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Estimating the Performance of Salt-stressed Sesame Plant Treated with Antitranspirants

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Abstract: A pot experiment was conducted at the green-house of National Research Centre, Cairo, Egypt. The experiment included 48 treatments which were the combination of five (1.5, 2.3, 3.12, 3.9 and 4.7 $dS,^{-1}$)salinity levels in addition to the control, three types of antitranspirants (Kaolin, $CaCO_3$ and paraffin wax) and two sesame cultivars namely (Giza 32 and Shandaweel 3). At the flowering stage, low salinity levels of 1.5 and 2.3 dSm^{-1} did not show a significant effect on most of the growth parameters, although higher salinity levels induced a marked significant reduction in all growth parameters. Kaolin was significantly effective in increasing growth especially under 2.3 dSm^{-1} salinity level. Although, Giza 32 cv. Surpassed that of shandaweel 3 cv. in growth parameters but Shandaweel 3 cv. overcame Giza 32 cv. in yield components values. The highest significant values were attained by Shandaweel 3 cv. irrigated with 2.3 dSm-1 and sprayed with Kaolin compared to the control. Increasing salinity showed an increase in CSI%, however application of antitranspirants reduced the CSI%, Kaolin treatment showed the highest reduction in CSI %. Giza 32cv. revealed higher CSI% than Shandaweel 3 cv. The relative water content percentage RWC % of Shandaweel 3 cv. was higher than Giza 32 cv. The highest significant increase in RWC % was recorded for Shandaweel 3 cv. grown under 2.3 dSm^{-1} salinity level and sprayed with Kaolin or paraffin wax.

Key words: Salinity - antitranspirants - growth – yield components - relative water content (RWC%) – chlorophyll stability index (CSI%).

INTRODUCTION

Sesame is an important oil seed crop. The sesame seed has excellent nutritional value having high and unique protein composition making them a nearly perfect food[1].

Crops vary in their relative resistance to salinity. Improving tolerance of crops grown under salinization using antitranspirants has been an important but largely unfulfilled aim to modern agricultural technique.

Antitranspirants are chemical compounds, their role is to practice plants of hardening to stress, as a method of reducing the impact of drought due to salinity. There are different types of antitranspirants, film-forming which stop almost all transpirantion, stomatic which only affect the stomata and reflecting materials[2]. Reducing the transpiration can play a useful role in this respect by preventing the luxurious loss of water to atmosphere via stomata. Recently, efforts have been made to find substances, which when applied to the plant, reduce transpiration, i.e. antitranspirant materials. However, since the processes of transpiration and photosynthesis involve the passage of water vapor and carbondioxide via the stomata, both processes may be affected when these stomata were narrowed or curtailed by antitranspirants application[3]. The purpose of the present study was to determine the effect of salinity, antitranspirants application and their interaction on sesame plant growth, yield and some physiological and biochemical process.

MATERIALS ANS METHODS

A pot experiment was conducted during the summer season of 2001 and 2002 at the green house of the National Research Centre, Dokki, Cairo (Data of one growing season was tabulated), seeds of two pure sesame (Sesamum indicum) cultivars Giza 32 and Shandaweel 3 were sterilized with $HgCl_2$ for three minutes then washed with sterile water and planted in earth ware pots of 30 cm diameter filled with 10kg 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%.

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All pots received recommended dose of NPK fertilizers 2g calcium superphosphate 15% P, 1.68g potassium sulphate 48% K and 2.61g ammonium nitrate 33.5% N and equal amount of organic matter. Three weeks after sowing date plants were thinned to three plants per pot. Seeds were irrigated till emergence of seedlings with tap water to avoid salinization shock on seedlings. Then seedlings were subjected to different salinity levels of NaCl. The pots were arranged in six group [tap water, 1.5, 2.3, 3.12, 3.9 and 4.7 dSm^{-1}] each group included four sets [control (without antitranspirans), 6% Kaolin, 6% Calcium carbonate and 10% paraffin wax], pots were replicated trice in a complete randomized design Antitranspirants were sprayed twice during the plant life cycle once during vegetative stage and another before flowering. Plant samples were collected at two phenological stages, vegetative and flowering for estimating different growth and yield parameters. Relative water content was measured according to[4]. Spectrophotometric method was used for determination of chlorophyll a and b according to[5]. Chlorophyll stability index (CSI%) was calculated according to[6]. Seed oil percentage was estimated according to the extraction method described by[7] means of various treatments were compared by Duncan's multiple range tests[8] at 5% probability level.

