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Full Length Research Paper

Effects of potassium and humic acid on emergence, growth and nutrient contents of okra (*Abelmoschus esculentus* L.) seedling under saline soil conditions

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The effects of potassium and humic acid (HA) on emergence, growth and nutrient contents of okra (*Abelmoschus esculentus* L cv. Sultani) seedlings in saline soil conditions were evaluated. Different levels of humic acid (0, 500, 1000 and 1500 mg kg^{-1}) and potassium (0, 75, 150 and 300 mg kg^{-1}) were applied on growing media treated with 50 mg NaCl kg^{-1} before seed sowing. The experiment was designed as randomized completely factorial block and each parcel had ten pots without drainage. Two okra seeds were sown in each pot having 300 cc volumes of growth media. The seedlings were thinned to one after emergence. The seedlings were irrigated with distilled water. Seed emergence, root and shoot size, leaf number, shoot and root dry weights of the plant seedlings were determined. Macro and micro nutrient (N, P, K, Ca, Mg, S, Cu, Fe, Mn and Zn) contents of seedlings were also determined. All data were subjected to a one-way analysis of variance and separated by Duncan's multiple range test which was performed using the Costat statistical software. There were statistical differences in terms of effects of potassium and HA on the okra seedling performances. The effects of K, Ca, Na, Cu, Fe, Mn, Zn and HA applications on plant mineral (N, P, K, Ca, Cu, Fe, and Mn) contents were significant at $p < 0.005$.

Key words: Okra (*Abelmoschus esculentus* L.), potassium, humic acid, nutrient content, seedling growth.

INTRODUCTION

Salinity is an important problem in more than one third of the world's agricultural lands and it causes yield decrease in many crops (Tekinel and Çevik, 1983). Turkey which consists of 78 million ha, uses 35.6% of its land for agriculture and 3.2% of the agricultural land has salinity problem.

It is well known that salinity tolerance level in seedling period of a plant should be taken into consideration, because if plants are sensitive to their late growing periods, they are most probably sensitive to salt in their seedling periods (Tekinel and Çevik, 1983; Akinci et al., 2004a). The natural and technological ways which might reduce salinity damages in agricultural crops have been among the most studied subjects for the last decades (Türkmen et al., 2005). Improvements of soil condition and establishing equilibrium among plant nutrients are important for soil productivity and plant production. For this purpose, organic matter and similar material are frequently applied to soils to improve their physical, chemical and biological properties (Türkmen et al., 2004). Humic substance and potassium could be used in order to obtain some level of salinity tolerance.

The salt tolerance in plants increases by reducing the sodium (Na) uptake of plants. In this reduction, potassium (K) plays an important role. The salt tolerance increases by increasing K/Na ratio (Litifi et al., 1992; Türkmen et al., 2000; Erdal et al., 2000; Akinci et al., 2004b). Ashraf et al. (1994), Türkmen et al. (2000) and Şensoy et al. (2007) reported that tolerant plants had more K uptake than the susceptible ones and they, also, reported that K had an important role in salt tolerance.

Humic substances constituting 65-75% of organic matter

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Table 1. Influences of potassium and humic acid on the seedling performance.

Seedling performance parameter	K dose (mg kg^{-1})				Humic acid dose (mg kg^{-1})			
	K_0	K_1	K_2	K_3	HA_0	HA_1	HA_2	HA_3
Seed emergence (%)	75.83 a	74.45 ab	69.63 bc	66.70 c	56.94 b	75.56 a	80.58 a	78.89 a
Root size (mm)	55.64 a	54.40 a	49.69 b	55.01 a	56.21 b	46.65 d	50.94 c	60.98 a
Shoot length (mm)	76.75 a	70.12 b	71.76 b	74.47 a	75.29 a	71.82 b	70.88 b	75.12 a
Leaf number	2.523 ab	2.332 b	2.560 ab	2.655 a	2.66 b	2.14 c	2.34 c	2.92 a
Shoot dry weight (g s^{-1})	0.880 a	0.756 b	0.831 ab	0.885 a	0.939 a	0.700 b	0.740 b	0.973 a
Root dry weight (g s^{-1})	0.095 a	0.087 ab	0.073 bc	0.060 c	0.083 b	0.060 c	0.073 bc	0.099 a
Stem-neck diameter (mm)	2.56 a	2.52 a	2.56 a	2.62 a	2.57 b	2.47 b	2.45 b	2.78 a

Potassium (K_0 = 0, K_1 = 75, K_2 = 150, K_3 = 300 mg K kg^{-1}) and humic acid (HA_0 = 0, HA_1 = 500, HA_2 = 1000, HA_3 = 1500 mg kg^{-1}). Values followed by some of the uppercase and lowercase letters, respectively, are not significantly different at P < 0.005.

in soils are the subjects of studies in various areas of agriculture such as soil chemistry, fertility, plant physiology as well as environmental sciences, as the multiple roles played by these materials can greatly improve plant growth. The major functional groups of humic acid (HA) include carboxyl, phenolic hydroxyl, alcoholic hydroxyl and ketone (Cacco and Agnolla, 1984). It was reported that HA application increased the plant growth and nutrient uptake (Türkmen et al., 2004; Dursun et al., 2002). It was also reported that HA application positively affected the plant parameters of plant grown in salinity condition (Türkmen et al., 2004; Türkmen et al., 2005).

