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EFFECTS OF DIFFERENT POTASSIUM DOSES ON GROWTH AND DEVELOPMENT OF DROUGHT-SENSITIVE BEAN PLANTS

Turgay Kabay✉

Ercis Vocational School, Van Yuzuncu Yil University, Van, Turkey

ABSTRACT

Root, stem and leaf development are all negatively influenced by drought stress which causes losses in yield and quality and ultimately serious economic losses for growers. This study was conducted to see the efficiency of potassium treatments in reducing the negative effects drought stress on yield and quality of beans largely consumed in Turkey. Zulbiye bean cultivar sensitive to drought stress and V71 bean genotype which was also previously identified as sensitive to drought stress were used as the plant materials of the experiments. Bean seeds were sown in 2 L pots filled with perlite. Different potassium (K) doses of 0 (control) ppm K, 500 ppm K, 100 ppm K and 2000 ppm K were applied to seed sown pots. Seeding was performed as to have two plants in each pot and experiments were conducted in randomized blocks factorial experimental design with 4 replications with 4 pots in each replication. Pots were irrigated with Hoagland nutrient solution throughout the experiments. Irrigations were totally terminated on 20th day for drought stress plants. Following 15 days of stress conditions, plant height, fresh weight, root collar diameter, number of leaves and leaf size, leaf relative contents and membrane damage index values were determined. It was concluded based on present findings that 2000 ppm K treatment was more efficient in reducing the negative effects of drought stress on investigated growth and development parameters.

Key words: *Phaseolus vulgaris*, drought stress, plant growth

INTRODUCTION

Drought negatively influences plant growth and development and ultimately ends up with significant yield losses. Under drought stress, cells get smaller, yellowing and dryings are observed in leaves and shoots. Such cases then negatively influence yield and quality [Kacar et al. 2006, Kabay and Şensoy 2017, Erdinc 2018, Alzahrani et al. 2018]. Plants should be well fertilized against drought-like abiotic stressors since the plants with a sufficient nutrient levels develop better defense mechanisms against biotic and abiotic stressors and resultant damages [Kacar et al. 2006, Yıldız and Terzi 2007, Wang et al. 2013, Kabay and Şensoy 2016, Fitzgerald et al. 2016]. It was reported in a study that organic and inorganic fertilizers significantly increased the growth and nutrient contents of pepper plants grown in a greenhouse [Özkan et al. 2013]. It was pointed out that supplementary potassium treatments significantly increased macro and micro nutrient contents of sunflower plants [Ertiflik and Zengin 2015]. In another study, 0, 40, 80, 120 and 160 kg K_2O ha^{-1} doses were applied to soil and the best effects on yield were obtained from 120 kg K_2O ha^{-1} treatment [Çolpan et al. 2013]. It was indicated in a study that foliar selenium and silicon treatments had positive impacts on number of leaves, plant height, the fruit number, fruit weight, fruit diameter, fruit length, N, P, K, Mg, Ca, Fe, Se and Si contents of cucumbers [Çetinsoy and Daşgan 2016]. Mycorrhizal fungus, hu-

✉ tkabay@yyu.edu.tr

mic acid and whey treatments significantly improved plant growth, yield and quality in melon, watermelon and summer squash species [Ekincialp et al. 2016]. Foliar potassium treatments were reported to increase grain fill ratio in wheat [Chen et al. 2017]. Under arid and semi-arid conditions, mycorrhiza treatments were reported to improve plant morphological and physiological characteristics and increased phosphorus, calcium and potassium contents [Jokar et al. 2016]. Nitrogenous fertilization and bacteria inoculation treatments were reported to increase number of nodules, plant height, number of pods, number of kernels per pod and hundred kernel weight of beans and 5 kg da^{-1} N treatment was recommended for high kernel yield in bean cultivation [Altunkaynak 2018]. It was reported that amino acid treatments significantly increased kernel yield and protein content of bean plants [Kavasoğlu 2017]. Decreases in fruit set and yields of tomatoes under high temperature and drought stress were reported to increase significantly with irrigation and GA_3 treatments [Çömlekçioğlu and Şimşek 2014].

