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Effect of salinity stress on seedlings parameters of some canola cultivars

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Key words: Canola, Cultivars, Salinity stress, seedlings characters.

Abstract

To study the effect of salinity concentrations on seedlings parameters of some canola cultivars, a laboratory experiment was conducted at Agronomy Department Laboratory of Seed Testing, Faculty of Agriculture, Mansoura University, Egypt, during December 2013. The experiment included two factor, the first factor included three cultivars of canola *i.e.* Serw 4, Serw 6 and Serw 51 and 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). The results showed that Serw 6 cultivar significantly exceeded the other studied cultivars in root and shoot lengths and shoot fresh and dry weights. Whilst, Serw 51 cultivar significantly exceeded the other studied cultivars in root fresh and dry weights, seedling height reduction (SHR), relative dry weight and chlorophyll content in leaves. Salinity stress significantly affected seedlings characters of canola. Due to increasing salinity levels from 0 (control) to 1.8% NaCl, seedlings characters of canola was significantly decreased. It could be concluded that for maximizing canola seedlings parameters, 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

In Egypt, there is a great shortage with respect to edible oils. The local production of vegetable oils fall to face the increasing rate of the consumption. This reflects the problem and shows the need for expanding oil seed crop productivity. Also, increasing the cultivated area of summer oil crops such as soybean, sunflower and sesame is unexpected in the Nile Valley and Delta due to the strong competition with other main summer crops such as cotton, rice, maize and vegetable crops for the very limited land area and the shortage in irrigation water. Therefore, introducing a new oil crop such as canola in the winter season seems to be practical due to its less water requirements than summer ones, moreover it could be cultivated in the newly reclaimed soils. Canola (*Brassica napus* var. *oleifera* L.) is considered as one of the most important oil seed crops all over the world. In Egypt, the cultivated area of canola is relatively small due to the strong competition between canola and other strategic winter crops such as wheat. 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.

Chosen the high yielding ability cultivars and tolerance to salinity are very important to raise canola productivity per unit area. For this reason, this study is aiming to evaluate the canola cultivars for focusing light on the most cultivar that can be used on a large scale under salinity stress. Mohammadi and Amiri (2010) pointed out that canola cultivars (Talayeh and Okapi) showed different responses to increased drought stress level. Increased drought stress level reduced radical length and seedling dry weight for Talayeh cultivar. Ozturk *et al.* (2010) stated that seed yield varied significantly among the two studied cultivars *i.e.* Pactol and Star. 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. Kandil *et al.* (2012) showed that a significant differences in studied canola cultivars (Serw 4, Serw 10, Pactol and Line 51-El Serw) in plumula length (cm), radical length (cm), seedling fresh weight (g), seedling dry weight (g), and seedling height reduction (SHR%). Line 51-El-Serw significantly exceeded other studied cultivars in plumula length, radical length and seedling dry weight. Slauenwhite and Qaderi (2013) reported that among cultivars, plants of Roundup Ready 45H21 cultivar were tallest with thickest stems and greatest dry matter. Farhoudi *et al.* (2015) stated that three studied canola (*Brassica napus*) cultivars *i.e.* Consul, Zarfam and Okapi were significantly differed in root length, shoot length and seedling dry weight.

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%. Even though salt stress affects all plant growth stages, seed germination and seedling growth stages are the most sensitive (Jovicic *et al.*, 2014). Therefore, the major constraint to seed germination and seedling establishment of canola is soil salinity that is a common problem in reclaimed soil in Egypt. The crop growth and yield is largely dependent on the success of germination and seedling establishment, which are largely affected by seed quality. Seed with rapid germination under salt stress may be expected to achieve a rapid seedling establishment and more salt tolerance and hence higher yield (Bybordi and Tabatabaei, 2009). 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. Kandil *et al.* (2012) found that increasing salinity concentrations from 0 to 1.75% NaCl significantly decreased plumula length (cm), radical length (cm), seedling fresh weight (g) and seedling dry weight (g) seedling height reduction (SHR%) and relative dry weight (RDW)While, SHR% was increased with increasing salinity concentrations.

