Pol. J. Environ. Stud. Vol. 33, No. 2 (2024), 1631-1641
DOI: *10.15244/pjoes/173989* ONLINE PUBLICATION DATE: 2023-12-08

Original Research

The Responses of Nutrient Uptakes in Different Organs of *Narcissus tazetta* (L.) Grown under Saline Conditions to Mycorrhizal Inoculation

Arzu Çığ[1]*, Füsun Gülser[2], Efdal Gülser[3]

[1]Siirt University, Faculty of Agriculture, Department of Horticulture, Siirt, Türkiye
[2]Van Yüzüncü Yıl University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, Van, Türkiye
[3]Atatürk University, Faculty of Agriculture, Department of Plant Protection, Erzurum, Türkiye

Received: 4 August 2023
Accepted: 10 Ocober 2023

Abstract

In this study, the effect of mycorrhiza (*Glomus intraradices* N.C. Schenck & G.S. Sm.) inoculation on the micronutrient and macroelement uptakes in different organs of daffodil (*Narcissus tazetta* L.) grown under saline conditions is examined. For this purpose, *Narcissus tazetta* plant grown in the climate chamber was treated with sodium chloride (NaCl) at three different concentrations such as salt-free (S0), 34 mmol (S1) and 68 mmol (S2) in mediums with mycorrhiza (M+) and without mycorrhiza (M-). At the end of the experiment, the uptakes of sodium (Na), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) uptakes in the bulb, root and leaves of the plant were analyzed. The effects of salt and mycorrhiza interactions on the N uptakes were statistically significant at the 5% level in bulbs. The effects of salt applications were found significant at 1% level for all nutrients uptakes of roots except Cu uptake (5%). The effects of interactions among salt and mycorrhiza were found significant at 5% level for P, Ca and Mn uptakes and at 1% level for Mg, Fe and Cu uptakes of leaves statistically. Increasing doses of sodium chloride had statistically negative effects on nutrient uptakes of different organs except Na and K uptakes of bulbs. Mycorrhiza applications generally increased nutrient uptakes of daffodil's roots and leaves under salinity conditions. The interactions between salt and mycorrhiza were significant for N in bulbs, for N, P and Fe in roots and for P, Ca, Mg, Fe, Mn and Cu in leaves. The decreases in these nutrients uptakes by 68 mmol NaCl applications were lower in mycorrhiza applications than those in non mycorrhiza applications.

Keywords: macronutrient elements, micronutrient elements, mycorrhiza, *Narcissus tazetta,* salinity

*e-mail: arzucig@yahoo.com

Introduction

Soil salinity, especially in arid and semi-arid regions that restrict plant growth and production is a worldwide problem [1]. About 20% global croplands have become less productive or uncultivable wastelands caused by soil salinization [2]. Therefore the researchers have given importance to these serious environmental problems in the last decade. Salinity is of concern because of its detrimental effect on plant growth, nutritional balance, and plant and flower marketable quality, including visual injury, flower distortion and reduced stem length [3-5].

The deterious effects of salinity on plant growth are associated with low osmotic potential of soil solution, nutrient disorders, specific ion effects or a combination of all those factors [6, 7]. Due to the increase in green areas in the urban environment, the demand for water supply is increasing [8, 9]. As demand for water continues to rise in agricultural, urban, industrial, environmental and recreational areas, shortages of quality water have become a concern in many regions [5, 10]. Such as recycled water, treated municipal wastewater and brackish groundwater used due to water scarcity alternative water sources generally contain higher levels of salt [11]. Salinity stress in ornamental plant cultivation draws attention worldwide. The salinity tolerance of plants is a polygenic character governed by many genetic factors [12, 13]. The effect of salt on ornamental value is an important criterion when searching for salinity-tolerant species and cultivars [14].

Arbuscular mycorrhizal fungi are common microorganisms that can form a symbiotic relationship with the roots of most terrestrial plants. Root-infected arbuscular mycorrhizal fungi (AMF) improve plant growth through uptake of soil nutrients via extra matrix hyphae. Furthermore, complementary effect of arbuscular mycorrhizal fungi, as an alternative for reducing fertilizer need of major crop species were reported [15]. AMF can form root interrelations in more than 80% of terrestrial plants worldwide [16]. This relationship improves plant growth and resistance to multiple abiotic stressors, including high temperature, cold, drought, and salinity stress [17-22]. Ornamental plants (herbaceous-woody) vary considerably in terms of degree salt tolerance [23]. Mycorrhizal symbiosis has been recognized as a plant biofertilizer and bioprotectant protecting it from environmental stresses such as drought and salinity [24], improving product [25]. The importance of arbuscular mycorrhiza against salinity should be considered in landscape studies [9].

Cut flowers are an important branch of the floriculture industry [26-28]. *Narcissus* is one of the cut flowers grown worldwide for its medicinal and ornamental values. The *Narcissus* species are mostly native to the Mediterranean region, although a few species are found from Central Asia to China [29]. *Narcissus tazetta* (L.) belonging to the Amaryllidaceae family is used as a cut flower in landscaping and cultivation. It has as much economic value as an ornamental bulbous plant.

The aim of this study was to determine the effect of mycorrhiza on the macro and micro nutrient uptakes in the bulbs, roots and leaves of *Narcissus tazetta* (L.) under saline conditions.

Experimental

The study was conducted with bulbs of *Narcissus tazetta* (L.) and completely randomized factorial design with three application so that each replication included five pots. In the experiment, different salt concentrations were applied with mycorrhiza (M+) (*Glomus intraradices* NC Schenck & GS Sm.) and without mycorrhiza (M-) planting soil. *G. intraradices* mycorrhizal fungus was mixed at 7.7% percentage to experimental soil. Bulbs were planted into 6 cm diameter plastic pots having 3 kg soil after one week following mycorrhizal inoculation. N:P:K: ratio of chemical fertilizers were applied so that 6:12:6 in pots. Soil properties of experimental soil were determined using the standard analyses methods [30]. Some physical and chemical properties of experimental soil were given in Table 1.

Physical and chemical properties of experimental soil had loamy texture, non-saline, slightly alkaline, low in organic matter, insufficient in phosphorus and zinc contents sufficient in calcium, magnesium, manganese and copper contents (Table 1).

