

## EFFECT OF SOWING DATES AND SULPHUR LEVELS ON SOME SESAME (*SESAMUM INDICUM* L.) CULTIVARS UNDER NEW VALLEY CONDITIONS

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Yield and quality of sesame may be improved by manipulating the cultural practices to suit the crop with the prevailing environment. Therefore, two field experiments were carried out in the Desert Research Center, Agriculture Experimental Station at El-Kharga Oasis, New Valley Governorate, Egypt during 2010 and 2011 growing seasons, to study the response of three Egyptian cultivars of sesame (Shandaweel-3, Toshka-1 and Giza-32) to four sowing dates (15<sup>th</sup> March, 1<sup>st</sup> April, 15<sup>th</sup> April and 1<sup>st</sup> May) under four levels of sulphur (0, 100, 200 and 300 kg S/fed). The obtained results indicated that planting sesame plants on 15<sup>th</sup> March (early sowing date) was the superior treatment recorded the highest values of yields, yield components and oil percentage. Shandaweel-3 cultivar gave the highest values of number and weight of capsules per plant, seeds weight per plant, 1000 seeds weight and seed, biological and sesame oil yield/fed. Fruiting zone length, branches and capsules number per plant and biological and seed yields/fed were increased up to 200 kg S/fed. It is evident from the obtained results that planting Shandaweel-3 cultivar on 15<sup>th</sup> March with adding 100 kg S/fed could be recommended for improving sesame yield under the New Valley conditions.

**Keywords:** Sesame, planting dates, cultivars, sulphur

New Valley region (located at the Western Desert of Egypt) is one of the most suitable locations with its oasis, weather is hot and dry as well as the cultivation depends mainly on ground water. Moreover, there is a dire need for increasing the production of crop oils due to increasing population nowadays, which created a very wide gap between production and consumption of food oils reaching 97.1%, approximately.

Sesame is typically a crop of small farmers in the developing countries and is considered as a drought tolerant crop (Jefferson, 2003). Boureima et al. (2011) indicated that sesame is one of the stress-tolerant crops that produces sorts of chemical components, unavailable in other edible oil crops that provide a resistance to oxidative rancidity, and has made sesame well known as queen of oilseed crops. Sesame seed contains about 50% oil, 25% protein, 20% carbohydrate in addition to amounts of vitamins, minerals, antioxidants and all essential amino and fatty acids. Also, seed meal is an excellent high protein (34-50%) feed for poultry and livestock (Balasubramaniyan and Palaniappan, 2001).

For synchronizing different stages of plant growth with environmental conditions, the appropriate sowing date is considered one of the most important determining factors for obtaining optimum yield. By selecting appropriate sowing date, different stages of plant growth with environmental conditions adapted that increase the efficiency of photosynthesis, thus assimilates stored seeds is desirable (Erhart et al., 2005). Determining the optimum time of sowing, which in turn improves unit land area utilization and selecting a cultivar with a high average yield is a major factor in ensuring a profitable return of sesame (Hamza and Abd El-Salam, 2015). Nath et al. (2000) reported that sesame can be cultivated in sub-optimal conditions, mainly during February to May in summer. Differential response of varieties to sowing dates showed that the yield of sesame was decreased with delay in sowing beyond third week of July (Mahdi et al., 2007).

The low yield could be due to lack of improved cultivars, sensitive to pests, diseases and environmental conditions. Nath et al., (2003) found that temperature and variety affected seed yield variation by 69 and 39%, respectively. Varietal differences in sesame yield and its components were stated by several researchers. Saady and Abd El-Momen (2009) found that Shandawel-3 was the potent cultivar for producing the highest values of plant height, capsules and seeds weights/plant as well as biological, seed and oil yields/fed, in Egypt.

The interaction between sowing date and cultivar affected significantly plant height, number of capsules/plant, seed weight/plant and seed yield (Nath et al., 2001 and Ali and Jan, 2014). Ultimately, higher yield can be achieved through suitable cultivars and optimum sowing date.

Sulphur (S) nutrition has a crucial impact in improving the growth and productivity of the oil seeds due to its vital role in protein metabolism. It is required for the synthesis of proteins, vitamins and chlorophyll and also, S containing amino acids such as cysteine and methionine, which are essential components of proteins (Jamal et al., 2010).

Lack of S causes retardation of terminal growth and root development. S deficiency induces chlorosis in young leaves and decreases seed yield by 45% (BARI, 2004). S is one of the essential macroelements of

plant and is regarded as the fourth key element after N, P and K (Lewandowska and Sirko, 2008). In oilseeds, S plays a significant role in the quality and development of seeds. Therefore, crops of oilseeds require a higher quantity of S for proper growth and development for higher yields (Salwa et al., 2010). The yield parameters like branches/plant, capsules/plant, seeds/capsule and 1000 seeds weight was improved by increased S in sesame (Tiwari et al., 2000; Sarkar and Panik, 2002 and Thakur and Patel, 2004). The response of sesame to S for producing higher yield was up to 40 Kg/ha according to Nagavani et al. (2001) and Kathiresan (2002) and up to 50 kg/ha (Sarkar and Panik, 2002).

