Effect of Sodium and Magnesium Sulfate on Forage Seed Germination

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Abstract

Initial screening of plant species for salt tolerance has often been accomplished by recording germination percent in various salt solutions under controlled environmental conditions. The objectives of this study were to: (1) determine the incubation time required to properly evaluate the germination percent of 8 forage species in sodium sulfate (Na_2SO_4) and magnesium sulfate ($MgSO_4$) solutions under controlled conditions; (2) to document the germination percent of the 8 forage species in response to the Na_2SO_4 and $MgSO_4$ solutions after the required incubation period.

The incubation time required to stabilize the germination percent for each species in the salt solutions varied. Alkali sacaton and switchgrass germination percent stabilized after 7 days; fourwing saltbush, little bluestem, red clover, and thickspike wheatgrass required 14 days; and green needlegrass, 21 days. The germination percent of Canby bluegrass increased throughout the 28-day study period. Germination, after the above incubation periods, was enhanced for fourwing saltbush by the Na_2SO_4 and $MgSO_4$ treatments. Germination of green needlegrass and red clover was depressed by all salt treatments; and alkali sacaton, little bluestem and switchgrass germination was depressed by the Na_2SO_4 treatment. Germination of thickspike wheatgrass and Canby bluegrass (at 28 days) was not affected by any of the salt treatments. Results show the importance of the incubation period used in the initial screening of forage species for salt tolerance. Fourwing saltbush, thickspike wheatgrass, and Canby bluegrass were the least sensitive to the Na_2SO_4 and $MgSO_4$ solutions studied.

Germination and plant response to salt concentration in soils and other growth media have been studied extensively for many cultivated crops but not for many native forage species. Reviews by Hayward (1956), Bernstein and Hayward (1958), and Bernstein (1962) summarized 2 general ways in which salinity affects plants: (1) it increases the osmotic tension of the soil or growth media solution which decreases the water availability, and (2) increases the concentration of specific ions which can have toxic or nutritional effects on plant functions.

More recently, Hyder and Yasmin (1972) reported that germination of alkali sacaton (*Sporobolus airoides* [Torr.]Torr.) was inhibited at a concentration of 275 meq/l of sodium chloride (NaCl) and that reduction in germination was greater with chlorides of magnesium (Mg^{++}) and potassium (K^{+}) than sodium (Na^{+}) and calcium (Ca^{++}) at equal osmotic tensions (1, 2, or 3 atm). Ryan et al. (1975) found that increasing salt concentrations (50, 100, 150, and 200 meq/l) inhibited germination. Inhibition was greatest with Mg^{++} and least with Ca^{++} salts. Magnesium sulfate inhibited germination less than the equivalent concentration of magnesium chloride ($MgCl_2$). Wilman lovegrass (*Eragrostis superba* Peyr.) and weeping lovegrass (*Eragrostis curvula* [Schrad.]. Nees) were found to be relatively salt tolerant. Miller and Chapman (1978) found both total germination and rate of germination of 3 perennial grasses were affected by concentration (electrical conductivity = 4, 10 and 16 mmhos/cm) of 6 salts. No specific ion effects were detected. Rate of germination decreased with increasing salt concentration. Reed canarygrass (*Phalaris canariensis* L.) had a significantly slower rate of germination than tall wheatgrass (*Agropyron elongatum* [Host] Beauv.) and tall fescue (*Festuca arundinacea* Schreb.). A study period of 12-16 days was used in these 3 recent studies.

For some purposes a screening or initial evaluation of plant germination response to salt solutions is necessary. Such studies when conducted in germinators or growth chambers, provide an evaluation under controlled environmental conditions without the complication of soil effects. While not directly applicable to field situations, they provide the first screening and initial evaluation. The length of time these studies are conducted is important to conclusions drawn. Little information is available in the literature on how salinity affects germination rate of many forage species.

The purposes of our study were: (1) to determine the incubation time required to properly evaluate the germination percent of 8 forage species in sodium sulfate (Na_2SO_4) and magnesium sulfate ($MgSO_4$) solutions under controlled conditions; (2) to document the germination percent of 8 forage species in response to the Na_2SO_4 and $MgSO_4$ solutions after the required incubation period.