Ten days after planting *Narcissus tazetta* plant was treated with sodium chloride (NaCl) at three different concentrations such as salt-free (S0), 34 mmol (S1) and 68 mmol (S2) in mediums with mycorrhiza (M+) and without mycorrhiza (M-). Because of the development of the bulb root system, until the first leaves emergence (36 days) all pots were left in 10ºC below the temperature of the cold laboratory, and then were taken to a climate chamber at 20-23ºC temperature. The nutrient uptakes were analyzed in dried and grinded leaf, bulb and root samples according to the methods reported by [31]. Na, Fe, Mn, Zn, Cu K, Ca and Mg uptakes were determined by using atomic absorption spectrophotometers. N and P uptakes content were analyzed by using Kjeldahl method and spectrophotometric method respectively. Statistical analyses of the data were done with MINITAB 14 program.

Results and Discussion

The variance analyses results belong the effects of mycorrhiza applications and salinity on plant nutrient uptakes of bulb, root and leaf are given in Table 2, Table 3, and Table 4.

The salt applications had significant effects on K and Na uptakes of bulbs at 5% and 1% levels respectively. The effects of mycorrhiza applications on macro and micro nutrient uptakes of bulbs were found non-significant statistically. The effects of salt and mycorrhiza interactions on the N uptakes were

Table 1. Properties of the experiment soil.

Texture	pH	Salinity	Lime	OM	P	K	Ca	Mg	Fe	Mn	Zn	Cu
		µS cm^{-1}	%	%	mg kg^{-1}							
Loamy	7.81	360.7	3.86	1.32	5.50	298	3034	405	5.58	29.84	0.58	0.81

statistically significant at the 5% level in bulbs (Table 2).

The effects of salt applications were found significant at 1% level for all nutrients uptakes of roots except Cu uptake. The Cu uptake means of roots were affected by salt applications at 5% significance level. Mycorrhiza applications had a statistically significant effect on all nutrient uptakes except Na and Mn at the level of 1% and for Mg at the level of 5%.

The effects of salt and mycorrhiza interactions on the Fe uptake was statistically significant at the 1% level and were significant at the 5% level for N and P uptakes of roots (Table 3).

All nutrient uptakes except Na of leaves were significantly affected by salt applications at 1% and Na uptakes were affected at 5% significance level. Mycorrhiza treatments had a statistically significant effect at 1% level on P uptakes and on Cu uptakes at 5% level. The effects of interactions among salt and mycorrhiza were found significant at 5% level for Ca, P and Mn uptakes and at 1% level for Mg, Fe and Cu uptakes statistically (Table 4).

The effects of salt and mycorrhiza applications on nutrient uptakes of *Narcissus tazetta*'s roots, leaves and bulbs were given in Table 5, Table 6 and Table 7.

The increasing salt doses had not significantly effects on nutrient uptakes of *Narcissus tazetta*'s bulbs except N, K and Na uptakes. The Na and K uptakes increased by increasing salt doses. The lowest K uptake was obtained in S0 application as 0.052 mg plant^{-1} and the highest K uptake was obtained in S2 application as 0.074 mg plant^{-1}. The lowest Na uptake was obtained in S0 application as 2.487 mg plant^{-1}, and the highest Na uptake was obtained in S2 application as 3.825 mg plant^{-1}. N uptakes obtained as 0.127% in S0 applications with mycorrhiza were higher than those obtained as 0.080% in salt applications without mycorhiza (Table 5).

The salt applications decreased macro and micro nutrients uptakes of roots. The lowest N, P, K, Ca, Mg, Na, Fe, Mn, Zn and Cu uptakes were determined as 0.003 mg plant^{-1} 0.043 mg plant^{-1} 0,008 mg plant^{-1}, 0.008 mg plant^{-1}, 0.002 mg plant^{-1}, 0.718 mg plant^{-1}, 896.443 mg plant^{-1}, 35.813 mg plant^{-1}, 7.695 mg plant^{-1} and 16.340 mg plant^{-1} in S2 applications respectively. Mycorrhiza applications increased macro and micro nutrients uptakes of roots. These increases did not significant for Na and Mn uptakes statistically. The interactions between salt and mycorrhiza significantly effected N, P and Fe uptakes of roots. The decreases

Table 2. Variance analysis results for nutrient uptakes in bulbs (F values).

					BULB						
Variation Sources	df	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
Salt (NaCl)	2	1.52 ns	3.40 ns	4.60 *	0.20 ns	1.02 ns	12.81 **	0.63 ns	0.77 ns	0.27 ns	0.00 ns
Mycorrhiza	1	1.38 ns	0.49 ns	1.30 ns	1.39 ns	0.53 ns	2.94 ns	1.04 ns	0.08 ns	1.10 ns	0.24 ns
Salt*Mycorrhiza	2	6.24 *	3.08 ns	0.29 ns	1.29 ns	0.24 ns	0.97 ns	2.57 ns	0.39 ns	2.78 ns	2.07 ns

*significant at 0.05, **significant at 0.01, ns not significant

Table 3. Variance analysis results for nutrient uptakes in roots (F values).

					ROOT						
Variation Sources	df	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
Salt (NaCl)	2	140.29 **	74.86 **	16.77 **	15.02 **	13.11 **	16.58 **	11.91 **	8.73 **	27.82 **	5.35 *
Mycorrhiza	1	15.33 **	21.35 **	12.20 **	14.40 **	4.78 *	1.20 ns	23.25 **	4.70 ns	12.62 **	24.88 **
Salt*Mycorrhiza	2	4.44 *	6.15 *	2.11 ns	0.32 ns	0.20 ns	2.46 ns	7.46 **	0.34 ns	1.40 ns	1.07 ns

*significant at 0.05, **significant at 0.01, ns not significant

Table 4. Variance analysis results for nutrient uptakes in leaf (F values).

LEAF											
Variation Sources	df	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
Salt (NaCl)	2	46.63 **	37.58 **	34.86 **	12.29 **	52.70 **	5.61*	45.90 **	22.16 **	37.41 **	20.23 **
Mycorrhiza	1	2.09 ns	11.53 **	0.58 ns	0.53 ns	0.01 ns	0.16 ns	1.30 ns	0.28 ns	0.81 ns	7.47 *
Salt*Mycorrhiza	2	3.29 ns	5.09 *	3.76 ns	4.52 *	8.96 **	1.93 ns	7.48 **	5.89 *	2.54 ns	14.79 **

*significant at 0.05, **significant at 0.01, ns not significant

in N, P and Fe uptakes by 68 mmol NaCl applications were lower in mycorrhiza applications than those in non mycorhizza applications (Table 6).

