jotaf Journal of Tekirdag Agricultural Faculty
Tekirdağ Ziraat Fakültesi Dergisi

Mayıs 2025, 22(2)
Başvuru/Received: 02/10/24
Kabul/Accepted: 11/04/25
DOI: 10.33462/jotaf.1559211

http://dergipark.gov.tr/jotaf
http://jotaf.nku.edu.tr/

ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Determination of The Reaction of Violet Plant (*Saintpaulia ionantha* L.) to Salinity*

Menekşe Bitkisinin (*Saintpaulia ionantha* L.) Tuza Reaksiyonunun Belirlenmesi

Ali Rıza DEMİRKIRAN[1*], Gülcan DEMİR POLAT[2]

Abstract

Salinity causes significant crop loss every year. Excessive salinity has different effects on plant nutrition and metabolism. In this experiment, violet plants (*Saintpaulia ionantha* L.) were used and the experiment was set up in 1.5 kg pots. Plants were grown under laboratory conditions. Water containing different salt concentrations prepared from sodium chloride (S1=control=0 dS m^{-1}, S2=2 dS m^{-1}, S3= 4 dS m^{-1}, S4=6 dS m^{-1}, S5=8 dS m^{-1} and S6=10 dS m^{-1}) were used. After 2 months, in order to investigate the plant development, leaf area, root fresh-dry weights and leaf fresh-dry weights were measured. In addition, P, K, Ca, Na, Fe, Cu, Zn and Mn contents in the roots and leaves of violet plants were also determined. Considering the obtained data, salt doses did not have a significant effect on leaf area, leaf fresh-dry weights and P, K and Ca values in roots. It was determined that fresh-dry weights of *Saintpaulia ionantha* L. plant roots and Na, Fe, Cu, Zn and Mn contents in roots changed significantly (P<0.01) with salt applications. It was found that salt applications decreased root fresh-dry weights. Na contents in plant roots were highest in 4 and 10 dS m^{-1} salt applications. Mn, Zn and Fe contents in roots increased up to 8 dS m^{-1} application, and Cu contents up to 10 dS m^{-1} application. When the nutrient elements in the leaves were examined, it was determined that Ca and Na contents increased significantly (P<0.01) and K contents increased but were not significant. It was found that micro elements (Mn, Zn, Cu and Fe) in plant leaves increased significantly (P<0.01) with salt applications. The microelements increases were determined up to 10 dS m^{-1} application in Zn, up to 8 dS m^{-1} application in Mn and Fe, and up to 4 dS m^{-1} application in Cu contents. According to the results obtained, it was determined that the violet plant is tolerant to salt applications up to a certain level.

Keywords: Violet plant (*Saintpaulia ionantha* L.), Salinity, Macro and micro elements

[1]***Sorumlu Yazar/Corresponding Author:** Ali Rıza Demirkıran, Bingol University, Agricultural Faculty, Soil Science and Plant Nutrition, Bingol, Türkiye. E-mail: ademirkiran@bingol.edu.tr OrcID: 0000-0002-0086-0137

[2]Gülcan Demir Polat, Bingol University, Institute of Sciences, Bingol, Türkiye. E-mail: g.dmrplt12@gmail.com OrcID: 0009-0008-5889-5667

Atıf: Demirkıran, A. R., Demir Polat, G. (2025). Menekşe bitkisinin (*Saintpaulia ionantha* L.) tuza reaksiyonunun belirlenmesi. *Tekirdağ Ziraat Fakültesi Dergisi,* 22(2): 483-495.

Citation: Demirkıran, A. R., Demir Polat, G. (2025). Determination of the reaction of violet plant (*Saintpaulia ionantha* L.) to salinity. *Journal of Tekirdag Agricultural Faculty,* 22(2): 483-495.

*This study was summarized from the Gülcan DEMİR POLAT's MSc thesis.

Öz

Tuzluluk her yıl önemli miktarda ürün kaybına neden olmaktadır. Aşırı tuzluluğun bitkinin beslenmesi ve metabolizması üzerinde farklı etkileri vardır. Bu denemede menekşe bitkileri (*Saintpaulia ionantha* L.) kullanılmış olup, deneme 1,5 kg'lık saksılarda kurulmuştur. Bitkiler laboratuvar şartlarında yetiştirilmiştir. Sodyum klorürden hazırlanan farklı tuz konsantrasyonlarını içeren su (S1=kontrol=0 dS m^{-1}), S2=2 dS m^{-1}, S3= 4 dS m^{-1}, S4=6 dS m^{-1}, S5=8 dS m^{-1} ve S6=10 dS m^{-1}) kullanılmış olup, 2 ay sonra bitkinin gelişimini incelemek amacıyla, yaprak alanı, kök taze-kuru ağırlıkları ile yaprak taze-kuru ağırlıkları ölçülmüştür. Ayrıca, menekşe bitkisinin köklerinde ve yapraklarındaki P, K, Ca, Na, Fe, Cu, Zn ve Mn içerikleri de belirlenmiştir. Elde edilen veriler dikkate alındığında, yaprak alanı, yaprak taze-kuru ağırlıkları ile kökteki P, K ve Ca değerleri üzerine tuz dozları önemli bir etkide bulunmamıştır. Menekşe köklerinin taze-kuru ağırlıkları ile köklerdeki Na, Fe, Cu, Zn ve Mn içeriklerinin tuz uygulamalarıyla önemli düzeyde (P<0.01) değiştiği belirlenmiştir. Tuz uygulamanın kök taze-kuru ağırlıklarını düşürdüğü tespit dilmiştir. Tuzun 4 dS m^{-1} ve 10 dS m^{-1} uygulamalarında bitki köklerindeki Na içerikleri en yüksek çıkmıştır. Köklerdeki Mn, Zn ve Fe içerikleri 8 dS m^{-1} uygulamasına kadar, Cu içerikleri ise 10 dS.m^{-1} uygulamasına kadar artmıştır. Yapraktaki besin elementleri incelendiğinde, Ca ve Na içeriklerinin önemli düzeyde (P<0.01) arttığı, K içeriklerinin de arttığı, fakat bu artışın önemli olmadığı belirlenmiştir. Tuz uygulamalarıyla bitki yapraklarındaki mikro elementlerin (Mn, Zn, Cu ve Fe) önemli düzeyde (P<0.01) arttığı tespit edilmiştir. Mikro elementlerdeki bu artışların, çinkoda 10 dS m^{-1} uygulamasına kadar, mangan ve demirde 8 dS m^{-1} uygulamasına kadar, bakırda 4 dS m^{-1} uygulamasına kadar olduğu tespit edilmiştir. Elde edilen sonuçlara göre, menekşe bitkisinin belirli bir düzeye kadar tuz uygulamalarına toleransı olduğu belirlenmiştir.

Anahtar Kelimeler: Menekşe bitkisi (*Saintpaulia ionantha* L.), Tuzluluk, Makro ve mikro elementler

1. Introduction

Nearly half of the lands in the world where irrigated agriculture is carried out and 20% of the agricultural lands in production are faced with salinity (Zhu, 2001). It is known that the salinity problem negatively affects agricultural soils and makes it difficult to obtain sufficient plant products (Demirkıran and Sohrabi, 2024). The anions that most cause salinity problems are; Cl^- and SO_4, cations; Na^+, Ca^{++} and Mg^{++} (Bischoff and Werner, 1999). Salt stress causes the plant's water use efficiency to decrease, salt ions to increase and stem elongation to decrease (Mandhania et al., 2006). Salt accumulation in the soil negatively affects plant growth and yield (Blum, 1986). Salt stress affects plants in various ways, including ion toxicity and nutritional disorders (Dhakar et al., 2017). High salt concentrations also cause a decrease in the length, mass and function of roots (Shannon and Grieve 1999; Boydak et al., 2025). In leaves, it causes cell elongation and division to decrease, resulting in a decrease in leaf area (Alarcon et al., 1993). However, the most delicate and crucial stages of most plants' establishment in saline settings are during their seedling establishment (Altuner et al., 2022).

