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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Determination of the alleviating effect of liquid vermicompost on germination and seedling development of Hungarian Vetch (*Vicia pannonica* Crantz.) under salt stress

Sıvı solucan gübresinin tuz stresi altında Macar Fiğ (*Vicia pannonica* Crantz.) tohumlarının çimlenmesi ve fide gelişimi üzerine iyileştirici etkisinin belirlenmesi

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Ö Z E T / A B S T R A C T

Aims: The alleviating aspects of liquid vermicompost (VCL) on the seed germination and juvenile seedling growth of Hungarian vetch, which is an important fodder plant in Turkey and in the world, under salt stress were evaluated.

Methods and Results: Two experiments in laboratory and greenhouse conditions were established according to a randomized plot design with three replications. In the experiments, liquid vermicompost levels were applied as control (0%) - 1% - 2.5% - 5% and 10% and salt solutions were prepared with control (pure water), 30 mM, 60 mM and 90 mM NaCl doses. At the end of the laboratory experiment, germination rate and index of Hungarian vetch seeds, length, fresh and dry weights of plumule, and length, fresh and dry weights of radicle were examined. In the greenhouse experiment, the emergence ratio, seedling height, seedling fresh and dry weights, root length, root fresh and dry weights of Hungarian vetch were investigated.

Conclusions: It was observed that the parameters measured in the germination and seedling period of Hungarian vetch were negatively affected by salt stress, but the negative effects of salt stress decreased due to the increase in the amount of liquid vermicompost applied.

Significance and Impact of the Study: The present study can be an important reference in terms of revealing the stimulating attribute of VCL and inhibiting attribute of salinity on the germination and various parameters of Hungarian vetch plant. The alleviative and regulatory effect of VCL appeared mostly in its 5% and 10% dose applications during the germination and juvenile seedling of Hungarian vetch, moderately sensitive to salt stress.

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INTRODUCTION

About 150 vetch (*Vicia*) species are common in temperate regions of the world. Vetch varieties have great value in terms of grass, animal feed, pastures, green manures and crop rotation. Common vetch (*V. sativa*), hairy vetch (*V. villosa*), Hungarian vetch (*V. pannonica*), narbon vetch (*V. narbonensis*) and bitter vetch (*V. ervilia*) are some of the important vetch species (Ekiz et al., 2011). Hungarian vetch is one of the most cold-resistant plants especially in Eastern Anatolia of Turkey. It is considered a forage crop and is successfully grown in these areas due to its semi-horizontal growth (Açıkgöz, 2013). The forage crops, which has a very high yield and quality, is very nutritious for animals (Twidwell et al., 1987).

Salinity is an abiotic stress factor affecting and threatening cultivated soils owing to many negative effects on plants grown in saline soils (Ekmekçi et al., 2005). As the salt concentration in the soil increases, it is difficult for plants to get water from the soil due to its osmotic stress, and also physiological and biochemical changes in the plant can occur (Bressan, 2008; Munns and Tester, 2008). Salt stress negatively affects plant growth and development, reduces the osmotic capacity of plant cells, and causes a series of reactions in plants (Glenn et al., 1997). Salinity is one of the most important environmental factors affecting germination negatively (Demir et al., 2003; Asci, 2011).

In order to obtain a high yield in agricultural production, the soil must contain sufficient plant nutrients. The preservation and maintenance of soil fertility in agricultural systems rely on the return of nutrients lost from the soil to the soil (Cebeci, 2017). Therefore, producers prefer organic fertilizers including both plant nutrients and soil-regulating substances (Demir and Işık, 2019a,b; Çiçek, 2021). Vermicompost is an organic fertilizer containing symbiotic and asymbiotic bacteria, and mycorrhizal fungi (Anonymous, 2009; Soylu et al., 2020). In addition to its positive effects on plant growth, suppression of plant disease and soil improvement, vermicompost is also known to have a supportive effect on plant stress tolerance by reducing the negative effects of toxic elements under salt stress conditions (Ayyobi et al., 2014; Bidabadi et al*.,* 2017, Jabeen and Ahmad, 2017; Soylu et al., 2020). Vermicompost provide the sustainability of organic agriculture, have the positive effect on human health by eliminating solid wastes and hence provide significant benefits to the economy (Çiçek, 2021). VCL is the diluted form of manure produced by earthworms and microorganisms during the conversion of organic matter into vermicompost (Hidalgo et al., 2006).

