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BRIEF COMMUNICATION

Seed germination in relation to salinity and temperature in *Sarcobatus vermiculatus*

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Abstract

Sarcobatus vermiculatus (Hook) Torrey is a leaf succulent, sodium-accumulating shrub usually found in saline substrates of the Great Basin desert, Utah, USA. Laboratory experiments were conducted to determine the effect of salinity (0, 200, 400, 600, 800 and 1000 mM NaCl) and temperature (day/night: 5/15, 10/20, 15/25, 20/30 and 25/35 °C) on seed germination. *S. vermiculatus* showed 100 % germination in non-saline controls, at all thermoperiods. Percentage and rate of germination decreased with increases in salinity and few seeds germinated at even 1000 mM NaCl. High salinity exposure caused the loss of viability at higher temperature regimes, while some recovery was recorded in low salinity treatments.

Additional key words: greasewood, recovery, stress.

Sarcobatus vermiculatus (Hook.) Torr. var. *vermiculatus* (*Chenopodiaceae*; common name greasewood) is a shrub which is widely distributed on medium to heavy textured saline or saline-alkali soils in the western United States (Rickards 1982). It is an important browse species for cattle and sheep, even though potentially poisonous due to sodium and potassium oxalate. Greasewood has deep roots (nearly 13 meters deep) and concentrates ions in leaves (as much as 9.5 % sodium in dry mass) for osmoregulation (Rickards 1982). Temperature interacts with salinity in determining the germination rate and total germination percentages of halophyte seeds (Baskin and Baskin 1998, Gul and Weber 1999, Khan and Ungar 1999, Sri Devi et al. 1999, Khan *et al.* 2000). The mechanism by which seeds of greasewood are able to germinate in salt-affected soils is unknown. Therefore, we examined seed germination response of *S. vermiculatus* to temperature and salinity at laboratory conditions.

Seeds of *S. vermiculatus* were collected during the autumn 1996 from salt flats in Utah, USA. To determine the effect of temperature on germination, alternating temperature regimes of 5/15, 10/20, 15/25, 20/30 and 25/35 °C, based on a 24-h cycle were used, where the higher temperature coincided with the 12-h photoperiod [*Sylvania* cool white fluorescent lamps, irradiance of 250 μmol m^{-2} s^{-1} (400 - 750 nm)]. Seeds were germinated in distilled water, 200, 400, 600, 800 and 1000 mM NaCl solutions under the above mentioned temperature regimes. Percent germination was recorded every alternate day for 20 d. After 20 d ungerminated seeds from the NaCl treatments were transferred to distilled water to study the recovery of germination, which was also recorded at 2 d intervals for 20 d. The recovery percentages was determined by the following formula: $(a - b)/(c - b) \times 100$, where a is the total number of seeds germinated after being transferred to distilled water, b is the total number of seed germinated in saline solution and c is the total number of seeds. Germination data was transformed (arcsin) before statistical analysis. These data were analyzed using *SPSS for Windows release 9.0.*

Germination of *S. vermiculatus* was highest in distilled water at all temperature regimes studied (Fig. 1). Germination of seeds decreased with increases in salinity and few seeds germinated at salt concentrations higher than 800 mM NaCl (Fig. 1). Optimal germination was obtained at a temperature regime of 20/30 °C at all salinity concentrations. Variation in temperature did not

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have a substantial effect on the final germination percentages (Fig. 1). After 20 d of salinity treatment, seeds were transferred to distilled water to study the recovery of germination. Seeds exposed to high salinity showed little or no recovery when transferred to distilled water at all temperature regimes (Table 1), however, about 50 % of the seeds recovered from low salinity stress. A two-way *ANOVA* indicated that germination recovery of *S. vermiculatus* seed was significantly affected by thermoperiod (F = 21.81, P < 0.0001), salinity (F = 141.20, P < 0.0001), and the interactions of two factors (F = 4.03, P < 0.0001).

