EFFECT OF SALINITY AND WATERLOGGING INTERACTION ON GROWTH AND IONIC DISTRIBUTION IN LEAVES OF WHEAT GENOTYPES

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The interactive effect of salinity and hypoxia was studied on the distribution of ions in leaves of four wheat genotypes grown with (75, 150 mol m\(^{-1}\)) and without NaCl salinity under aerated and hypoxic conditions. Number of tillers, shoot fresh weight and shoot length were negatively affected by salinity. The combined effect of salinity and hypoxia was more injurious to the number of tillers, shoot fresh weight and shoot length. Ionic concentrations (Na\(^+\), K\(^+\) and Cl\(^-\)) in different leaves indicated that the concentration of Na\(^+\) and Cl\(^-\) increased in leaves due to salinity and hypoxia and was higher in older leaves, whereas the order was reverse in case of K\(^+\)

Key words: growth, ionic distribution, salinity, waterlogging, wheat genotypes

INTRODUCTION
Soil salinity is inimical to plant growth due to specific ion toxicity, osmotic effect, induced nutrient deficiency, etc. (Flowers et al., 1991). A major part of the problem soils (over 1m ha out of 6.3m ha salt-affected land) are presently under rice cultivation and dense in nature with poor drainage (Chaudhry, 1978). Surface ponding (waterlogging) is a common feature of these soils; rainfall or heavy irrigation causes temporary oxygen stress to plant roots. Since wheat, unlike rice is sensitive to hypoxia (low oxygen conditions), its production is seriously affected (Parveen et al., 1991). Two approaches could increase wheat yield from these soils facing twin problem of waterlogging and salinity. One is the planting of wheat with such a technique which may facilitate oxygen supply to roots, the other is cultivation of a variety/line capable to grow under dual stress of waterlogging and salinity. However, both the approaches in combination could enhance wheat production manifold. Further, it is important to understand that how does a plant regulate toxic ions and essential plant nutrients under such adverse conditions since this information is essential in the development/selection of a cultivar. The aim of the present study is to understand the interactive effects of salinity and waterlogging on the distribution of ions in leaves of some selected wheat genotypes.

MATERIALS AND METHODS
Fibre glass pots filled with gravels and foam were used to grow wheat genotypes viz. SARC-I, SARC-III, Ph-85 and 7-Cerros. Prior to sowing, sufficient number of healthy seeds of all wheat genotypes were soaked in aerated distilled water for twenty-four hours. Then ten seeds of each genotype were placed in respective pots at a depth of 2 cm. During germination, 2mM Ca(NO\(_3\))\(_2\)\_4H\(_2\)O and 1m MgSO\(_4\)\_7Hp solution was sprinkled. After germination, half strength Hoagland nutrient solution (Hoagland and Arnon, 1950) prepared in canal water was applied to the pots. Ten days after germination (at 2-3 leaf stage) thinning was done and salinity levels of 75 and 150 mol m\(^{-1}\) were developed in three equal increments (each increment applied after 24 hours) followed by a hypoxic stress. Nutrient solutions were changed at a week's interval. Plants were harvested forty days after the imposition of salt and hypoxic stress and growth data recorded. Leaf sap was analyzed for Na\(^+\),K\(^+\), and Cl\(^-\) concentrations using flame photometer and chloride analyzer.

RESULTS AND DISCUSSION
Growth: Tillering decreased due to increase in salinity under aerobic, as well as hypoxic conditions (Table 1). Greater number of tillers ensure better crop stand and ultimately better yield. Hypoxia, however, increased the tillering under control and moderate salinity; these results are contradictory to the initial findings which showed that introduction of hypoxia decreased tillering in wheat (Parveen et al., 1991). Probably the reason is the difference in growth medium as well as matrix culture as was used in this experiment. Among the four wheat genotypes, the maximum tillering was in the
case of Pb-85 and the minimum in 7-Cerros. Shoot length and shoot fresh weight decreased with increasing salinity in the rooting medium (Table 1). Imposition of hypoxia over salinity further affected these parameters. Similar results were obtained by Drew (1988). Among the varieties, Pb-85 was affected the least while 7-Cerros the maximum due to combined stress of high salinity and hypoxia. Maximum shoot fresh weight was recorded in the case of control treatment. However, shoot fresh weight decreased with increasing salinity levels (Table 1). The reduction in shoot fresh weight might be due to the reduced crop growth because of salinity and hypoxia (Barrett-Lennard, 1986). Among the genotypes, SARC-III produced the higher shoot fresh weight under all sets of treatments i.e. salinity and hypoxia, whereas the performance of 7-Cerros was found poor.

