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EFFECTS OF NaCl SALINITY ON SOME PHYSIOLOGICAL CHARACTERS OF WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract

Two wheat varieties, Aghrani and Kanchan were grown in pots and subjected to 50, 100 and 150 mM NaCl till their maturity. Water relations, chlorophyll content and mineral ions accumulation in wheat plants were analyzed. Water retention capacity and relative water content were decreased while water uptake capacity and water saturation deficit were increased with the increasing levels of salinity. Salinity increased diffusive resistance but decreased transpiration rate. Chlorophyll content was decreased due to salinity in both Aghrani and Kanchan. Accumulation of Mg^{2+}, Ca^{2+} and Na^{+} increased while that of K^{+} decreased in the salt treated plants. In general, Aghrani accumulated greater amount of Mg, Ca and Na ions than that of Kanchan. It is appeared thal Aghrani possesses a better mechanism of salt tolerance than that of Kanchan.

Introduction

Wheat is one of the major food crops of the world. It ranks second to rice in production and area coverage in Bangladesh. The crop has been established as a staple cereal food of Bangladesh. In addition to supplying carbohydrates, it provides protein, minerals and other important vitamins.

Wheat Research Centre of Bangladesh Agricultural Research Institute has released many improved varieties of wheat. They are well grown all over the country though the yield level depend on the agro-climatological conditions. Even in the southern part of Bangladesh, where salinity is a threat for a good harvest, wheat is grown extensively. The crop under such saline conditions absorbs unusual amount of Na ion. Na^{+} competes with Ca^{++} for the same binding site in the plasmalema and thus affect the cell function (Blum 1988, Lutts *et al.* 1996). Moreover, a plant under saline conditions suffers from appropriate water relation (Greenway and Munns, 1980). Only a judicial selection of a crop or a variety of a crop for saline soil can minimize yield loss caused by salinity. Since wheat shows variation in salinity tolerance (Karim *et al.* 1993), it is necessary to test the available varieties against salinity tolerance. In a study Hossain (2002) observed that wheat variety Aghrani was more tolerant to salinity than Kanchan. Information on some key physiological characters such as water retention capacity (WRC), relative water content (RWC), water uptake capacity (WOC) and water saturation deficit (WSD), chlorophyll content and mineral ions accumulation pattern under saline conditions might help to clarify the mechanisms of salinity tolerance of the two wheat varieties. This study was initiated to understand physiological mechanisms of salinity tolerance in relation to water relations and mineral nutrition of two wheat varieties differing in salinity tolerance.

Materials and Methods

Two wheat varieties, Aghrani and Kanchan, were used in the study. The experiment was conducted under semi-controlled environment in the field during December 6 to March 22, 2001. Four levels of NaCI salinity, *viz.* 50, 100, 150 mM and tap water as the control were applied till maturity. The experiment was laid out in a completely randomized design with ten replications having four treatments.

The experiment was carried out in pots filled with 12 kg air-dried soil per pots after mixing 41 g of TSP, 0.5 g of MP and 0.81 g of gypsum and sufficient water was added to saturate the soil. The pots were kept under natural sunshine till harvesting.

Seeds of uniform size were directly sown in December 2000. Tap water was applied in all pots up to emergence of seedlings. After establishment of seedling, tap water was applied in control pots, while 12.5 mM NaCI solution was applied in treatment pots. When the first leaf appeared i.e. ten days after emergence (DAE) NaCl solutions were applied to the respective treatments only till maturity. Ten randomly selected plants were used from each treatment for collection of data. Chlorophyll content and leaf water status were measured from the plants at 45 DAE (days after emergence). Mineral ions concentration of dried leaf samples was analyzed at maturity.

The leaf chlorophylls were extracted with cold 80% acetone and measured Spectrophotometrically (Spectronic Unicam, England) following the method of Mckinney (1940) and the formula of Machlachalan and Zalik (1963). Measurement of plant water status: Five fresh leaves of same size and same age (60 DAE) of five plants from each treatment were collected and weight. Leaf segments were kept immersed in distilled water for 24 hours at room temperature in the dark. The turgid weighted of leaves were measured and then oven-dried at 80°C for 72 hours. The fresh weights, turgidity and dry weights of the leaf segments were used to determine the RWC, WSD, WRC and WUC following Sangakkara *et al.* (1996).

Diffusive resistance and transpiration rate were measured directly under field conditions with a steady state porometer (Licor, Model LI-1600).

