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Response of Vegetative Growth of Maize (*Zea mays*) to a Range of Salinity

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Abstract: A pot experiment was conducted with five levels of salinity (EC 0, 2.0, 4.0, 6.0 and 8.0 dSm^{-1}) obtained by adding NaCl with soil in order to study the effect of salinity on vegetative growth of maize. Higher salinity levels caused significant reduction in growth parameters like leaf length, leaf breadth, leaf number and leaf area, root dry weight, shoot dry weight and total dry weight. However, it had less effect on root: shoot ratio.

Key words: QPM CV. Nutricta (Quality Protein Maize), salinity, Vegetative growth

Introduction

Salinity is one of the oldest and most serious environmental problems in the world (McWillium, 1986). Usually saline soils are characterized by high NaCl content and high osmotic potentials. Three hectares of arable lands are lost each minute because of soil salinization which is 30% of the world's total losses.

In Bangladesh over 30% of the cultivatable land along the coast is affected by varying degrees of soil salinity. Agricultural production in these areas is very poor and the cropping intensity is much lower (62-144%) than the national average intensity (159%) (Karim ***et al.***, 1990). The Soil Resources Development Institute (SRDI) reported that salinity in these areas is increasing rapidly during the dry season when the concentration of salts in the soil surface builds up by rapid evapotranspiration. As a result, soil and water of those areas become unfit for locally conventional crop production. For this reason, about 3,00,000 hectares of otherwise cultivated land is not cropped for several months during the dry season (Anonymous, 2000). Ultimately salinity causes a drastic reduction in crop yield in these areas.

Maize (***Zea mays***) is an important cereal crop in the world and it ranks third after rice and wheat in Bangladesh (Hossain ***et al.***, 1999). According to FAO report the average yield of maize in the world was 3.4 tons ha^{-1} as compared to 1.9 tons and 2.9 tons for wheat and rice, respectively (Islam and Kaul, 1996). More than 70 countries of the world including 53 developing countries are farming maize (Ignazi, 1981). It can be cultivated throughout the Bangladesh. Now the potential demand for maize is 0.27 million tons and the demand is expected to increase to

0.44 million tons soon (BBS, 1994). The cultivation method of maize is very easy and the production cost is comparatively lower than that of other grain crops.

In Bangladesh works on salinity are limited. Similar studies in other countries of the world although provided useful information; those may not be applicable directly to climate, soil and other soil conditions in Bangladesh. Therefore the goal and objective of the present study is to evaluate the effect of salinity on vegetative growth of maize.

Materials and Methods

Completely randomized designs of pot experiment with 4 replications were carried out in the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh. Five levels of salinity viz. 2.0, 4.0, 6.0 and 8.0 dSm^{-1} including zero salinity obtained by adding NaCl at different proportions were examined in maize plant development at five successive harvest dates. Quality protein maize cv. Nutrica was used as the test material in the experiment.

Pot preparation

The soil was collected from the farm of the Bangladesh Agricultural University, Mymensingh. In every pot the soil was incorporated with 2 g N, 1 g P and 1 g K in the form of urea, TSP and MP respectively. Depending on different treatments, various amounts of NaCl were thoroughly incorporated with the soil. Twenty kilogram of processed soil was taken in each of the polyethylene lined earthen pots measuring 50 cm in diameter. All pot surfaces were sterilized by 70% ethyl alcohol. The bottom hole of each pot was filled with small earthenware pieces. The pots were arranged at random. Fifty cm space was left in between pots and 80 cm space was left between rows for the convenience of cultural operations. Polyethylene shades were used in order to protect the plants from rain.

Seed sowing and cultural practices

The seeds were surface sterilized by soaking in 0.2% sportak solution for 30 min. and rinsed out by distilled water. Ten seeds were pressed downward 2 cm below the soil surface of each pot. Watering was done regularly with distilled water to maintain appropriate moisture level in the soil for suitable plant growth. A certain amount of distilled water was applied every day after planting and kept enough soil moisture level for appropriated plant growth. The plants were thinned out to 6 plants/pot at 12 days after planting. In every pot, nitrogen fertilizer was applied @ 2 g N/pot as urea solution at 4, 6 and 8 weeks after sowing. During growing period, the parathion E 605 was sprayed twice, once at 4 and then at 6 weeks after sowing.

