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Response of germination parameters of some canola cultivars to salinity stress

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Abstract

A laboratory experiment was conducted at Agronomy Department Laboratory of Seed Testing, Faculty of Agriculture, Mansoura University, Egypt, during December 2013 to study the effect of salinity concentrations on germination and seedlings parameters of some canola cultivars. The aim of this experiment was the study performance of three cultivars of canola *i.e.* Serw 4, Serw 6 and Serw 51 under different concentrations of salinity as NaCl *i.e.* 0.0 (control treatment), 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, and 1.8 %NaCl. The results indicated that Serw 6 cultivar exceeded the other studied cultivars in germination percentage, germination index, mean germination time and seedling vigor index. While, Serw 51 cultivar surpassed other studied cultivars in germination rate and speed germination index. As a result of increasing salinity levels from 0 (control) to 1.8% NaCl, studied germination parameters were significantly decreased. It could be concluded that for maximizing canola germination parameter, germinated seeds of Serw 6 or Serw 51 cultivars under control treatment (without salinity stress) or under conditions of 0.2% NaCl.

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Introduction

Canola (*Brassica napus* var. *oleifera* L.) is considered as one of the most important oil seed crops all over the world. Canola seeds contains about 40-50 % oil (Marinkovic *et al.*, 2009) of high quality for human consumption and the remaining is a high protein meal for livestock feed. Canola oil have the best fatty acid profile of any edible oil. It is characterized by less than 1 % erucic acid and higher percent of oleic which has been shown to reduce serum cholesterol level. Canola is a moderately salt-tolerant crop, grown mainly for its edible oil. However, its production and quality are greatly reduced by soil salinity (Akbari *et al.*, 2011). The cultivated area of canola in Egypt is relatively small due to the strong competition between canola and other strategic winter season crops. Increasing plant productivity is one of the main targets of the Ministry of Agriculture in Egypt. This could be achieved through the suitable agricultural practices *i.e.* using promising cultivars under salinity stress.

No doubt those chosen the high yielding ability cultivars and tolerance to salinity are very important to raise canola productivity per unit area. Zamani *et al.* (2011) reported that the assessment between canola cultivars showed the strong correlation between leaf relative water and enzyme super oxide dismutase activity. SLM046 cultivar showed the least changes in leaf relative water level and the highest enzyme activity and was resistant cultivar and Elite were the most sensitive cultivar to salinity. Kandil *et al.* (2012) showed that a significant differences in studied canola cultivars (Serw 4, Serw 10, Pactol and Line 51-El Serw) in means of final germination percentage (FGP%), germination rate (GR) and speed germination index (SGI). Slauenwhite and Qaderi (2013) reported that among cultivars, plants of Roundup Ready 45H21 cultivar were tallest with thickest stems and greatest dry matter.

Salinity is one of the major abiotic stresses in arid and semi-arid regions that sustainability reduces the yield of major crops by more than 50%. Salinity also limits soil fertility in irrigated regions of the world, this effect due to low rainfall in these areas besides soil leaching does not occur (Corwin *et al.*, 1996). Moreover, salinity affects 7% of the world's land area for around 930 million ha (Qasim *et al.*, 2003). Although all soils contain some amount of soluble salts of multifarious nature, when soil and environmental conditions allow the concentrations in soil profiles to a high level, soil salinity becomes severe threat to land degradation and crop productivity (Munnus, 2002). Bybordi *et al.* (2010) concluded that high soil salinity affected the agricultural production in a large proportion in worldwide. Saline soils and saline irrigation water present potential hazards to canola production. A major constraint to seed germination and seeding establishment of canola is soil salinity that is a common problem in irrigated areas with low rainfall. Farhoudi (2010) showed salt stress declined root length, shoot length and seedling dry weight of canola, although increased seedling electrolyte leakage and catalase (CAT) and peroxidase (POD) activity. Kandil *et al.* (2012) found that increasing salinity concentrations from 0 to 1.75% NaCl significantly decreased final germination percentage (FGP%), germination rate (GR) and speed germination index (SGI). Hassen *et al.* (2014) indicated that salt stress *i.e.* concentrations of NaCl (0, 2, 4, 6, 8, 10 and 12 g/l) significantly affected germination parameters. Zhang *et al.* (2014) concluded that the yield and quality of canola is commonly susceptible by environmental stresses including drought, cold and high salinity. Farhoudi *et al.* (2015) reported that salt stress increased seedling electrolyte leakage and catalase (CAT) and peroxidase (POD) activities. Long *et al.* (2015) reported that canola yield has been constrained by salt stress and they provided new applicant salt stress responding genes, which may function in novel assumed nodes in the molecular pathways of salt stress resistance. Therefore, the objective of this investigation was aimed to study the effect of salinity stress on germination character of some canola cultivars as well as their interaction under conditions of laboratory experiment.

