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Effect of drought stress and silica spraying on some physiological and functional traits of canola cultivars

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Abstract

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This experiment was designed with the aim of evaluation of the effect of silica spraying on physiological and functional reactions of canola cultivars under drought stress conditions during stages of stem elongation to flowering, podding and filling the grains in field conditions during the 2016-2017 season. The factors studied included different canola cultivars: Hyola 401 (V1), Agamax (V2), Jacamo (V3) and Jerry (V4); drought stress levels D1(normal irrigation), D2 (high stress conditions in stage of stem elongation to flowering), D3 (high stress conditions in stage of flowering, D4 (high stress conditions in stage of podding, D5 (high stress conditions in stage of grain filling) and spraying levels 0 (S0) and 30 mM (S1). Silica spraying has a positive effect on the amount of proline in drought stress conditions. The highest and the lowest amount of proline were observed in D3S1 (24.38 mg g^{-1} FW) and D1S0 (12.85 mg g^{-1} FW), respectively. The results showed that silica spraying improved the ability of canola cultivars to respond to drought stress by increasing physiological and functional traits.

Keywords: canola; drought stress; silica spraying; proline

Introduction

Water deficits in plants may lead to physiological disorders, such as reduction in photosynthesis and transpiration (Petropoulos et al., 2008). The numerous physiological and morphological changes are common in plants subjected to drought stress (Hasanuzzaman et al., 2013). The information obtained suggests that managing water supply at reproductive stage to reduce yield losses in canola under the environments with low moisture availability (Haq et al., 2014). Silicon (Si) may be a "semi-essential" element for plants. The beneficial effects of silicon on the plant, increasingly, reduce the biotic and abiotic stresses (Pilon-Smits et al., 2009). Supplementation with Si has been adopted as an effective strategy for alleviating the negative effects of drought stress and improving the drought resistance of plants (Zhu and Gong, 2014). Si is the second most abundant element in the earth's crust (Ma et al., 2006), and several studies have demonstrated that Si plays an important role in plant tolerance to environmental stresses (Gunes et al., 2008). Some studies have shown that application of Si induced higher proline concentrations under conditions of water deficit (Gunes et al., 2007). Grain yield showed high sensitivity to water deficit, proving that irrigation can definitely benefit crop grain yield (Bilibio et al., 2011). Recent studies have shown the beneficial effects of silicon in times of environmental stress by increasing the amount of osmolytes that play an important role in tolerance to biotic and abiotic stresses in plants (Lee et al., 2010). Plants react differently in the face of drought stress. One of the most common reactions, synthesis and accumulation of low molecular weight compounds is called osmotic protection (Rezaei, 2010). Soluble carbohydrates include sugar, proline, and osmotic protection, which under moisture stress conditions are accumulating in plant cells (Soltani-Gardferamarzi et al., 2012). Drought stress encumbers the rice growth predominantly by oxidative damage to biological membranes and disturbed tissue water status (Farooq et al., 2009). The differential drought tolerance in canola cultivars was related to leaf area and root growth (Kauser et al., 2006). Tale Ahmad and Haddad (2011) reported that Si alleviates water deficit of wheat by preventing the oxidative membrane damage and may be associated with plant osmotic adjustment. Research results of Zadeh Bagheri et al. (2012) showed that the accumulation of more potassium and proline in beans under drought can be a kind of adaptation for tolerating dryness, which can in turn help the plant to survive and reproduce under drought conditions.

There is significant difference among canola genotypes for the grain yield and oil yield in two normal experiments and drought stress (Rashidi et al., 2012). Therefore the objectives of this investigation were aimed the effect of silicon as an anti-stress substance on canola under drought stress has been investigated. Spray silicon was used as an effective ingredient in increasing plant resilence to drought stress. Reducing the effect of drought stress and its effects on growth and increasing yield is one of the goals of this research.

