Journal of Applied Sciences Research, 3(9): 879-885, 2007

The Effect of Antitranspirant Application on Yield and Fatty Acid of Sesame Cultivars Grown under Saline Conditions

B. Abou Leila, M.S. Gaballah, H.A. El-Zeiny and S. Khali

Water Relations and Field Irrigation Department, National Research Centre, Cairo, Egypt.

Abstract: A pot experiment was carried out at the greenhouse of National Research Centre, Cairo, Egypt. The experiment was conducted for two growing seasons to evaluate the effect of salinity, antitranspirant and their interaction on sesame cultivars yield and fatty acid content and composition in Giza 32cv and Shandaweel 3cv seeds. Five salinity levels of NaCl (1.5, 2.3, 3.12, 3.9 abd 4.7 dSm^{-1}) were used for plant irrigation and three types of antitranspirants were selected (Kaolin, calcium carbonate and paraffin wax) to be sprayed twice during the plant cycle. Obtained results proved that Shandaweel 3 cv overcame Giza 32 in fruit zone length (cm), number of capsules, seed index and oil percentage. Kaolin treatment increased the recorded mean values of yield components, under saline water irrigation of 2.3 dSm^{-1}. Low salinity level of 1.5 and 2.3 dSm^{-1} increased total saturated fatty acids (%) in seed oil of Giza 32 cv and decreased in Shandaweel 3 cv. Increasing salinity level up to 4.7 dSm^{-1} showed an increase in Plamitic and Linoleic acids in both tested cultivars while an opposite trend was observed by oleic acid. Using Kaolin antitranspirant under 2.3 dSm^{-1} salinity level led to an increase in saturated fatty acids while the peaks corresponding to arachidic and stearic disappeared when salinity levels increased and in addition to antitranspirant application.

Key words: Salinity – antitranspirants - yield - saturated fatty acid - unsaturated fatty acid.

INTRODUCTION

Sesame plant (*Sesamum indicum* L.) is an important oil seed crop. Sesame crop has an important advantage as it could be grown under fairly high temperature, low water supply and low levels of other inputs[23,5]. In Egypt the local production of sesame seed still did not exceed the optimum limit of the national requirements[9]. Sesame is a broad leaf summer crop that belongs to pedaliaceae plant family which has bell shaped flowers and opposite leaves. The sesame seed has excellent nutritional value. They have high and unique protein composition making them a nearly perfect food. Sesame oil is stable and resistance to rancidity also used in soaps, cosmetics, perfumes, insecticides and the residue used as animal diet. Improving salinity and tolerance of crop plants using antitranspirants has been an important but largely unfulfilled aim of modern agricultural technique. However several lines of evidence have been reported that salinity caused a yield drop in many crops. In this respect[6,13,18,21,1], noted that yield components of sesame plant and other crops decreased under salinity stress. However,[15,2] found that the use of antitranspirants under saline condition reduced the deleterious effect of salinity on yield and increased K, Ca as well as proline and consequently productivity.

The aim of the present work was to evaluate the efficiency of using different types of antitranspirants on yield and fatty acid content of sesame cultivars grown under saline conditions.

MATERIALS AND METHODS

A pot experiment was conducted during the summer season of 2001 and 2002 at the green house of National Research Centre, Dokki, Cairo. Two pure sesame cultivars Giza 32 and Shandaweel 3 seeds were sterilized with $HgCl_2$ for three minutes then washed with sterile water and sown in pots of 30 cm diameter filled with 10 kg prewashed sandy soil with 0.1 N HCl followed by water. The characteristics of the soil was sandy in texture where the clay was 8.19%, the sand 83.3% and silt 6.4% the pH of 7.41 EC = 0.007 dSm^{-1}, organic matter 0.09% total nitrogen 0.015% and available phosphorus 0.08%.

