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Impact of salinity concentrations on physiological indices of some canola cultivars

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Abstract

With the intention of examine the impact of salinity concentrations on physiological indices 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 was carried out in factorial experiment in completely randomized design (CRD). The first factor included canola cultivars (Serw 4, Serw 6 and Serw 51). The second factor included salinity concentrations as NaCl, which were 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 obtained results showed that shoot length stress index (SLSI), shoot fresh stress index (SFSI) and shoot dry stress index (SDSI) of germinated canola seedlings was insignificantly differed among all studied canola cultivars (Serw 4, Serw 6 and Serw 51). The maximum values of root length stress index (RLSI) and root fresh stress index (RFSI) were produced from Serw 4 cultivar, which significantly exceeded other studied cultivars. While, the maximum value of root dry stress index (RDSI) was produced from Serw 51 cultivar, which significantly exceeded other studied cultivars. Shoot length stress index (SLSI), root length stress index (RLSI), shoot fresh stress index (SFSI), root fresh stress index (RFSI), shoot dry stress index (SDSI) and root dry stress index (RDSI) of germinated canola seedlings was considerably decreased due to increasing NaCl levels from 0 to 1.8% NaCl. It could be concluded that for maximizing canola physiological indices, germinated seeds of Serw 4 or Serw 51 cultivars under control treatment (without salinity stress) or under conditions of 0.2% NaCl.

Keywords: Canola, *Brassica napus*, Cultivars, Verities, Genotypes, Salinity concentrations, Physiological indices.

Introduction

Canola (*Brassica napus* var. *oleifera* L.) is considered as one of the most important oil seed crops all over the world. Canola oil have high quality for human consumption, which have the best fatty acid profile of any edible oil and the remaining of oil extraction is a high protein meal for livestock feed. The cultivated area of canola in Egypt is relatively small due to the strong competition between canola and other strategic winter season crops. It is well known that high productivity of any crop is the final goal of many factors and operations. In addition, the pronounced role of the agronomical processes such as using promising cultivars under salinity stress.

Crop genotypes play a dominant role in crop production systems. It affect crop productivity by their higher yield potentials, resistance against insect pest and diseases under salinity stress conditions. For this reason, this study is aiming to evaluate the new promising cultivars for scooping light on the best cultivar that can be used under salinity stress conditions. **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 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 cultivars (Consul, Zarfam and Okapi) were significantly differed in seedling dry weight. **Kandil *et al.* (2016)** showed that 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. **Channaoui *et al.* (2017)** illustrated that rapeseed varieties significantly differed in root length and shoot length. The varieties 'INRA-CZH2' and 'INRA-CZH3' exhibited the highest germination percentage and the best early seedling growth. **Fallahi-Pashaki *et al.* (2017)** showed that the difference among canola genotypes (Zarfam, Sarigol, Hyola308, SLM046 and RGS003) were significant, except root length, radicle shoot rate and shoot growth rate. **Rezayian *et al.* (2018)** reported that RGS003 canola cultivar was more tolerant and obtained more biomass than that of Sarigol cultivar. Proline content and pyrroline-5-carboxylate synthetase expression increased in Sarigol cultivar.