Materials and Methods

This experiment was carried out at the research farm of Behbahan University, located in the south west of Iran at 30°36′N latitude, 50°14′E longitude, 313 m above sea level, in the 2016-2017 growing season. The sowing date was 12 November 2016. This experiment was conducted as split factorial based on a randomized complete block design with 3 replications. Factors included canola cultivars Hyola 401 (V1), Agamax (V2), Jacamo (V3), Jerry (V4), drought stress levels D1 (normal irrigation or 75% available water) and high stress conditions or 25% available water in stages of stem elongation to flowering (D2), flowering (D3), podding (D4) and grain filling (D5), as before and after the mentioned stages irrigation is normal. Spraying was carried out at two levels – 0 (S0) and 30 mM (S1). At each stress stage only once spraying was performed. To measure the number of pods per plant and the number of grains per pod, 10 plants per plot was selected randomly and the average of 10 plants was considered as the final measurement. The method NMR was used to measure the oil percentage. Oil yield was obtained by multiplying oil percentage in grain yield. Grain yield was obtained by multiplying the number of plants per unit area, number of pods per plant, number of grains per pod and 1000-grain weight. Proline colorimetric determination proceeded according to Bates et al. (1973) based on proline's reaction with ninhydrin. For proline colorimetric determinations, 1:1:1 solution of proline, ninhydrin acid and glacial acetic acid was incubated at 100ºC for 1 hour. The reaction was arrested in an iced bath and the cromophore was extracted with 4 ml toluene and its absorbance at 520 nm was determined in a spectrophotometer (Thermo Spectronic). The amount of protein (AP) in the samples was determined according to the method described by Bradford (1976). Protein content was expressed as gluten equivalent in mg per g of leaf fresh weight.

The data were statistically analyzed using the SAS 9.2 software. Significant or non-significant interaction effects were shown using columnar graphs and error bar.

Results and Discussion

Analysis of variance showed significant differences among cultivars, stress and spraying levels in terms of number of pods per plant (Table 1). Interactions of stress levels-cultivars were meaningful. The highest and the lowest num-

Table 1. Analysis of variance of yield components and physiological traits in canola cultivars under drought stress and spraying

S.O.V	df	Mean of square				
		Number of pods per plant	Number of grains per pod	Oil yield (kg ha^{-1})	Proline (mg g^{-1} FW)	Protein (mg g^{-1} FW)
Rep	2	5.75 ^{ns}	7.25 ^{ns}	614.04 ^{ns}	4.78^{ns}	18.58^{ns}
Drought	4	911.10**	85.59**	2602933.59**	383.28**	408.26**
Error	8	5.34	2.27	27784.51	1.58	4.46
Cultivars	3	4305.60**	440.14**	8374927.48**	88.27**	1200.46**
Spraying	1	255.20**	54.67**	1033579.55**	108.87**	16.16^{ns}
Drought × Cultivars	12	33.53 ^{ns}	3.39 ^{ns}	392273.26**	48.87**	3.76^{ns}
C.V.		5.81	9.93	18.97	13.43	14.15

ns (non significant); * and ** (significant at 5 and 1% probability, respectively) ber of pods was observed in normal irrigation-Hyola 401 (D1V1) and drought stress during flowering stage-Jacamo (D3V3), respectively (Fig. 1). Silicon spray has a significant effect on the number of pods per plant (Table 2). Taylor and Smith (1992) reported that the decrease in the seed yield of canola caused a decrease in the number of pods per plant, and the number of pods per plant had the main role in decreasing the seed yield.

