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INFLUENCE OF FOLIAR APPLICATION OF POTASSIUM ON WHEAT (*TRITICUM AESTIVUM* L) UNDER SALINE CONDITIONS

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Abstract

A potted experiment was conducted in the Department of Biological Sciences, University of Sargodha, to determine the effect of potassium (K) on wheat under saline and non-saline conditions. Foliar spray of K (0, 300, 600 mgL^{-1}) was applied on wheat under different salinity levels (0, 150 mmol). Salinity levels were created according to the saturation percentage of the soil. Each pot was filled with 7kg well-mixed soil. This experiment was laid out in a randomised complete block design with two factors factorial arrangement and with three replications. Different growth and physiological attributes were collected from the conducted experiment. Application of K increased the shoot and root fresh and dry weight. Salinity also affected the chlorophyll contents but the application of K enhanced the chlorophyll contents under saline and non-saline conditions. Foliar application of K also minimised the toxicity of sodium. Similarly, grains yield was also decreased under saline conditions but the foliar application of K reduced the salinity stress and enhanced the grains yield. These results indicated that foliar-applied K ameliorated the effect of salinity on wheat plants.

Keywords: Wheat, Salinity, Potassium (K), Foliar spray.

Introduction

Salinity is a major threat limiting the productivity of crop plants. Currently, there are nearly 954 million hectares soil areas in the world which are salt affected (Munns et al., 2006; FAO, 2008). There are so many sources by which salts are transported to the soil surface. Soil salinity problems inhibit the growth of the plants at different levels (Nasim et al., 2013). Crop production rate decreases due to salinity toxicity every year (Hirt and Shinizaki, 2004). Salinisation is a process that results from high level of soluble salts in the soil. High salinity causes hyper osmotic stress and ion imbalance that produce secondary effects on plants growth (Hasegawa et al., 2000; Zhu, 2001). Salt stress inhibits the germination of seed as well growth of the plants. Different plants species have different salinity toleration levels, which mostly depend on the physiological phenomenon of the plants species (Winicov, 1993). There are different methods to control salinity in plants such as application of phosphorus as a foliar spray, which ameliorates the salinity effect in wheat plants (Khan et al., 2013). Application of nitrogen and K as foliar spray on wheat plants under saline conditions ameliorated the effect of salinity (Khan et al., 2013). Nitrogen application mitigates the effect of salinity in wheat plants (Shahzad et al., 2013).

K acts as a very essential and important nutrient for the plant development. K in plants is necessary to improve the efficiency of photosynthesis and use of water (Rose, 2001). In wheat, deficiency of K causes so many problems and shows many deficiency symptoms in plants growth such as weaker straw, increased lodging and decrease in growth (Ross, 2001). Application of K to wheat plants under saline conditions enhances the growth of the plants and decreases the effect of salinity (Safaa et al., 2013).

Wheat is a major agricultural crop on which more than one third of world's population depends for food (Mujeeb et al., 2008).

One of the major objectives was to determine the mechanism of salinity tolerance in wheat plants by the foliar application of K.

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Materials and Methods

The potted experiment was conducted in the Department of Biological Sciences, University of Sargodha, Pakistan, to determine the effect of K on wheat under different saline conditions (0, 150 mmol). Different levels (0, 300, 600 mg/L) of K were prepared in distilled water containing 0.1% solution of Tween-20 as a surfactant (~2 ml per wheat plant) and applied as a foliar. Each pot was filled with 7kg well mixed soil. This experiment was laid out in a randomised complete block design with two factors factorial arrangement and with three replications. Different salinity levels were adjusted on the base of saturation percentage of well-mixed soil. The wheat variety Inqlab-91 was obtained from Ayub Agriculture Research Institute, Faisalabad.

Data collection

Data for different parameters were collected including plant height (cm), shoot length (cm), root length (cm), leaf length (cm), number of leaves/plant, shoot and root fresh and dry weight (g/plant), grains yield/plant (g/plant) and chlorophyll a, b and total (mg/g f. wt) apart from K^+, Na^+ and Ca^{2+}(mg/g d.wt) ions.