The salt desert region of Utah and vicinity appears to be a center of dispersal for inland halophyte species since it has the most species diversity (Ungar 1974). The few studies done on the germination of Great Basin halophytes indicate that these species are highly salt tolerant and could germinate in up to 1 M NaCl (Khan and Weber 1986, Gul and Weber 1999, Khan *et al.* 2000, 2001) and germination increased with increase in temperature, with maximum germination obtained at 25/35 °C. We determined that seed of *S. vermiculatus* were not dormant and had the highest germination in distilled water. Germination of *S. vermiculatus* decreased with an increase in salinity, and was substantially inhibited at 1000 mM NaCl. Seeds of *S. vermiculatus* showed little change in germination response to salinity with the change in temperature regimes. However, a 20/30 °C temperature regime yielded a relatively better germination response. The ability of *S. vermiculatus* seeds to recover from salinity stress progressively decreased with an increase in salinity and few seed

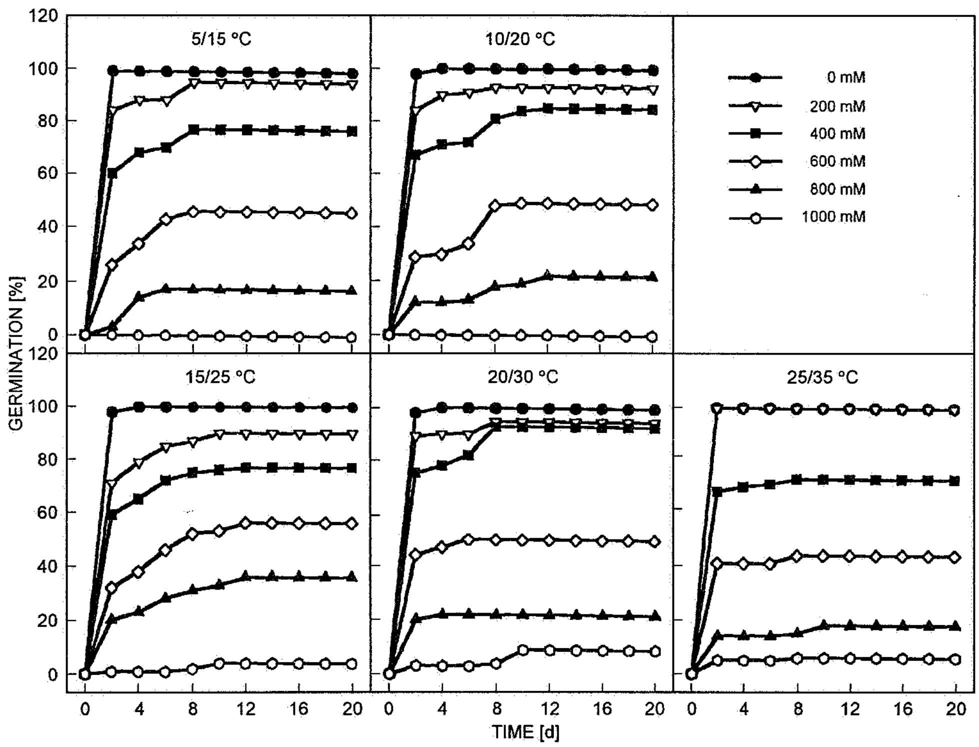

Fig. 1. Rate of germination of *Sarcobatus vermiculatus* seeds in 0, 200, 400, 600, 800 and 1000 mM NaCl at thermoperiods of 5/15, 10/20, 15/25, 20/30, and 25/35 °C.

Table 1. Recovery percentage (mean ± SE) of germination of *Sarcobatus vermiculatus* seed after they were transferred from 200, 400, 600, 800 and 1000 mM NaCl to distilled water at day/night temperatures of 5/15, 10/20, 15/25, 20/30, and 25/35 °C.

NaCl [mM]	5/15 °C	10/20°C	15/25°C	20/30°C	25/35°C
200	50 ± 2.9	50 ± 2.9	38 ± 2.3	15 ± 1.5	0 ± 0.0
400	69 ± 14.0	52 ± 16.0	46 ± 16.0	0 ± 0.0	61 ± 13.0
600	21 ± 6.0	37 ± 3.8	23 ± 9.0	40 ± 10.0	47 ± 7.2
800	12 ± 2.0	15 ± 4.9	12 ± 4.0	20 ± 5.4	22 ± 4.0
1000	0 ± 0.0	1 ± 1.0	4 ± 1.1	11 ± 2.2	10 ± 2.1

recovered from the 1000 mM NaCl treatment at higher thermoperiods. Some *S. vermiculatus* seeds could germinate in up to 1000 mM NaCl and they were able to germinate well at all temperature regimes at lower salinities. This species showed relatively poor recovery responses at all salinity and temperature treatments, and failed to recover in the low temperature and highest salinity treatment. Our investigation demonstrates that seeds of *S. vermiculatus* are highly salt tolerant and exposure to low salinity and various temperatures does not affect their viability. Seeds had low recovery under high salinity conditions and at the lowest temperature regime indicating an inhibition indicating between the lowest temperature regime and salinities > 600 mM NaCl.

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