Keeping these points, the present study was carried out to determine the optimum sowing date, cultivar and S level and their combinations for higher productivity of sesame under the New Valley conditions in Egypt.

## MATERIALS AND METHODS

### 1. Site Description

A two-year field experiment was carried out in the Desert Research Center (DRC), Agricultural Experimental Station at EL-Kharga Oasis, New Valley Governorate, Egypt, during the two growing seasons of 2010 and 2011. The soil of the site was sandy clay loam containing 2.08% organic matter, total sulphur of 8.24 ppm, pH of 8.11 and EC of 2.31 dS/m. The preceding crop was wheat in both seasons.

### 2. Experimental Treatments and Design

The study aimed to investigate the effect of three factors, i.e. sowing dates (15<sup>th</sup> March, 1<sup>st</sup> April, 15<sup>th</sup> April and 1<sup>st</sup> May), cultivars (Shandaweel 3, Toshka 1 and Giza 32) and S levels (0, 100, 200 and 300 kg S/fed applied in the form of agricultural sulphur at sowing).

A split-split plot design with three replicates was used. Whereas, sowing dates were arranged in the main plots, cultivars were distributed in the sub plots, and S levels occupied the sub-sub plots. The experimental unit area was 10.5 m<sup>2</sup> containing five ridges (3.5 m length and 60 cm apart).

Seeds of sesame cultivars were sown in hills, 20 cm apart at a rate of 3.0 kg/fed, 21 days after sowing; plants were thinned to secure two plants per hill. Nitrogen fertilizer was added at a rate of 60 kg N/fed in the form of ammonium sulfate (20% N) at three equal portions, after thinning, before the second and the third irrigation. Phosphorus fertilizer was applied in the form of calcium super phosphate (15% P<sub>2</sub>O<sub>5</sub>) at a rate of 30 kg P<sub>2</sub>O<sub>5</sub> /fed during soil preparation. Potassium fertilizer was applied in the form of potassium sulfate (48% K<sub>2</sub>O) at a rate of 48 kg K<sub>2</sub>O /fed, 75 days after sowing. Well water was the source for irrigation, pH of 7.4 and EC of 1.09 dS/m, was used. Irrigation was applied through gated pipe irrigation system. All other

recommended agricultural practices were adopted throughout the two experimental seasons.

### **3. Sampling and Assessments**

#### **3.1. Yield traits**

At harvest, ten guarded plants were taken randomly from each plot to measure plant height, fruiting zone length, branches number/plant, number and weight of capsules/plant, 1000 seeds weight and seeds weight/plant. Moreover, whole plants of each plot were collected to measure biological and seeds yield/fed.

#### **3.2. Seed oil content**

Seed oil percentage was determined by extracting the oil using Soxhlet apparatus with hexane as an organic solvent according to A.O.A.C. (1995), and then oil yield was calculated.

### **4. Statistical Methods**

All the obtained data of each season were exposed to the proper statistical analysis of variance, according to Gomez and Gomez (1984). The combined analysis of variance for the data of the two seasons was performed after testing the error homogeneity and least significant difference (LSD) test at 0.05 level of significance was used for the comparison between means.

## **RESULTS AND DISCUSSION**

### **1. Effect of Sowing Dates**

Planting sesame in early sowing date was the potent practice for enhancing all yield, yield attributes and oil percentage of sesame plants (Table 1). In this respect, plant height, fruiting zone length, branches number/plant, number and weight of capsules/plant, seeds weight/plant, weight of 1000 seeds, biological and seeds yield/fed, as well as oil percentage and oil yield were significantly increased with planting sesame on 15<sup>th</sup> March. The increments in these traits due to the early sowing date surpassed the late one (on 1<sup>st</sup> May) amounted to 33.9, 47.2, 25.1, 36 and 43.9% for plant height, weight of capsules/plant, seeds weight/plant, seeds yield/fed and oil yield/fed, respectively. The obtained results show that the adequate environmental growth factors synchronized with the growth stages of sesame planted in early sowing date promoting the growth and yield. Accordingly, the enhancements in sesame yields, yield components and oil percentage with early planting date may be due to that the plants had optimum vegetative growth, adequate photosynthetic activity and more assimilates than planting latter. Bhardwaj et al. (2014) indicated that earlier sowing date resulted in significantly higher seed yield by about 56%. Abdalla et al. (2004) found that flowering and maturity periods were reduced by 18 days due to delayed sowing. Also, the increasing in the yield

components in early sowing date could be the effect of prolonged photoperiod, which might have resulted in more assimilates in yield components, which have been reflected on yields. The early sowing date as an optimum date for higher yield and its attributes compared to late sowing date in sesame was confirmed by Nath et al. (2001), Abdallah et al. (2004), Tahir et al. (2012), Abarghoui et al. (2015) and Hamza and Abd El-Salam (2015).

