International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 9, No. 2, p. 65-80, 2016

INNSPUB

RESEARCH PAPER

OPEN ACCESS

# Germination characters as affected by seed priming of some safflower cultivars under salinity stress

**A. A. Kandil[1], A. E. Sharief*[1], Manal F. Kasim[2]**

[1]*Department of Agronomy, Mansoura University, Egypt*

[2]*Central Administration for Seed Certification (CASC), Ministry of Agriculture, Egypt*

**Article published on August 14, 2016**

**Key words:** Safflower cultivars, Seed priming in NaCl or $KNo_3$, Salinity concentrations, Germination characters

**Abstract**

To investigate the effect of seed priming treatments *i.e.* NaCl or $KNo_3$ and non-primed seed of some safflower cultivars *i.e.* Giza 1, Line 168, and Line1697 on critical stage of germination under salinity concentrations of. 0, 3, 6, 9, 12, 15 and 18 $dSm^{-1}$ NaCl. Laboratory experiment was conducted at Giza Central Seed Testing Laboratory of Central Administration for Seed Certification (CASC), Ministry of Agriculture, Egypt. Germination characters *i.e.* final germination percentage, germination rate, germination index, energy of germination and seedling vigour index were estimated. The results indicated that highest averages of final germination percentage, germination rate, germination index, energy of germination, seedling vigor index were produced from primed seed in NaCl or $KNo_3$. Line 168 surpassed other studied cultivars in final germination percentage, germination rate, germination index, energy of germination and seedling vigor index. Increasing salinity levels from 0 to 3, 6, 9, 12, 15 and 18 $dSm^{-1}$ NaCl significantly decreased all studied characters. Results revealed that final germination percentage, germination rate, germination index and energy of germination significantly affected by the interaction between seed priming treatments and cultivars. Final germination percentage, germination rate, germination index, energy of germination and seedling vigor index significantly affected by the interaction between cultivars and salinity concentrations and by the interaction among seed priming treatments, cultivars and salinity concentrations. Priming seed of Line168 or Line 1697 using NaCl or $KNo_3$ were more tolerant to salinity stress, which must be put in breeding program of safflower for enhancing of safflower productivity under salinity conditions for reducing the gab of oil production in Egypt.

*** Corresponding Author:** Rico A. Marin ✉ shariefali42@gmail.com

## Introduction

Safflower *Carthamus tinctorus* L. has been grown commercially as one of the oldest oil-seed crop. It is suitable for newly reclaimed soils where other oil-seed crops are difficult to grow. In order to reduce the gap between production and consumption of oil crops to face the universe consumption of oil requirements in Egypt. So, it must be increase oil crops cultivated area such as safflower in saline New Reclaimed soils. Priming safflower seed is a technique that might be resulted in increasing seed germination and emergence under stress condition such as salinity.It is an effective technique that improves germination of several crops under saline conditions. In this respect, Kaya *et al.* (2006) concluded that hydro priming increased germination and seedling growth under salt and drought stress. Saadateyan *et al.* (2009) showed that increases in germination and seedling growth under salt and drought stresses. Bajehbaj (2010) reported that germination percentage of primed seeds were greater than that of non-primed seeds. El-Saidy *et al.* (2011) concluded that seed priming treatments reduced the mean germination time and increased germination percentage, germination energy and germination index. It may be concluded that seed priming agents can be used for improving the germination of sunflower seeds. Elouaer and Hannachi (2012) showed that NaCl and KCl priming seed have improved germination percentage, mean germination time, germination index and coefficient of velocity and vigor index. Moghanibashi *et al.* (2012) showed that hydro priming for 4h increased germination percentage, germination rate, germination index of seed sunflower as compared with the control treatment. Nawaz *et al.* (2013) reported that seed priming of safflower improves germination, hydro-priming significantly be helpful in order to obtain good crop establishment. Khomari *et al.* (2014) reported that pretreatment increased percentage and speed of germination and vigor index. Ashrafi *et al.* (2015) indicated that treatment of seeds with hydro priming increase germination index and germination uniformity, while decrease days to 50% germination under salt and water stress. Seed treated with $KNo_3$ reduced abnormal germination percentage in salt stress. $KNo_3$ improved germination uniformity and germination index of the low water potentials. Khajeh *et al.*(2015)point out that highest germination characteristics such as; germination percentage, germination index, normal seedling percentage, 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.Jamil *et al.*(2006) indicated that salinity caused a significant reduction in germination percentage and germination rate. Siddiqi *et al.* (2007) reported that Salt stress caused a marked reduction in germination percentage. Maximum reduction was observed at higher levels (180 and 240 m*M*) of NaCl. Nikbakht *et al.* (2010) showed that salt stress had a significant influence on the germination rate in laboratory conditions. Brasileira (2011) showed that the germination rate, germination vigor index. The NaCl induced "0.450 MPa osmotic treatment did not result in significant changes in the germination rate and vigor index compared to the controls. Çulha and Çakırlar (2011)point out that safflower cultivars were negatively affected from different NaCl concentrations *i.e.* 0, 75, 150, 225 and 300 mM. Kaya *et al.* (2011)concluded that increased NaCl resulted in an increase in the $Na^+$ and $Cl^-$ content of the seedlings produced by all seed sizes, while the $K^+$ content was not changed. Khodadad (2011) reported that salt stress adversely affected the germination percentage, germination rate, seed vigor, germination index and mean germination time 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 that osmotic potential significantly decreased germination percentage, germination index and rate. Elouaer and Hannachi (2012) reported that germination parameters were improved germination percentage, mean germination time, germination index and vigor index of safflower under saline conditions. Tanveer *et al.* (2012) showed that increases in salinity levels from 0 to 125 mM resulted in gradual decreases in germination percentage of *Carthamus oxyacantha*. Time to start germination or emergence increased and mean germination or emergence time and germination or emergence index decreased with increases in salt stress. Basiri *et al.* (2013) showed that salinity decreased percent and rate of germination. Jabeen *et al.* (2013) showed that increasing salinity stress from 3.4 to 10.8 $dSm^{-1}$ significantly decreased germination percentage and germination rate. Panahi *et al.* (2013) showed that salt stress adversely affected significantly on of germination percentage, germination rate, root to shoot ratio, germination index, mean germination time and seed vigor. 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 the germination percentage, germination rate, seed vigor, germination index and mean germination time of all 6 genotypes of safflower. Jajarmi *et al.* (2014) concluded that germination is a critical stage of the plant life and resistance against salinity during the germination is important for stability. Ashrafi *et al.* (2015) showed that increasing salt stress germination index and shoot/root ration were decreased, while germination uniformity, days to 50% germination and abnormal germination percentage were increased. Wu (2015) showed that high salinity (200 mmol) remarkably inhibited the germination of seed and delayed germination time in sunflower. Recently, Yari *et al.* (2015) studied the effect of NaCl solution levels (0.0, 10 and 15 $dsm^{-1}$) on three cultivars *i.e.* Azrgol, Eurofler and Record. Result showed NaCl caused higher mean germination time.

With respect to the interaction between seed priming treatments on studied safflower cultivars as affected on seed germination. EL- Saidy *et al.* (2011) reported that priming seed improved significantly germination percentage in Sakha 53 cultivar and increased significantly seed germination percentage in Giza 102 cultivar. Moghanibashi *et al.* (2012) concluded that highest and lowest, of germination rate was recorded with non-primed seed of Urfloar cultivar and non-primed seed of Blazar cultivar, respectively. But the highest and lowest of germination time was recorded with primed seed of Urfloar cultivar and non-primed seeds of Blazar cultivar, respectively. Gaballah and El Meseiry (2014) showed that the Euroflor cultivar showed further reduction of another one day than the other genotypes when its seeds were primed in 3000 ppm NaCl solution.