Salinity is one of the most serious factories limiting crops production, especially the sensitive ones **(Zadeh and Naeni, 2007)**. According to the Food and Agriculture Organization (FAO), about 20 to 30 million hectares of irrigated land are currently seriously damaged by salinity, and 0.25 to 0.50 million hectares are lost from production every year as a result of salt accumulation. 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)**. **Farhoudi *et al.* (2015)** reported that salt stress decreased canola cultivar seedling dry weight, but increased seedling electrolyte leakage and catalase (CAT) and peroxidase (POD) activities. **Ataei-Somagh *et al.* (2016)** revealed that undesirable effects of salinity on canola seed germination leads to decrease the rate of deployment of canola in areas that are facing salinity of soil or irrigation water. **Kandil *et al.* (2016)** showed that 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. **Falcinelli *et al.* (2017)** reported that increasing salinity slightly decreased the bound fractions of total phenolics (TP), non-flavonoids (NF), tannins (TAN) and phenolic acids (PAs), while it increased markedly the free ones and their antioxidant activity. **Fallahi-Pashaki *et al.* (2017)** showed that all the studied characters including; radicle length, shoot length, radicle/shoot ratio, radicle fresh weight and radicle dry weight were significantly affected by salinity, and also showed a decreased pattern with increasing salinity. In the most of characters, the highest amount was observed in control and the lowest one was in12 ds/m treatment. For all of studied characters, 8 ds/m could be considered as salinity tolerance threshold. **Khan *et al.* (2017)** showed that salinity stress reduced seed germination and disturbed the morphological and physiological attributes of canola. **Kholghi *et al.* (2018)** reported that salinity stress increase reduced fresh and dry masses of shoots and roots, chlorophyll content, relative water content and K^+ content of shoots and roots of canola. Proline content, shoot and root Na^+ content and electrolyte leakage were increased by salinity stress. **Sharif *et al.* (2018)** indicated that salinity stress was significantly affected chlorophyll content and relative dry weight of leaves. The most chlorophyll content in leaf was obtained at non-stress treatment. **Dolatabadi *et al.* (2019)** found that an increase in proline and the Na^+ content of leaf and a reduction in seedling height, relative dry weight, plant height, K^+ content and K^+/Na^+ ratio were observed by increasing NaCl concentration from 0 to 150 and 300mM. **El-Sabagh *et al.* (2019)** stated that the productivity of canola tends to decrease under different abiotic stresses (among them salimity) due to their adverse effect on morphological, physiological and biochemical processes, including lowered or reduced leaf area, leaf relative water content, stability of cell membranes, photosynthetic capacity, stomatal conductance, damage to chlorophyll and the production of reactive oxygen species.

Hence, the object of this study was investigate the influence of salinity concentrations on physiological indices of some canola cultivars under conditions of laboratory experiment.

Materials and Methods

In order to investigate the impact of salinity concentrations on physiological indices 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 was carried out in factorial experiment in completely randomized design (CRD). The first factor included canola cultivars (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 salinity concentrations as NaCl, which were 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.

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 2013 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:

Six physiological indices were calculated according to **Ashraf *et al.* (2008)** as follows:

1- Shoot length stress index (SLSI): It was calculated by using the following formula:

$$SLSI = \frac{\text{Shoot length of stressed seeds}}{\text{Shoot length of the control}} \times 100$$

2- Root length stress index (RLSI): It was calculated by using the following formula:

$$RLSI = \frac{\text{Root length of stressed seeds}}{\text{Root length of the control}} \times 100$$

3- Shoot fresh stress index (SFSI): It was calculated by using the following formula:

$$SFSI = \frac{\text{Shoot fresh of stressed seeds}}{\text{Shoot fresh of the control}} \times 100$$

4- Root fresh stress index (RFSI): It was calculated by using the following formula:

$$RFSI = \frac{\text{Root fresh of stressed seeds}}{\text{Root fresh of the control}} \times 100$$

5- Shoot dry stress index (SDSI): It was calculated by using the following formula:

$$SDSI = \frac{\text{Shoot dry of stressed seeds}}{\text{Shoot dry of the control}} \times 100$$

6- Root dry stress index (RDSI): It was calculated by using the following formula:

$$RDSI = \frac{\text{Root dry of stressed seeds}}{\text{Root dry of the control}} \times 100$$

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

1- Shoot length stress index (SLSI):

Shoot length stress index (SLSI) means of germinated canola seedlings as affected cultivars and salinity stress as well as their interaction are presented in Table 1.

Shoot length stress index (SLSI) of germinated canola seedlings was insignificantly differed among all studied canola cultivars (Serw 4, Serw 6 and Serw 51) as obviously seen from results found in Table 1.

