http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 6 (24): 2001-2006, 2003
ISSN 1028-8880

Effect of NaCl and Na_2SO_4 Salinity on Leaf Appearance Stage, Tiller Production and Percent Motality of Spring Wheat

Rana Muhammad Iqbal
Cholistan Institute of desert studies, Islamia University, Bahawalpur, Pakistan

Abstract: A solution culture pot study was carried out to see the effect of two contrasting salt species i.e., NaCl and Na_2SO_4 on leaf extension growth of spring wheat. Na^+ concentrations in both the salt species were 0, 50, 100 and 200 mM. Plants under both salt species with low Na^+ concentrations had dark green leaves compared to control but yellowing and necrosis was observed with high Na^+ concentrations. Almost similar trends for leaf appearance stage and tiller production were observed in both the salt species. Higher Na^+ concentration suppressed both of these parameters. Nacl was found slightly more toxic than Na_2SO_4 and rapid mortality of plants was observed in higher salt concentrations.

Key words: Wheat, salinity, leaf appearance stage, tiller production, mortality, NaCl and Na_2SO_4

INTRODUCTION

Spring wheat varieties are grown both in subtropics and temperate areas of sever winters, cold winds and little snow. Spring wheat being day-neutral does not require vernalization for heading but low temperature promotes tillering. For winter and spring wheat, minimum daily temperature for measurable growth is about 5°C. Main daily temperature for optimum growth and tillering is between 15 and 20°C.

Wheat crop can be grown on a wide range of soils but medium textured soils are considered good for optimum production. Soils containing high sodium, magnesium or iron are not suitable for wheat cultivation. The optimum pH ranges from 6 to 8. Wheat is relatively tolerant to a high ground water table; for sandy loam to silt loam a depth of ground water of 0.6 to 0.8 m can usually be tolerated and for clay 0.8 to 1 m. For short periods, the crop can withstand without visible harm to a minimum depth of 0.25 m. With a rise of ground water table to 0.5 m for long periods, the yield decrease is 20 to 40 percent (F.A.O., 1980).

Under salt conditions, wheat plants are highly tolerant during germination although quite sensitive during early growth and boot stages. The suppression of plant growth increases as the salt concentrations increases (Maas and Hoffman, 1978; Lauchli and Epstein, 1984; Iqbal, 1988; Khan *et al.*, 1995). Both shoot as well as root growth are influenced by salinity but shoot is usually the more sensitive (Rashid, 1986; Iqbal, 1992). Haqqani *et al.* (1984) found that salinity and sodicity levels reduce the ear bearing and non-ear bearing tillers, spikelets per spike and 1000 grains weight in wheat. The number of effective tillers per plat was the most seriously affected component in wheat whereas 1000 grains weight showed a relatively higher degree of resistance to salinity (Qureshi *et al.*, 1980; Francois *et al.*, 1986; 1qbal, 1992).

Ions which contribute to soil salinity include Cl^-, SO_4^{2-}, HCO_3^-, Na^+, Ca^{2-}, Mg^{2+} and rarely, NO_3^- or K^+. Most saline soils are high in Cl^- and Na^+, though there are some soils in which the soluble salts consist mainly of Na^+ and Mg^{2+} sulphates. According to a study conducted by Shahid (1988), the salinity problem in Pakistan is mainly due to sulphates and chlorides and only partly due to carbonates and bicarbonates as these are relatively insignificant as compared to other anions. He found that SO_4^{2-} is dominating in all the salt crusts over the other anions. Among the cations Na^+ is dominant in all the salt crusts, accompanied by variable amounts of K^+, Ca^{2+} and Mg^{2+}. He concluded that sulphate minerals of sodium are dominant in soils of Pakistan, with lesser amounts of chlorides, whereas chloride is found as the second dominant anion.

Most of the research work conducted on salt tolerance in crop plants uses NaCl in solution culture, which does not reflect true picture of salinity problems. Hence, it was contemplated in this preliminary investigation to see the effects of two contrasting salt species i.e., NaCl and Na_2SO_4 on the growth physiology of spring wheat.