### Leaf Ionic Concentration

Salinity significantly increased the accumulation of sodium in the leaves compared with control (Table 2). Concentration of sodium in leaf sap of plant at all salinity levels was related to the relative concentration of salt in the rooting medium. This could be due to high transport of salts from the root zone to the shoot and reduced growth of plants (Rashid, 1986; Gorham, 1990; Aslam et al., 1991). Under hypoxic conditions efflux of Na⁺ is not possible due to lack of energy. It was observed that Pb-85 had the minimum Na⁺ concentration while 7-Cerros retained the maximum Na⁺ concentration in their leaf saps, respectively. This indicated that Pb-85

<table>
<thead>
<tr>
<th>Variety</th>
<th>Control</th>
<th>75</th>
<th>150</th>
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<tbody>
<tr>
<td></td>
<td>Aerobic</td>
<td>Hypoxic</td>
<td>Aerobic</td>
</tr>
<tr>
<td>SARC-I</td>
<td>5.42 ef</td>
<td>7.67ab</td>
<td>3.75gi</td>
</tr>
<tr>
<td>SARC-III</td>
<td>5.42ef</td>
<td>6.67bd</td>
<td>4.25fh</td>
</tr>
<tr>
<td>Pb-85</td>
<td>6.08de</td>
<td>5.25a</td>
<td>4.33fg</td>
</tr>
<tr>
<td>7-Cerros</td>
<td>6.42</td>
<td>7.33ab</td>
<td>4.08gi</td>
</tr>
<tr>
<td>Mean</td>
<td>5.83B</td>
<td>7.50A</td>
<td>4.10D</td>
</tr>
</tbody>
</table>

Means followed by the same letter(s) are statistically similar at P=0.05.
Salinity and waterlogging interaction

had a better mechanism to exclude sodium at the root level therefore it seemed to be a better tolerant to combined stress of salinity and hypoxia. Concentration of Na⁺ was the highest in older leaf (L-3 from the top) and the lowest in the youngest. Concentration of chloride in the leaf sap followed the same pattern as that of sodium. Distribution of KT in various leaves was opposite to that of Na⁺ and Cl⁻ (Table 2). Maximum K⁺ concentration was observed in a fully expanded young leaf. Salinity had a significant effect on K⁺ concentration which decreased with increasing salinity. However, under hypoxic condition it also decreased due to oxygen stress. Barrett-Lennard et al. (1988) reported that K⁺ concentration was reduced by anaerobiosis, which might be due to the K⁺ selectivity in plants (energy demanding process). It required the utilization of oxygen for the production of ATP which in turn was required for selective absorption of K⁺. Salt tolerant wheat genotypes SARC-III and Pb-85 had the maximum K⁺ concentration in their leaf saps due to poor selectivity of K⁺ over Na⁺. K:Na ratio decreased with the age of the leaf, the younger leaves had the higher K:Na ratio (Table 2). The higher K:Na ratio in younger leaves may be due to the reason that in the vacuoles of mature leaves, K could be exchanged for Na imported into leaf by xylem. The phloem could take up K directly from xylem. The higher K:Na ratio in the younger leaves is presumably critical for maintenance of metabolism in the cytoplasm of these young cells (Aslam et al., 1989). This ratio also decreased markedly due to salt as well as oxygen stress. The higher K:Na ratio was observed in the case of SARC-III followed by Pb-85 which were statistically equal but different from 7-Cerros. Though tolerant wheat genotypes (SARC-III and Pb-85) have the same K⁺ concentration and statistically at par with 7-Cerros (salt sensitive) but marked difference for K:Na ratio in these three genotypes was recorded. This clearly indicates that it is not the concentration of K but K:Na ratio which provides stress tolerance. Thus K:Na ratio can be used as a criterion to screen the wheat genotypes against the combined stress of salinity and hypoxia.

REFERENCES

Aslam, Ahmad, Qureshi, Nawaz & Parveen