Growth parameters

Plant height: Height of three randomly selected plants from each pot was measured in centimeters from soil surface to top of the plants and their means were determined.

Root and shoot fresh weight: Shoot and root were separated for each plant and fresh weight was obtained separately with the help of a digital electrical balance.

Shoot and root dry weight: Shoot and root of each plant were dried in an oven at 58^0C for 30 hours and their dry weight was noted with the help of electrical balance.

Biochemical attributes

Chlorophyll contents: The chlorophyll a and chlorophyll b concentrations were determined by the method of Arnon (1949). The fresh leaves were cut into small pieces of 0.5cm, extracted and kept overnight with 80% acetone at -10°C. The extract was centrifuged at 14000 × g for 5 min. and the absorbance of the supernatant was noted at 480, 645, and 663nm, using a spectrophotometer (IRMECO U2020).

Chlorophyll a and chlorophyll b were calculated by the following formulas:

$$\textbf{Chl.a} = [12.7(OD663) - 2.69(OD645)] \times V / 1000 \times W$$

$$\textbf{Chl.b} = [22.9(OD645) - 4.68(OD663)] \times V / 1000 \times W$$

V = Volume of the extract (ml)

W = Weight of the fresh leaf tissue (g)

Determination of Na^+, K^+ and Ca^{2+}

Sodium (Na^+), potassium (K^+) and calcium (Ca^{2+}) ions in the leaves and roots were determined by the methods described by Allen et al. (1986). Ground dry plant samples (0.1g) were digested in 2mL of sulfuric-peroxide digestion mixture until a clear and colourless solution was obtained. After digestion, the volume of each sample was made to 100 mL with distilled de-ionized water. Ions, i.e., Na^+, K^+ and Ca^{2+} were determined with a flame photometer (Jenway PFP7; Bibby Sterilin, Essex, UK).

Statistical analysis

The data for all the traits were analysed by analysis of variance technique. Differences for various characters were compared, using the least significant differences test at .05 level of acceptance.

Results

Salinity through the root zone significantly reduced the plant height, shoot and root length of the wheat plant (Table 1). Foliar application of K^+ ameliorated the effect of salinity (Table 3). In case of non-saline conditions, foliar application of 300 mgL^{-1} of K was more effective as compared to 600 mgL^{-1} of K (Table 3) for the enhancement of plant height, shoot length and root length of wheat plant (Table 3). Under saline conditions, same trend of plant height, shoot and root length was noted by the foliar application of 300 mgL^{-1} of K (Table 3).

Salinity application through root zone also affected the shoot fresh and dry weight (Table 1). Foliar application of 600 mgL^{-1} of K enhanced the shoot fresh and dry weight under saline and non-saline conditions but in case of root fresh and dry weight, 300 mgL^{-1} application of K was more effective under saline and non-saline conditions (Table 3). Chlorophyll a and chlorophyll b were also affected by the application of salinity through root zone (Tables 1 and 2). Application

Table 1. Analysis of variance for data of plant height, shoot, root length, shoot, root fresh and dry weight and chlorophyll a contents under saline and non-saline conditions of wheat when different concentration of K were applied as a foliar spray.

Source of variation	DF	Plant Height	Shoot length	Root length	Shoot fresh weight	Shoot dry weight	Root fresh weight	Root dry weight	Chlorophyll a
Salinity (S)	1	24.500**	32.00**	9.38**	0.075**	0.012**	0.075**	0.471**	0.038**
Potassium (K)	2	28.222*	23.722*	6.176*	0.232	0.027*	0.232*	0.082	0.093*
S x K	2	4.667	12.167	2.056	0.080	0.007	0.080	0.066	0.011
Error	12	29.556	8.833	5.389	0.619	0.067	0.619	0.055	0.025
Total	17								

Table 2. Analysis of variance for data of chlorophyll b, total chlorophyll, potassium, sodium, calcium, in shoot and root and grains yield/plant of wheat under saline and non-saline conditions when different concentration of K were applied as a foliar spray.