MATERIALS AND METHODS

A solution culture pot study was carried out at University Farm, Aber, University of Wales, Bangor, United Kingdom to see the effects of two contrasting salt species on the growth and physiology of spring wheat. The test variety was Wembley whereas two salt species were NaCl @ 0, 50, 100 and 200 mM and Na_2SO_4 @ 0, 25, 50 and 100 mM concentrations. In this experiment Na^+ concentrations were comparable to 0, 50, 100 and 200 mM in both salt species, hence the individual effects of Cl^- and SO_4^{2+} ions can be postulated.

The experiment was conducted under glass-house conditions with no control of temperature and no supplementary lightings. Seeds of spring wheat variety Wembley were soaked for overnight in capillary matting under tap water during second week of July. Sprouted seeds were transferred to capillary matting on plastic supports, suspended over well-aerated tap water containing 5 grams of "Phostrogen". Seven days old seedlings were transferred block by block during 3rd week of July to black painted plastics pots having 10 L water capacity. The plants were supported by foam in 16 round holes at distance of 4.5 cm in black painted polystyrene sheets placed over the pots. In case of NaCl 4 Molar stock solution was made, while Na_2SO_4 could only be dissolved up to 2 Molar. After two days of seedling establishment, salt stress was imposed by adding ½ dose in the first instance. The final dose was added after 3rd day of the first dose.

A modified Long Ashton Nutrients solution was used in combination with 'Phostrogen' (Phostrogen Limited, Corven, Clwdy, U.K.) which is a blended 10-10-27% NPK fertilizer, with 1.3% Mg^{2+}, 0.4% Fe^{3+} and 200 mg kg^{-1} Mn^{2-}. Five grams of 'Phostrogen' were added in 10 liters of water directly into each pot at the time of transplanting while 10 grams were added directly into each pot at the time of solution change after 21 days of transplanting. Stock solutions of FeEDTA (monosodium complex), $MnSO_4.4H_2O$, $CuSO_4.5H_2O$, $ZnSO_4.7H_2O$, H_3BO_3 and $Na_2MoO_4.2H_2O$ were made as 37.33, 22.3, 2.5, 2.9, 31.0, 58.5 and 1.21 g L^{-1}, respectively. The composition of micronutrient in stock solution was:Fe 2.8, Na 1.0; Mn 0.55; Cu 0.064; Zn 0.065; B 0.54 and Mo 0.048 $\mu g\ cm^{-3}$, respectively.

It was observed during solution renewing that Na_2SO_4 stock solution solidified quickly as soon as it came in contact with air, which needed a vigorous shaking. Keeping this difficulty in mind both NaCl and Na_2SO_4 salts were directly added to individual pot according to the layout of experiment.

After every second day, fully emerged leaves were recorded to compare the leaf appearance stage in each treatment. Tiller production of each central test plant was recorded after every second day starting from the day of transplanting till final harvest. Numbers of dead plants in each pot were recorded after visualizing the toxicity symptoms on leaves and death of some plants in high salt stress after every day. Those plants were considered dead whose the youngest emerging leaf was completely yellow and dry.

The statistical analysis of the data was performed by the analysis of variance method. When a significant 'F' value was obtained for treatment effect, Tukey's test at 5 % probability level was applied to the treatment means (Snedecor and Cochran, 1980). In the figures, the vertical bars indicate the value of the least significant difference for comparison between treatment means at the last date of measurements.

RESULTS

Leaf appearance rate

Effects of salt species: The main results related to leaf appearance stage are presented in Fig.1. Both the salt species have similar effects on leaf appearance stage of spring wheat up to 29 days after transplanting. After this period in NaCl treated plants, leaf appearance was checked while in Na_2SO_4 leaves continued to appear up to 39 days after transplanting and this difference was observed as significant.

Effect of Na^+ concentrations: The main results of Na^+ concentrations on leaf appearance stage are shown in Fig. 2. During early growth stage after transplanting, a non-significant difference was observed on leaf appearance of spring wheat in all the Na^+ concentrations. This trend continued in case of control and 50 mM Na^+ treatments. In case of 100 mM Na^+ a reduction in leaf number per plant was observed but this difference was non-significant. A drastic reduction in leaf appearance was observed in case of 200 mM Na^+.