As shown from results listed in Table 1, NaCl levels (salinity stress) viz; 0.0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6 and 1.8% caused significant effect on shoot length stress index (SLSI) of germinated canola seedlings. Generally, SLSI of germinated canola seedlings was considerably decreased due to increasing NaCl levels from 0 to 1.8% NaCl. Besides, the highest value of SLSI of germinated canola seedlings (100) was resulted from control treatment (0% NaCl). The second best SLSI of germinated canola seedlings (92.04) was produced from the second salinity concentration (0.2% NaCl). The percentages of reduction in SLSI 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 7.96, 16.90, 28.91, 48.13, 59.49, 71.33, 81.67, 85.01 and 86.53%, respectively. In general, SLSI of germinated canola seedlings was more and more decreased as affected by increasing salinity concentrations. The reduction in SLSI of germinated canola seedlings due to increasing salinity concentrations may be due to undesirable effects of salinity on plant growth may be ascribed to ion cytotoxicity and/or osmotic stress, which cause ionic imbalances, oxidative and osmotic stress and nutritional deficiencies (**Zhu, 2002**).

Shoot length stress index (SLSI) of canola seedlings was insignificantly affected by the interaction between canola cultivars and salinity stress as clearly from results in Table 1.

Table 1: Means of shoot length stress index (SLSI) as affected by salinity concentrations, canola varieties and their interaction.

Salinity concentrations	Varieties			Salinity means	F. test	LSD (5 %) for salinity
	Serw 4	Serw 6	Serw 51			
0 (control)	100.00	100.00	100.00	**100.00**	*	7.07
0.2 %	88.88	97.22	90.04	**92.04**		
0.4 %	84.59	89.38	75.33	**83.10**		
0.6 %	70.11	79.68	63.48	**71.09**		
0.8 %	54.45	52.90	48.27	**51.87**		
1.0 %	35.67	42.23	43.63	**40.51**		
1.2 %	21.89	26.44	37.69	**28.67**		
1.4 %	15.04	18.29	21.65	**18.33**		
1.6 %	14.62	15.47	14.87	**14.99**		
1.8 %	6.39	19.37	14.66	**13.47**		
Varieties means	**49.16**	**54.10**	**50.96**	**51.41**		
F. test	NS					
LSD (5 %) for varieties	-					
Interaction significance	NS					
LSD (5 %) for interaction	-					

2- Root length stress index (RLSI):

Means of root length stress index (RLSI) as affected cultivars and salinity stress as well as their interaction are listed in Table 2.

The studied canola cultivars viz; Serw 4, Serw 6 and Serw 51 were significantly differed in their root length stress index (RLSI) as cleared from the results presented in Table 2. The maximum value of RLSI (53.60) was produced from Serw 4 cultivar, which significantly exceeded other studied cultivars. While, Serw 6 cultivar came in the second rank after Serw 4 cultivar concerning it effect on RLSI, which recorded 50.10. In the meantime, Serw 51 cultivar produced the lowest value of RLSI, which was 47.77. The differences among canola cultivars in RLSI might due to the genetical factors and hereditary variation among the four canola cultivars under study, which caused variation in relative dry weight.

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 root length stress index (RLSI), the results presented in Table 2 demonstrate that there were significant differences in RLSI among all studied salinity stress. From obtained results, due to increasing salinity levels from 0 (control) to 1.8% NaCl, RLSI was significantly decreased. Thus, the highest RLSI (100.00) 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 89.14, 72.09, 67.70, 53.56, 39.37, 25.81, 18.62, 17.86 and 20.76, respectively. It could be concluded that RLSI was gradually decreased as affected by increasing salinity concentration. The reduction in RLSI due to due to increasing salinity levels may be due to salinity becomes a problem when enough salts accumulate in the root zone to negatively affect plant growth, because it hinders plant roots from diminishing water from the surrounding soil (**Warrence *et al.*, 2003**).

Regarding the effect of the interaction between canola cultivars and salinity stress on root length stress index (RLSI), the statistical analysis of obtained results showed that it was insignificant (Table 2).

Table 2: Means of root length stress index (RLSI) as affected by salinity concentrations, canola varieties and their interaction.

