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# Effect of Salinity on the Chlorophyll Content, Yield and Yield Components of QPM CV. Nutricta

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**Abstract:** A pot culture experiment was conducted with five levels of salinity (EC 0, 2.0, 4.0, 6.0 and 8.0 dS $m^{-1}$) obtained by dissolving NaCl in distilled water to study the effect of salinity on chlorophyll content, yield and yield components of Quality Protein Maize (QPM) CV. Nutricta. Ear length, ear diameter, number of seeds per ear and 100 seed weight were also reduced at high salinity levels. Increasing salinity decreased the content of chlorophyll a, chlorophyll b and total chlorophyll and had little or no effect on chlorophyll a/b. A gradual and significant decrease in nitrogen and potassium contents was recorded in maize shoot and grain with an increasing salinity. Accumulation of $N^+$ and $K^+$ in grains were smaller than in shoot or straw. Due to its high yield potential I normal soil and high yield reduction in salinity it is regarded as a highly saline sensitive crop.

**Key words:** Salinity, Chlorophyll, QPM CV. Nutricta

## Introduction

Salinity is a significant global problem causing a great reduction in agricultural productivity In Bangladesh about 0.82 million hectares of croplands are affected by salinity problem (Shaheed, 1994). Agricultural land uses in these areas is very poor (60 -114 %) which is much lower than the country's average cropping intensity (166 %). In order to utilize such lands, an understanding of the tolerance limits for different crops, varieties and growth stages with respect to salinity is required under different AEZ conditions and soil types. Reclamation of saline soils being a costly and cumbersome process growing crops/crop varieties tolerant to saline conditions provides a more desirable way of tackling the problem (Yadav and Mehta, 1964).

Maize *(Zea mays* L.) is the most important cereal crop in the world after rice and wheat. As regard cultivated area, it ranks third position after wheat and rice in world statistics. Besides these, since maize is C4 plant, it is photosynthetically more efficient than C3 plants i.e. rice and wheat. It is also year-round crop for its wider range of climatic adaptability. According to Mass and Hoffman, maize is generally regarded as a highly salt sensitive species. Quality Protein Maize (QPM) CV. Nutricta recently developed by CIMMYT is nutritionally improved maize containing high levels of essential amino acids. Comparative adaptability of this cultivar to our local climate has been tested. But its salt tolerance limits is not well documented. Knowledge of physiological basis of salt tolerance in any crop plant is an essential pre-requisite for selecting or breeding salt tolerant varieties and for developing agronomic practices. In view of the above, a study was conducted to evaluate the effect of saline water on growth, yield and chemical composition of maize crops.

## Materials and Methods

A pot experiment was carried out with maize as a test crop on sandy loam soils at the grill house of Dep. of Crop Botany, Bangladesh Agricultural University, Mymesingh. The soil was mixed well with cowdung. Urea, TSP and MP at corresponding to 260 kg/ha, 133 kg/ha, 83 kg/ha, respectively were applied as per recommendation of Islam and Kaul (1986). Common salt (NaCl) at different proportion were mixed well with the potted soil to raise its electrical conductivity (EC) of different values. Thus the treatments of the experiment were as follows: $T_1$ = 0.4 dS $m^{-1}$ (control, no salt was used), $T_2$ = 2.0 dS $m^{-1}$, $T_3$ = 4.0 dS $m^{-1}$, $T_4$ = 6.0 dS $m^{-1}$ and $T_5$ = 8.0 dS $m^{-1}$.

Earthen pots (490 $cm^2$) were arranged in rows that were 0.8 m apart and the pots within each row were 0.5 m apart. Equal amount of mixed soil (20 kg/pot) was filled in earthen pots. Five pots representing each of five treatments (a control and four saline treatments) were distributed randomly within each of the three experimental rows (i.e. each row contained one replication). Five seeds of the QPM cv. Nutricta were sown in each pot on 22 March 1994. After emergence, seedlings were thinned to one per pot. A bottom hole of each pot was sealed up by polythene. Irrigation was done four times at 15 days interval throughout the crop growth period with NaCl solution. Other cultural practices were also done as and when required.