Drought stress reduced number of leaves and leaf areas, plant height and weight, root collar diameter and leaf relative water content and increased membrane damage index values of the beans [Kabay et al. 2017, Kabay and Şensoy 2017]. Decreases were observed in plant weights, number of leaves, root collar diameter and leaf relative water content and increases were observed in membrane damage index of tomato plants exposed to drought stress [Sanchez-Rodriguez et al. 2010, Alp and Kabay 2017]. While water and drought stress negatively influenced the development of sensitive bean cultivar, drought stress significantly decreased fresh and dry weights, leaf areas and leaf relative water contents of tomatoes as compared to the control treatment [Zahoor et al. 2017]. In a study with drought and semi-drought conditions in beans, 50% PEG 6000 treatments resulted in dry out of roots, flowers and pods [Rathi et al. 2018]. In another study, drought and deficit irrigations (0, 25, 50, 75 and 100%) were experimented in beans and it was observed that number of leaves, leaf weight, leaf area, pod weight, pod diameter, pod height, plant height, total number of fruits per plant, total pod weight per plant, yield, leaf relative water content, chlorophyll content, macro and micro nutrients increase with increasing irrigation ratios, but leaf damage index, leaf thickness, membrane damage in leaf cells and leaf temperatures decreased with increasing irrigation water quantities [Yarış 2018]. It was reported that drought stress created through applying 75% and 50% of available water holding capacity significantly reduced leaf area and transpiration efficiency of chickpea [Farooq et al. 2018].

In this study, effects of different potassium doses on plant height, fresh weight, root collar diameter, number of leaves and leaf size, leaf relative water content and membrane damage index of bean plants (Zulbiye and V71) sensitive to drought stress were investigated.

MATERIALS AND METHODS

In this study, plant height, fresh weight, root collar diameter, number of leaves and leaf size, leaf relative water content and membrane damage index of drought stress-sensitive Zulbiye bean cultivar and V71 bean genotype were investigated under different potassium doses (0 ppm, 500 ppm K, 1000 ppm K and 2000 ppm K). Bean seeds were sown in 2 L pots containing perlite + potassium doses (0, 500 ppm, 1000 ppm, 2000 ppm) as to have two plants in each pot. Experiments were conducted in randomized blocks factorial experimental design with 4 replications with 4 pots in each replication. The climate chamber in which the plants are grown had a temperature of between 22–26°C. Pots were irrigated with Hoagland nutrient solution throughout the experiments. Irrigations were totally terminated on 20^{th} day for drought stress plants. Following 15 days of stress conditions, plant height, fresh weight, root collar diameter, number of leaves and leaf size, leaf relative contents and membrane damage index values were determined. It was observed that 2000 ppm K treatment was more efficient in reducing negative impacts of drought stress.

Determination of fresh weights. All plants were weighed on a precision scale (±0.1 g).

Determination of the plant height and diameter. The stem lengths in bean plants were measured with a ruler (±0.1 cm), and their stem diameters were measured with a digital display caliper (±0.1 mm).

Determination of the number of leaves and leaf area. At the end of the drought experiment, the number of leaves was counted and the leaf areas were determined as cm^2 with a planimeter in all bean genotypes.