The macro and micro nutrient uptakes of leaves decreased by increasing salt doses. The lowest N, P, K, Ca, Mg, Na, Fe, Mn, Zn and Cu uptakes were determined as 0.058 mg plant^{-1}, 0.597 mg plant^{-1}, 0.072 mg plant^{-1}, 0.028 mg plant^{-1}, 0.008 mg plant^{-1}, 2.613 mg plant^{-1}, 261.422 mg plant^{-1}, 48.177 mg plant^{-1}, 105.540 mg plant^{-1} and 55.037 mg plant^{-1} in S2 applications respectively. The highest nutrient uptake means of leaves were obtained in control.

Mycorrhiza applications significantly increased P uptake of leaves. The P uptake means were determined as 1.422 mg plant^{-1} and 1.007 mg plant^{-1} in mycorrhiza and non mycorrhiza applications respectively. The effects of interactions were found significant for P, Mg, Fe, Mn, Ca and Cu uptakes of leaves. The decreases in P, Mg, Fe, Mn and Cu by 68 mmol NaCl applications were lower in mycorrhiza applications than those in non mycorhizza applications (Table 7).

According to the results, increasing doses of sodium chloride had negative effects on nutrient uptakes of different organs except Na and K uptakes of bulbs. [5] reported that salinity have negative effects on plant growth and nutritional balance of ornamental plants. Salt stress affects all the major processes, such as growth, photosynthesis, protein synthesis, and energy and lipid metabolisms [32-34]. [3] reported that excessive concentration of ions, especially Na^+ and Cl^- may limit the uptake of other ions. [35] in carnation (*Dianthus caryophyllus* L.) and gerbera (*Gerbera jamesonii* L.), [36] in *Limonium* species determined that increased level of salinity inhibits water uptake and crop nutritional elements from soil via roots. The most common consequences of salinity stress on plants are the reduction of nutrient ions, especially potassium content [37]. In this study, the K uptake of roots, and leaves decreased significantly while K uptake increased significantly in bulbs by increasing NaCl doses. It was reported that salinity has also different effects on plant organs. Plants are affected in a different way by amount and kind of salt depending on their growth and development stage. For example, plant leaves against salinity more sensitive than plant roots [38]. Similarly in this study Na and K uptakes of bulbs increased by increasing salt doses. The decreases in the K+ concentrations of the roots and shoots by the increase in salinity stress were reported by [39]. They declared that The K+ concentration in the roots and shoots significantly decreased depending on the increase in salinity stress in *Tagetes erecta* L. 'Sumo orange'.

Several researchers have reported that Na and Cl can affect the uptake of nutrients by competing with nutrients or by affecting the ion permeability of the membrane. Increasing salinity can lead a decrease in N, P, K and Ca uptakes in most plants [40-42]. [39] declared that decreases in the concentration of Cu and Zn in the roots and Mn and Fe in the shoots were significant depend on salinity degree.

Mycorrhiza applications generally increased nutrient uptakes of daffodil's roots. These increases were significant for P, K, Ca, Mg, Fe and Zn. P uptake of leaves also increased significantly with mycorrhiza applications. Several researchers reported that root colonization with arbuscular mycorrhizal fungi (AMF) have enhanced the uptake of especially P, N, and other nutrients [16, 43, 44, 45].

Enhancement of plant P uptake by AMF has been reported [46-50] and has been recognized as one of the main reasons for the improvement of growth in salt-affected plants colonized by AMF [51]. [52] declared that hydrolysis of organic P as a result of secretion of alkaline phosphate compounds by arbuscular mycorrhizal fungi leads to higher plant productivity under P-deficient conditions. [53] reported that mycorrhizal association enhances plant growth and productivity by increasing nutrient element uptake. Arbuscular mycorrhizal fungi are common microorganisms that can form a symbiotic relationship with the roots of most terrestrial plants. Root-infected arbuscular mycorrhizal fungi (AMF) improve plant growth through uptake of soil nutrients via extra matrix hyphae [15, 54]. These extra-radical hyphae act as absorbent structures for mineral elements and water. Since radical hyphae can extend several centimes from the roots can effectively bridge over the nutrient depletion zone around roots and can absorb inert elements from the bulk soil [15, 55]. Arbuscules are the structures, where metabolites exchanges take place between the fungus and host cytoplasm [56-62].

Table 5. Effects of salt and mycorrhiza applications on nutrient uptakes of *Narcissus tazetta*'sbulbs and Duncan differentiation groups among means.

BULB					
Nutrient	Mycorrhiza	Salinity			
		S0 (control)	S1 (34 mmol NaCl)	S2 (68 mmol NaCl)	Mean
N (mg plant^{-1})	+M	0.127 a*	0.117 ab	0.110 ab	0.118
	-M	0.080 b	0.120 ab	0.126 a	0.109
	Mean	0.104	0.118	0.118	
P (mg plant^{-1})	+M	1.930	1.520	2.563	2.004
	- M	1.477	2.080	2.033	1.863
	Mean	1.703	1.800	2.298	
K (mg plant^{-1})	+M	0.058	0.063	0.078	0.067
	- M	0.047	0.063	0.070	0.060
	Mean	0.052 b	0.063 ab	0.074 a*	
Ca (mg plant^{-1})	+M	0.051	0.046	0.046	0.048
	- M	0.036	0.042	0.049	0.042
	Mean	0.044	0.044	0.047	
Mg (mg plant^{-1})	+M	0.015	0.012	0.014	0.014
	- M	0.012	0.011	0.014	0.012
	Mean	0.014	0.011	0.014	
Na (mg plant^{-1})	+M	2.513	2.787	3.550	2.950
	- M	2.460	3.403	4.100	3.321
	Mean	2.487 c**	3.095 b	3.825 a	
Fe (mg plant^{-1})	+M	152.720	127.943	138.900	139.854
	- M	117.253	182.223	171.720	157.066
	Mean	134.987	155.083	155.310	
Mn (mg plant^{-1})	+M	72.503	66.617	76.682	71.934
	- M	63.370	70.737	76.347	70.151
	Mean	67.937	68.677	76.514	
Zn (mg plant^{-1})	+M	183.400	193.867	242.613	206.627
	- M	235.293	231.843	205.183	224.107
	Mean	209.347	212.855	223.898	
Cu (mg plant^{-1})	+M	69.670	85.290	80.583	78.514
	- M	90.060	74.273	80.600	81.644
	Mean	79.865	79.782	80.592	

*,**Means followed by different capital letters, in columns, and followed by different small letters, in lines,differ statistically at 0.05 and 0.01

The interactions between salt and mycorrhiza were significant for N in bulbs, for P and Fe in roots and for P, Ca, Mg, Fe, Mn and Cu in leaves. The decreases in these nutrients uptakes by 68 mmol NaCl applications were lower in mycorrhiza applications than those in non mycorrhiza applications.