Source of variation	DF	Chlorophyll b	Total Chlorophyll	Shoot K	Root K	Shoot Na	Root Na	Shoot Ca	Root Ca	Grain yield
Salinity (S)	1	0.000**	0.101**	0.361**	0.587**	0.096**	0.802**	22.267**	1.799**	2.801**
Potassium (K)	2	0.011*	0.220*	1.765	0.005*	0.986	0.802*	1.231*	7.552*	0.185
S x K	2	0.038	0.033	0.146	0.143	0.648	0.118	2.124	0.922	0.121
Error	12	0.013	0.073	0.849	0.143	1.052	0.905	22.852	11.386	0.083
Total	17									

Table 3. Influence of foliar application of potassium on plant height, shoot, root length, shoot, root fresh and dry weight and chlorophyll a, chlorophyll b, total chlorophyll, K, sodium, calcium, in shoot and root and grains yield/plant of wheat under saline and non saline conditions.

Salinity levels (mmol)	0			150		
Potassium levels (mgL^{-1})	0	300	600	0	300	600
Plant Height (cm)	35±5.2	39±6.1	38±4.2	27±3.1	30±4.2	29±2.1
Shoot length (cm)	20±2.3	24±4.4	22±5.2	10±3.1	17±3.3	15±2.1
Root length (cm)	11±3.2	9±2.1	8±2.0	9±3.1	8±2.2	7±2.4
Shoot fresh weight (g/plant)	17±2.2	19±4.2	20±3.1	15±4.1	17±4.2	18±3.1
Shoot dry weight (g/plant)	6±1.2	7±1.5	8±1.8	5±1.5	6±1.7	7±1.4
Root fresh weight (g/plant)	2.5±0.9	2.85±0.83	2.7±0.76	2.4±0.67	2.70±0.23	2.6±0.17
Root dry weight (g/plant)	0.2±0.012	0.3±0.008	0.5±0.01	0.6±0.04	0.7±0.07	0.5±0.02
Chlorophyll a (mg/ g f.wt)	0.5±0.04	0.52±0.01	0.5±0.02	0.3±0.03	0.4±0.01	0.4±0.012
Chlorophyll b (mg/ g f.wt)	0.3±0.02	0.32±0.05	0.22±0.01	0.3±0.02	0.33±0.03	0.34±0.01
Total chlorophyll (mg/ g f.wt)	0.8±0.1	0.84±0.08	0.72±0.06	0.6±0.04	0.73±0.03	0.74±0.02
Shoot K (mg/ g d.wt)	1.5±0.03	2.0±0.02	1.9±0.01	1.4±0.02	1.7±0.01	2.0±0.012
Root K (mg/ g d.wt)	1.9±0.02	1.8±0.01	1.7±0.012	1.3±0.03	1.4±0.02	1.5±0.01
Shoot Na (mg/ g d.wt)	1.5±0.02	1.3±0.01	1.3±0.012	11.7±3	11±3	9.5±2.6
Root Na (mg/ g d.wt)	2.0±0.02	2.2±0.03	3.0±0.12	15.5±4	10.6±3.5	8.5±3
Shoot Ca (mg/ g d.wt)	2.5±0.04	2.4±0.03	3.5±0.01	1.2±0.03	1.3±0.01	1.4±0.007
Root Ca (mg/ g d.wt)	4.0±0.3	6.1±0.1	6.2±0.05	2.0±0.02	3.0±0.07	4±0.08
Grain yield/ Plant (g)	3.8±0.1	4.2±0.4	4.0±0.4	2.4±0.3	2.8±0.4	2.6±0.5