All pots received recommended dose of NPK fertilizers 2g calcium super phosphate 15 % P, 1.68 g

Corresponding Author: B. Abou Leila, Water Relations and Field Irrigation Department, National Research Centre, Cairo, Egypt
E-mail: Msgaballa54@yahoo.com

potassium sulphate 48% K and 2.61 g ammonium nitrate 33.5% N and equal amount of organic matter. Seeds were irrigated till emergence of seedlings with tap water to reach 65% of total holding capacity of the soil, then was subjected to different salinity levels of 1.5, 2.3, 3.12, 3.9 and 4.7 dSm^{-1} in addition to control (0.31 dSm^{-1}). The experiment was arranged in a complete randomized design with three replicates. Three types of antitranspirants (6% calcium carbonate, 6% Kaolin and 10% paraffin wax) were sprayed twice, once during vegetative and another before flowering. At maturity, plant samples were collected randomly to record fruit zone length (cm) number of capsules/plant, seed index (g) and seed oil %. Seed oil percentage was estimated according to the extraction method described by[3]. Fatty acids composition were determined according to[20]. Means of various treatments were compared by Duncan's multiple range tests[10] at 5% probability level.

RESULTS

The effect of cultivars, salinity, antitranspirants and their interaction on yield components and oil percentage.

It was evident in Table (1) that Shandaweel cv surpassed Giza 32 cv in most of yield parameters except for seed index.

Irrespective to cultivar type, the effect of salinity on yield components was presented in Table (2). Increasing salinity levels in irrigation water up to 4.7 dSm^{-1} led to a decrease in all yield parameters compared to the control for both seasons.

Comparing between different types of antitranspirants on yield parameters was presented in Table (3) where Kaolin followed by calcium carbonate were the most effective in increasing significantly both fruit zone length (cm) as well as oil % in both seasons, while the paraffin wax led to marked decrease of previously mentioned parameters. Also the highest increment over the control for both seed index and number of capsules / plant were achieved by Kaolin application.

The combined effect between different salinity levels and chosen antitranspirants on sesame yield parameters irrespective to cultivars were presented in Table (4). It has been noticed that Kaolin proved to be effective in increasing yield parameters under salinity stress, while paraffin wax suppressed yield components.

Data presented in Table (5 and 6) detected in chosen cultivars six dominant fatty acid constituents which were palmitic ($C_{16:0}$), Stearic ($C_{18:0}$), Oleic ($C_{18:1}$), Linoleic ($C_{18:2}$) and Linolinic ($C_{18:3}$) while arachidic ($C_{20:0}$) were detected as traces. However, the predominant saturated fatty acids was palmitic while Oleic acid was the predominant as unsaturated fatty acid.

Table 1: Yield and its components of sesame cultivars during the two growing seasons of (2001 and 2002).

Yield	First season				Second season			
Cultivars	Fruit zone length (cm)	Number of capsules/ plant	Seed index (g)	Oil (%)	Fruit zone length (cm)	Number of capsules/ plant	Seed index (g)	Oil (%)
CV_1	27.83	20.25 b	2.96 a	36.92	19.08	16.96 b	2.10 b	31.78 b
CV_2	27.88	27.38 a	2.81 b	37.03	21.5	26.38 a	2.62 a	32.44 a

Table 2: The effect of different salinity levels on yield and its components during the two growing seasons of (2001 and 2002)

Yield	First season				Second season			
Salinity	Fruit zone length (cm)	Number of capsules/ plant	Seed index (g)	Oil (%)	Fruit zone length (cm)	Number of capsules/ plant	Seed index (g)	Oil (%)
S_0	33.62 b	31.25 b	3.33 c	47.13 b	24.00 c	26.88 c	2.85 a	43.96 a
S_1	34.75 a	31.75 b	3.53 b	47.21 b	24.88 b	27.88 b	2.85 a	42.99 b
S_2	34.25 a	33.50 a	3.82 a	48.38 a	25.63 a	29.25 a	2.97 a	44.42 a
S_3	25.79 c	20.88 c	3.12 d	41.33 c	19.88 d	25.38 d	2.28 b	28.83 c
S_4	20.63 d	15.13 d	2.04 e	22.63 d	14.50 e	13.50 e	1.75 c	17.88 d
S_5	18.13 e	10.38 e	1.48 f	15.17 e	12.88 f	7.13 f	1.46 d	14.58 e