Concerning the interaction among safflower cultivars and salinity concentrations on germination characters. Ghazizade *et al.* (2012) reported that Golsefid and Isfahan14 could be considered as salt tolerant as possessing higher germination percentage and better seedling growth under salinity stress. Moghanibashi *et al.* (2012) showed that Urfloar cultivar produced higher the germination percentage, germination index, germination rate and time of germination as compared with cultivar Blazar. Panahia *et al.* (2013) found that at the highest salt level, Kose cultivar produced maximum germination percentage and germination rate of all genotypes and they were considered as relatively tolerant.

Regarding the interaction between seed priming treatments and salinity concentrations on safflower seed germination characters. Bajehbaj (2010)revealed that the total emergence of seedlings from both priming and non-priming seeds decreased with increasing NaCl salinity. Percentage of seed germination decreased with rising of salinity levels in both primed and non-primed seeds. Elouaer andHannachi (2012)showed that NaCl and KCl priming have improved germination parameters i.e. germination percentage, mean germination time, germination index and coefficient of velocity and vigor index of safflower under saline condition. Moghanibashi *et al.* (2012) showed that primed seeds clearly produced higher germination index, germination rate days to 50% germination and germination index than non-primed seeds under all salinity levels. Pahoja *et al.* (2013)indicated that hydro priming proved significantly better than the osmo-priming ($KNo_3$) under the wide range of salinity levels. Recently, Ashrafi *et al.* (2015) concluded that hydro priming enhanced germination all cultivars under both salt and drought stresses and non-stress condition. Therefore, the objectives of this investigation was aimed to germinate 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 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 in252 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 characteristics*

Final germination percentage (FGP): Final germination count was calculated after 14 days from sowing date and expressed as percentage according to the following equation as described by Ellis and Roberts, (1981) and Ruan *et al.* (2002):

$$(FGP) = \frac{\text{Number of germinated seeds}}{\text{Total Number of tested seeds}} \times 100$$

Germination Rate (GR): It was calculated according to the following equation described by Ellis and Roberts (1981).

$$GR = \frac{\text{Number of germinated seeds}}{\text{Number of germination days}}$$

Germination Index (%): It was calculated according to Karim *et al.* (1992)as the following equation:

$$GI = \frac{\text{Germination percentage each treatment}}{\text{Germination percentage in the control}} \times 100$$

Energy of germination (EG): Energy of germination was recorded at the fourth day as the percentage of germinated seeds four days after sowing relative to the number of seeds tested according to Ruan *et al.* (2002). Number of germinated seeds after four days

$$EG = \frac{}{\text{Number of seed tested}} \times 100$$

Seedling Vigor index (SVI): It was calculated as described by Abdel-Baki and Anderson (1973) according to the following equation:

(SVI) = (Average shoot length + Average root length) × Germination percentage.

*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. The results showed a significant difference due to seed priming treatments on final germination percentage, germination rate, germination index, energy of germination except seedling vigor index.

**Table 1.** Means of final germination percentage (%), germination rate, germination index (%),energy of germination and seedling vigor index as affected by seed priming treatments.

| Treatments | Germination percentage (%) | Germination index (%) | Germination rate (day) | Seedling vigor index | Energy of germination |
|---|---|---|---|---|---|
| Non priming | 76.5 | 83.1 | 2.38 | 1329.7 | 58.76 |
| Priming in $KNo_3$ | 80.4 | 88.6 | 2.45 | 1416.7 | 63.95 |
| Priming in NaCl | 78.4 | 87.0 | 2.39 | 1255.4 | 59.77 |
| F-Test | ** | ** | * | NS | * |
| LSD at 5% | 0.5 | 0.4 | - | - | - |

**Table 2.** Means of final germination percentage (%), germination rate, germination index (%), energy of germination and seedling vigor index as affected by safflower cultivars.

| Treatments | Germination percentage (%) | Germination Index (%) | Germination Rate (day) | Seedling vigor index | Energy of germination |
|---|---|---|---|---|---|
| Giza 1 | 70.3 | 83.4 | 2.27 | 1184.0 | 55.68 |
| Line 168 | 87.2 | 90.6 | 2.57 | 1616.6 | 63.96 |
| Line 1697 | 77.9 | 84.8 | 2.39 | 1201.2 | 62.84 |
| F-Test | ** | ** | ** | ** | ** |
| L.S.D. 5 % | 0.5 | 0.4 | 0.02 | 111.1 | 1.3 |

The results indicated that seed priming using $KNo_3$ was produced highest averages of final germination percentage, germination index, germination rate and energy of germination. It could be noticed that priming seed in NaCl surpassed non-priming seed in final germination percentage, germination rate, germination index and energy of germination by 2.5, 6.6, 0.4, and 1.7 %, respectively. Seed primed had better efficiency for water absorption from growing media that is why metabolic activities in seed during germination process (Hopper *et al.*, 1979). Katembe *et al.* (1998) reported that seed priming leads to the initiation of primary metabolic processes, so the time required for germination is reduced. This positive effect is probably due to the stimulatory effect of priming on later stages of the germination process through the mediation of cell division in germinated seed. These results are in good agreement with those reported by Similar findings were reported by Kaya *et al.* (2006), El- Saidy *et al.* (2011), Elouaer and Hannachi (2012), Moghanibashi *et al.* (2012), Moghadam and Mohammadi (2013) and Khomari *et al.* (2014).

*Cultivars performance*

The results showed a significant effect of studied safflower cultivars on averages of final germination percentage, germination rate, germination index, energy of germination and seedling vigor index (Table 2). Line 168 recorded highest averages of final germination percentage, germination rate, germination index, energy of germination and seedling vigor index, 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 final germination percentage by 11.93, 24.03, germination index by 6.84, 8.63, germination rate by 7.5, 13.2, energy of germination by 14.87, 15.94% seedling vigor index by 34.6, 36.5%, respectively, compared with Line 1697 and Giza 1 cultivars.

**Table 3.** Means of final germination percentage (%), germination rate, germination index (%), energy of germination and seedling vigor index as affected by salinity concentrations.

| Treatments | Germination Percentage (%) | Germination index (%) | Germination Rate (day) | Seedling vigor index | Energy of germination |
|---|---|---|---|---|---|
| 0 $dSm^{-1}NaCl$ | 91.5 | 100 | 100.00 | 2061.9 | 79.00 |
| 3 $dSm^{-1}NaCl$ | 85.2 | 94.9 | 89.88 | 1717.9 | 69.33 |
| 6 $dSm^{-1}NaCl$ | 82.4 | 91.4 | 84.77 | 1496.1 | 64.15 |
| 9 $dSm^{-1}NaCl$ | 78.7 | 87.7 | 77.42 | 1289.6 | 61.26 |
| 12 $dSm^{-1}NaCl$ | 74.4 | 82.2 | 71.34 | 1099.9 | 57.78 |
| 15 $dSm^{-1}NaCl$ | 71.4 | 76.9 | 66.74 | 984.5 | 52.15 |
| 18 $dSm^{-1}NaCl$ | 65.7 | 70.6 | 59.33 | 687.5 | 42.15 |
| F-Test | ** | ** | ** | ** | ** |
| L.S.D 5 % | 0.7 | 0.09 | 2.49 | 169.8 | 2.01 |

The differences between cultivars in germination might be due to genetically factors and heredity (Ghazizade *et al.*, 2012). These results in harmony with those reported by (Jajarmi (2006), Siddiqi *et al.* (2007), Nikbakht *et al.* (2010), El- Saidy *et al.* (2011), Khodadad (2011), Elouaerand Hannachi (2012), Moghanibashi *et al.* (2012),Panahia *et al.* (2013) and Give *et al.* (2014), Hussian *et al.* (2014) and Khomari *et al.*(2014).