## **2. Effect of Cultivars**

All yield, yield components and oil percentage were significantly affected by varietal differences among sesame cultivars as shown in table (1). The highest values of plant height, fruiting zone length, branches number/plant and oil percentage were gained from Giza-32 cultivar. On the other hand, Shandaweel- 3 gave the maximum values of number and weight of capsules/plant, seeds weight/plant, 1000 seeds weight and seed, biological and oil yields/fed. Herein, Shandaweel-3 cultivar possessed 44, 17.8, 26.5 and 24.2% increases in capsules weight/plant, seeds weight/plant and seed and oil yields/fed, respectively compared to Giza-32 cultivar. Such superiority of Shandaweel-3 may be due to the biochemical activity in leaves associating with higher translocation of photosynthetic and sink capacity in addition to its adaptability to environmental stress than other cultivars, which has been reflected on yield components and consequently seed and oil yields. The number of capsules per plant is one of the main components that determine crop yield potentiality; such trait is affected by genetic factors (Ahmad et al., 2002). Our results are in harmony with those obtained by Kassab et al. (2012), Ali and Jan (2014), Hamza and Abd El-Salam (2015) and Mahrous et al. (2015).

## **3. Effect of S Levels**

Results in table (1) illustrate that all studied traits of sesame were significantly affected by S levels. In this regard, adding 100 kg S/fed was the excelsior practice being recorded the maximal values of plant height, capsules and seeds weight/plant, weight of 1000 seeds, oil percentage and oil yield/fed. Potency of such treatment for plant height, capsules weight/plant, seeds weight/plant and oil yield/fed amounted to 12.4, 70.6, 140.5 and 97.7%, respectively, compared to without adding S treatment. Otherwise, adding 200 kg S/fed possessed the highest values of fruiting zone length, branches and capsules number/plant and biological and seeds yield/fed. The increments due to application of 200 kg S/fed for biological and seeds yield/fed reached 71.1 and 76.9%, respectively, compared to without adding S treatment. It is of interest to mention here that adding 200 kg S/fed achieved the significantly highest values of biological and seeds yield/fed but, statistically at par with those of adding 100 kg S/fed. Moreover,

increasing S levels up to 300 kg S/fed resulted in the decrease of all studied traits. The remarkable influence of applied S levels on sesame yields, yield components and oil percentage may be due to the fact that S application improves the soil chemical properties (i.e. decrease the pH of soil solution) and therefore increases the availability of nutrients. Application of S-containing fertilizer can result in soil acidification and may eventually influence nutrient uptake (Havlin et al., 2007). Also, Shilpi et al. (2014) found that different levels of S caused significant variation for NPKS uptake by plant of sesame. Additionally, nitrogen and S metabolism are linked to each other. S-deficiency resulted in decrease in nitrate reductase activity and in the accumulation of chlorophyll, amino acid and sugar (Jamal et al., 2009 and Shilpi et al., 2012).

In oil seeds, S plays a significant role in the quality and development of seeds. Therefore, crops of oil seeds require a higher quantity of S for proper growth and development for higher yields (Jamal et al., 2010 and Salwa et al., 2010). Unlike, the excess S application (300 kg S/fed) as shown in table (1) resulted in declined sesame yields and its attributes.

Thus, it can be inferred that adding 100 kg S/fed was the best treatment for improving and economical applied to enhancing the productivity of sesame plants compared to adding 200 or 300 kg S/fed. Such results are in full agreement with those obtained by Raja et al. (2007), Shilpi et al. (2012), De et al. (2013), Shah et al. (2013) and Puste et al. (2015).

#### **4. Effect of Interactions**

First order interactions, i.e. sowing dates  $\times$  cultivars; sowing dates  $\times$  S levels and cultivars  $\times$  S levels are presented in tables (2, 3 and 4, respectively) as well as the second order one i.e. sowing dates  $\times$  cultivars  $\times$  S levels is shown in table (5).

##### **4.1. Sowing dates $\times$ cultivars**

Remarkable influence of the interaction between sowing dates  $\times$  cultivars on all sesame yields, yield components and oil percentage were obtained, except for weight of 1000 seeds, which was not significantly affected (Table 2). Herein, planting sesame Giza-32 cultivar in 15 March was the most effective practice for increasing plant height, fruiting zone length, branches number/plant and oil percentage. Also, planting Shandaweel-3 cultivar in 15<sup>th</sup> March was the effective pattern for promoting capsules number and weight/plant, seeds weight/plant and biological seeds and oil yields/fed. These results are in accordance with those obtained by Ali and Jan (2014), Chongdar et al. (2015) and Hamza and Abd El-Salam (2015). The interaction between sowing dates and varieties was also highly significant as found by Hazarika (1998) and Chongdar et al. (2015).

**Table (1).** Effect of sowing dates, cultivars and sulphur levels on sesame yields, its components and oil percentage (combined analysis of 2010 and 2011 seasons).