RESULTS

Growth Parameters: Obtained results in Table (1) presented a clear comparison between the two chosen cultivars irrespective to salinity and antitranspirants. Giza 32 surpassed that of Shandaweel cv. in plant height, leaf area, number of leaves/plant, root length, plant fresh and dry weights.

The effect of salinity levels on growth characters was presented in Table (2) where it was proved that increasing salinity up to 4.7 dSm^{-1} led to a significant decrease in different growth parameters. The percentages of reduction were 38.8. 24.8, 27.9 and 50.9% in plant height, number of leaves/plant, root length and leaf area respectively, while that of fresh weights of stem, leaves and root the percentages of reduction were 59.6, 57.0 and 76.0% and 66.8, 66.4 and 58.5% respectively for dry weights compared with their controls.

The effect of antitranspirants application on growth characters of sesame chosen cultivars was presented in Table (3). It was clear that using Kaolin revealed significant increase in all growth parameters compared to the control. Kaolin increased each of plant height, leaves number/plant, root length, leafarea, plant (stem, leaves and root) fresh and dry weights by 5.8, 6.8, 3.7, 8.9% (13.7, 11.5 and 9.9 for fresh weight) and (19.4, 11.7 and 12.4% for dry weight).

Moreover, for the combined effect of salinity and antitranspirants on mean values growth parameters were presented in Table (4), data revealed that the highest significant record for growth parameters (plant height, number of leaves, leaf area fresh and dry weights of stem leaves roots) were observed under 2.3 dSm^{-1} salinity level and treated with Kaolin followed by calcium carbonate compared to the control.

Table 1: Growth parameters of sesame cultivars at the flowering stage.

Parameters	Growth parameters				Fresh weight (g)/plant			Dry weight (g)/plant		
Cultivars	Plant height (cm)	No. of leaves/ plant	Root length (cm)	Leaf area (cm^2)	Stem	Leaves	Root	Stem	Leaves	Root
Giza 32	53.54a	21.25a	16.49a	34.68a	11.68a	6.30a	4.03a	1.39a	1.48a	1.12
Shandaweel 3	43.29b	18.10b	15.65b	23.53b	8.38 b	3.90b	2.78b	1.09b	1.03b	1.08

Table 2: The effect of different salinity levels on growth parameters of sesame plant at the flowering stage.

Parameters	Growth parameters				Fresh weight (g)/plant			Dry weight (g)/plant		
Cultivars	Plant height (cm)	No. of leaves/ plant	Root length (cm)	Leaf area (cm^2)	Stem	Leaves	Root	Stem	Leaves	Root
S_0	54.31b	21.38b	16.96c	33.84c	10.63c	5.77bc	4.04b	1.43c	1.46c	1.30b
S_1	58.58a	22.50a	19.60a	35.65b	12.01b	5.92b	4.19b	1.65b	1.62b	1.50a
S_2	59.08a	22.00a	18.76b	36.64a	16.73a	7.61a	5.08a	2.03a	2.03a	1.57a
S_3	44.35c	18.17c	15.15d	49.40d	9.93d	5.27c	3.44c	1.27d	1.11d	0.90c
S_4	40.9d	17.92c	14.13c	22.50c	6.6	3.57d	2.71d	0.57	0.8	0.81c
S_5	33.2	16.08d	12.04f	16.60f	4.29f	2.48	0.97	0.47	0.49f	0.54d

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}

The Figure of the same letters have no significant differences

Table 3: The effect of different antitranspirant types on growth parameters of sesame plant at the flowering stage.

Parameters	Growth parameters				Fresh weight (g)/plant			Dry weight (g)/plant		
Anti-transpirants	Plant height (cm)	No. of leaves/ plant	Root length (cm)	Leaf area (cm^2)	Stem	Leaves	Root	Stem	Leaves	Root
A_0	47.25c	19.06b	15.90b	27.93c	9.48c	5.03b	3.40b	1.17b	1.22b	1.09b
A_1	50.01a	20.36a	16.49a	30.43a	10.79a	5.67a	3.74a	1.39a	1.37a	1.23a
A_2	49.04b	20.06a	16.11ab	29.89b	10.03b	4.98b	3.35b	1.24b	1.25b	1.04b
A_3	47.33c	19.22b	15.76b	28.17c	9.87bc	4.78b	3.19b	1.19b	1.19b	1.04b

A_0 : No antitranspirants A_1 : Kaolin A_2 : Calcium carbonate A_3 : Paraffin wax
The Figure of the same letters have no significant differences

Table 4: The effect of interaction between different salinity levels and antitranspirants on growth parameters of sesame plant at the flowering stage.