Determination of the leaf relative water content (LRWC). At the end of the drought experiment, fresh leaf samples were sampled, weighted (FW) and kept in distilled water for four hours to calculate their turgor weights (TW). Then, the samples were kept in an oven (65°C) for 48 hours and weighted (DW). The below formula was used in order to calculate the relative water content of the bean genotypes [Kuşvuran 2010].

$$LRWC = \frac{(FW - DW)}{(TW - DW)} \times 100$$

Determination of the membrane damages in the leaf cells. Membrane Damage Index (MDI) in bean leaves was calculated by measuring the electrolyte out of the cell. The 17 mm diameter discs taken from the bottom 3 leaves were incubated for 5 hours in 10 ml distilled water, and their EC values were measured. The same disc samples were kept at 100°C for 10 minutes, and their EC values were measured again. Membrane Damage Index (MDI) was calculated by the following formula [Kuşvuran 2010].

$$MDI = \frac{Lt - Lc}{1 - Lc} \times 100$$

Lt: The first EC value of drought stressed leaf disk samples / The second EC value of drought stressed leaf disc samples kept at 100°C for 10 min;
Lc: The first EC value of control leaf disk samples / The second EC value of control disk samples kept at 100°C for 10 min.

The statistical analysis. Analysis of Variances based on general linear models [Yesilova and Denizhan 2016] carried out by SAS 9.4.1 statistical program was used. Duncan multiple Comparison tests was used to measure the statistical differences between genotype.

RESULTS AND DISCUSSION

Since drought reduces yield and quality in plant production, decreases are evident in market value of the products. Such a case results in serious economic losses for the producers. Present potassium treatments were found to be quite effective in reducing drought-induced damages on plant roots, shoots and leaves. Plant weights of V71 bean genotypes and Zulbiye bean cultivar decreased with the negative effects of drought. However, increases were observed in plant weights with potassium treatments. Plant weights un-

Table 1. Effects of potassium treatments on plant weight (g) and height (cm) of bean plants under drought stress

Beans	Treatment	Fresh weight in control (g)	Fresh weight in drought stress (g)	Change (fresh weight) (%)	Control plant height (cm)	Plant height in drought stress (cm)	Change (plant height) (%)
Zulbiya	0 ppm K	4.53g	1.85e	-59.16	51.35d	36.49d	-28.94
	500 ppm K	5.17e	2.31d	-55.32	53.17c	41.82c	-21.35
	1000 ppm K	6.88b	3.12b	-54.65	55.96b	45.22b	-19.19
	2000 ppm K	7.25a	3.43a	-52.68	56.43a	47.13a	-16.48
Means		5.78A	2.68A	-63.86	54.09B	43.69A	-29.48
V71	0 ppm K	3.68h	1.33f		46.26h	32.62h	
	500 ppm K	4.77f	1.78e	-62.68	47.15g	33.31g	-29.35
	1000 ppm K	5.58d	2.73c	-51.07	47.87f	34.01f	-28.95
	2000 ppm K	6.24c	3.39a	-45.67	48.68e	34.94e	-28.23
Means		4.91B	2.30A		60.22A	31.34B	

There is significant differences ($P \leq 0.01$) among the different letters in each column. The capital letters for the varieties and the small-case letters for the interaction between variety and K doses

Table 2. Effects of potassium treatments on leaf number (leaf) and area (cm^2) of bean plants under drought stress

Beans	Treatment	Leaf number in control	Leaf number in drought stress	% Change (leaf number)	Leaf area in control	Leaf area in drought stress	% Change (leaf area)
Zulbiya	0 ppm K	17.26e	8.84f	-48.78	27.65c	12.78f	-53.78
	500 ppm K	18.79d	9.68e	-48.48	29.37b	14.48e	-50.69
	1000 ppm K	21.55b	11.47d	-46.77	29.85b	15.42d	-48.34
	2000 ppm K	22.17a	11.89c	-46.37	31.24a	16.53c	-47.08
Means		23.56A	13.54A	-52.99	31.75A	15.55A	-50.22
V71	0 ppm K	15.21g	7.15h		24.69g	12.29g	
	500 ppm K	16.48f	8.13g	-50.67	25.32f	13.02f	-48.57
	1000 ppm K	19.08d	12.26b	-35.74	26.12e	17.54b	-32.84
	2000 ppm K	19.69c	12.74a	-35.29	26.87d	18.96a	-29.44
Means		19.45B	10.15B		32.48A	15.45A	

There is significant differences ($P \leq 0.01$) among the different letters in each column. The capital letters for the varieties and the small-case letters for the interaction between variety and K doses

der drought stress decreased by 59.16% in Zulbiye bean cultivar and decreased by 63.86% in V71 bean genotype (Tab. 1). Plant weights increased with increasing potassium doses. In 2000 ppm K treatment, loss in plant weight decreased to 52.68% in Zulbiye bean cultivar and to 45.67% in V71 bean genotype (Tab. 1).