Although the reactions of plants to salt in their nutrient intake are different, these reactions can generally be summarized as follows; i) selective accumulation or removal of ions, ii) control of the uptake of ions from the roots or transport to the leaves, and iii) accumulation of ions in the cells or some parts of the plant (Parida and Das, 2005). Salt-tolerant genotypes generally can restrict Na transport to above-ground growth zones (shoots). Some tolerant genotypes can tolerate high Na concentrations in their tissues. This depends on the ion uptake of plants, the species genotype, the salinity level and the chemical composition of the soil solution (Niu and Rodriguez, 2008).

In general, decreases are observed in many physiological characteristics of ornamental plants exposed to salt stress. Among these, decreases in the fresh weight of the plant (Acosta-Motos et al., 2017; Salachna and Piechocki, 2016), decreases in the dry weight of the plant (Cirillo et al., 2016; Sabra et al., 2012; Beyaz and Kazankaya, 2024), in plant height (Álvarez and Sánchez-Blanco, 2014; Acosta-Motos et al., 2017), in root length (~~;~~Acosta-Motos et al., 2017) and in leaf area (Cirillo et al., 2016; Acosta-Motos et al., 2017; Álvarez and Sánchez-Blanco, 2014;) have been stated by many researchers. It was emphasized that this decrease was more evident, especially in the above-ground parts (Dodd, 2005; Acosta-Motos et al., 2017).

In this study, the responses of the African violet (*Saintpaulia ionantha* L. Wendl.), whose response to salt has not yet been fully understood in the literature (Anonymous, 2024), to salt stress were investigated by watering it with different doses of salt water.

2. Materials and Methods

African violet (*Saintpalia ionantha* L.), the plant used in the experiment, grows as an annual herbaceous and ornamental plant. It has been used for breeding purposes in gardening for more than a hundred years. According to the results of the studies, hybrids of this plant species are found in most parts of the world and are used as well-known ornamental plant (Kolehmainen, 2008). The plants were grown in standard pots of 10-12 cm and were purchased commercially from a company and used. The soil type used in the pot is forest soil, which is intensively found in Bingöl, Turkey. The soil was passed through a 2 mm sieve, dried in air, and put into 1.5 kg soil and used. The examined properties of the soil are texture (Bouyoucos, 1951), organic matter (Nelson and Sommers, 1982), lime (Richards, 1954), pH (in saturation), EC (U.S. Salinity Laboratory, 1954), available phosphorus (Olsen et al., 1954) and exchangeable potassium (Pratt, 1965). As a result of the soil analysis, texture is sandy and clayey, the contents of lime (1.4%) and organic matter (1.3%) are low, there is no salinity problem (0.1 dS m^{-1}), the soil reaction is slightly acidic (6.3), the exchangeable K content is high (308 ppm) and available P content was determined to be at high (28 ppm) level (FAO, 1990).

Pure water was used as control in the research. As salty water for irrigation, water containing different salinity conditions prepared from sodium chloride (S1 = control = 0 dS m^{-1}, S2 = 2.0 dS m^{-1}, S3 = 4.0 dS m^{-1}, S4 = 6.0 dS m^{-1}, S5=8.0 dS m^{-1} and S6=10.0 dS m^{-1}) were used. The experiment was planned according to the randomized plot design with 4 replications. Plants were grown under laboratory conditions at the Bingol University Agricultural Faculty Soil Science and Plant Nutrition, Bingol, Türkiye.

The subjects investigated in the experiment were; in order to examine the development of the plant as a result of salt applications, plant fresh weights, plant dry weights and P, K, Ca, Na, Fe, Cu, Zn, and Mn analyzes were made after 2 months in the roots and leaves. The weights of the plant were measured with a precision scale. After wet weights, in order to calculate the root and stem weights of the plants, the plants were kept in the oven to dry for 24 hours. Leaf area index was measured with a crawler leaf area measuring device. For the determination of elements in plants, the samples were burned by the wet burning method (with nitric-perchloric acid), then the Ca, Fe, Cu, Mn, and Zn contents were analyzed on the atomic absorption spectrometer, and the Na and K concentrations were determined on the flame photometer. The P contents were recorded on the spectrophotometer (Kacar, 1972). The data were statistically evaluated with the help of SPSS program.

3. Results and Discussion

3.1. Effects of salt on some physical properties of the plant (leaf area, root fresh weight, leaf fresh weight, root dry weight and leaf dry weight)

Some changes in the leaf area, root fresh-dry weights and leaf wet-dry values of the *S. ionantha* as a result of the applied salt water solution are given in *Table 1*. Leaf area changes were not found to be statistically significant. It was observed that the highest value was at 2 dS m^{-1} application and the lowest value was at 6 dS m^{-1} application. Similar results were found in some previous studies. Salt applications reduced the leaf area in *Cotoneaster lacteus*, increased it to a certain level in *Eugenia myrtifolia*, then decreased it (Cassaniti et al., 2012) and firstly decreased it and then slightly increased it in *Callistemon citrinus* and *Viburnum titus* plants (Toscano et al., 2021).

There are studies showing that salt concentrations reduce leaf area in various ornamental plants (Cirillo et al., 2016, Acosta-Motos et al., 2017; Atal et al., 2022). Applied salt is effective in some ornamental plants such as *Salvia splendens* (Karimian et al., 2019), *Gerbera jamesonii* (Farooq et al., 2024), *Scabiosa columbaria*, *Lobelia cardinalis*, *Amelanchier canadensis*, *Cuphea hyssopifolia*, *Dikliptera suberecta*, *Pavonia lasiopetala*, *Caryopteris x clandonensis*, *Anisacanthus quadrifidus* (Wu et al., 2016), *Cyclamen hederifolium* (Akçal and Kaynaş, 2021) and *Calendula officinalis* (Bayat et al., 2012). The decrease in leaf growth due to the decrease in water in the leaves is one of the first reactions of plants to reduce salt stress (Blum, 1986), in addition, it has been stated that there are decreases in the length and weight of plant roots (Wild, 1988) and decreases in leaf area due to the decrease in the proliferation and growth of leaf cells (Atal et al., 2022).

Table 1. Average leaf area, root fresh-dry weights, and leaf fresh-dry weights of plant obtained as a result of salt applications

Salt application (dS m^{-1})	Leaf area (cm g^{-1})	Root fresh weight (g)	Root dry weight (g)	Leaf fresh weight (g)	Leaf dry weight (g)
0	15.71	8.79a	1.75a	51.97	2.61
2	20.08	5.32bc	1.03bcd	46.54	2.19
4	15.58	4.60bc	0.81cd	58.77	2.43
6	14.08	6.06b	1.30b	47.28	2.17
8	17.52	3.81c	0.65d	40.11	2.33
10	16.05	5.14bc	1.09bc	52.24	2.51
$LSD_{0.05}$	n.s.	-1.9610**	-0.4435**	n.s.	n.s.

*n.s.: Not significant, **Within a column, mean values followed by the same letter were not statistically different at the 1% level (n=4).