of 300 mgL^{-1} of K applied as foliar spray enhanced chlorophyll a and chlorophyll b under non-saline conditions whereas under saline conditions, 600 mgL^{-1} of K was more effective to control the salinity (Table 3). Salinity application also affected the K concentration in shoot and root of the wheat plants (Table 2). Application of 300 mgL^{-1} of K was more effective in controlling the salinity under non-saline conditions in shoot of wheat plant and 600 mgL^{-1} application of K was effective in controlling the salinity under saline conditions (Table 3). In case of root K, opposite effect of K application was observed under saline and non-saline conditions as compared to shoot K of wheat under saline and non-saline conditions (Table 3). Sodium concentration in shoot and root was increased by the application of salinity (Table 1). Application of K 600 mgL^{-1} as foliar spray decreased the sodium concentration in shoot of wheat under saline conditions (Table 3). In case of root of wheat, same results were observed by the application of K as foliar spray (Table 3). Salinity application reduced calcium concentration in shoot and root of wheat plants but the application of K as foliar spray enhanced the calcium contents in shoot and root of wheat plants under saline conditions (Table 3). Grain yield was also affected by salinity stress but application of K 600 mgL^{-1} increased the grain yield in wheat plants under saline conditions (Table 3).

Discussion

Among abiotic factors, salinity is one of the most serious threats that decreases plant productivity and plant growth (Panda and Khan, 2008). The plants that grow in saline conditions have many different kinds of ionic compositions and a wide range of concentration of dissolved salts (Volkmar et al., 1998). Osmotic and oxidative stress in terms of antioxidant defense systems and membrane lipid peroxidation has also been indicated in plants (Candan and Tarhan, 2013). Due to reduction in leaf area, photosynthesis process can be reduced (Alam et al., 1994). The results of the study experiments are in accordance with Singla and Garg (2005). Concentration of sodium in leaf increased and decreased the calcium uptake. The results noted from the study experiment are also same as noted by Marschner (1995). K content was decreased because high sodium content is known to have antagonistic effect on K uptake in plant. Chlorophyll contents also decrease due to salinity stress (Ashraf, 2004). Chlorophylls a and chlorophyll b decreased significantly with increases in salt concentrations. As the plants are immobile and cannot move from one place to other to tolerate stresses but the application of K reduced the effect of salinity (Amin et al., 1989). There are different methods to control salinity in plants such as application of phosphorus as a foliar spray ameliorated the salinity effect in wheat plants (Khan et al., 2013).Application of K to wheat plants under saline conditions enhanced the growth of the plants and decreased the effect of salinity (Safaa et al., 2013). Application of potassium and nitrogen applied as foliar spray reduced the effect of salinity (Khan et al., 2013). K is an essential nutrient for plant growth and plays an important role in many metabolic processes. The exact function of K in plant growth has not been clearly defined. K is associated with movement of water, carbohydrates and nutrients in plant tissue. If K^+ is deficient or not supplied in adequate amounts, growth is stunted and yields are reduced (George and Schmitt, 2002).

These findings led us to conclude that application of potassium as a foliar spray counteracted the adverse effects of salt stress on growth of wheat by improving photosynthetic capacity of wheat plants against salt-induced oxidative stress and maintaining ion homeostasis.

References

Alam, S.M. 1994. Nutrient by plants under stress conditions. In: Pessrakli, M. (Ed.), Handbook of Plant and Crop Stress. Marcel Dekker, New York, pp. 227-246.

Allen, S.E., H.M. Grimshaw and A.P. Rowland. 1986. Chemical analysis. In: Methods in Plant Ecology, 2nd ed., eds. P.D. Moore and S.B. Chapman, Oxford: Blackwell Scientific Publications. pp. 285–344.

Amin, R., M.S. Zia, K.C. Berger and A. Khan. 1989. Effect of fertilizer rates and phosphorus placement methods on corn production. *Sarhad J. Agric*., 5(3): 221-227.

Arnon, D. L. 1949. A copper enzyme is a isolated chloroplast polyphenol oxidase in Beta vulgaris. *Plant Physiol*., 24:1-15.

Ashraf, M. 2004. Some important physiological selection criteria for salt tolerance in plants. Flora: 9.361-376.

