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EFFECT OF DIFFERENT SALINITIES ON SUCCESSIVE GROWTH AND IONIC COMPOSITION OF TETRA- AND HEXAPLOID WHEATS

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Seeds of two wheats 'Langdon (tetraploid) and 'Chinese Spring' (hexaploid) were grown at different salinities (NaCl) in hydroponic culture under controlled conditions. The growth and foliar ionic concentrations were measured after gradual salination of the growth medium. The results indicated that with an increase in the age of seedlings an increase in Na^+ and Cl^- and a decrease in K^+ occurred in both the wheats at 75, 150 or 225 mol m^{-3} NaCl level. 'Chinese Spring', however, was capable of maintaining lower Na^+, Cl^- and osmotic pressure than 'Langdon'. At 150 mol m^{-3} NaCl, recovery in shoot growth was observed in 'Chinese spring' in the last harvest when seedlings were 23 days old. At the highest salinity (225 mol m^{-3} NaCl), 'Chinese Spring' seedlings showed no growth after the seedlings were 15 days old and a similar trend existed in 'Langdon'. The presence of 'DD'genome in 'Chinese Spring' and its implications on the exclusion from the shoots are discussed.

INTRODUCTION

Hexaploid bread wheat *(Triticum aestivum* L.) is an allopolyploid containing three genomes designated as 'A', 'B', and 'D'. Hexaploid wheat in comparison with either diploid or tetraploid wheats has a higher shoot root ratio (Bamakhramah *et al.,* 1984), larger leaves containing larger cells with a lower photosynthetic rate per unit leaf area at saturating light intensities (Planchon and Fesquet, 1982). Water use efficiency of hexaploid wheat, however, is higher because of limited stomatal opening. The presence of 'D' genome, also contributes to bread-making qualities of hexaploid wheat (Kerber and Tipples, 1969) and enhances yield characteristics in the hexaploid wheat (Shah *et al.,* 1987).

'D' genome is also found to improve cation selectivity. A high K^+/Na^+ ratio combined with low leaf salt contents is characteristic of salt-tolerant members of the grass tribe Triticeae (Gorham *et al.,* 1986). A positive correlation of yield of bread wheats with leaf K^+ contents under saline conditions and a negative correlation with Na^+ contents has been reported from field studies (Singh and Rana, 1985). It has also been reported that durum wheats (AABB genome) having low leaf K^+/Na^+ ratios are less tolerant of salt and alkalinity than hexaploid bread wheats (AA BB DD genome) (Rana, 1986).

In order to exploit this character in a hexa- and a tetraploid wheat, the present investigations were conducted to test the effect of 'D' genome over a range of salinities and as a function of time after primary exposure to salinity.

MATERIALS AND METHODS

Germinated seeds of *Triticum turgidum* cv. 'Langdon' and *Triticum aestivum* cv. 'Chinese Spring' were grown hydroponically for four weeks at three salinities (75, 150 and 225 mol m^{-3} NaCl). The seedlings were grown for one week without salt, samples for measuring shoot length, fresh weight and determining foliar ionic composition were taken and then NaCl (Na^+:Ca^{+2} ratio of 20:1) salt was added to the growth medium. Modified 'phostrogen' solution was added to growth medium as a source of macronutrients (Gorham *et al.,* 1984); while micronutrients were the same as recommended by Hoagland and Arnon (1950).

The growth medium was kept aerated throughout the experiment and in the controlled environment cabinet (Fisons 2340) the plants were grown at 25 °C with a 16 hours photoperiod (warm white fluorescent + tungsten lighting, 400 μ mol photons m^{-2} s^{-1} PAR (400-700 nm), 70% relative humidity)).

During sampling, one seedling each of 'Langdon' and 'Chinese Spring' was taken at each harvest. The seedlings were separated into shoot and root, blotted dry and shoot fresh weight and shoot length were recorded. Shoot tissue sap was expressed to determine osmotic pressure and inorganic ions concentrations.

Shoot tissue sap was extracted by crushing frozen and thawed tissue (approximately 1 g) in the Eppendrof tubes using a metal rod with a tapered end. Small holes were made in the cap and base of the tube and it was placed in another empty Eppendrof tube. The cell sap was expressed by centrifuging at about 6000 x g and collected in the second tube.

