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Seedling parameters as affected by seed priming of some safflower cultivars under salinity stress

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Key words: Safflower cultivars, Seed priming, Salinity levels, Seedling characters.

Abstract

A laboratory experiment was conducted at Giza Central Seed Testing Laboratory of Central Administration for Seed Certification (CASC), Ministry of Agriculture, Egypt. Seedling parameters *i.e.* shoot and root length, shoot and root fresh weights, shoot and root fresh dry weights; seedling height reduction and relative dry weight were estimated. Highest averages of shoot and root lengths, shoot and root fresh weights, shoot and root dry weights, seedling height reduction and relative dry weight were produced from seed priming in NaCl or KNo_3. Line 168 cultivar surpassed other studied cultivars in of shoot and root length, shoots and root fresh weights, shoots and root fresh dry weights, seedling height reduction and relative dry weigh. Increasing salinity levels from 0 to 3, 6, 9, 12, 15 and 18 dSm^{-1} NaCl significantly decreased all studied characters except seedling height reduction percentage which was increase. Shoot length, shoot and root fresh weights, root dry weights, seedling height reduction and relative dry weight significantly affected by the interaction between seed priming treatments and cultivars. Shoot length, shoot and root fresh weights, shoot and root fresh dry weights, seedling height reduction and relative dry weight significantly affected by the interaction between cultivars and salinity concentrations, by the interaction among seed priming, cultivars and salinity concentrations. It could be concluded that seed priming in in NaCl or KNo_3 of Line168 or Line 1697 cultivars were more tolerant to salinity stress, which must be put in breeding program of safflower for enhancing of safflower productivity under salinity conditions.

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Introduction

Safflower *Carthamus tinctorus* L. has been grown commercially as one of the oldest oil-seed crop. Therefore, it is suitable for newly reclaimed soils where other oil-seed crops are difficult to grow. To reduce the gap between production and consumption of oil crops to face the universe consumption of oil requirements. So, it must be increase oil crops cultivated area such as safflower in saline New Reclaimed soils. Priming safflower seed is one of seed enhancement technique that might be resulted in increasing seed emergence under salinity stress condition. Seed priming is an effective technique that improves germination of several crops under saline conditions. In this respect, Kaya *et al.* (2006), Saadateyan *et al.* (2009) and Bajehbaj (2010) concluded that hydro priming increased germination and seedling growth under salt and drought stress. EL-Saidy *et al.* (2011) found that seed priming treatments improved seedling length and seedling dry weight. Elouaer and Hannachi (2012) showed that NaCl and KCl priming seed have improved seedling growth parameters *i.e.* radical and seedling length, seedling fresh and dry weight and vigor index. Moghanibashi *et al.* (2012) showed that hydro priming for 24 h increased root and shoot length, root and shoot weight of seed sunflower as compared with the control treatment. Moghadam and Mohammadi (2013), Nawaz *et al.* (2013), Nawaz *et al.* (2013) and Moghadam and Mohammdi (2014) reported that seed priming of safflower improves germination, reduces seedling emergence time, and improves stand establishment. They concluded that hydro priming significantly be helpful in order to obtain good crop establishment. Hussian *et al.* (2014) showed that the importance of seed vigor and role of seed enhancement treatments in a biotic stress tolerance. Khomari *et al.* (2014) reported that pretreatment increased seedling length. Recently, Khajeh *et al.* (2015) showed that highest seedling length, vigor index, catalase and ascorbate peroxidase were attained from priming by gibberellins, under non-aged conditions.

A salt tolerance of safflower cultivar is usually the results of a combination of different physiological mechanisms. Environmental stress, especially salinity stress can play an important role in reduction of germination and seedling characters. Safflower cultivar different in their response to salinity level. In this respect, Jamil *et al.* (2006) and Siddiqi *et al.* (2007) indicated that salinity caused a significant reduction in root, shoot lengths and fresh root, and shoot weights. Nikbakht *et al.* (2010) and Brasileira (2011) showed that salt stress had a significant influence on radical length, dry weight, fresh weight and shoot length in laboratory conditions. Çulha and Çakırlar (2011) and Khodadad (2011) reported that salt stress adversely affected the shoot length, root length, seedling length and root/shoot length ratio of all 6 genotypes of safflower, which demonstrates high diversity among genotypes that enabled us to screen salinity tolerant cultivar. Mahdavi *et al.* (2011)showed osmoticpotential significantly decreased length and weight of root and shoot. Elouaer and Hannachi (2012) point out that growth parameters radical and seedling length, seedling fresh and dry weight of safflower under saline conditions. Ghazizade *et al.* (2012) showed salt stress affected significantly on root length, shoot length, fresh weight and dry weight of seedlings. Basiri *et al.* (2013) showed that salinity decreased length, fresh and dry weights of radical and plumule were measured and radicle was more sensitive to salinity stress thanplumule. Salinity resulted from NaCl had the greater negative effect on the seedling characteristics than $CaCl_2$ salinity. Jabeen*et al.* (2013a) showed that increasing salinity stress from 3.4 to 10.8 dSm^{-1} significantly decreased length and weight of root and shoot. Panahi *et al.* (2013) showed that salt stress adversely affected significantly on of root length, root fresh weight and shoot fresh weight. Soheilikhah *et al.* (2013) indicated that the accumulation of Na^+ ions and osmolytes could play an important role in osmotic adjustment in safflower cells under saline stress. Give *et al.* (2014) showed that increasing salt stress adversely affected shoot length, root length, seedling length and root shoot length ratio of all six genotypes of safflower.

Jajarmi *et al.* (2014) indicated salinity stress effects on the root length more than -12 bar causes the reduction in root length. Recently, Yari *et al.* (2015) point out that NaCl caused lower root and shoot length.

It is very important to study the interaction between seed priming treatments on studied safflower cultivars as affected on seedling parameter. In this respect, Bajehbaj (2010) showed that total emergence of seedlings from both priming and non-priming seeds decreased with increasing NaCl salinity. EL-Saidy *et al.* (2011) reported that seed priming improved seedling length and seedling dry weight in both Sakha 53 and Giza 102 cultivars. Gaballah and El Meseiry (2014) stated that Vidoc cultivar seeds showed partial response to priming in saline solution. Bajehbaj (2010) showed that total emergence of seedlings from both priming and non-priming seeds decreased with increasing NaCl salinity. Elouaer and Hannachi (2012) showed that NaCl and KCl priming have improved germination parameters i.e. growth parameters i.e. radical and seedling length, seedling fresh and dry weight and vigor index of safflower under saline condition. Pahoja *et al.* (2013) point out that hydro-priming recorded highest mean values for most traits viz seed germination percentage, germination rate, germination index, seedling vigor index, root/shoot length, root/shoot fresh weight and root/shoot relative water content under various concentrations i.e. 0.1, 0.5, 1.0, 1.5 and 2.0% of NaCl. Ashrafi *et al.* (2015) concluded that hydro priming enhanced germination under both salt and drought stresses and non-stress condition. Therefore, the specific objectives of this investigation was aimed to evaluate performance seed priming of some safflower cultivars in response to different levels of NaCl salinity. Safflower germplasms display a spectrum of salt tolerance capability from high too low for increasing oil crops area in newly reclaimed soils.

Materials and methods

A laboratory experiment was conducted at Giza Central Seed Testing Laboratory of Central Administration for Seed Testing and Certification, Ministry of agriculture, Egypt during April and May 2014, to study the response of seed priming of some safflower *Carthamus tinctorus* L. cultivars to germinate under salinity concentrations.

Treatments and experimental design

The experiment was arranged in factorial experiment in Randomized Complete Block Design in four replications. The experiment include the experiment included three factors, the first one includes three levels i.e. priming in NaCl or KNo_3 and non-priming seed. The second one included three cultivars of safflower *i.e.* Giza 1, Line 168, Line 1697 which were obtained from oil section, Field Research Institute, ARC, Ministry of Agriculture and Reclamation Egypt. Selected cultivars were stored under normal conditions in paper bags. The third factor included seven different NaCl levels plus to the control i.e. 0, 3,6,9,12,15 and 18 NaCl. Each cultivar was immersion for 12 hours in sodium chlorite solution, with 2% NaCl (2 gm/Liter) or with 0.3 % KNo_3 (0.3 gm/ liter) under chamber condition at 25±1°c with darkness**.** Under different NaCl concentrations except the control. Thereafter, the seeds were moistened with distilled water three times. The seeds of primed with NaCl or kNo_3 and non-primed seed of cultivars were sown in paper roll was used fifty seeds per each treatment for each cultivar were allowed to germinate on a roll paper each roll paper was moistened with a water solution at seven different NaCl concentrations except the control. The experiment comprised in 252 roll paper arranged in a factorial experiment in Randomized Complete Block Design (RCBD) at four replications the roll paper was placed in a growth chamber for 14 days at 25 ±1 °c for germination in the dark condition according to ISTA, 2013.

Studied characters

Shoot length: The length of five seedlings from the seed to the tip of the leaf blade were recorded and expressed in centimeters as the shoot length.

Root length: The root length of five seedlings from the seed to the tip of the root and recorded and expressed in centimeters (cm) as the root length.

Shoot fresh weight: Weight of five seedling shoots were measured and expressed in gram (mg) as the shoot fresh weight.

Root fresh weight: Weight of five seedling roots were measured and expressed in gram (mg) as the root fresh weight.

Shoot dry weight: Weight of five seedling shoots were recorded and expressed in gram (mg) after oven drying at 70 °c for 24h according to Ahmadvand *et al.* (2012).

Root dry weight: Weight of five seedling roots were recorded and expressed in gram (mg) after oven drying at 70 °C for 24h according to Ahmadvand *et al.* (2012).

Seedling height reduction (%): The seedling height reduction (SHR) was calculated according to Islam and Karim (2010) using the following equation:

Seedling height at control - Seedling height at saline condition

SHR———————————————----------× 100

Seedling height at control condition 8- Relative dry weight (%): The relative dry weight (RDW) was calculated according to Islam and Karim (2010) using the following equation:

Total dry weight under saline condition

RDW (%) = ———-------———————————— ×100

Total dry weight under control condition

Statistical analysis

All data of this study were statistically analyzed according to the technique of variance (ANOVA) for the factorial Randomized Complete Block Design as published by Gomez and Gomez (1991). Combined analysis was done between seed priming and non-priming to obtain the main effect of seed priming and its interaction with other treatments according to Waller and Duncne (1969). Least Significant Difference (LSD) method was used to test the differences between treatment means at 5 % and 1 % level of probability as described by Snedecor and Cochran (1980).The data were analyzed statistically following RCBD design by MSTAT-C computer package developed by Russel (1986).

Results and discussion

Seed priming effects

Results presented in Table 1 clearly indicated a significant difference due to seed priming treatments of shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight and seedling height reduction.

Table 1. Means of shoot length, root length, shoot fresh weight, shoot dry weight, root fresh weight root dry weight relative dry weight as affected by priming and non-priming.