Tiller production: Tiller production is an important parameter in determining the final yield of wheat crop. The results related to tiller production are described as follows:

Effect of salt species: The main effects of salt species on tiller production are represented in Fig. 3. Salt species had no effect on tillering up to 18 days after transplanting. Plants treated with Na_2SO_4 had more tillers as compared to NaCl treated plants after 19 days of transplanting and this significant effect continued upto final harvest.

Effect of Na^+ concentrations: The results related to effect of Na^+ concentration on tiller production are shown in Fig. 4. No effect of salinity on tiller production was observed during first 6 days after transplanting. After 7 days, as the

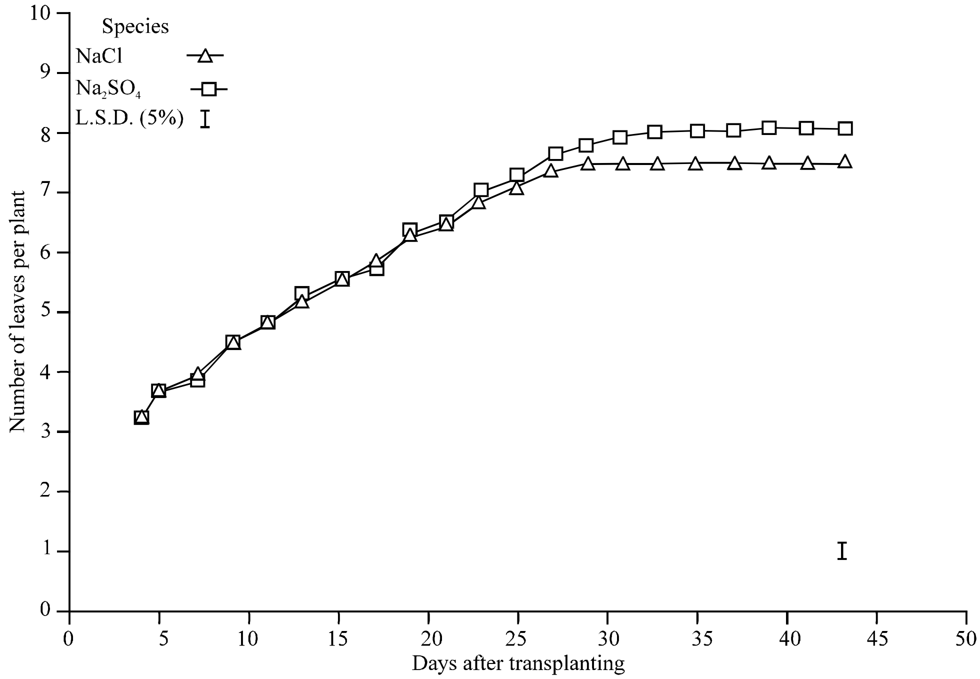

Fig. 1: Effect of salt species on leaf appearance stage