In the present study, alleviating effect of VCL toward salt stress during germination and seedling stage of Hungarian vetch, a moderately salt sensitive plant, was investigated. In addition, the appropriate doses of VCL were suggested by testing in the greenhouse and laboratory.

MATERIALS and METHODS

Tarım Beyazı-98 cultivar used in the experiment was registered in 1998 by the Field Crops Central Research Institute. The main stem length is 40-80 cm. Its cluster-shaped flowers are white in color. The seed of the cultivar is ellipsoid round in shape and its color is black spotted and dotted. The 1000 grain weight of the cv. Tarm White-98 which is resistant to cold and drought varies from 35 g to 50 g.

Germination experiment with three replications was carried out in the Laboratory of Forestry Faculty, Çankırı Karatekin University. For each replication, 25 Hungarian vetch seeds applied surface sterilization (treated with 5% sodium hypochlorite for 5 minutes and then rinsed with distilled water) were placed in sterile petri dishes. Then, control (pure water), 30 mM, 60 mM and 90 mM NaCl solutions and control (0%), 1%, 2.5%, 5% and 10% liquid vermicomposts (Table 1) were added to each petri dish. Hungarian vetch seeds were germinated at 20±2 °C in the dark (ISTA, 1996). During the germination period, no plant nutrients were applied in the experiment. Germinated seeds (when the radicle of the seeds reaches 2 mm in length) were counted and recorded every 24 hours. The experiment, which was established on 14 December 2020, was ended on 24 December 2020. At the end of the experiment, the germination rate (Eq(1); Akıncı and Çalışkan, 2010) and index (Eq(2); Wang et al., 2004) of Hungarian vetch seeds were determined as:

$$\text{Germination Rate (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds}} \text{x}100 \qquad \text{Eq(1)}$$

$$\text{Germination Index} = \sum\left(\frac{\text{The rate of germinated seeds on the } i^{th} \text{ day}}{\text{Count day}}\right) \qquad \text{Eq(2)}$$

At the end of the experiment, 5 germinated seeds were randomly selected from each petri dish to determine length (cm), fresh and dry weights (g) of plumule, length (cm), fresh and dry weights (g) of radicle in Hungarian vetch seedlings. Weights of plumule and radicle were determined after oven drying at 65-70 °C for 72 h.

The juvenile seedling experiment was carried out in plastic pots with a volume of 0.5 L containing a mixture of peat and perlite (3:1) (Table 1) in Çankırı Karatekin University Research and Application Greenhouse. The experiment was established using a randomized complete block design with three replications on 15 December 2020. 15 Hungarian vetch seeds were sown in each pot. After germination, 15 juvenile seedlings were thinned to 10. After seed sowing, distilled water (control), 30 mM, 60 mM and 90 mM NaCl solutions and 0%, 1%, 2.5%, 5% and 10% liquid vermicomposts were added to each pot.

Table 1. Some physical and chemical properties of peat and vermicompost liquid

Parameter	**Peat**	**Vermicompost liquid**
pH (saturation extract)	5.50	8.56
EC (dS m^{-1})	0.49	5.31
Organic material (g kg^{-1})	950	-
Water-soluble NH_4-N (mg kg^{-1})	0.75	-
Water-soluble NO_3-N (mg kg^{-1})	5.75	-
Water-soluble P (mg kg^{-1})	5.56	0.20
Water-soluble K (mg kg^{-1})	53	12
Water-soluble Ca (mg kg^{-1})	172	-
Water-soluble Mg (mg kg^{-1})	55	-
Total humik+fulvik asit (g kg^{-1})	-	100
Total N (g kg^{-1})	-	10.6

On 15 January 2021, a total of 5 juvenile seedlings for each pot were uprooted without harming the roots (Figure 1). Emergence ratio (%), length (cm), fresh and dry weights (g), root length (cm), root fresh and dry weights (g) of juvenile seedlings were measured to determine the effects of CVL doses on Hungarian vetch seedlings.