Sap was used directly for osmotic pressure determination in a Wescor 5100 B vapour pressure Osmometer, or diluted for the estimation of inorganic ions with a Pye SP 90 atomic absorption spectrophotometer. Chloride was determined with an automated chloride meter (Corning EEL, 920) directly calibrated in me L^{-1}.

RESULTS

'Chinese Spring' in general was higher in shoot length and shoot fresh weight than 'Langdon' when the seedlings were 15 days old and above. A consistent increase in shoot lengths of 'Chinese Spring' seedlings was observed at 75 mol m^{-3} NaCl and it was the maximum (60 cm) at the final harvest (Fig. 1 B). In 'Langdon' the seedlings attained maximum height of 45 cm when they were 12 days old (Fig. 1 A) and non-significant increase in height occurred in later harvests. Shoot fresh weights of 'Chinese Spring' seedlings were statistically the same until they were 12 days old but increased to 5 and 8 g (0.6 g day^{-1}) when the seedlings were 18 and 23 days old, respectively (Fig. 2 B).

At 150 mol m^{-3} NaCl, the 'Chinese Spring' seedlings showed an inconsistent increase in height until 18 days of growth. Later on, the seedlings recovered in growth and in the last harvest maximum shoot height of 51 cm was achieved (Fig. 1 B). At the same salinity shoot fresh weight did not show a significant increase until the maximum fresh weight (5 g) was recorded which significantly differed from other harvests (Fig. 2 B). The shoot length in 'Langdon' remained similar at all the harvests and a similar trend was observed in shoot fresh weights (Fig. 1 A and 2 A).

At the highest salinity, the shoot lengths and shoot fresh weight of both 'Langdon' and 'Chinese Spring' seedlings were similar at all the harvests (Fig. 1 A, B and 2 A and B).

These results show that 'Chinese Spring' seedlings compared to 'Langdon' tended to gain shoot length and shoot fresh weight until the last harvest when the seedlings were 23 days old at 75 or 150 mol m^{-3} NaCl. At the highest salinity, however, this trend was not seen.

