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Parameters Response of Salt-Silicon Interactions in Wheat

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Abstract

Wheat is the most important plant in the history of mankind, especially in terms of nutrition, by increasing its resistance from the past to the present. The negative change in the environmental conditions increases the stress factors in the soil and seriously affects agricultural productivity. Some physiological analyzes were carried out to examine salt, silicon and salt-silicon interactions on wheat seedlings. In the present study salt, silicon, salt–silicon and their interactions were investigated on wheat (*Triticum aestivum* L cv. Dağdaş and ES-14). Root dry weight, shoot dry weight, shoot and root length. In our study; Si increased shoot dry matter and weight in 200 mM salt+ Si treatment.

Keywords:

Root dry weight, shoot dry weight, shoot length, root length.

Article history:

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Introduction

Abiotic stress factors such as salinity, drought and chills cause significant loss of yield in terms of plant growth and development. It is becoming more important to reduce this loss of yield in agricultural products and to shed light on these mechanisms & osmotic stress caused by salt stress, compete with ions such as K^{+} and Ca^{2+}, which are necessary for the plant, and reduce the uptake of these elements (Hu & Schmidhalter, 2005; Guo et al., 2021). NaCI stress makes negative effects on the chloroplast organelle. It causes ROS accumulation by resulting in swelling in stroma and thylakoids (Çulha & Çakırlar, 2011). It was reported that NaCI stress reduced dry and wet weight in the stem, reduced chlorophyll content (Rohanipoor et al., 2013) as well as seed in fruit, dry matter amount and seed weight (Kardoni et al., 2013; Farooq et al., 2019). Also, Kahrizi et al. (2012) reported that antioxidant enzymes changed POX, SOD, CAT and ATPase activity. Also, it

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was reported that the proportional water amount decreased, free proline amount increased (Öncel & Keleş, 2002), water intake decreased and germination decreased (Rahman et al., 2008).

Silicon contributes to the growth of wheat under salt stress by inhibiting Na uptake, providing nutritional balance and improving physiological parameters (Javaid et al., 2019). Although Silicon (Si) is the second most abundant element on earth, it is not yet included in the list of essential elements for plants. However, the useful effect of Si on growth and development in many plant varieties is striking. In soil, Si is generally available in the form of silicic acid (H_4SiO_4), and the uptake of Si by plants differs among plant families. The Poaceae generally take Si much more than the other species (Reichert et al., 2015). It is known that Si reduces the harmful effects of heavy metal stress such as Si, manganese, aluminium, salt, drought, chill and freezing stresses (Liang et al., 2006). However, there is not sufficient information on the role of Si in abiotic stresses.

In this study, mean root and shoot dry weights, root and shoot lengths, were analyzed in wheat (*Triticum aestivum* L. cv. Dağdaş and ES-14) seedlings in NaCI, Si and $NaCI^+$ Si interactions.

Materials and Methods

Seeds (*Triticum aestivum* L. cv. Dağdaş, ES-14) were used as plant material. The wheat seeds were obtained from Field Crops Central Research Institute (Ankara). In the process of growing the wheat, seeds were sterilized with a solution including 2% sodium hypochlorite (NaOCl) (Rubio et al., 1994) for 20 minutes and then washed with distilled water. The seeds were grown in wooden containers containing perlite and watered with distilled water for five days in the climate cabin. Arnon and Hoagland's solution (Arnon & Hoagland, 1940) adjusted to pH 5.7 was used as a nutrient solution. On the 5th day, the solutions in the containers were discharged, and they were filled with new nutrient solutions. When the seedlings were 15 days old were performed by mixing Salt and Si treatments them into the nutrient solutions. After the sixth day, four different groups were formed, which are as follows: NaCl 150 mM, NaCI 200 mM, NaCl 150 mM+Si 1 mM, NaCl 200 mM+Si 1 mM and Si 1 mM. The roots of the seedlings spared for biochemical analysis were cut from the root-shoot separation zone.