Plant heights under drought stress decreased by 28.94% in Zulbiye bean cultivar and decreased by 29.48% in V71 bean genotype (Tab. 1). However in 2000 ppm K treatment, plants heights decreased by 16.48% in Zulbiye bean cultivar and by 28.23% in V71 bean genotype (Tab. 1).

Abiotic stress negatively influences plant growth and fruit set [Yıldız and Terzi 2016, Erdinc 2018, Alzahrani et al. 2018]. Drought stress was reported to reduce plant height and weight of the beans [Kabay et al. 2017, Yarış 2018]. Decreases were reported in plant weight and height of tomatoes under drought stress [Sanchez-Rodriguez et al. 2010, Alp and Kabay 2017]. Plants should be well-supplemented with nutrients, especially with potassium to improve plant resistance to abiotic stressors like drought [Kacar et al. 2006, Yıldız and Terzi 2007, Wang et al. 2013, Fitzgerald et al. 2016]. It was reported that organic and inorganic fertilizers significantly increased growth and nutrient content of pepper plants [Özkan et al. 2013]. Supplementary potassium treatments had positive effects on yields of tomatoes and sunflowers [Çolpan et al. 2013, Ertiflik and Zengin 2015].

It was observed that number of leaves and leaf sizes of bean plants decreased under drought stress, but such decreases were reduced by K treatments. Number of leaves under drought stress decreased by 48.78% in Zulbiye bean cultivar and decreased by 52.99% in V71 bean genotype. On the other hand in 2000 ppm K treatments, such decreases were observed as 46.37% in Zulbiye bean cultivar and as 35.29% in V71 bean genotype (Tab. 2). Leaf areas under drought stress decreased by 53.78% in Zulbiye bean cultivar and decreased by 50.22% in V71 bean genotype (Tab. 2). In 2000 ppm K treatments, such decreases were observed as 47.08% in Zulbiye bean cultivar and as 29.44% in V71 bean genotype (Tab. 2). Decreases are also reported in number of leaves and leaf areas of bean and tomato plants under drought stress [Sanchez-Rodriguez et al. 2010, Zhou et al. 2017, Kabay et al. 2017, Kabay and Şensoy 2017, Alp and Kabay 2017]. Foliar potassium treatments increased grain fill ratios in wheat [Chen et al. 2017]. Mycorrhiza treatments under arid and semi-arid conditions were reported to improve plant morphological and physiological characteristics and increased phosphorus, calcium and potassium contents [Jokar et al. 2016]. Nitrogenous fertilization and bacteria inoculation treatments were reported to increase number of nodules, plant height, number of pods, number of kernels per pod of a bean cultivar [Altunkaynak 2018]. It was reported that amino acid treatments significantly increased kernel yield and protein content of bean plants [Kavasoğlu 2017]. Decreases in fruit set and yields of tomatoes under high temperature and drought stress were reported to increase significantly with irrigation and GA_3 treatments [Çömlekçioğlu and Şimşek 2014].

Under drought stress, root collar diameters decreased by 27.37% in Zulbiye bean cultivar and decreased by 46.21 in V71 bean genotype. However under 2000 ppm K supplementary treatments, the decreases were observed as 15.25% in Zulbiye bean cultivar and as 44.77% in V71 bean genotype (Tab. 3).

