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# EFFECTS OF SALINITY ON ION ACCUMULATION IN MAIZE (*ZEA MAYS* L. CV. BARI-7)

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**Abstract**

NaCl salinity in the range of 50 to 200 mM increased $Na^+$ accumulation in the root and shoot of 7-, 14- and 21-day-old maize seedlings. The accumulation of $Na^+$ and $Cl^-$ increased but $K^+$ accumulation decreased with the increase in NaCl concentration from 50 to 200 mM in the root and shoot of maize in all the three ages.

Salinity is a common abiotic stress factor seriously affecting crop production in different regions, particularly in arid and semi-arid regions. Salinity is the single largest soil toxicity problem, and about 52.8% of the net cultivable area in the coastal and offshore areas of Bangladesh is affected by varying degrees of salinity (Karim *et al*. 1990). Salinity stress causes an imbalance in the uptake of mineral nutrients and their accumulation within the plants (Grattan and Grieve 1992). Osmotic stress, ion imbalances, particularly with $Ca^{2+}$ and $K^+$, and direct toxic effects of $Na^+$ and $Cl^-$ ions on the metabolic processes are the most important and widely studied physiological impairments caused by salt stress (Munns 2002, Munns *et al*. 2006). Maintaining a better nutrition with $K^+$ and $Ca^{2+}$, while limiting N uptake, is a highly important trait contributing to salt-stress tolerance in plants. Consequently higher $K^+/Na^+$ or $Ca^+/Na^+$ ratios are typical to the tissues of salt tolerant varieties, and are often used as a screening parameter for identification of salt-stress tolerant varieties, and are often used as a screening parameter for identification of salt-stress tolerant varieties (Munns and James 2003, Song *et al*. 2006). To grow maize and other crops in the saline areas, understand physiological changes of various crops under salinity is important. This knowledge is useful for the plant breeders to develop salt tolerant crops. Therefore, the present investigation was undertaken to study the effect of NaCl-induced salinity on the accumulation of ions in maize with a view to understand the mechanism of adaptation.

Seeds of maize (*Zea mays* L. cv. BARI-7) were collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Seeds were sown and seedlings were raised in water culture for ion accumulation study. Modified half-strength Hoagland solution (Hoagland and Arnon 1950) was used as nutrient solution. The plants were subjected to different salinity treatments *viz.*, 50, 100, 200 mM NaCl made in the half-strength Hoagland solution. Half-strength Hoagland solution was used as control. The accumulation of ion was measured in roots and shoots of the seedlings at 7, 14, 21 days of salinity treatments. $Na^+$ and $K^+$ accumulation were measured using a flame photometer (Gallenkamp, Model FGA 330ºC) at wavelength of 589 and 767 nm, respectively while $Cl^-$ accumulation was measured following titrametric method (Begum *et al*. 1992). Three replicates were used for each measurement.

*Effects of salinity on ion accumulation*: In 7-day-old maize seedlings, $Na^+$ was increased 6.0 to 11.5% in the root (Fig. 1a) and 4.5 to 22.8% in the shoot (Fig. 1b) with the increase in salinity level from 50 to 200 mM NaCl. Under salinity treatment, $K^+$ accumulation was decreased in general and a maximum decrease of 41.2% in the root was noticed under 200 mM NaCl treatment (Fig. 1c). In the shoot, $K^+$ accumulation was also decreased by 10.9 and 20.7% in 100 and 200 mM NaCl treatment, respectively (Fig. 1d). In the root, $Cl^-$ accumulation was increased by 38.9, 43.7 and 49.2% over the control at 50, 100 and 200 mM NaCl, respectively (Fig. 1e) while in the shoot it was increased up to 76.4% at 200 mM NaCl treatment (Fig. 1f).

In 14-day-old seedlings, maximum increase (14.5%) of $Na^+$ accumulation in the root was found at 200 mM NaCl treatment (Fig. 1a) while in the shoot the same treatment caused a 22.9% increase (Fig. 1b). In the root, $K^+$ content was decreased to a maximum of 31.2% at 200 mM NaCl (Fig. 1c) while it decreased to a maximum of 17.6% in the shoot (Fig. 1d). Accumulation of $Cl^-$ increased by 52.9% and 2.7-fold in the root (Fig. 1e) and by 24.8% and 2.1-fold in the shoot (Fig. 1f) at 50 and 200 mM NaCl treatment, respectively.