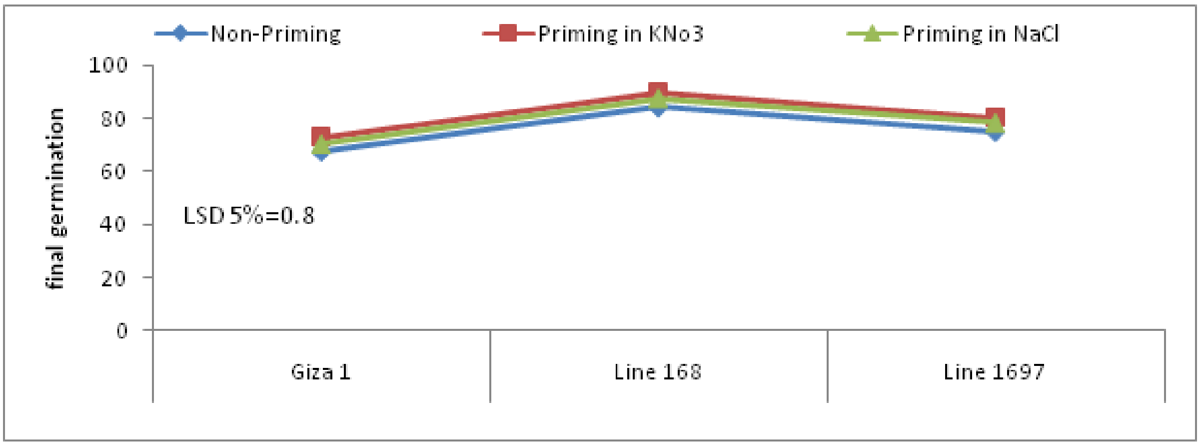


**Fig. 1.** Means of final germination as affected by the interaction between seed priming treatments and studied cultivars.

*Salinity concentrations effect*

Results in Table 3 reported that salinity concentrations concerning salinity concentrations showed a significant effect on averages of final germination percentage, germination index germination rate, energy of germination, seedling vigor index. Increasing salinity levels from3, 6, 9, 12, 15 and 18 dsm-1 NaCl reduced final germination percentages by 6.9, 9.9, 13.9, 18.7, 21.9 and 28.2 %, respectively as the salinity levels order compared with the control treatment. Energy of germination by (12.2, 18.8, 22.5, 26.9, 33.9 and 46.6%) and seedling vigor index by (16.7, 27.4, 37.5, 46.7, 52.3 and 66.7%), respectively as the salinity levels order compared with the control treatment. In general, increasing salinity causes a decrease in germination percentage this may be due to the toxic effects of Na+ and Cl- in the process of germination (Khajeh-Hosseini *et al.*, 2003) when related it to the decrease in the water potential at the high salt concentration. The presence of salt at low concentrations could have contributed to a decrease in the internal osmotic potential of germination structures due to ions penetration (Almansouri *et al.*, 2001).

These results are in agreement with those reported by Dadkhah *et al.* (2006), Jamil *et al.* (2006), Siddiqi *et al.* (2007), El- Saidy *et al.* (2011), Kaya *et al.* (2011), Brasileira (2011), Khodadad (2011), Mahdavi *et al.* (2011), Nikbakht *et al.* (2010), Elouaer and Hannachi (2012), Tanveer *et al.* (2012), Basiri *et al.* (2013), and Give *et al.* (2014).

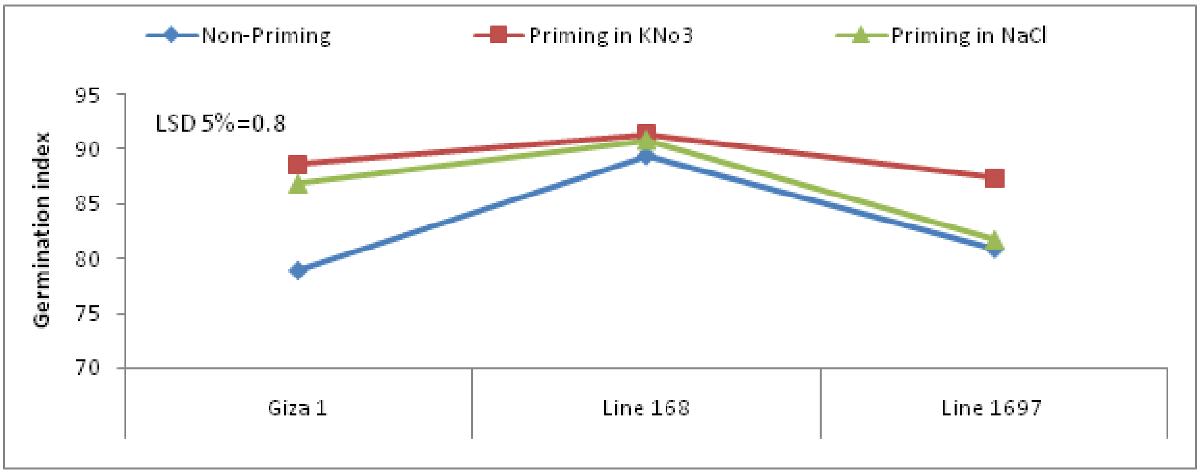


**Fig. 2.** Means of germination index as affected by the interaction between priming and non-priming seed and studied cultivars.

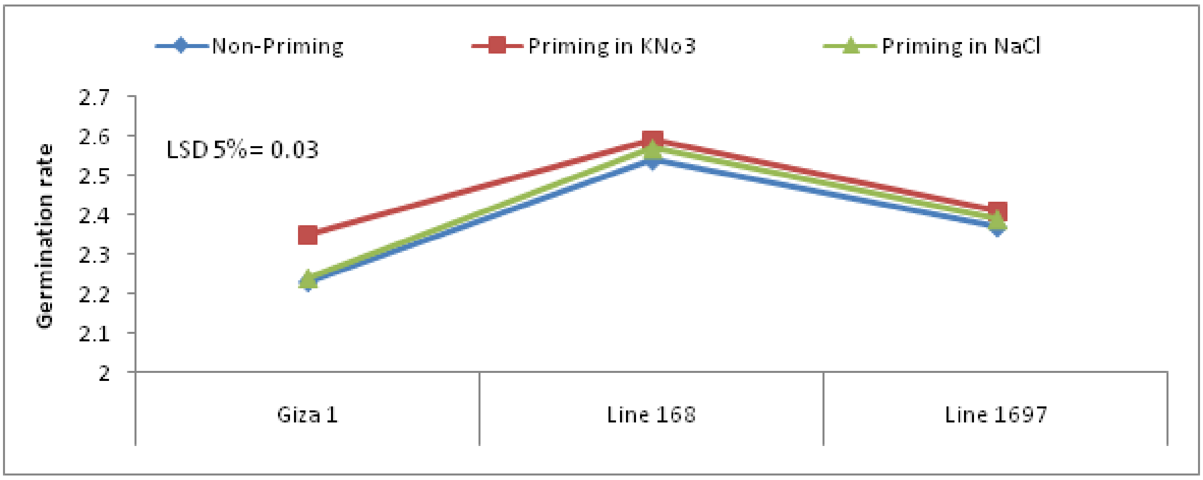


**Fig. 3.** Means of germination rate as affected by the interaction between priming and non-priming seed and studied cultivars.