Leaf relative water contents decreased under drought stress by 31.49% in Zulbiye bean cultivar and decreased by 38.19% in V71 genotype. On the other hand, such decreases in 2000 ppm K dose were observed as 20.29% Zulbiye bean cultivar and as 27.14% in V71 bean genotype (Tab. 3).

Membrane damage index under drought stress was observed as 72.78% in Zulbiye bean cultivar and as 77.21% in V71 bean genotype. The values decreased with supplementary K doses and membrane damage index in 2000 ppm K treatment was observed as 55.26% in Zulbiye bean cultivar and as 58.93% in V71 bean genotype (Tab. 3).

Drought stress significantly decreased fresh and dry weights, leaf areas and leaf relative water contents of tomatoes as compared to the control treatment [Zhou et al. 2017]. Mycorrhiza treatments under arid and semi-arid conditions improved plant morphological and physiological characteristics and increased phosphorus, calcium and potassium contents [Jokar et al. 2016]. In a drought and deficit irrigation study with beans and tomatoes, it was observed that number of leaves, leaf weight, leaf area, pod weight, pod diameter, pod height, plant height, total number of fruits per plant, total pod weight per plant, yield, leaf relative water content, chlorophyll content, macro and micro nutrients increased with increasing irrigation ratios, but leaf damage index,

Table 3. Effects of potassium treatments on Stem diameter (mm), leaf relative water content (LRWC) (%) and membrane damage Index (MDI) (%), of bean plants under drought stress

Beans	Treatment	Stem diameter in control	Stem diameter in drought stress	% Change (stem diameter)	LRWC in control	LRWC in drought stress	% Change (LRWC)	MDI in drought stress
Zulbiya	0 ppm K	2.85e	2.07c	-27.37	77.42d	53.04e	-31.49	72.78c
	500 ppm K	3.12c	2.52b	-19.23	78.63b	54.09d	-31.2	66.68f
	1000 ppm K	3.37a	2.81a	-16.62	78.87a	54.81c	-30.51	68.16e
	2000 ppm K	3.41a	2.89a	-15.25	78.93a	62.91a	-20.29	55.26h
Means		4.29A	2.56A	-46.21	76.96A	56.21A	-38.19	65.72B
V71	0 ppm K	2.77f	1.49f		74.67g	46.15g		77.21a
	500 ppm K	2.95d	1.61e	-45.42	75.28f	46.68g	-37.99	76.52b
	1000 ppm K	3.22b	1.77d	-45.03	75.77e	51.09f	-32.57	68.90d
	2000 ppm K	3.35a	1.85d	-44.77	78.11c	56.91b	-27.14	58.93g
Means		2.61B	1.71B		72.18B	50.21B		70.39A

There is significant differences ($P \leq 0.01$) among the different letters in each column. The capital letters for the varieties and the small-case letters for the interaction between variety and K doses leaf thickness, membrane damage in leaf cells and leaf temperatures decreased with increasing irrigation water quantities [Sanchez-Rodriguez et al. 2010, Alp and Kabay 2017, Kabay et al. 2017, Kabay and Şensoy 2017, Yarış 2018]. Foliar selenium and silicon treatments had positive impacts on number of leaves, plant height, number of fruits, fruit weight, fruit diameter and fruit length of cucumbers [Çetinsoy and Daşgan 2016]. Mycorrhizal fungus, humic acid and whey treatments significantly improved plant growth, yield and quality in melon, watermelon and summer squash species [Ekincialp et al. 2016]. In a study with drought and semi-drought conditions in beans, 50% PEG 6000 treatments resulted in dry out of roots, flowers and pods [Rathi et al. 2018].

Foliar potassium treatments were reported to increase grain fill ratios in wheat [Kavasoğlu 2017, Chen et al. 2017]. Decreases in fruit set and yields of tomatoes under high temperature and drought stress were reported to increase significantly with irrigation and GA_3 treatments [Çömlekçioğlu and Şimşek 2014].