Candan, N. and L. Tarhan. 2012. Tolerance or sensitivity responses of *Mentha pulegium* to osmotic and water logging stress in terms of antioxidant defense systems and membrane lipid peroxidation. *Environ. Exp. Bot*., 75: 83-88.

FAO. 2008. Global Network on Integrated Soil Management for Sustainable use of Salt-affected Soils. Rome, Italy: FAO Land and Plant Nutrition Management Service. http://www.fao.org/ag/agl/agll/spush.

George, R. and M. Schmitt. 2002. Potassium for crop production. Minn Ext 800, 863-876.

Hasegawa, P.M., R.A., Bressan, J.K. Zhu, and P. Bohernet. 2000. Plant cellular and molecular responses to high salinity. Annu. Rev. Plant Physiol, *Plant Mol. Boil*., 51, 463-499.

Hirt, H., K. Shinozaki, 2004. Plant Responses to Abiotic Stress. Springer, Berlin – Heidelberg - New York – Hong Kong – London – Milan – Paris – Tokyo

Khan, A., Z. Shaheen and M. Nawaz. 2013. Amelioration of salt stress in wheat (*Tririicum aestivum* L.) by foliar application of nitrogen and potassium. *Sci., Tech. and Dev*., 32 (2): 85-98.

Khan A, I. Ahmad, A. Shah, F. Ahmad, A. Ghani, M. Nawaz, F. Shaheen, H.U. Fatima, F. Pervaiz, S. Javed, F. Hayat and H. Nawaz. 2013. Amelioration of salinity stress in wheat (*Triticum aestivum* L) by foliar application of phosphorus. FYTON. 82: 281-287.

Marschner, H. 1995. Mineral nutrition of higher plants. 2nd edn. London: Academic Press.

Mujeeb, R., A.S. Umed, Z. Mohammad and G.Shereen. 2008. Effects of NaCl Salinity on Wheat (*Triticum aestivum* L.) Cultivars. *World J. Agri. Sci.*, 4 (3), 398-403.

Munns, R., R.A. James, and A. Lauchli. 2006. Approaches to increasing the salt tolerance of wheat and other cereals. *J. Exp. Bot.* (57) 5: 1025-1043.

Nasim R., N.S. Roodbari, A. Ganjali, F.S. Nejad and M. Ansarifar. 2013. The Effect of Salinity Stress on Growth Parameters and Essential oil percentage of Peppermint (*Mentha piperita* L.). *Int. J. Adv. Biol. and Biom. Res.* 9: 1009-1015.

Panda, S.K., I. Chaudhury and M.H. Khan. 2008. Heavy Metals Induce Lipid Peroxidation and affect antioxidants in Wheat Leaves Plant Biochemistry Laboratory, School of Life Sciences, Assam (Central) University, Silchar, 788011, India.

Ross, M.K. 2001. Potassium as fertilizer for plants. *J. Plant Nutr*.425-433.

Safaa, R., L. El, T. Magdi, H. Abde and R. Fatma. 2013. Effect of Potassium Application on Wheat (*Triticum aestivum* L.) Cultivars grown under salinity stress. *World Applied Sciences Journal*, 26 (7): 840-850, 2013.

Shahzad, K., A. Khan and I. Nawaz. 2013. Response of wheat cultivars to different nitrogen levels under agro-climatic conditions in Mansehra. *Sci., Tech. and Dev*., 32 (2): 99-103.

Singla, R. and N. Garg. 2005. Influence of salinity on growth and yield attributes in chickpea cultivars. *Turk. J. Agric.*, 29: 321-235.

Volkmar, K.M., Y. Hu and H. Steppuhun.1998. Physiological responses of plants to salinity: A Review. *J. Plant Sci.*, 78, 19-27.

Winicov, I. 1993: Gene expression in relation to salt stress. Stress-induced Gene Expression in Plants. *Journal GmbH*.61-85.

Zhu, J.K. 2001. Plant salt tolerance. Trends in plant Sci. 61, 66-77. *Sci., Tech. and Dev*., 32 (2): 99-103, 2013.