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SCREENING NEW SESAME (*Sesamum Indicum L.*) LINES AT TWO LEVELS OF Na Cl INCORPORATED WITH ALGAE FOR SALT TOLERANCE

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Abstract

The development salt-tolerant sesame lines that have the resilient to the effects of climate changes are becoming an urgent need. The screening focuses on the response of 23 lines of sesame grown in a nature field and subjected to two levels of NaCl **(**70 and 105 mM) incorporated with algae. Experiments carry out at the Agricultural Production and Research Station, National Research Center, Egypt for two summer seasons (2017 and 2018). Six traits namely: plant height (PH), stem height to 1st capsule (SHC), fruiting zone length (FZL), number of capsules/m^2 (NC), seed yield/ ha^{-1} (SYH) were used to characterize salinity tolerant. The objectives of investigate were to use algae to reduce the severe effect of salinity on sesame and to identify the lines that best adapt to salinity stress. The experiment was arranged in randomized complete blocks design with three replications for each line in both treatments. The results of combined analysis of variance indicated that interaction between lines and salinity levels was highly significant for studied traits**.** Mean performance of lines for studied traits were negatively affected by levels of salinity with algae compared to normal condition. While irrigation with saline water without algae the lines could not grow, which indicates that algae are important to lessen the negative effect of salinity. The correlation coefficients indicated that select index contains PH, FZL, NC and SYH could be effective to identify the salinity tolerant lines. Two lines, C8.4 and C8.8 showed the best rank and low value of stander deviation than other lines. Final produce from this study was two lines, C8.4 and C8.8 showed promising marks in studies on adaptation to saline stress, and these lines could be use as new sources of salinity tolerance in sesame. .

Key words: Sesame-Salinity-Algae-Correlation-Rank Correlation.

Introduction

The crop sesame in Egypt has a great future as oil crop because possess many advantages than other oil crops, more resilience for climatic changes, drought tolerant and more income for farmers. Sesame protein has a sufficient amount of essential amino acids (methionine, cysteine and tryptophan) compared to soy (Fasuan et al.2018). Sesame oil includes sesamin and sesaminol lignans which have significant role as antioxidative activity (Xu et al. 2005 and Dar et al.2015). It also use as a cooking oil, appetizer, snack**,** and a flavoring agent in some foods (Myint et al.2020) .It has short season and this allows for fast cultivation, intensification, and diversification of agricultural systems (Oyeogbe et al. 2015). Sesame plays a very significant role in maintaining food and nutritional security and livelihood enhanced in developing world. But, water salinization is a major constrained to spread of sesame cultivation in Egypt. Salt aggregation suppresses plant growth and minimizes the activity to uptake water and nutrients (Hanin et al.2016). Injurious effects of Na Cl on sesame seed have been documented by several authors (Koca et al.2007, Bazrafshan and Ehsanzadeh 2014 and Bahrami et al.2016).

Plant breeding is one of the effective ways to keep crop production stable under salinity condition that posed by climatic changes. Development of new lines of oil crops such as sesame adapted to their own environmental stress conditions is important step for the sustainability development. Barhrami, et al. (2016) pointed that for a more realistic response to salt, the tolerance lines must be evaluated in ordinary field soil to facilitate the development of crops abiotic stress tolerant should be evaluated in nature filed to decrease the gab might between the knowledge gained and required. Selection and adaptation of new lines of sesame saline stress is much significant to increase productivity, therefore, this study applied in a nature conditions.

For enhancing productivity of crop at a high level of salinity applied of exogenous growth-promoting compounds such as algae. The algae are release of bioactive compounds in algal extracts including proline, plant hormones, citric and ascorbic acid, can contribute to the mitigation of salinity stress (Ibrahim 2016). Fabio et al. (2014) announced that algae able to compromise with salinity by developed a chemical structural diversity in metabolic pathways.

Correlation coefficients provide a measure of the associations between traits and may be useful as indicators of the more important ones under considerations (Sarwar et al., 2005).To identify of salinity tolerant lines based on a single trait may be not enough; thus, rank correlation, mean rank and standard deviations of ranks for all studied traits will be used (Naghavi et al.2013). The objectives of investigate were to use algae to reduce the severe effect of salinity on 23 advanced lines of sesame and to identify the lines that best adapt to salinity stress.