Final harvest was made following physiological maturity. It was assumed that physiological maturity (black layer formation) occurred when 50 percent of the plants had at least one kernel in the central portion of the ear that had a black or brown area near the tip. Observations on ear length (cm), ear diameter (cm), seed number per ear, 100 seed weight (g), seed yield (g/plant) were recorded at harvest. After harvest, the plant parts were separated into root, shoot (stem and leaves) and seeds. They were ovens dried at 80°C for 24 hours and these weights were recorded individually. Total dry matter (TDM) and Harvest index (HI) was calculated y the following formula:

Table 1: Effect of salinity on the yield and yield components of maize

| Treatment | Ear length (cm) | Ear diameter (cm) | Seed number ear | 100 seed wt. (g) | Seed yield (g/plant) | Total dry matter (g/plant) | Harvest index |
|---|---|---|---|---|---|---|---|
| T1 | 14.17a | 4.28a | 395.00a | 28.30a | 111.83a | 277.25a | 0.40a |
| T2 | 12.67ab | 3.38b | 307.33b | 27.50a | 84.54b | 228.33b | 0.37ab |
| T3 | 10.83bc | 2.98bc | 222.00c | 26.20b | 58.33c | 169.83c | 0.34b |
| T4 | 9.17c | 2.65c | 124.00d | 24.85b | 30.59d | 119.27d | 0.26c |
| T5 | 5.67d | 1.98d | 68.00e | 23.30c | 15.73e | 65.90e | 0.24c |
| CV (%) | 10.4 | 11.5 | 11.5 | 7.4 | 14.1 | 10.3 | 9.2 |

Table 2: Changes in chlorophyll contents in maize leaves grown under different salinity levels at 21 DAS and 42 DAS. Values in parentheses indicate percent activity with reference to respective controls

| Treatment | 21 days after sowing | | | | 42 days after sowing | | | |
|---|---|---|---|---|---|---|---|---|
| | Chl.a | Chl.b | Total Chl.(a+b) | Chl.(a/b) | Chl.a | Chl.b | Total Chl.(a+b) | Chl.(a/b) |
| | mg $g^{-1}$ fresh weight | | | | mg $g^{-1}$ fresh weight | | | |
| T1 | 2.85a (100) | 1.12a (100) | 3.97a (100) | 2.55a | 2.89a (100) | 1.36a (100) | 4.25a (100) | 2.13b |
| T2 | 2.59b (90.88) | 0.99b (88.39) | 3.58b (90.81) | 2.61a | 2.74ab (94.81) | 1.07c (78.68) | 3.81b (89.65) | 2.55a |
| T3 | 2.58b (90.53) | 0.98b (87.50) | 3.56b (89.67) | 2.64a | 2.68b (92.73) | 1.22b (89.71) | 3.90b (91.76) | 2.20b |
| T4 | 2.91c (76.84) | 0.83c (74.11) | 3.02c (76.01) | 2.65a | 2.50c (86.51) | 1.09c (80.15) | 3.58c (84.24) | 2 . 30b |
| T5 | 1.98d (69.47) | 0.83c (74.11) | 2.81d (70.78) | 2.39a | 1.63d (56.40) | 0.78d (57.35) | 2.41d (56.71) | 2.10b |
| CV (%) | 3.2 | 4.5 | 2.5 | 6.0 | 3.7 | 3.6 | 2.6 | 5.8 |

Means in a column followed by the same letter are not significantly different at P=0.05

$$HI = \frac{\text{Economic Yield (Grain yield)}}{\text{Biological Yield (TDM)}}$$

**Estimation of chlorophyll:** Chlorophyll a and chlorophyll b were estimated following the formula of Yoshida *et al.* (1976).

**Analysis of Na, K and N content:** Plant from each pot was uprooted 7 days interval starting from 21 DAS and continued up to 49 DAS and at final harvest. The plant samples were duly washed and dried at 80°C for 24 hours. For the determination of Na & K shoot, straw and grains were digested with acid digestion method as outlined by Page *et al.* (1989) and N was determined after wet $H_2SO_4$ digestion by the Microkjeldahl method. Concentrations of $Na^+$ and $K^+$ were determined by flame emission spectrophotometry using Atomic Absorption Spectrophotmetery (AAS). The data were statistically analyzed by the analysis of variance and the treatment means were compared by Duncan's New Multiple Range Test (DMRT).

## Results and Discussion

**Ear Length and Ear diameter:** Ear length and ear diameter were significantly affected by applied salinity treatment (Table 1). The reduction in ear length was 10.59, 23.57, 35.29 and 59.99 percent in T2, T3, T4 and T5 respectively compared to control. The extent of reduction in ear diameter varied from 21.03 to 53.74 percent over control. Maximum ear length and diameter was recorded in control. The reduction in eat length and ear diameter might be due to less water supply because of salinity. Another probable reason is the resultant nutrient imbalance under high salt concentration and short supply of photosynthates to the sink due to the inhibitory effect of salinity. Joshi (1992) noticed similar results.

