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Effect of Different Levels of Foliar Application of Potassium on Hysun-33 and Ausigold-4 Sunflower (*Helianthus annuus* L.) Cultivars under Salt Stress

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Abstract. A hydroponic study was conducted to see the growth response of two cultivars of sunflower (Hysun-33 and Ausigold-4) to K^+ nutrition under salt stress during the growing season 2011, at National Agriculture Research Centre, Islamabad, Pakistan. Nursery of *Helianthus annuus* was raised in sand and ten-day old seedlings per hole were transplanted in each pot having four holes per pot lid. Half strength Hoagland's nutrient solution was filled in each pot. After the establishment of seedlings, salt stress (6 dS/m) was developed artificially. The treatments were, control, 2 and 4 % K^+ as K_2SO_4 foliar applications. Salt present in the growing medium caused a significant (P<0.00l), reduction in fresh and dry weights of sunflower. Salt stress suppresses the K uptake from pot. Application of varying levels of K_2SO_4 improved the fresh and dry weights of sunflower under both control and saline conditions. However, the highest increase in fresh and dry weight of control and stressed plants was observed when 2% K was applied. Further increase in the level of K application did not improve fresh and dry weights of salt stress and unstressed plants. The growth medium salts reduced sunflower growth.

Keywords: *Helianthus annuus*; salinity; K foliar application; biomass

Introduction

The demand for oil seeds has increased several times for the last few years but the acreage cannot be increased due to the increasing competition with major cereal crops. Sunflower is one of the four major oilseed crops (soybean, peanut, rapeseed and sunflower) grown for edible oil in the world, which is cultivated on about 23.31 million hectares (mha) all over the world. In Pakistan, it is grown on about 0.363 mha (MINFA, 2010). Oil seed crops are mostly grown on marginal lands and the productivity of oilseed crops is much less on saline soils because salinity exerts a number of adverse effects on plants including osmotic effects, ion toxicity and nutritional imbalance resulting in reduced growth and yield (Riaz *et al*., 2008; Munns, 2005; 2002; Ashraf, 2004). High external Na^+ inhibits the uptake of other nutrients particularly K^+, by interfering with the transport mechanism at the root plasma membrane such as K^+ selective ion channels (Tester and Davenport, 2003). Potassium ions constitute the most important macronutrients taken up by plants in salt-affected soils. Na^+ competes with K^+ and reduces its uptake and causes potassium deficiency (Carden *et al*., 2003). The capacity of plants to counter balance salt stress depends largely on the status of their K nutrition because it plays a vital role in many cell processes such as enzyme activity, cell turgor, regulation of stomatal movement and maintenance of osmotic pressure (Shabala *et al*., 2005; Shabala, 2003). Potassium increases the protein content, improves the efficiency of water use and produces resistance to diseases and insects. However, salinity stress greatly reduces the uptake and translocation of nutrient ions like K^+ and Ca^{2+} (Nawaz *et al*., 2002; Rangel, 1992). These problems can be tackled by growing the tolerant crops i.e., the crops able to produce high yields on such marginal lands (Sandhu and Qureshi, 1986). Salt-affected soils comparatively demand more nutrients for plant growth and optimum yield. The major fraction of potash fertiliser directly applied to soil gets fixed with clay fraction and becomes unavailable to crop plants (Ali *et al*., 2005). Further, the price of K fertilisers is increasing and is becoming unaffordable to farmers (NFDC, 2005). Keeping in view the economic importance of sunflower as oil seed crop, hydroponic experiment was conducted to test foliar application of K_2SO_4 using two sunflower cultivars (Hysun-33 and Ausigold-4) under salt stress during the growing season 2011, at Soil Salinity Laboratory, Land Resources Research Institute, National Agricultural Research Centre (NARC), Islamabad, Pakistan.

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Materials and Methods

Nursery of both cultivars was raised in sand at NARC and 10-day old one seedling per hole was transplanted in each pot having four holes per pot lid. Half strength Hoagland's nutrient solution was filled in each pot and after the seedling establishment; a salt stress of 60 mM (6 dS/m) was developed artificially. The treatments were 0, 2 and 4 % K^+ as K_2SO_4 foliar application. Crop was grown up to 4 weeks and data on fresh biomass per plant was recorded at the time of harvest. Plant samples were dried in oven at 60 ºC to a constant weight and the dry matter yield was recorded. Ground plant samples were digested in diacid (perchloric-nitric acid 2:1 ratio) mixture (Rhoades, 1982) to estimate Na and K by atomic absorption spectrophotometer (Perkin-Elmer, 4000). The experiment was set up in completely randomised design (factorial) with four replicates. The data obtained were subjected to statistical analysis using MSTAT-C and the treatment means were compared using Duncan's Multiple Range (DMR) test (Gomez and Gomez, 1984).