Traits	Plant height (cm)	Fruiting zone length (cm)	Branches no./plant	Capsules/plant		Seeds weight /plant (g)	Weight of 1000 seeds (g)	Yield/fed		Oil	
				No.	Weight (g)			Biological (kg)	Seed (kg)	%	Yield (kg/fed)
<b>Treatments</b>											
<b>Sowing dates</b>											
D <sub>1</sub>	133.7	65.97	2.63	42.03	15.86	6.43	3.68	1616.0	459.9	49.53	229.5
D <sub>2</sub>	126.4	61.50	2.09	38.47	14.06	6.13	3.63	1401.3	432.6	48.86	212.9
D <sub>3</sub>	116.8	58.11	1.74	32.53	11.92	5.66	3.58	1168.4	365.2	47.60	175.2
D <sub>4</sub>	99.8	57.64	1.57	27.86	10.81	5.14	3.51	1003.7	338.1	46.77	159.5
<b>LSD (0.05)</b>	0.81	0.32	0.02	0.78	0.12	0.03	0.02	23.92	5.01	0.06	2.34
<b>Cultivars</b>											
C <sub>1</sub>	121.3	62.56	2.09	31.77	10.98	5.40	3.51	1065.8	350.5	49.03	173.8
C <sub>2</sub>	115.7	58.75	1.92	35.31	12.85	5.76	3.60	1283.8	402.9	47.37	193.3
C <sub>3</sub>	120.4	61.10	2.01	38.58	15.65	6.36	3.69	1542.4	443.3	48.17	215.8
<b>LSD (0.05)</b>	0.88	0.40	0.03	0.49	0.22	0.04	0.02	12.93	4.51	0.05	2.02
<b>Sulphur levels</b>											
S <sub>1</sub>	110.9	50.11	1.43	17.81	9.28	2.89	3.15	888.5	264.4	44.87	118.9
S <sub>2</sub>	124.6	65.89	2.27	44.75	15.83	6.95	3.82	1520.3	467.6	50.16	234.9
S <sub>3</sub>	124.3	67.78	2.30	45.67	14.86	6.94	3.77	1525.6	472.4	49.33	233.5
S <sub>4</sub>	116.7	59.44	2.04	32.67	12.67	6.58	3.65	1255.0	391.3	48.39	189.7
<b>LSD (0.05)</b>	1.25	0.70	0.03	1.09	0.32	0.08	0.02	28.90	7.69	0.07	3.78

Note: D<sub>1</sub> is 15<sup>th</sup> March, D<sub>2</sub> is 1<sup>st</sup> April, D<sub>3</sub> is 15<sup>th</sup> April, D<sub>4</sub> is 1<sup>st</sup> May, C<sub>1</sub> is Giza 32, C<sub>2</sub> is Toshka 1, C<sub>3</sub> is Shandaweel 3, S<sub>1</sub> is 0 kg S/fed, S<sub>2</sub> is 100 kg S/fed, S<sub>3</sub> is 200 kg S/fed, S<sub>4</sub> is 300 kg S/fed, L.S.D is Least Significant Difference.

**Table (2).** Effect of sowing dates and cultivars interaction on sesame yields, its components and oil percentage (combined analysis of 2010 and 2011 seasons).

Traits		Plant height (cm)	Fruiting zone length (cm)	Branches no./plant	Capsules/plant		Seeds weight /plant (g)	Weight of 1000 seeds (g)	Yield/fed		Oil	
Treatments					No.	Weight (g)			Biological (kg)	Seed (kg)	%	Yield (kg/fed)
<b>Sowing dates × cultivars</b>												
<b>D<sub>1</sub></b>	C <sub>1</sub>	140.5	67.67	2.66	39.00	13.33	6.06	3.58	1408.3	399.3	50.51	203.7
	C <sub>2</sub>	126.7	64.25	2.61	41.92	15.33	6.28	3.69	1599.2	477.8	48.59	234.4
	C <sub>3</sub>	133.9	66.00	2.62	45.17	18.92	6.94	3.76	1840.6	502.4	49.48	250.4
<b>D<sub>2</sub></b>	C <sub>1</sub>	126.7	62.58	2.19	35.83	11.75	5.75	3.54	1156.6	369.3	49.60	184.6
	C <sub>2</sub>	124.8	59.50	1.99	38.75	13.75	6.01	3.63	1399.0	443.2	47.95	214.6
	C <sub>3</sub>	127.6	62.42	2.09	40.83	16.67	6.63	3.72	1648.4	485.4	49.03	239.6
<b>D<sub>3</sub></b>	C <sub>1</sub>	117.8	60.58	1.86	28.67	9.92	5.22	3.49	933.3	334.0	48.61	163.6
	C <sub>2</sub>	114.6	55.83	1.62	32.42	11.67	5.62	3.56	1154.7	355.8	46.94	168.6
	C <sub>3</sub>	117.8	57.92	1.74	36.50	14.17	6.13	3.68	1417.2	405.9	47.26	193.5
<b>D<sub>4</sub></b>	C <sub>1</sub>	100.3	59.42	1.66	23.58	8.92	4.57	3.43	765.1	299.5	47.39	143.2
	C <sub>2</sub>	96.7	55.42	1.48	28.17	10.67	5.11	3.50	982.4	335.1	46.00	155.6
	C <sub>3</sub>	102.4	58.08	1.58	31.83	12.83	5.75	3.60	1263.5	379.6	46.91	179.6
<b>LSD (0.05)</b>		1.75	0.81	0.05	0.97	0.44	0.07	NS	25.86	9.02	0.11	4.04

Note: D<sub>1</sub> is 15<sup>th</sup> March, D<sub>2</sub> is 1<sup>st</sup> April, D<sub>3</sub> is 15<sup>th</sup> April, D<sub>4</sub> is 1<sup>st</sup> May, C<sub>1</sub> is Giza 32, C<sub>2</sub> is Toshka 1, C<sub>3</sub> is Shandaweel 3, LSD is Least Significant Difference.