S_0 : 0.31 dSm^{-1} S_1 : 1.5 dSm^{-1} S_2 : 2.3 dSm^{-1} S_3 : 3.12 dSm^{-1} S_4 : 3.9 dSm^{-1} S_5 : 4.7 dSm^{-1}
CV_1 : Giza 32 CV_2 : Shandaweel 3
The Figures of the same letters have no significant differences

Table 3: The effect of different antitranspirant types on yield and its components during the two growing seasons of (2001 and 2002)

Yield	First season				Second season			
Antitranspirants	Fruit zone length (cm)	Number of capsules/ plant	Seed index (g)	Oil (%)	Fruit zone length (cm)	Number of capsules/ plant	Seed index (g)	Oil (%)
A_0	26.33 d	20.42 d	2.67 c	36.61 b	20.25 b	20.42 c	2.17 b	32.08 b
A_1	29.92 a	25.42 a	3.08 a	37.64 a	21.33 a	22.00 a	2.48 a	32.72 a
A_2	28.00 b	23.83 b	2.99 a	36.86 b	20.00 be	21.83 ab	2.43 a	32.14 b
A_3	27.17 c	23.33 c	2.80 b	36.78 b	19.58 c	21.42 b	2.36 a	31.50 c

A_0 : No antitranspirants A_1 : Kaolin A_2 : Calcium carbonate A_3 : Paraffin wax

Table 4: 7rThe effect of interaction between different salinity and antitranspirant types on yield and its components during the two growing seasons of (2001 and 2002)

Yield	First season				Second season			
Interaction	Fruit zone length (cm)	Number of capsules/ plant	Seed index (g)	Oil (%)	Fruit zone length (cm)	Number of capsules/ plant	Seed index (g)	Oil (%)
S_0 x A_0	34.00 bcd	32.00 bc	3.25 de	47.00 bc	26.50 a	26.50 efg	2.96	45.33 a
S_0 x A_1	33.50 cde	31.00 cd	3.32 de	47.33 bc	26.50 a	26.50 efg	2.73	44.17 ab
S_0 x A_2	33.00 de	30.50 d	3.25 de	46.84 c	25.50 abc	27.50 cde	2.85	44.17 ab
S_0 x A_3	34.00 bcd	31.50 cd	3.49 cd	47.34 bc	24.00 de	27.00 def	2.86	44.00 bc
S_1 x A_0	35.50 e	30.50 d	3.35 d	47.50 bc	24.50 cd	27.50 cde	2.67	42.83 cd
S_1 x A_1	37.50 a	33.00 b	3.75 bc	47.17 bc	25.00 bcd	28.00 cd	3.05	44.50 ab
S_1 x A_2	35.00 b	31.50 cd	3.57 cd	47.17 bc	26.00 ab	28.00 cd	2.80	42.50 d
S_1 x A_3	34.00 bcd	32.00 bc	3.46 cd	47.00 bc	24.00 de	28.00 cd	2.86	42.17 d
S_2 x A_0	33.00 de	32.00 bc	3.45 cd	48.33 b	24.50 cd	28.50 bc	2.65	43.34 bcd
S_2 x A_1	36.50 a	35.00 a	3.98 ab	49.67 a	24.50 cd	30.50 a	3.20	44.50 ab
S_2 x A_2	34.50 bc	35.00 a	4.07 a	48.00 bc	23.00 e	29.50 ab	3.08	43.84 bc
S_2 x A_3	33.00 de	32.00 bc	3.69 c	47.50 bc	24.00 de	28.50 bc	2.96	44.17 ab
S_3 x A_0	24.50 h	19.00 g	2.92 f	41.00 d	19.50 g	24.00 h	1.92	30.00 e
S_3 x A_1	28.50 f	23.00 e	3.52 cd	41.50 d	21.50 f	26.00 fg	2.36	29.17 e
S_3 x A_2	26.50 g	21.00 f	3.01 ef	41.50 d	19.00 g	26.300 fg	2.38	29.17 e
S_3 x A_3	23.50 h	20.50 f	3.02 ef	41.34 d	19.50 g	25.50 g	2.45	27.00 f
S_4 x A_0	19.00 k	14.00 h	1.83 I	22.00 f	14.00 I	15.00 I	1.47	17.17 h
S_4 x A_1	22.00 I	18.50 g	2.17 gh	24.00 e	16.00 h	14.00 I	2.02	18.67 g
S_4 x A_2	20.50 j	14.00 h	2.25 g	22.00 f	14.00 I	12.50 j	1.90	18.00 gh
S_4 x A_3	21.00 ij	14.00 h	1.91 hi	22.50 f	16.00 I	12.50 j	1.61	17.67 gh
S_5 x A_0	15.00 m	8.50 k	1.12 j	16.17 g	12.50 j	7.00 k	1.33	13.83 j