Results

In Dağdaş cultivar, 200 mM NaCI treatment decreased root length while 150 mM NaCl+1 mM Si and 200 mM NaCl+1 mM Si treatments led to increases when compared to the control group (Table 1).

Table1. Effects of NaCI and NaCI -Si interactions on average root and shoot length, root and shoot dry weight of wheat (*Triticum aestivum* L.cv.) Dağdaş and ES-14 seedlings (cm/plant) (n = 3).

	Root length (cm/plant)		**Root dry weight (mg/plant)**	
	Dağdaş	**ES-14**	**Dağdaş**	**ES-14**
CONTROL	9.7± 0.416	9.633±0.669	4.666±0,333	3.266±0.266
1mM Si	9.573± 0.436	10.866±0.328	1±0	6±0.577
150 mM NaCI	10.5± 0.871	8.166±0.811	4.2±0,20	2±0
150 mM NaCI +1mM Si	11.306±0.619	8.7±0.360	5±0,577	3±0
200 mM NaCI	8.293± 0.522	9.053±0.177	2±0	4±0
200 Mm NaCI+1mMSi	10.433±1.04	8.5±0.288	2.233±0,333	5.333±0.333
	Shoot length (cm/plant)		**Shoot dry weight (mg/plant)**	
	Dağdaş	**ES-14**	**Dağdaş**	**ES-14**
CONTROL	23.4± 0.750	18.5± 2.203	15.733±0,896	15.933±1.572
1mM Si	22.1± 0.556	17.566± 0.433	16.333±0,881	13.666±0.666
150 mM NaCI	22.926±1.268	15.8± 0.781	14.133±0,696	13±1
150 mM NaCI +1mM Si	23.733±0.433	17.833± 0.371	15.466±0,29	15.2±0.416
200 mM NaCI	20.4± 0.503	16.266± 0.233	11.666±0,881	14.333±1.201
200mM NaCI +1 mM Si	22.766± 0.29	16.566± 0.317	18±1	15.333±0.666

These results are in line with those obtained by Rohanipoor et al. (2013) in corn plants under NaCl stress. According to Table 1, there is an increase in the ES-14 cultivar compared to the control group in 1 mM Si treatment. Also, decreases obtained in the treatments containing NaCI are consistent with the data reported by Rohanipoor et al. (2013) with corn plants under salt stress. It is known that NaCI stress reduces the uptake of elements such as K, which are essential for plants (Ali et al., 2012). Elements such as K play a key role in the development of plant growth. In all treatments where salt was added in the ES-14 cultivar, the decrease in root length might be attributed to less tolerance of this cultivar compared to the Dağdaş cultivar (Table 1). As for the Dağdaş cultivar, only the increases observed in 150 mM NaCl and 150 mM NaCI+1 mM Si treatments can be considered to be important (Table 1). Significant differences were obtained between the wheat cultivars in terms of dry weight in salt-silicone treatments ($p \leq 0.05$). The wheat silicon decreases are consistent with the results obtained by Rohanipoor et al. (2013) in corn under salt stress and the results obtained by Öncel & Keles (2002) in the wheat exposed to salt stress.

Discussions

In wheat-salt interaction, the difference detected in both wheat cultivars was found to be significant at $p \leq 0.05$ level (Table 1). In salt silicon treatment in both wheat cultivars analyzed, the difference in the root dry weight was found to be significant at $p \leq 0.05$ level (Table 1). The difference found in wheat, silicon and salt interaction was at $p \leq 0.05$ level (Table. 1). In the Dağdaş cultivar, there were decreases in 1 mM Si, 150 mM NaCI and 200 mM NaCI treatments while an increase was observed in 150 mM NaCl+1 mM Si treatment (Table 1). In the ES-14 cultivar, there was an almost two-fold increase in 1 mM Si treatment while a decrease was observed in 50 mM NaCl treatment (Table 1). An increase was observed in 200 mM NaCl + 1 mM Si treatment (Table 1). NaCI stress in salt treatments leads to osmotic stress by preventing water uptake in plants (Çulha & Çakırlar, 2011). The resulting osmotic stress causes a decrease in the number of cells.