The change in root fresh and dry weight values of *S. ionantha* was found to be statistically significant. Classification was made accordingly, the highest wet and dry weight values were observed in the 0 dS m^{-1} (control) salt application, and the lowest values were observed in the 8 dS m^{-1} application. It was determined that fresh and dry root weights decreased as salt applications increased (*Table 1*). It has been stated in previous studies that such a situation was generally observed. It has been reported that salt causes a decrease in the root mass and function of plants (Shannon and Grieve, 1999). Salt applications on *Chrysanthemum paludosum* (Yasemin et al., 2017), *Petunia hybrida*, *Gazania splendes*, *Tagates erecta* (Türkoğulları et al., 2013), *Plectranthus scutellarioides* (Hawrylak-Nowak et al., 2019) caused a decrease in root fresh weight. Similarly, salt is found in *Argyranthemum coronopifolium* (De Herralde et al., 1998), *C. officinalis* (Bayat et al., 2012), *Aloe vera*, *Kalanchoe blossfeldiana* and *G. splendens* (García-Caparrós et al., 2016; 2017) was found to cause a decrease in root dry weight. It has also been emphasized that salt applications reduce the dry weight of *C. lacteus*, *Cestrum aurantiacum*, *E. myrtifolia*, *Pyracantha*, *Teucrium fruticans* (Cassaniti et al., 2009b) and *S. splendens* plants (Soundararajan et al., 2013), *Ipomoea purpurea*, *I. tricolor* (Mircea et al., 2023), *Helianthus annuus* (Ahsan et al., 2022), It has also been determined that salt reduces the fresh and dry weight of roots in some ornamental plants, e.g. *Limonium gmelinii* (halophyte) (Honfi et al., 2023), *Sesleria caerulea*, *Sorghastrum nutans* and *Koeleria glauca* (Henschke, 2017). In addition, it has been reported that salt first reduces and then increases the root dry weight of *Brassica oleracea*, but overdose reduces it again (Karagoz and Dursun, 2021). On the other hand, salt applied to *Chrysanthemum morifolium* varieties increased the root fresh-dry weights (Rahi and Singh, 2011).

As a result of the salt applications, it did not cause significant changes in the leaf fresh weight values of the *S. ionantha*. The highest wet weight was observed in the 4 dS m^{-1} application, and the lowest weight was observed in the 8 dS m^{-1} application. It was determined that with the increase in salt application, there was a slight decrease in leaf fresh weight and then an increase again (*Table 1*). Similarly, seawater was applied to *V. titus*, the biomass weight first decreased and then increased again (Toscano et al., 2021). Salt application on *T. erecta* firstly increased and then decreased the fresh bioma (Sayyed et al., 2014). It was found that salt stress negatively affected by reducing fresh leaf weight in *I. tricolor* (Mircea et al., 2023) with *Ornithogalum saundersiae* (Salachna et al., 2016) and by reducing leaf weight in rose rootstocks (Cabrera et al., 2009).

One of the physiological characteristics to salt is the decrease in plant fresh weight (Álvarez and Sánchez-Blanco, 2014; Salachna and Piechocki, 2016; Acosta-Motos et al., 2017). Salt was applied to halophytic *L. gmelinii* and fresh weights decreased (Honfi et al., 2023). Salt applications on ornamental plants, e.g., sunflower (Ahsan et al., 2022), *P. hybrida*, *G. Splendes*, *T. erecta* (Turkogullari et al., 2013), *Hibiscus rosa-sinensis*, *Mandevilla splendens* (Yu et al., 2021), *P. scutellarioides* (Hawrylak-Nowak et al., 2019), *S. caerulea*, *S. nutans*, *K. glauca* (Henschke, 2017), *C. officinalis* (Kozminska et al., 2017) and *S. splendens* (Soundararajan et al., 2013) significantly reduced the above-ground fresh weight. However, when salt water was applied to *C. morifolium* varieties, the fresh stem weights of the varieties increased (Rahi and Singh, 2011).

As seen in *Table 1*, it was stated that salt applications did not significantly affect the leaf dry weight of *S. ionantha*, and the lowest weight was seen in the 6 dS m^{-1} application compared to the control. It was emphasized that salt applications reduced the dry weight of plants (Acosta-Motos et al., 2016; 2017; Cirillo et al., 2016) and halophytic *L. gmelinii* (Honfi et al., 2023).

The applications of salt were been effective in *C. lacteus* and *E. myrtifolia* (Cassaniti et al., 2009a, 2009b), *I. purpurea* and *I. tricolor* (Mircea et al., 2023), *A. coronopifolium* (De Herralde et al., 1998).), ornamental sunflower (Ahsan et al., 2022), *S. columbaria*, *L. cardinalis*, *A. canadensis*, *C. hyssopifolia*, *D. suberecta*, *P. lasiopetala*, *Caryopteris x clandonensis*, *A. quadrifidus* and *Cestrum parqui* (Wu et al., 2016), *C. officinalis* (Bayat et al., 2012), *S. caerulea*, *S. nutans*, *K. glauca* (Henschke, 2017) and *S. splendens* (Soundararajan et al., 2013) was reported to reduce the dry weight of the above-ground parts. It was determined that salt applications similarly caused a decrease in dry weights on some ornamental plants, e.g., *A. vera*, *K. blossfeldiana*, *G. splendens* (García-Caparrós et al., 2016; 2017), *C. lacteus*, *C. aurantiacum*, *E. myrtifolia* and *Pyracantha* (Cassaniti et al., 2009a, 2009b). However, in *C. morifolium* varieties, salt increased the stem dry weight (Rahi and Singh, 2011).

3.2. Effects of salt on some macronutrient element contents (P, K, Ca and Na) in plant roots

The changes in the values of some macro elements (P, K, Ca and Na) in the root of *S. ionantha* with salt application are given in *Table 2*. The effects of salt applications on phosphorus, potassium and calcium contents were not statistically significant, but they significantly affected sodium content of root of *S. ionantha*.

Phosphorus values in the root of *S. ionantha* with salt application were found to be between 0.013% and 0.014%. From previous studies, it was reported that P content decreased as a result of salt applications for example, in *Antirrhinum majus* (Carter and Grieve, 2008), in *Chamaerops humilis* and *Washingtonia robusta* (Simón et al., 2010), in *Diantus caryophyllus* (Navarro et al., 2012), in *Cordyline fruticosa* (Plaza et al., 2012a; 2012b), in *Nepeta x faassenii* and *Phlox subulata* (Eom et al., 2007) and *C. morifolium* (Rahi and Singh, 2011). In addition, it was stated that salt applications increased the P content in *Alchemilla mollis*, but did not cause any change in *Sedum acre*, *Solidago cutleri* and *Thymus praecox* (Eom et al., 2007). It can be said that these different results are due to plant type and application differences.

Table 2. Average of phosphorus, potassium, calcium, and sodium in the root obtained as a result of salt applications

Salt application ($dS\ m^{-1}$)	Phosphorus (%)	Potassium (%)	Calcium ($mg\ kg^{-1}$)	Sodium ($mg\ kg^{-1}$)
0	0.013	1.93	11.60	430.0b
2	0.014	1.25	11.68	360.0b
4	0.014	2.24	11.71	635.0a
6	0.013	1.75	11.50	437.5b
8	0.014	1.78	11.92	450.0b
10	0.014	1.72	11.79	680.0a
$LSD_{0.05}$	n.s.	n.s.	n.s.	-176.60**

n.s.: Not significant, **Within a column, mean values followed by the same letter were not statistically different at the 1% level (n=4).