CONCLUSION

It was observed in this study that increasing potassium doses had positive effects on growth parameters of drought-sensitive bean genotypes. Drought stress negatively influenced plant height, fresh weight, root collar diameter, number of leaves and leaf area, leaf relative water content and membrane damage index. However, increasing potassium treatments reduced negative impacts of drought stress on these parameters. Under drought stress conditions, plant height, fresh weight, root collar diameter, number of leaves and leaf size, leaf relative water content of sensitive bean plants decreased and membrane damage index values increased. On the other hand, with increasing potassium doses, plant height, fresh weight, root collar diameter, number of leaves and leaf size, leaf relative water content increased and membrane damage index values decreased. It was observed that investigated parameters of drought stress-sensitive Zulbiye bean cultivar and V71 bean genotype were positively influenced and improved by increasing K doses.

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REFERENCES

Alp, Y., Kabay, T. (2017). The effect of drought stress on plant development in some native and commercial tomato genotypes. YYU J. Agric. Sci., 27(3), 387–395.

Altunkaynak, A.Ö. (2018). Effects of different nitrogen doses and bacterial inoculation on grain yield and yield characteristics in the bean (*Phaseolus vulgaris* L.). Selcuk University Institute of Science and Technology (Doctoral dissertation).

Alzahrani, Y., Kuşvuran, A., Alharby, H. F., Kuşvuran, S., Rady, MM. (2018). The defensive role of silicon in wheat against stress conditions induced by drought, salinity or cadmium. Ecotoxicol. Environ. Saf., 154, 187–196. DOI: 10.1016/j.ecoenv.2018.02.057

Chen, G., Liu, C., Gao, Z., Zhang, Y., Jiang, H., Zhu, L., Qian, Q. (2017). OSHAK1, a high-affinity potassium transporter, positively regulates responses to drought stress in rice. Front. Plant Sci., 8, 1885. DOI: 10.3389/fpls.2017.01885

Çetinsoy, M.F., Daşgan, H.Y. (2016). Effects of foliar selenium and silicon fertilizers on cucumbers. Nevsehir J. Sci. Technol., 243–252. DOI: 10.17100/nevbiltek.211003

Çolpan, E., Zengin, M., Özbahçe, A. (2013). The effects of potassium on the yield and fruit quality components of stick tomato. Hortic. Environ. Biotechnol., 54(1), 20–28. DOI: 10.1007/s13580-013-0080-4

Çömlekçioğlu, N., Şimşek, M. (2014). Effect of gibberellic acid (GA3) at high temperature conditions and different water levels on the fruit attitude in industrial tomatoes. YYU J. Agric. Sci., 24(3), 270–279.

Ekincialp, A., Erdinç, Ç., Eser, F., Demir, S., & Şensoy, S. (2016).The effect of Arbuscular Mycorrhizal Fungus (AMF), whey and Humic acid applications on plant growth, yield and quality in different cucurbit types. Yüzüncü Yıl University J. Agric. Sci., 26 (2), 274–281.

Ekincialp, A., S. Sensoy, S. (2013). Determination of some vegetables traits in the Van lake basin bean genotypes. YYU J. Agric. Sci., 23(2), 102–111.

Erdinc, C. (2018). Changes in ion (K, Ca and Na) regulation, antioxidant enzyme activity and photosynthetic pigment content in melon genotypes subjected to salt stress – a mixture modeling analysis. Acta Sci. Pol., Hortorum Cultus, 17(1), 165–183. DOI: 10.24326/asphc.2018.1.16

Ertiflik, H., Zengin, M., (2015). Effects of increasing rates of potassium and magnesium fertilizers on the nutrient contents of sunflower leaf. Selcuk J. Agr. Food Sci., 29(2), 51–61.

Farooq, M., Ullah, A., Lee, D.J., Alghamdi, S.S., Siddique, K.H. (2018). Desi chickpea genotypes tolerate drought stress better than *kabuli* types by modulating germination metabolism, trehalose accumulation, and carbon assimilation. Plant Physiol. Biochem., 126, 47–54. DOI: 10.1016/j.plaphy.2018.02.020

Fitzgerald, C.B., Hutton, M. (2016). Soil quality and nutrient levels in new and established high tunnels in Maine. J. NACAA, 9(2).