In the Dağdaş cultivar, while 150 mM NaCl + 1 mM Si treatment caused an increase in root dry weight, 1 mM Si treatment resulted in a decrease (Table 1). For this cultivar, based on the fact that Si alone did not make any improvement and resulted in an improvement in 150 mM NaCl + 1 mM Si treatment, it can be concluded that the concentration value of 150 mM NaCI is a regulatory value. For the ES-14 cultivar, it was concluded that the stress of 200 mM NaCl concentration was an important threshold value for this cultivar while the treatment of Si alone caused a substantial increase (Table 1). It was determined that the differences between the shoot lengths of the seedlings of the Dağdaş and the ES-14 wheat cultivars were significant ($p \leq 0.05$) (Table 1). In the Dağdaş cultivar, decreases were observed in 150 mM NaCl and 200 mM NaCI treatments (Table 1). In the ES-14 cultivar, decreases were reported in 150 mM NaCl and 200 mM NaCI treatments, as well (Table 1). These results concerning the shoot lengths are consistent with those reported by Rahman et al. (2008) concerning wheat samples under salt stress. In our study, significant differences were found in both cultivars in wheat Si, wheat NaCI and wheat Si+NaCI interactions ($p \leq 0.05$, Table 1). In the Dağdaş cultivar, increases were observed in 1 mM Si and 200 mM NaCl + 1 mM Si treatments (Table 1). These results are consistent with those reported by Rohanipoor et al. (2013) in the study where increases were observed in the shoot lengths of corns under salt stress as well as increases obtained with Si treatment. In 150 mM NaCl and 200 mM NaCI treatments, decreases were observed in comparison to the control group (Table 1). The increase observed in 200 mM NaCl + 1 mM Si treatment is greater than that obtained in 150 mM NaCl + 1 mM Si treatment, and this shows that Si made a greater impact on the shoot dry weight in 200 mM NaCI concentration (Table 1). Decreases were observed in the shoot dry weights in all groups of the ES-14 cultivar after NaCI treatment and Si made a curative effect in 200 mM NaCI concentration, and this shows that 200 mM NaCI concentration is a significant concentration value (Table 1). It is considered that studying the intermediate values between 200 mM NaCl and 150 mM NaCI concentrations is highly important.

In this study, the difference between the average root lengths of the Dağdaş and the ES-14 cultivars was found to be significant ($p \leq 0,05$). Significance of the interaction between wheat and salt might be attributed to the difference between salt tolerance levels of two cultivars. Likewise, the difference between the wheat shoot lengths was significant. It can be concluded that the Dağdaş cultivar, which is a more durable wheat genotype, and the ES-14 cultivar, which is more fragile, did not react to the same stress at the same level.

In this study, a substantial decrease was observed in the average root dry weight of the Dağdaş cultivar in 1 mM Si treatment while an increase was observed in 150 mM salt + 1 mM Si treatment when compared to the control group. In ES-14 cultivar, a two-fold increase was detected in 1 mM Si treatment in comparison to the control group. While there were increases in 150 mM salt and 150 mM salt+1 mM Si treatments when compared to the control group, increases were observed in 200 mM salt and 200 mM salt+1 mM Si treatment, as well. In the ES-14 cultivar, it can be concluded that 200 mM salt concentration was a critical value in salt tolerance.

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Author Contributions

M.H.A. and N.E. performed all the experiments and drafted the main manuscript text. M.H.A. and N.E. designed the experimental work, final versions of statistics table. N.E. reviewed and approved the final version of the manuscript.

Conflict of Interest

The authors declared that no conflict of interest.

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