*Interaction effects*

Regarding to the interaction effect the results illustrated in Fig. 1, Fig. 2, Fig. 3 and Fig. 4 clearly showed that final germination, germination rate, germination index and energy of germination were significantly affected by the interaction between seed priming and studied cultivars. Results clearly indicated that highest final germination percentage, germination index, germination rate and energy of germination was produced from seed priming with $KNo_3$ and sown Line 168. The lowest final germination, germination rate, germination index and energy of germination was produced from non-primed seed and sown Giza 1 cultivar.

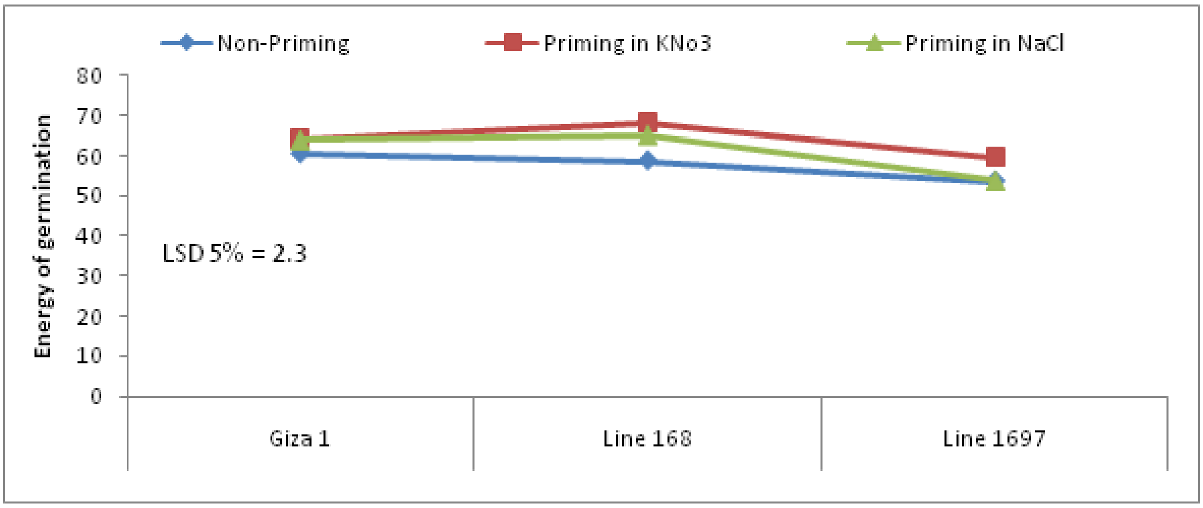


**Fig. 4.** Means of energy of germination as affected by the interaction between priming and non-priming seed and studied cultivars.

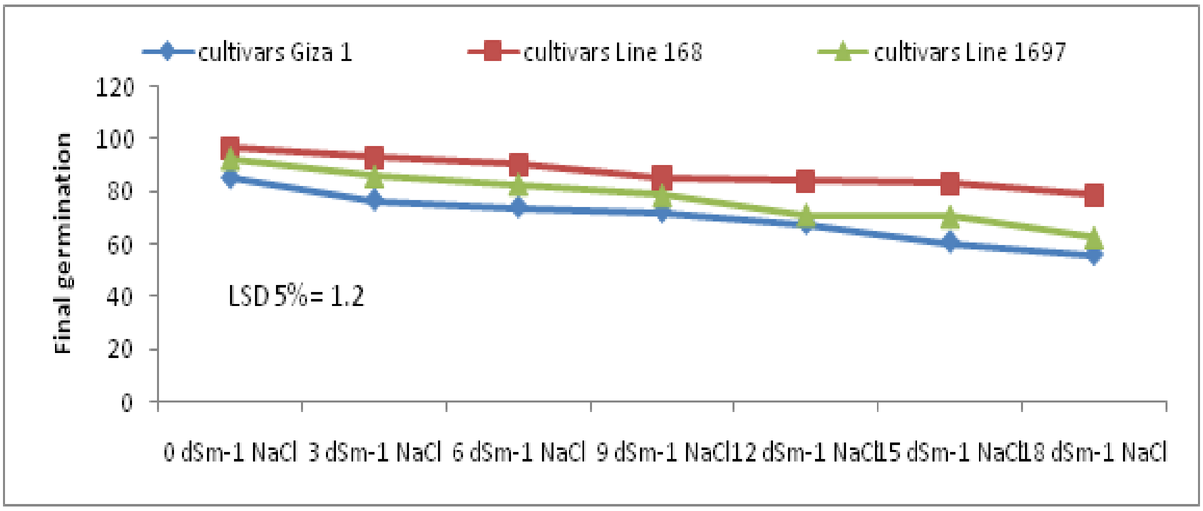


**Fig. 5.** Means of final germination as affected by the interaction between studied cultivars and salinity concentrations.

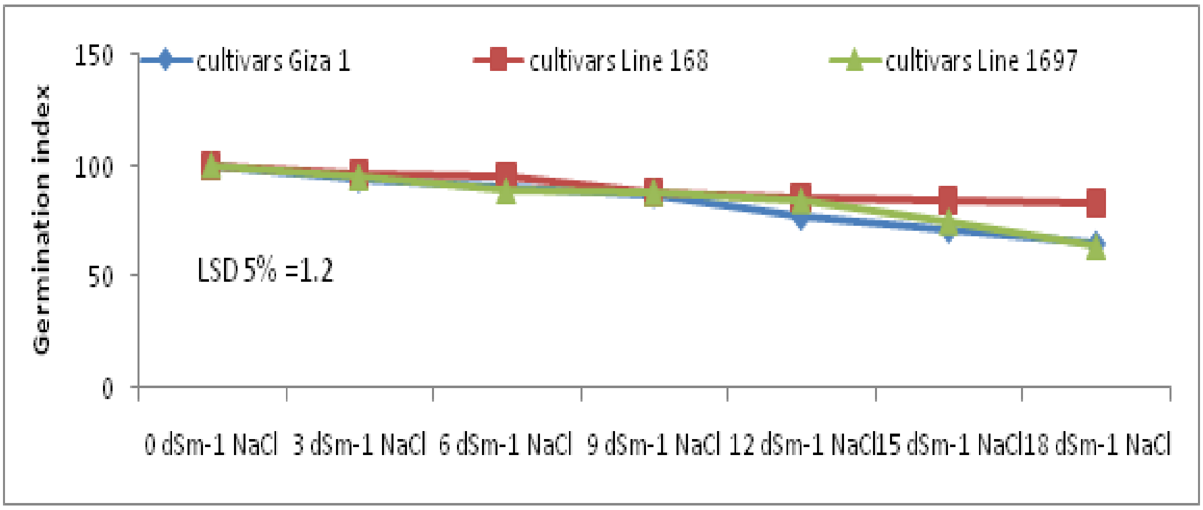


**Fig. 6.** Means of germination index as affected by the interaction between studied cultivars and salinity concentrations.