It was observed that salt applications did not significantly affect the potassium values in the roots of *S. ionantha*, the highest value was at 4 dS m^{-1} and the lowest was at 2 dS m^{-1} application. There are previous studies that salt applications reduced K content, e.g., in *A. majus* (Carter and Grieve, 2008), *Arbutus unedo* (Navarro et al., 2008), *C. humilis* and *W. robusta* (Simón et al., 2010), *Cichorium spinosum* (Ntatsi et al., 2017), *D. caryophyllus* (Navarro et al., 2012), *Escallonia exoniensis*, *Raphiolepis indica* and *Buxus microphylla* (Valdez-Aguilar et al., 2011), *Matthiola incana* (Grieve et al., 2006), *C. fruticosa* (Plaza et al., 2012a; 2012b), *Osteospermum hybrida* (Valdés et al., 2015), *Rosa hybrida* (Niu et al., 2013), *Tagetes erecta* (Koksal et al., 2014; 2016), *T. praecox* (Eom et al., 2007), *Gaura lindheimeri* and *Westringia fruticosa* (Ferrante et al., 2011), *Quercus robur* and *Tilia cordata* (Marosz and Nowak, 2008). In addition, it has been stated that salt applications do not cause changes in K content of plants such as *Nepeta x faassenii*, *P. subulata*, *S. cutleri* (Eom et al., 2007), *H. rosa sinensis*, *Juniperus chilensis* (Valdez-Aguilar et al., 2011), *C. citrinus*, *Jasminum sambac* (Ferrante et al., 2011), *Chaenomeles speciosa*, *Hydrangea macrophylla*, *Parthenocissus quinquefolia* (Liu et al., 2017), Acer negundo and *A. platanoides* (Marosz and Nowak, 2008). Despite this, salt applications were reported to increase K content in plants, such as in *A. mollis*, *S. acre* (Eom et al., 2007), *C. morifolium* (Rahi and Singh, 2011), *Acacia cultriformis*, *Carissa edulis* (Ferrente et al., 2011), *C. speciosa*, *Diervilla rivularis* varieties, *Forsythia x intermedia* and *Hibiscus syriacus* (Liu et al., 2017). It can be said that the different results caused from varietie of plants and diversity of applications.

With salt applications, the calcium values in the roots of *S. ionantha* were highest at 8 dS m^{-1} application and lowest at 6 dS m^{-1} application. It has been observed that salt applications do not significantly affect calcium values. Similarly, in *Nepeta x faassenii*, *S. acre*, *S. cutleri* and *T. praecox* (Eom et al., 2007), *A. cultriformis*, *C. citrinus* and *C. edulis microphylla* (Ferrante et al., 2011) and *A. negundo* (Marosz and Nowak, 2008) found that calcium content did not change significantly with salt applications. On the other hand, root Ca contents decreased with salt applications to ornamental sunflower (Ahsan et al., 2022), *G. lindheimeri* and *W. fruticosa* (Ferrante et al., 2011), *A. unedo* (Navarro et al., 2008), *W. robusta* (Simón et al., 2010), *D. caryophyllus* (Navarro et al., 2012), *M. incana* (Grieve et al., 2006), *R. hybrida* (Niu et al., 2013), *G. lindheimeri* and *W. fruticosa* (Ferrante et al., 2011) and *A. platanoides* (Marosz and Nowak, 2008). In contrast, calcium contents increased in some plants for example, in *J. sambac* (Ferrante et al., 2011), in *C. morifolium* cultivars (Rahi and Singh, 2011), in *T. erecta* (Koksal et al., 2014; 2016), in *A. mollis* and *P. subulata* (Eom et al., 2007), in *C. speciosa*, *C. speciosa*, *D. rivularis* varieties, *Forsythia x intermedia*, *H. syriacus*, *H. macrophylla* varieties and *P. quinquefolia* (Liu et al., 2017) and *Q. robur* (Marosz and Nowak, 2008) with salt treatments.

With salt application, significant changes were found in the sodium values in the root of *S. ionantha*. As the salt content increased, the amount of sodium in the root also increased and the highest value was observed at 10 dS m^{-1} and the lowest at 2 dS m^{-1}. A similar situation has been observed in previous studies. Salt applications were increased Na concentrations in the plant root, e.g., in different rose rootstocks (Cabrera et al., 2009), ornamental sunflower (*H. annuus*) (Ahsan et al., 2022), *A. mollis*, *Nepeta x faassenii*, *S. acre*, *P. subulata*, *S. cutleri* and *T. praecox* (Eom et al., 2007), *C. morifolium* varieties (Rahi and Singh, 2011), *Narcissus sp.*, *Amaryllidaceae* (Veatch-Blohm et al., 2014), *S. caerulea*, *S. nutans* and *K. glauca* (Henschke, 2017) and *A. vera*, *K. Blossfeldiana* and *G. splendens* (García-Caparrós et al., 2016; 2017).

In this study, excess sodium ion in the medium did not cause a significant change in calcium and potassium ions in the roots of *S. ionantha*. Lewitt (1980) stated that in some salt-resistant or tolerant plants, potassium and calcium are taken up more as the sodium in the environment increases, and the ratios of potassium and calcium increase along with sodium. In the light of this information, it can be stated that *S. ionantha* has low salt tolerance and poor tolerance to a salty environment.

3.3. Effects of salt on some micronutrient contents (Mn, Zn, Cu and Fe) in plant roots

The changes in the contents of some microelements (Mn, Zn, Cu and Fe) in the root of *S. ionantha* due to salt applications were found to be statistically significant (*Table 3*). The application with the highest manganese content was 8 dS m^{-1} and the lowest application was 10 dS m^{-1}. Accordingly, the Mn content first decreased, then increased, and then decreased again. Similarly, it was reported that salt applications increased the Mn content in the root in *A. mollis* (Eom et al., 2007).

***Table 3. Average Mn, Zn, Cu, and Fe in the plant root of S. ionantha* L.**

Salt application (dS m^{-1})	Manganese (mg kg^{-1})	Zinc (mg kg^{-1})	Copper (mg kg^{-1})	Iron (mg kg^{-1})
0	82.55abc	61.00b	142.75b	3.43b
2	68.60bc	77.30a	142.90b	3.38b
4	72.05bc	55.45bc	153.20a	3.75b
6	100.00ab	55.35bc	152.00ab	4.70b
8	108.75a	66.45ab	154.45a	6.19a
10	53.85c	39.80c	157.75a	3.34b
$LSD_{0.05}$	-33.100**	-17.416**	-9.154**	-1.428**

**Within a column, mean values followed by the same letter were not statistically different at the 1% level (n=4).

Zinc and iron rates in the root of *S. ionantha* with salt application first increased and then decreased, and the lowest values were observed at 10 dS m^{-1}. It was determined that the applications with the highest copper content in the root were 4, 8, and 10 dS m^{-1}, and the lowest applications were 0 dS m^{-1} and 2 dS m^{-1}. It was observed that as salt applications increased, Mn, Zn, and Fe contents in the root increased up to 8 dS.m^{-1} application, while Cu content increased up to 10 dS.m^{-1} application. Previous studies have also emphasized that excessive salt reduces the Zn and Fe content in corn and beans (Malkoç and Aydın, 2003), and the Fe content in *O. saundersiae* (Salachna et al., 2016).

3.4. Effects of salt on some macronutrient contents (P, Ca, K and Na) in the leaves of S. ionantha L.

With the salt applications, changes in the calcium and sodium contents of some macro element contents in the leaves of *S. ionantha* were statistically found to be significant, and an increase in the Ca, K and Na contents, except P, was observed in the *Table 4*.