Material and Method

Study area

The present investigation was carried out at Agricultural Production and Research Station, Al-Nubaria district, Al-Behra Governate, National Research Center (NRC),Egypt during the two summer growing seasons (2017 and 2018). The nature of the soil presented in Table 1. Drip irrigation was applied weekly

Table 1: Physical and chemical properties of the soil of the Nubria

Physical properties				
Soil layer depth (cm)	0–25	25-50	50-75	75-100
Texture	Sandy	Sandy	Sandy	Sandy
Course sand (%)	48.66	55.71	37.76	37.57
Fine sand (%)	48.83	40.58	58.43	57.32
Silt+ clay (%)	2.51	3.71	3.81	5.11
Bulk density (t m-3)	1.69	1.68	1.67	1.69
Chemical properties				
EC1:5 (dS m-1)	0.44	0.53	1.00	1.56
pH (1:2.5)	8.60	8.70	9.32	9.03
Total CaCO3 (%)	7.00	2.34	4.66	5.02

Table 2. The origin, breeding status and description for parents

Lines	Breeding status	Seed source*	Specific characters
P1(HM19)	F8-hybrid pop	Cairo Univ.*	Early maturity, non branching first capsule set low, 3 capsules/axil
P2 (EUL90)	Mutant line	Cairo Univ.*	Early maturity, non-branching, first capsule set low, 3 capsule/axil
P3(Mutant 48)	Mutant line	Cairo Univ.*	Branching, 3 capsules/axil.
P4 (Giza 32)	Local cultivar	Ministry of Agric.& Land Reclamation, Egypt	Heavy seed weight, medium branching, one capsule/axil, long capsule, late maturity.
P5 (NM59)	Exotic line	India through IAEA**	Stiff stem, late maturity, one capsule/axil.
P6 (Babil)	Exotic variety	Iraq through IAEA**	Low branching, 3 capsules/axil, semi- shattering capsules

* Advanced breeding materials resulted from the breeding program conducted at Agron. Dept. Fac. of Agric. Cairo Univ.
* * Inter. Atomic Energy Agency.

Table 3: Analysis of mineral analysis and amino acids of alga Amphora coffeaeformis

Mineral analysis											
Mo	B	Cu	Mn	Zn	Fe	MgO	S	CaO	K2O	P2O5	N
250	100	100	500	1000	1000	0.25	0.8	0.4	1.5	1.5	8.0
CP	TC	EE	TC	AS	FI	MO		-	-	-	-
25.7	23.6	6.4	3.1	18.3	8.6	6.5		-	-	-	-
Amino acids analysis (%)on dry weight basis											
Essential g/100g											
HI	IS	LU	LY	ME	PH	TH	TR	VA		-	-
0.24	0.71	1.29	0.7	0.33	0.87	0.83	3.2	1.1		-	-
Non-essential g/100g											
AL	AR	As	CY	GU	Glycine	PR	SE	TY		-	-
1.5	0.98	1.8	0.22	2.2	1.07	0.67	0.70	0.53		-	-

CP:Crude protein, TC:Total Carbohydrate,EE: Ether extract,TC: Total chlorophyll, AS:Ash, FI:Fibers, MO:Moisture
Essential/100g (HI: Histidine, IS: Isoleucine,LU: Lucien, ME: Methionine, PH: Phenyl Alanine, TH:Therionine, TR:Tryptophan,VA: Valine).
Non-essential/100g (AL: Alanine, AR:Arginine, CY:Cystin, GU:glutamic, GL:Glycine,PR: Proline, SE:Serine,TY: tyrosine.

Breeding materials and experiment design

Breeding materials used in this investigation was comprised of 23 advanced lines of sesame obtained via pedigree selection from a Agronomy Department, Faculty of Agriculture, Cairo University cooperation with Field Crops Research Department, Agricultural and Biological Division, National Research Center. Their parents' description is shown in Table 2.