Okra (*Hibiscus esculentus* L.) offers a great promise to its growers and consumers and is one of the major vegetable crops in many countries. Despite its considerable importance as vegetable crops, little work has been done on this species with particular reference to its ability to withstand salt stress.

Either humic acid or potassium applications on the soil could be relatively successful in attaining some level of salinity tolerance. This study was, therefore, aimed at investigating the effects of dual application of HA and K on salinity tolerance on the seedling development and nutrient content of okra grown under saline soil condi-tions.

MATERIALS AND METHODS

The experiment was conducted at the Department of Horticulture, Faculty of Agriculture, Selçuk University in Turkey. Different levels of HA (HA_0: 0 mg kg^{-1}, HA_1: 500 mg kg^{-1}, HA_2: 1000 mg kg^{-1}, HA_3: 1500 mg kg^{-1}) and potassium (K_0: 0 mg K kg^{-1}, K_1: 75 mg K kg^{-1}, K_2: 150 mg K kg^{-1} and K_3: 300 mg K kg^{-1}) were applied to growth media treated with 50 mg NaCl kg^{-1} before seed sowing. Sultani okra cultivar was used as plant material in the experiment. Constant doses of nitrogen (N) (250 mg N kg^{-1}) and phosphorus (P) (80 mg P kg^{-1}) were applied to the growing media. The seedlings were irrigated with distilled water. The study was carried out as a 'randomized completely factorial design' with three replicates and each replicate had ten pots consisting of 300 g of growing media (soil (40%), sand (40%) and manure (20%), respectively). The experimental period was four weeks after sowing. Seed emergence, root and shoot size, leaf number, shoot and root dry weights of the plant seedlings were determined. Macro and micro nutrient (N, P, K, Ca, Mg, S, Cu, Fe, Mn and Zn) contents of seedlings were also determined. Plant samples were oven-dried at 68°C for 48 h and were then ground. K^+, Ca^{2+} and Mg^{+2} were determined after wet digestion of dried and ground sub-samples in a H_2SO_4-Se-Salisylic acid preparation. P was measured spectrofotometrically by the indophenols-blue method, after reaction with ascorbic acid. K^+ and Ca^{+2} were determined by flame photometry and Mg^{+2}, Cu, Fe, Mn, Na and Zn by atomic absorption spectrometry using the AOAC (1990) method. All data were subjected to a one-way analysis of variance and separated by Duncan's multiple range test performed using the Costat statistical software.

RESULT AND DISCUSSION

Seedling growth

Influences of potassium and humic acid on the okra seedling performances of the seedling are given in Table 1.

Seed emergence

K and HA applications significantly influenced seed emergence. The highest percentage of seed emergence was obtained from HA_2 and K_0 applications (Table 1). However, the effect of humic acid on seed emergence was greater ($p < 0.005$) than that of potassium ($p < 0.005$).

Root size

There were significant differences among K and HA application levels in terms of root size of okra seedlings (Table 1). The highest root size in okra seedlings was determined at K_0 and HA_3 application levels.

Shoot length

K and HA applications significantly affected shoot length of the okra seedlings. The highest shoot lengths were obtained from K_0 and HA_0 application levels (Table 1).

Table 2. Mineral contents in okra exposed to potassium and humic acid.

Seedling performance parameter (Dw)	K dose (mg kg^{-1})				Humic acid dose (mg kg^{-1})			
	K_0	K_1	K_2	K_3	HA_0	HA_1	HA_2	HA_3
N (g 100 g $plant^{-1}$)	2.75	2.80	2.71	2.82	2.59 a	2.83 ab	2.90 a	2.76
P (g kg $plant^{-1}$)	2046	2059	1996	2125	2017 b	2265 a	1913 b	2031 b
K (g kg $plant^{-1}$)	10753 b	11864 a	7553 c	10417 b	9353 b	11433 a	10027 b	9774 b
Ca (g kg $plant^{-1}$)	17054 ab	16391 b	18526 a	17333 ab	18235 a	16657 b	16930 ab	17485 ab
Mg (g kg $plant^{-1}$)	2585	2599	2728	2584	2613	2606	2678	2599
Na (mg kg $plant^{-1}$)	2165 a	2319 a	1435 b	1972 a	1902	2097	1969	1923
Cu (mg kg $plant^{-1}$)	24.42 ab	22.50 c	23.50 bc	26.17 a	21.58 b	23.33 b	25.25 a	26.42 a
Fe (mg kg $plant^{-1}$)	160.5 b	124.1 c	183.3 b	247.8 a	131.6 c	164.8 b	228.7 a	190.6 b
Mn (mg kg $plant^{-1}$)	401 a	343 b	419 a	405 a	406 ab	338 c	392 b	431 a
Zn (mg kg $plant^{-1}$)	56.67 a	60.00 a	46.67 b	56.67 a	58.33	55.00	51.67	55.00