***Table 4. Average P, Ca, K, and Na in the plant leaves of S. ionantha* L.**

Salt application (dS m^{-1})	Phosphorus (%)	Calcium (mg kg^{-1})	Potassium (mg kg^{-1})	Sodium (mg kg^{-1})
0	0.010	11.72d	10.90	3.79c
2	0.011	13.12cd	10.67	4.13c
4	0.010	14.79bc	10.75	11.34b
6	0.010	17.01ab	11.13	12.84b
8	0.010	18.31a	12.12	16.01a
10	0.010	16.41ab	12.44	17.48a
$LSD_{0.05}$	n.s.	-2.2343**	n.s.	-2.592**

n.s.: Not significant, **Within a column, mean values followed by the same letter were not statistically different at the 1% level (n=4).

Similarly, salt applications were reported that *Potentilla fruticosa* "Longacre" (Marosz, 2004), *S. acre*, *S. cutleri* and *T. praecox* (Eom et al., 2007), *A. negundo*, *A. platanoides*, *Q. robur* and *T. cordata* (Marosz and Nowak, 2008) of the P contents in leaves were determined to not change. In contrast, salt applications to plants, e.g., *S. caerulea*, *K. glauca* (Henschke, 2017), A. majus (Carter and Grieve, 2008), *C. humilis*, *W. robusta* (Simón et al., 2010), *D. caryophyllus* (Navarro et al., 2012), *C. fruticosa* (Plaza et al., 2012a; 2012b), *Nepeta x faassenii*, *P. subulata* (Eom et al., 2007) and *C. morifolium* (Rahi and Singh, 2011), was determined that reduced leaf P content. However, it has also been reported that leaf P content of *Cotoneaster*, *Spiraea* (Marosz, 2004) and *A. mollis* (Eom et al., 2007) increased with salt applications.

It was observed that the highest calcium rate in the leaves of *S. ionantha* was 8 dS m^{-1}, and the lowest application was 2 dS m^{-1}. It has also been stated in previous studies that an increase in Ca content of leaves was detected with salt applications to different plants, e.g. *S. caerulea*, *S. nutans*, *K. glauca* (Henschke, 2017), *Spiraea*, *Cotoneaster horizontalis* (Marosz, 2004), *Rose chinensis* (Li et al., 2016), *Plectranthus ciliatus* (Salachna et al., 2016), *T. erecta* (Koksal et al., 2014; 2016), *A. mollis*, *S. acre* (Eom et al., 2007), *C. morifolium* (Rahi and Singh, 2011), *C. speciosa* varieties, *D. rivularis* varieties, *Forsythia x intermedia*, *H. syriacus*, *H. macrophylla* varieties, *P. quinquefolia* (Liu et al., 2017) and *Q. robur* (Marosz and Nowak, 2008).

Despite this, it has been emphasized that salt reduces the amount of leaf calcium (Salachna et al., 2016; Navarro et al., 2008; 2012; Simón et al., 2010; Grieve et al., 2006; Niu et al., 2013; Ferrante et al., 2011; Nowak, 2008; Marosz, 2004), and sometimes it has been reported that it does not cause any change significantly (Eom et al., 2007; Ferrante et al., 2011; Marosz and Nowak, 2008).

There was no significant increase in the potassium values in the leaves as a result of the salt applied to *S. ionantha*. In parallel with our study, it was found that the salt applications did not significantly change the K content in plant leaves, e.g., *I. purpurea* (Mircea et al., 2023), *P. fruticosa*, *C. horizontalis* (Marosz, 2004) and *C. officinalis* (Kozminska et al., 2017). Differently from these results, in other plants, e.g., *I. tricolor* (Mircea et al., 2023), *Rose chinensis* (Li et al., 2016), *A. cultriformis*, *C. edulis microphylla* (Ferrante et al. 2011), *O. saundersiae* (Salachna et al., 2016), *S. acre* and *A. mollis* (Eom et al., 2007), and *C. morifolium* varieties (Rahi and Singh, 2011), it was reported that leaf K content increased. In the different studies have stated that salt reduces the K content in the leaf (Hu and Schmidhalter, 1997; Biçer, 2016; Karakas et al., 2021; Hooks and Niu, 2019; Salachna et al., 2016; El-Serafy et al., 2021; Ahsan et al., 2022; Ferrante et al., 2011; Marosz, 2004; Eom et al., 2007; Henschke, 2017).

With the application of salt, there was a significant increase in the amount of sodium in the leaves of *S. ionantha*, the highest rate was observed at 10 dS m^{-1} and the lowest value was observed at 0 dS m^{-1}. Similar results were encountered in studies conducted on different plants (Mircea et al., 2023; Salachna et al., 2016; Li et al., 2016; El-Serafy et al., 2021; Cabrera et al., 2009; Ahsan et al., 2022; Ferrante et al., 2011; Honfi et al., 2023; Marosz, 2004; Eom et al., 2007; Rahi and Singh, 2011; Henschke, 2017; Kozminska et al., 2017).

This situation, which occurs with the increase in sodium, which is a nutrient element for the *S. ionantha* plant, has a positive reflection on other nutritional elements, especially potassium and calcium, and the intake of potassium and calcium along with sodium has increased up to a certain level. These results are consistent with previous studies reporting that sufficient amounts of sodium or salt supplied or present in the environment increase potassium and calcium uptake in some plants (Eom et al., 2007; Rahi and Singh, 2011; Liu et al., 2017).

3.5. Effects of salt on some micronutrient contents (Mn, Zn, Cu, and Fe) in the leaves of S. ionantha L.

The Mn, Zn, Cu and Fe elements examined in the leaves of *S. ionantha* plants increased significantly with salt applications (*Table 5*).

It was similarly reported that salt applied to *A. mollis* increased its Mn content (Eom et al., 2007). It has been reported that Mn and Zn nutrients in wheat leaves are not significantly affected by salinity (Hu et al., 2000; Hu and Schmidhalter, 2001).

It was determined that the copper values in the leaves of *S. ionantha* increased up to certain levels (4, 6, and 8 dS m^{-1}) and then decreased. A similar result was reported by Malkoç and Aydin (2003) in different plant.

It was observed that salt applications increased the iron content in the leaves of *S. ionantha* plant, the highest application was obtained from 8 dS m^{-1} application and the lowest application was obtained from 2 dS m^{-1} application. It was reported that nutrient Fe in wheat leaves was largely unaffected by salinity (Hu et al., 2000; Hu and Schmidhalter, 2001).

Table 5. Average Mn, Zn, Cu, and Fe in the plant leaves of S. ionantha **L.**

Salt application (dS m^{-1})	Manganese (mg kg^{-1})	Zinc (mg kg^{-1})	Copper (mg kg^{-1})	Iron (mg kg^{-1})
0	75.20c	89.20b	152.25d	2.01b
2	49.55c	81.10b	151.65d	1.79b
4	181.80b	163.90a	172.70a	2.58b
6	27.50a	172.40a	166.75ab	5.61a
8	283.95a	161.80a	160.80bc	5.63a
10	220.75ab	165.45a	157.45cd	3.30ab
$LSD_{0.05}$	-67.44**	-40.528**	-6.739**	-2.4532*

* Within a column, mean values followed by the same letter were not statistically different at the 5% level (n=4),
**Within a column, mean values followed by the same letter were not statistically different at the 1% level (n=4).

