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Araştırma Makalesi

Effects Of Drought on Plant Growth and Some Macro and Micro Element Contents in Spinach Produced in Soil Supplemented with Vermicompost and Algae

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ABSTRACT

One of the ways to protect plants in adverse environmental conditions such as drought is to help plant nutrition by using organic and biological environments. In the present study, in order to determine the effects of drought stress on spinach, plants were produced in 2-liter pots filled with garden soil (as the control group), 1:1 ratio of garden soil + vermicompost, or 1:1 ratio of garden soil + algae, and 4 seeds were planted in each pot. The spinach seedlings in each pot was thinned to two at the true leaf stage. Two spinach cultivars (cv. Matador and cv. Catrina) were used in the study. The spinach plants were irrigated every 2 or 3 days depending on the water condition in the pots until field capcity for a month. Then, the irrigation was terminated for 15 days to create drought stress. The study was designed with 3 replications and 3 pots in each replicate, according to the randomized plots factorial design. In the study in which plant fresh weights, number of leaves, K, Ca, Mg, Cu, Fe and Zn contents were examined, plant weights and leaf numbers of Matador and Catrina spinach cultivars in the soil environment were more affected by drought stress than vermicompost + soil and algae + soil media. It has been observed that vermicompost and algae media reduce the effect of drought, increase plant weight and leaf number, increase K, Ca, Mg, Cu, Fe and Zn contents and have a positive effect on plant growth.

Key words: Algae, drought, spinach, vermicompost

Kuraklığın Vermikompost ve Su Yosunu ile Takviye Edilen Ortamlarında Üretilen Ispanakta Bazi Makro Ve Mikro Element İçeriğine Etkileri

ÖZ

Kuraklık gibi olumsuz çevre şartlarında bitkileri korumanın yollarından biride organik ve biyolojik ortamlar kullanılarak bitki beslenmesine yardımcı olmaktır. Yapılan bu çalışmada, Ispanakta kuraklık stresinin ortaya çıkardığı etkilerin belirlenebilmesi amacıyla, 1:1 oranında bahçe toprağı + vermikompost, 1:1 oranında bahçe toprağı + su yosunu, kontrol grubu olarak sadece toprak doldurulan 2 litrelik saksılara, her saksıya 4 tohum ekilmiştir. Her saksıdaki ıspanaklar gerçek yaprak aşamasında, saksıda iki bitki olacak şekilde bırakılmıştır. Çalışma iki adet ıspanak çeşidi (Matador ve Catrina) kulanılmıştır. Kuraklık uygulanan saksılara 15 gün su verilmemiş, ancak kuraklık uygulanmayan kontrol grubu saksılara ise sulamaya devam edilmiştir. Sulama, saksılardaki su durumuna göre 2 veya 3 günde bir yapılmıştır. Deneme 3 tekrarlı ve her tekrarda 3 saksı olacak şekilde tesadüf parselleri faktöriyel deneme desenine göre dizayn edilmiştir. Bitki yaş ağırlıkları, yaprak sayısı, K, Ca, Mg, Cu, Fe ve Zn içeriklerinin incelendiği çalışmada, Matador ve Catrina ıspanak çeşitlerinin toprak ortamındaki bitki ağırlıkları ve yaprak sayıları vermikompost + toprak ve su yosunu + toprak ortamlarına göre kuraklık stresinden daha fazla etkilenmiştir. Vermikompost ve su yosunu ortamlarının kuraklık etkisini azaltarak bitki ağırlığı ve yaprak sayısını K, Ca, Mg, Cu, Fe ve Zn içeriklerini artırdığı ve olumlu etki ettiği görülmüştür.