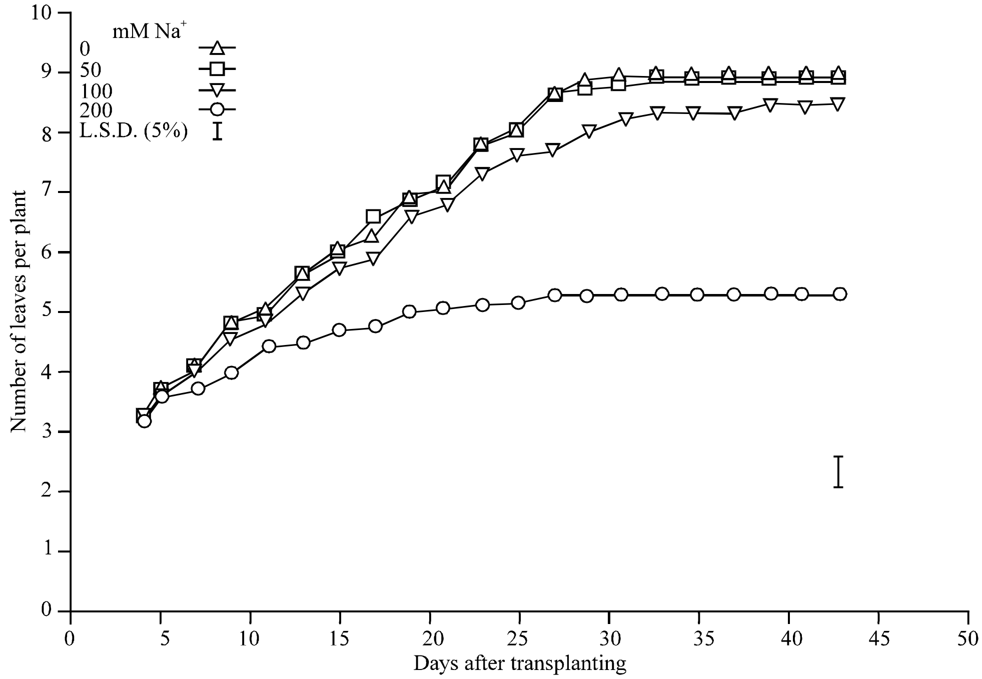

Fig. 2: Effect of Na^+ concentrations on leaf appearance stage

salt stress was predominant, suppression of tiller production started in case of high Na^+ concentrations.

The minimum tiller suppression was observed in case of 50 mM Na^+, while this trend progressed with higher concentrations. The maximum effect was seen in case of 100 mM Na^+ where minimum numbers of tillers per plant were produced.

Percent mortality of plants: The results concerning to mortality percentage of spring wheat plants under various concentrations of two salt species are presented in Fig. 5 and 6. NaCl was more toxic to wheat plants as compared to Na_2SO_4. Plants under 200 mM Na^+ in both the salts species were found with wilting and drooping symptoms of leaves, 4 h after second dose of salt stress. Yellowing