Material and Methods

Eight forage species of importance in revegetation work were used for this study: alkali sacaton (*Sporobolus airoides* [Torr.] Torr.), Canby bluegrass (*Poa canbyi* [Scribn.] Piper), fourwing saltbush (*Atriplex canescens* [Pursh] Nutt.), green needlegrass (*Stipa viridula* Trin.), little bluestem (*Andropogon scoparius* Michx.), red clover (*Trifolium pratense* L.), switchgrass (*Panicum virgatum* L.), and thickspike wheatgrass (*Agropyron dasystachyum* [Hook.] Scribn.). Alkali sacaton and red clover are classified in the literature as having good and poor salt tolerance, respectively, (Bernstein 1958) and were included as reference species.

Three salt treatments were established by adding Na_2SO_4 and $MgSO_4$ to distilled water. These salts were selected because of their importance in soils and mine spoils of the Fort Union geologic group in the Northern Great Plains area of North Dakota, Montana, and Wyoming. Concentrations of these salts were mixed to simulate Na_2SO_4 and $MgSO_4$ concentrations observed in naturally

Table 1. Salinity treatments used in germination study for 8 forage species.

Salt treatment	Cation	Anion	Electrical conductivity (dS m^{-1})	Osmotic potential (MPa)
Control[1]	<1 mmol L^{-}	—	.009	<.01
Na_2SO_4	120 mmol $(Na^{+})L^{-}$	SO_4^{--}	10.3	-.31
$MgSO_4$	100 mmol $(Mg^{++})L^{-}$	SO_4^{--}	8.8	-.24
Na_2SO_4 plus $MgSO_4$	66 mmol $(Na^{+})L^{-}$ + 33 mmol $(Mg^{++})L^{-}$	SO_4^{--}	9.2	-.26

[1]Distilled water.

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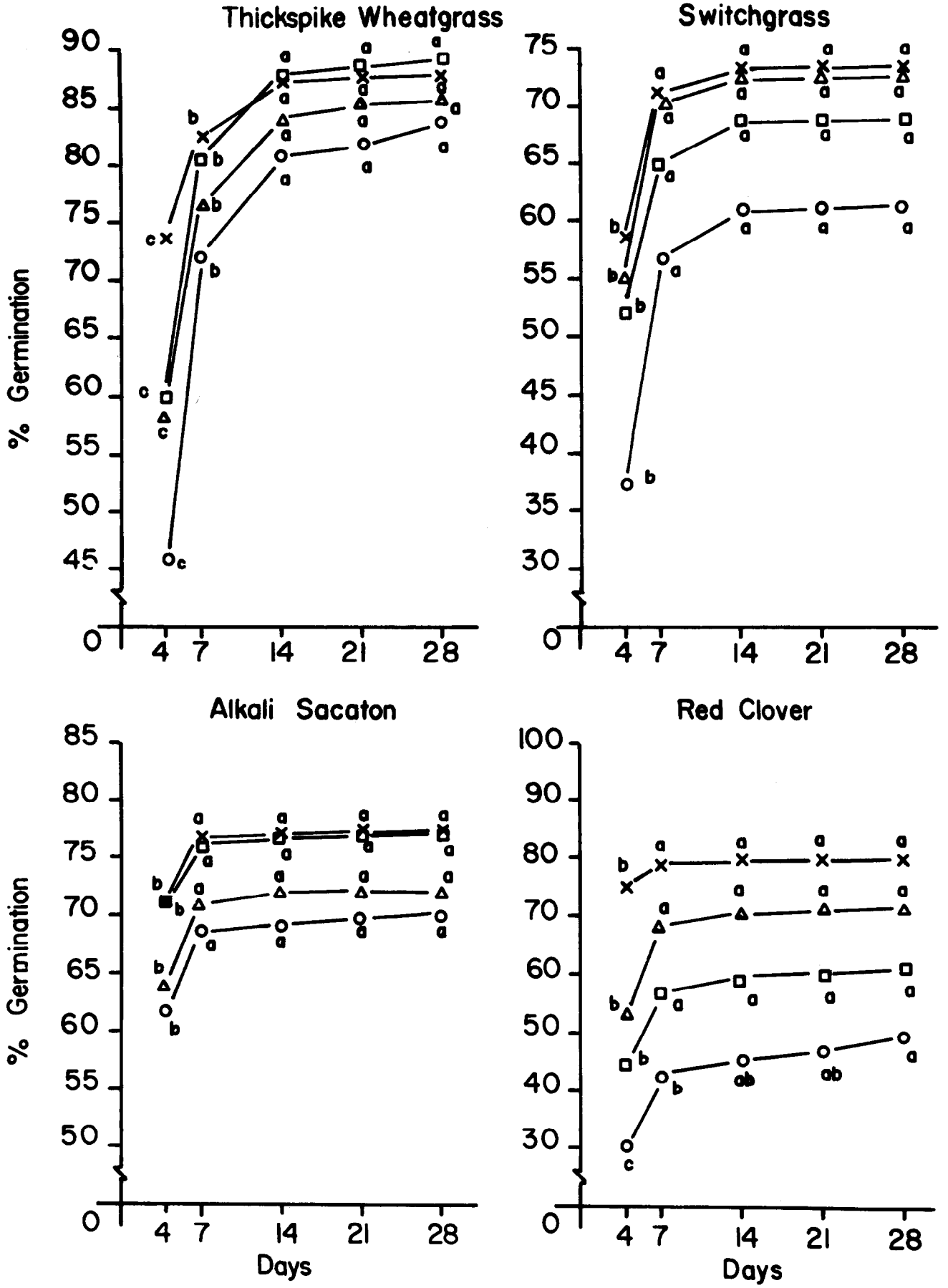