Treatments	Shoot length	Root length	Shoot fresh weight	Shoot dry weight	Root fresh weight	Root dry weight	Relative dry weight	Seedling height reduction
Non priming	6.34	9.67	26.971	2.165	5.43	0.401	84.08	30.95
Priming in KNo_3	6.58	10.14	27.813	2.250	5.83	0.428	86.17	25.59
Priming in NaCl	6.43	9.82	27.310	2.201	5.62	0.412	85.28	26.17
F-Test	*	**	**	**	*	*	NS	**
LSD 5%	0.09	0.20	0.46	0.028	0.06	0.005	-	0.0

The results clearly indicated that seed priming using KNO_3 was produced highest averages shoot length, root length, shoot fresh and dry weight, root fresh and dry weight and relative dry weight. It could be noticed that priming seed in NaCl surpassed non-priming seed in shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight and seedling height reduction by 1.4, 1.5, 1.3, 1.8, 3.5, 2.7and 15.4 %, respectively.

Seed priming had a better efficiency for water absorption from growing media that is why metabolic activities in seed during germination process commence much earlier than radical and plmule appearance (Hopper *et al.*, 1979). Similar findings were reported by Pajehbaj (2010), El-Saidy *et al.* (2011), Elouaer and Hannachi (2012), Moghanibashi *et al.* (2012), Kandil *et al.* (2012e) and Kandil *et al.* (2013), Khomari *et al.* (2014) and Moghadam and Mohammdi (2014).

Table 2. Means of shoot length, root length, shoot fresh weight, shoot dry weight, root fresh weight root dry weight relative dry weight as affected by safflower.

Cultivars	Shoot length	Root length	Shoot fresh weight	Shoot dry weight	Root fresh weight	Root dry weight	Relative dry weight	Seedling height reduction
Giza1	5.39	8.68	24.700	1.978	4.82	0.354	81.81	29.46
Line168	7.39	11.26	30.026	2.615	6.21	0.485	87.76	25.24
Line 1697	6.56	9.69	27.368	2.025	5.84	0.402	85.96	28.01
F-Test	**	**	**	**	**	*	**	**
LSD 5%	0.09	0.20	0.460	0.028	0.06	0.005	1.21	0.20

Table 3. Means of shoot length, root length, shoot fresh weight, shoot dry weight, root fresh weight root dry weight relative dry weight as affected by salinity concentrations.

Salinity concentrations	Shoot length	Root length	Shoot fresh weight	Shoot dry weight	Root fresh weight	Root dry weight	Relative dry weight	Seedling height reduction
0 dSm^{-1} NaCl	9.43	13.16	38.262	2.546	7.10	0.518	100.0	0.00
3 dSm^{-1} NaCl	8.48	11.55	35.313	2.409	6.60	0.475	93.89	10.46
6 dSm^{-1} NaCl	7.86	10.68	32.250	2.315	6.10	0.435	89.74	16.25
9 dSm^{-1} NaCl	6.55	9.73	27.187	2.212	5.82	0.418	85.64	28.34
12 dSm^{-1} NaCl	5.39	9.02	23.509	2.109	5.17	0.391	81.36	36.70
15 dSm^{-1} NaCl	4.28	8.22	19.959	2.021	4.72	0.360	76.96	45.06
18 dSm^{-1} NaCl	3.14	6.79	15.074	1.831	3.87	0.300	68.64	56.18
F-Test	**	**	**	**	*	*	**	**
LSD 5%	0.20	0.29	0.700	0.043	0.09	0.008	1.90	0.30

Cultivars performance

The results in Table 2 clearly showed a significant effect of studied safflower cultivars on averages of shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight and seedling height reduction.

Root dry weight and seedling height reduction Line 168 recorded highest averages of shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, relative dry weight and seedling height reduction.

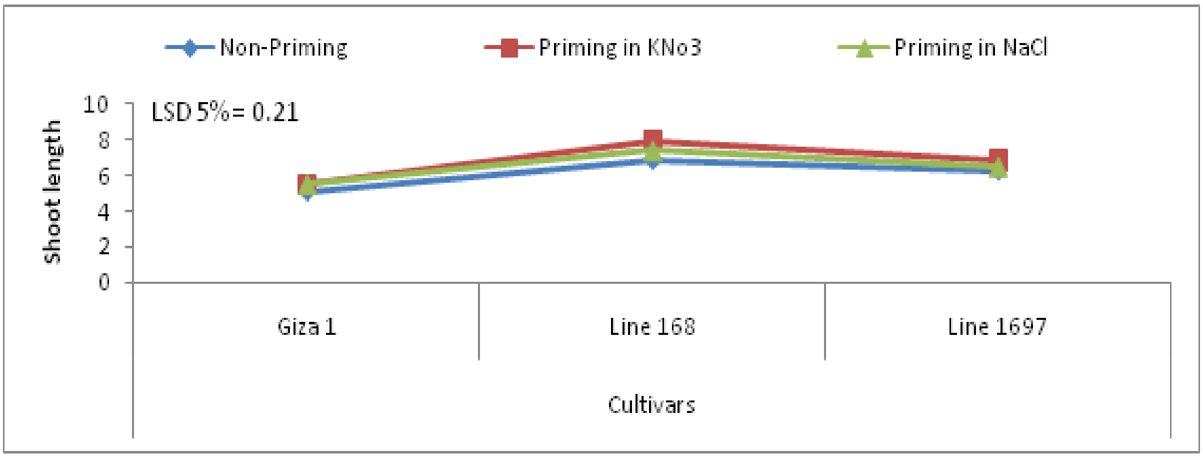

Fig. 1. Means of shoot length as affected by the interaction between seed priming treatments and studied cultivars.

While, the lowest values of these characters were produced from sown Giza 1 cultivar. Line 168 surpassed Line 1697 and Giza 1 cultivar averages in shoot length by 12.7% and 37.1 %. Root length by 16.2% and 29.7%, shoot fresh weight by 9.71% and 21.58 %, root fresh weight by 6.34 % and 28.84 %. Root dry weight by 20.64 and 37.0 %, relative dry weight by 2.09 and 7.27% and seedling height reduction by 4.92 and 14.32 %, respectively, compared with Line 1697 and Giza 1 cultivars.

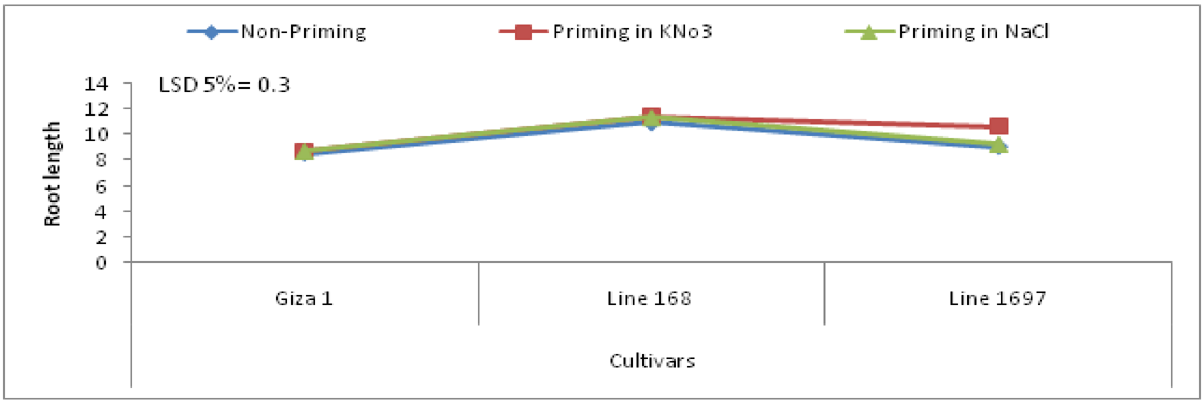

Fig. 2. Means of root length as affected by the interaction between seed priming treatments and studied cultivars.

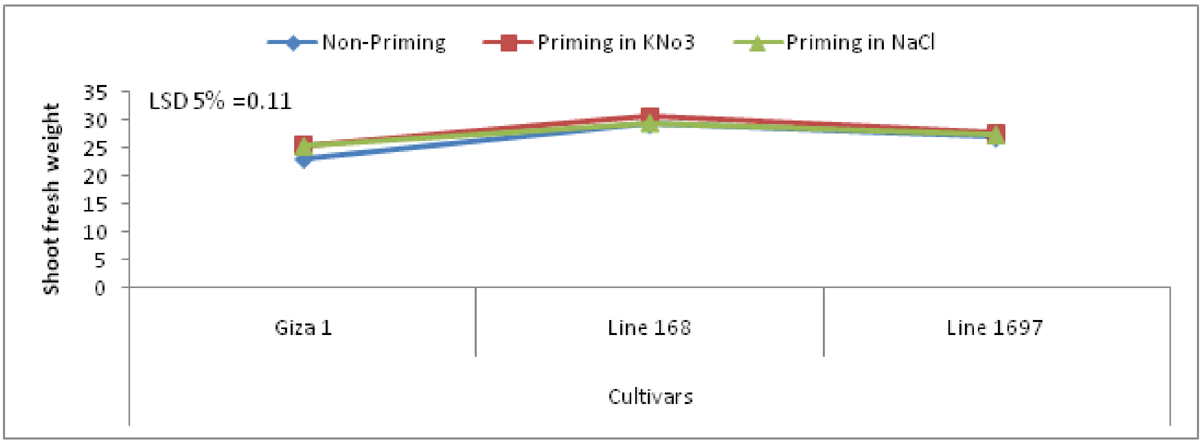

Fig. 3. Means of shoot fresh weight as affected by the interaction between seed priming treatments and studied cultivars.

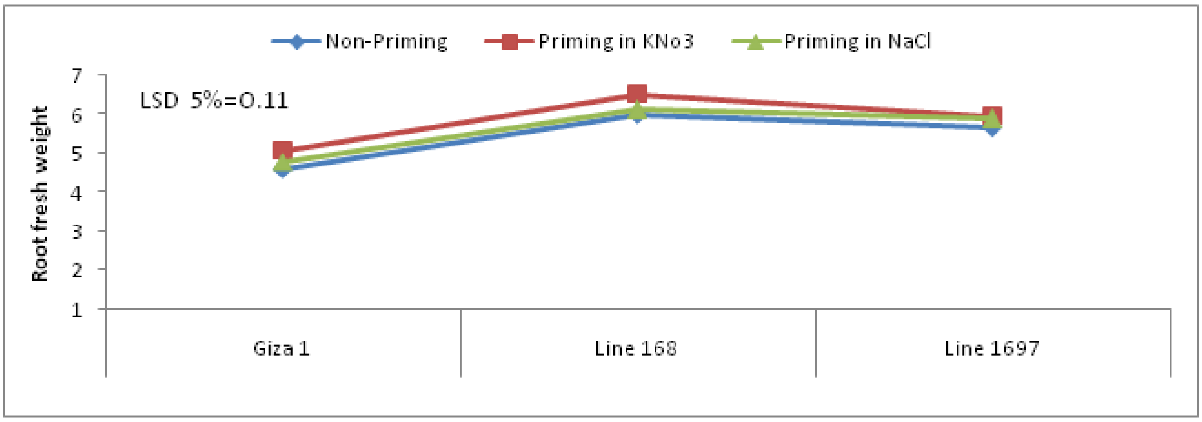

Fig. 4. Means of root fresh weight as affected by the interaction between seed priming treatments and studied cultivars.