Figure 1. First seedling stage of Hungarian vetch

Kolmogorov-Smirnov test was used for the normality of data distributions. Homogeneity of variance was controlled using Levene test. Two-way analysis of variance was done to determine whether the averages of the factors, including VCL concentration (1) and salt concentration (2), differed and whether there was an interaction between them. Similar and different factors were determined by Duncan test, which is one of the multiple comparison tests ($p<0.05$). All analyses were performed with SPSS program.

RESULTS and DISCUSSION

Germination rate and index

Liquid vermicompost, salt concentration and their interaction had effects on germination rate and index at 0.01 probability level. The interaction of VCL-10 and NaCl-90 resulted in the lowest germination rate (64%) and index (7.81). The highest germination rate (100%) and index (18.86) were found in the interactions of VCL-2.5 and NaCl-0 (Table 2). It was reported that salt stress reduced the germination rate and index of Hungarian vetch (Ertekin et al., 2018) and some bread wheat genotypes (Bilgili, 2016). The present study indicated that the increase in VCL did not appearently cause an increase in germination rate and index. However, some researchers found that VCL increased the germination rate and index of soybean (Kaya and Erdönmez, 2020) and pepper (Başay and Alpsoy, 2019). As the salt concentration increases in the germination medium, the osmotic pressure increases and thus the seed in the medium cannot take up enough water to germinate (Day and Uzun, 2016). As a result, inadequate water imbibition can not activate enyzemes in the seeds.

Table 2. Effects of NaCl concentration and VCL on germination rate and Index of Hungarian vetch seeds

			Germination Rate (%)		
	NaCl-0	**NaCl-30**	**NaCl-60**	**NaCl-90**	**Mean**
VCL-0	92.00^{a-d}	85.33^{c-e}	80.00^{e-g}	78.67^{f-g}	84.00**b***
VCL-1	97.33^{a}	92.00^{a-d}	88.00^{b-e}	86.67^{c-f}	91.00**a**
VCL-2.5	100.00^{a}	94.67^{a-c}	84.00^{d-f}	86.67^{c-f}	91.33**a**
VCL-5	97.33^{a}	92.00^{a-d}	84.00^{d-f}	81.33^{e-f}	88.67**a**
VCL-10	96.00^{a-b}	94.67^{a-c}	73.33^{g}	64.00^{h}	82.00**b**
Mean	96.53**A**	91.73**B**	81.87**C**	79.47**C**	87.40
			Germination Index		
VCL-0	16.41^{a-d}	14.69^{c-f}	13.77^{d-f}	12.50^{e-f}	14.34**ab**
VCL-1	16.3^{a-d}	18.09^{a-b}	15.44^{b-e}	11.63^{f}	15.38**a**
VCL-2.5	18.86^{a}	15.14^{b-e}	13.05^{e-f}	14.78^{c-f}	15.46**a**
VCL-5	13.79^{d-f}	16.4^{a-d}	13.05^{e-f}	13.83^{d-f}	14.27**ab**
VCL-10	18.84^{a}	17.64^{a-c}	8.42^{g}	7.81^{g}	13.18**b**
Mean	16.85**A**	16.39**A**	12.75**B**	12.11**B**	14.53

[*] Different letters in columns and rows indicate that the averages of the applications tested differed significantly ($p<0.05$).

Plumule length, fresh and dry weights

Interaction of VCL and salt concentration had an effect on plumule length ($p<0.001$) but no effect on plumule fresh and dry weights ($p>0.05$). Both VCL and salt concentration had an effect on length, fresh and dry weights of plumule at 0.01 level. The lowest plumule length (6.22 cm) in the interactions with NaCl-90 of VCL-10 and VCL-0 and the highest plumule length (11.75 cm) in the interaction of VCL-5 and NaCl-30 were found. The lowest fresh weights (0.159 g and 0.171 g) were obtained from NaCl-90 and VCL-1. NaCl-30 and VCL-5 showed the highest fresh weights (0.193 g and 0.187 g). The lowest dry weight (0.030 g) was obtained from both VCL-0 and NaCl-90. VCL-10 and NaCl-0 gave the highest dry weights (0.035 g and 0.036 g) (Table 3). In the present study, plumule fresh and dry weights decreased with the increasing NaCl concentration. Similar results for plumule fresh and dry weights were found in Hungarian vetch (Ertekin et al., 2018) and some bread wheat genotypes (Bilgili, 2016). VCL increased plumule fresh and dry weights of soybean (Kaya and Erdönmez, 2020) and pepper (Başay and Alpsoy, 2019). High salt concentration during germination may inhibit the gibberellin synthesis of seeds (Bozcuk, 1991; Ertekin et al., 2017) and cause a decrease in α amylase activity (Adda et al., 2014). This situation negatively affects length, fresh and dry weights of plumule.