Table 4: Continued

S_5 x A_1	21.50 ij	12.00 I	1.74 I	15.67 g	14.50 I	7.00 k	1.53	15.33 I
S_5 x A_2	18.50 kl	11.33 ij	1.82 I	13.83 h	12.50 j	7.500 k	1.55	15.17 I
S_5 x A_3	17.50 L	10.00 j	1.22 j	15.00 g	12.00 j	7.00 k	1.43	14.00 j

S_0 : 0.31 dSm^{-1} S_1 : 1.5 dSm^{-1} S_2 : 2.3 dSm^{-1} S_3 : 3.12 dSm^{-1} S_4 : 3.9 dSm^{-1} S_5 : 4.7 dSm^{-1}
A_0 : No antitranspirants A_1 : Kaolin A_2 : Calcium carbonate A_3 : Paraffin wax

Table 5: The effect of different salinity levels, antitranspirant types and their interaction on fatty acids (%) of Giza 32 cv.

Fatty acids %								
Interaction	($C_{16:0}$) Palmitic acid	($C_{18:0}$) Stearic acid	($C_{20:0}$) Arachidic acid	Total saturated fatty acids	($C_{18:1}$) Oleic acid	($C_{18:2}$) Linoleic acid	($C_{18:3}$) Linolnic acid	Totalsaturated fatty acids
S_0 x A_0	9.76	4.25	Trace	14.01	46.59	34.01	4.78	85.38
S_0 x A_1	9.77	4.21	-	13.98	44.01	34.99	4.91	83.91
S_0 x A_2	9.69	4.10	-	13.79	44.51	34.03	4.72	83.26
S_0 x A_3	9.60	4.24	-	13.84	44.55	34.03	4.61	80.19
S_1 x A_0	11.46	4.20	Trace	15.84	34.89	37.51	4.76	77.16
S_1 x A_1	11.90	4.31	-	16.21	34.01	36.10	4.86	74.97
S_1 x A_2	11.61	4.21	-	15.82	34.01	36.43	4.66	75.10
S_1 x A_3	11.62	4.30	-	15.92	32.99	36.41	4.71	74.11
S_2 x A_0	13.01	3.90	0.71	17.62	34.09	42.01	5.21	81.31
S_2 x A_1	13.43	3.62	0.79	17.84	32.55	40.91	5.99	79.45
S_2 x A_2	13.11	3.50	0.70	17.31	32.09	40.61	5.63	78.33
S_2 x A_3	13.02	3.59	0.70	17.31	33.62	40.64	5.96	80.22
S_3 x A_0	12.33	1.91	0.64	14.88	41.11	44.35	5.41	90.87
S_3 x A_1	12.51	1.52	0.69	14.72	32.21	40.88	5.62	78.71
S_3 x A_2	12.31	1.33	0.63	14.27	33.20	41.28	5.53	80.01
S_3 x A_3	12.33	1.34	0.65	14.29	32.69	37.58	5.57	75.84
S_4 x A_0	12.30	1.00	0.61	14.32	47.69	38.13	5.99	91.81
S_4 x A_1	12.22	-	-	12.22	31.61	38.13	-	69.63
S_4 x A_2	12.70	-	-	12.70	31.51	38.25	5.99	75.75
S_4 x A_3	12.00	-	-	12.00	31.61	38.20	-	69.81
S_5 x A_0	12.30	1.01	-	13.31	40.11	49.88	5.44	95.43
S_5 x A_1	12.00	-	-	12.00	30.25	49.00	-	79.25
S_5 x A_2	12.12	-	-	12.12	30.00	49.10	-	79.10
S_5 x A_3	12.33	-	-	12.33	30.99	49.00	-	79.99