4. Conclusions

According to the results, it can be said that salt, brine, or NaCl applications up to a certain level have a positive effect on the plant development and nutritional content of *S. ionantha*. However, it is also a fact that plants exposed to salt applications above a certain level or in excessive doses experience physiological regressions and problems in nutrient uptake. According to the results of the research, it was observed that salinity after a certain level negatively affected some nutritional physical properties and nutrient uptake of *S. ionantha* plant. Therefore, it should be taken into consideration that excessive salt content in the water in which plants are fed may cause some adverse conditions. It has also been predicted that the uptake of some elements decreases due to the effect of osmotic pressure created by salt. It has been observed that some elements are taken up in large amounts by the roots due to the effect of excess salt. Again, it has been observed that some physiological properties of the plant are negatively affected due to salinity. In order to avoid the problems mentioned above, it should be taken into consideration that optimum amounts of Na can be given to many other plants, as in the *S. ionantha* plant discussed in this study, but excessive salt or irrigation with water with high salt content may adversely affect the physiological and nutritional status.

Acknowledgment

This work was not supported.

Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

Conflicts of Interest

We declare that there is no conflict of interest between us as the article authors.

Authorship Contribution Statement

Concept: Demirkıran, A.R., Polat, G.; Design: Demirkıran, A.R., Polat, G.; Data Collection or Processing: Demirkıran, A.R., Polat, G.; Statistical Analyses: Demirkıran, A.R.; Literature Search: Demirkıran, A.R.; Writing, Review and Editing: Demirkıran, A.R.

References

Acosta-Motos, J. R., Ortuño, M. F., Álvarez, S., López-Climent, M. F., Gómez-Cadenas, A. and Sánchez-Blanco, M. J. (2016). Changes in growth, physiological parameters and the hormonal status of *Myrtus communis* L. plants irrigated with water with different chemical compositions. *Journal of Plant Physiology,* 191: 12–21.

Acosta-Motos, J. R., Ortuño, M. F., Bernal-Vicente, A., Diaz-Vivancos, P., Sanchez-Blanco, M. J. and Hernandez, J. A. (2017). Plant responses to salt stress: adaptive mechanisms. *Agronomy*, 7(1): 18.

Ahsan, M., Zulfiqar, H., Farooq, M. A., Ali, S., Tufail, A., Kanwal, S., Shaheen M.R., Sajid M., Gul H., Jamal A., Saeed M.F., Mancinelli R. and Radicetti, E. (2022). Strigolactone (GR24) Application positively regulates photosynthetic attributes, stress-related metabolites and antioxidant enzymatic activities of ornamental sunflower (*Helianthus annuus* cv. Vincent's Choice) under salinity stress. *Agriculture*, 13(1): 50.

Akcal, A. and Kaynas, K. (2021). The effects of salinity stress on plant growth performance and flowering characteristics of cyclamen (*Cyclamen hederifolium* Aiton.). *Lapseki Meslek Yüksekokulu Uygulamalı Araştırmalar Dergisi,* 2(4): 109-116 (In Turkish).

Alarcon, J., Sanchez-Blanco, M. J., Bolarin, M. C. and Torrecillas, A. (1993). Water relations and osmotic adjustment in *Lycopersicon esculentum* and *L. pennellii* during short term salt exposure and recovery. *Physiologia Plantarum*, 89: 441-447.

Altuner, F., Oral, E. and Baran, İ. (2022). Determination of the effects of salt (NaCl) stress on germination in some barley (*Hordeum vulgare* L.) varieties. *Journal of Tekirdag Agricultural Faculty*, 19(1): 39-50.

Álvarez, S. and Sánchez-Blanco, M. J. (2014). Long-term effect of salinity on plant quality, water relations, photosynthetic parameters and ion distribution in *Callistemon citrinus*. *Plant Biology,* 6: 757–764.

Anonymous (2004). https://scholar.google.com/scholar?hl=tr&as_sdt=0%2C5&q=Saintpaulia+ionantha+Wendl.+african+violet+salt+stress&btnG=https://scholar.google.com/scholar?hl=tr&as_sdt=0%2C5&q=VIOLET+PLANT+%28Saintpaulia+ionantha+L.%29+TO+SALINITY&btnG= (Acsessed Date: 03.07.2024).

Atal, H. L., Srilakshmi, D., Debbarma, K., Jena, L. and Ichancha, M. (2022). A Review on breeding in ornamental crops for abiotic stress tolerance. *International Journal of Plant & Soil Science*, 34(20): 134-138.

Bayat, H., Alirezaie, M. and Neamati, H. (2012). Impact of exogenous salicylic acid on growth and ornamental characteristics of calendula (*Calendula officinalis* L.) under salinity stress. *Journal of Stress Physiology & Biochemistry*, 8(1): 258-267.

Beyaz, R. and Kazankaya, A. (2024). Effect of NaCl-induced salt stress on germination and initial seedling growth of *Lotus corniculatus* L. cv.'Leo'. *Journal of Tekirdag Agricultural Faculty*, 21(1): 24-34.

Bicer, A. (2016). *Effects of putrescine on growth and some physiological parameters of maize plant grown at saline conditions*. (MSc. Thesis). Harran University, Institute of Science, Şanlıurfa, Türkiye (In Turkish).

Bischoff, J. and Werner, H. (1999). Salt/Salinity Tolerance of Common Horticultural Crops in South Dakota: Garden and Vegetable/Woody Fruit Crops. South Dakota State University, SDSU Extension, p. 84.

Blum A. (1986). Salinity Resistance, In: Plant Breeding for Stress Environments, 1163- 1169, CRC Press, Boca Raton.

Bouyoucos, G. J. (1951). A recalibration of the hydrometer method for making mechanical analysis of soil. *Agronomy Journal,* 43: 434-437.

Boydak, E., Demirkıran, A. R. and Aslan, S. (2025). Effect of different doses of orange biochar material on relieving NaCl salt stress: Peanut (*Arachis hypogaea* L.) applications, *Turkish Journal of Agricultural and Natural Sciences*, 12(1), 62-73.

Cabrera, R. I., Solís-Pérez, A. R. and Sloan, J. J. (2009). Greenhouse rose yield and ion accumulation responses to salt stress as modulated by rootstock selection. *HortScience,* 44(7): 2000-2008.

Carter, C. T. and Grieve, C. M. (2008). Mineral nutrition, growth, and germination of *Antirrhinum majus* L. (Snapdragon) when produced under increasingly saline conditions. *HortScience,* 43: 710–718.

Cassaniti, C., Leonardi, C. and Flowers, T. J. (2009a). The effects of sodium chloride on ornamental shrubs. *Scientia Horticulturae,* 122: 586–593. doi: 10.1016/j. scienta.2009.06.032.

Cassaniti, C., Li Rosi, A. and Romano, D. (2009b). Salt tolerance of ornamental shrubs mainly used in the Mediterranean landscape. *In International Symposium on Strategies towards Sustainability of Protected Cultivation in Mild Winter Climate*. ISHS Acta Horticulturae 807, p. 675-680.

Cassaniti, C., Romano, D. and Flowers, T. J. (2012). The Response of Ornamental Plants to Saline Irrigation Water (Chapter 8). Book: Irrigation: Water Management, Pollution and Alternative Strategies, p. 131, 158.

Cirillo, C., Rouphael, Y., Caputo, R., Raimondi, G., Sifola, M. and De Pascale, S. (2016). Effects of high salinity and the exogenous application of an osmolyte on growth, photosynthesis, and mineral composition in two ornamental shrubs. *The Journal of Horticultural Science and Biotechnology,* 91: 14–22. doi: 10.1080/14620316.2015.1110988.

Cirillo, C., Rouphael, Y., Caputo, R., Raimondi, G., Sifola, M. I. and De Pascale, S. (2016). Effects of high salinity and the exogenous of an osmolyte on growth, phosynthesis and mineral composition in two ornamental shrubs. *The Journal of Horticultural Science and Biotechnology,* 91: 14–22.