Table 3. Effects of NaCl concentration and VCL on plumule length, fresh and dry weights of Hungarian vetch seeds

	NaCl-0	NaCl-30	NaCl-60	NaCl-90	Mean
Plumule Length (cm)					
VCL-0	10.41^{a-e}	9.91^{b-e}	9.08^{e-f}	6.64^{g-h}	9.01**b***
VCL-1	9.39^{d-f}	10.36^{a-e}	10.09^{a-e}	6.75^{g-h}	9.15**b**
VCL-2.5	9.80^{c-e}	11.75^{a}	9.67^{c-f}	9.48^{c-f}	10.18**a**
VCL-5	11.02^{a-d}	11.19^{a-c}	8.86^{e-f}	9.33^{d-f}	10.10**a**
VCL-10	11.59^{a-b}	10.17^{a-e}	8.07^{f-g}	6.22^{h}	9.01**b**
Mean	10.44**A**	10.68**A**	9.15**B**	7.68**C**	9.49
Plumule Fresh Weight (g)					
VCL-0	0.179	0.193	0.171	0.152	0.174**b**
VCL-1	0.171	0.181	0.175	0.158	0.171**b**
VCL-2.5	0.204	0.201	0.178	0.161	0.186**a**
VCL-5	0.202	0.196	0.182	0.167	0.187**a**
VCL-10	0.205	0.193	0.175	0.159	0.183**a**
Mean	0.192**A**	0.193**A**	0.176**B**	0.159**C**	0.180
Plumule Dry Weight (g)					
VCL-0	0.034	0.031	0.028	0.027	0.030**b**
VCL-1	0.035	0.036	0.032	0.030	0.033**a**
VCL-2.5	0.036	0.036	0.036	0.031	0.034**a**
VCL-5	0.037	0.035	0.034	0.031	0.034**a**
VCL-10	0.038	0.035	0.035	0.032	0.035**a**
Mean	0.036**A**	0.034**AB**	0.033**B**	0.030**C**	0.033

[*] Different letters in columns and rows indicate that the averages of the applications tested differed significantly ($p<0.05$).

Radicle length, fresh and dry weights

Length, fresh and dry weights of radicle were affected by both VCL and salt concentration at 0.01 level but not affected by their interaction ($p>0.05$). VCL-0 revealed the lowest radicle length (7.20 cm), radicle fresh (0.037 g) and dry weights (0.004 g) while VCL-10 showed the highest radicle length (8.45 cm), radicle fresh (0.044 g) and dry weights (0.005 g). The lowest radicle length (6.35 cm), radicle fresh (0.033 g) and dry weights (0.004 g) were obtained from NaCl-90. The highest radicle length (9.40 cm) and dry weight (0.005 g) in NaCl-0, and the highest fresh weight (0.048 g) in NaCl-30 were determined (Table 4). Bilgili (2016) stated that salt stress reduced length, fresh and dry weights of radicle in some bread wheat genotypes. In the current study, increase in VCL improved length, fresh and dry weights of radicle. Similarly, VCL increased radicle fresh and dry weights of soybean (Kaya and Erdönmez, 2020) and pepper (Başay and Alpsoy, 2019). Salt increase affects plant water and mineral substance uptake from the soil and hence lead to decrease in both plant and root growth.