The differences between cultivars in seedling parameters might be due to genetically factors and heredity (Ghazizade *et al.*, 2012). These results in harmony with those reported by Brasileira de Sementes (2011), Kaya *et al.* (2011), Elouaer and Hannachi (2012), Ghazizade *et al.* (2012), Kandil *et al.* (2012a) on rice, Kandil *et al.* (2012b) on wheat, Kandil *et al.* (2012a) on rice, Kandil *et al.* (2012b) on wheat, Kandil *et al.* (2012c) on chickpea, Moghanibashi *et al.* (2012) and Jajarmi *et al.* (2014).

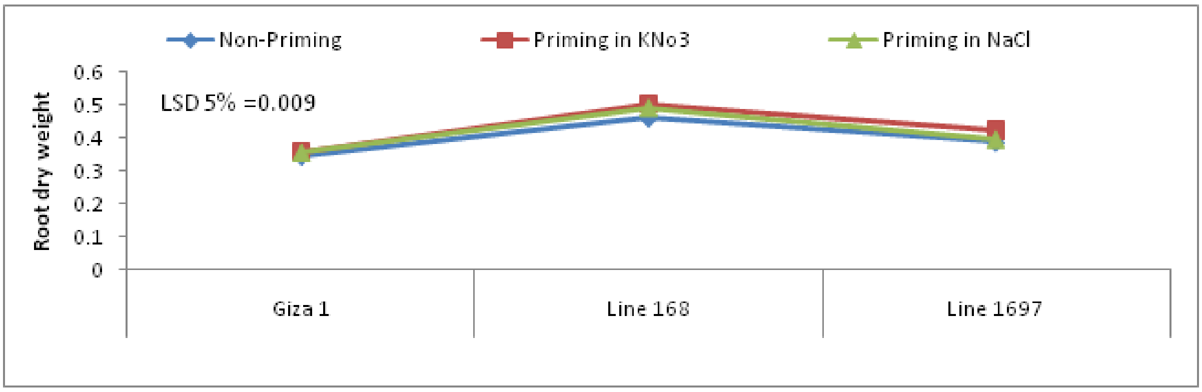

Fig. 5. Means of root dry weight as affected by the interaction between seed priming treatments and studied cultivars.

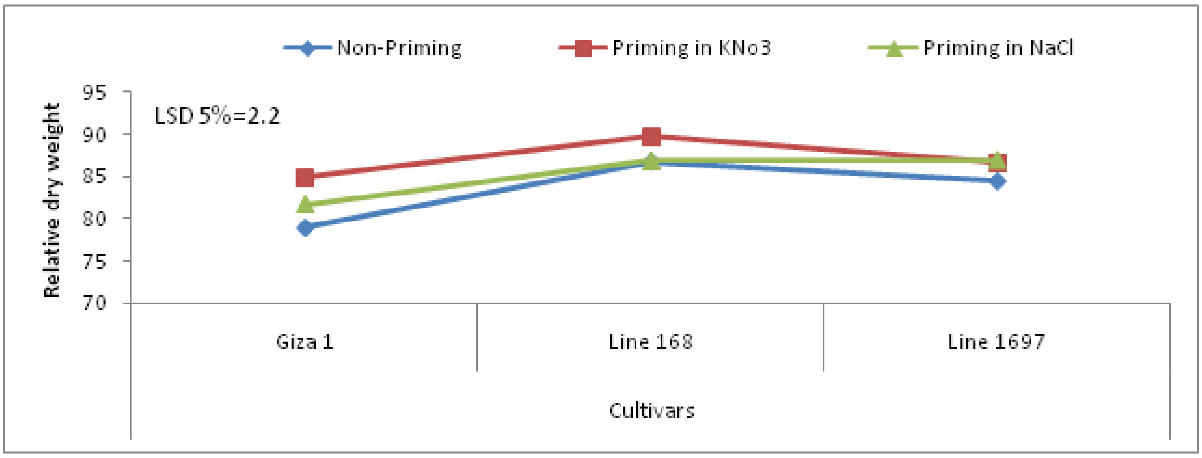

Fig. 6. Means of relative dry weight as affected by the interaction between seed priming treatments and studied cultivars.

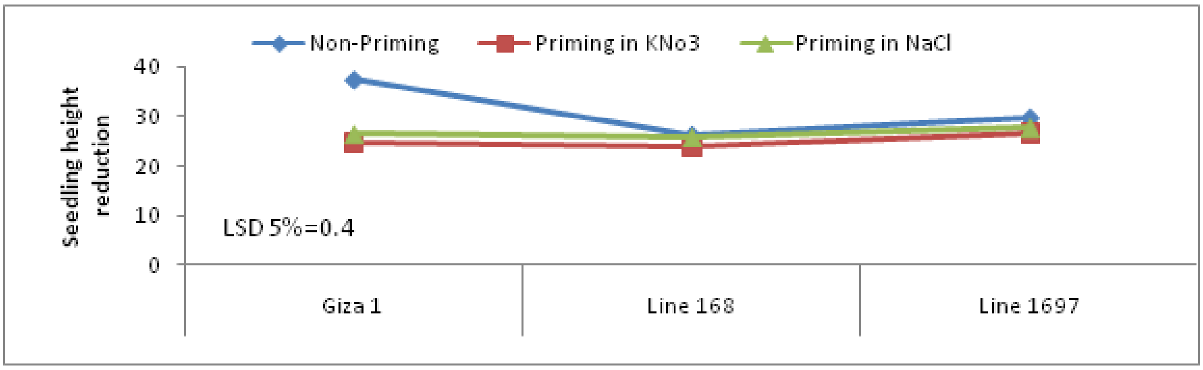

Fig. 7. Means of seedling height reduction as affected by the interaction between seed priming treatments and studied cultivars.

Salinity concentrations effect

Results in Table 3 revealed that salinity concentrations concerning salinity concentrations showed a significant effect on averages of shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight and relative dry weight.

Increasing salinity levels from 3, 6, 9, 12, 15 and 18 dsm^{-1} NaCl reduced shoot length by 10.1, 16.6, 30.5, 42.8, 54.6 and 66.7 %, respectively. Root length by 12.2, 18.8, 26.1, 31.5, 37.5 and 48.4 %. Shoot fresh weight by 7.7, 15.7, 28.9, 38.6, 47.8 and 60.6 %, respectively. Shoot dry weight by 5.4, 9.1, 13.1, 17.2, 20.6 and 28.1 %.

Root fresh weight by 7.1, 14.1, 18.1, 27.2, 33.5 and 45.6 %, root dry weight by 8.3, 16.0, 19.3, 24.5, 30.5 and 42.1 %. Relative dry weight by 6.1, 10.2, 14.4, 18.6, 23.0 and 31.36 %, respectively compared with the control treatment.

In general, increasing salinity causes a decrease in germination this may be due to the toxic effects of Na^+ and Cl^- in the process of germination (Khajeh Hosseini *et al.*, 2003).

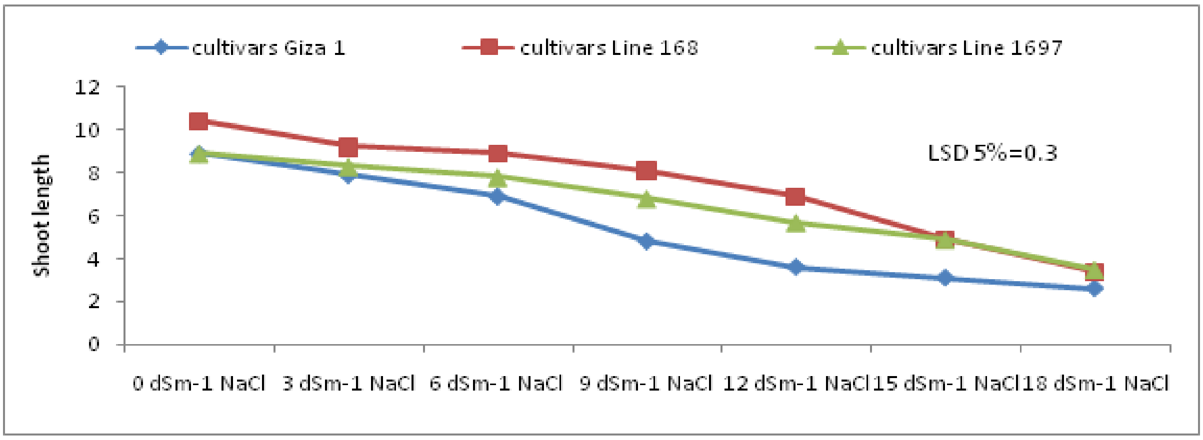

Fig. 8. Means of shoot length as affected by the interaction between studied cultivars and salinity concentrations.

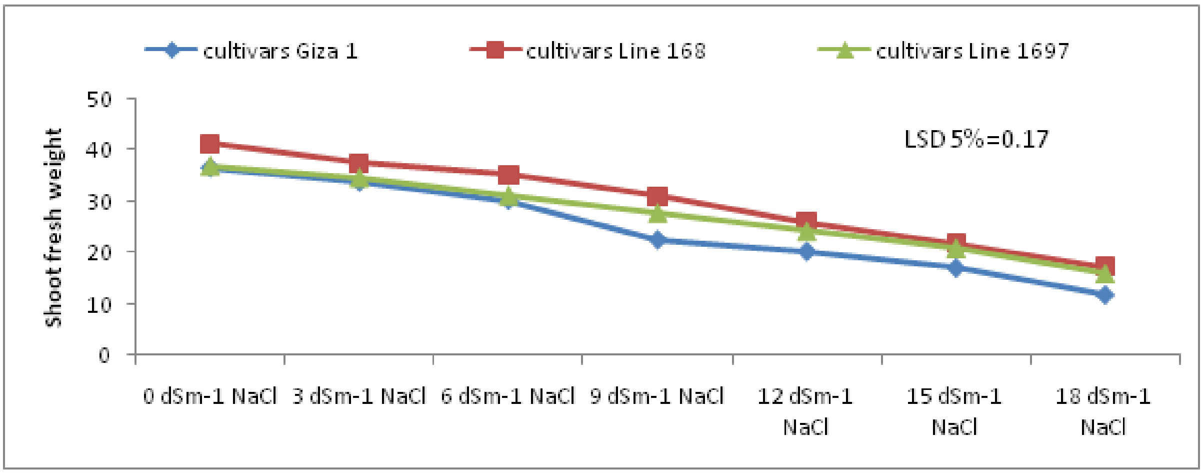

Fig. 9. Means of shoot fresh weight as affected by the interaction between studied cultivars and salinity concentrations.