Parameters	Growth parameters				Fresh weight (g)/plant			Dry weight (g)/plant		
Interaction	Plant height (cm)	No. of leaves/ plant	Root length (cm)	Leaf area (cm^2)	Stem	Leaves	Root	Stem	Leaves	Root
S_0 x A_0	54	21	16.6	33.61d	10.93eh	5.6	4.2de	1.45eg	1.60df	1.3
S_0 x A_1	54.42	21.8	17	33.95d	10.97eg	6.19	3.99ef	1.38eg	1.37fg	1.3
S_0 x A_2	54.33	21.3	16.6	33.90d	10.42fi	5.64	3.96ef	1.50df	1.45eg	1.3
S_0 x A_3	54.5	21.3	16.7	33.88d	10.19gi	5.65	3.96ef	1.39eg	1.44eg	1.3
S_1 x A_0	57.50cd	21.7	19.1	34.65cd	11.57def	5.92	4.24de	1.48df	1.57ef	1.5
S_1 x A_1	60.67a	23.7	20.1	35.84bc	12.34d	6.27	4.32de	1.85bc	1.69ce	1.6
S_1 x A_2	58.83b	23	19.8	35.81bc	11.97de	5.84	3.99ef	1.65ce	1.63df	1.3
S_1 x A_3	57.33cd	21.7	19.4	36.23b	12.17de	5.66	4.23de	1.62ce	1.58ef	1.6
S_2 x A_0	57.83bc	21	19	35.49bc	14.63c	7.04	4.68cd	1.74cd	2.09ab	1.6
S_2 x A_1	61.67a	23	19.8	37.90a	18.45a	8.62	5.45a	2.43a	2.27a	1.8
S_2 x A_2	60.50a	22.7	18.3	37.90a	16.89b	7.47	5.38ab	2.06b	1.93bc	1.5
S_2 x A_3	56.33d	21.3	18	35.16bc	16.96b	7.29	4.87bc	1.89bc	1.84bd	1.5
S_3 x A_0	42.00i	17	14.5	27.82g	9.35i	8.08	3.15g	1.210fg	1.08hij	0.8
S_3 x A_1	46.5f	16.7	15.6	31.72	10.66fgh	5.45	4.1	1.45eg	1.26gh	1.1
S_3 x A_2	44.92g	19	15.5	29.72f	10.08ghi	5.37	3.36g	1.28fg	1.12hi	0.9
S_3 x A_3	44.00gh	18	15	28.35g	9.64hi	5.18	3.16g	1.16g	0.97ij	0.8
S_4 x A_0	39.50j	17.3	14.3	19.47i	6.37jk	4.23	3.17g	0.63h	0.49k	0.8
S_4 x A_1	43.08hi	18.3	14.3	25.48h	7.39j	4.19	3.47fg	0.67h	0.99ij	1
S_4 x A_2	42.00i	18.3	14.3	24.57h	6.52jk	3.06	2.17h	0.52h	0.88ij	0.8
S_4 x A_3	39.00j	17.7	13.6	20.49i	6.11k	2.77	2.03h	0.47h	0.822j	0.7
S_5 x A_0	32.67k	16.3	12	16.56j	4.09 l	2.34	0.93i	0.49h	0.49k	0.6
S_5 x A_1	33.75k	16.7	12.3	17.61j	4.93 l	2.97	1.09i	0.54h	0.56k	0.7
S_5 x A_2	33.67k	16	12	17.30j	4.31 l	2.48	0.92i	0.45h	0.46k	0.5
S_5 x A_3	32.83k	15.3	11.9	14.92k	3.82 l	2.13	0.94i	0.42h	0.46k	0.3

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
The Figure of the same letters have no significant differences

Table 5: Relative water content (%) of sesame cultivars leaves at the flowering stage.

Cultivars	RWC %
CV_1	59.10 b
CV2	62.94 a

Table 6: The effect of different salinity levels on relative water content (%) of sesame plants leaves at the flowering stage.

Salinity	RWC %
S_0	66.54 c
S_1	67.24 b
S_2	72.35 a
S_3	60.46 d
S_4	51.59 e
S_5	47.93 f

Table 7: The effect of different antitranspirant types on relative water content (%) of sesame plants leaves at the flowering stage.