Fig. 1. *Changes in seed germination percent with time for thickspike wheatgrass, switchgrass, alkali sacaton, and red clover at salinity levels control (x), Na_2SO_4 (o), $MgSO_4$ (Δ) and Na_2SO_4 plus $MgSO_4$ (□), over a 28-day period. Treatment means across dates with different letters differ significantly at the .05 probability level, according to Duncan's multiple range test.*

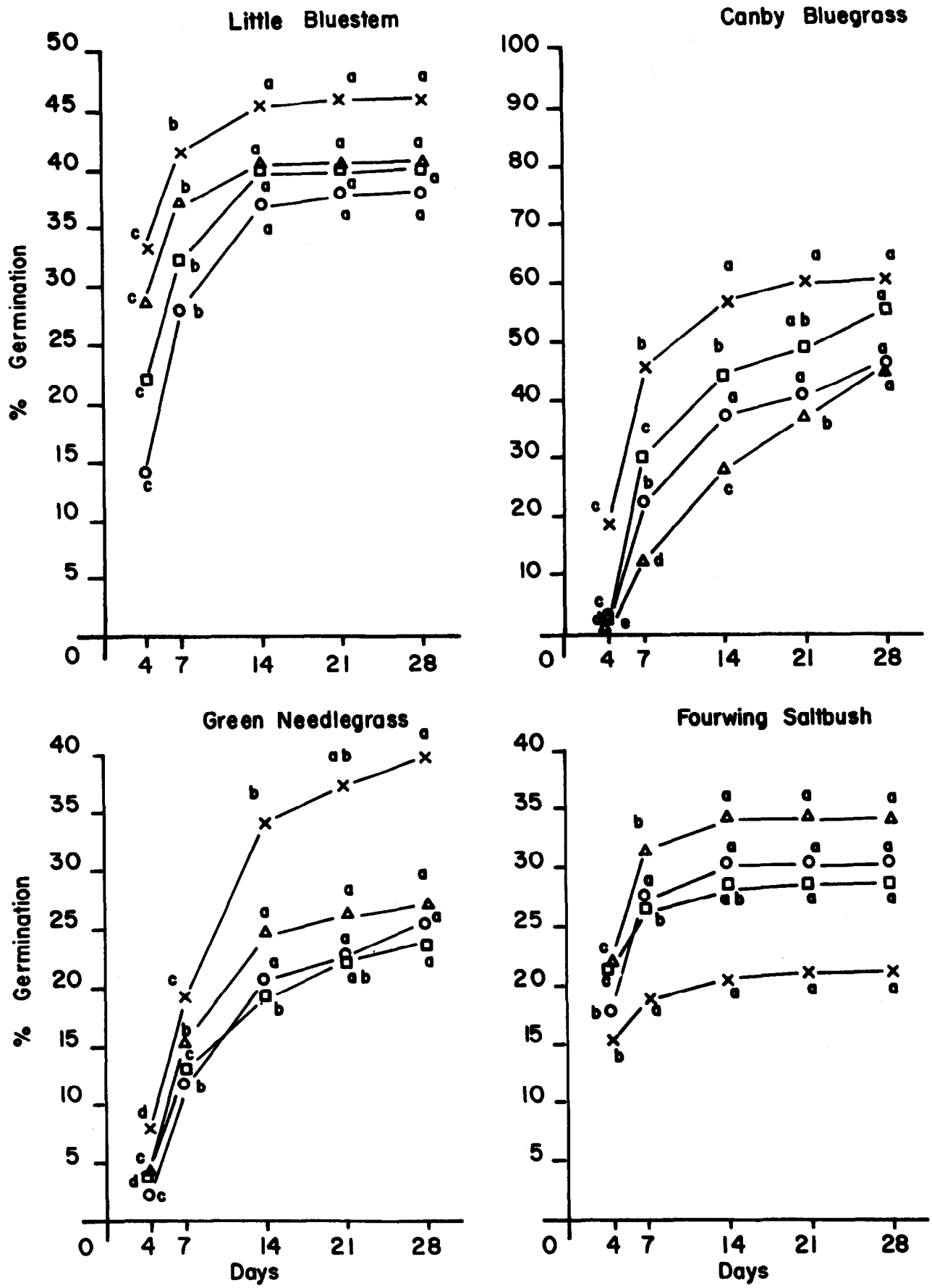

Fig. 2. *Changes in seed germination percent with time for little bluestem, Canby bluegrass, green needlegrass, and fourwing saltbush, at salinity levels control (x), Na_2SO_4 (o), $MgSO_4$(Δ), and Na_2SO_4 plus $MgSO_4$(□), over a 28-day period. Treatments means across dates with different letters differ significantly at the .05 probability level, according to Duncan's multiple range test.*

Table 2. Required incubation time and germination percent in Na_2SO_4 and $MgSO_4$ solutions for 8 forage species.

	Incubation time	Control (x)	Germination % Salt treatments Na_2SO_4 (o)	$MgSO_4$ (Δ)	$Na_2SO_4 + MgSO_4$ (□)	LSD .05
Thickspike wheatgrass	14 days	87	82	84	88	8
Switchgrass	7	71	57*[1]	70	65	9
Alkali sacaton	7	77	68*	71	76	7
Red clover	14	79	45*	70*	60*	8
Little bluestem	14	46	37*	40	40	8
Canby bluegrass	28+[3]	61	46	46	55	16
Green needlegrass	21	37	23*	26*	22*	8
Fourwing saltbush	14	20	30**[2]	34**	28	9

[1]Salts reduced germination percent compared to control.
[2]Salts enhanced germination percent compared to control.
[3]Germination percent increased throughout 28-day study period. Salt response was tested at 28 days.

occurring spoil material in the region. Some spoils are high in only Na_2SO_4, others are high in only $MgSO_4$, and other spoils have a mixture of Na_2SO_4 and $MgSO_4$. Distilled water was used as control media. The 4 treatment solutions are described in Table 1.

Soluble salt content of the solutions was measured with a conductivity bridge, and this electrical conductivity was converted graphically to osmotic potential for each individual salt combination (U.S. Salinity Laboratory Staff 1954).