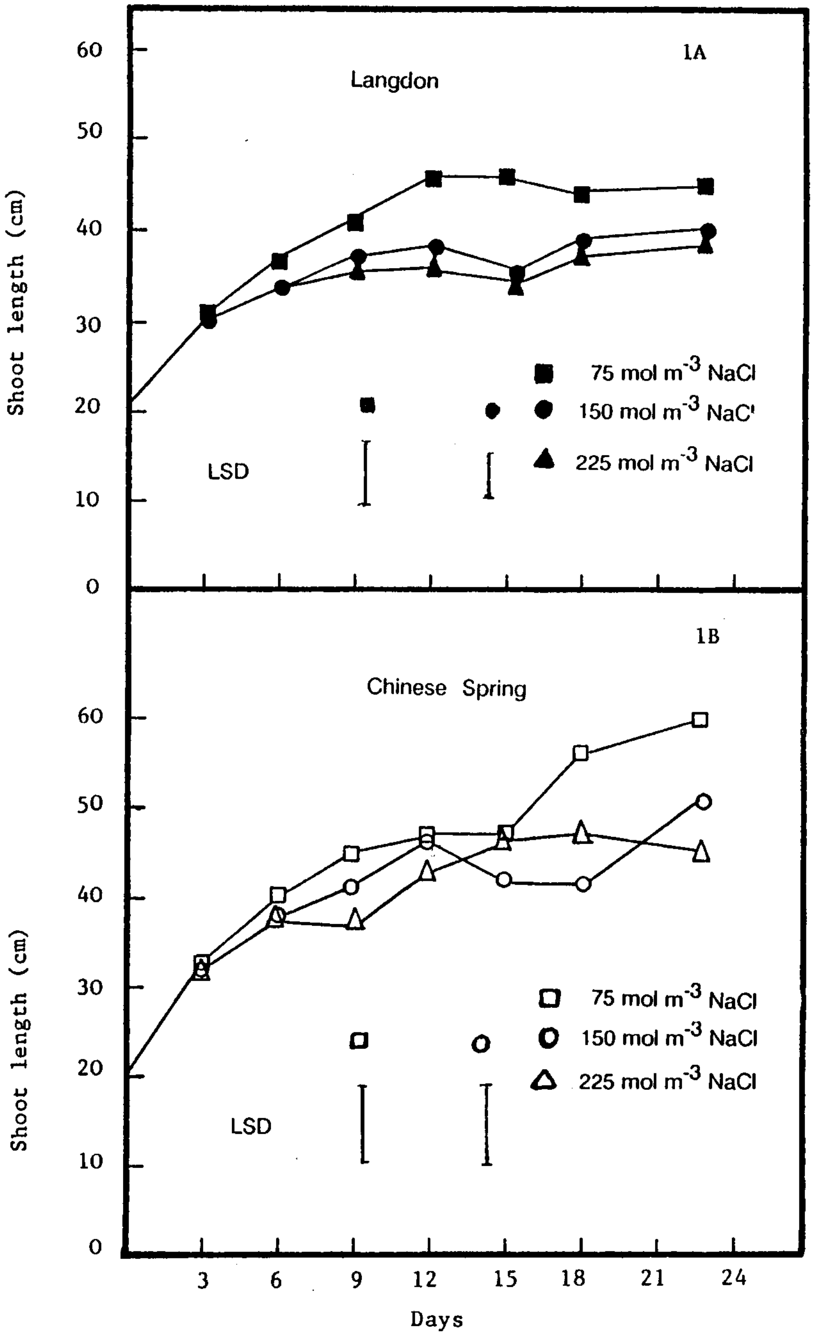

Fig. 1. (A & B). Shoot lengths of Langdon and Chinese Spring seedlings at different time intervals after an exposure to three salinity levels.

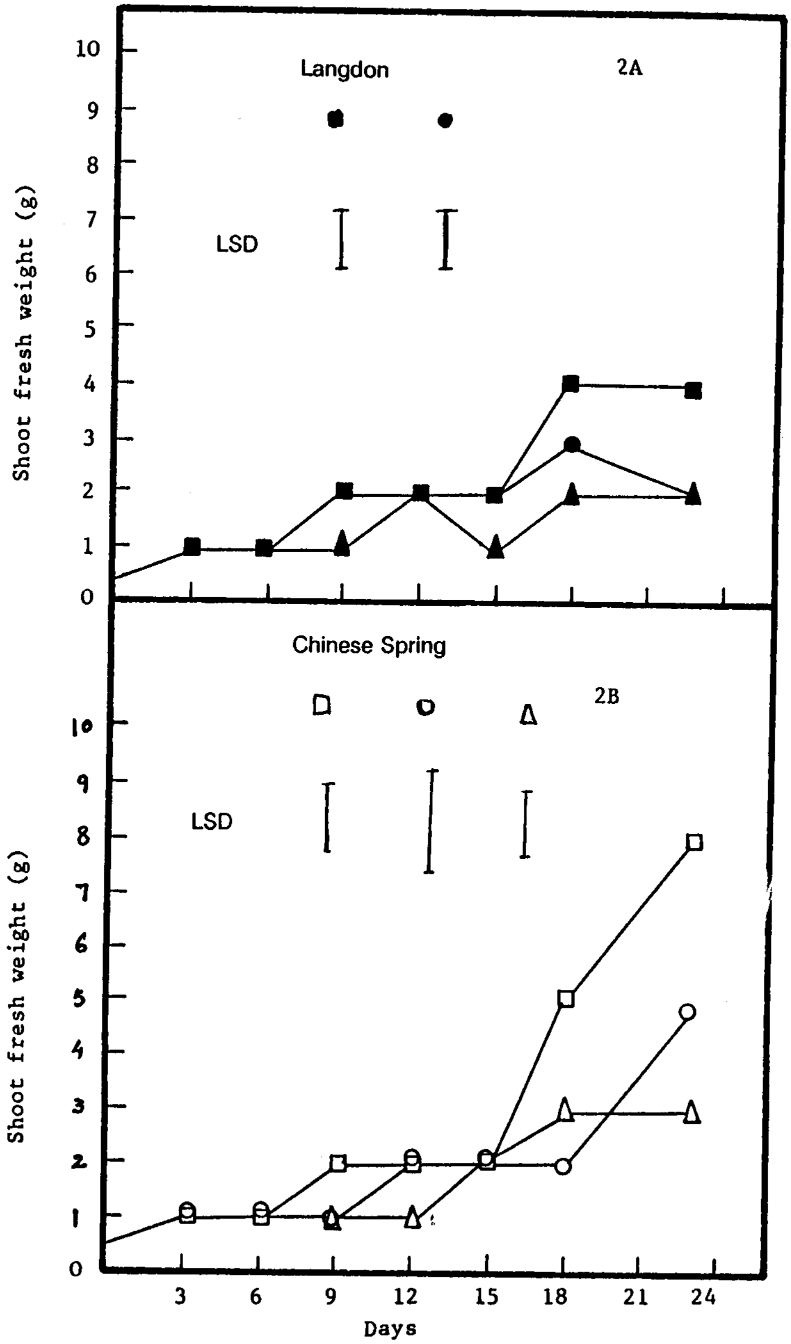

Fig. 2. (A & B). Shoot fresh weeights of Langdon and Chinese Spring seedlings harvested at different time intervals after an exposure to three salinity levels.