The namely of lines as follows:C1.3, C1.5, C1.6,C1.8, C1.9, C1.10, C2.2, C2.3, C2.6, C3.4, C3.8,C5.7,C6.3, C6.5, C6.7, C6.9,C8.4,C8.8,C8.11,C9.6,C9.7,C9.15 and C9.20.The experiment was arranged randomized complete blocks design with three replications for each line in both treatments. The plots consisted of 1 row that was 1.5 m long and spaced 0.70 m. For the Na Cl, two concentrations were tested including 70 and 105 mM of NaCl on 23 sesame lines and one check variety (cv. Sohag) in the nature filed. Salinity levels were prepared by the put NaCl in tanks (10 m3) and used to irrigate the lines in a natural saline field. The algae were incorporated in tanks during irrigation in six equal split (at the rate 2 g/L) from germination to flowering stages. Two controls were applied, irrigation with non-saline water as control (C1) and irrigation saline water without algae as control (C2). The recommendations of Agriculture Ministry were applied.

Algae extract specification

The locally isolated Bacillaropyhte alga Amphora coffeaeformis (El-Sayed et al., 2018) was massively produced by Algal Biotechnology Unit (NRC). The obtained biomass was then dried and subjected to produce water soluble extract. Biomass was also oriented to biochemical analysis mainly ash content and amino acids. A description of the properties of algae shown in Table 3.

Data collection:

At harvest, 5 plants were selected in all plots and five traits were measured namely: plant height (cm), stem height to 1st capsule (cm), fruiting zone length (cm), number of capsules/m2, seed yield (t/ ha).

Statistical analysis:

Data were subjected to analysis of variances (Steel and Torrie 1980). Combined analysis of variance for studied traits was implemented.Duncan's Multiple Range Test (Duncan, 1955) was applied. The coefficients of correlation between traits were estimated. These estimations were computed by computer program MSTAT-C (1991).The coefficients of correlation were tested using 'r' tabulated value at n-2 degrees of freedom at 5 % probability level, where n denote as number of lines studied. Rank correlation was calculated according to Spearman (1904) as follows: R= 1- (6ΣD2/ N(N2—1)) Where D is rank x – rank y (i.e. the difference in the ranks) and n is the number of data pairs.

Results and Discussion

Combined analysis of variance for studied traits illustrated in Table 4. The salinity levels, lines and lines by salinity levels interaction variances were decomposed to provide a general formation in relation to the studied traits and mean performance of the genotypes. The salinity levels, genotypes and salinity levels × lines interaction components showed statistically highly significant variation ($p < 0.05$) for the studied traits. This statistical difference was due to both of the main and interaction effects of the lines with salinity levels. Moreover, Table 4 cleared that the response of the lines were unstable and fluctuated in their trait expression under the salinity levels.

The significant differences among genotypes may be due to the variations in their genetic makeup that compelled the lines to exhibits varied behavior under salinity levels. These lines need to evaluation for many years and locations due to significant of interaction between lines and salinity levels.

Table 4: Combined analysis of variance for studied traits at two salt concentrations.

			Traits			
S.V.	D.F	PH	SHC	FZL	NC	SYH
Rep.	2	832.0**	620.6**	451.0**	729.2**	7952.6**
A	1	66654.9**	12788.2**	2105.5**	93051.0**	1732362.6**
B	22	1291.3**	153.6**	787.8**	1465.1**	16777.0**
AB	22	971.5**	289.0**	343.0**	922.3**	12746.0**
Error	90	40.4	17.4	21.0	30.6	503.0
CV%		17.4	27.0	17.0	15.0	15.7

Mse: mean square, A: salinity levels, B: lines, AB: interaction between salinity levels and lines, Plant height (PH), Stem height to 1st capsule (SHC), Fruiting zone length (FZL), Number of capsules/m2 (NB), Seed yield (t/ha) (SYH), Coefficient of variability (cv),** Significant level at 0.05%.

Quantifying the effects of salinity on sesame lines

In this study, we applied the experiments in open field for a more realistic response to salt, the tolerance lines must be evaluated in ordinary field soil to facilitate the development of crops abiotic stress tolerant should be evaluated in nature filed to decrease the gab might between the knowledge gained and required (Barhrami, et al. 2016). Salt tolerance is described as a loop function of yield incline across a range of salt concentrations (Maas and Hoffman, 1977).