De Herralde, F., Biel, C., Save, R., Morales, M. A., Torrecillas, A., Alarcon, J. J. and Sánchez-Blanco, M. J. (1998). Effect of water and salt stresses on the growth, gas exchange and water relations in *Argyranthemum coronopifolium* plants. *Plant Science,* 139(1): 9-17.

Demirkiran, A. R. and Sohrabi, M. (2024). The Application of Nanotechnology on Plant Nutrition and Agriculture: A Review. *Journal of Agriculture,* 7(1), 100-112.

Dhakar, S., Soni, A. and Kumari, P. (2017). Breeding for abiotic stress tolerance in ornamental crops: a review. *Chemical Science Review and Letters,* 6(23): 1549-1554.

Dodd, I. C. (2005). Root-to-shoot signalling: Assessing the roles of 'up' in the up and down world of long-distance signalling in planta. *Plant Soil,* 74: 257–275.

El-Serafy, R. S., El-Sheshtawy, A. N. A., Atteya, A. K., Al-Hashimi, A., Abbasi, A. M. and Al-Ashkar, I. (2021). Seed priming with silicon as a potential to increase salt stress tolerance in *Lathyrus odoratus*. *Plants,* 10(10): 2140.

Eom, S. H., Setter, T. L., DiTommaso, A. and Weston, L. A. (2007). Differential growth response to salt stress among selected ornamentals. *Journal of Plant Nutrition,* 30(7): 1109-1126.

FAO (1990). Micronutrient. Assessment at the country level: an international study. FAO soil bulletin by Mikko Sillanpaa. Rome, Italy.

Farooq, M., Uzma, J. and Mamidala, P. (2024). Salicylic acid induced salt tolerance in Gerbera jamesonii, an ornamental plant. *Vegetos,* 1: 1-8.

Ferrante, A., Trivellini, A., Malorgio, F., Carmassi, G., Vernieri, P. and Serra, G. (2011). Effect of seawater aerosol on leaves of six plant species potentially useful for ornamental purposes in coastal areas. *Scientia Horticulturae,* 128(3): 332-341.

García-Caparrós, P., Llanderal, A. and Lao, M. T. (2017). Effects of salinity on growth, water-use efficiency, and nutrient leaching of three containerized ornamental plants. *Communications in Soil Science and Plant Analysis,* 48(10): 1221-1230.

García-Caparrós, P., Llanderal, A., Pestana, M., Correia, P. J. and Lao, M. T. (2016). Tolerance mechanisms of three potted ornamental plants grown under moderate salinity. *Scientia Horticulturae,* 201: 84-91.

Grieve, C. M., Poss, J.A. and Amrhein, C. (2006). Response of *Matthiola incana* to irrigation with saline wastewaters. *Hortscience,* 41: 119–123.

Hawrylak-Nowak, B., Rubinowska, K., Molas, J., Woch, W., Matraszek-Gawron, R. and Szczurowska, A. (2019). Selenium-induced improvements in the ornamental value and salt stress resistance of (*Plectranthus scutellarioides* L. R. Br. Folia). *Horticulturae,* 31(1): 213-221.

Henschke, M. (2017). Response of ornamental grasses cultivated under salinity stress. *Acta Scientiarum Polonorum Hortorum Cultus,* 16(1):95-103.

Honfi, P., Eisa, E. A., Tilly-Mándy, A., Kohut, I., Ecseri, K. and Mosonyi, I. D. (2023). Salt tolerance of *Limonium gmelinii* subsp. hungaricum as a potential ornamental plant for secondary salinized soils. *Plants,* 12(9): 1807.

Hooks, T. and Niu, G. (2019). Relative salt tolerance of four herbaceous perennial ornamentals. *Horticulturae,* 5(2): 36.

Hu, Y. and Schmidhalter, U. (1997). Interactive effects of salinity and macronutrient level on wheat. II. Composition. *Journal of Plant Nutrition,* 20(9): 1169-1182.

Hu, Y. and Schmidhalter, U. (2001). Effects of salinity and macronutrient levels on micronutrients in wheat. *Journal of Plant Nutrition,* 24: 273–28.

Hu, Y., von Tucher, S. and Schmidhalter, U. (2000). Spatial distributions and net deposition rates of Fe, Mn and Zn in the elongating leaves of wheat under saline soil conditions. *Australian Journal of Plant Physiology,* 27: 53–59.

Kacar, B. (1972). Bitki ve Toprağın Kimyasal Analizleri II. Bitki Analizleri. *Ankara Üniversitesi Ziraat Fakültesi Yayınları,* 453 pp. (In Turkish).

Karagoz, F. P. and Dursun, A. (2021). Calcium nitrate on growth and ornamental traits at salt-stressed condition in ornamental kale (*Brassica oleracea* L. var. Acephala). *Ornamental Horticulture,* 27: 196-203.

Karakas, S., Bolat, I. and Dikilitas, M. (2021). The use of halophytic companion plant (*Portulaca oleracea* L.) on some growth, fruit, and biochemical parameters of strawberry plants under salt stress. *Horticulturae,* 7(4): 63.

Karimian, Z., Samiei, L. and Nabati, J. (2019). Alleviating the salt stress effects in *Salvia splendens* by humic acid application. *Acta Scientiarum Polonorum Hortorum Cultus,* 18(5): 73-82.

Koksal, N., Alkan-Torun, A., Kulahlioglu, I., Ertargin, E. and Karalar, E. (2016). Ion uptake of marigold under saline growth conditions. *Springerplus,* 5: 1–12. doi: 10.1186/s40064-016-1815-3.

Koksal, N., Kulahlioglu, I., Ertargin, E. and Torun, A. A. (2014). Relationship between salinity stress and ion uptake of hyacinth (*Hyacinthus orientalis*). *Turkish Journal of Agricultural and Natural Science*, 1: 578–583.

Kolehmainen, J. (2008). *Ecology, population genetics and conservation of the African violet (Saintpaulia, Gesneriaceae).* PhD. Thesis, University of Helsinki, Finland.

Kozminska, A., Al Hassan, M., Kumar, D., Oprica, L., Martinelli, F., Grigore, M. N., Vicente, O. and Boscaiu, M. (2017). Characterizing the effects of salt stress in *Calendula officinalis* L. *Journal of Applied Botany and Food Quality,* 90: 323-329.

Lewitt J. (1980). Responses of Plants to Environmental Stresses. Vol. II, 2nd ed. Academic Press, New York, pp.607.

Li, X., Wan, S., Kang, Y., Chen, X. and Chu, L. 2016. Chinese rose (*Rosa chinensis*) growth and ion accumulation under irrigation with waters of different salt contents. *Agricultural Water Management,* 163: 180-189.

Liu, Q., Sun, Y., Niu, G., Altland, J., Chen, L. and Jiang, L. (2017). Morphological and physiological responses of ten ornamental taxa to saline water irrigation. *HortScience,* 52(12): 1816-1822.

Malkoc, M. and Aydin, A. (2003). Effect of different salt sources on *Zea mays* and *phaseolus* growth and mineral content. *Research in Agricultural Sciences.* 34(3): 211-216 (In Turkish).

Mandhania, S., Madan, S., Sawhney, V. and Haryana, C. C. S. (2006). Antioxidant defense mechanism under salt stress in wheat seedlings. *Biologia Plantarum,* 50(2): 227-231.