Potassium (K_0 = 0, K_1 = 75, K_2 = 150, K_3 = 300 mg K kg^{-1}) and humic acid (HA_0 = 0, HA_1 = 500, HA_2 = 1000, HA_3 = 1500 mg kg^{-1}). Values followed by some of the uppercase and lowercase letters, respectively, are not significantly different at P < 0.005.

Stem-neck diameter

HA applications had significant effects on the stem-neck diameter; however, K applications were not significant (Table 1). The applications of 1500 mg HA kg^{-1} caused the thickest stem-neck (2.78 mm). The difference value between HA_3 and HA_0 is 0.21 mm.

Leaf number

This trait was significantly affected by K and HA application levels (Table 1). The highest leaf number of seedlings was obtained from K_3 and HA_3 when compared to the non-applied ones.

Shoot and root dry weight

Shoot and root dry weights were significantly affected by the humic acid and potassium applications (Table 1). The 300 mg K kg^{-1} application seedling had 0.88 g shoot dry weight, while the 1500 mg HA kg^{-1} application had 0.97 g shoot dry weight. Root dry weights were higher by 0 mg K kg^{-1} and 1500 mg HA kg^{-1} application than that of the other levels.

Seedling mineral contents

The effects of K and HA applications on seedling mineral (N, K, P, Zn, Fe, Mn, Na, Ca and Mg) contents were significant at $p < 0.005$ (Table 2). In the present study, K and HA applications were determined to have increased mineral contents of okra seedlings as compared with control treatment. All K applications particularly have an effect in the increase of K, Ca, Na, Cu, Fe, Mn and Zn contents of the plant. The highest K, Ca, Na, Cu, Fe, Mn and Zn contents were obtained from K_1 (11864), K_2 (18526), K_1 (2319), K_3 (26.17), K_3 (247.8), K_2 (419) and K_1 (60.00), respectively. K applications affecting N, P and Mg contents of the seedlings were not significant (Table 2). HA applications particularly have an effect in the increase of N, P, K, Ca, Cu, Fe, and Mn contents of okra seedlings. The highest N, P, K, Ca, Cu, Fe and Mn contents were obtained from HA_2 (2.90), HA_1 (2265), HA_1 (11433), HA_0 (18235), HA_3 (26.42), HA_2 (228.7) and HA_3 (431), respectively. HA applications affecting Mg, Na and Zn contents of the seedlings were not significant (Table 2).

HA and K applications to plant growth media significantly increased mineral contents and growth of okra seedlings. This evidence confirms the data showing that seedling growth performance and the quantity of mineral contents were significantly or relatively related to HA and K treated with growth media, which may be explained by their concentration. In terms of HA application, the study's results were in agreement with those reported on tomato by Chen and Aviad (1990) and Tattini et al. (1991). It is possible that the enhancement in growth of okra seedlings, after incorporation of HA and K into the plant growth medium, could be attributed at least partially to the increased nutrient uptake of plants. HA have been reported to enhance mineral nutrient uptake by plants, increasing the permeability of membranes of root cells (Valdrighi et al., 1996). Moreover, the positive effects of HA on plant growth and productivity, which seem to be concentration-related, could mainly be due to hormone-like activities of the HA through their involvement in cell respiration, photosynthesis, oxidative phosphorylation, protein synthesis, antioxidant and various enzymatic reactions (Vaughan et al., 1985; Chen and Aviad, 1990; Zhang and Schmidt, 1999; Muscolo et al., 1999; Zhang and Schmidt, 2000; Zhang et al., 2003).

Conclusion

In conclusion, the effects of K and HA applications depend on the crop species. K and HA application is safe and as a result, it is effective and easily adopted by farmers. It is well known that HA not only increased macro-nutrient contents, but also enhanced micro-nutrient contents of the plant organs. The study assumes that humic substances play a major role in plant nutrient uptake and growth parameters in plant seedlings. In terms of the first report on okra, the results of this study showed that K and HA have a great potential to increase the performance, growth and mineral contents of okra plant. They also have the potential to benefit such farmers in many ways and hence, its importance is recognized by farmers as well as researchers. Therefore, they, especially HA, may be put to good use as natural fertilizer for vegetable production in sustainable and ecological agricultural systems.

Finally, the study assumes that humic substances and K may play a major role in the plant nutrient uptake and growth parameters in okra seedling under saline soil condition.

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