Table 5: Mean performance of sesame lines under two concentrations of salinity incorporated with algae for studied traits.

70 mM					
Genotypes	PH	SHC	FZL	NC	SYH
C1.3	55.0	19.0	36.0	110.0	0.219
C1.5	45.0	25.0	21.0	83.0	0.188
C1.6	60.0	25.0	34.0	111.0	0.208
C1.8	58.0	23.0	33.0	109.0	0.207
C1.9	35.0	15.0	20.0	61.0	0.158
C1.10	63.0	30.0	32.0	100.0	0.200
C2.2	65.0	29.0	48.0	130.0	0.225
C2.3	55.0	25.0	30.0	90.0	0.196
C2.6	80.0	25.0	55.0	140.0	0.230
C3.4	52.0	35.0	17.0	59.0	0.155
C3.8	60.0	30.0	30.0	105.0	0.201
C5.7	30.0	20.0	10.0	47.0	0.143
C6.3	53.0	26.0	27.0	88.0	0.191
C6.5	55.0	29.0	26.0	85.0	0.190
C6.7	40.0	30.0	10.0	70.0	0.161
C6.9	69.0	34.0	35.0	110.0	0.216
C8.4	81.0	15.0	65.0	180.0	0.250
C8.8	61.0	10.0	50.0	144.0	0.232
C8.11	70.0	22.0	47.0	133.0	0.222
C9.6	50.0	16.0	31.0	110.0	0.209
C9.7	55.0	27.0	28.0	90.0	0.194
C9.15	69.0	34.0	35.0	127.0	0.210
C9.20	45.0	27.0	18.0	60.0	0.156
$\bar{X}$	56.8	24.8	32.1	101.8	0.198
s	50.0	28.0	22.0	100.0	121.0
LSD $_{0.05}$	18.6	4.3	5.5	13.3	15.1
105 mM					
C1.3	43.5	31.0	14.0	51.0	100.0
C1.5	44.0	33.0	12.0	39.0	88.0
C1.6	52.0	34.0	20.0	57.0	99.0
C1.10	53.0	44.0	9.0	40.0	89.0
C2.2	56.0	41.0	16.0	59.0	105.0
C3.8	55.5	40.0	15.0	60.0	112.0
C8.4	69.0	31.0	38.0	110.0	138.0
C8.8	59.0	31.0	28.0	100.0	125.0
$\bar{X}$	54.0	35.6	18.4	64.5	105.0
S	0.0	0.0	0.0	0.0	0.0
LSD $_{0.05}$	14.3	15.0	16.3	13.0	16.2
C_1	128.0	39.0	88.0	220	800.0
C_2	0.0	0.0	0.0	0.0	0.0

Plant height (PH), stem height to 1st capsule (SHC), fruiting zone length (FZL), number of capsules/m2 (NB), seed yield (t/ha) (SYH), commercial cultivar(S), mean ($\bar{X}$). C1: sowing in normal condition, C2: sowing under salinity conditions without algae

The results in Table 5 depicted differences among the 23sesame lines for studied traits under two levels of salinity. Studied traits were affected by the increase in salt concentration, which varied with lines (Suassuna et al.2017). Studied traits were negatively affected by two levels of salinity with algae compared to C1 While irrigation with saline water without algae (C2) the lines could not grow, indicating that algae have a negative effect on salinity.

The line C8.4 had the highest plant height under two concentrations compared S and C1 may be due to impeding normal metabolic pathways by combination of specific ion (Cl- and Na+) and osmotic and effects. Koca et al.(2007) and Bekele et al.(2017) found that salinity reduced PH. Line C8.8 showed less SHC compared to C1 and S under two concentrations. Wide range of FZL was showed under two levels of salinity whereas, five lines, C8.4, C2.6, C8.8, C8.11 and C2.2 were showed higher aeries (40cm<) than other lines, C1and S. The higher NC and SYH were recorded for two lines, C8.4 and C8.8 compared to C1 and S under two concentrations.Reduction in the NC and SYH may be due to reduction in the PH (Gaballah et al.2007 and Bahrami et al.2016).