Anahtar kelimeler: Su yosunu, Kuraklık, Ispanak, Vermikompost

INTRODUCTION

Increasing the biological and organic matter content of the production environment with good fertilization in plant production increases the endurance of plants against adverse conditions such as drought. In the study investigating the effect of seaweed on the echinacea plant under drought stress, it is stated that the negative effects of drought stress on the plant decreased with seaweed applications and the decrease in root fresh and dry weight, stem fresh and dry weight of the plant due to drought stress (Bat et al., 2019). In another study in which the effect of algae and bacterial preparations on the yield and nutritional parameters of lettuce was determined, and it was stated that the application of bacterial-algal preparation significantly affected the plant weight of lettuce both in the spring and summer seasons (Kopta et al., 2018). In the study of the effects on the development and some quality characteristics of grafted and ungrafted tomato plants grown in soils where seaweed fertilizer was applied, it was reported that applying liquid seaweed fertilizer to the soil at different growth stages (seedling, flowering and fruit formation) supported the growth of the plant and increased the nutrient content of both tomato varieties (Sen, 2016). It is stated that eggplant, tomato, pepper, cabbage, onion plants are better in brown seaweed liquid fertilizer compared to control (Patel et al., 2018). It is also stated that green algae (*Ulva lactuca* L.), brown algae (*Cystoseiraspp*.) and red algae (*Gelidium crinale Gaillon*) applications reduce the negative effects of salt on canola plants (Ha et al., 2019). In a study conducted in radish, it is stated that seaweed reduces the negative effect of salt (Kasim et al., 2016). In the study of vermicopost and algae applied to spinach plants under salt stress, it is stated that spinach plants in environments with algae and vermicompost are less affected by the harmful effects of salt (Başdinç and Kabay, 2022).

In the study examining the effects of using vermicompost and mycorrhiza separately and together on pepper development and mineral nutrition, it was found that mycorrhiza and vermicompost applications had a positive effect on the fresh, dry weight and nutrient content of the pepper plant, and more nutrients are obtained (Küçükyumuk et al., 2014). In the study, in which vermicompost, cow and sheep manures were applied to curly lettuce development, it was stated that vermicompost provided earliness in curly lettuce and vermicompost gave good results in plant growth and nutrient uptake (Hınıslı, 2014). It is stated that vermicompost applications contribute to the head yield of broccoli (*Brassica oleracea* L. var. *italica*) plant in terms of plant nutrients in soil and leaves (Zahmacıoğlu, 2017). It was reported in a study carried out in pumpkin with no fertilization (control), humic substances (HS) fertilizer, complex fertilizers, compost and mixture of complex fertilizers, and humic substances fertilizers, the highest average content of the macro- and micro -elements was found in pumpkins fertilized with the complex fertilizers and it was reported all the applied fertilizers increased the content of calcium, iron, manganese, sodium and zinc in the pumpkin fruit (Paulauskiene et al. 2018). In a study evaluating the growth, physiological and biochemical parameters of lettuce (*Lactuca sativ* var. *crispa*) plants under drought stress conditions, it was stated that vermicompost fertilizer application increased the lettuce plants' shoot length, shoot fresh weight, relative water content, stomatal conductivity and reduced the negative effects of drought compared to the control. (Kiran, 2019).

The present study aimed to investigate the effects of drought on some macro and micro element contents in spinach produced in soil supplemented with vermicompost or algae.

MATERIALS AND METHODS

Two spinach cultivars (cv. Matador and cv. Catrina) were used in the study. The spinach seedlings were produced in 2-liter pots filled with garden soil (as the control group), 1:1 ratio of garden soil + vermicompost, or 1:1 ratio of garden soil + algae (green alg-Spirogyra), and 4 seeds were planted in each pot. The spinach seedlings in each pot was thinned to two at the true leaf stage. The spinach plants were irrigated every 2 or 3 days depending on the water condition in the pots until field capcity for a month. Then, the irrigation was terminated for 15 days to create drought stress. The study was designed with three replications and three pots in each replicate, according to the randomized plots factorial design (Kuşvuran, 2010; Kabay 2014).

During the study, it was observed that the average temperature in the daytime ranged from 19 to 22 C^{o} and the average temperature at night varied from 14 to 17 C^{o}. In the study, the following parameters were studied:

Determination of fresh plant weights:

Plant fresh weights were determined by weighing all plants harvested as a result of drought stress application and dividing by the number of plants. (Kuşvuran, 2010; Kabay, 2014).

Determining the number of leaves:

The number of leaves in spinach plants at the end of drought stress with the control group was calculated as number/plant by counting all the leaves on the plant.

Mineral element analysis:

At the end of the drought experiment, the shoot and root samples from stressed and control plants were dried in an oven at 65 Cº until reaching to a constant weight. Then the dry samples (200 mg) were grounded, pre-lit by ethyl alcohol, and lit until ash formation at 550 C°. The ash samples were dissolved with a 3.3 % HCl solution, filtered with a blue-band filter paper, and Na, K, and Ca was determined in an atomic absorption device (Thermo trade brand serial no: ice3000 series aa spectrometer) (Kusvuran, 2010; Bagci 2010; Kabay and Şensoy, 2016; Kabay and Şensoy, 2017).