Salinity concentrations	**Varieties**			Salinity means	F. test	LSD (5 %) for salinity
	Serw 4	Serw 6	Serw 51			
0 (control)	100.00	100.000	100.000	**100.00**	*	8.56
0.2 %	95.91	83.677	87.845	**89.14**		
0.4 %	69.34	79.492	67.430	**72.09**		
0.6 %	81.49	66.550	55.070	**67.70**		
0.8 %	64.67	50.595	45.415	**53.56**		
1.0 %	47.04	36.435	34.650	**39.37**		
1.2 %	23.00	27.633	26.807	**25.81**		
1.4 %	13.81	20.053	22.012	**18.62**		
1.6 %	17.11	18.125	18.367	**17.86**		
1.8 %	23.67	18.447	20.173	**20.76**		
Varieties means	**53.60**	**50.10**	**47.77**	**50.49**		
F. test	*					
LSD (5 %) for varieties	4.60					
Interaction significance	NS					
LSD (5 %) for interaction	-					

3- Shoot fresh stress index (SFSI):

The averages of shoot fresh stress index (SFSI) affected cultivars and salinity stress as well as their interaction are cleared in Table 3.

The studied canola cultivars viz; Serw 4, Serw 6 and Serw 51 were insignificantly differed in their shoot fresh stress index (SFSI) as cleared from the results presented in Table 3.

Salinity stress conditions which expressed as concentrations of NaCl salt (0.0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6 and 1.8%) significantly affected shoot fresh stress index (SFSI) as shown in Table 3. It could be noticed that from our results of this study, increasing NaCl levels from 0 (control) to 1.8% NaCl caused gradual and significant decreases in SFSI. So, the highest value of SFSI (100.00) was obtained from control treatment (0% NaCl), followed by (95.03) which result from 0.2% NaCl and (93.27) 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 SFSI; 88.64, 82.92, 78.72, 74.53, 66.14, 55.34 and 62.13, respectively. Overall, that obtained results suggested that SFSI was steadily decreased as affected by increasing salinity concentrations. The reduction in SFSI due to salinity stress may be owing to salinity stress reduces cell turgor pressure and inhibits root and shoot growth. When the content of Na and Cl is high in plant cells, cells fail to divide normally, especially at the germination phase (**Hirt and Shinozaki, 2003**).

The interaction between canola cultivars and salinity stress was insignificantly affected shoot fresh stress index (SFSI) as shown from results in Table 3.

Table 3: Means of shoot fresh stress index (SFSI) as affected by salinity concentrations, canola varieties and their interaction.

Salinity concentrations	Varieties			Salinity means	F. test	LSD (5 %) for salinity
	Serw 4	Serw 6	Serw 51			
0 (control)	100.00	100.27	100.00	**100.00**	*	15.01
0.2 %	92.34	100.00	95.33	**95.03**		
0.4 %	94.04	97.41	90.94	**93.27**		
0.6 %	88.45	94.83	85.20	**88.64**		
0.8 %	79.57	92.28	81.45	**82.92**		
1.0 %	86.99	87.73	68.11	**78.72**		
1.2 %	86.36	81.07	67.36	**74.53**		
1.4 %	75.42	69.86	56.67	**66.14**		
1.6 %	62.30	66.34	45.62	**55.34**		
1.8 %	100.00	58.12	41.10	**62.13**		
Varieties means	**86.57**	**79.27**	**73.18**	**79.67**		
F. test	NS					
LSD (5 %) for varieties	-					
Interaction significance	NS					
LSD (5 %) for interaction	-					

4- Root fresh stress index (RFSI):

Root fresh stress index (RFSI) of germinated canola seedlings as affected cultivars and salinity stress as well as their interaction are presented in Table 4.

Root fresh stress index (RFSI) of germinated canola seedlings was significantly differed among all studied canola cultivars (Serw 4, Serw 6 and Serw 51) as obviously seen from results found in Table 4. The maximum value of RFSI (84.94) was produced from

Serw 4 cultivar, which significantly exceeded other studied cultivars. While, Serw 51 cultivar came in the second rank after Serw 4 cultivar concerning it effect on RFSI, which recorded 65.06. Meanwhile, Serw 6 cultivar produced the lowest value of RFSI, which was 64.69. The differences among canola cultivars in RFSI might due to the genetical factors and hereditary variation among the four canola cultivars under study, which caused variation in relative dry weight.