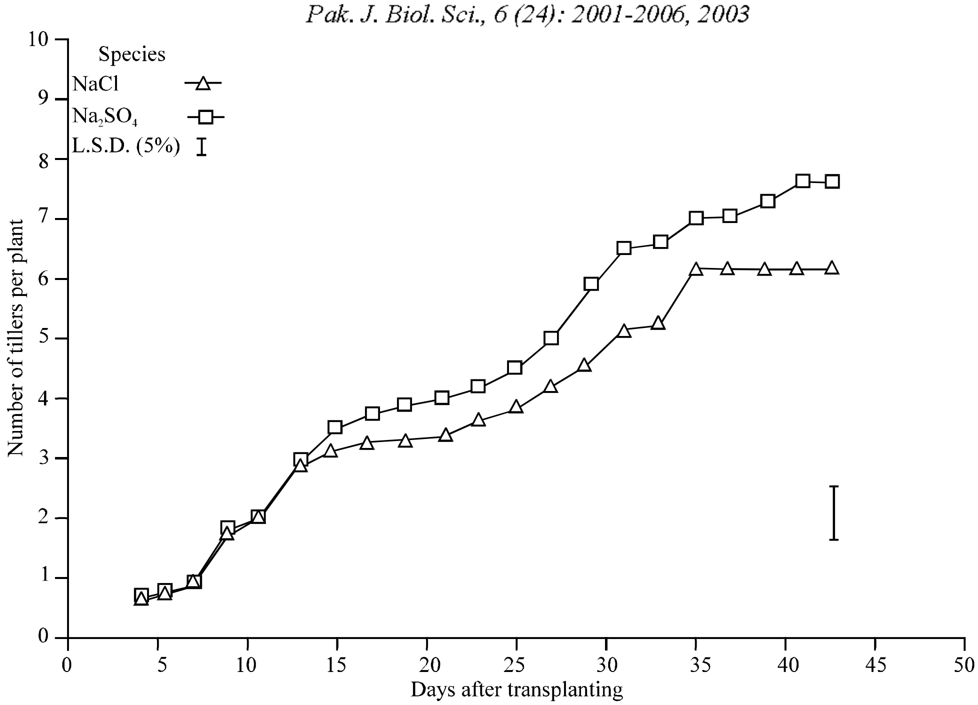

Fig. 3: Effect of salt species on tiller production

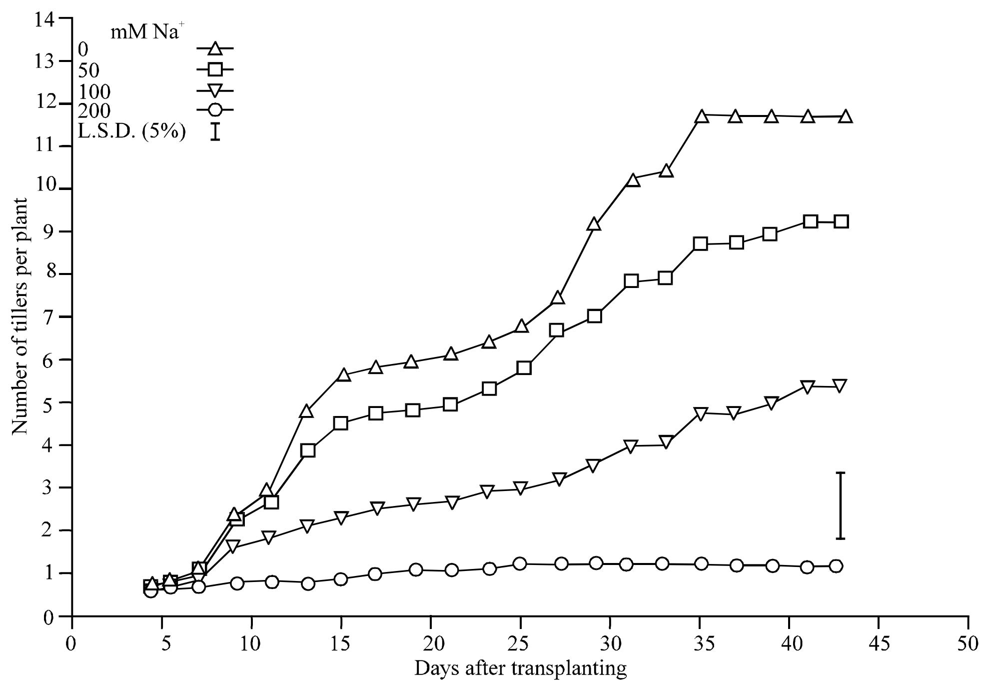

Fig. 4: Effect of salt species on tiller production

and chlorosis of first leaves from tips was observed 8 days after transplanting in case of 200 mM NaCl which was followed by curling and bending symptoms. Chlorosis and bending symptoms of leaves were also observed in 50 and 100 mM Na_2SO_4. The plants in 25 mM Na_2SO_4 and 50 mM NaCl survived well and there was not single plant mortality in both the treatments. The maximum percent mortality was recorded in case of 200 mM NaCl which reached to 100 percent within 26 days after transplanting. In case of 100 mM Na_2SO_4 treatment, the plant survived well up to 18 days after transplanting, then progressive mortality percentage continued upto 41 days after transplanting when 100 percent plants were dead. These results suggest that 200 mM NaCl concentration is