It was reported that under salinity stress conditions, AMF inoculated plants can improve adverse effects

Table 6. Effects of salt and mycorrhiza applications on nutrient uptakes of *Narcissus tazetta's* roots and Duncan differentiation groups among means.

ROOT					
Nutrient	Mycorrhiza	Salinity			
		S0 (control)	S1 (34 mmol NaCl)	S2 (68 mmol NaCl)	Mean
N (mg plant^{-1})	+M	0.014 a*	0.007 c	0.004 d	0.008 a**
	- M	0.011 b	0.007 c	0.002 d	0.006 b
	Mean	0.012 a**	0.007 b	0.003 c	
P (mg plant^{-1})	+M	0.187 a*	0.097 bc	0.063 cd	0.115 a**
	- M	0.123 b	0.097 bc	0.023 cd	0.081 b
	Mean	0.155 a**	0.097 b	0.043 c	
K (mg plant^{-1})	+M	0.029	0.020	0.013	0.021 a**
	- M	0.017	0.019	0.004	0.013 b
	Mean	0.023 a**	0.020 a	0.008 b	
Ca (mg plant^{-1})	+M	0.021	0.022	0.011	0.018 a**
	- M	0.012	0.016	0.004	0.011 b
	Mean	0.017 a**	0.019 a	0.008 b	
Mg (mg plant^{-1})	+M	0.004	0.006	0.003	0.005 a*
	- M	0.003	0.006	0.002	0.003 b
	Mean	0.003 b**	0.006 a	0.002 b	
Na (mg plant^{-1})	+M	1.810	1.413	0.920	1.381
	- M	1.447	1.707	0.517	1.223
	Mean	1.628 a**	1.560 a	0.718 b	
Fe (mg plant^{-1})	+M	1754.493 a*	1170.247 a	1376.010 a	1433.583 a**
	- M	1248.280 a	1169.730 a	416.877 b	944.962 b
	Mean	1501.387 a**	1169.988 b	896.443 c	
Mn (mg plant^{-1})	+M	120.403	113.883	50.207	94.831
	- M	72.333	95.260	21.420	63.004
	Mean	96.368 a**	104.572 a	35.813 b	
Zn (mg plant^{-1})	+M	28.333	18.693	11.207	19.411 a**
	- M	18.920	16.370	4.183	13.158 b
	Mean	23.627 a**	17.532 b	7.695 c	
Cu (mg plant^{-1})	+M	36.180	34.143	26.003	32.109 a**
	- M	15.360	24.370	6.677	15.469 b
	Mean	25.770 a*	29.257 a	16.340 b	

*,**Means followed by different capital letters, in columns, and followed by different small letters, in lines,differ statistically at 0.05 and 0.01

by increasing regulation on ion homeostasis, osmotic balance and antioxidant enzyme activity [63,64]. In addition AMF inoculated plants can ameliorate negative effects caused by salinity on photosynthetic activity, nutrient acquisition, and water uptake [65-68]. The results of this study are in agreement with referred similar studies results and literature knowledge.

Table 7. Effects of salt and mycorrhiza applications on nutrient uptakes of *Narcissus tazetta's* leaves and Duncan differentiation groups among means.

LEAF					
Nutrient	Mycorrhiza	Salinity			
		S0 (control)	S1 (34 mmol NaCl)	S2 (68 mmol NaCl)	Mean
N (mg plant^{-1})	+M	0.220	0.131	0.087	0.146
	- M	0.199	0.154	0.029	0.127
	Mean	0.210 a**	0.142 b	0.058 c	
P (mg plant^{-1})	+M	2.233 a*	1.087 b	0.947 bc	1.422 a*
	- M	1.550 ab	1.223 b	0.247 c	1.007 b
	Mean	1.892 a**	1.155 b	0.597 c	
K (mg plant^{-1})	+M	0.268	0.151	0.106	0.175
	- M	0.243	0.203	0.039	0.161
	Mean	0.256 a**	0.177 b	0.072 c	
Ca (mg plant^{-1})	+M	0.069 a	0.057 ab	0.042 ab	0.056
	- M	0.080 a	0.094 a	0.013 b	0.062
	Mean	0.074 a**	0.075 a	0.028 b	
Mg (mg plant^{-1})	+M	0.030 a	0.015 b	0.011 bc	0.019
	- M	0.028 a	0.025 a	0.004 c	0.019
	Mean	0.028 a**	0.020 b	0.008 c	
Na (mg plant^{-1})	+M	7.327	4.530	3.633	5.163
	- M	5.753	6.917	1.593	4.754
	Mean	6.540 a*	5.723 a	2.613 b	
Fe (mg plant^{-1})	+M	753.020 ab	428.717 c	408.950 c	530.229
	- M	811.300 a	512.227 bc	113.893 d	479.140
	Mean	782.160 a**	470.472 b	261.422 c	
Mn (mg plant^{-1})	+M	120.957 ab	98.760 ab	72.843 bc	97.520
	- M	153.627 a	133.850 ab	23.510 c	103.662
	Mean	137.292 a	116.305 a	48.177 b	
Zn (mg plant^{-1})	+M	324.053	211.657	146.887	227.532
	- M	324.057	238.537	64.193	208.929
	Mean	324.055 a**	225.097 b	105.540 c	
Cu (mg plant^{-1})	+M	105.647 bc**	100.840 bc	88.793 bc	98.427 b
	- M	240.320 a	159.437 ab	21.280 c	140.346 a**
	Mean	172.983 a**	130.138 b	55.037 c	

*,**Means followed by different capital letters, in columns, and followed by different small letters, in lines,differ statistically at 0.05 and 0.01

Today, there are many studies [69-81] that reveal the effects of biological fertilization, bacterial and fungal inoculations that positively encourage development and growth, such as plant resistance, yield and quality parameters and uptake of nutrients, instead of chemical fertilizers against stress conditions.

In addition to these studies, this study, which determined the effect of mycorrhiza on the nutrient uptake of *Narcissus* plant in saline growing conditions, provided additional information to the literature.