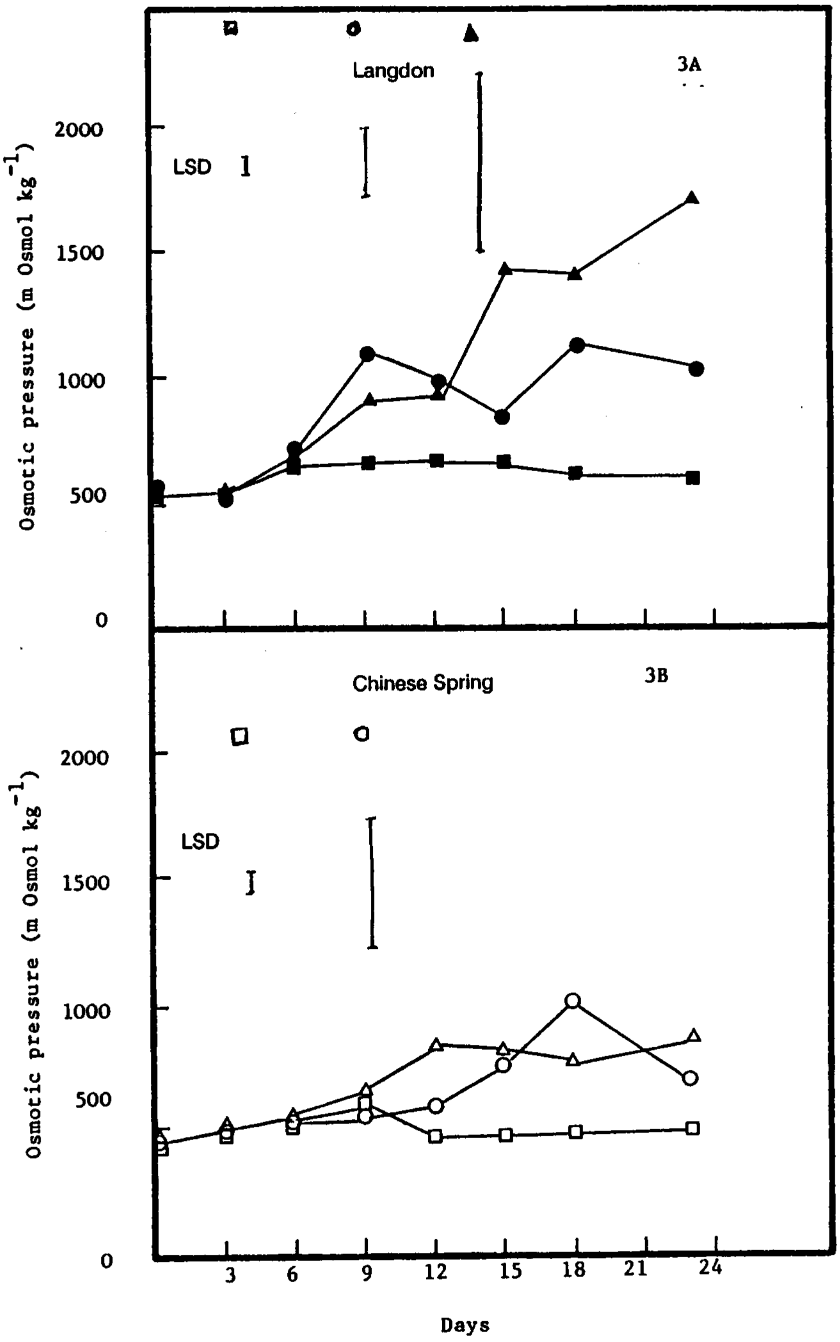

Fig. 3. (A & B). Shoot osmotic pressures of Langdon and Chinese Spring seedlings harvested at different time intervals after an exposure to three salinity levels.