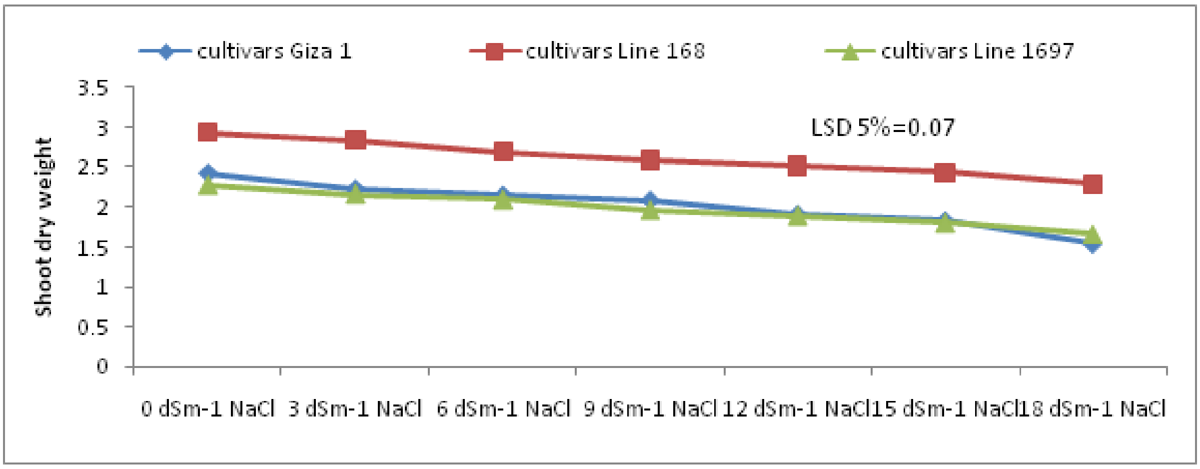

Fig. 10. Means of shoot dry weight as affected by the interaction between studied cultivars and salinity concentrations.

Hajghani *et al.* (2008) showed that salt stress at the germination stage decreases the plumule and radical length and dry weight of plumule, and among applied salt solutions, KC l had minimum negative effect on the length and weight of plumule and radical in safflower.

These results are in harmony with the result of Jamil *et al.* (2006), Nikbakht *et al.* (2010), Brasileira de Sementes (2011), Kaya *et al.* (2011), Mahdavi *et al.* (2011), Elouaer and Hannachi (2012), Ghazizade *et al.* (2012), Basiri *et al.* (2013) and Jabeen *et al.* (2013).

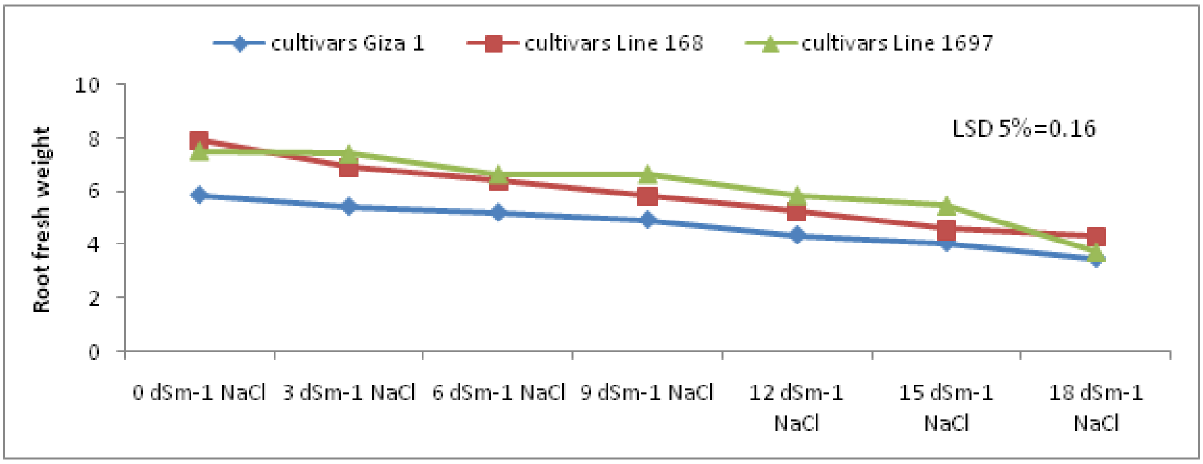

Fig. 11. Means of root fresh weight as affected by the interaction between studied cultivars and salinity concentrations.

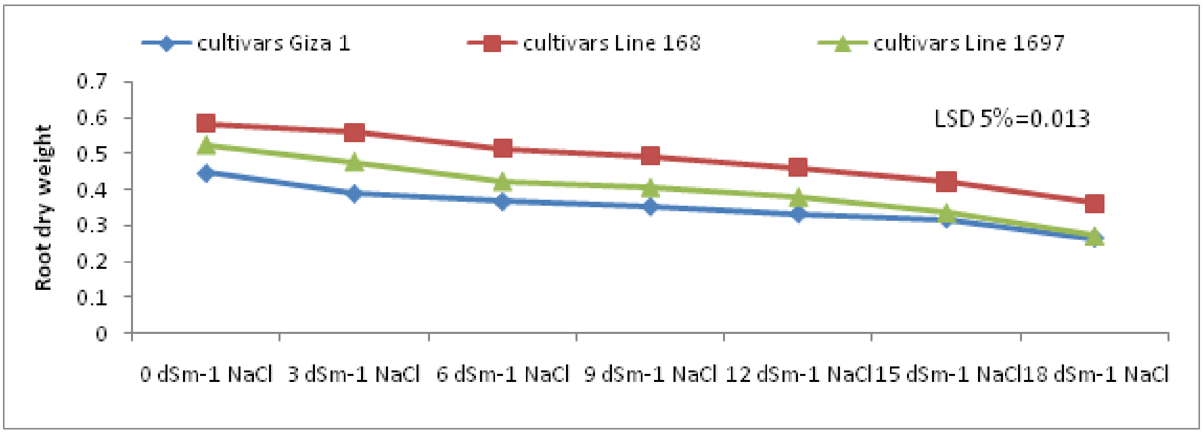

Fig. 12. Means of root dry weight as affected by the interaction between studied cultivars and salinity concentrations.

In addition, the results indicated that increasing salinity levels up to 18 dSm^{-1} NaCl significantly recorded highest seedling height reduction percentage, which was 56.18%. It could be concluded that increasing salinity levels from 0, 3,6,9,12,15 and 18 dSm^{-1} NaCl increased seedling height reduction percentage by 10.46, 16.25, 28.34, 36.70, 45.06 and 56.18 %, respectively compared with the control treatment. Similar results were reported by Kandil *et al.* (2012d) on sorghumand Kandil *et al.* (2013) on sugar beet.

Interaction effects

Regarding to the interaction between seed priming treatments and studied cultivars effects on shoot length, the results illustrated in Fig. 1, clearly revealed that this interaction significantly affected shoot length. Results clearly indicated that tallest shoots were obtained from seed priming with KNo_3 and sown Line 168. However, the shortest shoots were produced from non- primed seed and sown Giza 1 cultivar. The results illustrated in Fig. 2, clearly revealed that this interaction significantly affected root length.

Results clearly indicated that tallest roots were obtained from seed priming with KNo_3 and sown Line 168. However, the shortest roots were produced from non-primed seed and sown Giza 1 cultivar.

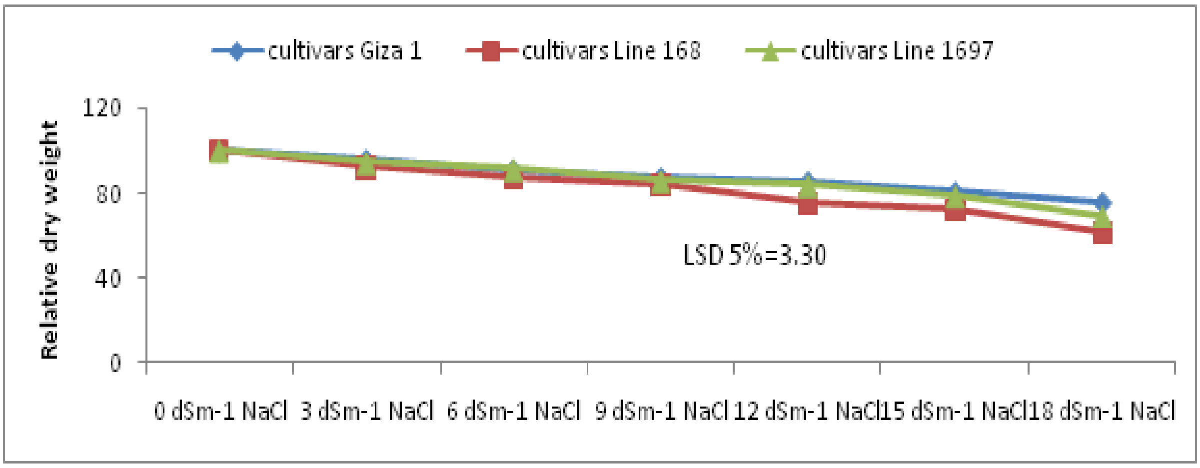

Fig. 13. Means of relative dry weight as affected by the interaction between studied cultivars and salinity concentrations.

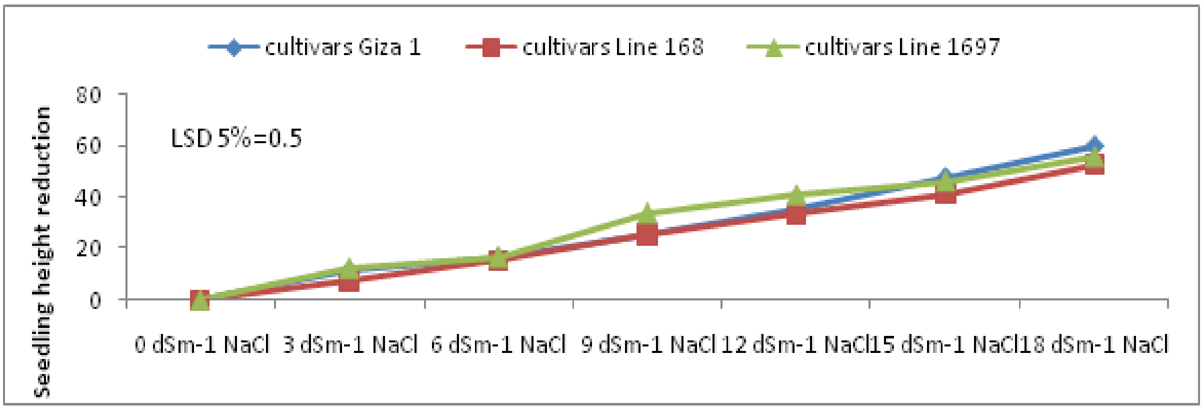

Fig. 14. Means of seedling height reduction as affected by the interaction between studied cultivars and salinity concentrations.