**Table (3).** Effect of sowing dates and sulphur levels interaction on sesame yields, its components and oil percentage (combined analysis of 2010 and 2011 seasons).

Traits	Plant height (cm)	Fruiting zone length (cm)	Branches no./plant	Capsules/plant		Seeds weight /plant (g)	Weight of 1000 seeds (g)	Yield/fed		Oil	
				No.	Weight (g)			Biological (kg)	Seed (kg)		%
<b>Treatments</b>											
<b>Sowing dates × sulphur levels</b>											
<b>S<sub>1</sub></b>	123.0	56.56	2.33	23.67	11.56	3.43	3.22	1182.2	302.6	46.13	139.4
<b>S<sub>2</sub></b>	140.3	70.33	2.79	51.22	18.89	7.54	3.88	1883.1	538.2	51.57	277.2
<b>S<sub>3</sub></b>	140.2	71.67	2.77	51.78	17.44	7.53	3.84	1862.2	546.0	50.79	277.1
<b>S<sub>4</sub></b>	131.3	65.33	2.63	41.44	15.56	7.20	3.76	1536.4	452.7	49.61	224.3
<b>S<sub>1</sub></b>	118.4	52.56	1.34	19.78	9.89	3.24	3.17	959.8	288.7	45.57	131.4
<b>S<sub>2</sub></b>	130.9	66.00	2.40	48.44	16.78	7.22	3.84	1619.3	504.6	50.65	255.3
<b>S<sub>3</sub></b>	132.4	67.67	2.52	49.22	15.67	7.19	3.78	1645.6	512.0	49.96	255.7
<b>S<sub>4</sub></b>	123.7	59.78	2.10	36.44	13.89	6.87	3.71	1380.7	425.2	49.26	209.4
<b>S<sub>1</sub></b>	109.9	47.00	1.12	15.89	8.11	2.74	3.14	795.1	238.8	44.47	106.1
<b>S<sub>2</sub></b>	122.4	63.44	2.04	42.11	14.67	6.77	3.79	1375.4	430.6	49.71	213.9
<b>S<sub>3</sub></b>	121.0	65.44	2.00	43.33	13.67	6.73	3.75	1378.2	435.8	48.65	211.7
<b>S<sub>4</sub></b>	113.7	56.56	1.79	28.78	11.22	6.40	3.62	1124.7	355.8	47.59	169.0
<b>S<sub>1</sub></b>	92.6	44.33	1.00	11.89	7.56	2.16	3.07	616.9	227.6	43.32	98.5
<b>S<sub>2</sub></b>	104.9	63.78	1.84	37.22	13.00	6.28	3.75	1203.3	397.2	48.73	193.4
<b>S<sub>3</sub></b>	103.7	66.33	1.90	38.33	12.67	6.29	3.72	1216.2	395.8	47.93	189.7
<b>S<sub>4</sub></b>	98.1	56.11	1.62	24.00	10.00	5.84	3.51	978.2	331.7	47.10	156.2
<b>LSD (0.05)</b>	2.51	0.41	0.07	2.18	0.63	NS	0.04	57.80	15.38	0.14	7.56

Note: D<sub>1</sub> is 15<sup>th</sup> March, D<sub>2</sub> is 1<sup>st</sup> April, D<sub>3</sub> is 15<sup>th</sup> April, D<sub>4</sub> is 1<sup>st</sup> May, S<sub>1</sub> is 0 kg S/fed, S<sub>2</sub> is 100 kg S/fed, S<sub>3</sub> is 200 kg S/fed, S<sub>4</sub> is 300 kg/fed, LSD is Least Significant Difference.

**Table (4).** Effect of cultivars and sulphur levels interaction on sesame yields, its components and oil percentage (combined analysis of 2010 and 2011 seasons).

Traits Treatments	Plant height (cm)	Fruiting zone length (cm)	Branches number/plant	Capsules/plant		Seeds weight /plant (g)	Weight of 1000 seeds (g)	Yield/fed		Oil %	Yield (kg/fed)	
				No.	Weight (g)			Biological (kg)	Seed (kg)			
<b>Cultivars × sulphur levels</b>												
<b>C<sub>1</sub></b>	S <sub>1</sub>	112.3	52.42	1.50	14.67	7.33	2.42	3.07	651.8	223.7	45.96	102.9
	S <sub>2</sub>	127.6	67.25	2.35	40.25	13.58	6.49	3.72	1289.4	412.0	51.22	211.6
	S <sub>3</sub>	127.3	69.25	2.39	41.42	12.58	6.52	3.68	1294.8	421.5	49.88	210.9
	S <sub>4</sub>	118.1	61.33	2.12	30.75	10.42	6.17	3.58	1027.1	344.8	49.05	169.6
<b>C<sub>2</sub></b>	S <sub>1</sub>	108.4	47.83	1.35	17.42	8.92	2.74	3.14	871.8	358.3	43.71	113.2
	S <sub>2</sub>	119.9	64.08	2.17	45.17	15.58	6.87	3.81	1502.4	473.8	49.00	232.8
	S <sub>3</sub>	120.8	65.75	2.21	46.33	14.50	6.85	3.78	1517.8	482.3	48.72	235.7
	S <sub>4</sub>	113.7	57.33	1.96	32.33	12.42	6.57	3.66	1243.3	397.4	48.05	191.4
<b>C<sub>3</sub></b>	S <sub>1</sub>	112.2	50.08	1.44	21.33	11.58	3.52	3.24	1141.9	311.2	44.94	140.4
	S <sub>2</sub>	126.3	66.33	2.28	48.83	18.33	7.50	3.92	1769.1	517.0	50.27	260.5
	S <sub>3</sub>	124.9	68.33	2.29	49.25	17.50	7.44	3.87	1764.0	513.4	49.40	253.9
	S <sub>4</sub>	118.3	59.67	2.03	34.92	15.17	7.00	3.72	1494.7	431.8	48.06	208.2
<b>LSD (0.05)</b>	NS	NS	NS	1.88	NS	NS	NS	NS	NS	NS	0.12	6.55

