Germination Responses of Three Forage Grasses to Different Concentrations of Six Salts

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Highlight: Both total germination and rate of germination of three species of perennial grasses were affected by concentration of six salts. A significant salt by species interaction was detected, and species differed in their response to concentrations, but both the salts and specific cations and anions affected all three species in the same way.

In many areas of the Western United States, Canada, and elsewhere worldwide, the reclamation of saline soils is becoming a major environmental-conservation concern. The problem is extremely complex, but one important facet is developing repeatable methods of screening seed stocks for tolerance to salts, so that salt tolerant lines can be identified and selected.

Dewey (1962) has suggested that germination provides a fair measure of general salt tolerance. Ayers and Hayward (1948) state that no generalization can be drawn between salinity tolerance during germination and tolerance at other development states. Pearson et al. (1966) reported that salinity slows the rate of germination, but does not reduce total germination; and Donovan and Day (1969) noted that germination is affected by both salt concentration (the osmotic pressure) and by the type of salt. Germination of alkali sacaton was reduced more by MgCl than by KCl or NaCl and more by KCl than NaCl (Hyder and Yasmin 1972).

In our study, we sought to determine the impact of salts and their concentrations on the germination of three species of perennial grasses.

Materials and Methods

Seeds (caryopses) of three species of perennial grass—tall wheatgrass (*Agropyron elongatum*), tall fescue (*Festuca arundinacea*), and Reed canarygrass (*Phalaris canariensis*)—were germinated in each of three concentrations, determined by electrical conductivity (4, 10, and 16 mmhos) of each of six salts (NaCl, Na_2SO_4, $MgCl_2$, $MgSO_4$, KCl, and K_2SO_4) in the dark in a germinator with 15–25°C alternating temperatures (16 and 8 hours, respectively). One hundred seeds of each species were placed in separate, standard germination boxes on blotters that had been saturated with one of the six salt solutions. Blotters were wetted with distilled water as necessary throughout the 14-day study period. The design was a randomized complete block with blocking in time; the same germinator was used for each of two successive replications. Germination was scored daily. A seed was deemed to be germinated when both radicle and plumule growth were evident.

Total germination and rate of germination (RG) were analyzed. Rate of germination was calculated following Carleton et al. (1968) as:

> $\Sigma(X_{i+1} - X_i)/N_{i+1}$ where X_{i+1} and X_i are the number of seeds germinated on any given day, and on the previous day, respectively, and N_i is any given day of the experiment. Day 1 was the day the experiment was started.

Results and Discussion

For total germination, statistically significant variation ($p \leq .05$) was detected for differences among species and among salt concentrations and for the species × concentration interaction. Other effects, including blocks, salts (and their components cations, anions, and the anion × cation interaction), and the interactions species × salt, salt × concentration, and species × salt × concentration, were statistically nonsignificant. The significant species effect was due to significantly lower germination of Reed canarygrass compared with tall wheatgrass and tall fescue (Table 1). For all species germination was not significantly reduced between the distilled water check and a 4-mmhos salt solution (Fig. 1). In the salt solutions, germination decreased in a linear fashion from 73% at 4 mmhos to about 59% at 16 mmhos (Table 1). The significant interaction is

Table 1. Mean number of seeds germinated and rate of germination for three species, for six salts, and for three concentrations of salts, measured by electrical conductivity.

	Seeds germinated		Rate of germination	
Species	Salt[1]	Control[2]	Salt[1]	Control[2]
Tall wheatgrass	80.8[a]*	89.0[a]	12.3[a]	14.1[a]
Tall fescue	77.1[a]	87.0[a]	10.8[a]	13.2[a]
Reed canarygrass	41.7[b]	56.5[b]	5.8[b]	7.9[b]
Salt		66.8[a]		9.5[a]
NaCl		67.4[a]		9.5[a]
Na_2SO_4		65.5[a]		9.7[a]
Mg_2Cl_2		66.9[a]		9.6[a]
Mg_2SO_4		67.1[a]		9.8[a]
KCl		67.2[a]		9.7[a]
K_2SO_4				
Concentrations				
4 mmhos	73.4[a]		11.3[a]	
10 mmhos	68.4[b]		9.7[b]	
16 mmhos	58.6[b]		7.9[c]	

[1] Mean of six salts at three concentrations.
[2] Mean of distilled water control.
* Means in the same column for each effect (species, salts, or concentrations) with a letter in common are not significantly different ($p \leq .05$, Duncan's multiple range test).

