
INFLUENCE OF SALINITY AND TEMPERATURE ON SEED GERMINATION¹

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ABSTRACT

Experiments with two halophytic and one non-halophytic species indicate that there is an interaction between the effects of temperature and salinity on seed germination. *Salicornia europaea*, the most salt-tolerant species studied, was stimulated by high temperatures, whereas germination of *Medicago sativa* and *Spergularia marina* was inhibited by the highest temperature regime (32°C).

INTRODUCTION

The effect of high temperatures in reducing seed germination at various salinities has been reported for alfalfa and clover by Ahi and Powers (1938). Beadle (1952) reported the effect of temperature extremes on germination of five halophytic species of *Atriplex* in distilled water, and found that they achieved optimum germination at 10°C. Germination was reduced about 75 per cent at 35° (Beadle, 1952). In this present study the effects of three temperature regimes, 13°, 21°, and 32°, on germination at various salinities were tested on two succulent halophytes, *Salicornia europaea* L., *Spergularia marina* (L.) Griseb., and a glycophyte, *Medicago sativa* L. (alfalfa). Dotzenko and Dean (1959) report a great variance in the salt tolerance of alfalfa varieties, but in all cases there is a decrease in germination percentage from 1 to 12 atmospheres osmotic pressure. The primary goal of this research was to determine whether or not there was any interaction between temperature and salinity in their effect on seed germination, or whether temperature requirements appeared to follow the ecological needs of a species. If there is a positive interaction at high temperatures and salinities, this would indicate that the uptake of water at high salinities is probably associated with osmotic adjustment, as suggested by Bernstein (1961), which would proceed more rapidly at higher temperatures until the optimum temperature for a given species was reached.

METHODS

Alfalfa seed used in this study was the Kansas Common variety, which was obtained in the fall, 1962. Seed of *Spergularia marina* and *Salicornia europaea* were collected in 1961 along the northeast border of Point Judith Pond, Washington County, Rhode Island. The number of seeds germinated was counted daily for thirty days for *Spergularia* and *Salicornia* and for ten days for *Medicago*. Seeds were considered germinated if the radicle reached one centimeter in length or when the plumule and radicle emerged from the seed. Germination occurred in petri dishes on two sheets of Whatman #2 filter paper, in solutions ranging from

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distilled water to five per cent NaCl. Two fifty-seed replicas were used at each salinity regime. Constant temperature chambers were used to maintain $13 \pm 1^\circ$, $21 \pm 1^\circ$, and $32 \pm 1^\circ\text{C}$ temperatures for germination.

All seed of *Spergularia* which showed no germination at 32° were placed at 21° to 28°C , in order to determine whether germination would occur at room temperature or whether the high temperatures had caused permanent injury.

RESULTS AND DISCUSSION

The results indicate that *Medicago sativa* and *Spergularia marina* show a reduction in germination at the highest temperature regime (table 1). There was little variation in the behavior of seed of *Medicago* at 13° and 21° ; however the deleterious effect of high temperatures (32°) increased with increased salinities. There was only a slight difference in germination percentage in distilled water at the three temperature regimes, but at one per cent NaCl, 73 per cent germinated at 13° , 70 per cent at 21° , while none germinated at 32° . These results corroborate the findings of Ahi and Powers (1938), though no great retardation of germination at 32° in distilled water was obtained in this present study. Ahi and Powers (1938) obtained 94 per cent germination at 13° and a reduction to 18 per cent at 32° .

TABLE 1
Percentage germination of two fifty seed replicas at 5, 10, 20 and 30 days

Species	Day	Percent sodium chloride														
		0.0%			0.5%			1.0%			3.0%			5.0%		
		13°	21°	32°	13°	21°	32°	13°	21°	32°	13°	21°	32°	13°	21°	32°
<i>Medicago sativa</i>	5	80	71	82	41	77	62	16	62	0	0	0	0	0	0	0
	10	88	81	82	77	78	66	73	70	0	0	0	0	0	0	0
<i>Spergularia marina</i>	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	37	0	1	4	1	0	3	0	0	0	0	0	0	0	0
	20	49	15	1	8	47	0	5	26	0	0	0	0	0	0	0
	30	50	20	1	11	51	0	6	31	0	0	0	0	0	0	0
<i>Salicornia europaea</i>	5	12	10*	40	5	15	18	6	15	17	9	10	11	4	8	10
	10	15	28	52	5	17	30	6	15	20	9	10	11	4	8	10
	20	19	32	55	9	17	31	6	15	23	9	10	12	4	8	10
	30	19	40	55	9	21	35	6	16	23	9	12	12	4	8	10

*Data from Ungar (1962) $23^\circ \pm 2$.