It could be stated that Line 168 cultivar surpassed other studied cultivars in final germination, germination rate, germination index and energy of germination when seed primed with $KNo_3$. These results in good agreement with those reported by El-Saidy *et al.*(2011), Elouaer and Hannachi (2012), Moghanibashi *et al.* (2012) , Jabeen and Ahmed (2013b), Jajarmi *et al.* (2014). Khomari *et al.* (2014) and Moghadam and Mohammadi (2014).

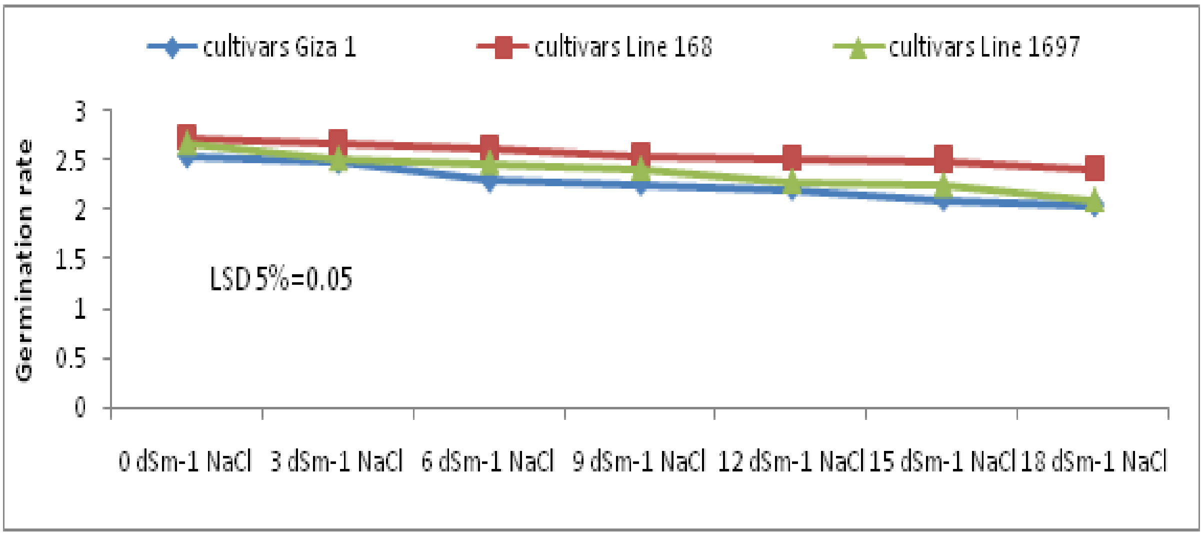


**Fig. 7.** Means of germination rate as affected by the interaction between studied cultivars and salinity concentrations.

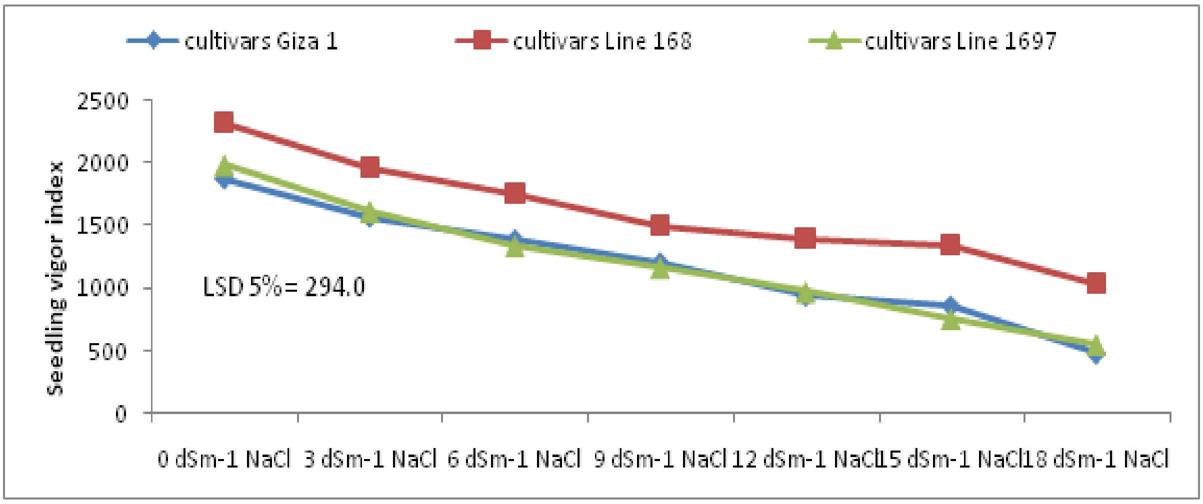


**Fig. 8.** Means of seedling vigor index as affected by the interaction between studied cultivars and salinity concentrations.

With respect to interaction effect effects results illustrated in Fig. 5, Fig. 6, Fig. 7,Fig. 8 and Fig. 9 clearly showed that final germination percentage, germination rate, germination index, energy of germination and seedling vigor index were significantly affected by the interaction between saflower cultivars and salinity concentrations. Highest final germination percentage, germination rate, germination index, energy of germination and seedling vigor index was obtained from Line 168 under the control treatment. On contrary, the lowest final germination percentage, germination rate, germination index, energy of germination and seedling vigor index was produced from Giza 1 cultivar and salinity concentration of 18 $dSm^{-1}$ NaCl.

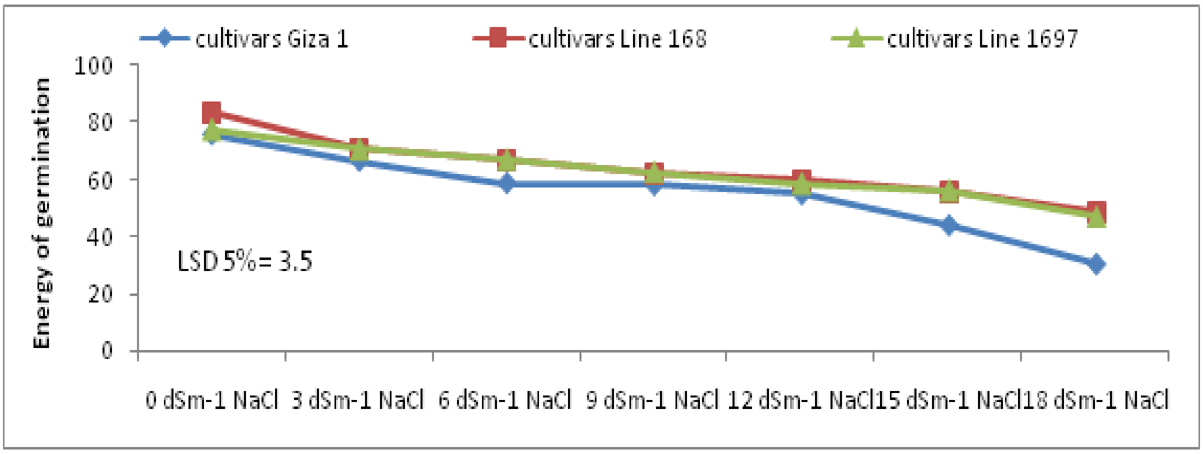


**Fig. 9.** Means of energy of germination as affected by the interaction between studied cultivars and salinity concentrations.