The statistical analysis:

Analysis of variances based on general linear models (Yesilova and Denizhan, 2016) was carried out by SAS 9.4.1 statistical program. Duncan's Multiple Comparison tests was used to measure the statistical differences between genotype.

RESULTS AND DISCUSSION

Due to the abundance of organic and biological substances in our country, their use in plant production to improve the growing media is increasing. Increasing drought in agricultural areas has become a world problem. Increasing organic and biological media in agricultural areas reduces the negative effects of abiotic stresses such as drought.

The effects of drought on plant weight and leaf number of spinach produced in soil supplemented with vermicompost or algae are presented in Table 1. The plant weight of cv. Matador and cv. Catrina was significantly ($p<0.05$) different in drought stressed condition. While the plant weight of cv. Matador and cv. Catrina were determined as 6.83 g and 6.39 g, respectively in the soil, the plant weigth values of the same cultivars with 1:1 ratio of garden soil + vermicompost were 10.45 g and 9.86 g, respectively (Table 1). Moreover, the plant weigth values of the same cultivars with 1:1 ratio of garden soil + algae were 9.43g and 8.49 g, respectively (Table 1). Leaf numbers of Matador and Catrina spinach cultivars were found to be significantly ($p<0.05$) different in drought stressed condition. While the leaf number of cv. Matador and cv. Catrina were determined as 7.16 and 7.69, respectively in the soil, the leaf number values of the same cultivars with 1:1 ratio of garden soil + vermicompost were 8.52 and 8.28, respectively (Table 1). Moreover, the leaf number values of the same cultivars with 1:1 ratio of garden soil + algae were 7.64 and 8.28, respectively (Table 1).

It is stated that the negative effects of drought stress are reduced with seaweed applications and the effect on root length, stem length, root fresh weight, stem fresh weight, root and stem dry weight of echinacea plant is positive and increasing (Bat et al., 2019). Another researcher states that bacterial-algal preparation application increases both lettuce leaf and lettuce plant weight in spring and summer seasons (Kopta et al., 2018). In another study, in which vermicompost, cow and sheep manures were applied to curly lettuce development, it was stated that vermicompost provided earliness in curly lettuce and vermicompost gave good results in plant growth and nutrient uptake (Hınıslı, 2014). It is stated that vermicompost has a positive effect on lettuce growth under drought stress conditions (Kiran, 2019). As seen in these results, it has been observed that drought stress affects plants grown only in sole soil condition, and vermicompost or algae supplementation to soil reduce the negative effects of drought.

Table 1: Plant weight and number of leaves of spinach plants under drought stress

Cultivar	Growth media	Plant weigth (g)	Leaf number
Matador	Garden soil	6.83 e*	7.16 d*
	Garden soil+Vermicompost	10.45 a	8.52 a
	Garden soil+Algae	9.43 c	7.64 c
Catrina	Garden soil	6.39 f	7.69 c
	Garden soil+Vermicompost	9.86 b	8.35 b
	Garden soil+Algae	8.49 d	8.28 b

*: There is a significant difference ($p<0.05$) among the different letters in each column.

Tables 2 and 3 show that the amounts of potassium (K), calcium (Ca), magnesium (Mg), copper (Cu), iron (Fe) and zinc (Zn) decreased in control group plants (only soil) of spinach plants under drought stress. It is seen in Table 2 that the K, Ca and Mg amounts of the plants grown in the medium where vermicompost and algae were added increased compared to the control plants.

The lowest K content of spinach plants was found as 4.59% in the control group of the cv. Catrina, while the highest K content was found in the vermicompost + soil mixture with 5.28% in cv. Matador and 5.24% in cv. Catrina which were statistically in the same group (Table 2). While the lowest Ca content in spinach was found in the control group of Matador (0.64%) and Catrina (0.63%), the highest Ca content was found in algae + soil medium in cv. Matador (Table 2). The lowest Mg content was found in the control group of cv. Matador (0.57%) and cv. Catrina (0.59%), while the highest Mg content was found in algae + soil medium of cv. Catrina (Table 2).

