

Short Communication

Role of Potassium in Reducing Oxidative Damage in Maize under Salt Stress

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Abstract. Hydroponic experiment was carried out to assess the effect of K in reducing the oxidative damage in maize (Pioneer-3335) under salt stress. Seedlings were transplanted to three levels of K (3, 6 and 9 mM) with 100 mM NaCl stress. Plant growth parameters, membrane stability index, K^+ / Na^+ ratio and antioxidant enzymes activity were reduced due to salt stress. Addition of K significantly improved the morphological and physiological attributes along with the antioxidant enzymes (SOD, CAT and POD) activity. With increasing K levels an improvement in crop growth was observed but the treatment with 9 mM K was found to give the best results. Maximum shoot and root lengths (61.2 and 30.6 cm) were observed at 9 mM applied K level. The similar trend regarding shoot and root fresh weight was observed for maize genotype. Improved membrane stability was observed at 9 mM K level in (Pioneer-3335) (75.6%) under salt stress. Similarly, improved antioxidant enzymes (SOD, CAT and POD) activity was found in maize plants (35.5, 65.6 and 49.6 unit/g fresh weight) as compared to salt stress at 9 mM K level. The antioxidant enzymes activity was improved with the application of potassium under salt stress which ultimately induced oxidative stress tolerance in maize (Pioneer-3335).

Keywords: maize, salt stress, potassium, oxidative damage, antioxidant enzymes

Saline soil and water are the major constraints in reduced agricultural yield of many crops (Chaum *et al.*, 2011; Ashraf, 2009; Azevedo Neto *et al.*, 2006; Alam *et al.*, 2000). The metabolic activities in most crops ceased due to higher salt concentration in soils that ultimately results in low agricultural productivity (Karsensky and Jonak, 2012; Munns and Tester, 2008; Cramer *et al.*, 1996).

Along with osmotic stress, ionic imbalance and specific ion toxicity, the reactive oxygen species (ROS) generation is also coupled with salinity (Ali *et al.*, 2011; Nabati *et al.*, 2011; Gapinska *et al.*, 2008; Mittler, 2002).

Among all other macro nutrients potassium has the significant role in plant survival under salt stress (Mahmood, 2011; Cherel, 2004; Mengel and Kirkby, 2001).

Keeping in mind these factors this study was planned to assess the ameliorative efficiency of potassium under salt mediated oxidative stress.

This study was conducted in the Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan. Three potassium levels (3, 6 and

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9 mM) were applied with 100 mM NaCl stress. Maize genotype (Pioneer-3335) was used for this study. Maize seeds were germinated in sand containing trays and were transplanted in thermo pore sheets floating over Hoagland solution containing tubs at two leaf stage (Hoagland and Arnon, 1950). In respective saline treatments salinity was developed after two days of transplantation in 3 increments. 8 h daily aeration was provided through aeration pump and pH was maintained daily from 6-6.5.

After four weeks plants were harvested, recorded the growth attributes and stored in refrigerator for further analysis. The samples were analysed for membrane stability index according to method of Sairam *et al.* (2002). Sodium and potassium ion concentration was analysed using flame photometer.

Antioxidant enzymes activity (SOD, CAT, POD) was recorded using spectrophotometer from enzyme extract (For extracting antioxidant enzymes, 0.5 g fresh leaf samples were ground using a tissue grinder in 5 mL of 50 mM cooled phosphate buffer (pH 7.8) placed in an ice bath. The homogenate is centrifuged at 15000 × g

for 20 min at 4 °C. The supernatant is used for determination of antioxidant enzymes) following the method of Giannopolitis and Ries (1977) for SOD by recording the decrease in absorbance of nitro blue tetrazolium 560 nm (1955). Catalase enzyme activity was recorded by calculating the decomposition of H₂O₂ at 240 nm and peroxidase enzyme activity was determined by recording the absorbance at 470 nm after 0 sec for 5 min (Chance and Maehly, 1955). The experiment was laid out using CRD-Factorial arrangement and data was analyzed statistically using statistics 8.1. Plant growth attributes under salt stress have been shown in Table 1.

The data regarding K⁺/Na⁺ ratio in maize genotype (Pioneer-3335) has been showed in Table 2. These results depicted the fact that saline environment subjects the plants to uptake more Na⁺ as compared to K⁺ hence decreasing the K⁺/Na⁺ ratio. This ratio in plants grown in saline soils could be improved by the application of K.

Table 1. Effect of potassium on growth parameters of maize grown under salt stress

Treatments	Pioneer-3335			
	SL (cm)	SFW (g)	RL (cm)	RFW (g)
Control	99.9	45	42.4	6.47
100 mM NaCl	50.1 (50)	21 (47)	22.5 (53)	3.25 (50)
100 mM NaCl +3 mM K	53.3 (53)	23.9 (53)	24.2 (57)	3.67 (57)
100 mM NaCl +6 mM K	58.1 (58)	28 (62)	27 (64)	4.44 (69)
100 mM NaCl +9 mM K	61.2 (61)	31.5 (70)	30.6 (72)	5.12 (79)

Values in () are the percentage of control. (SL, SFW, RL and RFW are the abbreviations of shoot length shoot fresh weight, root length and root fresh weight), respectively.

Table 2. Effect of potassium on K⁺/Na⁺ ratio and membrane stability index of maize grown under salt stress

Treatments	Pioneer-3335	
	K ⁺ /Na ⁺ ratio	MSI
Control	2.67	88.6
100 mM NaCl	0.46 (17)	60.2 (68)
100 mM NaCl +3 mM K	0.51 (19)	66.5 (76)
100 mM NaCl +6 mM K	0.56 (21)	71.2 (80)
100 mM NaCl +9 mM K	0.60 (22)	75.6 (85)

Values in () are the percentage of control.

Results regarding antioxidant enzymes (SOD, CAT and POD) activity are presented in Table 3.

Table 3. Effect of potassium on antioxidants enzyme activity (SOD, CAT and POD) of maize grown under salt stress

Treatments	Pioneer-3335		
	SOD	CAT	POD
	(Unit/g FW)		
Control	25.6	64.6	43.8
100 mM NaCl	24.7 (96)	53.4 (82.8)	41.9 (95)
100 mM NaCl +3 mM K	26.9 (105)	58.7 (91)	44 (100)
100 mM NaCl +6 mM K	32.1 (125)	61.9 (95.9)	47 (105)
100 mM NaCl +9 mM K	35.5 (138)	65.6 (101.6)	49.6 (113)

Values in () are the percentage of control.

These results are supported by the facts that under salt stress plant photosynthesis rate, plant growth and biomass production is reduced (Akram *et al.*, 2011; Sun *et al.*, 2011; Cicek and Cakirlar, 2002). Application of K under saline treatment significantly improved membrane stability and plant growth parameters as supported by the fact that plant growth and yield of the crop is significantly increased by increasing the potassium dose (Fayez and Bazaid, 2013; Kaya *et al.*, 2007; Nadia and Bardan, 2006).

From these results it is clear that ROS production is triggered under saline treatment (100 mM NaCl) and suppressing the activity of antioxidant enzymes (Yu and Rengel, 1999; Hernandez *et al.*, 1995). Potassium is the major macro-nutrient that helps out the plants to overcome the salt stress conditions and its role in activating the enzymes is clearly depicted in this study that enhanced levels of K were helpful in improving the antioxidant enzymes activity. Such results are also previously revealed by Soleimanzadeh *et al.* (2010); Zheng *et al.* (2008).

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