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Response of Maize (*Zea mays* L.) Genotypes to NaCl Salinity Induced at Various Growth Stages of Crop

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Abstract

Two maize inbreds (B-73 and MO-17) and their hybrid (YHS-202) were subjected to NaCl salinity induced at four growth stages in a pot experiment during 1998. It comprised of three salinity treatments viz. 10, 15 and 20 dSm⁻¹ along with control having normal field soil (EC 2.5 dSm⁻¹). A progressive decrease occurred in all parameters with increasing salinity levels. Grain yield was reduced by 22 percent at 20 dSm⁻¹ as compared with control. Salinity affected all the genotypes but MO-17 proved comparatively better than other two. Deterioration was caused by salinity at all growth stages but it was more pronounced at earlier than later growth stages.

Introduction

Salinity is a global problem that largely limits crop production especially on irrigated area of the world. In Pakistan, as well salinity is one of the major soil problems. The soil of Pakistan has a great productive potential but salinity has hampered its crop production in some areas and inhibited it completely in others. The rapid increase in unproductive salt affected land is adversely affecting the economy of Pakistan. Many curative and management practices have been adopted by soil scientists to overcome the problem, but they are highly expensive. One of the possible alternatives is development of cultivars tolerant to high salt concentrations. The biological approach has received considerable attention in the last few decades. All the varieties of a crop are some times not equally sensitive to salinity (Ashraf *et al.*, 1986; Ahsan and Wright, 1998). This differential response has been reported for maize as well (Jan *et al.*, 1995). Plant growth is severely affected by salinity at all stages of development but sensitivity varies from one growth stage to another. New genotype combinations of maize are being tested and introduced continuously by the plant breeders and promising ones are released to the market. They need thorough threshing for various aspects including their capability to tolerate some adverse environmental and edaphic conditions. The present studies were planned to furnish the knowledge about growth and yield of two maize inbreds and their hybrid under saline conditions.

Materials and Methods

The experiment was conducted during spring 1998 at University of Agriculture Faisalabad, to study the effect of salinity on two maize inbred lines namely B-73 (G₁) and MO-17 (G₂) and their hybrid YHS 202 (G₃) obtained from Maize and Millets Research Institute Yousafwala, Sahiwal. Plants were sown in polyethylene lined pots filled with well mixed sand and field soil in a 40:60 ratio respectively. Experiment was laid out in a completely randomized design under split plot arrangement. The experiment comprised of four treatments in which salinity was induced using NaCl at

ECe levels of 10 (SL₂), 15 (SL₃) and 20 (SL₄) dSm⁻¹, while fourth treatment (control) comprised normal soil at ECe 2.5 dSm⁻¹ (SL₁). Salinity was applied as 6 percent NaCl solution in 3, 5 and 6 instalments for ECe 10, 15 and 20 dSm⁻¹ respectively at four different stages of growth i.e., seedling stage (30 days after sowing), Vegetative stage (45 days after sowing), reproductive stage (60 days after sowing) and at physiological maturity (75 days after sowing) named as GS₁, GS₂, GS₃ and GS₄, respectively. Each time crop was harvested one month after imposition of salinity.

Data were recorded for various growth and yield parameters at each harvest and analysed statistically using analysis of variance technique. Treatment means were compared by applying LSD test (Steel and Torrie, 1980).

Results and Discussion

All plant growth parameters progressively decreased with increasing salinity levels (Table 1). Plant height, number of leaves per plant and fresh weight as well as dry weight of plant were significantly less than control at higher salinity levels. Like other growth parameters leaf area per plant also differed significantly across various salinity levels. Reduction in leaf area occurs either due to reduction in leaf number (Huang and Redmann, 1995) or leaf size (Zidan *et al.*, 1992) and mostly as a result of reduction in both these parameters (Kayani and Rahman, 1988). Results inferred during this study resemble third category where a reduction in leaf area may be attributed to smaller and significantly lesser number of leaves. As compared with control a reduction upto 29 percent was noted in leaf area which might have affected the photosynthetic efficiency of the plants. Net Assimilation Rate (NAR) was the highest in control plants and the lowest in ECe 20 dSm⁻¹ which resulted in accumulation of less dry mass by plants at higher salinity levels. Reduction in formation of dry mass is one of the generally observed effects of salinity (Izzo *et al.*, 1993; Saqib and Qureshi, 1998). A reduction upto 50 per cent in dry matter of maize has been reported by Soliman (1988). This reduction can be attributed to