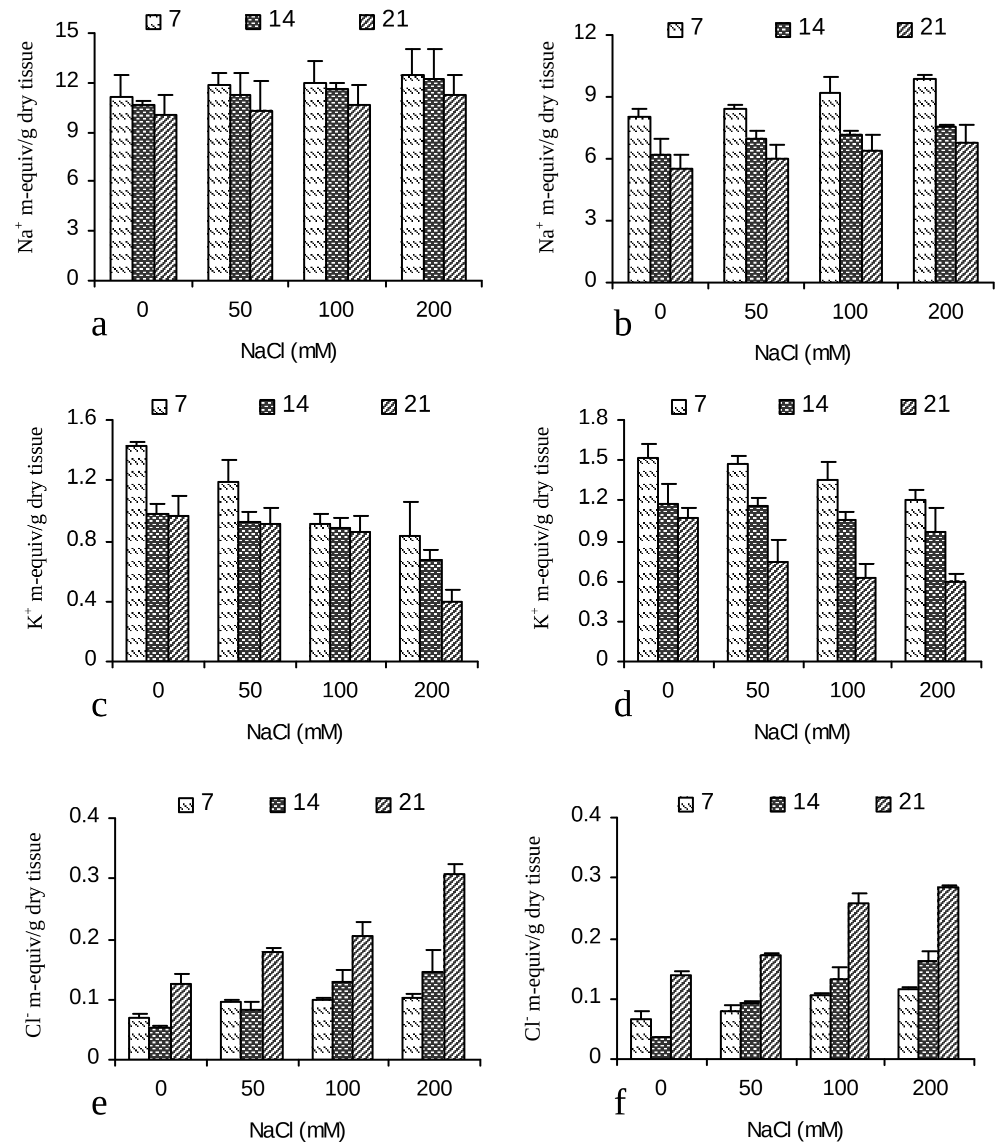

Fig. 1. Effects of different concentrations of NaCl-induced salinity on $Na^+$ accumulation in the root (a) and shoot (b); $K^+$ accumulation in the root (c) and shoot (d) and $Cl^-$ accumulation in the root (e) and shoot (f) of 7-, 14- and 21-day-old seedlings of maize. Zero (0) represents control. Bar represents ± standard error.

In 21-day-old seedlings, NaCl salinity stress caused a 2.3 to 11.5% increase in accumulation of $Na^+$ in the root (Fig. 1a) and 10.0 to 23.7% increase in the shoot as compared to control (Fig. 1b). A maximum decrease of $K^+$ content amounting to 58.9% was found in the root at 200 mM NaCl treatment (Fig. 1c) while the same treatment resulted in 45.2% decrease in $K^+$ content in the shoot (Fig. 1d). Accumulation of $Cl^-$ increased by 41.3% to 2.4-fold in the root at 50 and 200 mM NaCl, respectively (Fig. 1e). In the shoot, $Cl^-$ accumulation increased by 24.8% and 2.1-fold at 50 and 200 mM NaCl treatment, respectively (Fig. 1f).

In maize, $Na^+$ and $Cl^-$ accumulation in root and shoot increased following 50 to 200 mM NaCl treatment while $K^+$ content in root and shoot decreased with the increase in salinity levels at all the three ages. Beck *et al*. (2004) found increased accumulation of $Na^+$ and strong inhibition of $K^+$ and $Ca^{+2}$ accumulation in the root, stem and leaves with NaCl-induced salinity. Hu and Schmidhalter (1997) also reported that $Na^+$ and $Cl^-$ concentration in leaves and stem of wheat increased significantly whereas $K^+$ concentration decreased with the increase in salinity. In NaCl-salt-stressed *Melilotus segetalis*, the concentration of $Na^+$ in stem was seven times higher than that of control whereas salinity reduced the concentration of $K^+$ in the root and the shoot (Romereo and Maranon 1996). In maize, $Na^+$ concentration of root was higher than in shoot with increasing salinity levels at 7, 14 and 21 days of treatment (Fig. 1 a and b). This result is in agreement with the work of Sagi *et al.* (1997) who found that in annual rye-grass, $Na^+$ concentration in roots was higher than in shoots irrespective of the salinity level suggesting a restriction of $Na^+$ transport from the root to shoot. Chow *et al*. (1990) found that $Na^+$ is accumulated predominantly under saline condition. They suggested that $K^+$ content in the cytoplasm must be maintained at a reference level for normal metabolism and this is an essential criterion for survival under salinity.

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