Table 4. Effects of NaCl concentration and VCL on radicle length, fresh and dry weights of Hungarian vetch seeds

	NaCl-0	NaCl-30	NaCl-60	NaCl-90	Mean
Radicle Length (cm)					
VCL-0	8.17	7.43	7.15	6.05	7.20**c***
VCL-1	9.05	7.78	7.97	6.11	7.73**bc**
VCL-2.5	9.15	8.46	8.05	6.81	8.12**ab**
VCL-5	9.79	8.75	8.69	6.55	8.45**a**
VCL-10	10.87	8.19	8.51	6.23	8.45**a**
Mean	9.40**A**	8.12**B**	8.07**B**	6.35**C**	7.99
Radicle Fresh Weight (g)					
VCL-0	0.042	0.044	0.036	0.026	0.037**c**
VCL-1	0.046	0.046	0.040	0.030	0.041**b**

Table 4 (continued). Effects of NaCl concentration and VCL on radicle length, fresh and dry weights of Hungarian vetch seeds

VCL-2.5	0.047	0.046	0.041	0.035	0.043**ab**
VCL-5	0.046	0.050	0.042	0.036	0.043**ab**
VCL-10	0.049	0.052	0.041	0.036	0.044**a**
Mean	0.046**A**	0.048**A**	0.040**B**	0.033**C**	0.042
			Radicle Dry Weight (g)		
VCL-0	0.005	0.004	0.004	0.004	0.004**c**
VCL-1	0.005	0.004	0.004	0.004	0.004**bc**
VCL-2.5	0.005	0.004	0.004	0.004	0.004**b**
VCL-5	0.005	0.005	0.005	0.004	0.005**a**
VCL-10	0.006	0.005	0.005	0.004	0.005**a**
Mean	0.005**A**	0.004**B**	0.004**C**	0.004**D**	0.004

* Different letters in columns and rows indicate that the averages of the applications tested differed significantly ($p<0.05$).

Emergence ratio

Both NaCl concentration and its interaction with VCL had no effect on emergence ratio of Hungarian vetch but VCL affected it at 0.01 level. The lowest (51.67%) and highest (60%) emergence ratio were found in the VCL-0 and VCL-10, respectively (Table 5). The present study apparently revealed that emergence ratio of Hungarian vetch was reduced by salt stress and increased by VCL. Similar results were reported by Bilgili (2016) in some bread wheat genotypes and Kaya and Erdönmez (2020) in soybean. Na^+ and Cl^-, which increase the osmotic pressure in the germination medium, are diluted by being absorbed by organic materials such as VCL. Thus, the amount of VCL in the medium is considered to increase the resistance of seeds against salt stress.

Table 5. Effects of NaCl concentration and VCL on emergence ratio of Hungarian vetch seeds

			Emergence Ratio (%)		
	NaCl-0	**NaCl-30**	**NaCl-60**	**NaCl-90**	**Mean**
VCL-0	51.11	53.33	51.11	51.11	51.67**c***
VCL-1	55.55	53.33	55.55	51.11	53.89**bc**
VCL-2.5	62.22	57.78	53.33	53.33	56.67**ab**
VCL-5	60.00	55.56	55.55	55.56	56.67**ab**
VCL-10	60.00	64.45	57.78	57.78	60.00**a**
Mean	57.78**A**	56.89**A**	54.67**A**	53.78**A**	55.78

* Different letters in columns and rows indicate that the averages of the applications tested differed significantly ($p<0.05$).

Length, fresh and dry weights of juvenile seedling

Both VCL and NaCl had an effect on length, fresh and dry weights of Hungarian vetch juvenile seedling at 0.001 level but their interaction had no effect. VCL-0 showed the lowest seedling length (20.62 cm), fresh (0.320 g) and dry (0.035 g) weights while VCL-10 revealed the highest seedling length (24.13 cm), fresh (0.447 g) and dry (0.047 g) weights. NaCl-90 had the lowest seedling length (16.07 cm), fresh (0.234 g) and dry (0.030 g) weights. The highest seedling length (27.79 cm), fresh (0.509 g) and dry (0.036 g) weights were obtained from NaCl-0 (Table 6). The present study clearly showed that salt stress reduced length, fresh and dry weights of Hungarian vetch juvenile seedling. Bilgili (2016) found similar results in juvenile seedlings of some bread wheat genotypes. As the results in the present study, VCL increased length, fresh and dry weights of soybean (Kaya and Erdönmez, 2020) and pepper (Başay and Alpsoy, 2019) juvenile seedlings. Salt in the plant increasing in osmotic pressure and ion stress (Prada and Das, 2005) prevents water and plant nutrient intake. Thus, length, fresh and dry weights of juvenile seedling are reduced due to negative cell division and growth (Bresson, 2008; Oral et al., 2020).