Results and Discussion

The fresh and dry weights of two sunflower cultivars are given in Table 1-2. Application of varying levels of K_2SO_4 improved the fresh and dry weights of sunflower under both normal and saline conditions. However, the highest increase in fresh and dry weight of control and stressed plants was observed with 2% foliar application of K as K_2SO_4. Sultana *et al*. (2001) concluded that foliar application of nutrient solutions partially alleviates the adverse effects of salinity and yield related components through mitigating the nutrient demands of salt-stressed plants. Further increase in the level of K application did not improve fresh and dry weights of salt stressed and unstressed plants. The concentrations of Na^+ and K^+ in sunflower tissue are presented in Table 3-4. Salt stress suppresses the uptake of K from soil but foliar application of K_2SO_4 improved the growth of sunflower cultivars under both control and saline conditions. However, the highest increase of control and stressed plants was observed when 2% K applied as a foliar spray. These findings are supported with the results of Kaya *et al*. (2001a). They suggested that supplementary P and K can reduce the adverse effects of high salinity on plant growth and physiological development. Further increase in the level of K application did not further improve the growth of salt stressed and unstressed plants.

Table 1. Fresh biomass (g/plant) of sunflower as affected by foliar application of K

Treat-ments	Salinity levels (dS/m)					
	0			6.0		
	Hysun-33	Ausigold-4	Mean	Hysun-33	Ausigold-4	Mean
Control	1.26c	1.28c	1.27C	1.17c	1.19b	1.18C
2% K	1.62a	1.55a	1.59A	1.55a	1.76a	1.67A
4% K	1.58ab	1.37b	1.48AB	1.33b	1.77a	1.57AB
Mean	1.49	1.4		1.35B	1.57A	

Means followed by different letter (s) within the columns differ significantly at 1% level of significance.

Table 2. Dry weight of sunflower (g/plant) as affected by foliar application of K

Treat-ments	Salinity levels (dS/m)					
	0			6.0		
	Hysun-33	Ausigold-4	Mean	Hysun-33	Ausigold-4	Mean
Control	0.04	0.05	0.045B	0.05	0.06	0.045C
2% K	0.07	0.06	0.065A	0.07	0.08	0.075A
4% K	0.05	0.07	0.060A	0.06	0.07	0.065B
Mean	0.05	0.06		0.06	0.07	

Means followed by different letter (s) within the columns differ significantly at 1% level of significance.

Table 3. Na Concentration (%) in sunflower tissue at harvesting

Treat-ments	Salinity levels (dS/m)					
	0			6.0		
	Hysun-33	Ausigold-4	Mean	Hysun-33	Ausigold-4	Mean
Control	0.30bc	0.43b	0.35AB	0.43bc	0.58bc	0.50BC
2% K	0.43b	0.43b	0.43A	0.53b	0.65b	0.59B
4% K	0.80a	0.53a	0.44A	0.73a	0.83a	0.78A
Mean	0.51		0.45		0.56B	0.68A

Means followed by different letter (s) within the columns differ significantly at 1% level of significance.

Table 4. K Concentration (%) in sunflower tissue at harvesting

Treat-ments	Salinity levels (dS/m)					
	0			6.0		
	Hysun-33	Ausigold-4	Mean	Hysun-33	Ausigold-4	Mean
Control	2.88c	2.40bc	2.64C	3.73bc	2.70c	3.21C
2% K	4.18b	2.95b	3.56B	3.98b	3.43b	3.70B
4% K	6.50a	3.43a	4.96A	5.53a	4.68a	5.10A
Mean	4.53A	2.92B		4.43A	3.60B	

Means followed by different letter (s) within the columns differ significantly at 1% level of significance.

The growth medium salts caused a marked reduction in growth of sunflower. However, application of potassium sulphate improved the growth of sunflower plants under both non-saline and saline conditions. Kaya *et al*. (2001b) suggested that sodium concentration in plant tissues increased in both cultivars of strawberry in the high NaCl treatment. Concentrations of P and K were in the deficient range in plants grown at high NaCl and these deficiencies were corrected by foliar application of these nutrients under salt stressed conditions. These results can be correlated to the findings that exogenous application of potassium offset the adverse effects of salinity and improved the growth attributes in different crop plants eg., strawberry (Kaya *et al*., 2001c), cucumber and pepper (Kaya *et al*., 2003). Similarly, in a study on *Lagenaria siceraria*, Ahmad and Jabeen (2005) reported that foliar application of potassium nitrate counteracted the salt induced growth inhibition in rice plants. However, in the present study 2% K_2SO_4 was found to be effective in minimizing the adverse effects of salt stress on sunflower plants.

Conclusion

Application of varying levels of K improved the fresh and dry mass of sunflower under both control and saline conditions. However, the highest increase in fresh and dry weight of controlled and stressed plants were observed when 2% K was applied as foliar spray. Further, 2% K foliar application increased the K^+ concentration of plant tissues grown under normal as well as salt stress conditions resulting in more biomass production. Nevertheless, the foliar application has no significant effect on both genotypes.