Table 1: Mean values showing effect of NaCl induced salinity on various parameters of maize genotypes

Parameters	Salinity levels (dSm ⁻¹)				Genotypes		
	SL ₁	SL ₂	SL ₃	SL ₄	G ₁	G ₂	G ₃
	2.5	10.0	15.0	20.0	B-73	M0-17	YHS-202
Plant height (cm)	91.70a	78.30b	72.20c	63.70d	76.30	76.80	76.50
Number of leaves/plant	8.60a	7.80b	7.20c	6.40d	7.40	7.70	7.40
Leaf area/plant (cm ²)	101.60a	91.90b	81.40c	72.50d	88.40	83.40	88.90
Plant fresh weight (g)	42.20a	34.90b	29.80c	25.30d	33.50	31.20	34.60
Plant dry weight (g)	10.30a	8.80b	7.60c	6.70c	7.40b	8.80a	8.90a
NAR (mg/cm ² /day)	0.004	0.003	0.003	0.002	0.004	0.004	0.003
Cob length (cm)	9.20	8.60	8.30	8.10	8.30b	9.40a	8.00b
Number of kernel rows/cob	11.40	11.00	10.20	9.90	10.20b	11.30a	10.40b
No. of kernel/row	10.00a	9.50ab	9.40ab	9.10b	9.30b	10.00a	9.20b
100 kernel wt. (g)	9.32	9.37	9.04	8.87	9.58	9.21	8.71
kernel wt./plant(g)	10.70a	10.00a	9.00b	8.30b	9.10b	10.50a	9.00b

Table 2: Response of maize genotypes to various salinity levels

Parameters	SL ₁ (2.5 dSm ⁻¹)			SL ₂ (10 dSm ⁻¹)			SL ₃ (15 dSm ⁻¹)			SL ₄ (20 dSm ⁻¹)		
	G ₁	G ₂	G ₃	G ₁	G ₂	G ₃	G ₁	G ₂	G ₃	G ₁	G ₂	G ₃
Plant height (cm)	92.2	90.8	92.2	75.9	79.8	79.4	73.0	72.3	71.3	64.2	63.8	63.2
Number of leaves/plant	8.5	8.8	8.4	7.8	8.0	7.7	7.1	7.3	7.2	6.2	6.6	6.4
Leaf area/plant (cm ²)	104.0	97.0	104.0	92.0	88.0	96.0	84.0	78.0	82.0	74.0	70.0	73.0
Plant fresh weight (g)	46.0	38.3	42.4	34.3	33.6	36.9	29.0	28.8	31.6	24.7	24.1	27.0
Plant dry weight (g)	9.6	11.1	10.4	7.8	9.0	9.6	6.5	8.0	8.4	5.9	7.1	7.2
Cob length (cm)	9.3	9.9	8.4	8.2	9.4	8.2	8.0	9.2	7.8	7.5	9.2	7.7
Number of rows/cob	11.6	11.8	10.9	10.9	11.6	10.6	9.3	11.1	10.1	9.1	10.9	9.8
No. of kernel/row	10.1	10.3	9.6	9.2	10.0	9.2	9.1	10.0	9.2	8.7	9.8	8.6
100 kernel wt. (g)	9.7	8.7	9.6	9.5	9.6	9.0	9.4	9.4	8.4	9.4	9.3	7.9
Kernel wt./plant (g)	10.8	11.5	9.8	9.6	10.8	9.4	8.0	10.1	8.6	7.6	9.4	7.9

Table 3: Effectiveness of various salinity levels at different growth stages of maize