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 radicle and plumule length, fresh weight and dry weight of seedlings. Mousavi *et al.* (2014) indicated that increasing NaCl concentration from 0 to 250 mM reduced shoot dry weight from 241.4 g/m^2 to 189.23 g/m^2. Farhoudi *et al.* (2015) reported that salt stress decreased canola cultivar root length, shoot length and seedling dry weight. Therefore, the objective of this investigation was aimed to study the effect of salinity stress on seedlings 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 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. The pedigree of the three studied cultivars was showed in Table 1. 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.

Table 1. Name, name of genotype, type, pedigree and year of release of studied canola cultivars.

Number	Name	Name of genotype	Type	Pedigree	Year of release
1	Serw 4	Brassica napus	Spring	Anthur culture from variefy (fido)	1998
2	Serw 6	Brassica napus	Spring	Serw 4 × line 562	2008
3	Serw 51	Brassica napus	Spring	Anthur variety (Tower)	1992

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

Root length: Averages of root length of ten seedlings taken by random per each replicate from the grain to the tip of the root and recorded and expressed in centimeters (cm) as the root length at the end of standard germination test.

Shoot length: Averages of shoot length of the ten seedlings taken by random per each replicate from the grain to the tip of the leaf blade were recorded and expressed in centimeters as the shoot length at the end of standard germination test.

Root fresh weight: The fresh weight of ten seedling roots at random per replicate were recorded and expressed in gram (g) at the end of standard germination test.

Root dry weight: The weight of ten seedling roots at random per replicate were recorded and expressed in gram (g) after oven drying at 70 º C until constant weight (Agrawal, 1986).

Shoot fresh weight: The fresh weight of ten seedling shoots at random per replicate were recorded and expressed in gram (g) at the end of standard germination test.

Shoot dry weight: The weight of ten seedling shoots at random per replicate were recorded and expressed in gram (g) after oven drying at 70 º C until constant weight (Agrawal, 1986).

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

$$\mathrm{SHR\%} = \frac{\text{Plant height at control – plant height at saline condition}}{\text{Plant height at saline condition}} \times 100$$

Relative dry weight (RDW): The relative dry weight (RDW) was calculated according to Islam and Karim (2010) using the following equation:

$$\mathrm{RDW\%} = \frac{\text{Total dry weight under saline condition}}{\text{Total dry weight under control condition}} \times 100$$

Total chlorophyll (SPAD): Total chlorophyll content was assessed in leaves of shoot by SPAD-502 (Minolta Co. Ltd., Osaka, Japan).

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 explain that there were significant differences in root length, root fresh and dry weights, shoot fresh and dry weights and relative rate of dry weight of canola seedlings among all studied cultivars *i.e.* Serw 4, Serw 6 and Serw 51. On the contrast, the differences in shoot length, seedling height reduction (SHR) and chlorophyll content in leaves among studied canola cultivars were insignificant. It could be noticed that Serw 6 cultivar significantly exceeded the other studied cultivars in root and shoot lengths and shoot fresh and dry weights. Whilst, Serw 51 cultivar significantly exceeded the other studied cultivars in root fresh and dry weights, seedling height reduction (SHR), relative rate of dry weight and chlorophyll content in leaves. On the other hand, Serw 4 cultivar produced the lowest values of all studied seedlings characters. These results might be attributed to the genetically factors and heredity variation among the four canola cultivars under study which caused differed in seedlings characters. These results were in synchronization with results reported by Mohammadi and Amiri (2010), Kandil *et al.* (2012) and Farhoudi *et al.* (2015).

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 seedlings characters of canola, the results presented in Tables 1 and 2 demonstrate that there were significant differences in root and shoot lengths, root fresh and dry weights, shoot fresh and dry weights, seedling height reduction (SHR), relative rate of dry weight and chlorophyll content in leaves of canola among all studied salinity stress. From obtained results, due to increasing salinity levels from 0 (control) to 1.8% NaCl, seedlings characters of canola was significantly decreased. The longest root of canola seedlings (3.98 cm) resulted from 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 3.55, 2.90, 2.70, 2.13, 1.55, 1.01, 0.73, 0.72 and 0.70 cm, respectively.

Table 2. Root and shoot lengths, root fresh and dry weights and shoot fresh dry weight as affected by salinity concentrations of some canola cultivars.