Antitranspirants	RWC %
A_0	58.75 c
A_1	62.59 a
A_2	60.57 b
A_3	62.18 a

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
CV_1 : Giza 32 CV_2 : Shandaweel 3
A_0 : No antitranspirants A_1: Kaolin A_2 :Calciumcarbonate
A_3 : Paraffin wax
The Figure of the same letters have no significant differences

Relative Water Content (RWC): The percentage of RWC was calculated to determine its change under different estimated factor (cultivars, salinity, antitranspirants and their interaction). In Table (5), the RWC% values of tested cultivars were evaluated, where Shandaweel 3 recorded a higher RWC % of 62.94 than in Giza 32 cv. (59.10) during the growing season. The effect of salinity levels on RWC% was observed in Table (6) where low salinity levels of 1.5 and 2.3 dSm^{-1} led to a significant increase in RWC % and at higher salinity levels of 3.12, 3.9 and 4.7 dSm^{-1} a significant decrease was maintained compared to the control, during the growing season. Spraying plants with chosen types of antitranspirants as in Table (7) showed a significant increase in RWC of sesame plants during the growing sesame. Kaolin increased RWC% by 11.65% while CaCO3 increased RWC % by 3.1% moreover the paraffin wax increased RWC % by 5.84 % as compared to the control.

In Table (8), the effect of bi-interaction between different salinity levels and antitranspirants on leaf RWC % of sesame plant was illustrated which indicated that the interaction between all tested salinity levels and chosen types of antitranspirants led mostly to a significant increase in RWC % compared to the control.

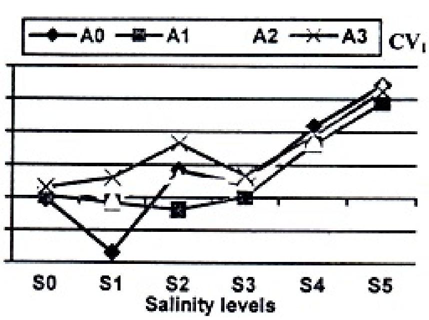
Table 8: The effect of interaction between different salinity levels and antitranspirants on relative water content (%) of sesame plant leaves at the flowering stage

Interaction	RWC %
S_0 x A_0	66.19 g
S_0 x A_1	67.01 fg
S_0 x A_2	66.36 g
S_0 x A_3	66.61 g
S_1 x A_0	66.37 g
S_1 x A_1	68.04 ef
S_1 x A_2	68.59 de
S_1 x A_3	65.96 g
S_2 x A_0	69.72 cd
S_2 x A_1	73.81 b
S_2 x A_2	70.77 c
S_2 x A_3	75.11 a
S_3 x A_0	58.83 j
S_3 x A_1	62.66 h
S_3 x A_2	60.01 i
S_3 x A_3	60.34 i
S_4 x A_0	48.13 m
S_4 x A_1	54.11 k
S_4 x A_2	49.90 l
S_4 x A_3	54.24 k
S_5 x A_0	43.22 n
S_5 x A_1	49.90 l
S_5 x A_2	47.80 m
S_5 x A_3	50.80 l

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_0 : No antitranspirants A_1 : Kaolin A_2 : Calcium carbonate
A_3 : Paraffin wax

Chlorophyll Stability Index (CSI): The CSI indicates how well chlorophyll performs under salt stress conditions.

In Fig. 1 chlorophyll stability index of tested sesame cultivars treated with different types of antitranspirants during the growing season showed some variations in



CV1: Giza 32 CV2: Shandaweel 3
S0 : 0.31 dSm-1 S1: 1.5 dSm-1
S2 : 2.3 dSm-1 S3: 3.12dSm-1
S4 : 3.9 dSm-1 S5 : 4.7 dSm-1
A0 : No antitranspirants A 1 : Kaolin
A2 : Calcium carbonate A3 : Paraffin wax

Table 9: The effect of interaction between different salinity levels and antitranspirant on yield parameters.