As shown from results listed in Table 4, NaCl levels (salinity stress) viz; 0.0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6 and 1.8% caused significant effect on root fresh stress index (RFSI) of germinated canola seedlings. Generally speaking, RFSI of germinated canola seedlings was considerably decreased due to increasing NaCl levels from 0 to 1.8% NaCl. Besides, the highest value of RFSI of germinated canola seedlings (100.00) was resulted from control treatment (0% NaCl). The second best RFSI of germinated canola seedlings (94.97) was produced from the second salinity concentration (0.2% NaCl). The percentages of reduction in RFSI 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 5.03, 10.27, 14.33, 25.35, 37.97, 39.32, 45.49, 52.37 and 54.22 %, respectively. In general, RFSI of germinated canola seedlings was more and more decreased as affected by increasing salinity concentrations. The reduction in RFSI of germinated canola seedlings due to increasing salinity concentrations may be due to undesirable effects of salinity on plant growth may be ascribed to ion cytotoxicity and/or osmotic stress, which cause ionic imbalances, oxidative and osmotic stress and nutritional deficiencies (**Zhu, 2002**).

Root fresh stress index (RFSI) of canola seedlings was significantly affected by the interaction between canola cultivars and salinity stress as clearly from results in Table 4. Germinated seeds of all studied cultivars under control treatment (without salinity stress) produced the highest value of RFSI (100.00). Followed by germinated seeds of Serw 4 cultivar under conditions of 0.2 % NaCl 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 RFSI (30.07) was obtained from germinated seeds of Serw 51 cultivar under highest level of salinity stress (1.8% NaCl). Generally, increasing salinity stress conditions (NaCl level) associated with notable reduction in RFSI of all studied canola cultivars seedlings.

Table 4: Means of root fresh stress index (RFSI) as affected by salinity concentrations, canola varieties and their interaction.

Salinity concentrations	Varieties			Salinity means	F. test	LSD (5 %) for salinity
	Serw 4	Serw 6	Serw 51			
0 (control)	100.00	100.00	100.00	**100.00**	*	8.27
0.2 %	97.21	94.06	93.64	**94.97**		
0.4 %	93.99	86.39	88.82	**89.73**		
0.6 %	94.10	80.45	82.44	**85.67**		
0.8 %	87.30	67.40	69.26	**74.65**		
1.0 %	84.07	45.72	56.29	**62.03**		
1.2 %	80.50	50.08	51.47	**60.68**		
1.4 %	73.81	46.40	43.32	**54.51**		
1.6 %	66.90	40.72	35.26	**47.63**		
1.8 %	71.57	35.70	30.07	**45.78**		
Varieties means	**84.94**	**64.69**	**65.06**	**71.56**		
F. test	*					
LSD (5 %) for varieties	10.77					
Interaction significance	*					
LSD (5 %) for interaction	14.32					

5- Shoot dry stress index (SDSI):

Means of shoot dry stress index (SDSI) as affected cultivars and salinity stress as well as their interaction are listed in Table 5.

Regarding to the performance of canola cultivars, the results in Table 5 explain that there were insignificant differences in shoot dry stress index (SDSI) among all studied cultivars *i.e.* Serw 4, Serw 6 and Serw 51.

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 shoot dry stress index (SDSI), the results presented in Table 5 demonstrate that there were significant differences in SDSI among all studied salinity stress. From obtained results, due to increasing salinity levels from 0 (control) to 1.8% NaCl, SDSI was significantly decreased. Thus, the highest SDSI (100.00) 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 87.09, 70.91, 62.55, 52.45, 44.53, 32.29, 27.00, 19.78 and 32.73, respectively. It could be concluded that SDSI was gradually decreased as affected by increasing salinity concentration. The reduction in SDSI due to due to increasing salinity levels may be due to salinity becomes a problem when enough salts accumulate in the root zone to negatively affect plant growth, because it hinders plant roots from diminishing water from the surrounding soil (**Warrence *et al.*, 2003**).

Regarding the effect of the interaction between canola cultivars and salinity stress on shoot dry stress index (SDSI), the statistical analysis of obtained results showed that it was insignificant (Table 5).

Table 5: Means of shoot dry stress index (SDSI) as affected by salinity concentrations, canola varieties and their interaction.