Materials and methods

A laboratory experiment was conducted at Agronomy Department Laboratory of Seed Testing, Faculty of Agriculture, Mansoura University, Egypt, during December 2013 to study the effect of salinity concentrations on germination and seedlings parameters of some canola cultivars. The experiment was carried out in factorial experiment in completely randomized design (CRD). The first factor included three cultivars of canola *i.e.* Serw 4, Serw 6 and Serw 51. Seeds of three studied canola cultivars were produced and obtained from Oil Crops Section, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. The second factor included ten concentrations of salinity as NaCl *i.e.* 0.0 (control treatment), 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, and 1.8 %NaCl). Seeds of canola cultivars were surface sterilized before start of germination test by immersion for 5 minutes in sodium hypochlorite solution, then repeatedly washed with distilled water.

Standard germination test

Random sample of 100 seeds per each treatment for each cultivar were allowed to germinate under the environmental conditions of Laboratory for Seed Testing in Agronomy Department, Faculty of Agriculture, Mansoura University, Egypt at 1st December 2012 as the rules of International Seed Testing Association (ISTA, 1996) on top filter paper in sterilized Petri-dishes (14 cm diameter) and each Petri-dish contains 25 seeds.

Each filter paper was moistened as required with a water solution at ten different NaCl concentrations. The papers belong to each dish were replaced every two days to prevent accumulation of salt according to (Rehman *et al.* 1996 and 1998). The whole experiment comprised 120 Petri dishes arranged in factorial experiment in completely randomized design (CRD). Seeds are considered physiologically germinated when the radical pierced the coleorhiza and reach approximately 2 to 3 mm long.

The germinated seeds were counted and first count defined as the number of germinated seeds at the fifth day. Then, every 24 hours the number of germinated seeds were counted until end of germination test (7 days). Seeds were categorized as germinated (radical 2 mm long), hard (no imbibitions or swelling) or nonviable (abnormal, dead or infected seeds) as described ISTA (1996).

Studied characters

- Final germination percentage (FG %): Normal seedlings of each replicate were counted after 7 days from planting and expressed as percentage according to the following equation described by ISTA (1996):

$$\text{FG \%} = \frac{\text{Number of normal seedlings}}{\text{Number of total grains}} \times 100$$

- Germination rate (GR): It was calculated according to the following equation (Ellis and Roberts (1981).

$$\text{GR} = \frac{\mathbf{n}}{\mathbf{Dn}}$$

Where GR is the germination rate, n is the number of seeds germinated on day and D is the number of days from the start of test.

- Speed germination index (SGI): It was calculated by the following formula (ISTA, 1996):

$$\text{SGI} = \frac{\text{No. of germinated grains}}{\text{Days to first count}} + \frac{\dots\dots\dots}{\dots\dots\dots} + \frac{\text{No. of germinated grains}}{\text{Days to final count}}$$

- Germination index (GI): It was calculated according to the following equation (Karim *et al.* 1992):

$$\text{GI} = \frac{\textbf{Germination percentage in each treatment}}{\textbf{Germination percentage in control treatment}}$$

- Mean germination time (MGT): It was calculated based on the following equation (Ellis and Roberts, 1981):

$$\text{MGT} = \frac{\sum \text{Dn}}{\sum \text{n}}$$

Where (n) is the number of grains, which were germinated on day, D is number of days counted from the beginning of germination.

- Seedling vigor index (SVI): It was calculated according to the formula as suggested by AbdulBaki and Anderson (1970):

$$SVI = \frac{(\text{radical + plumel length}) \times \text{Germination percentage}}{100}$$

Data were subjected to the statistical analysis according to the technique of analysis of variance (ANOVA) for the factorial experiment in completely randomized design (CRD) as published by Gomez and Gomez (1991) by using "MSTAT-C " computer software package. Least significant of difference (LSD) method was used to test the differences between treatment means at 5 % level of probability as described by Snedecor and Cochran (1980).