Interaction	Plant height (cm)	Fruit zone length (cm)	Number of capsules/ plant	Seed index(g)	Oil(%)
S_0 x A_0	103.00fg	34.00bcd	32.00bc	3.25de	47.00bc
S_0 x A_1	101.50h	33.50cde	31.00cd	3.32de	47.33bc
S_0 x A_2	105.00e	33.00de	30.50d	3.25de	46.84c
S_0 x A_3	93.50 I	34.00bcd	31.50cd	3.49cd	47.34bc
S_1 x A_0	104.50e	32.50e	30.50d	3.35d	47.50bc
S_1 x A_1	109.50c	37.50a	33.00b	3.75bc	47.17bc
S_1 x A_2	107.00d	35.00b	31.50cd	3.57cd	47.17bc
S_1 x A_3	102.50gh	34.00bcd	32.00bc	3.46cd	47.00bc
S_2 x A_0	104.00ef	33.00de	32.00bc	3.54cd	48.33b
S_2 x A_1	119.50a	36.50a	35.00a	3.98ab	49.67a
S_2 x A_2	114.00b	34.50bc	35.00a	4.04a	48.00bc
S_2 x A_3	107.00d	33.00de	32.00bc	3.69c	47.50bc
S_3 x A_0	84.50 l	24.50h	19.00g	2.92f	41.00d
S_3 x A_1	92.50ij	28.50f	23.00e	3.52cd	41.50d
S_3 x A_2	91.50jk	26.50g	21.00f	3.01ef	41.50d
S_3 x A_3	91.00k	23.50h	20.50f	3.02ef	41.34d
S_4 x A_0	74.00p	19.00k	14.00h	1.83i	22.00f
S_4 x A_1	82.50m	22.00i	18.50g	2.17gh	24.00e
S_4 x A_2	78.50n	20.50j	14.00h	2.25g	22.00f
S_4 x A_3	77.00o	21.00ij	14.00h	1.91hi	22.50f
S_5 x A_0	68.00s	15.00m	8.50 k	1.12j	13.83h
S_5 x A_1	72.50q	21.50ij	12.00i	1.74i	16.17g
S_5 x A_2	70.00r	18.50kl	11.33ij	1.82i	15.67g
S_5 x A_3	67.500s	17.50 l	10.00j	1.22j	15.00g

S_0 : 0.31 dS1m^{-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

CSI %, Giza 32 cv recorded higher CSI % values than Shandaweel 3 cv. especially at high salinity levels of 4.7 dSm^{-1} where Giza 32 cv. reached 53%, while that of Shandaweel 3 cv. reached 40%.

Moreover the interaction between different salinity levels and antitranspirant types on sesame yield was recorded in Table (9).

Recorded data proved that Kaolin was so effective in increasing yield parameters under different salinity levels especially under low salinity levels of 1.5 and 2.3 dSm^{-1} compared to the control, followed by CaCO3 while that of paraffin wax did not show a marked difference in any of yield parameters but suppressed yield in many cases.

Discussion: Obtained data for growth characters of the two sesame cultivars (Giza 32 and Shandaweel 3) affected by different salinity levels were significantly increased under low salinity levels of 1.5 and 2.3 dSm^{-1} and it decreased under high salinity levels.[9] recorded stimulatory effect of moderate salinity on growth of some plants, this may be due to the improve of the shoot osmotic status as a result of increasing ion uptake. Also[10] grown two sesame cultivars with different sensitivity to NaCl found that salinity caused marked decrease of shoot growth and clear toxic symptoms in the leaves. Also, obtained data revealed that spraying plants with antitranspirants increased plant grown under saline condition. Highest values for growth characters were recorded for Kaolin followed by $CaCO_3$, while paraffin wax treatment showed insignificant increase compared to control plants. This was explained by several authors as[11] who reported that a film which effectively retards transpiration increases the turgidity of the leaves and stomata guard cells, resulting in wider stomatal aperture. Also[12] indicated that the increase in growth characters of salt treated plants from antitranspirant treatments may be due to their effects on increasing plant water potential at a time when the growth of particular plant part was more dependent on water status than on photosynthesis. For the relative water content R.W.C. (%), was significantly decreased with the increase of salinity. Also obtained results pointed out that Shandaweel 3 cv. had significantly higher relative water content (%) than Giza 32 cv. The use of antitranspirants increased the RWC (%) where the Kaolin was more effective than the other chosen ones. It has been also noted that spraying plants with antitranspirants decreased transpiration and increased the RWC of the leaves. Also[13] stated that antitranspirants use may lead to turgor regulation.

In the present study, the chlorophyll, stability index percentage CSI % increased with increasing salinity, Kaolin treatment showed the highest reduction in CSI % under saline condition for both tested sesame cultivars[14].and[15] reported that plants grown under saline condition are accompanied by low chlorophyllase activity.

Recorded data revealed the superiority of Shandaweel 3 cv. in most yield parameters. Yield and its components were significantly increased by low salinity level of 2.3 dSm^{-1} while further increase in salinity caused a significant decrease in all yield parameters. Kaolin treatment increased the recorded yield components compared to the control followed by $CaCO_3$ although paraffin wax was not so effective.[16] studied the effect of antitranspirants on crop yield, he reported that the increase in yield by using antitranspirants may be attributed to possible increase in photosynthesis due to improving water status of the plant or may be due to reduction in transpiration resulting in higher leaf water status consequently favoring greater photosynthesis and translocation of photosynthates towards grain.

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