Under 105 Mm, 8 out of 23 lines were completed their life cycle while commercial cultivar (S) did not. And the same two lines (C8.4 and C8.8) were higher, lower SHC, longer FZL, more NC and higher SYH than other lines. The reason for this may be due to these lines switch genes for salinity tolerant in the presence of algae. Islam et al. (2016) pointed that exposure to salt and biotic factors were decreased sesame seed yield ha-1 around 300–400 kg/ha. Aghajari et al.(2014) found that grains being decreased by 66% when plants were irrigated with water of 55 mM of Na Cl compared to normal condition. Mahmood et al. (2003) pointed that seed yield decreased under high salinity level caused by the abscisic acid, because ABA synthesis in plants under saline stress, as a result, the flowers and fruits fall down. Reduction in the seed yield/ha-1 under salinity conditions may be due to many reasons: it could be due to drought stress caused by the salt effect on water system in plant tissues and cell magnification and increase in leaf senescence and abscission (Jaleel et al. 2008),ionic imbalances (Khan et al.2000), reduction in protein synthesis and chlorophyll content (Srivastava et al.2008).As a result, decrease in cell division,wilting ,closure of stomata and decrease of water content in the cell (Tester and Davenport 2003). From this study, two lines (C8.4 and C8.8) showed a good performance for studied traits under salinity levels compared to check variety, so it could be use as new sources of salinity tolerance in sesame.

Effects of algae on salinity level

Algae extract found that able to overcoming the adverse effects of saline stress on plants, possibly due to the presence of proline in algae (Table 3). Algae help the plant tolerate the stress (Pazuki et al.2015 and El-Sayed et al. 2018).Algae were early considered as an important group of microorganisms capable of fixing atmospheric nitrogen in addition enhance the tolerance to stress conditions (Ghalab and Salem, 2001). Algae cause significant increase in root growth, fresh and dry weights of roots, total biomass, yield component, photosynthetic pigments and growth promoting hormones (Abdel-Maguied et al., 2004 and Enan et al.2016). Algae extract was considered as a source of nutrition for sustainable agriculture especially in the newly reclaimed soil. Chemical analysis of algae extract revealed the presence of a wide variety of plant growth regulators such as auxins and cytokinins (Zhang and Ervin, 2004) which in turn stimulate root establishment, root elongation and promoting vegetative growth of plants. In addition, algae extract induce many positive effects in concern improve crop yield and quality, increase nutrient uptake, resistance to frost and stress conditions. As a result of the functional activity, there is an increase of photosynthetic apparatus through raising the contents of total carbohydrates, starch, amino acids and protein (Raupp and Oltmanns, 2006 and Yassen et al., 2007). In this study we found that algae have a negative effect on the high salinity level in sesame production. Thus, sesame can be grown in areas affected by salinity.

Correlation analysis

To determine traits more related to seed yield under stress, the correlations between studied traits were calculated. Sserumaga et al. (2018) pointed that direct selection for high seed yield in normal condition may be leads to improve seed yield in stress condition. Data in Table 6 showed that PH had positive and highly significant correlation with FZL, NC and SYH.

FZL was positively correlated with NC and SYH while non significant negative correlation was found between SHC and FZL. As expect, the highest positively correlated recorded between NC and SYH because NC is the main component of sesame seed yield components. The significant of correlation coefficients under two concentrations were same. In short, the select index that contains traits, PH, FZL, NC and SYH will be effective to identify the salinity tolerant lines of sesame.

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Ranking of lines for salt tolerance

To identify of salinity tolerant lines of sesame based on a single trait may be not enough therefore, rank, mean rank and standard deviations of ranks for five traits were calculated (Table 7).

The results in Table 7 indicated that two lines, C8.4 and C8.8 recorded the best rank and low SD than other lines under two concentrations, consequently classified as the most salinity tolerant lines. Bekele et al.(2017) ranked accessions of Ethiopian sesame for salt tolerance based on nine traits while both Farshadfar et al., (2012) and Naghavi et al., (2013) were used the rank correlation to identify of drought tolerant in wheat and maize.