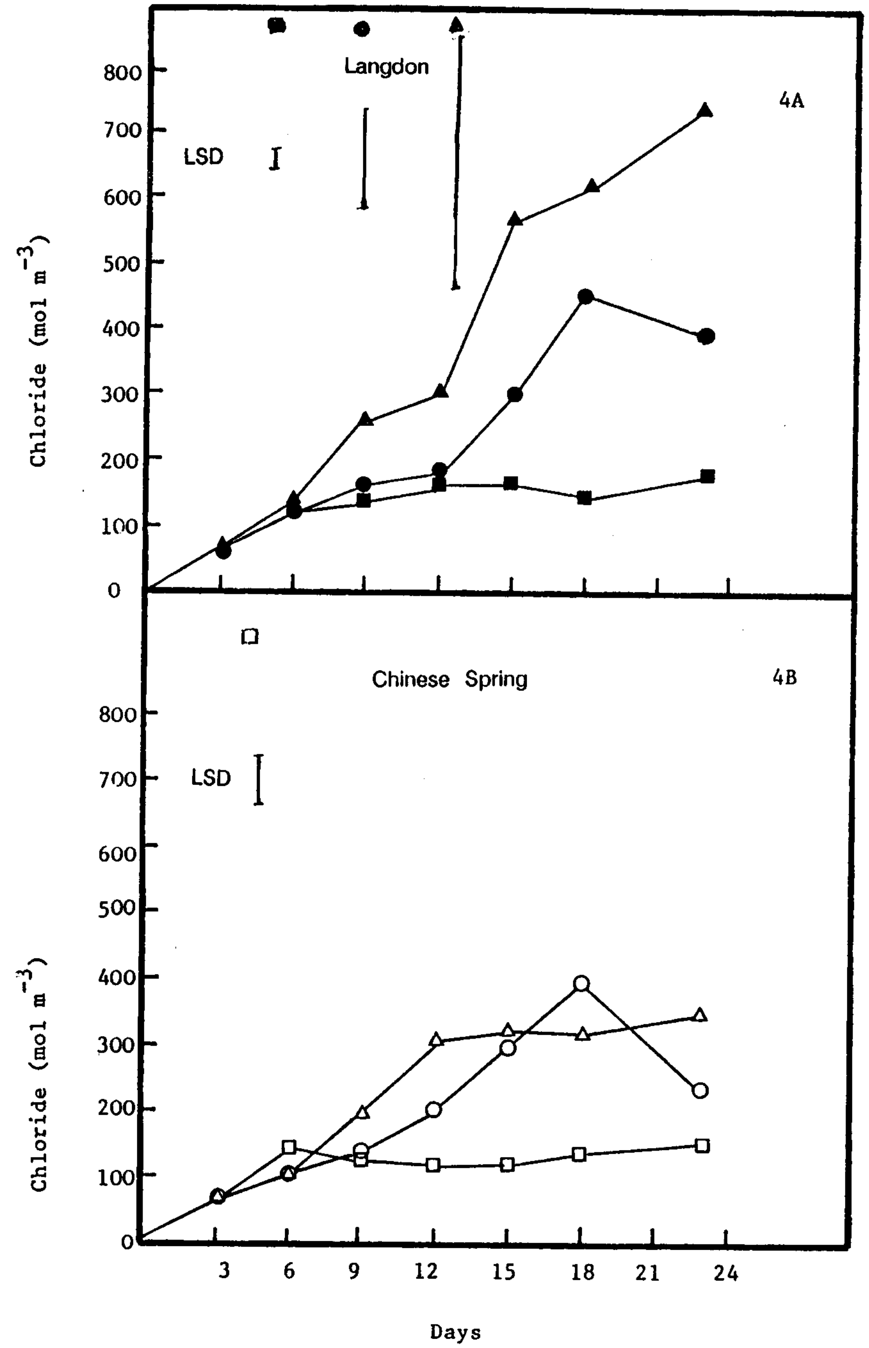

Fig. 4. (A & B). Shoot chloride content of Langdon and Chinese Spring seedlings harvested at different time intervals after an exposure to three salinity levels.