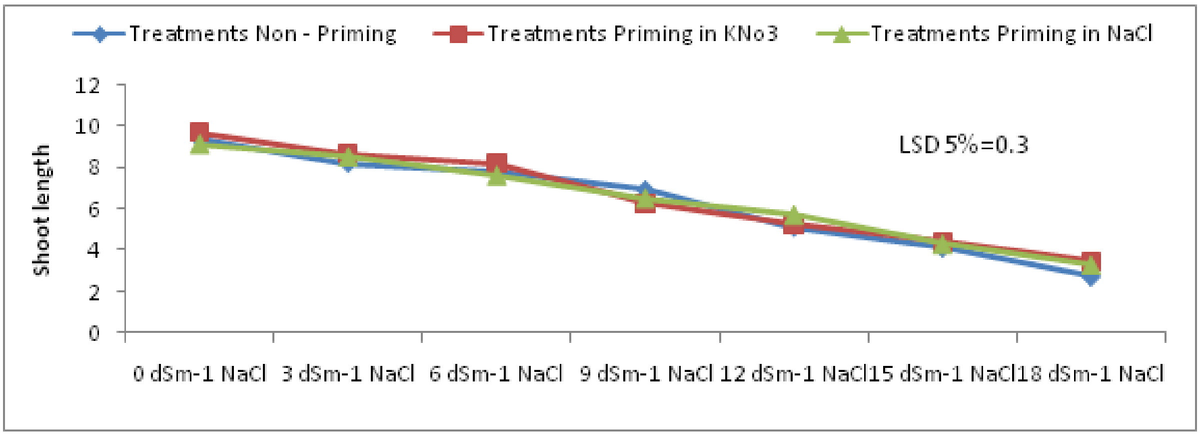

Fig. 15. Means of shoot length as affected by the interaction between seed priming treatments and salinity concentrations.

The results illustrated in Fig. 3, clearly revealed that this interaction significantly affected shoot fresh weight. Results clearly indicated that highest shoot fresh weight were obtained from seed priming with KNo_3 and sown Line 168. However, the lowest shoot fresh weight produced from non- primed seed and sown Giza 1 cultivar.

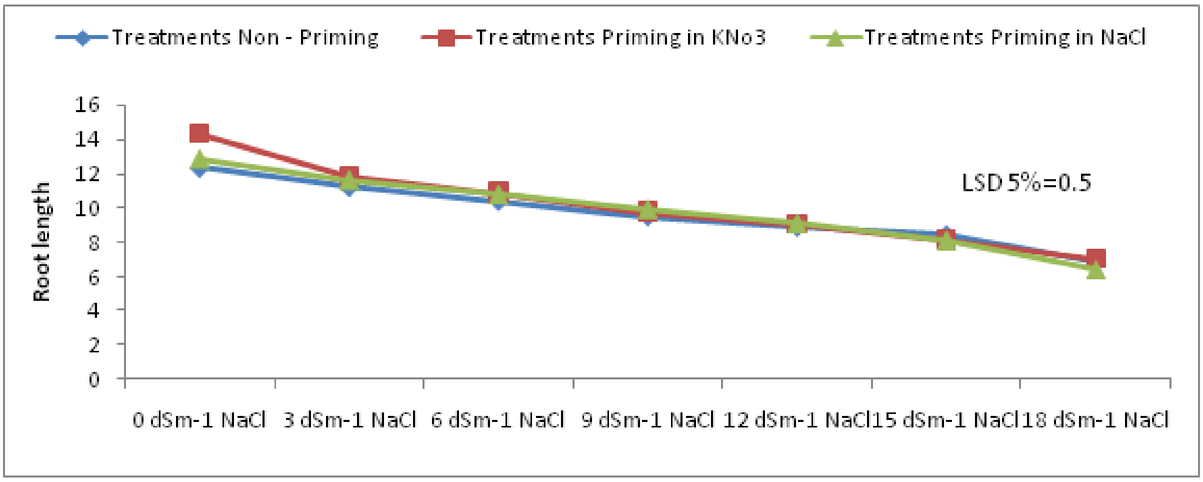

Fig. 16. Means of root length as affected by the interaction between seed priming treatments and salinity concentrations.

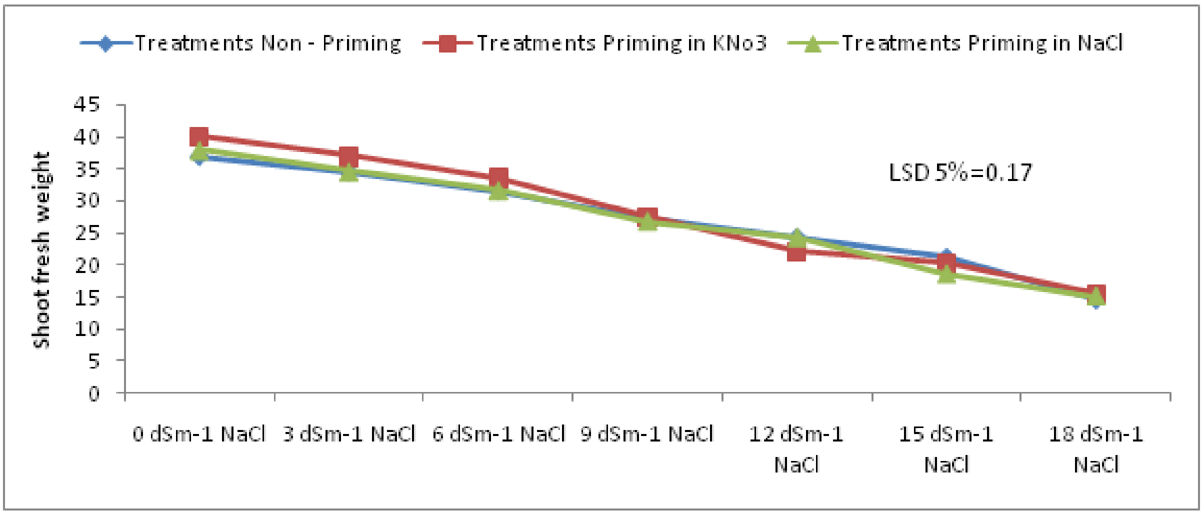

Fig. 17. Means of shoot fresh weight as affected by the interaction between seed priming treatments and salinity concentrations.

The results illustrated in Fig. 4, clearly revealed that this interaction significantly affected root fresh weight. Results clearly indicated that highest root fresh weight were obtained from seed priming with $KNO_3$and sown Line 168. However, the lowest root fresh weight produced from non- primed seed and sown Giza 1 cultivar. The results illustrated in Fig. 5, clearly revealed that this interaction significantly affected root dry weight. Results clearly indicated that highest root dry weight were obtained from seed priming with KNo_3 and sown Line 168. However, the lowest root dry weight produced from non- primed seed and sown Giza 1 cultivar. The results illustrated in Fig. 6, clearly revealed that this interaction significantly affected seedling height reduction. The results clearly showed that of relative dry weight and seedling height reduction were significantly affected by the interaction between seed priming treatments and studied cultivars. Results clearly indicated that highest seedling height reduction was produced from seed priming with KNo_3 and sown Line 168.

The lowest seedling height reduction was produced from non- primed seed and sown Giza 1 cultivar. The results illustrated in Fig. 7, results clearly revealed that this interaction significantly affected seedling height reduction.

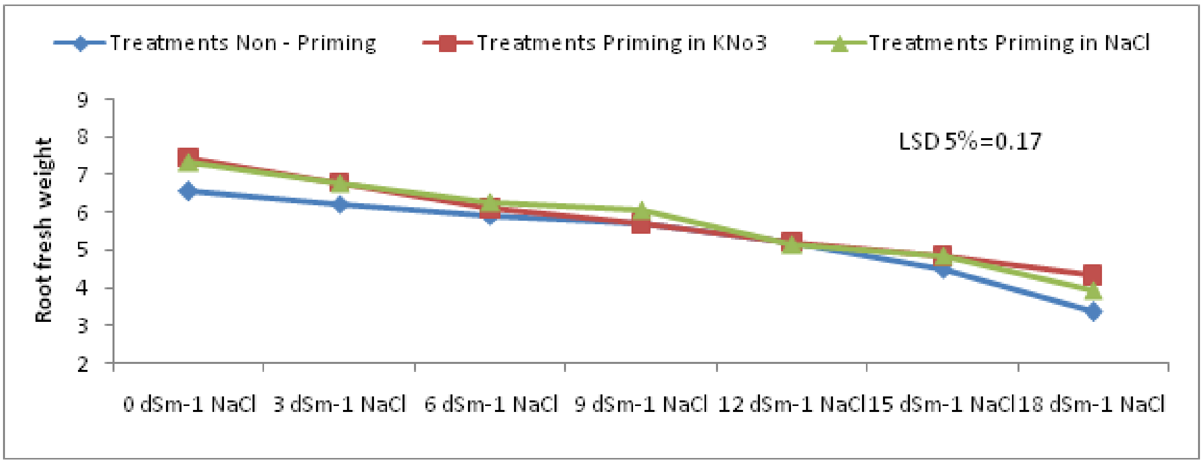

Fig. 18. Means of root fresh weight as affected by the interaction between seed priming treatments and salinity concentrations.

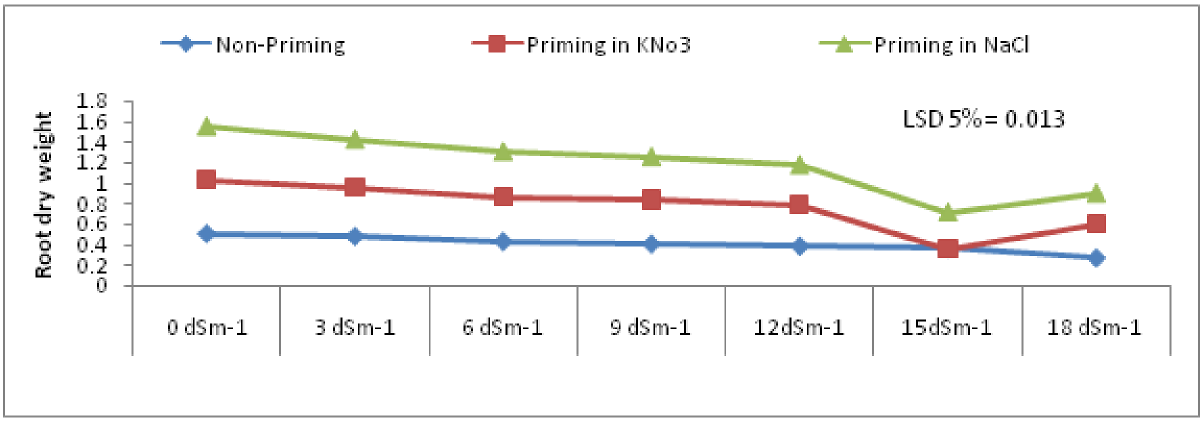

Fig. 19. Means of root dry weight as affected by the interaction between seed priming treatments and salinity concentrations.