References

Ahmad, R., Jabeen, R. 2005. Foliar spray of mineral elements antagonistic to sodium-a technique to induce salt tolerance in plants growing under saline conditions. *Pakistan Journal of Botany*, **37:** 913-920.

Ali, A., Salim, M., Zia, M.S., Mahmood, LA., Shahzad, A. 2005. Performance of rice as affected by foliar application of different K fertilizer sources. *Pakistan Journal of Agricultural Sciences*, **42:** 38-41.

Ashraf, M. 2004. Some important physiological selection criteria for salt tolerance in plants. *Flora*, **199:** 361-376.

Carden, D.E., Walker, D.J., Flowers, T.J., Miller, A.J. 2003. Single cell measurements of the contribution of cytosolic Na^+ and K^+ to salt tolerance. *Plant Physiology*, **131:** 676-683.

Gomez, K.A., Gomez, A.A. 1984. *Statistical Procedures for Agriculture Research*, 680 pp., 2nd edition, John Wiley & Sons, Inc. New York, USA.

Kaya, C., Ak, B.E., Higgs, D. 2003. Response of salt stressed strawberry plants to supplementary calcium nitrate and/or potassium nitrate. *Journal of Plant Nutrition*, **26:** 543-560.

Kaya, C., Higgs, D., Kirnak, H. 2001a. The effects of high salinity (NaCl) and supplementary phosphorus and potassium on physiology and nutrition development of spinach. *Journal of Plant Physiology,* **27:** 47-59.

Kaya, C., Kirnak, H., Higgs, D. 2001b. The effects of supplementary potassium on strawberry cultivars grown at high salinity (NaCl). *Journal of Plant Nutrition*, **24:** 285-294.

Kaya, C., Kirnak, H., Higgs, D. 2001c. An experiment to investigate the ameliorative effects of foliar potassium phosphate sprays on salt-stressed strawberry plants. *Australian Journal of Agricultural Research*, **52:** 995-1000.

MINFA, 2010. *Agricultural Statistics of Pakistan*, Ministry of Food and Agriculture and Livestock (Economic Wing), Government of Pakistan Islamabad, Pakistan.

Miller, R.O. 1998. Nitric-perchloric acid wet digestion in an open vessel. In: *Hand Book of Reference Methods for Plant Analysis*, Y. P. Kalra (ed.), Soil and Plant Analysis Council, Inc., CRC Press, Washington DC., USA.

Munns, R. 2005. Genes and salt tolerance: bringing them together. *New Phytology*, **167:** 645-663.

Munns, R. 2002. Comparative physiology of salt and water stress. *Plant Cell Environment*, **25:** 239-250.

NFDC, 2005. *Fertilizer Use Related Statistics*, National Fertilizer Development Centre, Planning Division, Government of Pakistan, Islamabad, Pakistan.

Rengel, Z. 1992. The role of calcium in salt toxicity. *Plant Environment*, **15:** 625-632.

Rhoades, J.D. 1982. Cation exchange capacity. In: *Methods of Soil Analysis*, *Part-II*: *Chemical and Microbiological Properties*, A.L. Page (ed.), pp. 149-158, 2nd edition, American Society of Agronomy, SSA Madison, Wisconsin, USA.

Sandhu, G.R., Quereshi, R.H. 1986. Salt-affected soils of Pakistan and their utilization. *Reclamation and Revegetation Research*, **5:** 105-113.

Shabala, S., Shabala, L., Van Volkenburgh, E., Newman, I. 2005. Effect of divalent cations on ion fluxes and leaf photochemistry in salinized barley leaves. *Journal of Experimental Botany*, **56:** 1369-1378.

Shabala, S. 2003. Regulation of potassium transport in leaves from molecules to tissue levels. *Annual Botany*, **92:** 627-634.

Sultana, N., Ikeda, T., Kashem, M.A. 2001. Effect of foliar spray of nutrient solutions on photosynthesis, dry matter accumulation and yield in seawater-stressed rice. *Environment and Experimental Botany*, **2:** 129-140.

Tester, M., Davenport, R. 2003. Na^+ tolerance and Na^+ transport in higher plants. *Annual Botany*, **91:** 503-509.

Wright, R.J., Stuczynski, T. 1996. Atomic absorption and flame emission spectrometry. In: *Methods of Soil Analysis, Part-III*: *Chemical Methods*. D.L. Sparks, A. L. Page, P. A. Hlmke, R. H. Loeppert, P. N. Soltanpour, M. A. Tabatabai, C. T. Johnston and M. E. Sumner (eds.), pp. 65-90, Soil Science Society of America, Inc., Madison, WI, USA.