Conclusions

In this study increasing doses of sodium chloride had negative effects on nutrient uptakes of different organs except Na and K uptakes of bulbs. Mycorrhiza pplications generally increased nutrient uptakes of daffodil's roots and leaves under salinity conditions. The interactions between salt and mycorrhiza were significant for N in bulbs, for N, P and Fe in roots and for P, Ca, Mg, Fe, Mn and Cu in leaves. The decreases in these nutrients uptakes by 68 mmol NaCl applications were lower in mycorrhiza applications than those in non mycorrhiza applications. According to results of this study it was thought that mycorrhiza applications can be improve adverse effects of salinity on nutrient uptakes in *Narcissus tazetta*. Mychorrhiza applications can be useful for growing bulbous ornamental plants under salinity conditions.

Acknowledgments

We thank to Assoc. Prof. Dr. Nazire MİKAİL at Siirt University, Faculty of Agriculture, Department of Animal Science in Siirt-Türkiye for statistical analyses.

Conflict of Interest

The authors declare no conflict of interest.

References

1. TORBAGHAN M.E., LAKZIAN A., ASTARAEI A.R., FOTOVAT A., BESHARATI H. Salt and alkali stresses reduction in wheat by plant growth promoting haloalkaliphilic bacteria. J. Soil Sci. Plant Nutr. **17** (4), 1058-1087, **2017**. http://dx.doi.org/10.4067/S0718-95162017000400016
2. FAO. The state of food and agriculture 2020. Overcoming water challenges in agriculture. Rome., Italy, pp: 210, **2020**. ISBN: 978-92-5-133441-6 https://doi.org/https://doi.org/10.4060/cb1447en
3. MARSCHNER H. Mineral Nutrition of Higher Plants. Second edition, Academic Press, London, UK. **1995**.
4. ADİKU S.G.K., RENGER M., WESSOLEK G., FACKLAM M., HECHT-BUCHOLTZ C. Simulation of the dry matter production and seed yield of common beans under varying soil water and salinity conditions. Agr Water Manage. **47**, 55, **2001**. https://doi.org/10.1016/S0378-3774(00)00094-9
5. VALDEZ-AGUİLAR L.A., GRİEVE C.M., POSS J., MELLANO M.A. Hypersensitivity of *Ranunculus asiaticus* to salinity and alkaline pH in irrigation water in sand cultures. HortScience. **44** (1), 138, **2009**. https://doi.org/10.21273/HORTSCI.44.1.138
6. PARİDA A.K., DAS A.B. Salt tolerance and salinity effects on plants: a review. Ecotoxicol Environ Saf. **60** (3), 324, **2005**. https://doi.org/10.1016/j.ecoenv.2004.06.010
7. ETESAMI H., NOORI F. Soil salinity as a challenge for sustainable agriculture and bacterial-mediated alleviation of salinity stress in crop plants. In: Kumar, M., Etesami, H., Kumar, V. (Eds.), Saline soil-based agriculture by halotolerant microorganisms. Springer, Singapore, 1, **2019.**
8. MCCAMMON T.A., MARQUART-PYATT S.T., KOPP K.L. Water-conserving landscapes: an evaluation of homeowner preference. JOE, **47** (2), 1-, **2009.**
9. CASSANİTİ C., ROMANO D., FLOWERS T.J. The response of ornamental plants to saline irrigation water. Chapter: 8, In: I. García-Garizábal (Eds.), Irrigation-Water Management, Pollution and Alternative Strategies, Inc., InTech., 132, **2012**. https://doi.org/10.5772/31787
10. NOURI M., HOMAEE M., BANNAYAN M. Quantitative trend, sensitivity and contribution analyses of reference evapotranspiration in some arid environments under climate change. Water Resour Manage. **31**, 2207, **2017**. https://doi.org/10.1007/s11269-017-1638-1
11. NİU G., RODRİGUEZ D.S., AGUİNİGA L., MACKAY W. Salinity tolerance of *Lupinus havardii* and *Lupinus texenis.* HortScience. **42** (3), 526, **2007**. https://doi.org/10.21273/HORTSCI.42.3.526
12. ARZANI A., ASHRAF M. Smart engineering of genetic resources for enhanced salinity tolerance in crop plants. Crit Rev Plant Sci. **35** (3), 146, **2016**. https://doi.org/10.1080/07352689.2016.1245056
13. EL SABAGH A., ISLAM M.S., SKALICKY M., ALI RAZA M., SINGH K., ANWAR HOSSAIN M., HOSSAIN A., MAHBOOB W., IQBAL M.A., RATNASEKERA D., SINGHAL R.K., AHMED S., KUMARI A., WASAYA A., SYTAR O., BRESTIC M., ÇIG F., ERMAN M., HABIB UR RAHMAN M., ULLAH N., ARSHAD A. Salinity stress in wheat (*Triticum aestivum* L.) in the changing climate: adaptation and management strategies. Front. Agron. **3**, 661932, **2021**. https://doi.org/10.3389/fagro.2021.661932
14. ZOLLİNGER N., KOENİG R., CERNY-KOENİG T., KJELGREN R. Relative salinity tolerance of intermountain Western United States native herbaceous perennials. HortScience. **42** (3), 529, **2007**. https://doi.org/10.21273/HORTSCI.42.3.529
15. LİNDERMAN R.G., DAVİS E.A. Varied response of marigold (*Tagetes* spp.) genotypes to inoculation with different arbuscular mycorrhizal fungi. SCI Hortic-Amsterdam. **99** (1), 67, **2004**. https://doi.org/10.1016/S0304-4238(03)00081-5
16. SMİTH S.E., READ D.J. Mycorrhizal Symbiosis. Academic Press, Inc San Diego California. **1996**. ISBN O-12-652840-3.
17. PORCEL R., REDONDO-GÓMEZ S., MATEOS-NARANJO E., AROCA R., GARCİA R., RUİZ-LOZANO J.M. Arbuscular mycorrhizal symbiosis ameliorates the optimum quantum yield of photosystem II and reduces non-photochemical quenching in rice plants subjected to salt stress. J Plant Physiol. **185**, 75, **2015**. https://doi.org/10.1016/j.jplph.2015.07.006
18. PEDRANZANİ H., RODRÍGUEZ-RİVERA M., GUTİÉRREZ M., PORCEL R., HAUSE B., RUİZ-LOZANO J.M. Arbuscular mycorrhizal symbiosis regulates physiology and performance of *Digitaria eriantha* plants subjected to abiotic stresses by modulating antioxidant and jasmonate levels. Mycorrhiza. **26** (2), 141, **2016**. https://doi.org/10.1007/s00572-015-0653-4