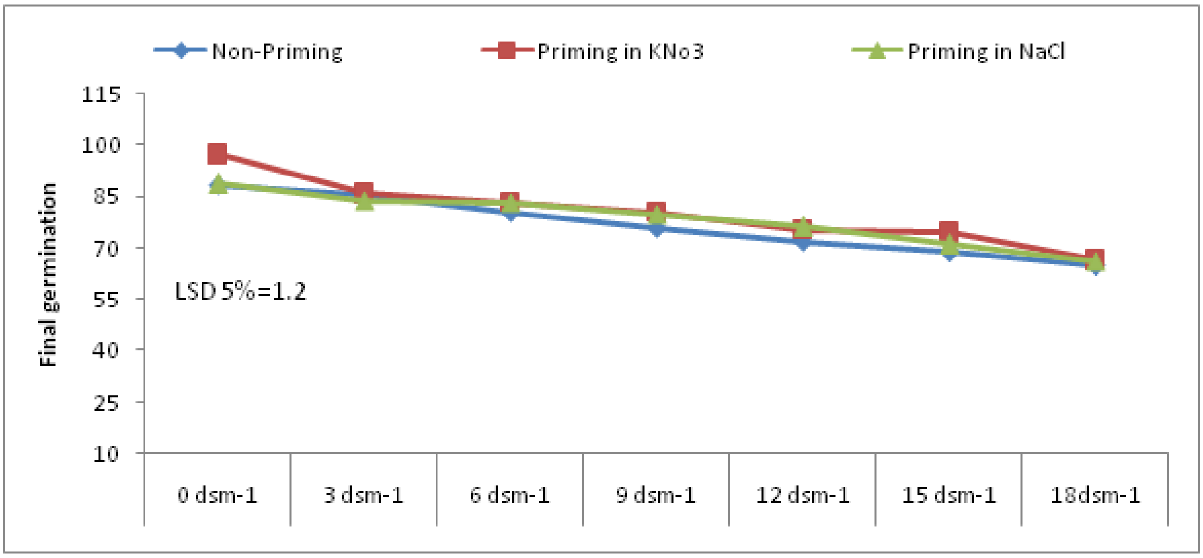


**Fig. 10.** Means of final germination as affected by the interaction between seed priming treatment and salinity concentrations.

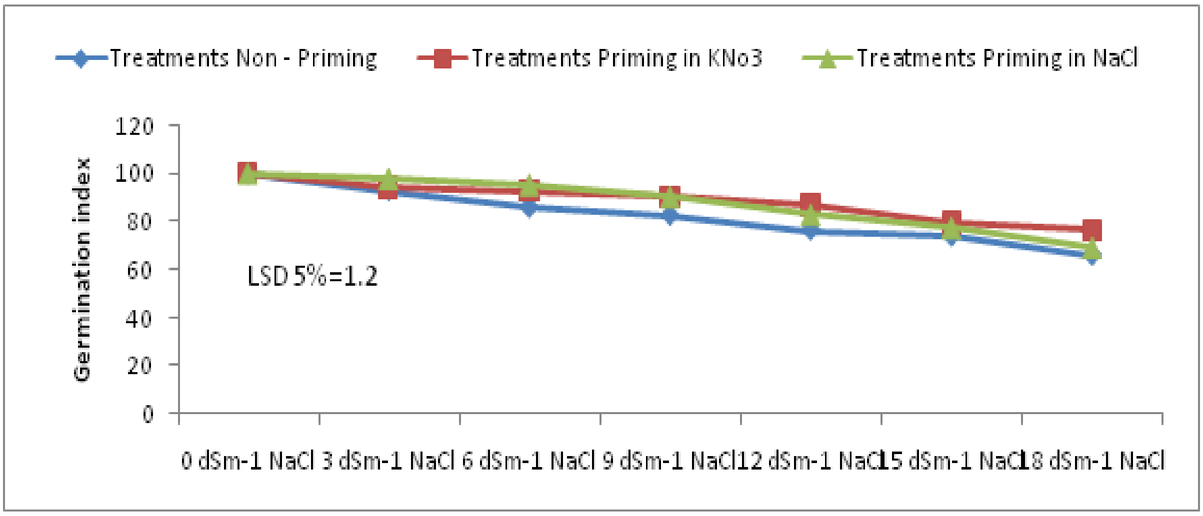


**Fig. 11.** Means of germination index as affected by the interaction between seed priming treatment and salinity concentrations.

It could be noticed that Line 168 surpassed other studied cultivars in final germination percentage, germination rate, germination index, energy of germination and seedling vigor index 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).

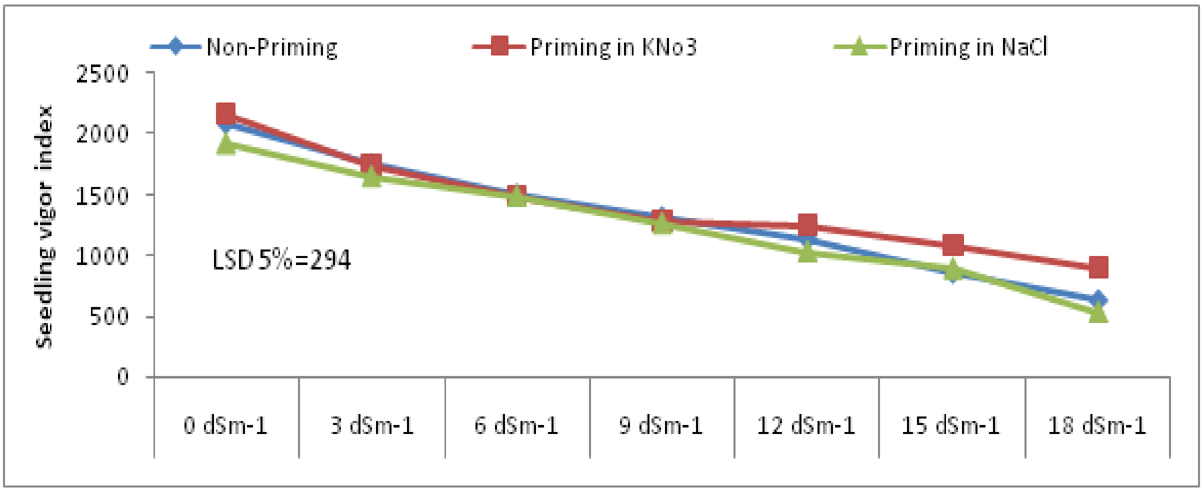


**Fig. 12.** Means of seedling vigor index as affected by the interaction between seed priming treatment and salinity concentrations.