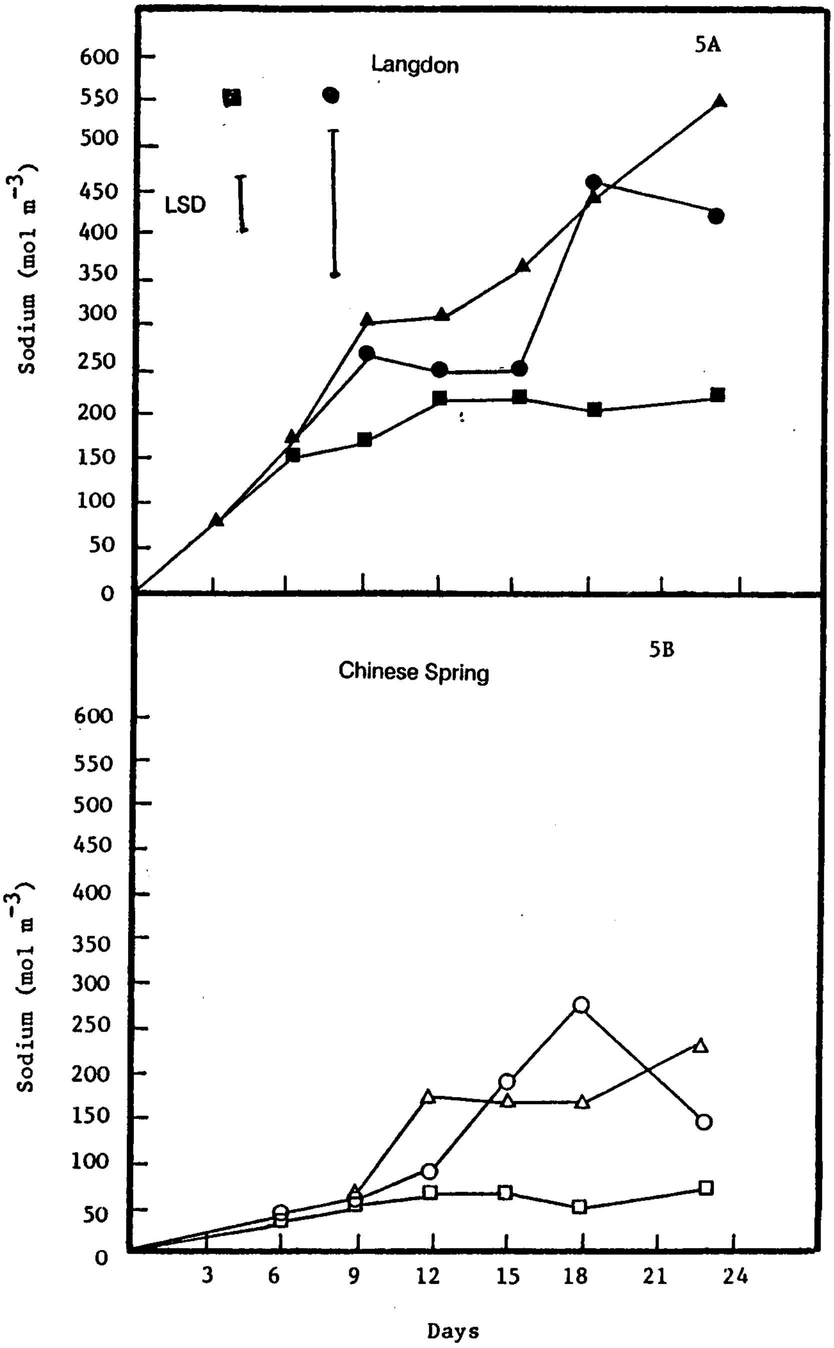

Fig. 5. (A & B). Shoot sodium content of Langdon and Chinese Spring seedlings harvested at different time intervals after an exposure to three salinity levels.