Note: C<sub>1</sub> is Giza 32, C<sub>2</sub> is Toshka 1, C<sub>3</sub> is Shandaweel 3, S<sub>1</sub> is 0 kg S/fed, S<sub>2</sub> is 100 kg S/fed, S<sub>3</sub> is 200 kg S/fed, S<sub>4</sub> is 300 kg/fed, LSD is Least Significant Difference.

**Table (5).** Effect of sowing dates, cultivars and sulphur levels interaction on sesame yields, its components and oil percentage (combined analysis of 2010 and 2011 seasons).

Traits	Plant height (cm)	Fruiting zone length (cm)	Branches number/plant	Capsules/plant		Seeds weight / plant (g)	Weight of 1000 seeds (g)	Yield/fed		Oil	
				No.	Weight (g)			Biological (kg)	Seed (kg)	%	Yield (kg/fed)
<b>Treatments</b>											
<b>S<sub>1</sub></b>	125.0	58.67	2.40	19.33	9.33	3.03	3.13	959.3	242.0	47.07	113.9
<b>C<sub>1</sub></b>	<b>S<sub>2</sub></b>	149.0	2.83	48.00	16.33	7.13	3.77	1653.7	472.7	52.77	249.4
	<b>S<sub>3</sub></b>	151.3	2.80	48.67	14.67	7.17	3.74	1665.0	488.7	51.66	252.5
	<b>S<sub>4</sub></b>	136.7	2.60	40.00	13.00	6.90	3.68	1355.0	394.0	50.54	199.1
<b>D<sub>1</sub></b>	<b>C<sub>2</sub></b>	<b>S<sub>1</sub></b>	120.0	2.27	23.67	11.00	3.17	1162.3	295.0	45.25	133.5
		<b>S<sub>2</sub></b>	130.7	2.73	50.33	18.33	7.43	1854.7	559.0	50.19	280.6
		<b>S<sub>3</sub></b>	131.7	2.77	52.00	17.00	7.43	1849.3	579.3	50.06	290.0
		<b>S<sub>4</sub></b>	124.3	2.67	41.67	15.00	7.10	1530.3	478.0	48.85	233.5
<b>C<sub>3</sub></b>	<b>S<sub>1</sub></b>	124.0	2.33	28.00	14.33	4.10	3.30	1425.0	370.7	46.06	170.7
	<b>S<sub>2</sub></b>	141.0	2.80	55.33	22.00	8.07	3.98	2141.0	583.0	51.75	301.8
	<b>S<sub>3</sub></b>	137.7	2.73	54.67	20.67	8.00	3.94	2072.3	570.0	50.65	288.7
	<b>S<sub>4</sub></b>	133.0	2.63	42.67	18.67	7.60	3.81	1724.0	486.0	49.44	240.3
<b>C<sub>1</sub></b>	<b>S<sub>1</sub></b>	120.0	1.40	17.67	7.67	2.87	3.09	696.7	233.7	46.70	109.1
	<b>S<sub>2</sub></b>	131.7	2.50	43.00	14.67	6.77	3.74	1382.7	436.0	51.67	225.3
	<b>S<sub>3</sub></b>	132.0	2.63	44.67	13.33	6.83	3.67	1392.0	445.0	50.34	223.9
	<b>S<sub>4</sub></b>	123.0	2.23	38.00	11.33	6.53	3.65	1155.0	462.3	49.69	180.1
<b>D<sub>2</sub></b>	<b>S<sub>1</sub></b>	117.0	1.27	19.00	9.67	3.10	3.15	957.0	276.3	44.26	122.3
	<b>S<sub>2</sub></b>	127.7	2.27	50.67	16.67	7.10	3.85	1609.7	520.3	49.55	257.8
	<b>S<sub>3</sub></b>	132.0	2.40	51.33	15.33	7.00	3.80	1653.3	539.7	49.27	265.9
	<b>S<sub>4</sub></b>	122.7	2.03	34.00	13.33	6.83	3.71	1376.0	436.3	48.71	212.5
<b>C<sub>3</sub></b>	<b>S<sub>1</sub></b>	118.3	1.37	22.67	12.33	3.77	3.27	1225.7	356.0	45.74	162.8
	<b>S<sub>2</sub></b>	133.4	2.43	51.67	19.00	7.80	3.93	1865.7	557.3	50.72	282.7
	<b>S<sub>3</sub></b>	133.3	2.53	51.67	18.33	7.73	3.88	1891.3	551.3	50.27	277.2
	<b>S<sub>4</sub></b>	125.3	2.03	37.33	17.00	7.23	3.78	1611.0	477.0	49.37	235.5

