Salt Tolerance and Cation Interaction in Alkali Sacaton at Germination

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Highlight

Salt tolerance and cation interaction in alkali sacaton (Sporobolus airoides Torr.) was studied during the germination stage. Germination was inhibited at a concentration of 275 meq/liter of sodium chloride. Mannitol and other salts at iso-osmotic pressure restricted germination in the following decreasing order: MgCl\(_2\), KCl, CaCl\(_2\), NaCl, and mannitol. Inhibitory effects of magnesium on germination were partially counteracted by calcium and sodium. Greater recovery in germination was noted by addition of calcium than sodium in seeds previously treated with a high concentration of sodium chloride. The role of sodium and calcium in counteracting magnesium effects has been discussed. It is also concluded that specific effects of salts are more important than osmotic effects on the seed germination of this species.

Cultivation of salt tolerant forage plants which can grow under natural rainfall is profitable where land is highly saline and adequate water for leaching down the salt is not available (Malcolm, 1969). This approach is one utilization rather than reclamation of saline soils. Vast areas of land with low rainfall and high salinity are found throughout West Pakistan. Neither crops nor good quality grasses can grow on such lands. In the southern region of West Pakistan this problem is more acute because of fodder shortage. In order to make the best use of such land, a search is being made for exotic species which can thrive and produce fodder under our local conditions.

Alkali sacaton (Sporobolus airoides Torr.) is an important forage plant of southwestern United States. It has a reputation of being highly salt tolerant (Hayward and Bernstein, 1958), and is particularly used for soil stabilization (Aldon, 1969). The climate of southwestern United States is similar to that of the southern region of West Pakistan. For these reasons this plant was included in our preliminary studies carried out for determining salt tolerance under laboratory conditions. The present report describes the results of this study.

Materials and Methods

Seeds of alkali sacaton were obtained from the Crops Research Laboratory, Utah State University, Logan, Utah. Healthy seeds were selected for experiments and sterilized with 0.1% HgCl\(_2\) solution for one minute. These seeds were soaked in distilled water for 18 hours prior to imposing treatments. Seeds were germinated in water culture in a laboratory at room temperature. The temperature ranged between 90 F to 100 F during the day and 65 to 75 F during the night. Small polythene cups of 200 ml capacity were used as culture vessels. Polythene nets were used to support seeds in the vessels. These nets were suspended over the treatment solutions in the culture vessels and the treatments were replicated 4 times.

Results

Effects of Various NaCl Concentrations

Concentrations of NaCl used for imposing salinity were 25, 75, 125, 225, 275, 325 meq/liter. Figure 1 shows that 125 meq/liter of NaCl inhibited germination more than 50%, with a greater depression at higher concentrations of NaCl. Germination of seeds continued at 275 meq/liter of NaCl, but virtually stopped at the highest concentration of NaCl used.

Effects of Different Salts

NaCl, KCl, CaCl\(_2\), and MgCl\(_2\) at 1 and 2 atm were compared for their effects on seed germination. Figure 2 shows that NaCl at 1 atm had little inhibitory effect on seed germination, but at 2 atm some inhibition in germination was noted. The other salts depressed germination even at 1 atm and the effects became more pronounced at 2 atm. The depression effect in decreasing order was MgCl\(_2\), KCl, CaCl\(_2\), and NaCl.
Comparison of Effects of Salts and Mannitol

NaCl, KCl, CaCl₂, and MgCl₂ at 3 atm were used to distinguish between osmotic and non-osmotic effects on germination. Mannitol at 3 atm slightly depressed germination only, but other salts depressed germination significantly at this level of salinity (Fig. 3). The depression of germination by the salts was in the same order as in Figure 2.