Treatments / Characters	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Root dry weight (g)	Shoot fresh weight (g)
A- Cultivars:					
Serw 4	1.90	2.50	0.998	0.228	3.017
Serw 6	2.07	2.90	1.228	0.777	3.834
Serw 51	2.03	2.86	1.383	0.976	3.317
F. test	*	NS	*	*	*
LSD at 5 %	0.12	-	0.207	0.230	0.342
B- Salinity concentrations:					
0 (control)	3.98	5.41	1.732	1.238	4.330
0.2 % NaCl	3.55	5.00	1.640	1.003	4.128
0.4 % NaCl	2.90	4.51	1.543	0.856	4.043
0.6 % NaCl	2.70	3.86	1.463	0.756	3.859
0.8 % NaCl	2.13	2.79	1.260	0.691	3.588
1.0 % NaCl	1.55	2.16	1.008	0.593	3.391
1.2 % NaCl	1.01	1.51	1.003	0.513	3.186
1.4 % NaCl	0.73	0.98	0.900	0.422	2.862
1.6 % NaCl	0.72	0.80	0.782	0.312	2.414
1.8 % NaCl	0.70	0.53	0.699	0.220	2.091
F. test	*	*	*	*	*
LSD (5 %)	0.37	0.40	0.173	0.132	0.321
D- Interaction (F. test):					
A × B	NS	*	*	*	*

Table 3. Shoot dry weight, seedling height reduction (SHR), relative rate of dry weight and chlorophyll content in leaves as as affected by salinity concentrations of some canola cultivars.

Treatments / Characters	Shoot dry weight (g)	Seedling height reduction (SHR)	Relative rate of dry weight	Chlorophyll content (SPAD)
A- Cultivars:				
Serw 4	1.168	0.468	0.368	1.143
Serw 6	2.119	0.491	0.467	1.215
Serw 51	1.691	0.496	0.646	1.271
F. test	*	NS	*	NS
LSD at 5 %	0.287	-	0.122	-
B- Salinity concentrations:				
0 (control)	3.126	0.000	1.000	1.589
0.2 % NaCl	2.768	0.079	0.682	1.481
0.4 % NaCl	2.291	0.173	0.642	1.352
0.6 % NaCl	2.008	0.285	0.608	1.242
0.8 % NaCl	1.700	0.455	0.530	1.148
1.0 % NaCl	1.457	0.577	0.430	1.113
1.2 % NaCl	1.065	0.713	0.324	1.110
1.4 % NaCl	0.907	0.817	0.317	1.048
1.6 % NaCl	0.672	0.850	0.243	1.014
1.8 % NaCl	0.598	0.898	0.160	1.000
F. test	*	*	*	*
LSD (5 %)	0.256	0.064	0.101	0.072
D- Interaction (F. test):				
A × B	NS	*	NS	NS

The longest shoot (5.41 cm) was obtained from control treatment (0% NaCl), followed by (5.00 cm) which result from 0.2% NaCl and (4.51 cm) which produced from 0.4% NaCl. 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 produced the following values of shoot length of canola seedlings; 3.86, 2.79, 2.16, 1.51, 0.98, 0.80 and 0.53 cm, respectively. The heaviest fresh weight of seedlings (1.732 g) was resulted from control treatment (0% NaCl). The second best root fresh weight of seedlings value (1.640 g) was produced from the second salinity concentration (0.2% NaCl). The percentages of reduction in root fresh weight of germinated canola seedlings 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 5.31, 10.91, 15.53, 27.25, 41.80, 42.09, 48.04, 54.85 and 59.64%, respectively. The highest values of root dry weight of canola seedlings 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 1.238, 1.003, 0.856, 0.756, 0.691, 0.593, 0.513, 0.422, 0.312 and 0.220 g, respectively. The highest value of shoot fresh weight of canola seedlings (4.330 g) was obtained from control treatment (0% NaCl), followed by (4.128 g) which result from 0.2% NaCl and (4.043 g) 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 shoot fresh weight of canola seedlings; 3.859, 3.588, 3.391, 3.186, 2.862, 2.414 and 2.091 g, respectively. The highest value of shoot dry weight of canola seedlings (3.126 g) was resulted from control treatment (0% NaCl). The second best value of shoot dry weight of canola seedlings (2.768 g) was produced from the second salinity concentration (0.2% NaCl). The percentages of reduction in shoot dry weight of canola seedlings 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 11.45, 26.71, 35.76, 45.62, 53.39, 65.93, 70.99, 78.50 and 80.87%, respectively. The lowest seedling height reduction (0.000) resulted from 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 0.079, 0.173, 0.285, 0.455, 0.577, 0.713, 0.817, 0.850 and 0.898, respectively. The highest value of relative dry weight (1.000) was obtained from control treatment (0% NaCl), followed by (0.682) which result from 0.2% NaCl and (0.642) which produced from 0.4% NaCl. 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 produced the following values of relative dry weight (RDW); 0.608, 0.530, 0.430, 0.324, 0.317, 0.243 and 0.160, respectively. the highest value of total chlorophyll of germinated canola seedlings (1.589 SPAD) was resulted from control treatment (0% NaCl). The second best total chlorophyll of germinated canola seedlings (1.481 SPAD) was produced from the second salinity concentration (0.2% NaCl). The percentages of reduction in total chlorophyll of germinated canola seedlings 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 6.80, 14.92, 21.84, 27.75, 29.96, 30.14, 34.05, 36.19 and 37.07%, respectively. The reduction in seedlings characters of canola due to salinity stress concentration may be due to occur of some metabolically disorders (Ayaz *et al.*, 2002). These results are in good agreement with those reported by Farhoudi (2010), Kandil *et al.* (2012), Hassen *et al.* (2014), Mousavi *et al.* (2014) and Farhoudi *et al.* (2015).