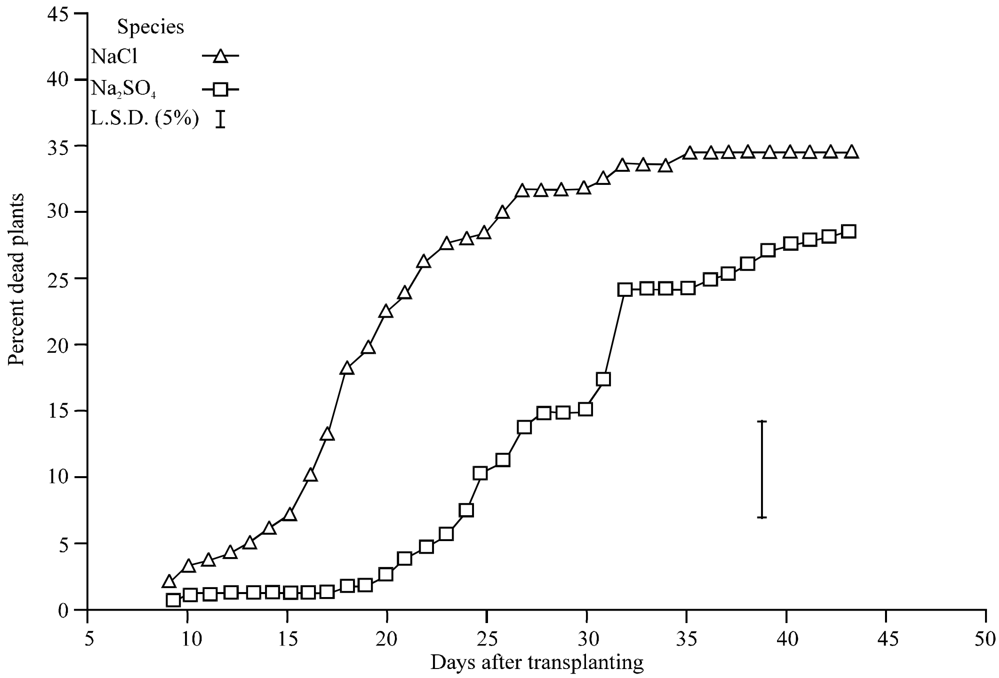

Fig. 5: Effect of salt species on percent mortality of wheat plants

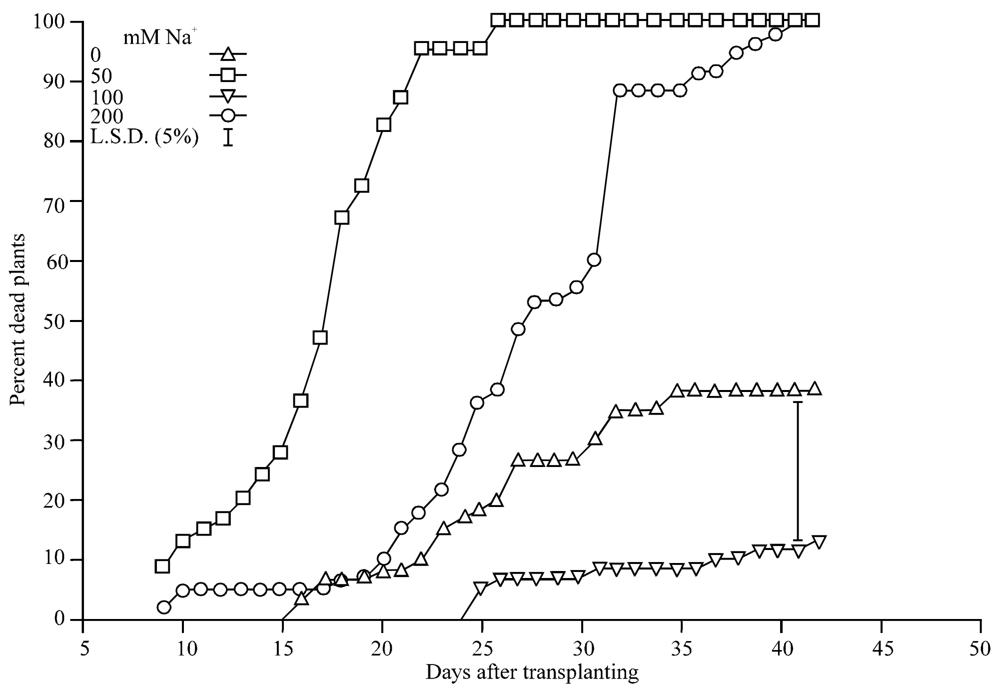

Fig. 6: Effect of salt X Na^+ concentrations on percent mortality of wheat plants

much more toxic to wheat plants as compared to 100 mM Na_2SO_4. Similarly 100 mM NaCl is more toxic to wheat plants as compared to 50 mM Na_2SO_4.

DISCUSSION

During this short duration study, no interaction between salts and concentration was observed for leaf appearance stage and tiller production. The results showed no evidence that NaCl is more toxic than Na_2SO_4 for these parameters. However, bigger effect of salts and concentrations interaction was seen on mortality of plants. These results suggest that $Na^+ + Cl^-$ interact with each other to increase the osmotic pressure greater than $Na^+ + SO_4^{2-}$ where former promote the rapid mortality of plants (Iqbal, 1988, 2003; Khan *et al.,* 1995). It was also observed that in NaCl leaf 9 reached to maximum size earlier than in Na_2SO_4 where it continued to grow.