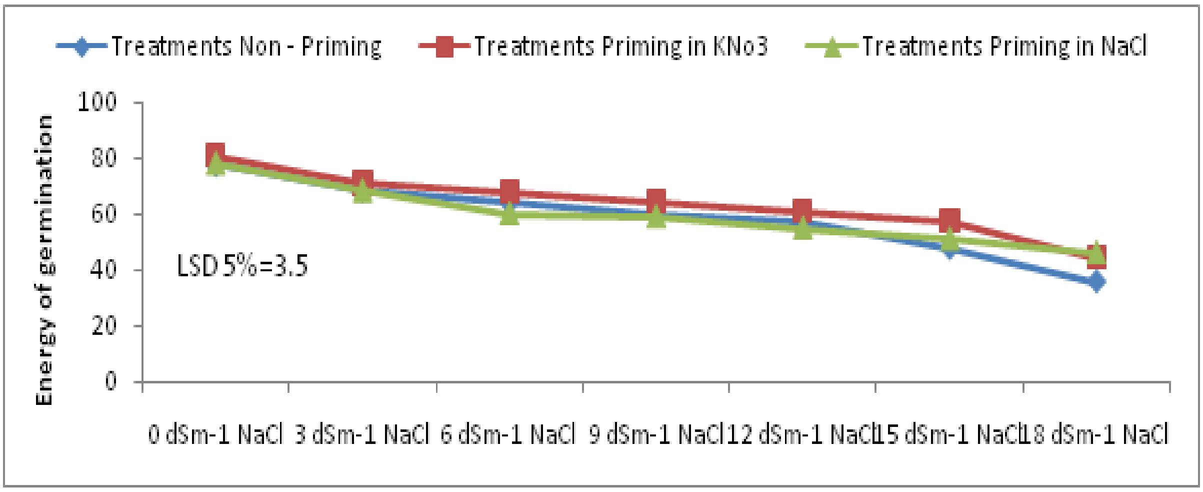


**Fig. 13.** Means of energy of germination as affected by the interaction between seed priming treatments and salinity concentrations.

These results are in agreement with those obtained by Siddiq *et al.* (2007), El- Saidy *et al.* (2011), Elouaer and Hannachi (2012), Khodadad (2011), Ghazizade *et al.* (2012), and Moghanibashi *et al.* (2012), Panahia *et al.* (2013) and Give *et al.* (2014).

*Concentrations*

Regarding to the interaction effect between seed priming treatments and salinity concentrations, results illustrated in Fig. 10, Fig. 11, Fig. 12 and Fig.13. clearly showed that final germination percentage, germination index, energy of germination and seedling vigor index were significantly. Highest final germination percentage, germination index, energy of germination and seedling vigor index was produced from seed priming with $KNo_3$ under the control treatment. While, the lowest final germination percentage, germination rate, germination index, energy of germination and seedling was 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 final germination percentage. These results are in agreement with those reported by Kaya *et al.* (2006), Elouaer and Hannachi (2012) and Khomari *et al.* (2014). Moghanibashi *et al.* (2012) and Pahoja *et al.* (2013).

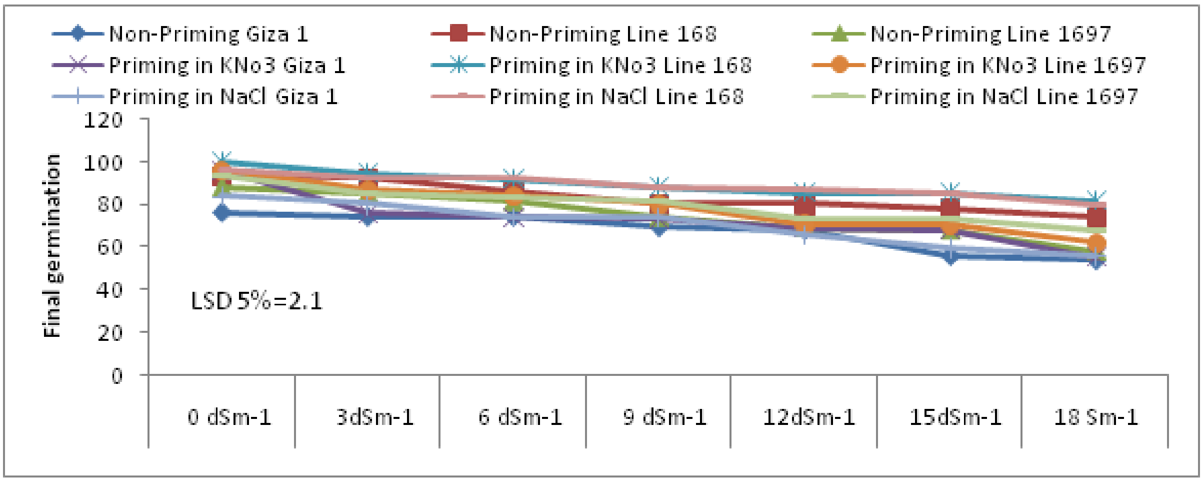


**Fig. 14.** Means of final germination as affected by the interaction between seed priming treatments, studied cultivars and salinity concentrations.

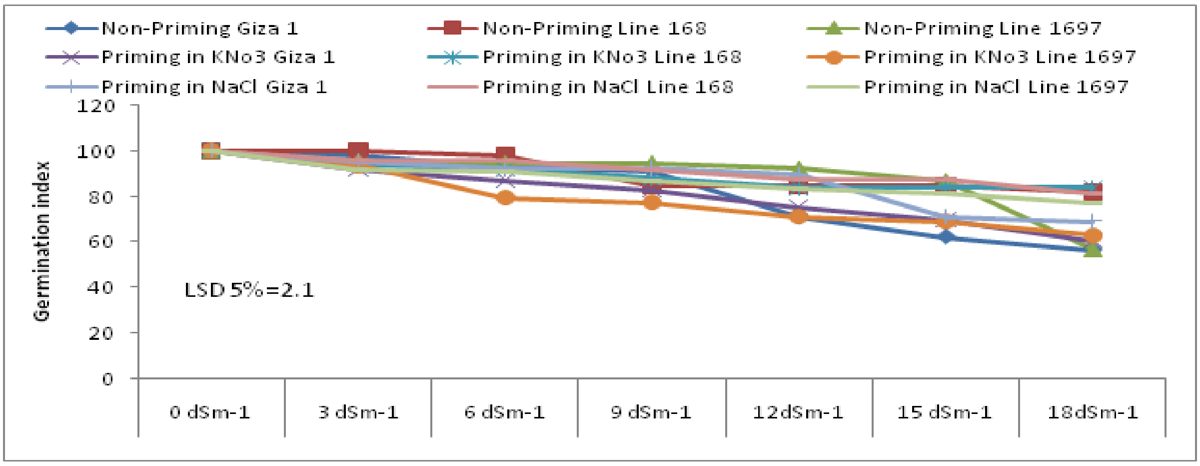


**Fig. 15.** Means of germination index as affected by the interaction between seed priming treatments, studied cultivars and salinity concentrations.

Concerning effect of the interaction between seed priming treatments, studied cultivars and salinity concentrations results illustrated in Fig. 14, Fig. 15, Fig. 16 and Fig. 17 clearly showed that final germination percentage, germination index, energy of germination and seedling vigor index were significantly affected by the interaction between seed priming, safflower cultivars and salinity concentrations. Highest final germination percentage, germination index, energy of germination and seedling vigor index was obtained from seed priming in $KNo_3$ and sown Line 168 under the control treatment.

While, the lowest final germination percentage was produced from non-primed seed or priming in $KNo_3$ of Giza 1 cultivar under salinity concentrations of 18 $dSm^{-1}$ NaCl without signif differences. 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). These results in good agreement with those reported by Moghanibashi *et al.* (2012), Jabeen and Ahmed (2013), Gaballah and El Meseiry (2014), Khomari *et al.* (2014) and Moghadam and Mohammadi (2014).