**Grain Number per plant:** Seed number per ear decreased significantly with increased salinity levels (Table 2). The extent of reduction over control varied from 21.19 to 82.78 per cent under different salinity levels. Haqqani *et al.* (1984) has also recorded analogous findings. It might be explained as short supply of assimilates from the vegetative parts to the grain due to salinity.

Table 3: Effect of salinity on mineral composition in different parts of maize plant at different growth stages

| Treatment | Days after sowing | | | | | % N, Na, & K in stover at harvest | % N, Na & K in grain |
|---|---|---|---|---|---|---|---|
| | 21 | 28 | 35 | 42 | 49 | | |
| | | | | Nitrogen content (%) | | | |
| T1 | 2.85a | 2.54a | 2.18a | 2.09a | 2.01a | 0.88a | 1.59a |
| T2 | 2.50b | 2.22b | 1.93b | 1.82b | 1.71b | 0.75b | 1.46b |
| T3 | 2.39c | 2.06c | 1.75c | 1.68c | 1.57c | 0.64c | 1.33c |
| T4 | 2.03d | 1.83d | 1.60d | 1.49d | 1.39d | 0.58c | 1.25d |
| T5 | 1.93e | 1.52e | 1.14e | 1.06e | 1.05e | 0.48d | 1.04e |
| | | | | Potassium content (%) | | | |
| Ti | 2.47a | 2.34a | 2.11a | 1.97a | 1.90a | 1.12a | 0.37a |
| T2 | 2.16b | 2.00b | 1.69b | 1.55b | 1.46b | 0.79b | 0.31b |
| T3 | 2.01b | 1.81c | 1.61b | 1.48b | 1.39c | 0.67c | 0.24c |
| T4 | 1.79c | 1.69d | 1.55b | 1.44b | 1.31d | 0.56d | 0.22c |
| T5 | 1.58d | 1.42e | 1.37c | 1.27c | 1.10e | 0.30e | 0.18d |
| | | | | Sodium content (%) | | | |
| T1 | 0.017c | 0.018e | 0.018d | 0.016d | 0.011e | 0.013c | 0.004d |
| T2 | 0.840b | 0.962d | 1.006c | 1.014d | 1.117d | 1.214c | 0.006cd |
| T3 | 1.044b | 1.288c | 1.364bc | 1.274c | 1.620c | 1.618c | 0.007bc |
| T4 | 1.146b | 1.353b | 1.559b | 1.696b | 1.887b | 1.828b | 0.008ab |
| T5 | 1.284a | 1.499a | 1.747a | 1.857a | 2.128a | 1.939a | 0.009a |

Means in a column followed by the same letters are not significantly different at P =0.05

**100-Grain weight:** It was revealed from the Table 2 revealed that 100 grain weight (28.30 g) was observed in control followed by 27.50 g in T2 and was minimum (23.30 %) in T5. The results are In accordance with the findings of Haqqani *et al.* (1984). In the grain filling process grains act as a physiological sink. The source for this sink is provided by the leaves and to a much lesser extent by hulls and awns (Mengel and Kirkby, 1982). Salinity enhances senescence of leaf so that grain-filling process is hampered. As a result grain size was hindered. Salinity decreased K content progressively (Table 1). Inadequate K nutrition affects grain filling which may lead to deformation of the cobs.

**Grain yield and total dry matter:** Values for grain yield (g/pant) and TDM (g/plant) in the control treatment were significantly higher than those at different salinity levels (Table 2). Grain yield and TDM decrease gradually as the salinity levels increased. A drastic reduction was found in T5 both for seed yield and TDM. The salinity levels of T2, T3, T4 and T5 significantly reduced grain yield by 24.40, 47,84, 72.65, 88.88 percent and TDM by 17.64, 38.74, 56.98, 76.23 percent respectively compared the control. Hence reduction was less in TDM than in grain yield with increase in salinity levels, as also reported by Khandelwal and Lal (1991).

Grain yield reductions were associated with reduced grain weight and reduced grain number per ear with increasing salinity. Reduction in plant height lowered the dry weight of the vegetative parts and thereby lowered the straw yield. The grain yield determined by the ability to translocate assimilates from the foliage to grain. The salinity-induced reduction in yield can be explained from the increased number of sterile florets per ear and a short supply of assimilates due to the growing grains.

**Harvest Index (HI):** The highest harvest index (0.40) was observed in control and the lowest harvest index (0.24) in T5 treatment. It reflects that grain yield i.e. economic yield was much more sensitive to salt than stover yields. Harvest index varied from 0.24 to 0.40 (Table 1). These results are in agreement with the findings of Kaddah and Ghowail (1964).