Germination tests were conducted in a germinator maintained at $27 \pm 1°$ C during a 16-hour light period and at $18 \pm 1°$ C during an 8-hour dark period. The light system consisted of cool-white fluorescent bulbs that produced a quantum flux density of 38u mol $m^{-2}s^{-1}$. An experimental unit consisted of 100 seeds of a particular species placed on blotter paper over an absorbent pad in a covered germination dish (11 by 11 cm) with 65 ml of distilled water or salt solution added. Each experimental unit was replicated 4 times in the germinator in a randomized complete block design. Number of germinated seeds (radicle exposed) was counted at 4, 7 14, 21, and 28 days. Weight loss of the germination dishes during the study was small (<.5 g/dish), and no additional solution was added.

Differences between mean germination percent for each species and treatment across count dates were determined by Duncan's multiple range test at the .05 probability level (Steel and Torrie 1960). The incubation time required for accurate evaluation of salt effects was considered to be at the count date when the germination percent for each species in relation to all salt treatments did not change ($p = .05$) throughout the rest of the 28-day study period. The germination percent at this date for each treatment was compared to the distilled water control by the least significant difference test at the .05 probability level to determine salt response for each species (Steel and Torrie 1960).

Results

The germination percent for fourwing saltbush, little bluestem, red clover, and thickspike wheatgrass did not change after 14 days into the 28-day study period (Fig. 1 and Fig. 2). Alkali sacaton and switchgrass germination percent remained constant from day 7 throughout the remainder of the 28-day study period (Fig. 1). Percent germination of green needlegrass increased until day 21 (Fig. 2). Canby bluegrass germination percent increased at each count throughout the 28-day study period (Fig. 2).

The incubation time required for the germination percent for each species to stabilize is presented in Table 2. At this count date, the germination percent for each species and salt treatment was compared to the distilled water control (Table 2). Fourwing saltbush had higher germination percent than the control in the Na_2SO_4 and $MgSO_4$ treatments. Green needlegrass and red clover had less germination in all salt treatments than the control. Alkali sacaton, little bluestem, and switchgrass had less germination than the control only in the Na_2SO_4 treatment. Thickspike wheatgrass and Canby bluegrass (at 28 days) had no decrease in germination from any of the salt treatments.

Discussion

The incubation time required to make an accurate assessment of salt effects during germination differed for the various species (Table 2). Switchgrass and alkali sacaton germination percent remained stable after 7 days, fourwing saltbush, little bluestem, red clover and thickspike wheatgrass stabilized after 14 days, and green needlegrass germination percent remained constant after 21 days. Canby bluegrass germination percent in the salt treatments continually changed throughout the 28-day study period. These data indicate that the effect of the salt treatments on the germination percent of these species is time dependent and is in agreement with the findings for rice germination reported by Kaddah (1963). Some plant species appear to be able to tolerate or adjust to the salt media even though germination was initially inhibited or, as in the case of fourwing saltbush, accelerated. The length of the incubation period is therefore critical when seed germination is used for initial screening of plant species in relation to salt solutions. This should be considered in designing salt studies to insure proper interpretation.

The second part of this study was to document the germination response of the 8 forage species to the Na_2SO_4 and $MgSO_4$ in solutions under a controlled environment and without the influence of soil. The Na_2SO_4 treatment had the greatest effect on germination. Alkali sacaton, green needlegrass, little bluestem, red clover and switchgrass all had lower germination in the Na_2SO_4 solution than in the distilled water control. Germination of fourwing saltbush was greater in both the Na_2SO_4 and $MgSO_2$ solutions than in control. Germination of Canby bluegrass (at 28 days) and thickspike wheatgrass was unaffected by any of the salt treatments. Green needlegrass and red clover also had lower germination than the control in the $MgSO_4$ and $Na_2SO_4 + MgSO_4$ solutions. These salt responses are similar to salt responses for other species reported in the literature (Ryan et al. 1975; Miller and Chapman 1978). The salt responses observed in this study provide initial screening information on the tolerance of these species to Na_2SO_4 and $MgSO_4$ salts during germination without soil. The germination of these species in soil under field conditions has not been investigated. However, one would expect green needlegrass and red clover to be least suited for germination on areas where the saturated soil solution contained Na_2SO_4 and $MgSO_4$ concentrations similar to those studied and found in soil and spoil of the Fort Union geologic group in the Northern Great Plains. On the other hand, thickspike wheatgrass and fourwing saltbush appear well suited for such conditions.

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