Interaction of Na⁺ and Mg²⁺

The interaction of NaCl and MgCl₂ was studied because at iso-osmotic concentrations NaCl was much less inhibitory than MgCl₂. NaCl at 10, 20, and 25 meq/liter was added to a solution containing MgCl₂ at 3 atm. For comparison, NaCl at 4 atm was also tested. MgCl₂ at 3 atm greatly depressed germination (Fig. 4). The inhibitory effects of Mg²⁺ were partly neutralized by adding various concentrations of NaCl.

Interaction of Na⁺, K⁺, and Ca²⁺ with Mg²⁺

NaCl, KCl, and CaCl₂ at 20 meq/liter with MgCl₂ at 3 atm were studied in order to determine if these salts also counteract the inhibitory effects of Mg²⁺ on germination. The inhibitory effects of Mg²⁺ were counteracted more by addition of CaCl₂ than NaCl; addition of KCl, however, had little effect (Fig. 5).

Recovery in Germination on Addition of Na⁺ and Ca²⁺

After pretreatment of seeds in 3 atm MgCl₂ for 24 or 48 hours, 20 meq/liter of CaCl₂ or NaCl was added to the MgCl₂ solution to determine the relative effectiveness of NaCl and CaCl₂ in counteracting the inhibitory effects of MgCl₂. The percentage of recovery was greater in the presence of Ca²⁺ than Na⁺ in the 24 hour pretreatment period (Fig. 6). A similar trend, though less pronounced, was also noted in the 48-hour pretreatment period.

Discussion

There is very scanty information on the salt tolerance of alkali sacaton. However, Richards et al. (1954) have shown that this species grows better between 0.3% and 0.5% soil salinity than at higher concentrations. In the present investigation the germination of seed continued at 275 meq/liter of NaCl, indicating a good salt tolerance of this species, at least during germination. Salt relations of seed during germination are as important as during later growth stages. In the present study, high concentrations of salt in the medium restricted germination. Ionic species differed in their inhibitory effects on germination. For example, there was greater reduction in germination in chlorides of Mg²⁺ and K⁺ than Na⁺ and Ca²⁺ at equal osmotic concentrations (Fig. 2).

Interionic influences on the uptake process have been studied in the past but their effects on seed germination have not been thoroughly investigated. With mea-
ger data in hand it is difficult to arrive at definite conclusions on the cause of reduced germination in MgCl₂. It is likely that the ionic balance of seeds in solution of high MgCl₂ concentration was drastically changed. Mg²⁺ may have a direct effect on seed metabolism and thus restrict the germination process. In studying the interaction of MgCl₂ with other ions it was found that addition of Ca²⁺ and Na⁺ counteracted the deleterious effects of Mg²⁺.

Effects of Na⁺ in counteracting Mg²⁺ inhibition of germination are surprising but the possibility of its nutritive role cannot be ruled out since its essentiality in some halophytes such as Atriplex vesicaria has been established (Brownell, 1965). The interaction of Ca²⁺ and Mg²⁺ is well known. Both are divalent and may compete for similar absorption sites. Greater recovery in germination on addition of Ca²⁺ than Na⁺ (Fig. 6) may be due to effects of Ca²⁺ on seed membranes. Calcium is important in maintaining the structure of the protoplasm and semipermeability of the membranes (Fisher, 1966). Epstein (1961) has shown that Ca²⁺ is essential for maintaining the integrity of selective ion transport mechanisms. High MgCl₂ may replace the endogenous Ca²⁺ from seeds and consequently cause disorganization of protoplasm and depression of germination.

Germination in a saline environment is affected by osmotic and specific ion effects (Uhvits, 1946). Knipe (1968) reported that germination of alkali sacaton was severely restricted by moisture tension greater than 1 atm. In the present study the major factor restricting germination was the specific effect of salts: germination was more severely depressed in various salt solutions than in the iso-osmotic concentration of mannitol.

The conclusion which can be drawn from the present study is that the establishment of this grass in the field will depend on the salt concentration and ionic composition of the soil. Soil rich in Mg²⁺ and low in Ca²⁺ will not favor germination.

**Literature Cited**


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