Oven-dried leafblades were used for measuring the mineral ions concentrations. Na^+, K^+, Ca^{2+} and Mg^{2+} were extracted by following the methods Umezawa *et al.* (2001) and concentrations were determined by atomic absorption spectrophotometer (Model, 170-30, Hitachi) following Karim *et al.* 1993)

Ten randomly selected plants were used from each treatment for collection of data. Chlorophyll content and leaf water status were measured from plants at 45 DAE. Mineral ions concentration of dried leaf samples was analyzed at maturity.

Data were analyzed statistically by using SPSS program 10.05. Treatment means were compared by LSD (Gomez and Gomez 1984).

Results and Discussion

Chlorophyll-a content of Aghrani was higher (1.5 mg/g) than Kanchan (1.3 mg/g) in control. Chlorophyll-b content of Aghrani (1.3 mg/g) was also higher than that of Kanchan (1.1 mg/g) in control samples (Fig. 1). Chlorophyll-a as well as chlorophyll-b contents decreased with the increasing of salinity levels. The value of chlorophyll-a and chlorophyll-b contents in all the treatments were significantly lower than that the control except for chlorophyll-a at 50 mM NaCl. It was also revealed that the contents of chlorophyll-a and b in Aghrani were less affected by salinity than that in Kanchan. At 150 mM NaCl salinity, the chlorophyll-a and b contents in Agrani were reduced to 40 and 46.6%, respectively while of Kanchan, it was reduced to 38.5 and 63.14%, respectively. Kolchevskii *et al.* (1995) reported that the decline in photosynthetic pigment by salinity obviously affected the photosynthetic activities of plants. Present findings agreed with Kolchevskii *et al.* (1995).

Salinity decreased the WRC from 5.22 at 0 mM NaCI to 4.19 at 150 mM NaCl (Table 1). The reduction was greatest at the highest level of salinity (150 mM). At 150 mM NaCl, the WRC of Aghrani was reduced to 17.51% while in Kanchan it was reduced to 21.55%, though at 100 mM NaCl the trend of reduction was just opposite. Reduction of WRC in Kanchan was much higher than that of Aghrani. The higher reduction of WRC indicated a greater damage in cell structure due to salinity (Sangakkara *et al.* 1996).

The capacity of plant cells to absorb water per unit dry weight depends at a particular stage. Salinity resulted in an increasing WUC with the increasing level of salinity. At all levels of salinity Kanchan had higher WUC than Aghrani (Table 1). An increasing WUC from 0.58 in control to 1.92 at 150 mM NaCI was obvious. A higher WUC under saline condition means a plant is subjected to water stress at a greater degree, because the plant would absorb more water to reach turgidity than plant under control condition.

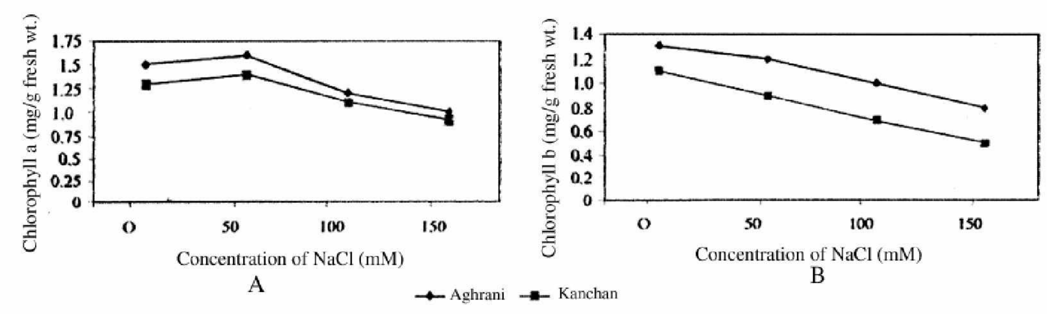

Fig. 1. Effect of NaCl salinity on chlorophyll-a (A) and chlorophyll-b (B).

Although Kanchan showed a little higher absolute WUC than Aghrani, the relative increase in WUC was greater in Kanchan. Probably Kanchan suffered more with water stress than Aghrani. The results showed that the crop has to take up relatively more amount of water to reach turgidity under saline condition (Sangakkara *et al.* 1996, Islam 2001).