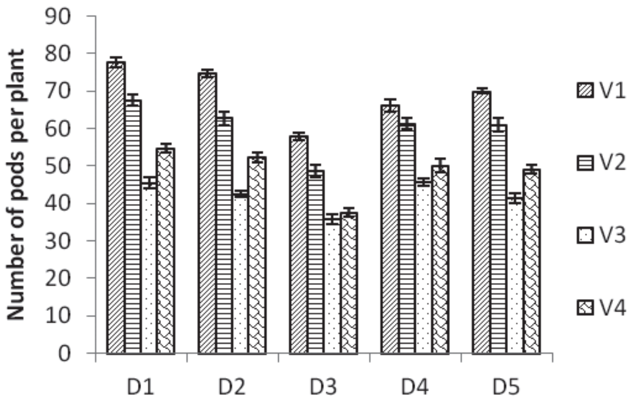

Fig. 1. Interaction of drought stress and cultivars on number of pods per plant

Analyze of variance showed significant differences among cultivars, stress and spraying levels in terms of number of grains per pod (Table 1). Interactions stress levels-cultivars were meaningful. In relation to interactions of stress levels and cultivars, the highest and the lowest number of grains per pod were observed in normal irrigation-Hyola 401 (D1V1) and drought stress during flowering stage-Jacamo (D3V3), respectively (Fig. 2). Silicon spray has a positive and significant effect on the number of grains per pod (Table 2).

Oil yield showed significant differences among cultivars and stress and spraying levels (Table 1). In relation to interactions of stress levels and cultivars, the highest and lowest oil yield was observed in normal irrigation-Hyola 401 (D1V1) and drought stress during flowering stage-Jacamo (D3V3), respectively (Fig. 3). As shown in Table 2, silicon spray has a positive and significant effect on oil yield. According to

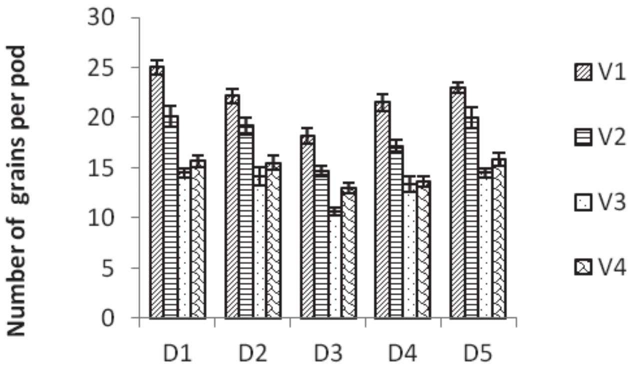

Fig. 2. Interaction of drought stress and cultivars on number of grains per pod

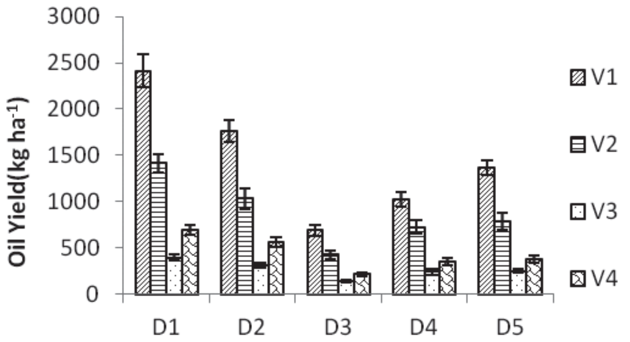

Fig. 3. Interaction of drought stress and cultivars on oil yield

Shirani Rad and Zandi (2012) drought stress causes reduction of oil content and oil yield in canola.

The results showed that there was a significant difference in the content of proline among stress and spraying levels and cultivars (Table 1). In relation to interactions of stress levels and cultivars, the highest and the lowest amount of proline were observed in D3V1 and D1V1, respectively (Fig. 4). Silicon spray application has a positive and significant effect on proline (Table 2). Proline content increased in silicon treatment under drought stress conditions (Hasanuzzaman et al., 2013). The amount of protein (AP) showed significant differences among cultivars and stress levels (Table 1). In-

Table 2. Comparison of mean of yield components and physiological traits in canola cultivars under drought stress and spraying

Treatments	Number of pods per plant	Number of grains per pod	Oil yield	Proline	Protein
S0	53.75 b	16.41 b	674.29 b	16.73b	22.42a
S1	56.66 a	17.76 a	864.87 a	18.63a	23.15a

Values marked with different letters differ significantly at $P \leq 0.05$.

teractions of stress levels and cultivars showed that the most and least AP is related to normal irrigation stage-Hyola 401 cultivar (D1V1), and stress during grain filling stage-Jerry cultivar (D5V3), respectively (Fig. 5). Spray application of silicon did not have a significant effect on protein content (Table 2). It seems that the decrease of protein content under drought stress is related to the reaction of the protein with free radicals and as a result of the change in the amino acid, increased activity of protein degrading enzymes, decreased protein synthesis, and the accumulation of free amino acids, including proline (Ranjan et al., 2001).