S : Salinity S_0 : 0.31 dSm^{-1} S_1 : 1.5 dSm^{-1} S_2 : 2.3 dSm^{-1} S_3 : 3.12 dSm^{-1} S_4 : 3.9 dSm^{-1}
S_5 : 4.7 dSm^{-1}
A : Antitranspirant A_0 : No antitranspirants A_1 : Kaolin A_2 : Calcium carbonate A_3 : Paraffin wax

Table 6: The effect of different salinity levels and antitranspirant types and their interaction on fatty acids (%) of Shandaweel 3 cv.

Fatty acids %	($C_{16:0}$)	($C_{18:0}$)	($C_{20:0}$)	Total saturated	($C_{18:1}$)	($C_{18:2}$)	($C_{18:3}$)	Total saturated
Interaction	Palmitic acid	Stearic acid	Arachidic acid	fatty acids	Oleic acid	Linoleic acid	Linolnic acid	fatty acids
S_0 x A_0	9.51	8.99	Trace	18.5	35.74	37.39	5.68	78.81
S_0 x A_1	9.68	8.28	-	17.96	35.71	37.92	5.69	79.32
S_0 x A_2	9.60	8.10	-	17.7	35.70	37.00	5.08	78.38
S_0 x A_3	9.10	8.12	-	17.22	35.69	31.03	5.66	72.38
S_1 x A_0	9.81	2.91	0.59	13.3	44.02	38.05	5.10	87.17
S_1 x A_1	9.99	1.91	0.69	12.59	44.53	38.89	5.31	88.73
S_1 x A_2	9.89	1.92	0.58	12.4	44.13	35.36	5.10	84.59
S_1 x A_3	9.80	1.91	0.51	12.22	44.11	38.31	5.10	87.52
S_2 x A_0	10.80	3.99	0.61	15.4	43.01	39.03	5.05	87.09
S_2 x A_1	9.01	3.11	0.70	12.82	41.36	39.91	5.35	86.62
S_2 x A_2	9.42	3.12	0.61	13.15	41.60	39.65	5.35	86.60
S_2 x A_3	9.38	3.19	0.60	13.17	41.31	35.06	5.03	81.40
S_3 x A_0	10.05	3.50	0.61	14.16	42.00	39.66	5.06	87.72
S_3 x A_1	10.21	3.00	0.69	13.9	41.38	38.86	5.59	85.83
S_3 x A_2	10.11	3.00	0.61	13.72	40.31	39.62	5.66	85.59
S_3 x A_3	10.08	3.01	0.60	13.68	40.99	38.89	5.51	85.39
S_4 x A_0	10.02	3.00	0.81	11.13	44.22	39.67	5.86	89.75
S_4 x A_1	10.95	2.97	-	10.95	40.21	39.61	-	79.82
S_4 x A_2	10.87	-	-	10.87	40.32	39.41	-	79.73
S_4 x A_3	10.03	-	-	10.03	40.88	39.11	-	79.99
S_5 x A_0	10.04	-	-	10.04	45.00	39.31	5.13	89.44
S_5 x A_1	10.11	-	-	10.11	42.13	39.00	-	81.13
S_5 x A_2	10.00	-	-	10.00	42.20	39.01	-	81.30
S_5 x A_3	10.20	-	-	10.20	42.30	39.00	-	81.30

