

# SEED GERMINATION IN *IVA ANNUA* L.

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*Abstract.* Optimum germination of *Iva annua* seeds occurs at 15°C. Temperature and salinity interact in their effect on germination. Increases in osmotic concentration of media cause a gradual decrease in germination percentages at optimal temperatures. Sodium chloride, the most common salt in saline areas occupied by *I. annua,* has an osmotic rather than a toxic effect on germination.

## INTRODUCTION

The annual species *Iva annua* L. (= *I. ciliata* Willd.) occurs in moderately saline soils from Nebraska south to Texas. Its distribution is broader in nonsaline soils, but the capacity to germinate and establish itself under saline conditions is one of the important factors governing its distribution in the prairie region. The goals of this study were to determine the effect of salinity and temperature on seed germination of *I. annua* and to ascertain the level of salt tolerance of the seeds. The use of various salt concentrations and several temperature regimes determined toxicity effects and defined interactions between the two factors.

Studies with halophytic and glycophytic species indicate that high temperatures (30°C or higher) reduce seed germination and apparently affect the tolerance of a species to osmotic stress (Ahi and Powers 1938, Binet and Combes 1961, Ungar 1967*a*). Ungar (1967*a*) found that temperatures as high as 32°C promoted germination in *Salicornia europaea* L. In *Atriplex canescens* (Pursh) Nutt. germination was greater at 17°C than at 9°C and 30°C at all osmotic concentrations, and tolerance to osmotic stress was greater at optimum temperatures (Springfield 1966). In four species of halophytic *Atriplex* Beadle (1952) found that germination was optimum at 10°–25°C but decreased at temperatures beyond this range. Salinity and temperature seem to interact in their control of seed germination, with the greatest effects expressed at the extremes of the two environmental variables.

*Iva annua* L. occurs on the margins of saline marshes, but is only moderately salt tolerant. It apparently reaches its maximum tolerance in soils containing 1.3% total salts and was found growing in areas with as little as 0.1% total salts (Ungar, Hogan, and McClelland 1969). In Kansas and Nebraska it occurred in marshes with a salinity averaging 0.5% and 0.7%, respectively (Ungar 1967*b*, Ungar et al. 1969). In these marshes about 90.0% of the total salt composition was sodium chloride (Shirk 1924). Its occurrence was apparently limited to the marshes because of the high salinity of the salt flats, since it was never found invading areas dominated by the most salt-tolerant succulents, *Suaeda depressa* (Pursh) Wats., *Salicornia rubra* Nels., and *Sesuvium verrucosum* Raf.

Seed germination of *I. annua* occurs in April. Mean normal temperatures at this time average 11°C; daily minimum temperatures average 6°C and range from −1°C to 14°C; the daily maximum averages 18°C and varies from 4°C to 33°C in Lincoln, Nebraska (U.S. Department of Commerce 1965). Vegetative growth is slow from April to August, but there is a burst of growth late in the summer. In late August and September flowering is initiated, and ripened fruit can be collected in late September and October.

## METHODS

*Iva annua* seeds were collected on October 3, 1964, at Lincoln, Nebraska, and refrigerated at 5°C until utilized in 1967 and 1968. All germination tests were conducted in 9-cm petri dishes on two sheets of Whatman No. 2 filter paper with 6 ml of test solution in each dish. The dishes were placed in plastic bags to prevent evaporation of water.

A 12-hr thermoperiod of 10° ± 1°C day–5° ± 1°C night, and constant 24-hr temperatures of 15° ± 1°C, 25° ± 1°C, 30° ± 1°C, and 35° ± 1° C were used. Sodium chloride concentrations of 0.0, 0.5, 1.0, and 2.0% were applied to determine temperature-salinity interactions. Ten 25-seed replications were used at each of the environmental conditions.

To determine if high salt concentrations and

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temperature extremes were permanently damaging, seeds were soaked at 5° ± 1°C, 20° ± 1°C, and 35° ± 1°C in 0, 1, 2, 3, and 4 molal concentration of NaCl for 10 days. Four 25-seed replications were then placed in petri dishes and germinated at 20°C for 13 days.

An experiment was attempted to determine whether the effects of isotonic solutions (NaCl, $Na_2SO_4$, $NaHCO_3$, and ethylene glycol) were osmotic or if different osmotic agents were toxic. Solutions were made at 0, 4, 8, 16, 25, and 32 atm pressures with a Fiske model G66 osmometer, and the experiment was conducted for 20 days in petri dishes using ten 25-seed replications.

Differences in water uptake were measured using NaCl solutions at 0, 4, 8, 12, 16, and 25 atm pressure. Ten 25-seed samples were placed in petri dishes with solution at these osmotic pressures, allowed to soak for 2 days, and then weighed. After the second day weight at lower concentrations increased rapidly, but this was probably due to growth as observed by emerging seedlings.