Salinity concentrations	Varieties			Salinity means	F. test	LSD (5 %) for salinity
	Serw 4	Serw 6	Serw 51			
0 (control)	100.00	100.00	100.000	**100.00**	*	13.00
0.2 %	80.83	83.72	96.720	**87.09**		
0.4 %	58.85	66.95	86.940	**70.91**		
0.6 %	50.38	62.69	74.597	**62.55**		
0.8 %	39.06	51.72	66.577	**52.45**		
1.0 %	27.56	46.25	59.772	**44.53**		
1.2 %	17.00	33.82	46.042	**32.29**		
1.4 %	9.91	30.06	41.027	**27.00**		
1.6 %	7.41	18.95	33.003	**19.78**		
1.8 %	43.75	16.18	38.273	**32.73**		
Varieties means	**43.47**	**51.03**	**64.29**	**52.93**		
F. test	NS					
LSD (5 %) for varieties	-					
Interaction significance	NS					
LSD (5 %) for interaction	-					

6- Root dry stress index (RDSI):

The averages of root dry stress index (RDSI) as affected cultivars and salinity stress as well as their interaction are cleared in Table 6.

The studied canola cultivars viz; Serw 4, Serw 6 and Serw 51 were significantly differed in their root dry stress index (RDSI) as cleared from the results presented in Table 6. The maximum value of RDSI (70.58) was produced from Serw 51 cultivar, which significantly exceeded other studied cultivars. While, Serw 6 cultivar came in the second rank after Serw 51 cultivar concerning it effect on RDSI, which recorded 57.35. Meanwhile, Serw 4 cultivar produced the lowest value of RDSI, which was 25.21. The differences among canola cultivars in root dry stress index (RDSI) might due to the genetical factors and hereditary variation among the four canola cultivars under study, which caused variation in relative dry weight.

Salinity stress conditions which expressed as concentrations of NaCl salt (0.0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6 and 1.8%) significantly affected root dry stress index (RDSI) as shown in Table 6. It could be noticed that from our results of this study, increasing NaCl levels from 0 (control) to 1.8% NaCl caused gradual and significant decreases in RDSI. So, the highest value of RDSI (100.00) was obtained from control treatment (0% NaCl), followed by (82.39) which result from 0.2% NaCl and (67.06) 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 RDSI; 58.31, 51.60, 44.14, 38.20, 29.81, 22.13 and 16.84, respectively. Overall, that obtained results suggested that RDSI was steadily decreased as affected by increasing salinity concentrations. The reduction in root dry stress index (RDSI) due to salinity stress may be owing to salinity stress reduces cell turgor pressure and inhibits root and shoot growth. When the content of Na and Cl is high in plant cells, cells fail to divide normally, especially at the germination phase (**Hirt and Shinozaki, 2003**).

The interaction between canola cultivars and salinity stress was insignificantly affected root dry stress index (RDSI) as shown from results in Table 6.

Table 6: Means of root dry stress index (RDSI) as affected by salinity concentrations, canola varieties and their interaction.

Salinity concentrations	Varieties			Salinity means	F. test	LSD (5 %) for salinity
	Serw 4	Serw 6	Serw 51			
0 (control)	100.00	100.00	100.00	**100.00**	*	8.98
0.2 %	57.58	94.39	95.20	**82.39**		
0.4 %	32.92	83.62	84.64	**67.06**		
0.6 %	24.61	68.82	81.51	**58.31**		
0.8 %	14.08	64.88	75.84	**51.60**		
1.0 %	10.77	51.14	70.53	**44.14**		
1.2 %	10.23	41.08	63.29	**38.20**		
1.4 %	1.92	31.88	55.64	**29.81**		
1.6 %	0.00	23.04	43.36	**22.13**		
1.8 %	0.00	14.70	35.83	**16.84**		
Varieties means	**25.21**	**57.35**	**70.58**	**51.05**		
F. test	*					
LSD (5 %) for varieties	10.22					
Interaction significance	NS					
LSD (5 %) for interaction	-					

Conclusion

It could be concluded that for maximizing canola physiological indices, germinated seeds of Serw 4 or Serw 51 cultivars under control treatment (without salinity stress) or under conditions of 0.2% NaCl.

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