These results suggest that the increased build up of Cl^- ions in plant leaves might have occurred with passage of time. In NaCl, the last leaves were found smaller and reached their maximum size earlier than in Na_2SO_4. This may be due to the reason that the amount of Cl^- is double in NaCl than SO_4^{2-} in Na_2SO_4 at the same Na^+ concentrations (Iqbal, 2003). In additions the mobility of Cl^- is considered rapid as compared to SO_4^{2-}because the latter is heavier. It has been reported that NaCl salinity decreased K^+ concentration in many species, which is an essential nutrient to the shoot and it could limit cell expansion and growth. NaCl usually reduce NO_3^- concentration in leaves. Increasing the NO_3^-concentrations in the external medium can improve growth of plants but Glass and Siddiqi (1985) have found that the beneficial effect of NO_3^- may be due to its reducing Cl^- uptake rather than to its supplementing the nitrogen supply to the plant. Almost similar trends for leaf appearance stage and tiller production were found in both the salt species. Higher Na^+ concentrations suppression of various growth parameters, with increasing salinity, have been reported by many workers (Haqqani *et al.,* 1984; Lauchli and Epstein, 1984; Rashid, 1986; Francois *et al.,* 1986; Khan *et al.*, 1995; Iqbal, 2003). These findings confirmed the work of earlier workers that increasing the salinity reduce tiller production and other growth parameters.

During the course of study it was also found that plants under both salt species with low Na^+ concentrations had dark green leaves compared to control but yellowing, necrosis and rapid mortality was observed with high Na^+ concentrations. The results indicated the specific effect of ions; Cl^- and SO_4^{2-} but particularly of Na^+. Dark green colour with smaller leaves of plants under salt stressed conditions was also observed with rapid death of older leaves. This indicates that plants under stress conditions try to save the growing shoot apex by killing the older leaves to release the metabolites or this death may be due to toxic concentrations of ions, which needs further investigation. Plants growing under high Na^+ concentrations had very high osmotic pressure of cell sap in leaves, which might has lead to rapid mortality (Iqbal, 1988, 2003).

REFERENCES

Food and Agriculture organization, 1980. Yield response to water. F.A.O. Irrigation and drainage paper No.33. Food and Agriculture organization, the United Nations, Rome.

Francois, L.E., E.V. Maas, T. J. Donovan and V.L. Youngs, 1986. Effect of salinity on grain yield and quality, vegetative growth and germination of semidwarf and durum wheat. Agron. J., 78: 1053-1058.

Glass, A.D.M. and M.Y. Siddiqi, 1985. Nitrate inhibition of chlorides influx in barley: Implications for a proposed chlorides homeostat. J. Exp. Bot., 36: 556-66.

Haqqani, A.M., A. Rauf and M.A. Zahid, 1984. salt tolerance studies on wheat in farmer's field. Pakistan J. Agric. Res., 5: 78-82.

Iqbal, R.M., 1988. Effect of two contrasting salt species on growth and physiology of spring wheat. M.Sc. Thesis. Univ. of Wales.

Iqbal, R.M., 1992. Growth and physiology of spring wheat under salt conditions. Ph.D. Thesis. Univ. of Wales.

Iqbal, R.M., 2003. Leaf extension of wheat grown under NaCl and Na_2SO_4 salinity. Asian J. Plant Sci. In press.

Khan, A.H., M.Y. Ashraf, S.S.M. Naqvi, B. Khanzada and M. Ali, 1995. Growth, ion and solute contents of sorghum grown under NaCl and Na_2SO_4 salinity stress. Acta Physiol. Plant, 17: 261-268.

Lauchli, A. and E. Epstein, 1984. mechanism of salt tolerance in plants: III. How plants adapt to salinity. Calif. Agric., 38: 18-20.

Mass, E.V. and G.J. Hoffman, 1978. Crop salt tolerance–current assessment. J. Irrig. Drainage Div. Am. Soc. Civil. Engg., 103: 115-134.

Qureshi, R.H., R. Ahmad, M. Ilyas and Z. Aslam, 1980. Screening of wheat (*Triticum aestivum* L.) for salt tolerance. Pak. J. Agric. Sci., 27: 19-26.

Rashid, A., 1986. Mechanism of salt tolerance in wheat (*Triticum aestivum* L.) Ph.D. Thesis, Univ. Agric., Faisalabad, Pakistan.

Shahid, S.A., 1988. Studies on the micromorphology of salt-affected soils in Pakistan. Ph.D Thesis, University of Wales, U.K.

Snedecor, G.W. and W.G. Cochhron, 1980. Statistical Methods. 7th Edn. The Iowa State University Press, Iowa.