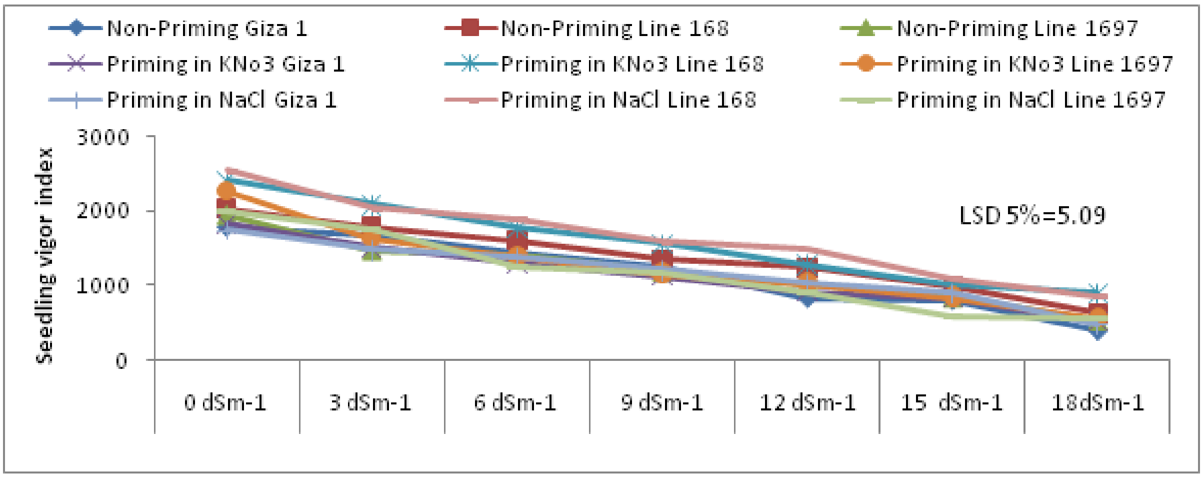


**Fig. 16.** Means of seedling vigor index as affected by the interaction between seed priming treatments, studied cultivars and salinity concentrations.

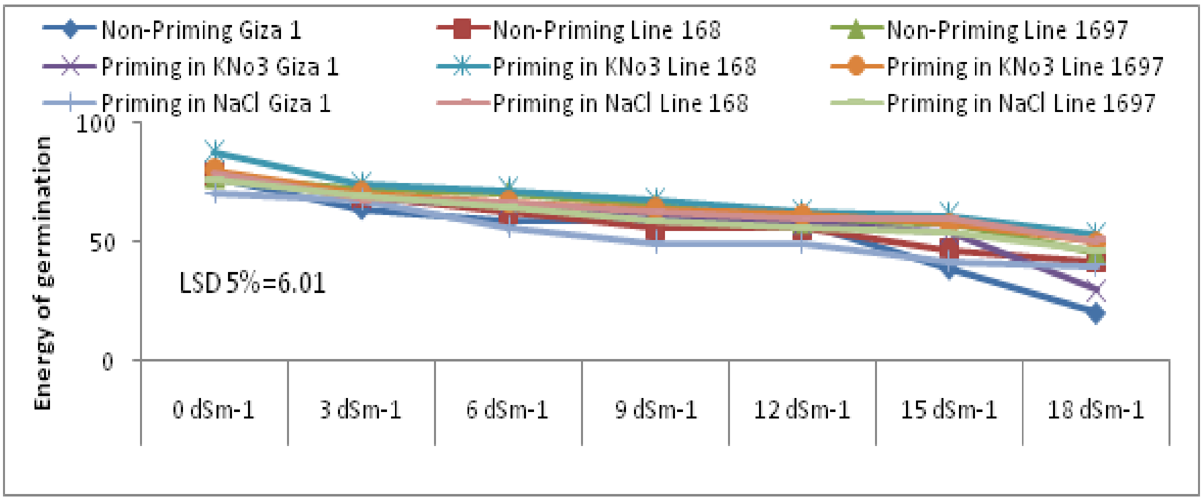


**Fig. 17.** Means of energy of germination as affected by the interaction between seed priming treatments studied cultivars and salinity concentrations.

## Conclusion

It could be concluded that for maximizing safflower germination characters and seedling parameters under salinity stress, seed priming with $KNo_3$ or 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.

## References

**Abdel- Baki AA, Anderson JD.** 1973. Viability and leaching of sugars from germinating barley. Crops Sciences **10**, 31-34.

**Almansouri M, Kinet JM, Lutts S.** 2001. Effect of salt and osmotic stresses on germination in durum wheat (*Triticum durum*). Plant and Soil **231**, 243-254.

**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.

**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.

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

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

**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.

**Ellis RA, Roberts EH.** 1981. The quantification of ageing and survival in orthodox seeds. Seed Science Technology **9**, 373-409.

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

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

**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.

**GiveHS, 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.

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

**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, RehmanA, 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.

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

**Jajarmi V,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.

**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.

**Karim MA, Utsunomiya N, Shigenaga S.** 1992. Effect of sodium chloride on germination and growth of hexaploid triticale at early seedling stage. Japanese J. of Crop Sci. **61**, 279 – 284.

**Katembe WJ, Ungar IA Mitchell JP.** 1998. Effect of salinity on germination and seedling growth of two A triplex species (*Chenopodiaceae).* Annals of Botany, **82**, 167-175.

**Kaya MD, Okgu G, Atak GY, Kolsarici O.** 2006. Seed treatments to overcome salt and drought stress during germination in sunflower *Helianthus annuus* 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 SA, 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.

**Nawaz J, Abdul Jabbar MH, Adeem GA, Sajid M, Subtainand M, Shabbir I.** 2013. Seed Priming A Technique. International Journal of Agriculture and Crop Science **6(20),** 1373-1381.

**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 Scienceand Research **3(2),** 71-80.

**Panahi M, Akbari GA, Golbashy M.** 2013. A study effects of salt stress on safflower genotypes *Carthamus tinctorius* L. germination and seedling characters. Advanced Crop Science **3(3),** 262 – 267.

**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.

**Ruan S, Xue Q, Tylkowska K.** 2002. Effects of seed priming on germination and health of rice *Oryza sativa* L. seeds. Seed Science and Technology **30**, 451-458.

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

**Saadateyan B, Solamani F, Ahmadvand G, Vojdane S.** 2009. Effect of hydro priming on germination index in sunflower under salt and drought stress conditions. National Conference on Oil Seed Crops 23-24 September, Iran, 622-624.

**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.

**Snedecor GW, Cochran WG.** 1980. Statistical Methods.7Th Ed. Iowa State University Press, Iowa, USA., ISBN-10: 0-81381560-6, 507.

**Soheilikhah Z, KarimiN, Ghasmpour AHR, Zebarjadi AR.** 2013. Effects of saline and mannitol induced stress on some biochemical and physiological parameters of (*Carthamus tinctorius* L). Varieties Callus Cultures., AJCS 7(12), 1866 – 1874.

**Tanveer A, Fard MZ, TahirM, Javaid MM, and Abdul-Khaliq.** 2012. Environmental factors affecting the germination and seedling emergence *Carthamus oxyacantha* M. Bieb. Wild Safflower Pak. J. Weed Sci. Res. **18**(2), 221-235.

**Wu GQ, JIAOO, SHUI QZ.** 2015. Effect of salinity on seed germination, seedling growth and inorganic and organic solutes accumulation in sunflower *Helianthus annuus* L. Plant Soil Environ, **61(5),** 220–226.

**Waller RA, Duncan BD.** 1969. A bays rule for the symmetric multiple comparison problem. J. Amer. Assoc. **64,** 1484-1503.

**Yari L, DaryaeiF, Sadeghi H.** 2015. Evaluation of seed size and NaCl stress on germination and early seedling growth of sunflower *Helianthus annuus* L. International Journal of Agronomy and Agricultural Research **7(3),** 60-65.