In the case of *Spergularia*, only one seed germinated at 32° in distilled water, while the optimum temperature appeared to be 13° in distilled water and 21° at 0.5 per cent NaCl (table 1). The highest temperature regime completely inhibited germination at higher salinities. When these seeds were placed at room temperature, 21° to 28° , germination occurred, indicating that the high temperature had caused no permanent injury (table 2). At 13° , *Spergularia* showed

TABLE 2
Percentage germination of *Spergularia marina* seed transferred from 32°C to room temperature (21° to 28°)

	Percent sodium chloride				
	0.0	0.5	1.0	3.0	5.0
<i>Spergularia marina</i>	68.0%	11.0%	0.0%	0.0%	0.0%

decline in germination with increased salinity, whereas at 21°, added salinity up to 1 per cent caused an increase in germination over that in distilled water. These results corroborate the report of Ungar (1962) where seed were germinated at 25°, and higher germination rates were obtained at salinities up to 1 per cent than in distilled water. Most species of halophytes and glycophytes show some reduction in germination with added salinity (Ungar, 1965, 1966).

The germination obtained from transferred seed averaged higher in distilled water than that obtained at all temperatures in the initial study (table 1), but no germination occurred at salinities higher than 0.5 per cent NaCl. Aging of *Spergularia* seed apparently cut down its germination rate, because earlier studies yielded germination percentages up to 82 per cent (Ungar, 1962).

The data for *Salicornia europaea* indicate better germination at all salinities at the higher temperatures, indicating that temperatures as high as 32° have a stimulatory effect rather than the retarding action exhibited in the first two species discussed. For this species, then, there appears to be some correlation between ability to germinate, which involves water uptake and possible osmotic adjustment, and temperature regimes.

There was a slight lag in germination of *Spergularia* and *Medicago* at increased salinities, but in *Salicornia* there was no indication of a delay, as was reported for other glycophytic species by Ayers (1951). This delay in germination was never longer than two days for the less salt-tolerant species, and, in the most salt-tolerant, *Salicornia*, it appears that salinity does not delay germination at all. Binet (1964, 1965) reports higher germination percentages for the halophyte, *Cochlearia anglica*, at temperatures of 5° and 15° than at higher temperatures between 20° and 25° in all salinities from distilled water to seawater. For *Plantago maritima*, another coastal halophyte, he reports an optimum germination at 25°. From the data of Binet (1964, 1965) and the results in this study, it would seem that there is an interaction between salinity and temperature and their effects upon seed germination, but this interaction varies with different species. These results indicate that *Salicornia europaea*, the most salt-tolerant species, has a greater percentage germination at higher temperatures, and the remainder have their salt tolerance limited at higher temperatures (table 1).

The response to temperature for the two halophytes appears to meet their ecological needs. Though both species grow in the same location, *Spergularia* begins growth much earlier, flowers from June through October, and is adapted to germinate at cooler temperatures. *Salicornia europaea* flowers from August to November, its germination regime adapted to warmer temperatures.

SUMMARY

Temperature is an important factor influencing seed germination at salinities ranging from 0 to 5 per cent NaCl. In *Medicago sativa*, the highest temperature (32°C) suppressed germination at higher salinities, while in *Spergularia marina* 32°C was beyond the maximum temperature for germination. In the most salt-tolerant species, *Salicornia europaea*, high temperatures appear to stimulate seed germination at all salinities. The response of the halophytes to temperature seems to fit their ecological requirements. *Salicornia*, a late-season species, has a germination optimum at 32°C, while *Spergularia* an early species reaches its optimum between 13°C and 21°C.

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