Table 6: Simple correlation between studied traits at two concentrations of salinity

Traits	SHC	FZL	NC	SYH
		70 mM		
PH	0.27	0.85**	0.62**	0.60**
SHC		-0.26	0.21	25.0
FZL			0.51**	0.47**
NC				0.93**
		105 mM		
PH	0.10	0.81**	0.84**	0.85**
SHC		-0.59**	0.25	0.27
FZL			0.96	0.92
NC				**0.97**

Plant height (PH), stem height to 1st capsule (SHC), fruiting zone length FZL), number of capsules/m2 (NB), seed yield (t/ha) (SYH), ** P <0.05

Table 7: Rank, ranks mean (R) and standard deviation of ranks (SD) of new sesame lines for studied traits under 70 and 105 mM of NaCl incorporated with algae in nature field.

				Traits			
Genotypes	PH	SHC	FZL	NC	SYH	R	SD
			70mM				
C1.3	13.0	5.0	19.0	11.0	7.0	11.0	5.5
C1.5	21.0	10.0	18.0	19.0	18.0	17.2	4.2
C1.6	8.0	11.0	9.0	7.0	9.0	8.8	1.5
C1.8	10.0	9.0	10.0	13.0	10.0	10.4	1.5
C1.9	23.0	3.0	20.0	21.0	21.0	17.6	8.2
C1.10	7.0	9.0	7.0	14.0	13.0	10.0	3.3
C2.2	6.0	8.0	5.0	4.0	3.0	5.2	1.9
C2.3	14.0	12.0	12.0	15.0	15.0	13.6	1.5
C2.6	2.0	13.0	2.0	5.0	2.0	4.8	4.8
C3.4	12.0	23.0	22.0	23.0	22.0	20.4	4.7
C3.8	9.0	19.0	13.0	12.0	11.0	12.8	3.8
C5.7	24.0	6.0	23.0	24.0	23.0	20.0	7.8
C6.3	17.0	14.0	15.0	17.0	17.0	16.0	1.4
C6.5	15.0	18.0	16.0	18.0	19.0	17.2	1.6
C6.7	19.0	15.0	24.0	20.0	8.0	17.2	6.1
C6.9	4.0	20.0	7.0	8.0	14.0	10.6	6.4
C8.4	1.0	2.0	1.0	1.0	1.0	1.2	0.4
C8.8	8.0	1.0	6.0	2.0	4.0	4.2	2.9
C8.11	3.0	7.0	4.0	3.0	12.0	5.8	3.8
C9.6	17.0	4.0	11.0	9.0	16.0	11.4	5.3
C9.7	11.0	17.0	14.0	16.0	5.0	12.6	4.8
C9.15	5.0	22.0	8.0	6.0	20.0	12.2	8.1
C9.20	22.0	16.0	21.0	22.0	24.0	21.0	3.0
S	18.0	16.0	17.0	10.0	6.0	13.4	5.2
			105mM				
C1.3	8.0	2.0	6.0	6.0	4.0	5.0	2.6
C1.5	7.0	4.0	7.0	8.0	8.0	6.4	2.5
C1.6	6.0	5.0	3.0	5.0	5.0	4.4	1.3
C1.10	5.0	8.0	8.0	7.0	7.0	7.0	1.2
C2.2	3.0	7.0	4.0	4.0	4.0	4.0	0.7
C3.8	4.0	6.0	5.0	3.0	3.0	4.2	1.3
C8.4	1.0	3.0	1.0	1.0	1.0	1.2	0.4
C8.8	2.0	1.0	2.0	2.0	2.0	2.2	0.4

Plant height (PH), stem height to 1st capsule (SHC), fruiting zone length (FZL), number of capsules/m2 (NB), seed yield (t/ha) (SYH), S:commercial cultivar, R: ranks mean, SD: standard deviation of ranks.

Conclusion

In this study, 23 advanced lines of sesame were screened in a nature field at two levels of Na Cl (70 and 105 mM) with add algae for five traits. We found that sesame lines respond differently to salt stress. Five traits were negatively affected by salinity levels with add algae. But at high level of salinity without algae the lines did not grow indicated that the significant role of algae on salinity stress may be due to release of bioactive compounds which contributed to the mitigation of salinity stress or contributed to catalyzed genes in lines. Based on overall and ranks of studied traits two lines, C8.4 and C8.8 were promising for studies on adaptation to saline stress in sesame.

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