Table 6. Effects of NaCl concentration and VCL on length, fresh and dry weights of Hungarian vetch juvenile seedlings

	NaCl-0	NaCl-30	NaCl-60	NaCl-90	Mean
Juvenile Seedling Length (cm)					
VCL-0	25.73	25.06	19.06	12.61	20.62**c***
VCL-1	27.50	25.68	21.47	16.57	22.80**b**
VCL-2.5	28.24	26.50	22.67	16.77	23.55**ab**
VCL-5	28.57	26.98	22.77	17.11	23.86**a**
VCL-10	28.91	27.37	22.95	17.30	24.13**a**
Mean	27.79**A**	26.32**B**	21.78**C**	16.07**D**	22.99
Juvenile Seedling Fresh Weight (g)					
VCL-0	0.436	0.410	0.263	0.170	0.320**d**
VCL-1	0.488	0.424	0.350	0.217	0.370**c**
VCL-2.5	0.502	0.450	0.373	0.232	0.389**c**
VCL-5	0.546	0.446	0.397	0.261	0.412**b**
VCL-10	0.571	0.512	0.414	0.290	0.447**a**
Mean	0.509**A**	0.449**B**	0.359**C**	0.234**D**	0.388
Juvenile Seedling Dry Weight (g)					
VCL-0	0.044	0.040	0.032	0.025	0.035**d**
VCL-1	0.051	0.045	0.035	0.028	0.040**c**
VCL-2.5	0.053	0.047	0.041	0.032	0.043**b**
VCL-5	0.058	0.050	0.044	0.035	0.047**a**
VCL-10	0.060	0.052	0.041	0.037	0.047**a**
Mean	0.036**A**	0.034**AB**	0.033**B**	0.030**C**	0.033

[*] Different letters in columns and rows indicate that the averages of the applications tested differed significantly ($p<0.05$).

Root length, fresh and dry weights of juvenile seedling

Both VCL and NaCl concentration had an effect on root length, fresh and dry weights of Hungarian vetch juvenile seedling at 0.001 level. The interaction of VCL and NaCl had an effect root fresh weight of juvenile seedlings but no effect on their root length and dry weight. The lowest root length (10.28 cm) and dry weight (0.007 g) were obtained from VCL-0 while the highest root length (13.01 cm) and dry weight (0.014 g) were found in VCL-10. The lowest root length (6.16 cm) and dry weight (0.006 g) were found in NaCl-90 while the highest root length (16.07 cm) and dry weight (0.018 g) were obtained from NaCl-0. The lowest root fresh weight (0.054 g) of juvenile seedlings were obtained from the interaction of VCL-0 and NaCl-90. Interaction of VCL-10 and NaCl-0 had the highest root fresh weight (0.322 g) of juvenile seedlings (Table 7). In the present study, salt stress considerably reduced root fresh and dry weights of juvenile seedlings. Similarly, Bilgili (2016) reported that salt stress decreased root fresh and dry weights in juvenile seedlings of some bread wheat genotypes. The present study showed that VCL improved root fresh and dry weights of juvenile seedlings as reported by Kaya and Erdönmez (2020) in soybean and Başay and Alpsoy (2019) in pepper juvenile seedlings. As length, fresh and dry weights of juvenile seedling, negative cell division and growth decrease root length, fresh and dry weights of juvenile seedling.

Table 7. Effects of NaCl concentration and VCL on root length, fresh and dry weights of Hungarian vetch juvenile seedlings

	NaCl-0	NaCl-30	NaCl-60	NaCl-90	Mean
Juvenile Seedling Root Length (cm)					
VCL-0	14.87	12.47	9.37	4.39	10.28**d***
VCL-1	15.85	13.01	9.60	5.50	10.99**cd**
VCL-2.5	16.24	13.80	10.48	6.45	11.74**bc**
VCL-5	16.56	14.35	11.01	6.57	12.13**b**
VCL-10	16.82	15.93	11.42	7.88	13.01**a**

Table 7 (continued). Effects of NaCl concentration and VCL on root length, fresh and dry weights of Hungarian vetch juvenile seedlings