19. SELVAKUMAR G., SHAGOL C.C., KIM K., HAN S., SA T. Spore associated bacteria regulates maize root K(+)/Na(+) ion homeostasis to promote salinity tolerance during arbuscular mycorrhizal symbiosis. BMC Plant Biol. **18** (1), 109, **2018**. https://doi.org/ 10.1186/s12870-018-1317-2
20. PAYMANEH Z., SARCHESHMEHPOUR M., BUKOVSKÁ P., JANSA J. Could indigenous arbuscular mycorrhizal communities be used to improve tolerance of pistachio to salinity and/or drought? Symbiosis. **79**, 269, **2019**. https://doi.org/10.1007/s13199-019-00645-z
21. SANTANDER C., SANHUEZA M., OLAVE J., BORIE F., VALENTINE A., CORNEJO P. Arbuscular mycorrhizal colonization promotes the tolerance to salt stress in lettuce plants through an efficient modification of ionic balance. J Soil Sci Plant Nut. **19**, 321, **2019**. https://doi.org/10.1007/s42729-019-00032-z
22. MOREIRA H., PEREIRA S.I.A., VEGA A., CASTRO P.M.L., MARQUES A.P.G.C. Synergistic effects of arbuscular mycorrhizal fungi and plant growth-promoting bacteria benefit maize growth under increasing soil salinity. J Environ Manage. **257**, 109982, **2020**. https://doi.org/10.1016/j.jenvman.2019.109982
23. SAVÉ R. What is stress and how to deal with it in ornamental plants? Acta Hortic. **813**, 241, **2009**. https://doi.org/10.17660/ActaHortic.2009.813.31
24. BOLANDNAZAR S., ALIASGARZAD N., NEISHABURY M.R., CHAPARZADEH N. Mycorrhizal colonization improves onion (*Allium cepa* L.) yield and water use efficiency under water deficit condition. SCI Hortic-Amsterdam. **114** (1), 11, **2007**. https://doi.org/10.1016/j.scienta.2007.05.012
25. AZCÓN-AGUİLAR C., BAREA J.M. Arbuscular mycorrhizas and biological control of soil-borne plant pathogens-an overview of the mechanisms involved. Mycorrhiza. **6**, 457, **1997**. https://doi.org/10.1007/s005720050147
26. TUNCER B. Investigation of the in vitro regeneration of some medical and aromatic wildplant species. Appl Ecol Env Res. **15** (4), 905, **2017**. https://doi.org/10.15666/aeer/1504_90591420.
27. TUNCER B. In vitro germination and bulblet and shoot propagation for wild edible *Eremurus spectabilis* M. Bieb. Not Bot Horti Agrobo. **48** (2), 814, **2020**. https://doi.org/10.15835/nbha4821188321.
28. SICAKYÜZ S., TUNCER B. Optimizing culture media for in vitro microbulb productionof medicinal wild plant: *Eremurus spectabilis* M. Bieb. Chil J Agr Res. **82** (4), 603, **2022**. https://doi.org/10.4067/S0718-58392022000400603
29. ANONYMOUS. Directorate of Floriculture. Government of the Punjab, Lahore, Pakistan, **2003**.
30. KACAR B. Soil Analysis. Nobel Publishing House, pp. 468. Ankara, **2009** [In Turkish].
31. KACAR B., İNAL A. Plant Analysis. Nobel Publication No: 1271, Science: 63, **2008** [In Turkish].
32. RAMOLİYA P.J., PATEL H.M., PANDEY A.N. Effect of salinization of soil on growth and macro- and micro-nutrient accumulation in seedlings of *Salvadora persica* (Salvadoraceae). For Ecol Manag. **202**, 181, **2004**. https://doi:10.1016/j.foreco.2004.07.020
33. KUMAR M., ETESAMI H., KUMAR V. Saline soil-based agriculture by halotolerant microorganisms. Springer Singapore. **1**, X, 253, **2019**. https://doi.org/10.1007/978-981-13-8335-9
34. BASAK N., BARMAN A., SUNDHA P., RAI A.K. In: RAKSHIT A., GHOSH S., CHAKRABORTY S., PHILIP V., DATTA A. (eds.), Recent Trends in Soil Salinity Appraisal and Management BT - Soil Analysis: Recent Trends and Applications. Springer, Singapore, Singapore, 143, **2020**. https://doi.org/10.1007/978-981-15-2039-6_9
35. BAAS R., NİJSSEN H.M.C., VAN DEN BERG T.J.M., WARMENHOVEN M.G. Yield and quality of carnation (*Dianthus caryophyllus* L.) and gerbera (*Gerbera jamesonii* L.) in a closed nutrient system as affected by sodium chloride. SCI Hortic-Amsterdam. **61** (3-4), 273, **1995**. https://doi.org/10.1016/0304-4238(94)00728-X
36. GRİEVE C.M., POSS J.A., GRATTAN S.R., SHOUSE P.J., LİETH J.H., ZENG L. Productivity and mineral nutrition of *Limonium* species irrigated with saline wastewaters. HortScience. **40** (3), 654, **2005**. https://doi:10.21273/HORTSCI.40.3.654
37. HELAL H.M., MENGEL K. Nitrogen metabolism of young barley plants as affected by NaCl salinity and potassium. Plant and Soil. **51**, 457, **1979**. https://doi.org/10.1007/BF02277567
38. HANNAH M. Cyberconference water quality. **1998**. www.greenbeam.com /cyberconference/wood -plants.1.html. Accessed 10 April 2010.
39. KOKSAL N., ALKAN-TORUN A., KULAHLİOGLU İ., ERTARGİN E., KARALAR E. Ion uptake of marigold under saline growth conditions. SpringerPlus. **5** (139), 1, **2016**. https://doi:10.1186/s40064-016-1815-3
40. KARİMİ G., GHORBANLİ M., HEİDARİ H., KHAVARİ NEJAD R.A., ASSAREH M.H. The effects of NaCl on growth, water relations, osmolytes and ion content in *Kochia prostrata*. Biol Plant. **49** (2), 301, **2005**. https://doi.org/10.1007/s10535-005-1304-y
41. TUNA A.L., KAYA C., ASHRAF M.., ALTUNLU H.., YOKAS I., YAGMUR B. The effects of calcium sulphate on growth, membrane stability and nutrient uptake of tomato plants grown under salt stress. Environ Exp Bot. **59** (2), 173, **2007**. https://doi.org/10.1016/j.envexpbot.2005.12.007
42. NAVARRO A., BAÑÓN S., CONEJERO W., SÁNCHEZ-BLANCO M.J. Ornamental characters, ion concentration and water status in *Arbutus unedo* seedlings irrigated with saline water and subsequent relief and transplanting. Environ Exp Bot, **62** (3), 364, **2008**. https://doi.org/10.1016/j.envexpbot.2007.10.010
43. ABDULLAHİ R., SHERİFF H.H. Effect of arbuscular mycorrhizal fungi and chemical fertilizer on growth and shoot nutrients content of onion under field condition in Northern Sudan Savanna of Nigeria. IOSR-JAVS. **3** (5), 85, **2013**. https://doi.org/10.9790/2380-0358590
44. GOLUBKİNA N., GOMEZ L.D., KEKİNA H., COZZOLİNO E., SİMİSTER R., TALLARİTA A., TORİNO V., KOSHEVAROV A., CUCİNİELLO A., MAİELLO R., CENVİNZO V. Joint selenium–iodine supply and arbuscular mycorrhizal fungi inoculation affect yield and quality of chickpea seeds and residual biomass. Plants. **9** (7), 804, **2020a**. https://doi.org/10.3390/plants9070804
45. AL MUTAİRİ A.A., CAVAGNARO T.R., KHOR S.F., NEUMANN K., BURTON R.A., WATTS-WİLLİAMS S.J. The effect of zinc fertilisation and arbuscular mycorrhizal fungi on grain quality and yield of contrasting barley cultivars. Funct Plant Biol **47** (2) 122, **2020**. https://doi.org/10.1071/FP19220
46. GİRİ B., KAPOOR R., MUKERJİ K.G. Improved tolerance of *Acacia nilotica* to salt stress by arbuscular mycorrhiza *Glomus fasciculatum* may be partly related to elevated K/Na ratios in root and shoot tissues. Microb