S : Salinity S_0 : 0.31 dSm^{-1} S_1 : 1.5 dSm^{-1} S_2 : 2.3 dSm^{-1} S_3 : 3.12 dSm^{-1} S_4 : 3.9 dSm^{-1} S_5 : 4.7 dSm^{-1}

A : Antitranspirant A_0 : No antitranspirants A_1 : Kaolin A_2 : Calcium carbonate A_3 : Paraffin wax

On comparing between cultivars Shandaweel 3 cv surpassed Giza 32 in total saturated fatty acids %. Concerning salinity effect it was evident that palmaitic acid increased with increasing salinity levels in both cultivars while total saturated fatty acid % in sesame seeds of Giza 33 cv increased at low salinity levels of 1.5 and 2.3 dSm^{-1}. However, stearic acid in both cultivars decreased in comparison with the control by increasing salinity levels while arachidic acid disappeared when salts in irrigation water reached 4.7 dSm^{-1}.

The data also revealed that the low salinity level of 1.5 and 2.3 dSm^{-1} caused a decrease in total unsaturated fatty acids %, of Giza 32 cv this decrease

was observed mainly in Oleic acids. On the other hand Shandaweel 3 cv showed an increase in unsaturated fatty acid by increasing salinity levels. It was observed mainly an increase in oleic and leinoleic acid but linolinic acid not affected. Also it has been proved in Tables (5 & 6) that spraying tested cultivars with antitranspirants did not affect fatty acid composition and content.

The combined effect between salinity levels and antitranspirants (koalin, calcium carbonate and paraffin wax) on the two tested cultivars, showed that the highest value for saturated fatty acids was attained when salinity in irrigation water reached 2.3 dSm^{-1}, although at salinity level of 4.7 dSm^{-1} the peaks corresponding to arachidic and stearic acids disappeared even in the presence of antitranspirants for both tested cultivars.

Discussions: As expected increasing salinity levels in irrigation water led to decrease in most yield parameters i.e. fruit zone length, number of capsules per plant, seed index and oil % of the two tested cultivars namely Giza 32 and Shandaweel 3 such results were in agreement with several researchers[21,1,7,4,12] reported that the presence of sodium in irrigation water increase the exchangeable sodium in the colloidal system of the soil which resulted in the deterioration of soil physical properties which in turn affected the plant growth and productivity, also[19] added that the effect of high salinity levels on yield losses may be due to fact that plants grown under saline environments were directly exposed to osmotic stress resulting from low external water potential induced by high salt concentration in soil.

The present results showed that further increase in salinity level from 0.31 dSm^{-1} (control) up to 2.3 dSm^{-1} caused mostly significant increase in yield parameters, such stimulatory effect of low salinity levels was recorded by[13,6] on different crops. According to presented data it was shown that paraffin wax applied as an antitranspirant had insignificant effect on yield components of sesame plant. While koaline treatment tended to increase sesame yield components, this may be due to the possible increase in photosynthesis due to improving plant water status[14] or to increase movement of photosynthetic assimilate from the leaves towards spikes of wheat. However,[11] reported that, sensitivity to salinity and cultivar response to antitranspirant differ genetically.

In the present study data revealed that when salinity in irrigation water was increased from 3.12 dSm^{-1} for Giza 32 cv. and from 1.5 dSm^{-1} for Shandaweel 3 cv. up to 4.7 dSm^{-1} led to a decrease in oil %, total saturated fatty acids and increased total unsaturated fatty acids content with apparent increase in oleic acid %, above mentioned results might be due to that salinity depress the incorporation of photosynthates into lipids[17]. Also presented data proved that, antitranspirants decreased total saturated fatty acids in both tested cultivars and caused disappearance of the peak corresponding to stearic, Arachidic and Linolinic acids when interacted with the high salinity levels. This may be attributed to an inhibitory effect on desaturation enzymatic system of the treated sesame plants[16,22,8].

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