**Chlorophyll Contents:** The effects of salinity on chlorophyll a, chlorophyll b, total chlorophyll (a + b) and chlorophyll a/b is shown in Table 3. Chlorophyll a content was highest in control and lowest in T5 both at 21 DAS and 42 DAS. There was no significant difference between T2 and T3 both at 21 DAS 42 DAS. At 42 DAS T1 and T2 did not differ significantly. It was also observed that chlorophyll a content showed gradual reduction under different salinity levels beginning from T1 and the extent of reduction varied from 9.12 to 30.52 percent and 5.12 to 43.59 percent at 21 DAS and 42 DAS respectively.

It is evident from the table 3 that control plant accumulated greater amount of chlorophyll b and with increasing salinity the chlorophyll b contents gradually declined, the decrease being more in T5 both at 21 and 42 DAS. Though T1 and T5 accumulated maximum and minimum amount of chlorophyll b, but there was no gradual reduction. The extent of reduction varied from 11.61 to 25.89 percent and 10.29 to 42.65 percent at 21 and 42 DAS respectively.

Total chlorophyll content showed a decreasing tend with increasing levels of salinity. As a result the maximum leaf chlorophyll was recorded at the control plant (T1) and minimum at the control plant (T1) and minimum at the highest salinity level (T5). It is notable that accumulation of total chlorophyll at 42 DAS was higher than that of 21 DAS except T5 at 42 DAS. The extent of reduction for total

chlorophyll varied from 9.82 to 29.21 percent and 8.24 to 43.29 percent at 21 and 42 DAS respectively.
No significant difference on Chl. a/b was observed among the treatments at 21 DAS. Except T2 and 42 DAS all treatment effects did not differ significantly. T2 showed higher result as because chlorophyll b was much more effected than chlorophyll a in treatment T2.
Salt stress markedly reduced the content of chlorophyll in the leaf and could be due to decreased pigment synthesis or a high rate of chlorophyll in the leaf and could be due to decreased pigment synthesis or a high rate of chlorophyll degradation (Yeo and Flowers, 1983; Sharma and Gupta, 1986). The high activity of chlorophyll as results lowering of chlorophyll content as reported earlier (Reddy and Vora, 1986). The decrease in total chlorophyll is mainly attributed to the destruction of chlorophyll-a, which is considered to be more sensitive to salinity than chlorophyll b.

**$Na^+$ content:** The effect of salinity on the accumulation of $Na^+$ in straw was significant at any stages of the plants. It was observed that accumulation of Na at maturity was higher as compared to its content at vegetative stage. Always control plants showed least amount of Na while T5 showed the maximum. John *et al.* (1977) noticed similar results.

**$K^+$ content:** The $K^+$ content was remarkably low in T5 and high in T1 (Control). The salinity effect was most prominent at 49 DAS. The older plants have less amount of $K^+$ than the young plants at any salinity levels. This finding is in agreement with other reports (Soliman, 1988; Izzo *et al.,* 1991; Dravid and Goswami, 1986). The decline in $K^+$ content occurs due to decrease in sink size with the higher concentrations of NaCl, which strongly inhibited shoot and root growth. Increased $Na^+$ content decrease the $K^+$ content (Siegel *et al.,* 1980) suggesting an antagonism between $Na^+$ and $K^+$. The very severely depressive effect of NaCl on $K^+$ absorption might be caused by the competitive relation between monovalent cations, in addition to the lowering of osmotic potential due to high concentration of NaCl.

**Total nitrogen content in plant:** Data presented in Table 3 revealed that plants grown under saline condition had lower nitrogen content in above ground plant parts than the control. Moreover, the N content of the above ground parts of maize plants was very sensitive to the levels of salinity. As a result, the treatments (levels of salinity) were able to maintain a similar trend in N content at any growth stages of the plants. Stover of maize of final harvest showed least amount of nitrogen. Decrease in accumulation of nitrogen by plants under salinity has also been reported by Yadav and Mehta (1964) but Maliwal and Paliwal (1971) reported that absorption of N increased up to an EC value of 4 to 6 mmhos/ch but decrease in yield at higher salinity levels.
It is possible that the salt tolerance of QPM CV. Nutricta can be improved through selective breeding with cultivars with higher salt tolerance. Other possibilities include the transfer of tolerance genes from more salt tolerant wild relatives through wide hybridization or the improvement of salt tolerance through in vitro selection and regeneration of cell cultures (Jena, 1994; Winicov, 1996). Until solutions can be found to improve the genetic tolerance of QPM CV. Nutricta growers will have to apply more careful management techniques to avoid yield losses due high salinity during early growth stages. Additional studies are needed to determine optimum management practices necessary to minimize yield losses.

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