Ecol. **54** (4), 753, **2007**. https://doi.org/10.1007/s00248-007-9239-9
47. ERGIN S.F., GÜLSER F. Effect of mycorrhiza on growth criteria and phosphorus nutrition of lettuce (*Lactuca sativa* L.) under different phosphorus application rates. Eurasian J. Soil Sci. **5** (4) 275, **2016**.
48. CHANDRA P., SINGH A., PRAJAPAT K., RAI A.K., YADAV R.K. Native arbuscular mycorrhizal fungi improve growth, biomass yield, and phosphorus nutrition of sorghum in saline and sodic soils of the semi–arid region. Environ Exp Bot. **201**, 104982, **2022**. https://doi.org/10.1016/j.envexpbot.2022.104982
49. WANG Y., WANG M., LI Y., WU A., HUANG J. Effects of arbuscular mycorrhizal fungi on growth and nitrogen uptake of *Chrysanthemum morifolium* under salt stress. PLoS One. **13** (4), e0196408, **2018**. https://doi.org/10.1371/journal.pone.0196408
50. KAZEMİ R., RONAGHİ A., YASREBİ J., GHASEMİ-FASAEİ R., ZAREİ M. Effect of shrimp waste–derived biochar and arbuscular mycorrhizal fungus on yield, antioxidant enzymes, and chemical composition of corn under salinity stress. J Soil Sci Plant Nut. **19**, 758, **2019**. https://doi.org/10.1007/s42729-019-00075-2
51. RUİZ-LOZANO J.M., AZCON R. Symbiotic efficiency and infectivity of an autochthonous arbuscular mycorrhizal *Glomus* sp. from saline soils and *Glomus deserticola* under salinity. Mycorrhiza. **10**, 137-143, **2000**. https://doi.org/10.1007/s005720000075
52. EVELIN H., DEVI T.S., GUPTA S., KAPOOR R. Mitigation of salinity stress in plants by arbuscular mycorrhizal symbiosis: current understanding and new challenges. Front. Plant Sci. **10**, 470, **2019**. https://doi.org/10.3389/fpls.2019.00470
53. AL-KARAKİS G.N. Benefit, cost and phosphorus use efficiency of mycorrhizal field grown garlic at different soil phosphorus levels. J Plant Nutr. **25** (6), 1175, **2002.** https://doi.org/10.1081/PLN-120004381
54. BHANTANA P., RANA M.S., SUN, X.-C., MOUSSA, M.G., SALEEM, M.H., SYAIFUDIN M., SHAH A., POUDEL A., PUN A.B., BHAT M.A., MANDAL D.L., SHAH S., ZHIHAO D., TAN Q., HU C.-X. Arbuscular mycorrhizal fungi and its major role in plant growth, zinc nutrition, phosphorous regulation and phytoremediation. Symbiosis. **84**, 19, **2021**. https://doi.org/10.1007/s13199-021-00756-6
55. BETHLENFALVAY G.J., LİNDERMAN R.G. Mycorrhiza in sustainable agriculture. ASA Special Publication Number 54, American Society of Agronomy, Inc. Madison, Wisconsin, USA, **1992**.
56. BASU S., RABARA R.C., NEGI S. AMF: The future prospect for sustainable agriculture. Physiol Mol Plant P. **102**, 36, **2018**. https://doi.org/10.1016/j.pmpp.2017.11.00
57. BEGUM N., QIN C., AHANGER M.A., RAZA S., KHAN M.I., ASHRAF M., AHMED N., ZHANG L. Role of arbuscular mycorrhizal fungi in plant growth regulation: implications in abiotic stress tolerance. Front. Plant Sci. **10**, 1068, **2019**. https://doi.org/ 10.3389/fpls.2019.01068.
58. BINDRABAN P.S., DIMKPA C.O., PANDEY R. Exploring phosphorus fertilizers and fertilization strategies for improved human and environmental health. Biol Fertil Soils. **56**, 299, **2020**. https://doi.org/10.1007/s00374-019-01430-2
59. GIOVANNINI L., PALLA M., AGNOLUCCI M., AVIO L., SBRANA C., TURRINI A., GIOVANNETTI M. Arbuscular mycorrhizal fungi and associated microbiota as plant biostimulants: research strategies for the selection of the best performing inocula. Agronomy. **10** (1), 106, **2020**. https://doi.org/10.3390/agronomy10010106
60. TESTE F.P., JONES M.D., DICKIE I.A. Dual-mycorrhizal plants: their ecology and relevance. New Phytol. **225** (5), 1835, **2020**. https://doi.org/10.1111/nph.16190
61. TANWAR A., SINGH A., AGGARWAL A., JANGRA E., PICHARDO S.T. Evaluation of municipal sewage sludge for arbuscular mycorrhizal fungi inoculum production. Eurasian J. Soil Sci. **10** (4), 343, **2021**.
62. WU Y., DENG M., HUANG J., YANG S., GUO L., YANG L., AHIRWAL J., PENG Z., LIU W., LIU L. Global patterns in mycorrhizal mediation of soil carbon storage, stability, and nitrogen demand: A meta-analysis. Soil Biol Biochem. **166**, 108578, **2022**. https://doi.org/10.1016/j.soilbio.2022.108578
63. PORCEL R., AROCA R., RUİZ-LOZANO J.M. Salinity stress alleviation using arbuscular mycorrhizal fungi. A review. Agron Sustain Dev. **32**, 181, **2012**. https://doi.org/10.1007/s13593-011-0029-x
64. HASHEM A., ALQARAWİ A.A., RADHAKRİSHNAN R., AL-ARJANİ A.F., ALDEHAİSH H.A., EGAMBERDİEVA D., ABD-ALLAH, E.F. Arbuscular mycorrhizal fungi regulate the oxidative system, hormones and ionic equilibrium to trigger salt stress tolerance in *Cucumis sativus* L. Saudi J Biol Sci. **25** (6), 1102, **2018**. https://doi.org/10.1016/j.sjbs.2018.03.009
65. RUİZ-LOZANO J.M., AZCÓN R., GÓMEZ M. Alleviation of salt stress by arbuscular mycorrhizal *Glomus species* in *Lactuca sativa* plants. Physiol Plantarum. **98** (4), 767, **1996**. https://doi.org/10.1111/j.1399-3054.1996.tb06683.x
66. SHENG M., TANG M., CHEN H., YANG B., ZHANG F., HUANG Y. Influence of arbuscular mycorrhizae on photosynthesis and water status of maize plants under salt stress. Mycorrhiza. **18**, 287, **2008**. https://doi.org/10.1007/s00572-008-0180-7
67. ÇEKİÇ F.Ö., ÜNYAYAR S., ORTAŞ İ. Effects of arbuscular mycorrhizal inoculation on biochemical parameters in *Capsicum annuum* grown under long term salt stress. Turk J Bot. **36**, 63, **2012**. https://doi:10.3906/bot-1008-32
68. PORCEL R., AROCA R., AZCON R., RUİZ-LOZANO J.M. Regulation of cation transporter genes by the arbuscular mycorrhizal symbiosis in rice plants subjected to salinity suggests improved salt tolerance due to reduced Na+ root-to-shoot distribution. Mycorrhiza. **26** (7), 673, **2016**. https://doi.org/10.1007/s00572-016-0704-5
69. BİNTAS P.A., ÇIĞ A., TÜRKOĞLU N. Investigation of the effects of some bacterial isolates and fertilizer applications on nutrient contents of hyacinth. Not Bot Horti Agrobo. **48** (2), 978, **2020**. https://doi.org/10.15835/nbha48211911
70. BİNTAŞ P.A., ÇIĞ A., TÜRKOĞLU N. Some phenological and morphological properties of *Hyacinthus orientalis* cv. "Delft Blue" with treated bacterial inoculations. Pol J Environ Stud. **30** (2), 1549, **2021**. https://doi.org/10.15244/pjoes/126484
71. CERİTOĞLU M., ERMAN M., ÇIĞ F., ŞAHİN S., ACAR A. A sustainable strategy on plant growth and improvement of stress tolerance: Priming technique. Turk J Agric Res. **8** (3), 374, **2021**. https://doi.org/10.19159/tutad.883564
72. ÇIĞ A., ÇIĞ F. The effect of bacteria applications showing ACCD activity on the seedling of *Sesbania punicea* (Cav.) Benth. seeds under salt stress. 3rd International Conference on Food, Agriculture and Veterinary, 19-20 June 2021, İzmir, Türkiye, 1128, **2021.**