Mean	16.07**A**	13.91**B**	10.38**C**	6.16**D**	11.63
			Juvenile Seedling Root Fresh Weight (g)		
VCL-0	0.256^{b}	0.166^{d}	$0.116^{g\text{-}j}$	0.054^{k}	0.148**c**
VCL-1	0.259^{b}	0.168^{d}	$0.122^{f\text{-}h}$	0.069^{k}	0.155**c**
VCL-2.5	0.270^{b}	0.199^{c}	$0.137^{e\text{-}g}$	0.069^{k}	0.169**b**
VCL-5	0.307^{a}	0.199^{c}	0.145^{e}	0.096^{j}	0.187**a**
VCL-10	0.322^{a}	0.216^{c}	$0.140^{e\text{-}f}$	$0.106^{h\text{-}j}$	0.196**a**
Mean	0.283**A**	0.190**B**	0.132**C**	0.079**D**	0.171
			Juvenile Seedling Root Dry Weight (g)		
VCL-0	0.014	0.007	0.004	0.002	0.007**c**
VCL-1	0.016	0.008	0.005	0.003	0.008**c**
VCL-2.5	0.018	0.014	0.010	0.007	0.012**b**
VCL-5	0.020	0.012	0.010	0.008	0.013**b**
VCL-10	0.021	0.015	0.010	0.009	0.014**a**
Mean	0.018**A**	0.011**B**	0.008**C**	0.006**D**	0.011

[*] Different letters in columns and rows indicate that the averages of the applications tested differed significantly ($p<0.05$).

In conclusion, as the number of researches regarding the effects of VCL and salinity on seed germination studies is limited, the present study can be an important reference in terms of revealing the stimulating attribute of VCL and inhibiting attribute of salinity on the germination and various parameters of Hungarian vetch plant. The alleviative and regulatory effect of VCL appeared mostly in its 5% and 10% dose applications during the germination and juvenile seedling of Hungarian vetch, moderately sensitive to salt stress.

ÖZET

Amaç: Türkiye'de ve dünyada önemli yem bitkisi olan Macar fiğin tohumlarının çimlenmesi ve fide büyümesi üzerine sıvı solucan gübresinin tuz stresi altında iyileştirici etkileri değerlendirilmiştir.
Yöntem ve Bulgular Laboratuar ve sera koşullarında iki deneme üç yinelemeli tesadüf blokları deneme desenine göre tesis edilmiştir. Denemelerde, kontrol (%0), %1, %2.5, %5 ve %10 sıvı solucan gübresi seviyeleri uygulanmış ve control (saf su), 30 mM, 60 mM ve 90 mM NaCl dozları hazırlanmıştır. Laboratuar denemesi sonunda, Macar fiği tohumlarının çimlenme oranı ve indisi ile plumula boyu, taze ve kuru ağırlığı, kökçük boyu, taze ve kuru ağırlıkları belirlenmiştir. Sera denemesinde ise, tohumların çıkma oranı, Macar fiğin fide boyu, taze ve kuru ağırlıkları ile fidelerin kök boyu, taze ve kuru ağırlıkları tespit edilmiştir.
Genel Yorum: Macar fiğin çimlenme ve fide aşamasında ölçülen parametreler tuz stresinden olumsuz etkilenmiştir ama tuz stresinin negatif etkileri uygulanan sıvı solucan gübresinin miktarındaki artış nedeniyle azalmıştır.
Çalışmanın Önemi ve Etkisi: Bu çalışma, Macar fiği bitkisinin çimlenmesi ve farklı parametreleri üzerine sıvı solucan gübresinin teşvik edici özelliği ile tuzun engelleyici etkisini ortaya koyma açısından önemli bir referans olabilir. Sıvı solucan gübresinin iyileştirici ve düzenleyici etkisi tuz stresine orta düzeyde duyarlı olan Macar fiğin çimlenme ve fide döneminde çoğunlukla %5 ve %10 doz uygulamalarında ortaya çıkmıştır.

Anahtar Kelimeler: Macar fiği, çimlenme, fide gelişimi, tuz toleransı, sıvı solucan gübresi.

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CONFLICT OF INTEREST
The authors declare no conflict of interest. The none of the authors have any competing interests in the manuscript.

AUTHOR'S CONTRIBUTIONS
The contribution of the authors is equal.

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