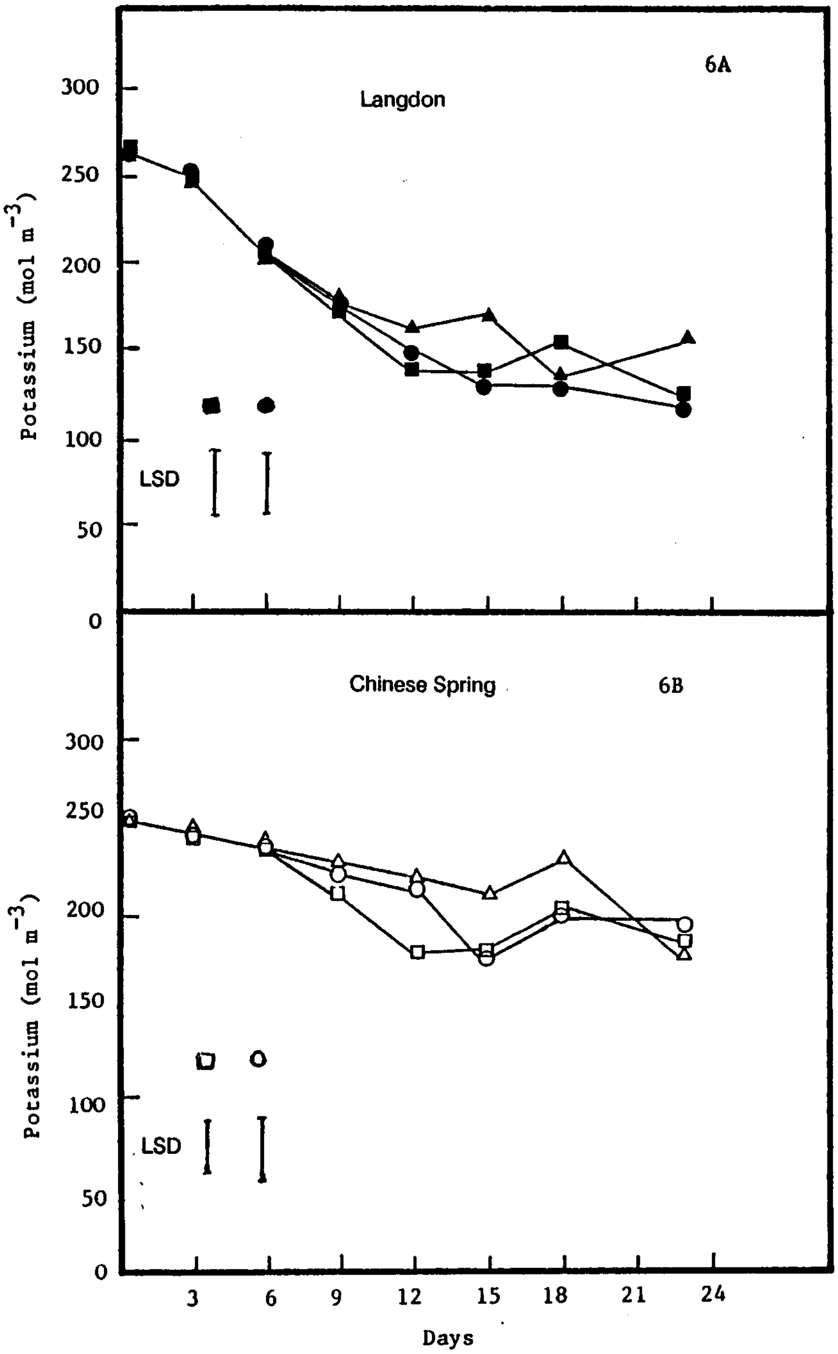

Fig. 6. (A & B). Shoot potassium content of Langdon and Chinese Spring seedlings harvested at different time intervals after an exposure to three salinity levels.

Osmotic pressure: It is apparent from Figure 3 A and 3 B that osmotic pressures of 'Langdon' seedlings were higher than those of 'Chinese Spring' at all the salinities. At the lowest salinity, an increase in the shoot osmotic pressure of 'Chinese Spring' was observed until the seedlings were 9 days old. Later on, it declined and simultaneously showed positive effects on shoot length and shoot fresh weight (Fig. 1 B and 2 B). Decrease in osmotic pressure (Fig. 3 A) and increase in shoot length (Fig. 1 A) were also noted in 'Langdon' but not to the extent as observed in 'Chinese Spring' (Fig. 3 B and 1 B).

At 150 mol m^{-3} NaCl though the results were non-significant, the osmotic pressure showed an increase with an increase in the age of 'Chinese Spring' seedlings until they were 18 days old (Fig. 3 B). A further 5 days growth period indicated an adjustment phase as the osmotic pressure decreased in the last harvest. In 'Langdon' osmotic pressure of 18 days old seedlings was significantly higher than those of 6 or 15 days old and was at par with others. Apparently a decrease in osmotic pressure took place when the seedlings increased in age from 9-15 days growth but it increased again (Fig. 3 A) showing that the seedlings could not possibly adjust themselves at 150 mol m^{-3} NaCl in the last two harvests.