73. ÇIĞ A., ÇIĞ F. The effect of some PGPBs on post-harvest weight, length and width of *Hyacinth* bulbs planted in different areas. 2nd International Conference on Food, Agriculture and Animal Sciences (ICOFAAS 2019), 8-11 November 2019, Antalya, Türkiye, 258, **2019**.
74. ÇIĞ A., MIKAİL, N. Prediction of lateral root numbers in *Sesbania punicea* with different minerals and bacteria applications by using sugeno fuzzy logic model. 4th International Conference on Food, Agriculture and Animal Sciences (ICOFAAS 2023), 27-29 April 2023, Sivas, Türkiye, 295, **2023**.
75. ÇIĞ F., ERMAN M., İNAL B., BEKTAŞ H., SONKURT M., MIRZAPOUR M., CERİTOĞLU M. Mitigation of drought stress in wheat by bio-priming by PGPB containing ACC deaminase activity. Atatürk University Journal of Agricultural Faculty, **53** (1), 51, **2022**. https://doi.org/10.54614/AUAF.2022.972753
76. ÇIĞ F., KARIPÇİN, M.Z. The effect of bacteria applications showing ACCD activity on the seedling of *Cucumıs melo* var. agrestis seeds under salt stress. Asian Congress on Contemporary Sciences-V, 1-2 June 2021, Azerbaijan, 731, **2021**.
77. ERMAN M., ÇIĞ, F., CERITOGLU F., CERITOGLU M. Plant growth promoting bacteria enhances photosynthesis, nodulation and root system architecture in lentil under lead toxicity. Journal of Central European Agriculture, **23** (3), 582, **2022**. https://doi.org/10.5513/JCEA01/23.3.3577
78. KARİPÇİN M.Z., ŞATIR N.Y. Effect of arbuscular mycorrhizal fungi (AMF) on growth and nutrient uptake of lettuce (*Lactuca sativa*) under water stress. YYU J Agr Sci. **26** (3), 406, **2016**.
79. KARIPÇİN M.Z., ÇIĞ F. The effect of bacteria applications showing ACCD activity on the seedling of *Lycopersıcon esculentum* L. seeds under salt stress. Asian Congress on Contemporary Sciences-V, 1-2 June 2021, Azerbaijan, 1259, **2021.**
80. SÖĞÜT S., ÇIĞ F. Determination of the effect of plant growth promoting bacteria on wheat (*Triticum aestivum* L.) development under salinity stress conditions. Appl Ecol Env Res. **17** (1), 1129, **2019**. http://dx.doi.org/10.15666/aeer/1701_11291141
81. SONKURT M., ÇIĞ F. The effect of plant growth-promoting bacteria on the development, yield and yield components of bread (*Triticum aestivum* L.) and durum (*Triticum durum*) wheats. Appl Ecol Env Res. **17** (2), 3877, **2019**. http://dx.doi.org/10.15666/aeer/1702_38773896