Effect on interaction

The interaction between canola cultivars and salinity stress was significantly affected shoot length, root fresh and dry weights, shoot fresh weight and seedling height reduction (SHR) as shown from results in Tables 1 and 2. As shown from results graphically illustrated in Fig. 1, germinated seeds of Serw 51 cultivar under control treatment (without salinity stress) produced the longest shoot of seedlings. Followed by germinated seeds of Serw 51 cultivar under conditions of under control treatment (without salinity stress), then Serw 6 cultivar under conditions of 0.2% NaCl and Serw 51 cultivar under conditions of 0.2% NaCl. On the contrary, the lowest shortest shoot of seedlings was obtained from germinated seeds of Serw 51 cultivar under highest level of salinity stress (1.8% NaCl).

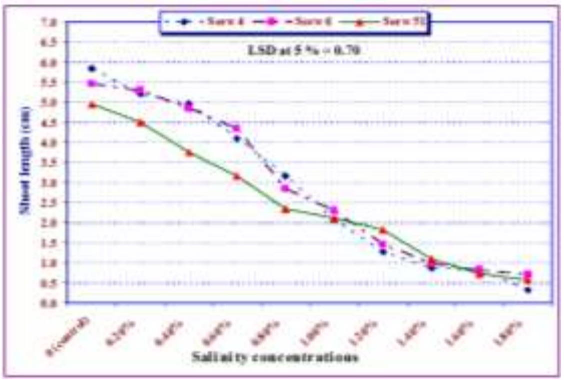

Fig. 1. Shoot length (cm) as affected by the interaction between salinity concentrations and canola cultivars.

The maximum value of root fresh weight of germinated canola seedlings was obtained from germinated seeds of Serw 51 cultivar under control treatment conditions (without salinity stress), followed by the same cultivars under conditions of 0.2, 0.4 and 0.6% NaCl as graphically illustrated in Fig.2. On the other hand, the lowest root fresh weight of germinated canola seedlings was recorded when germinated seeds of Serw 4 cultivar under highest level of salinity stress (1.8% NaCl).

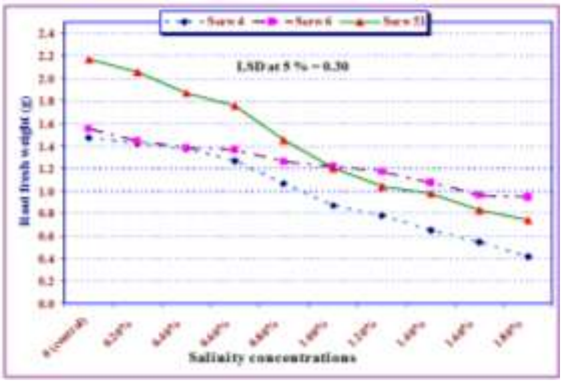

Fig. 2. Root fresh weight (g) as affected by the interaction between salinity concentrations and canola cultivars.