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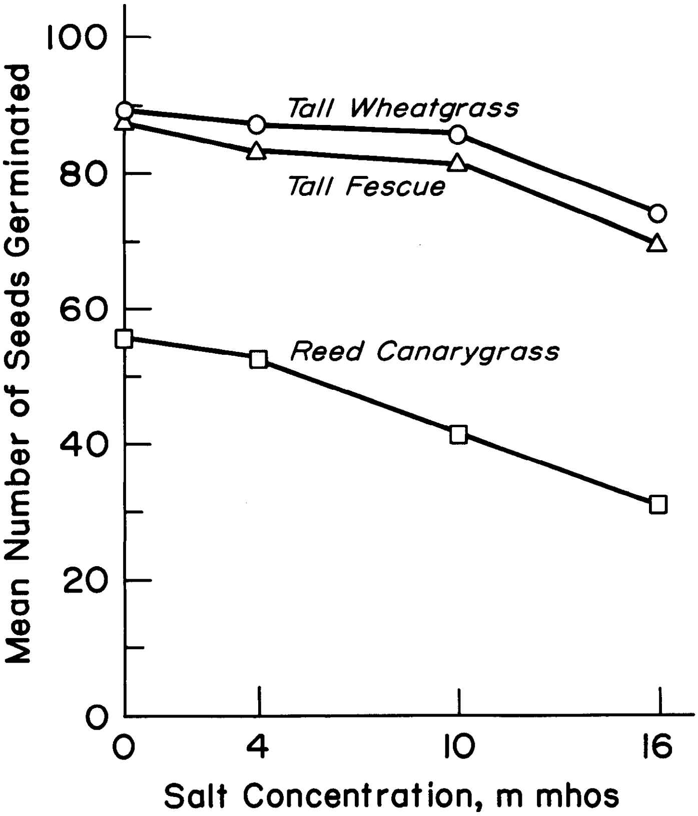

Fig. 1. *Relationship between number of seeds germinated in 14 days and salt concentration for three species of perennial grass.*

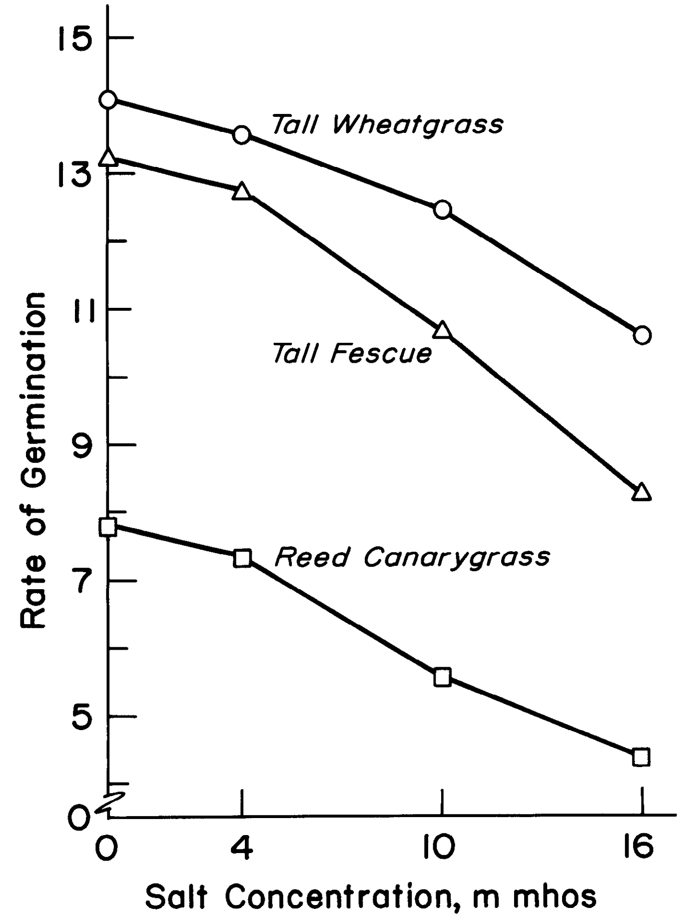

Fig. 2. *Relationship between rate of germination in a 14-day period and salt concentration for three species of perennial grasses.*

attributed to the constant decline in germination of seeds of Reed canarygrass from 4 to 16 mmhos salt concentration compared to the virtually uniform response of both tall wheatgrass and tall fescue from 4 to 10 mmhos salt concentration and then a uniform decline of each of these from 10 to 16 mmhos concentration (Fig. 1).

The analysis of rate of germination presented a picture comparable to that of total germination with respect to significant effects. The only difference was the unexplained, significant block effect in the rate study. Rate of germination decreased with increasing salt concentrations and Reed canarygrass had a significantly slower rate than tall wheatgrass and tall fescue, which were comparable (Table 1). The cause of the significant species × concentration interaction is not as evident for rate of germination as it was for total germination. The reduction in rate of germination was nearly linear over the three concentrations for tall fescue; the reduction in rate was less for both Reed canarygrass and tall wheatgrass from concentrations of 10 to 16 mmhos (Fig. 2).

From this study we conclude that although species differed with respect to their response to concentrations of salts, screening for salt tolerance would be done equally effectively with any of the six salts used.

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