Harvesting

The plants were harvested at 7 days interval starting from 21 DAS to till maturity. At each harvest, plant dry matter was evaluated after drying in the hot air oven at 100^{0}C for 48 h.

Leaf growth

Total number of leaves was recorded by counting the number of leaves produced on the main stem axis between the base and the tassel. Length (L) and greatest width (W) of leaf were measured with the help of a graduated scale and leaf area (LA) was calculated by using the formula as stated by Fakorede ***et al.*** (1977).

Percent reduction in number of leaves, leaf length, leaf breadth and leaf area were also calculated as follows:

$$\% \text{ Reduction} = \frac{\text{(Average value at control)-(Average value each salinity levels)}}{\text{Average value at control}}$$

Root:shoot ratio

Plants from each pot were uprooted at 7 days interval starting from 21 DAS and continued up to 49 DAS. The roots and shoots were separated, washed in running water and weighed separately (oven dried at 100°C for 48 h). The root:shoot ratio was calculated by the formula as given below:

$$\text{Root Shoot ratio} = \frac{\text{Dry weight of root (g)}}{\text{Dry weight of shoots (g)}}$$

Statistical analysis

The analysis of variance of parameters as affected by salinity was determined. Means were compared at 95% confidence using Duncan's new multiple range test (DMRT).

Results and Discussion

Leaf growth parameters

Influence of salinity on leaf growth was assessed in terms of leaf number, leaf length, leaf breadth and leaf area at various growth stages (Table 1, 2). The number of leaves per plant was reduced under salinity by 9.4-50.9%, 9.4-55.1%, 3.6-58.7%, 10.5-54.0 and 3.6-50.3% at 21, 28, 35, 42 and 49 DAS respectively. Leaf growth reductive reached 58.7% at EC 8.0 dSm^{-1} 35 DAS, but was only 3.6% at 2.0 dSm^{-1} for 49 DAS. One of the notable effects of salinity on leaf development

Table 1: Leaf length and leaf breadth of maize as affected by salinity

Salinity levels EC(dSm^{-1})	Leaf of number					Leaf area (cm^2)				
	Days after sowing					Days after sowing				
	21	28	35	42	49	21	28	35	42	49
0.0	33.56a	57.05a	80.77a	86.57a	93.07a	3.14a	4.84a	6.51a	6.64a	6.77a
2.0	27.76ab	52.55ab	77.33a	83.03a	89.00a	2.32b	4.19a	6.05a	6.25a	6.43ab
4.0	24.62bc	44.60b	65.07a	75.83a	82.67ab	2.21bc	3.30b	4.19b	5.16b	6.10ab
6.0	19.05c	34.76c	47.97b	60.32b	72.77bc	1.90c	2.84bc	3.80b	4.14bc	5.01bc
8.0	9.02d	18.73d	28.47c	47.77c	67.23c	1.35d	2.31c	3.25b	3.51c	4.10c

Table 2: Leaf number and leaf area of maize as affected by salinity

Salinity levels EC (dSm^{-1})	Leaf number					Leaf area (cm^2)				
	Days after sowing					Days after sowing				
	21	28	35	42	49	21	28	35	42	49
0.0	8.28a	9.62a	10.72a	12.57a	13.83a	811.63a	1656.3a	2352.2a	3745.7a	5377.6a
2.0	7.50a	8.72b	10.33ab	11.25ab	13.33a	427.05b	990.2b	1553.3b	2995.1b	4357.4b
4.0	7.08a	7.60c	9.22b	10.07b	12.67a	326.76bc	664.1c	1116.8c	2243.9c	4024.4b
6.0	4.65b	5.73d	6.45c	7.82c	9.17b	204.78c	500.2c	802.6c	1370.8d	2377.2c
8.0	4.07b	4.32e	4.43d	5.78d	6.87c	35.19d	145.1d	369.9d	677.8e	1350.9d

A different letter in each column indicates numbers are significantly different on a 95% confidence interval using DMRT.