Marosz, A. (2004). Effect of soil salinity on nutrient uptake, growth, and decorative value of four ground cover shrubs. *Journal of Plant Nutrition,* 27(6): 977-989.

Marosz, A. and Nowak, J. S. (2008). Effect of salinity stress on growth and macro elements uptake of four tree species. *Dendrobiology,* 59: 23-29.

Mircea, D. M., Li, R., Blasco Giménez, L., Vicente, O., Sestras, A. F., Sestras, R. E., Sestras R.E., Boscaiu M. and Mir, R. (2023). Salt and water stress tolerance in *Ipomoea purpurea* and *Ipomoea tricolor*, two ornamentals with invasive potential. *Agronomy,* 13(9): 2198.

Navarro, A., Bañón, S., Conejero, W. and Sánchez-Blanco, M. J. (2008). Ornamental characters, ion accumulation and water status in *Arbutus unedo* seedlings irrigated with saline water and subsequent relief and transplanting. *Environmental and Experimental Botany,* 62: 364–370.

Navarro, A., Elia, A., Conversa, G., Campi, P. and Mastrorilli, M. (2012). Potted mycorrhizal carnation plant sand saline stress: growth, quality and nutritional plant responses. *Scientia Horticulturae,* 140: 131–139.

Nelson, D. W. and Sommers, L. E. (1982). Total carbon, organic carbon, and organic matter. Methods of soil analysis: Part 2 - Chemical and Microbiological Properties, 9: 539-579.

Niu, G. and Rodriguez, D. S. (2008). Responses of growth and ion uptake of four rose rootstocks to chloride- or sulfate-dominated salinity. *Journal of American Society for Horticultural Science,* 133: 663–669.

Niu, G., Starman, T. and Byrne, D. (2013). Responses of growth and mineral nutrition of garden roses to saline water irrigation. *Hortscience*, 48: 756–761.

Ntatsi, G., Aliferis, K. A., Rouphael, Y., Napolitano, F., Makris, K., Kalala, G., Katopodis, G. and Savvas, D. (2017). Salinity source alters mineral composition and metabolism of *Cichorium spinosum*. *Environmental and Experimental Botany,* 141: 113–123.

Olsen, S. R. V., Cole, F. S., Watanable, L. and Dean, A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dep. of Agr. Cir. 939, Washington D.C., U.S.A.

Parida, A. and Das, A. B. (2005). Salt tolerance and salinity effects on plants: a review. *Ecotoxicology and Environmental Safety,* 60: 324-349.

Plaza, B. M., Jiménez, S. and Lao, M. T. (2012a). Influence of salt stress on the nutritional state of *Cordyline fruticosa* var. Red Edge: chloride, nitrogen and phosphorus. *Communications in Soil Science and Plant Analysis,* 43: 226–233.

Plaza, B. M., Jiménez, S. and Lao, M. T. (2012b). Influence of salt stress on the nutritional state of *Cordyline fruticosa* var. Red Edge 2: sodium, potassium, calcium and magnesium. *Communications in Soil Science and Plant Analysis,* 43: 234–242.

Pratt, P. F. (1965). Methods of Soil Analysis, Part 2. Chemical and Microbiological Properties. Ed. C. A. Black. Amer. Soc. Agr. Inc. Pub. Agron. Series No: 9, Madison, Wisconsin, USA.

Rahi, T. and Singh, B. (2011). Salinity tolerance in *Chrysanthemum morifolium*. *Journal of Applied Horticulture,* 13: 30–36. https://doi.org/10.37855/jah.2011.v13i01.07

Richards, L.A. (1954). Diagnosis and improvement of saline and alkaline soils (moisture retention curve), Dept. of Agri. Handbook, 60 pp. USDA.

Sabra, A., Daayf, F. and Renault, S. (2012). Differential physiological and biochemical responses of three *Echinacea* species to salinity stress. *Scientia Horticulturae.* 135: 23–31. doi: 10.1016/j.scienta.2011.11.024.

Salachna, P. and Piechocki, R. (2016). Effects of sodium chloride on growth and mineral nutrition of purpletop vervain. *Journal of Ecological Engineering,* 17: 148–152.

Salachna, P., Zawadzinska, A. and Podsiadlo, C. (2016). Response of *Ornithogalum saundersiae* Bak. to salinity stress. *Acta Scientiarum Polonorum Hortorum Cultus,* 15(1): 123-134.

Sayyed, A., Gul, H., Ullah, Z. and Hamayun, M. (2014). Effect of salt stress on growth of *Tagetes erecta* L. Pakhtunkhwa. *Journal of Life Science,* 2(3-4): 96-106.

Shannon M. C. and Grieve, C. M. (1999). Tolerance of vegetable crops to salinity. *Scientia Horticulturae,* 78: 5-38.

Simón, M. D., Nieves-Cordones, M. and Nieves, M. (2010). Differences in growth and ornamental parameters between young *Chamaerops humilis* L. and *Washingtonia robusta* H. Wendl palm trees in response to salinity. *The Journal of Horticultural Science and Biotechnology,* 85: 7–11.

Soundararajan, P., Sivanesan, I., Jo, E. H. and Jeong, B. R. (2013). Silicon promotes shoot proliferation and shoot growth of *Salvia splendens* under salt stress in vitro. *Horticulture, Environment, and Biotechnology,* 54: 311-318.

Toscano, S., Ferrante, A., Romano, D. and Tribulato, A. (2021). Interactive effects of drought and saline aerosol stress on morphological and physiological characteristics of two ornamental shrub species. *Horticulturae,* 7(12): 517.

Turkogullari. N., Ayyildiz. L. and Gulser, F. (2013). The effect of salinity on plant growth in seasonal flowers. *Iğdır University Journal of Institute of Science and Technology,* 3(4): 15-19 (In Turkish).

U.S. Salinity Laboratory (1954). Diagnosis improvement of saline and alkaline soils. Agri. Handbook, No: 60, USDA.

Valdés, R., Franco, J. A., Sánchez-Blanco, M. J. and Bañón, S. (2015). Relationships among electrical conductivity measurements during saline irrigation of potted Osteospermum and their effects on plant growth. *The Journal of Horticultural Science and Biotechnology,* 90, 571–577.

Valdez-Aguilar, L. A., Grieve, C. M., Razak-Mahar, A., McGiffen, M. M. and Merhaut, D. J. (2011). Growth and ion distribution is affected by irrigation with saline water in selected landscape species grown in two consecutive growing seasons: Spring-summer and fall-winter. *Hortscience*, 46: 632–642.

Veatch-Blohm, M. E., Sawch, D., Elia, N. and Pinciotti, D. (2014). Salinity tolerance of three commonly planted narcissus cultivars. *HortScience,* 49: 1158–1164. doi: 10.21273/HORTSCI.49.9.115.

Wild A. (1988). Russell's soil conditions and plant growth. 11th edn. Harlow, Longman.

Wu, S., Sun, Y. and Niu, G. (2016). Morphological and physiological responses of nine ornamental species to saline irrigation water. *HortScience,* 51(3): 285-290.

Yasemin, S., Koksal, N., Ozkaya, A. and Yener, M. (2017). Growth and physiological responses of '*Chrysanthemum paludosum*' under salinity stress. *Journal of Biological and Environmental Sciences,* 11(32): 59-66.

Yu, X., Her, Y., Chang, A., Song, J. H., Campoverde, E. V. and Schaffer, B. (2021). Assessing the effects of irrigation water salinity on two ornamental crops by remote spectral imaging. *Agronomy,* 11(2): 375.

Zhu, J. K. (2001). Plant salt tolerance. *Trends in Plant Science,* 6(2): 66-71.