Results and discussion

Cultivars performance

Regarding to the performance of canola cultivars, the results in Tables 1 and 2 show that there were significant differences in final germination percentage (FG %), germination rate (GR), speed germination index (SGI), germination index (GI) and mean germination time (MGT) among all studied cultivars *i.e.* Serw 4, Serw 6 and Serw 51. While, the differences in seedling vigor index (SVI) did not reach to level of significance. It could be observed that Serw 6 cultivar exceeded the other studied cultivars in germination percentage, germination index (GI), mean germination time (MGT) and seedling vigor index (SVI). Meanwhile, Serw 51 cultivar surpassed other studied cultivars in germination rate (GR) and speed germination index (SGI). At the same time as, Serw 4 cultivar produced the lowest values of all studied germination parameters. The differences among canola cultivars in germination parameters might due to the genetical factors and hereditary variation among the four canola cultivars under study, which caused variation in germination parameters. These results were in harmony with results obtained by Kandil *et al.* (2012).

Table 1. Final germination percentage (FG %), germination rate (GR) and speed germination index (SGI) as affected by salinity concentrations of some canola cultivars.

Characters / Treatments	Final germination (FG %)	Germination rate	Speed germination index
A- Cultivars:			
Serw 4	64.9	67.0	17.64
Serw 6	87.3	86.4	18.57
Serw 51	86.5	87.6	20.43
F. test	*	*	*
LSD at 5 %	4.9	6.0	1.41
B- Salinity concentrations:			
0 (control)	98.0	100.0	31.70
0.2 % NaCl	96.0	99.0	29.82
0.4 % NaCl	95.6	96.3	27.76
0.6 % NaCl	92.4	93.0	22.97
0.8 % NaCl	88.6	88.6	20.53
1.0 % NaCl	80.5	80.9	17.76
1.2 % NaCl	69.0	69.5	13.70
1.4 % NaCl	64.5	65.4	11.29
1.6 % NaCl	58.7	59.0	8.33
1.8 % NaCl	52.5	51.9	4.93
F. test	*	*	*
LSD (5 %)	5.0	4.5	1.68
D- Interaction (F. test):			
A × B	*	*	NS

Table 2. Germination index (GI), mean germination time (MGT) and seedling vigor index (SVI) as affected by salinity concentrations of some canola cultivars.

Characters / Treatments	Germination index (GI)	Mean germination time (MGT)	Seedling vigor index (SVI)
A- Cultivars:			
Serw 4	0.663	5.41	4.04
Serw 6	0.891	7.28	4.60
Serw 51	0.883	7.21	4.07
F. test	*	*	NS
LSD at 5 %	0.050	0.70	-
B- Salinity concentrations:			
0 (control)	1.000	8.17	9.07
0.2 % NaCl	0.980	8.00	8.37
0.4 % NaCl	0.976	7.97	7.09
0.6 % NaCl	0.943	7.70	6.05
0.8 % NaCl	0.905	7.38	4.33
1.0 % NaCl	0.821	6.71	2.96
1.2 % NaCl	0.704	5.75	1.80
1.4 % NaCl	0.659	5.38	1.15
1.6 % NaCl	0.599	4.89	0.90
1.8 % NaCl	0.537	4.38	0.66
F. test	*	*	*
LSD (5 %)	0.051	0.72	0.63
D- Interaction (F. test):			
A × B	*	*	*

Effect of salinity concentrations

With respect to the effect of salinity stress expressed as concentrations of salinity as *i.e.* 0.0 (control treatment), 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, and 1.8 % NaCl on germination parameters (final germination percentage, germination rate, speed germination index, germination index, mean germination time and seedling vigor index) of canola seeds, the results presented in Tables 1 and 2 show that there were significant differences in germination parameters among all studied salinity stress. From obtained results, as a result of increasing salinity levels from 0 (control) to 1.8% NaCl, final germination percentage (FG %) was significantly decreased. Where, the highest percentages of final germination were recorded with 0 (control) treatment, followed by 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, and 1.8 %NaCl, which recorded 98.0, 96.0, 95.6, 92.4, 88.6, 80.5, 69.0, 64.5, 58.7 and 52.5%, respectively. the highest germination rate value (100.0) was obtained from control treatment (0% NaCl), followed by (99.0) which result from 0.2% NaCl and (96.3) which produced from 0.4% NaCl without significant differences among them. The order of other salinity concentrations was as follows; 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, and 1.8 %NaCl, which registried the following values of germination rate; 93.0, 88.6, 80.9, 69.5, 65.4, 59.0 and 51.9, respectively. The highest SGI (31.70) was resulted from control treatment (0% NaCl). The second best SGI value (29.82) was produced from the second salinity concentration (0.2% NaCl). The percentages of reduction in speed germination index (SGI) as a result of increasing salinity concentrations from 0.0 to 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6 and 1.8 % NaCl were 5.93, 12.43, 27.54, 35.24, 43.97, 56.78, 64.38, 73.72 and 84.45%, respectively. The highest percentages of GI were recorded with 0 (control) treatment, followed by 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, and 1.8 %NaCl, which recorded 1.000, 0.980, 0.976, 0.943, 0.905, 0.821, 0.704, 0.659, 0.599 and 0.537, respectively. The highest MGT value (8.17) was obtained from control treatment (0% NaCl), followed by (8.00) which result from 0.2% NaCl and (7.97) which produced from