Table 3: Root and shoot dry weight of maize as affected by salinity

Salinity levels EC (dSm^{-1})	Root dry weight (g/plant)					Shoot dry weight (g/plant)				
	Days after sowing					Days after sowing				
	21	28	35	42	49	21	28	35	42	49
0.0	0.47a	3.18a	5.37a	6.27a	7.83a	4.03a	12.69a	22.40a	38.00a	57.60a
2.0	0.49a	0.96b	1.67b	4.56b	6.93ab	2.04b	8.69b	13.58b	29.93b	45.27b
4.0	0.13b	0.81b	1.39bc	3.78b	5.93b	1.36c	6.42c	10.39c	23.78b	39.67b
6.0	0.06bc	0.60bc	1.13c	2.34c	3.17c	0.97c	4.03d	7.82cd	14.83c	24.23c
8.0	0.03c	0.42c	0.68d	1.79c	2.28c	0.07d	3.38d	6.51d	13.73c	22.07c

Table 4: Total dry matter weight and root: shoot ratio of maize as affected by salinity

Salinity levels EC (dSm^{-1})	Root: shoot ratio					Total dry matter weight (g/plant)				
	Days after sowing					Days after sowing				
	21	28	35	42	49	21	28	35	42	49
0.0	0.12c	0.25a	0.24a	0.17a	0.14a	4.50a	15.86a	27.77a	44.13a	65.43a
2.0	0.24b	0.11b	0.12b	0.15a	0.16a	2.53b	9.66b	15.26b	34.49b	52.20b
4.0	0.09c	0.13b	0.14b	0.15a	0.15a	1.49c	7.23c	11.79c	27.57c	45.93b
6.0	0.06c	0.15b	0.15b	0.16a	0.13a	1.02d	4.63d	8.95d	17.17d	27.40c
8.0	0.56a	0.13b	0.11b	0.13a	0.11a	0.10e	3.81d	7.19d	15.52d	24.35c

Figures followed by different letter in a column differ significantly at 5% level by DMRT

was the reduction in the linear growth of leaves at different growth stages. Salinity caused significant reduction in leaf breadth over the control (Table 1). Reduction increased gradually as salinity increased and maximum reduction was noted the high salinity level at all sampling dates. Comparatively lower reduction was found at 49 DAS for every treatment. A drastic reduction was observed in leaf area under salinity as leaf length and leaf breadth, the component of leaf area, was highly affected by salinity. These results strengthened the earlier results of Kayani and Mujeeb-ur-Rahman (1988) and Zidan ***et al.*** (1992).

Root dry weight

The levels of salinity have profound effect on growth and development of root system. The dry root weight of the plants grown at normal condition was always higher than that grown at substantially higher salinity levels. At 49 DAS, the plants grown on zero EC had maximum root dry weight (7.83 g/plant) while those grown on EC 8.0 dSm^{-1} had only 2.28 g/plant. There was more than 90% reduction in root weight of the plants at 21 DAS in EC at 8.0dSm^{-1}. It was observed that the amount of reduction in dry root was minimum at later stages of plant growth. These results confirm the findings of Zidan ***et al.*** (1992) and Izzo ***et al.*** (1991).

Shoot dry weight

Accumulation of shoot dry weight decreased with increasing salinity (Table 3). Sharp decrease in shoot dry weight was found beginning from beginning at 2.0 dSm^{-1} and the effects of salinity were extreme at 8.0 dSm^{-1} during the whole study period. However, shoot dry weight increased with respect to time for all treatments. Although sometimes the difference between two treatments was not statistically significant, there was gradual decline in all dry matter accumulation with increasing salinities. These results were agreed with the findings of Kayani and Mujeeb-ur-Rahman (1988) and Soliman (1988).

Total dry matter weight

Total dry matter was decreased with the increasing levels of salinity in the soil (Table 4). Decreases in dry matter occurred across the entire range of salinity but were particularly sharp above the EC value of 4 dSm^{-1}. The decrease in dry matter probably resulted from the decreasing availability of soil water and increasing toxicity.

Root shoot ratio

The root: shoot ratio did not follow a particular trend in relation to the levels of salinity. Root shoot ratios at 0.0, 4.0 and 6.0 dSm^{-1} were statistically identical but they differed significantly from that in 8.0 dSm^{-1}. Thus it is evident from the results that salinity had little effect on the root: shoot ratio except only in plant development (Table 4).

From the above discussion it is clear that salinity decreased the vegetative growth of maize in terms of dry weight of root, shoot and total dry weight is affected by salinity. Salinity at 8.0 dSm^{-1} severely affected maize throughout the all-sampling dates. It is notable that both root and shoot dry weights were similarly affected by salinity so that salinity had little affect on the root:shoot ratio.

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