Growth stages	Salinity levels	Plant height (cm)	No. of leaves/plant	Leaf area/plant (cm ²)	Plant fresh wt. (g)	Plant dry wt. (g)	NAR (g/cm ² /day)
GS ₁	SL ₁	78.0	5.3h	86.0gh	29.5	3.59l	0.006
	SL ₂	68.0	4.8hi	77.0l	18.2	2.64ij	0.004
	SL ₃	61.0	4.4i	67.0k	15.1	1.91	0.004
	SL ₄	53.0	3.9i	58.0l	12.6	1.71	0.004
GS ₂	SL ₁	86.0	7.6e	97.0d	42.2	9.6def	0.005
	SL ₂	73.0	6.6f	88.0fg	37.7	8.8fg	0.004
	SL ₃	66.0	5.9g	77.0i	32.7	8.1g	0.003
	SL ₄	57.0	4.9hi	70.0j	27.2	6.3h	0.001
GS ₃	SL ₁	95.0	9.9bc	110.0b	55.0	11.64c	0.002
	SL ₂	86.0	9.5c	99.0d	48.9	10.1de	0.001
	SL ₃	75.0	8.8b	88.0f	41.7	9.2efg	0.001
	SL ₄	67.0	8.0e	77.0l	36.1	8.3g	0.001
GS ₄	SL ₁	108.0	11.5a	113.0a	-	16.4a	-
	SL ₂	87.0	10.4b	104.0c	-	13.5a	-
	SL ₃	87.0	9.6c	93.0e	-	11.3ab	-
	SL ₄	78.0	8.1d	85.0h	-	10.63cd	-

decrease in various growth parameters under saline conditions. Deterioration of vegetative parameters by salinity has been reported by numerous workers in different crops such as maize (Fortmeier and Schubert, 1995), wheat (Sharma, 1995) and rice (Aslam *et al.*, 1995).

The yield components were also negatively affected by salinity. The size of cob got shortened with increasing salinity concentration. Number of kernels formed per row were less than control in saline soil and this difference from normal got widened to significant level in EC 20 dSm⁻¹. Number of kernel rows also got reduced by salinity. The least affected yield component was 100-kernel weight and the plants in various salinity levels formed grains of almost similar size.

Decrease in yield components is reflected in the final produce. At EC 10 dSm⁻¹ grain yield was at par with control. A significant decrease amounting to 16 and 22 percent in total kernel weight at EC 15 and 20 dSm⁻¹ respectively was recorded as compared to grain yield under normal soil condition. These results corroborate the findings of Raghav and Pal (1994), Ashraf *et al.* (1998) and Saqib and Qureshi (1998) for decreased yield in various crops under saline conditions.

Cumulative means of three genotypes for growth and yield parameters (Table 1) revealed significant differences, among themselves for yield components such as cob length, number of kernel rows per cob and number of kernels, per row while non-significant difference existed for 100-kernel weight. For all the yield components MO-17 (G₂) surpassed other two cultivars B-73 (C₁) and YHS-202 (G₃). Consequently, the total kernel yield was the highest in MO-17 and it depicted a significant difference of 13 and 14 percent from G₁ and G₃ respectively exhibiting better performance than its two counterparts. Genotypes G₁ and G₃ indicated non-significant difference in almost all the parameters and stood at par with each other in total kernel weight.

The interaction of three genotypes with various salinity levels presented non-significant differences for all the parameters (Table 2). All genotypes showed a gradual decrease in various parameters with corresponding increase in salinity levels. However, cumulative performance of G₂ reflected better results and depicted higher kernel weight at all salinity levels than other genotypes. Differences in behaviour of various cultivars of a crop confirms numerous earlier reports (Jan *et al.*, 1995; Ashraf *et al.*, 1998).

Perusal of Table 3 indicates that salinity affected negatively at all growth stages. Vegetative parameters were affected more at the first three growth stages as compared with fourth stage (GS₄), as the plants were in full bloom of their vegetative growth during the early periods. These facts are supported by the results of Net Assimilation Rate (NAR) which exhibited a linear decrease from growth stage 1 (GS₁) to growth stage 4 (GS₄), as well as reduced NAR was observed with increase in salinity levels from 2.5 dSm⁻¹ to 20 dSm⁻¹. These results agree with those reported by Dutt and Bel (1988) that increasing level of salinity reduced the Net Assimilation Rate.

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