Jokar, N.G., Nadian, H., Moghaddam, B.K., Gharineh, M.H. (2016). Influence of arbuscular mycorrhizal fungi and drought stress on some macro nutrient uptake in three leek genotypes with different root morphology. Majallah-i āb va khāk (J. Water Soil), 29(1), 198–209.

Kabay, T., Erdinç, Ç., Şensoy, S. (2017). Effects of drought stress on plant growth parameters membrane damage index and nutrient content in common bean genotypes. J. Anim. Plant Sci., 27(3), 940–952

Kabay, T., Şensoy, S. (2016). Drought stress-induced changes in enzymes, chlorophyll and ions of some bean genotypes. YYU J. Agric. Sci., 26(3), 380–395.

Kabay, T., Şensoy, S. (2017). Enzyme, chlorophyll and ion changes in some common bean genotypes by high temperature stress. Ege Univ. J. Agric. Sci., 54(4), 429–437.

Kacar, B., Katkat, B., Öztürk, Ş. (2006). Plant Physiology, 2nd ed. Nobel Press, 493–533.

Kavasoğlu, A. (2017). Effects of aminoacid application on agricultural characteristics of red bean cultivar. Selcuk University Institute of Science and Technology (Master's thesis), 36 p.

Kuşvuran, Ş. (2010). Relationships between physiological mechanisms for drought and salinity tolerance of melons (unpublished Ph.D. Thesis). Çukurova University Institute of Natural and Applied Sciences, 356 p.

Özkan, C.F., Asri, F.Ö., Demirtaş, E.I., Arı, N. (2013). Effects of organic and chemical fertilizers on nutritional status and plant growth of peppers grown under-cover. J. Soil Water, 2, 96–101.

Rathi, M.S., Paul, S., Manjunatha, B.S., Kumar, V., Varma, A. (2018). Isolation and screening of osmotolerant endophytic bacteria from succulent and non-succulent drought tolerant plants for water stress alleviation in cluster bean (*Cyamopsis tetragonoloba*). Vegetos, 31(1), 57–66.

Sanchez-Rodriguez, E., Rubio-Wilhelmi, M., Cervilla, L. M., Blasco B., Rios, J. J., Rosales, M. A., Ruiz, J. M. (2010). Genotypic differences in some physiological parameters symptomatic for oxidative stress under moderate drought in tomato plants. Plant Sci., 178(1), 30–40. DOI: 10.1016/j.plantsci.2009.10.001

Wang, M., Zheng, Q., Shen, Q., Guo, S. (2013). The critical role of potassium in plant stress response. Int. J. Mol. Sci., 14, 7370–7390. DOI:10.3390/ijms14047370

Yarış, A. (2018). Farklı sulama oranlarının taze fasülyede meydana getirdiği fizyolojik, morfolojik ve kimyasal değişikliklerinin belirlenmesi (Master's thesis). Namık Kemal Üniversitesi Institute of Science and Technology, 84 p.

Yesilova, A., Denizhan, E. (2016). Modelling mite counts using poisson and negative binomial. Fresenius Environ. Bull., 25, 5062–5066.

Yıldız, M., Terzi, H. (2007). Identification of plant heat stress tolerance with cell vigor and photosynthetic pigmentation tests. Erciyes Univ. J. Sci., 23(1–2), 47–60.

Zahoor, R., Dong, H., Abid, M., Zhao, W., Wang, Y., Zhou, Z. (2017). Potassium fertilizer improves drought stress alleviation potential in cotton by enhancing photosynthesis and carbohydrate metabolism. Environ. Exp. Bot., 137, 73–83. DOI: 10.1016/j.envexpbot.2017.02.002