The maximum value of root dry weight of canola seedlings was obtained from germinated seeds of Serw 51 cultivars under control treatment conditions (without salinity stress), followed by germinated seeds of Serw 6 cultivars under control treatment conditions and then germinated seeds of Serw 51 cultivars under 0.2 % NaCl conditions as graphically illustrated in Fig. 3. On the other hand, the lowest final germination percentage was recorded when germinated seeds of Serw 4 cultivar under highest level of salinity stress (1.8% NaCl).

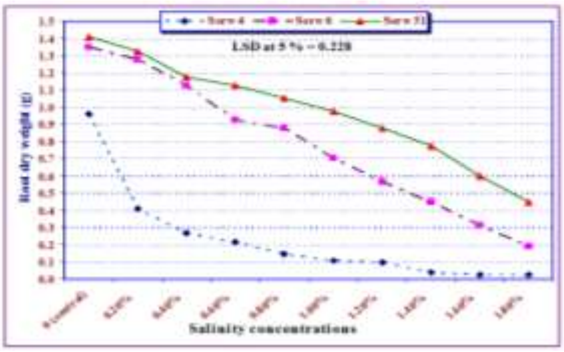

Fig. 3. Root dry weight (g) as affected by the interaction between salinity concentrations and canola cultivars.

As shown from results graphically illustrated in Fig. 4, germinated seeds of Serw 6 cultivar under control treatment (without salinity stress) produced the maximum value of shoot fresh weight of canola seedlings. Followed by germinated seeds of Serw 6 cultivar under conditions of 0.2%, 0.4% NaCl, then Serw 51 cultivar under conditions. On the contrary, the lowest value of shoot fresh weight of canola seedlings was obtained from germinated seeds of Serw 51 cultivar under highest level of salinity stress (1.8% NaCl).

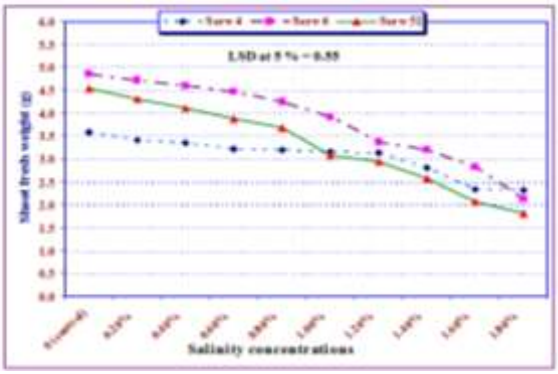

Fig. 4. Shoot fresh weight (g) as affected by the interaction between salinity concentrations and canola cultivars.

As shown from results graphically illustrated in Fig. 5, germinated seeds of all studied cultivars under control treatment (without salinity stress) produced the lowest value of seedling height reduction (0.000). Followed by germinated seeds of Serw 6 cultivar under conditions of 0.2 % NaCl then Serw 51 cultivar under conditions of 0.2% NaCl and Serw 4 cultivar under conditions of 0.2% NaCl. On the contrary, the highest seedling height reduction (SHR) was obtained from germinated seeds of Serw 4 cultivar under highest level of salinity stress (1.8% NaCl).

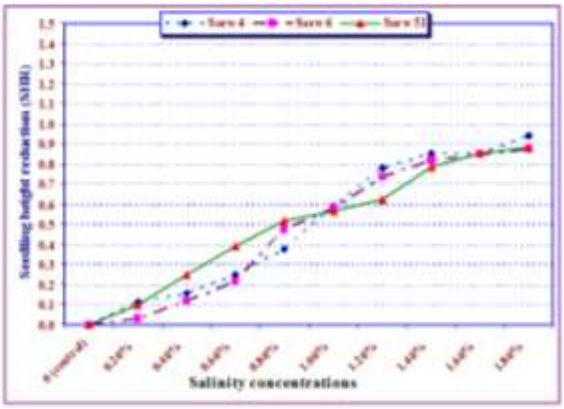

Fig. 5. Seedling height reduction (SHR) as affected by the interaction between salinity concentrations and canola cultivars.

Conclusion

It could be concluded that for maximizing canola seedlings parameters, germinated seeds of Serw 6 or Serw 51 cultivars and without salinity stress or under conditions of 0.2% NaCl.

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