Table 5. Continued

Traits		Plant height (cm)	Fruiting zone length (cm)	Branches number/plant	Capsules/plant	Seeds weight /plant (g)	Weight of 1000 seeds (g)	Biological (kg)	Yield/fed	Oil (kg/fed)			
Treatments		No.	Weight (g)	No.	Weight (g)	Seeds weight /plant (g)	Weight of 1000 seeds (g)	Biological (kg)	Yield/fed	Oil (kg/fed)			
<b>D<sub>3</sub></b>	<b>C<sub>1</sub></b>	S <sub>1</sub>	111.3	50.67	1.20	12.33	6.33	2.30	3.05	551.3	222.0	45.74	101.5
		S <sub>2</sub>	124.0	65.00	2.13	38.00	12.67	6.30	3.71	1157.0	385.3	50.72	195.4
		S <sub>3</sub>	121.3	67.67	2.17	39.00	11.33	6.33	3.67	1144.0	400.7	49.26	197.4
		S <sub>4</sub>	114.7	59.00	1.93	25.33	9.33	5.97	3.53	880.7	328.0	48.73	159.8
<b>C<sub>2</sub></b>		S <sub>1</sub>	107.7	44.00	1.03	15.67	7.67	2.63	3.11	779.3	232.0	43.25	100.3
		S <sub>2</sub>	119.7	61.67	1.97	42.00	14.33	6.73	3.75	1360.0	423.3	48.52	205.4
		S <sub>3</sub>	118.7	63.33	1.83	43.33	13.33	6.73	3.75	1368.3	421.0	48.16	202.8
		S <sub>4</sub>	112.3	54.33	1.63	28.67	11.33	6.40	3.64	1111.0	346.7	47.81	165.7
<b>C<sub>3</sub></b>		S <sub>1</sub>	110.7	46.33	1.13	19.67	10.33	3.30	3.26	1054.7	262.3	44.42	116.5
		S <sub>2</sub>	123.7	63.67	2.03	46.33	17.00	7.27	3.91	1609.3	483.0	49.88	240.9
		S <sub>3</sub>	123.0	65.33	2.00	47.67	16.33	7.13	3.84	1622.3	485.7	48.52	234.9
		S <sub>4</sub>	114.0	56.33	1.80	32.33	13.00	6.83	3.70	1382.3	392.7	46.22	181.5
<b>C<sub>1</sub></b>		S <sub>1</sub>	93.0	47.00	1.00	9.33	6.00	1.50	2.99	400.0	197.0	44.33	87.3
		S <sub>2</sub>	105.7	65.33	1.93	32.00	10.67	5.77	3.65	964.3	254.3	49.73	176.2
		S <sub>3</sub>	104.7	67.67	1.97	33.33	11.00	5.73	3.64	978.3	351.7	48.27	169.8
		S <sub>4</sub>	98.0	57.67	1.73	19.67	8.00	5.27	3.44	717.7	295.0	47.24	139.4
<b>D<sub>4</sub></b>	<b>C<sub>2</sub></b>	S <sub>1</sub>	89.0	41.33	1.00	11.33	7.33	2.07	3.07	588.3	230.0	42.08	96.8
		S <sub>2</sub>	101.7	62.00	1.73	37.67	13.00	6.20	3.74	1185.3	392.7	47.73	187.4
		S <sub>3</sub>	100.7	64.33	1.83	38.67	12.33	6.23	3.71	1200.3	389.0	47.37	184.3
		S <sub>4</sub>	95.3	54.00	1.50	25.00	10.00	5.93	3.50	955.7	328.7	46.82	153.9
<b>C<sub>3</sub></b>		S <sub>1</sub>	95.7	44.67	1.00	15.00	9.33	2.90	3.14	862.3	255.7	43.54	111.3
		S <sub>2</sub>	107.3	64.00	1.87	42.00	15.33	6.87	3.86	1460.3	444.7	48.73	216.7
		S <sub>3</sub>	105.7	67.00	1.90	43.00	14.67	6.90	3.81	1470.0	446.7	48.15	215.1
		S <sub>4</sub>	101.0	56.67	1.63	27.33	12.00	6.33	3.58	1261.3	371.3	47.23	175.4
<b>LSD (0.05)</b>			4.35	NS	NS	NS	NS	NS	NS	NS	26.63	0.25	13.10

Note: D<sub>1</sub> is 15<sup>th</sup> March, D<sub>2</sub> is 1<sup>st</sup> April, D<sub>3</sub> is 15<sup>th</sup> April, D<sub>4</sub> is 1<sup>st</sup> May, C<sub>1</sub> is Giza 32, C<sub>2</sub> is Toshka 1, C<sub>3</sub> is Shandaweel 3, S<sub>1</sub> is 0 kg S/fad, S<sub>2</sub> is 100 kg S/fad, S<sub>3</sub> is 200 kg S/fad, S<sub>4</sub> is 300 kg/fad, LSD is Least Significant Difference.