0.4% NaCl without significant differences among them. The order of other salinity concentrations was as follows; 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, and 1.8 %NaCl, which registried the following values of MGT; 7.70, 7.38, 6.71, 5.75, 5.38, 4.89 and 4.38, respectively. The highest SVI (9.07) was resulted from control treatment (0% NaCl). The second best SVI value (8.37) was produced from the second salinity concentration (0.2% NaCl). The percentages of reduction in speed germination index (SGI) as a result of increasing salinity concentrations from 0.0 to 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6 and 1.8 %NaCl were 7.72, 21.83, 33.30, 52.26, 67.36, 80.15, 87.32, 90.08 and 92.72, respectively. It could be concluded that final germination parameters was gradually decreased as affected by increasing salinity concentration. The reduction in germination parameters due to salinity stress concentration may influence the germination of canola seed either by creating an osmotic potential external to the seed preventing water uptake, or the toxic effect of Na^{+} and Cl^{-} ions on the germination seeds. These results are in good agreement with those reported by Kandil *et al.* (2012), Hassen *et al.* (2014), Zhang *et al.* (2014), Farhoudi *et al.* (2015) and Long *et al.* (2015).

Interaction effects

Regarding the effect of the interaction between canola cultivars and salinity stress on final germination percentage, germination rate, germination index, mean germination time and seedling vigor index, the statistical analysis of obtained results showed that it was significant (Tables 1 and 2). The maximum percentage of final germination (100%) was obtained from germinated seeds of Serw 6 or Serw 51 cultivars under control treatment conditions (without salinity stress), and also germinated seeds of Serw 51 cultivar under conditions of 0.2% NaCl as graphically illustrated in Fig. 1. On the other hand, the lowest final germination percentage was recorded when germinated seeds of Serw 6 cultivar under highest level of salinity stress (1.8% NaCl).

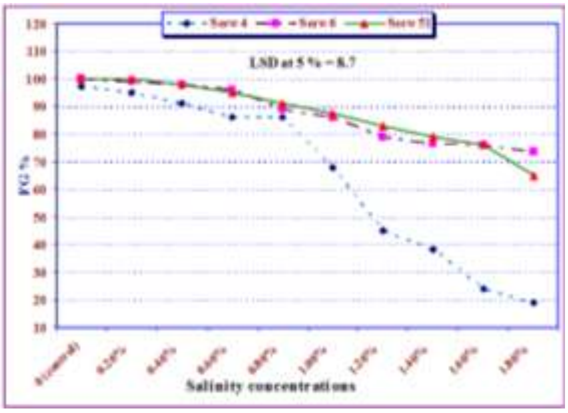

Fig. 1. Final germination percentage (FG %) as affected by the interaction between salinity concentrations and canola cultivars.

As shown from results graphically illustrated in Fig. 2, germinated seeds of all studied canola cultivars under control treatment (without salinity stress) and also Serw 51 cultivar under conditions of 0.2% NaCl produced the maximum percentage of germination rate (100%). Followed by germinated seeds of Serw 6 cultivar under conditions of 0.2% NaCl, then Serw 4 cultivar under conditions of 0.2% NaCl and Serw 51 cultivar under conditions of 0.4% NaCl. On the contrary, the lowest germination rate was obtained from germinated seeds of Serw 6 cultivar under highest level of salinity stress (1.8% NaCl).

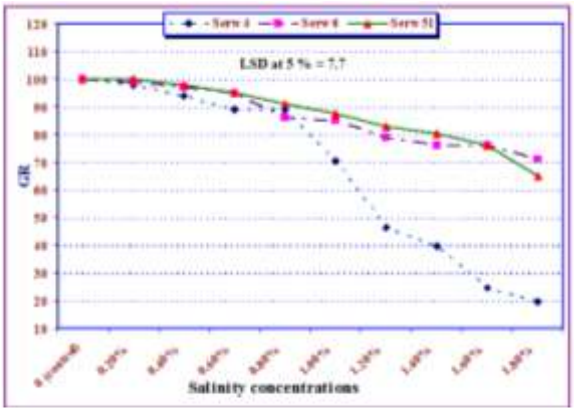

Fig. 2. Germination rate (GR) as affected by the interaction between salinity concentrations and canola cultivars.