Salinity decreased relative water content (Table 1). In Aghrani, the RWC was 56.37 and 49.67 in Kanchan at .150 mM: NaCl. The relative decrease was 29.63 % in Aghrani and 40.21 % in Kanchan. This result indicated that Kanchan suffered from more water stress than Aghrani. It is well-known that under saline conditions plant suffers from osmotic shock due to lower osmotic potential in the soil solution (Orcutt and Nilsen 2000). The better water relation in Aghrani under saline condition obviously contributed for maintenance of higher plant growth in Aghrani than Kanchan.

Water saturation deficit showed an inverse trend of RWC. Salinity increased the WSD with the increasing of salinity levels. At the control the WSD was 16.86 (mean value) while it was 41.98 in the highest level of salinity. At 150 mM NaCI, WSD in Aghrani was 39.93 while in Kanchan it was 44.03. The relative value was (% to the control) 235.99 in Aghrani and 262.08 in Kanchan at 150 mM NaCI (Table 2). It is clear that Kanchan showed higher relative WSD (% to the control) than Aghrani. This finding revealed that Kanchan suffered from more water deficit specially at high level of salinity than Kanchan (Orcutt and Nilsen 2000).

Diffusive resistance (Dr) increased with increasing levels of salinity (Table 2). At the control the Dr was 5.04 while at 150 mM NaCl that was 11.78. In Aghrani, at 150 mM NaCl, the Dr was

11.12 while that was 12.44 in Kanchan. The relative value was 211.41 for Aghrani and 258.63 for Kanchan in the higher level of salinity.

Transpiration rate (Tr) was decreased by salinity. At the control Tr was 2.92 while at 150 mM NaCl that was 1.27. At the highest level of salinity (150 mM), it was 1.31 for Aghrani and 1.23 for Kanchan. The relative value was 47.81 in Aghrani and 39.81 in Kanchan at the 150 mM NaCl (Table 2).

Mg^{2+} accumulation was increased with the increasing concentration of applied NaCl (Table 3). At the 100 mM NaCl it was 18 mg/g for Aghrani and while for Kanchan that was 19 mg/g. At the highest level of salinity (150 mM NaCl), the two varieties showed more or less similar accumulation of Mg^{2+}. Karim *et al.* (1992) did not find any clear pattern of Mg^{2+} accumulation between tolerant and susceptible varieties of triticale. Raptan *et al.* (2001) reported that blackgram and mungbean showed an increasing pattern of Mg^{2+} accumulation under saline condition. Accumulation of Mi^{+} of the plant was probably helpful to maintain osmoregulation to protect the plant cell from osmotic shock caused by salinity (Greenway and Munns 1980).

In general with the increase in salinity levels calcium ion accumulation was decreased, though there are also contrasting reports (Khan *et al.* 1997). At 50 and 100 mM NaCL Ca^{2+} accumulation in both the varieties was increased substantially (Table 3). This result is similar with the report of Raptan *et al.* (2001) in blackgm and mungbean. At the highest level of salinity (150 mM) it was decreased to 39 mg/g for Aghrani while for Kanchan it was 36 mg/g. There are also controversial reports on the accumulation pattern of Ca^{2+}.

K^{+} accumulation showed a decreasing tendency with the increasing of NaCl levels (Table 3). At 50 mM NaCl the accumulation of K^{+} was increased in both the varieties. The two varieties showed more or less similar amount K^{+} under saline conditions though their relative accumulation was different (Table 3). Salinity induced reduction in K^{+} accumulation was also reported earlier in different crop such as barley (Helal and Mengel 1979) and Chickpea (Singh and Singh 1999). Under salt stress, plays an important role in osmoregulation and stress tolerant varieties accumulate higher amounts of K^{+} than susceptible varieties (Blum 1988, Qadar 1988).

Na^{+} accumulation was increased with the increasing salinity levels in both the varieties (Table 3). Na^{+} accumulation was higher in Aghrani than in Kanchan. Blum (1988) reported that tolerant crop accumulated less amount of Na^{+} than susceptible one. At 150 mM NaCl the values increased to 73 mg/g for Aghrani and 66 mg/g for Kanchan. The result of this study was similar to the findings of Islam (2001). Karim *et al.* (1992) in triticale noticed that tolerant varieties maintained relatively larger amount of Na^{+} in the roots compared to those in salt susceptible varieties.

It appears that salinity affected normal physiological functions of wheat plants. This was expressed by the imbalance in water relation and mineral ions accumulation in the two varieties. The better physiological mechanisms associated with less affected water relation and mineral nutrition probably contributed for the higher salt tolerance in Aghrani than in Kanchan.

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