#### 4.2. Sowing dates × S levels

With the exception of seeds weight/plant, all sesame yields, yield components and oil percentage were markedly responded to the interaction between sowing dates and S levels (Table 3). In this concern, 15<sup>th</sup> March (early sowing date) with adding 100 kg S/fed secured the highest values of plant height, branches number/plant, capsules weight/plant, weight of 1000 seeds, biological and oil sesame yields/fed and oil percentage, respectively. In early sowing date, fruiting zone length, capsules number/plant and sesame seed yield/fed showed the maximum increases with adding 200 kg S/fed, but statistically at par with adding 100 kg S/fed in this respect.

#### 4.3. Cultivars × S level

Shandaweel-3 cultivar plants fertilized with 200 kg S/fed recorded the maximum values of capsules number/plant. While, with the same cultivar, pots received 100 kg S/fed was the most effective for enhancing sesame seed and oil yields/fed (Table 4). Otherwise, Giza-32 cultivar possessed the highest value of oil percentage in plots fertilized with 100 kg S/fed. Discriminated response of varieties to S levels showed that the yield of sesame was increased with adding S up to limited dose (Raja et al., 2007; Mondal et al., 2012 and Shah et al., 2013).

#### 4.4. Sowing dates × cultivars × S levels

The impact of possible interactions among the three tested factors on sesame yields, yield components and oil percentage are presented in table (5). Early sowing date of 15<sup>th</sup> March x Shandaweel-3 cultivar x adding 100 kg S/fed recorded the highest values of sesame seed and oil yields/fed. While, oil percentage gave the maximum increase with the interaction of early sowing date of 15<sup>th</sup> March × Giza-32 cultivar × adding 100 kg S/fed. Whereas, the tallest sesame plants were achieved with combination of early sowing date of 15<sup>th</sup> March × Giza-32 cultivar × adding 200 kg S/fed.

### CONCLUSION

It could be concluded that under the similar conditions of this investigation, early sowing date (15<sup>th</sup> March) with Shandaweel-3 cultivar and adding 100 kg S/fed could be recommended for increasing sesame yield and its components.

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## تأثير مواعيد الزراعة ومستويات الكبريت على بعض أصناف السمسم تحت ظروف الوادي الجديد

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يمكن تحسين الناتج المحصولي والجودة الغذائية للسمسم من خلال التحوير في المعاملات الزراعية بما يناسب المحصول. لذلك أجريت تجربتان حقليتان بمركز بحوث الصحراء بمحطة التجارب الزراعية بواحة الخارجة بمحافظة الوادي الجديد خلال موسمي ٢٠١٠ و ٢٠١١، لدراسة إستجابة ثلاثة أصناف مصرية من السمسم (شندويل-٣، توشكي-١، جيزة-٣٢) لأربعة مواعيد زراعة (١٥ مارس، ١ أبريل، ١٥ أبريل، ١ مايو) تحت أربعة مستويات من الكبريت (٠، ١٠٠، ٢٠٠، ٣٠٠ كجم كبريت/فدان).

أشارت النتائج المتحصل عليها أن ميعاد الزراعة المبكر رفع معنويا محصول السمسم ومكوناته ونسبة الزيت مقارنة بميعاد الزراعة المتأخر. في هذا الصدد، زراعة نباتات السمسم في ١٥ مارس (ميعاد الزراعة المبكر) كان المعاملة المتفوقة في هذا الشأن وسجلت أعلى القيم لكل الصفات المدروسة. صنف جيزة ٣٢ سجل أعلى القيم لصفات ارتفاع النبات، طول المنطقة الثمرية، عدد الأفرع لكل نبات، النسبة المئوية للزيت. على الجانب الأخر صنف شندويل ٣ أعطى أعلى القيم لصفات عدد ووزن الكبسولات لكل نبات، وزن البذور لكل نبات، وزن ١٠٠٠ بذرة، محصول البذور والبيولوجي والزيت للفدان. بزيادة مستويات الكبريت حتى مستوى ١٠٠ كجم كبريت للفدان زاد كل من ارتفاع النبات، وزن الكبسولات والبذور لكل نبات، وزن ١٠٠٠ بذرة، النسبة المئوية للزيت، محصول الزيت للفدان، بينما أشارت النتائج إلى استمرار تحسن وزيادة صفات طول المنطقة الثمرية، عدد الأفرع والكبسولات لكل نبات، والمحصول البيولوجي و البذور للفدان بزيادة مستويات الكبريت حتى مستوى ٢٠٠ كجم كبريت للفدان.

يتضح من النتائج المتحصل عليها أن زراعة صنف شندويل ٣ في ١٥ مارس مع إضافة ١٠٠ كجم كبريت للفدان هي المعاملة الموصى بها لزيادة إنتاجية محصول وجودة السمسم تحت ظروف الوادي الجديد.