The maximum germination index value was obtained from germinated seeds of Serw 51 cultivar under control treatment conditions (without salinity stress) as graphically illustrated in Fig. 3. On the other hand, the lowest germination index value was recorded when germinated seeds of Serw 4 cultivar under highest level of salinity stress (1.8% NaCl).

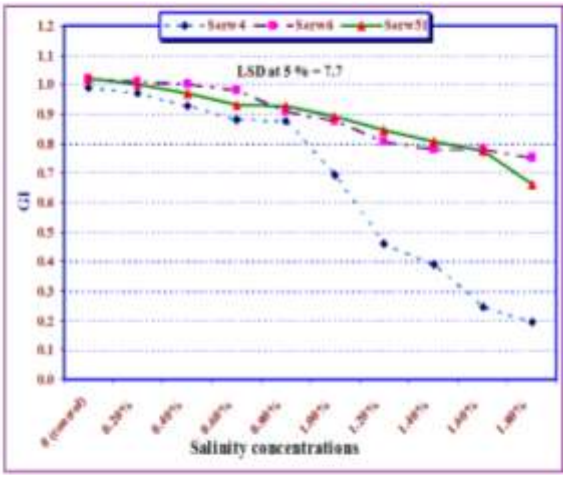

Fig. 3. Germination index (GI) as affected by the interaction between salinity concentrations and canola cultivars.

As shown from results graphically illustrated in Fig. 4, germinated seeds of Serw 6 or Serw 51 cultivars under control treatment (without salinity stress) produced the maximum MGT. Followed by germinated seeds of Serw 6 or Serw 51 cultivars under conditions of 0.2% NaCl. On the contrary, the lowest MGT was obtained from germinated seeds of Serw 4 cultivar under highest level of salinity stress (1.8% NaCl).

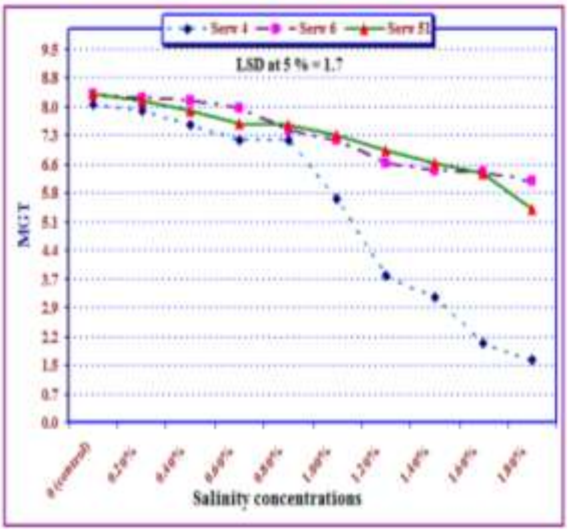

Fig. 4. Mean germination time (MGT) as affected by the interaction between salinity concentrations and canola cultivars.

As shown from results graphically illustrated in Fig. 5, germinated seeds of Serw 6 cultivar under control treatment (without salinity stress) produced the maximum seedling vigor index (SVI) (9.44). Followed by germinated seeds of Serw 6 cultivar under control treatment (without salinity stress), then germinated seeds of Serw 6 under conditions of 0.2% NaCl. On the contrary, the lowest SVI was obtained from germinated seeds of Serw 4 cultivar under highest level of salinity stress (1.8% NaCl).

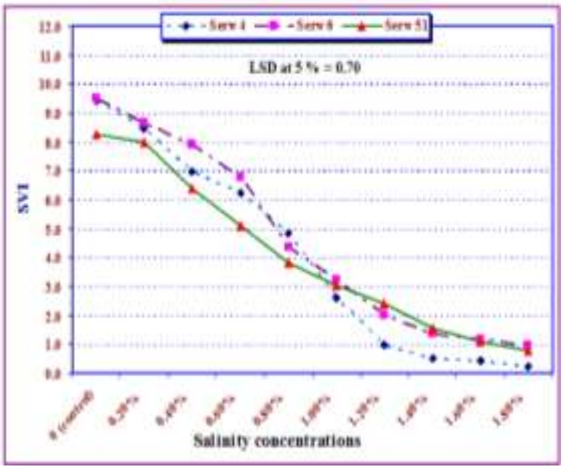

Fig. 5. Seedling vigor index (SVI) as affected by the interaction between salinity concentrations and canola cultivars.

Conclusion

It could be concluded that for maximizing canola germination parameter, germinated seeds of Serw 6 or Serw 51 cultivars under control treatment (without salinity stress) or under conditions of 0.2% NaCl.

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