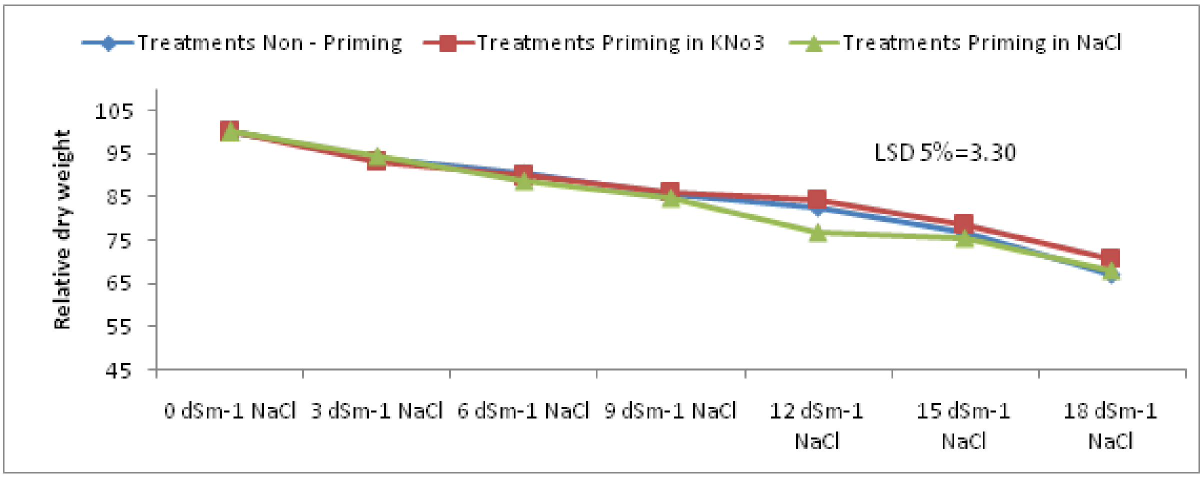

Fig. 20. Means of relative dry weight as affected by the interaction between seed priming treatments and salinity concentrations.

The results showed that highest seedling height reduction were obtained from no-primed seed of Giza 1 cultivar. It could be stated that Line 168 cultivar surpassed other studied cultivars in shoot length, root length, shoot fresh weight, root fresh weight, root dry weight, relative dry weight and seedling height reduction when seed primed with KNo_3. These results in good agreement with those reported by Jamil *et al.* (2006), Nikbakht *et al.* (2010), Brasileira (2011), Elouaer and Hannachi (2012),El-Saidy *et al.* (2011), Kandil *et al.* (2012d) on sorghum, Kandil *et al.* (2013) on sugar beet and Khomari *et al.* (2014).

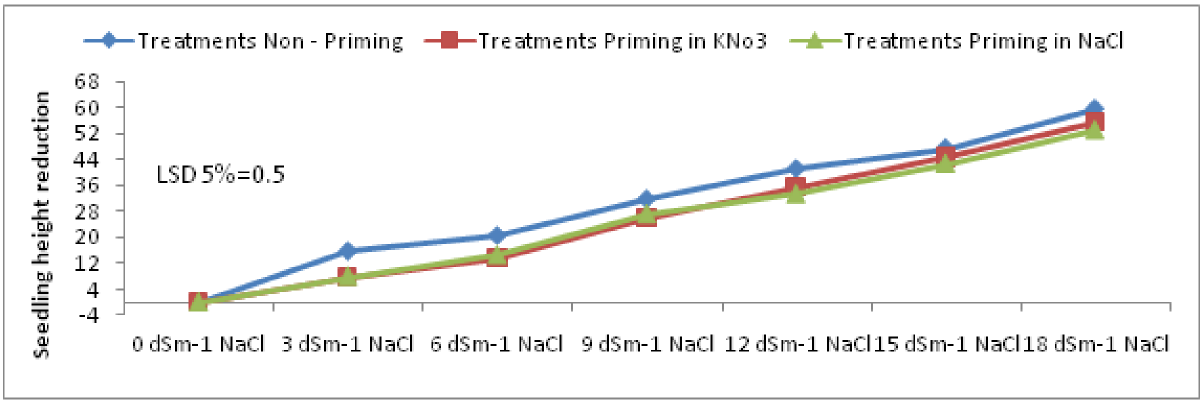

Fig. 21. Means of seedling height reduction as affected by the interaction between seed priming treatments and salinity concentrations.

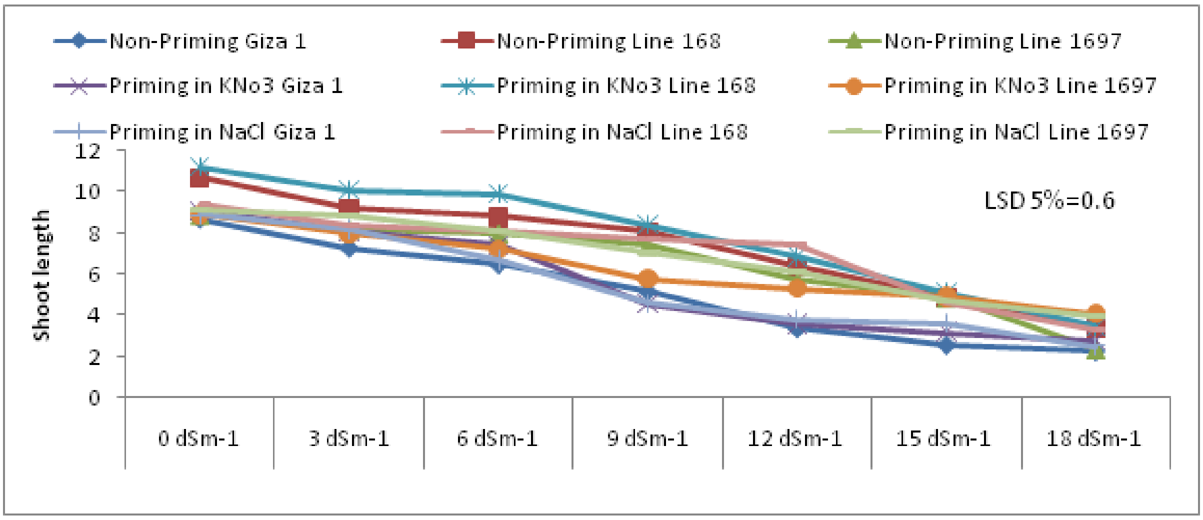

Fig. 22. Means of shoot length as affected by seed priming treatments, studied cultivars and salinity concentrations.

With respect to interaction between cultivars and salinity concentrations effects, the results illustrated in Fig.8 clearly indicated that this interaction significantly affected shoot length The results showed that tallest shoots were produced from Line 168 under the control treatment. The interaction between cultivars and salinity concentrations effects root fresh weight, the results illustrated in Fig.9 clearly indicated that this interaction significantly affected root fresh weight.

The results showed that highest weight of fresh root were produced from Line 168 under the control treatment. The interaction between cultivars and salinity concentrations effects shoot dry weight, the results illustrated in Fig.10 clearly indicated that this interaction significantly affected shoot dry weight. The results showed that highest shoot dry weight were produced from Line 168 under the control treatment.

Concerning to interaction between cultivars and salinity concentrations effects, the results illustrated in Fig.11 clearly indicated that this interaction significantly affected root fresh weight. The results showed that highest root fresh weight were produced from Line 168 under the control treatment. The interaction between cultivars and salinity concentrations effects root dry weight, the results illustrated in Fig.12 clearly indicated that this interaction significantly affected root dry weight.

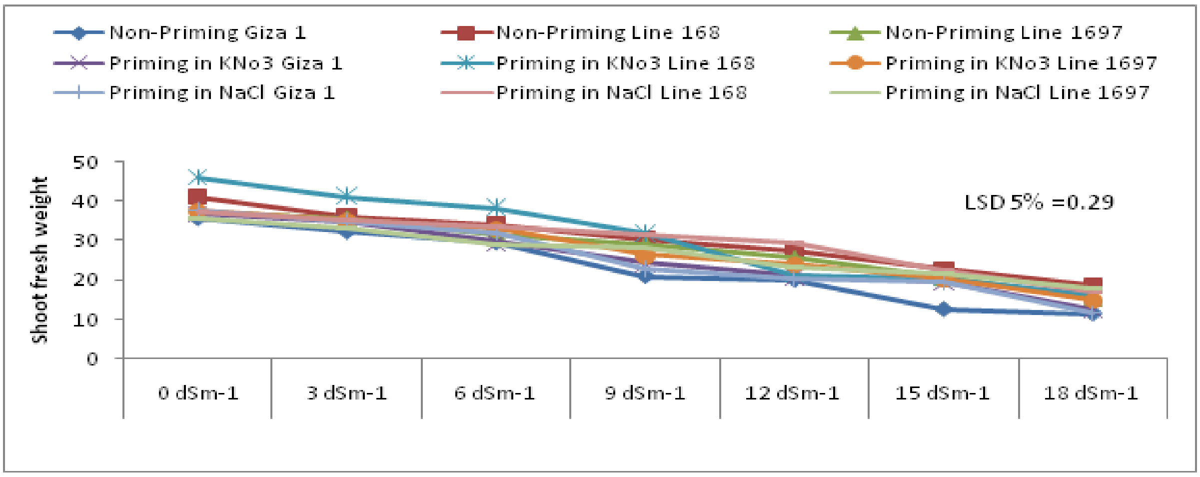

Fig. 23. Means of shoot fresh weight as affected by seed priming treatments, studied cultivars and salinity concentrations.

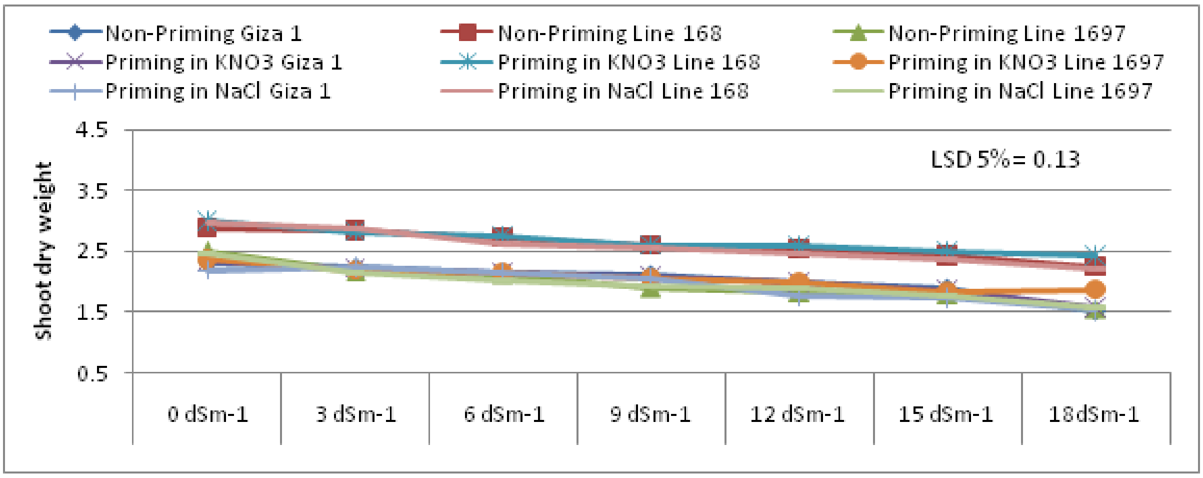

Fig. 24. Means of shoot dry weight as affected by seed priming treatments, studied cultivars and salinity concentrations.