At 225 mol m^{-3} NaCl, the osmotic pressure values of 'Chinese Spring' were statistically the same for all the harvests. A similar trend of results was noted for 'Langdon'. In 'Chinese Spring' seedlings, a substantial increase in osmotic pressure occurred in 12 days over that of 9 days old seedlings. Later on, the osmotic pressures were almost uniform until the last harvest (Fig. 3 B). In 'Langdon', however, osmotic pressure of 15 and 18 days old seedlings was about 1.5 times higher than 12 days old seedlings and it increased further with increased age of the seedlings (Fig. 3 A).

Inorganic ions: Shoot sap Cl^- and Na^+ concentrations of 'Chinese Spring' were statistically the same at all harvests and salinity treatments. A rise in Cl^- and Na^+ contents with increase in the age of seedlings was, however, observed at 150 mol m^{-3} NaCl until they were 18 days old after which these decreased (Fig. 4 B and 5 B) showing a possible adjustment in the later stages of seedlings growth. At 225 mol m^{-3} NaCl, the Cl^- contents reached a plateau after the seedlings were 12 days old and above and the average Cl^- contents were 338.5 mol m^{-3}. The Na^+ contents of 12-18 days old seedlings showed a uniformity at 225 mol m^{-3} NaCl but with increased age they increased substantially in 'Chinese Spring' (Fig. 5 B).

On the other hand, Cl^- and Na^+ contents of 'Langdon' (Fig. 4 A and 5 A) determined at different harvests showed significant differences at 75 and 150 mol m^{-3} NaCl. At 75 mol m^{-3}, Cl^- and Na^+ contents of 23 days old seedlings were significantly higher than those of 3 days old seedlings. A similar trend in Na^+ and Cl^- concentrations was observed at 150 mol m^{-3} NaCl.

The K^+ concentration in 'Chinese Spring' decreased with increased age until the seedlings were 12 days old at all the treatments after which they showed an inconsistent rise in the later growth stages (Fig. 6 B). At 75 and 225 mol m^{-3} NaCl, a decrease in K^+ content was noted in 'Langdon' (Fig. 6 A) until the seedlings were 12 days old but at 150 mol m^{-3} NaCl, the decrease in K^+ concentration occurred until the last harvest. The K^+ concentration of 6 days old seedlings was significantly higher than that of 12-23 days old seedlings, which in turn were at par with one another.

Overall, 'Chinese Spring' was lower in Na^+ and higher in K^+ concentration at all the harvests taken at different salinities than that of 'Langdon'. Consequently, K^+/Na^+ ratios were also higher for 'Chinese Spring' than 'Langdon'.

DISCUSSION

Salinity suppresses plant growth and the suppression increases as the salt concentration increases (Sharma and Garg, 1985). Similar observations were made in shoot length and shoot weight of 'Langdon' and 'Chinese Spring' wheats measured at different time intervals after primary exposure to salinities (Fig. 1 and 2). The decrease in shoot growth parameter was more in tetraploid than the hexaploid wheats which showed recovery in growth at 150 mol m^{-3}.

Sodium concentration in 'Langdon' increased with increase in the stress and age of the seedlings at each stress while the reverse was true for K^+. In contrast, 'Chinese Spring' seedlings had considerably lower Na^+ than that of tetraploid wheat at all the salinities (Fig. 4 A and 4 B). Although the Na^+ contents increased with increased external salinity, there were no significant increases in Na^+ levels with time in the seedlings at any of the salt levels. 'Chinese spring' seedlings maintained their K^+ concentrations equal to those of the lowest salt stress even if subjected to the highest salinity. Higher K^+ and lower Na^+ in *Triticum aestivum* L. in salt stress conditions were also noted by Joshi *et al.* (1982).

A rise in Cl^- concentrations of shoots of 'Langdon' occurred with an increase in stress and age of seedlings at each stress and were higher than those of hexaploid wheat. Accumulation of ions in the tetraploid wheat also contributed to its increased osmotic pressure over the hexaploid wheat (Fig. 3 A and 3 B). 'Chinese Spring' as a whole, maintained its osmotic pressure, Na^+ and Cl^- concentrations when the seedlings were 12 days old and above and seemed to adjust itself in the saline growth medium.

Maintenance of high K^+ concentration and K^+/Na^+ ratio and low Na^+ and Cl^- contents enabled the hexaploid (AABBDD) wheat to perform better than the tetraploid (AABB) wheat at both the variables, i.e. increase in stress level and the age of seedlings at each stress. Differences in the two wheats for the above mentioned parameters could be attributed to 'DD' genome. The results of this study are in line with the findings of Wyn Jones *et al.* (1984).

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