Table 2: Amounts of K, Ca and Mg of spinach plants under drought stress

Cultivar	**Growth media**	**K (%)**	**Ca (%)**	**Mg (%)**
	Garden soil	4.73 c*	0.64 d*	0.57 d*
Matador	Garden soil+Vermicompost	5.28 a	0.75 b	0.77 b
	Garden soil+ Algae	5.17 b	0.78 a	0.64 cd
	Garden soil	4.59 d	0.63 d	0.59 d
Catrina	Garden soil+Vermicompost	5.24 a	0.72 c	0.83 a
	Garden soil+S Algae	5.11 ab	0.71 c	0.69 c

*: There is a significant difference ($p<0.05$) among the different letters in each column.

When Table 3 is examined for micro nutrient content of spinach plants, the lowest Cu content was found as 7.16 mg kg^{-1} in the control group of cv. Catrina, while the highest Cu content was found in cv. Matador as 7.61 mg kg^{-1} in the vermicompost + soil mixture (Table 3). The lowest Fe content was found as 84.39 mg kg^{-1} in the control group of cv. Matador, while the highest Fe content was found as 85.63 mg kg^{-1} in the vermicompost + soil medium of cv.Catrina (Table 3). The lowest Zn content was found in the control group of cv. Catrina (34.51 mg kg^{-1}), while the highest Zn content was found as 35.48 mg kg^{-1} in the vermicompost + soil medium of cv. Catrina (Table 3).

Table 3: Amounts of Cu, Fe, and Zn of spinach plants under drought stress

Cultivar	**Growth media**	**Cu (mg kg^{-1}),**	**Fe (mg kg^{-1}),**	**Zn (mg kg^{-1}),**
	Garden soil	7.49 b*	84.39 d*	34.87 c*
Matador	Garden soil+Vermicompost	7.61 a	85.47 b	35.16 b
	Garden soil+ Algae	7.53 b	84.25 c	35.17 b
	Garden soil	7.16 d	85.36 bc	34.51 d
Catrina	Garden soil+Vermicompost	7.39 c	85.63 a	35.48 a
	Garden soil+ Algae	7.37 c	85.19 c	35.13 b

*: There is a significant difference ($p<0.05$) among the different letters in each column.

It is stated that vermicompost applications contribute to the head yield of broccoli (*Brassica oleracea* L. var. *italica*) plant in terms of plant nutrients in the soil and leaves (Zahmacıoğlu, 2017). It is stated that the pepper plant applications have a positive effect on the fresh and dry weights and nutrient content of the pepper plant, and with the mycorrhiza and vermicompost applied at the highest dose, the pepper plant is more developed and more nutrients are obtained (Küçükyumuk et al., 2014). Turan et al. (2022) reported that microalgae applications were found to have a positive effect on plant growth in garden rocket, and these researchers observed that the values increased in most parameters examined in algae-applied applications compared to the control group. In the study of the effects on the development and some quality characteristics of grafted and ungrafted tomato plants grown in soils where seaweed fertilizer was applied, it was reported that applying liquid seaweed fertilizer to the soil at different growth stages (seedling, flowering and fruit formation) supported the growth of the plant and increased the nutrient content of both tomato varieties. (Sen, 2016). It was reported was carried out in pumpkin no fertilization (control), humic substances (HS) fertilizer, complex fertilizers, compost and mixture of complex fertilizers, and humic substances fertilizers; The highest average content of the macro- and micro -elements was found in pumpkins fertilized with the complex

fertilizers and it was reported all the applied fertilizers increased the content of calcium, iron, manganese, sodium and zinc in the pumpkin fruit (Paulauskiene et al. 2018).

CONCLUSION

In the present study examining the plant fresh weight, leaf number, K, Ca, Mg, Cu, Fe and Zn contents of the spinach plants, the drought stress applied to the soil (control), vermicompost + soil and algae + soil medium in spinach cultivars was examined and the applications was found to reduce the effect of drought. Plant weights and leaf numbers of Matador and Catrina spinach cultivars were more affected by drought stress than vermicompost + soil and algae + soil medium. It has been observed that vermicompost and algae media reduce the drought effect and increase the plant weight and number of leaves. It has been observed that vermicompost and algae media increase the K, Ca, Mg, Cu, Fe and Zn contents of spinach plants and have a positive effect.

As a result of this study, it has been seen that organic and biological medium applied to plant production medium reduce the negative effects of abiotic stresses such as drought. We believe that the use of vermicompost and algae media in plant production will contribute to researchers and producers.

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