The results showed that highest root dry weight were produced from Line 168 under the control treatment. The interaction between cultivars and salinity concentrations effects relative dry weight, the results illustrated in Fig.13 clearly indicated that this interaction significantly affected relative dry weight. The results showed that highest relative dry weight were produced from Line 168 under the control treatment.

The interaction between cultivars and salinity concentrations effects seedling height reduction, the results illustrated in Fig.14 clearly indicated that this interaction significantly affected seedling height reduction. The results showed that seedling height reduction were produced from Line 168 under salinity concentration of 18 dSm^{-1} NaCl. On contrary, the lowest shoot length, shoot fresh weight, shoot dry weight, root fresh weight, root dry weight, relative dry weight and seedling height reduction was produced from Giza 1 cultivar and salinity concentration of 18 dSm^{-1} NaCl. It could be noticed that Line 168 surpassed other studied cultivars in shoot length, shoot fresh weight, shoot dry weight, root fresh weight, root dry weight and relative dry weight under all salinity levels. Salt induced inhibition of seed germination has been attributed to osmotic stress or to specific ion toxicity that affect the synthesis of hydrolytic enzymes limiting the hydrolysis of food reserves from storage tissues as well as to impaired translocation of food reserves from storage tissue to developing embryo axis (Ramagopal, 1990). These results are in agreement with those obtained by Jamil *et al.* (2006), Siddiq *et al.* (2007), Nikbakht *et al.* (2010), Kaya *et al.* (2011), Khodadad (2011) Brasileira (2011), Kandil *et al.* (2012e) on canola, Moghanibashi *et al.* (2012), Elouaer and Hannachi (2012), Nikbakht *et al.* (2010), Ghazizade *et al.* (2012), Khomari *et al.* (2014) and Kandil *et al.* (2013) on sugar beet.

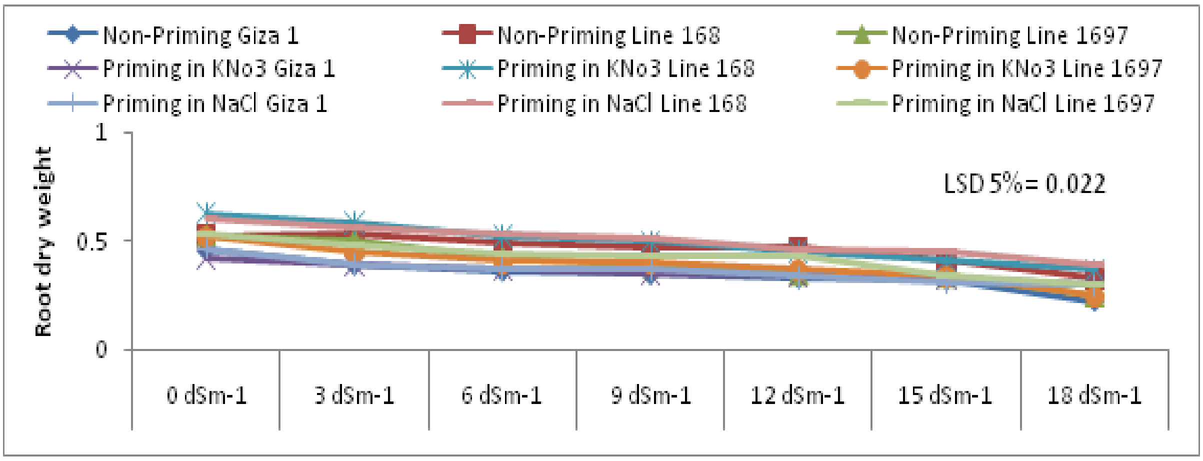

Fig. 26. Means of root dry weight as affected by seed priming treatments, studied cultivars and salinity concentrations.

Regarding to the interaction effect between seed priming treatments and salinity concentrations on shoot length, the results illustrated in Fig. 15 clearly indicated that this interaction significantly affected shoot length. The results showed that tallest shoots were produced from seed priming with KNo_3 under the control treatment. The interaction between seed priming treatments and salinity concentrations on shoot fresh weight, the results illustrated in Fig. 16 clearly indicated that this interaction significantly affected shoot root length. The results showed that tallest roots were produced from seed priming with KNo_3 under the control treatment. The interaction between seed priming treatments and salinity concentrations on root fresh weight, the results illustrated in Fig. 17 clearly indicated that this interaction significantly affected shoot fresh weight. The results showed that highest shoot fresh weight were produced from seed priming with KNo_3 under the control treatment. The interaction between seed priming treatments and salinity concentrations on root fresh weight, the results illustrated in Fig. 18 clearly indicated that this interaction significantly affected root fresh weight. The results showed that highest root fresh weight were produced from seed priming with KNo_3 under the control treatment. The interaction between seed priming treatments and salinity concentrations on root dry weight, the results illustrated in Fig. 19 clearly indicated that this interaction significantly affected root dry weight. The results showed that highest root dry weight were produced from seed priming with KNo_3 under the control treatment. The interaction between seed priming treatments and salinity concentrations on relative dry weight, the results illustrated in Fig. 20 clearly indicated that this interaction significantly affected relative dry weight. The results showed that highest relative dry weight were produced from seed priming with KNo_3 under the control treatment.

The interaction between seed priming treatments and salinity concentrations on relative dry weight, the results illustrated in Fig. 21 clearly indicated that this interaction significantly affected seedling height reduction. The results showed that seedling height reduction was significantly affected by this interaction. Highest seedling height reduction was produced from non-primed seed and salinity level of 18 dSm^{-1} of NaCl. While, the lowest shoot length, shoot fresh weight, shoot dry weight, root fresh weight, root dry weight and relative dry weight were produced from non-primed seed and salinity level of 18 dSm^{-1} of NaCl. It could be noticed that increasing salinity levels from 3, 9, 12, 15 and 18 dSm^{-1} NaCl of non-primed seed reduced seedling parameters. These results are in agreement with those reported by Kaya *et al.* (2006), Brasileira de Sementes (2011), Mahdavi *et al.* (2011), Elouaer *and* Hannachi (2012),Kandil *et al.*(2012a) on rice, Kandil *et al.* (2012d)on sorghum and Kandil *et al.* (2012c)on chickpea, Pahoja *et al.* (2013) and Khomari *et al.* (2014).

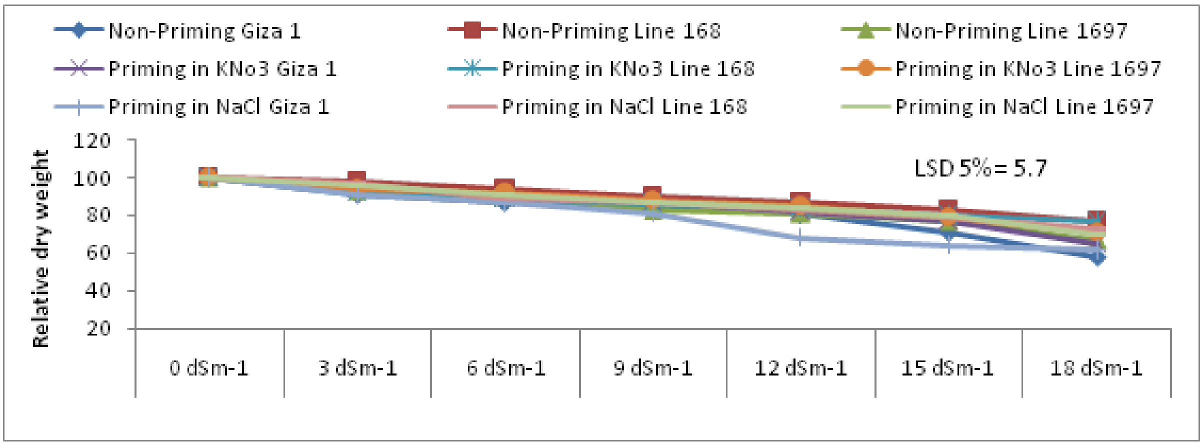

Fig. 27. Means of relative dry weight as affected by seed priming treatments, studied cultivars and salinity concentrations.

Concerning effect of the interaction between seed priming treatments, studied cultivars and salinity concentrations on shoot length, results illustrated in Fig. 22 showed significant differences due to this interaction on shoot length. The results indicated that tallest shoot was obtained from seed priming in KNo_3 and sown Line 168 under the control treatment.

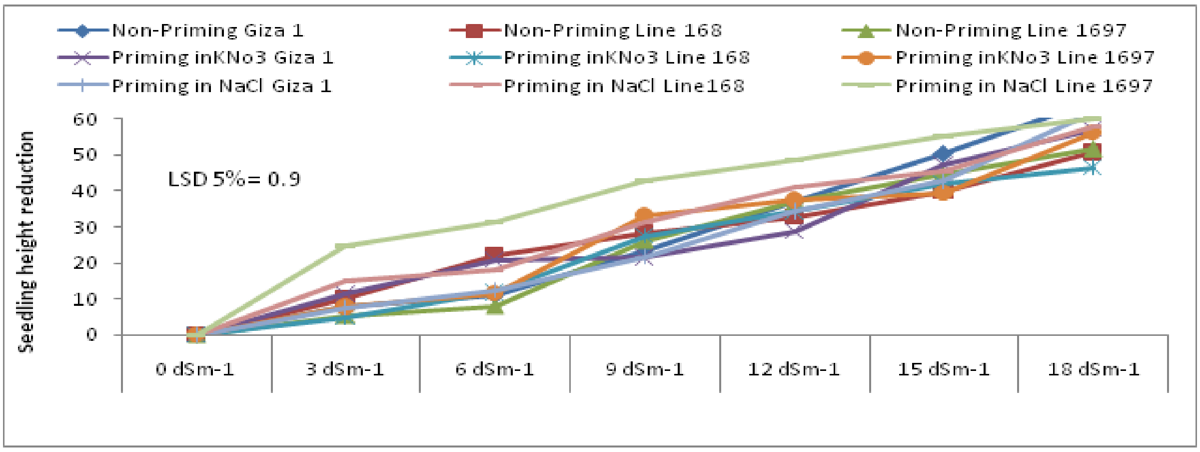

Fig. 28. Means of seedling height reduction as affected by seed priming treatments, studied cultivars and salinity concentrations.

