)، ٣٥٩-٣٧٥، ٢٠٠٨

استجابة الفول السودانى للتحميل ببعض أصناف السمسم تحت كثافات نباتية مختلفة

[٢٨]

محمد أبو العيون أبو كريشة[١] – رأفت عايد جاد الله[١] – إسماعيل عويس السيد محمدين[١]

١- قسم التكثيف المحصولي – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – الجيزة – مصر

أقيمت تجربتان حقليتان فى محطة بحوث شندويل (محافظة سوهاج) , نفذت هذه التجارب خلال صيف الموسمين ٢٠٠٥ و ٢٠٠٦ لدراسة استجابة الفول السودانى للتحميل ببعض أصناف السمسم تحت كثافات نباتية مختلفة وعلاقة ذلك بمكونات كلا المحصولين٠

وأستخدم تصميم القطع المنشقة مرة واحدة فى ثلاث مكررات٠ ووزعت أصناف السمسم شندويل ٣ و توشكى ١ وجيزة ٣٢ فى القطع الرئيسية بينما وزعت الكثافة النباتية وهى ١٠٠% , ٦٧% , ٥٠ % وكانت ثلاث مسافات بين الجور ٢٠ ، ٣٠ ، ٤٠ على التوالى لأصناف السمسم فى القطع المنشقة ٠ وزرع الفول السودانى (المحصول الرئيسى) فى كل الخطوط (الكثافة العادية) ٠ زرعت نباتات السمسم على الريشة الأخرى للخطوط على المسافات المدروسة ولقد أضحت الدراسة أن جميع الصفات المدروسة للفول السودانى قد أنخفضت بالتحميل وذلك بمقارنته بالزراعة المنفردة ٠ وكان الأنخفاض كبير عند التحميل بصنف جيزة ٣٢ بمقارنته بالتحميل مع الأصناف الأخرى٠ تأثر الحاصل ومكوناته للفول السودانى معنويا بالكثافة النباتيه لأصناف السمسم ٠ تفوق الحاصل للفول السودانى المحمل بكثافة نباتية منخفضة من السمسم (٥٠%) على حاصل الفول السودانى المحمل بكثافة عالية (١٠٠%) بمقدار ٣١,٦٦ و ٢٧,٥١ و ٢٩,٥٣ % فى الموسم الأول والثانى والتحليل التجميعى على التوالى٠ أظهرت النتائج أيضا أنخفاض حاصل أصناف السمسم مع حالة التحميل , وكان صنف جيزة ٣٢ أعلى من الأصناف الأخرى (شندويل ٣ , توشكى ١) فى طول النبات وعدد الأفرع وعدد الكبسولات على النبات وحاصل النبات وحاصل الفدان٠ كما تفوق حاصل الفدان للسمسم فى الكثافة النباتية العالية (١٠٠%) بمقدار ٤٩,٩٣ و ١٣,٥٠ % فى الموسم الأول , ٢,٤٦ و ٨,٧١ % فى الموسم الثانى , ٢٥,٨٦ و ١١,١٩ % فى التحليل التجميعى على التوالى عن كلا الكثافة المتوسطة والمنخفضة للنباتات ٠ وكانت معادلات الإستجابة خطية وكان حاصل الفول السودانى كبيرا مع إنخفاض الكثافة النباتية للسمسم تحت صنف توشكى ١ عن الصنفين الأخرين للسمسم٠ أعطت معاملة الفول السودانى المحمل مع صنف توشكى ١ تحت الكثافة النباتية المنخفضة أعلى معدل أستغلال الأرض ١,٤١, وكانت الفائدة التحميلية ٥٨٢,٨ ودليل صافى العائد ١٦٦٦,٨٥ ٠ وكان معدل الفقد فى الحاصل نتيجة التحميل مع صنف جيزة ٣٢ والكثافة النباتية المنخفضة عاليا + ١,٢٤٥ ٠ يتضح أن معاملة الفول السودانى المحمل مع السمسم صنف توشكى ١ بالكثافة النباتية المتوسطة يكون مفيدا للمحصولين ومربحا لكلا المحصولين٠

تحكيم: أ.د توكـــل يونـــس رزق
أ.د أحمد أنور عبد الجليل