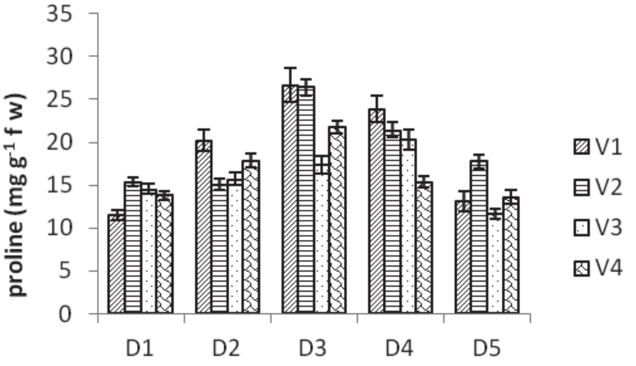

Fig. 4. Interaction of drought stress and cultivars on the mount of ploline

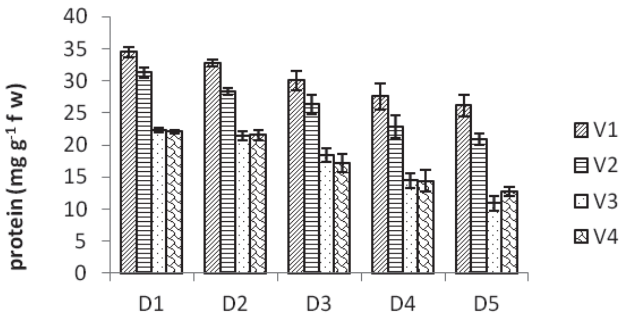

Fig. 5. Interaction of drought stress and cultivars on proteine content

Conclussion

According to the results of this study, it can be stated that silicon spray application improved the measured traits under drought stress conditions. Therefore, the increase in photosynthetic pigments and metabolites, especially proline, due to silicon spray application, can have a positive effect on drought tolerance mechanisms and increased yield. It seems that in order to achieve normal growth in canola, the drought stress should be avoided at flowering and podding stages. In the event of drought stress in these stages, silicon spray can prevent the negative effects of stress.

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References

Bates, L. S., Waldren, R. P., & Teare, I. D. (1973). Rapid determination of free proline for water-stress studies. *Plant and Soil*, *39*(1), 205-207.

Bilibio, C., Carvalho, J. D. A., Hensel, O., & Richter, U. (2011). Effect of different levels of water deficit on rapeseed (*Brassica napus* L.) crop. *Ciência e Agrotecnologia*, *35*(4), 672-684.

Bradford, M. M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Analytical Biochemistry*, *72*(1-2), 248-254.

Farooq, M., Basra, S. M. A., Wahid, A., Ahmad, N., & Saleem, B. A. (2009). Improving the drought tolerance in rice (*Oryza sativa* L.) by exogenous application of salicylic acid. *Journal of Agronomy and Crop Science*, *195*(4), 237-246.

Gunes, A., Inal, A., Bagci, E. G., & Pilbeam, D. J. (2007). Silicon-mediated changes of some physiological and enzymatic parameters symptomatic for oxidative stress in spinach and tomato grown in sodic-B toxic soil. *Journal of Plant Physiology*, *164*(6), 807-811.

Gunes, A., Pilbeam, D. J., Inal, A., & Coban, S. (2008). Influence of silicon on sunflower cultivars under drought stress, I: Growth, antioxidant mechanisms, and lipid peroxidation. *Communications in Soil Science and Plant Analysis*, *39*(13-14), 1885-1903.