The interaction between seed priming treatments, studied cultivars and salinity concentrations on shoot fresh weight, results illustrated in Fig. 23 showed significant differences due to this interaction on shoot fresh weight. The results indicated that highest shoot fresh weight was obtained from seed priming in KNo_3 and sown Line 168 under the control treatment. The interaction between seed priming treatments, studied cultivars and salinity concentrations on shoot dry weight, results illustrated in Fig. 24 showed significant differences due to this interaction on shoot dry weight. The results indicated that highest shoot dry weight was obtained from seed priming in KNo_3 and sown Line 168 under the control treatment. The interaction between seed priming treatments, studied cultivars and salinity concentrations on shoot dry weight, results illustrated in Fig. 25 showed significant differences due to this interaction on root fresh weight. The results indicated that highest root fresh weight was obtained from seed priming in KNo_3 and sown Line 168 under the control treatment. The interaction between seed priming treatments, studied cultivars and salinity concentrations on root dry weight, results illustrated in Fig. 26 showed significant differences due to this interaction on root dry weight. The results indicated that highest root dry weight was obtained from seed priming in KNo_3 and sown Line 168 under the control treatment. The interaction between seed priming treatments, studied cultivars and salinity concentrations on relative dry weight, results illustrated in Fig. 27 showed significant differences due to this interaction on relative dry weight. The results indicated that highest relative dry weight was obtained from seed priming in KNo_3 and sown Line 168 under the control treatment. Regarding to the effect of the interaction between seed priming treatments, studied cultivars and salinity concentrations on seedling height reduction, the results in Fig. 28 clearly showed that this interaction significantly affected seedling height reduction.

Highest seedling height reduction was obtained from non-primed seed of line 1676salinity concentrations of 18 dSm^{-1} NaCl. While, the lowest shoot length, shoot fresh weight, root fresh weight, root dry weight and relative dry weight were produced from non-primed seed or priming in $KNo_3$of Giza 1 cultivar under salinity concentrations of 18 dSm^{-1} NaCl without signify difference. In general, increasing salinity causes a decrease in safflower germination; this may be due to the toxic effects of Na+ and Cl in the process of germination (Khajeh-Hosseini *et al.*, 2003).

Conclusion

It could be concluded that for maximizing safflower germination characters and seedling parameters under salinity stress, it could be recommended that seed priming with KNO_3or NaCl and sown Line 168 under salinity stress. These cultivars were more tolerant to salinity and recommended to use in breeding program for enhancing safflower production in Egypt.

Reference

Ahmadvand G, Fatemeh S, Bijan S, Mehrdad P. 2012. Effects of Seed Priming on Seed Germination and Seedling Emergence of two soybean cultivars Under Salinity Stress. Intl. Res. J. Appl. Basic. Sci., 3(2), 234-241.

Ashrafi E, Razmjoo J. 2015. Salt and drought stresses during germination in safflower (*Carthamus tinctorius* L.). Journal of Plant Nutrition **38(14),** 2151-2158.

Bajehbaj AA. 2010. The effects of NaCl priming on salt Tolerance in Sunflower Germination and Seedling grown under salinity conditions. African Journal of Biotechnology **9(12),** 1764-1770.

Brasileira de SR. 2011. Influence of salinity and water deficit on the germination of *Carthamus tinctorius* L. seeds. **33(3),** 574-582.

Basiri HK, Sepehri A, Sedghi M. 2013. Effect of salinity stress on the germination of safflower seeds (*Carthamus tinctorius* L. cv. Poymar). Technical Journal of Engineering and Applied Sciences **3(11),** 934-937.

Casenave EC, Toselli ME .2007. Hydro priming as a pre-treatment for cotton germination under thermal and water stress conditions. Seed Science and Technology, **35(1),** 88 – 98.

Çulha S, Çakırlar H. 2011. Effect of Salt Stress Induced by NaCl on safflower (*Carthamus tinctorius* L.) Cultivars at Early Seedling Stage Hacettepe J. Biol. & Chem., **39(1),** 61–64.

EL-Saidy AEA, Farouk S, Abd EL-Ghany HM. 2011. Evaluation of different seed priming on seedling growth, Yield and Quality Components in two sunflowers (*Helianthus annuus* L.) Cultivars. **6(9),** 977-991.

Elouaer MA, Hannachi C. 2012. Seed priming to improve germination and seedling growth of safflower (*Carthamus tinctorius*) under salt stress Eurasian Journal of Biosciences **6**, 76-84.

Gaballah MS, El Meseiry T. 2014. Effect of Hydro priming on seed germination of sunflower (*Helianthus annuus* L.) under salt condition. Global Journal on Advances in Pure & Applied Sciences **2,** 124-131.

Gomez KA, Gomez AA. 1991. Statistical Procedures in Agricultural Research, John Wiley and Sons, New York.

Give HS, Firoozi M, Ahmadzadeh N. 2014. Investigation of seed germination and seedling characteristics of safflower variety under salt stress conditions. International Research Journal of Applied and Basic Sciences **8(11),** 2044 – 2049.

Ghazizade M, Golkar P, Salehinejad F. 2012. Effect of salinity stress on germination and seedling characters in safflower (*Carthamus tinctorius* L.) genotypes. Annals of Biological Research **3(1),** 114-118.

Hajghani M, Saffari M, Maghsoudi MA. 2008. The effect of different levels salinity (NaCl) on germination seedling growth of safflower (*Carthamus tinctorius* L.) cultivars. J. of Water & Soil Sci., **12(45),** 449 – 458.

Hopper NW, Overholt JR, Martin JR. 1979. Effect of cultivar, temperature and seed size on the germination and emergence of soybeans (*Glycine max*). Annals of Botany **44,** 301-308.

Hussian I, Ahmad R, Farooq M, Rehman A, Amin M, Abu Bakar M. 2014. Seed priming: a tool to invigorate the seeds. Scientia Agriculturae **7(3),** 122-128.

Islam MM, Karim MA. 2010. Evaluation of Rice (Oryza sativa L.) genotypes at germination and early seedling stage for their tolerance to salinity. The Agriculturists **8(2),** 57 – 65.

ISTA Rules 2013. International seed testing association. ISTA Germination Sec. Chapter **5,** 5 44.

Jabeen N, Ahmad R. 2013b. Variations in accessions of sunflower and safflower under stress condition. Pak. J. Bot, **45(2),** 383-389.

Jamil M, Lee DB, Jung KY,Shraf MA, Lee SC, Rha ES. 2006. Effect of salt (NaCl) stress on germination and early seedling growth of four vegetables species. journal center European agriculture **7(2),** 273-282.

JajarmiV,Abazarian R, Khosroyar K. 2014. Effect of water stress on germination indices in safflower cultivars (*Carthamus tinctorius* L.). Journal of Applied Science and Agriculture **9(5),** 2295 – 2298.

Kandil AA, Sharief AE, Nasser ESE. 2012a. Response of Some Rice (*Oryza sativa* L.) Cultivars to Germination under Salinity Stress. International J. of Agric. Sci. **4(6),** 272 – 277.

Kandil AA, Sharief AE, Elokda MA. 2012b. Germination and Seedling Characters of ifferent Wheat Cultivars under Salinity Stress. J. of Basic and Applied Sci., **8**, 585 – 596.

Kandil AA, Sharief AE, Ahmed SRH. 2012c. Germination and Seedling Growth of Some Chickpea Cultivars (*Cicer arietinum* L.) under Salinity Stress. Journal of Basic and Applied Sciences **8,** 561 – 571.
Kandil AA, Sharief AE, Abido WAE, Awed AM. (2013). Salttolerance study of six cultivars of sugar beet (*Beta vulgaris* L.) during seedling stage. Sky Journal of Agricultural Research **2(10),** 138 – 148.

Kandil AA, Sharief AE, Abido WAE Ibrahim MM. 2012d. Effect of Sorghum Cultivars. Intern. J. of Agric. Sciences **4(7),** 306 – 311.

Kandil AA, Sharief AE, Abido WAE, Ibrahim MMO. 2012e. Response of Some Canola Cultivars (*Brassica napus* L.) to Salinity stress and its Effect on Germination and Seedling properties. Journal of Crop Science **3(3),** 95 – 103.

KandilAA, Sharief AE, Abido WAE, Awed AM. 2014. Effect of Gibberellic Acid on Germination Behavior of Sugar Beet Cultivars under Salt Stress Conditions of Egypt. Sugar Tech., **16(2),** 211 – 221.

Kaya MD, Okgu G, Atak GY, Kolsarici O. 2006. Seed treatments to overcome salt and drought stress during germination in sunflower (*Helianthus annuus* L.). European Journal of Agronomy, **24,** 291-295.

Kaya MD, Bayramin S, Kaya G, Uzun O. 2011. Seed vigor and ion toxicity in safflower (*Carthamus tinctorius* L.) seedlings produced by various seed sizes under NaCl stress. Arch. Biol. Sci., Belgrade **63(3),** 723-729.

Khajeh-Hosseini M, Powell AA, Bimgham IJ. 2003. The interaction between salinity stress and seed vigor during germination of soybean seeds. Seed Science Technology **31,** 715-725.

Khodadad M. 2011. An evaluation of safflower genotypes (*Carthamus tinctorius* L.), seed germination and seedling characters in salt stress conditions. African Journal of Agricultural Research, **6(7),** 1667-1672.

Khomari S, Soltani-nezhad M, Sedghi M. 2014. Effect of Seed Vigor and Pretreatment on germ inability and Seedling growth of Safflower under Drought and Salinity Conditions International Journal of Farming and Allied Sciences **3(12),** 1229-1233.

Mahdavi B, Sanavy SAM, Aghaalikhani M, Sharifi M, Dolatabadian A. 2011. Chitosan Improves Osmotic Potential Tolerance in Safflower (*Carthamus tinctorius* L.) Seedlings Journal of Crop Improvement **25(6),** 728-741.

Moghanibashi M, Karimmojeni H, Nikneshan P, Behrozi D. 2012. Effect of hydro priming on seed germination indices of sunflower (*Helianthus annuus* L.) under salt and drought conditions Plant Knowledge Journal **1(1),** 10-15.

Moghadam AK, Mohammadi K. 2014. A laboratory and glasshouse evaluation of ascorbic and salicylic acid effect on germination traits and grain yield of safflower cultivars. Environmental and Experimental Biology **12**, 39–42.

Nikbakht E, Nejad GM,Yousefi K, Farahbakhsh H. 2010. Evaluation salinity tolerance of safflower (*Carthamus tinctorius* L.) genotypes at different vegetative growth stages. International Journal of Agronomy and Plant Production **1(4),** 105 – 111.

Pahoja VM, Siddiqui SH, Narejo MUN, Umrani JH. 2013. Response of hydro priming and osmopriming on germination and seedling growth of sunflower (*Helianthus annuus* L.) under salt stress. International Journal of Agricultural Science and Research **3(2),** 71-80.

Ramagopal S. 1990. Inhibition of seed germination by salt and its subsequent effect on embryonic protein synthesis in barley. J. Plant Physiol. **136**, 621-625.

Russell DF. 1986. MSTAT-C computer based data analysis software Crop and Soil Science Department, Michigan State University USA.

Siddiqi EH, Ashraf M, Akram NA. 2007. Variation in seed germination and seedling growth in some diverse; Ines of safflower (*Carthamus tinctorius* L.) under salt stress. Pak. J. Bot., **39(6),** 1937-1944.