Haq, T. U., Ali, A., Nadeem, S. M., Maqbool, M. M., & Ibrahim, M. (2014). Performance of canola cultivars under drought stress induced by withholding irrigation at different growth stages. *Soil Environ*, *33*(1), 43-50.

Hasanuzzaman, M., Nahar, K., Gill, S. S., & Fujita, M. (2013). Drought stress responses in plants, oxidative stress, and antioxidant defense. In: *Climate change and plant abiotic stress tolerance*, 209-250.

Kauser, R., Athar, H. U. R., & Ashraf, M. (2006). Chlorophyll fluorescence: a potential indicator for rapid assessment of water stress tolerance in canola (*Brassica napus* L.). *Pakistan Journal of Botany*, *38*(5 Spec. Iss.), 1501-1509.

Lee, S. K., Sohn, E. Y., Hamayun, M., Yoon, J. Y., & Lee, I. J. (2010). Effect of silicon on growth and salinity stress of soybean plant grown under hydroponic system. *Agroforestry Systems*, *80*(3), 333-340.

Ma, J. F., Tamai, K., Yamaji, N., Mitani, N., Konishi, S., Katsuhara, M., Ishiguro, M., Murata, Y. & Yano, M. (2006). A silicon transporter in rice. *Nature*, *440*(7084), 688-691.

Petropoulos, S. A., Daferera, D., Polissiou, M. G., & Passam, H. C. (2008). The effect of water deficit stress on the growth, yield and composition of essential oils of parsley. *Scientia Horticulturae*, *115*(4), 393-397.

Pilon-Smits, E. A., Quinn, C. F., Tapken, W., Malagoli, M., & Schiavon, M. (2009). Physiological functions of beneficial elements. *Current Opinion in Plant Biology*, *12*(3), 267-274.

Ranjan, R., Bohra, S. P., & Jeet, A. M. (2001). Book of plant senescence. *Jodhpur, Agro bios New York*, 18-42.

Rashidi, S., Shirani Rad, A. M., Ayene Band, A., Javidfar, F., & Lak, S. H. (2012). Study of relationship between droughts stresses tolerances with some physiological parameters in canola genotypes (*B. napus* L.). *Ann. Biol. Res*, *3*, 564-569.

Rezaei, M. A. (2010). Effects of exogenous glycine betaine on morphophysiological characteristics and yield of soybean (*Glycine max L.*). *Journal of Plant Science Researches*, *17*(1), 44-54.

Shirani Rad, A. H. S., & Zandi, P. (2012). The effect of drought stress on qualitative and quantitative traits of spring rapeseed (Brassica napus L.) cultivars. *Zemdirbyste-Agriculture*, *99*, 47-54.

Soltani Gardferamarzi, M., Kadhim, O., Habibi, H., Lebaschi, H., Hossein, M., & **Zarezadeh, A.** (2012). Effect of different glycine betaine varying on morphological traits and yield of German Chamomile under drought stress in Yazd region. *Scientific and Research Papers on Medicinal and Aromatic Plants*, *27*(2), 279-289.

Tale, A., & Haddad, R. (2011). Study of silicon effects on antioxidant enzyme activities and osmotic adjustment of wheat under drought stress. *Czech Journal of Genetics and Plant Breeding*, *47*(1), 17-27.

Taylor, A. J., & Smith, C. J. (1992). Effect of sowing date and seeding rate on yield and yield components of irrigated canola (*Brassica napus* L.) grown on a red-brown earth in south-eastern Australia. *Australian Journal of Agricultural Research*, *43*(7), 1629-1641.

Zadehbagheri, M., Mojtaba, M., Javanmardi, S., & Sharafzadeh, S. (2012). Effect of drought stress on yield and yield components, relative leaf water content, proline and potassium ion accumulation in different white bean (*Phaseolus vulgaris* L.) genotype. *African Journal of Agricultural Research*, *7*(42), 5661-5670.

Zhu, Y., & Gong, H. (2014). Beneficial effects of silicon on salt and drought tolerance in plants. *Agronomy for Sustainable Development*, *34*(2), 455-472.

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