## Results

### *Temperature-salinity interactions*

Germination experiments at five temperature regimes indicated optimum germination at 15°C (Fig. 1). No germination occurred at 35°C, and only after a 15-day delay germination began at the 5°C night–10°C day thermoperiod (Fig. 1). Total germination at 5°C night–10°C day averaged 35%, which was intermediate between germination at 25°C and 15°C (Fig. 1). The effect of temperature appeared to increase with increased salinity (Fig. 2). At 1.0% NaCl no germination occurred at the 5°C night–10°C day thermoperiod or at the 30°C temperature. Salt concentrations of 1.5% NaCl inhibited germination at all temperatures except 15°C. No germination occurred at any temperature regime at concentrations of

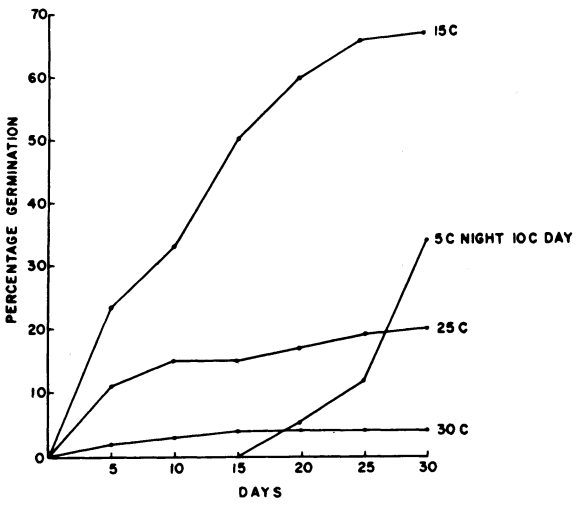


FIG. 1. Rate of germination of *Iva annua* in distilled water at temperatures of 5°C night–10°C day, and 15°, 25°, and 30°C day-night.

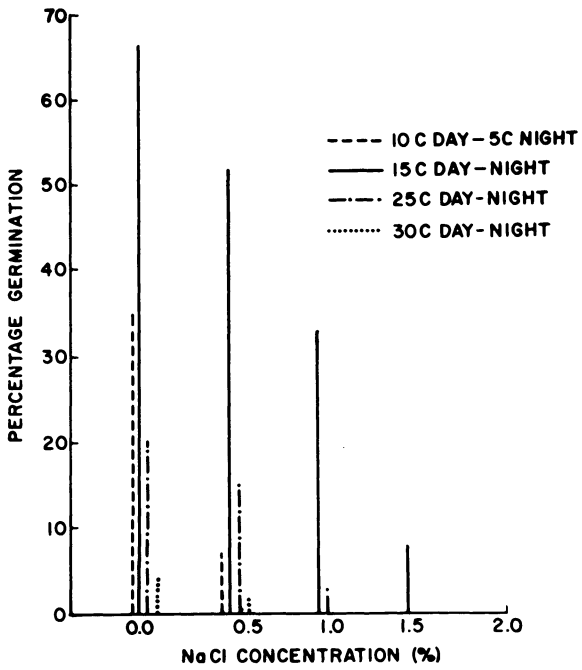


FIG. 2. Effect of salinity and temperature on the germination of *Iva annua* after 30 days. All differences are significant at $P = 0.01$ with the $t$ test.

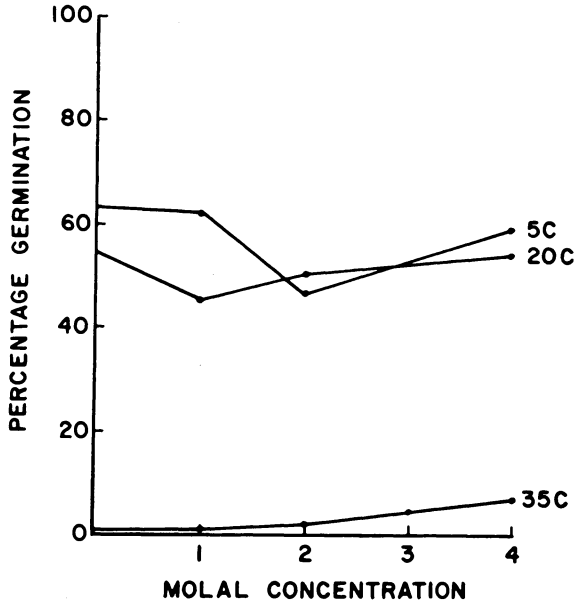


FIG. 3. Germination of *Iva annua* seed at 20°C in distilled water after 10 days soaking in 0–4 molal solutions (5.8%–23.3%) of NaCl at 5°C, 20°C, and 35°C. Differences in germination percentages between 35°C and other temperatures are significant at $P = 0.01$ with the $t$ test.

2.0% NaCl (Fig. 2). These data indicate a gradual decrease in germination at 15°C as salinity increased, but more abrupt changes in germination percentages with increased salinity at other temperatures.

Soaking seeds in NaCl solutions up to 4 molal (23%) concentrations does not inhibit germination at temperatures of 5°C and 20°C (Fig. 3). Significant differences were found between results at 35°C and the lower temperatures. At 35°C permanent injury takes place and germination is reduced from an average recovery at all salt concentrations of 57% at 5°C and 51% at 20°C to an average recovery of 3% at 35°C. These experiments also indicate that high salinities are not toxic to *I. annua* and at temperatures within its tolerance limits soaking at extremely high salinities does not impede germination. Ungar (1967*b*) found that *I. annua* seeds would recover from solutions containing up to 5.0% NaCl, and these tests indicate that salinities up to 23% (4 molal) may be tolerated if followed by treatment with distilled water.

### *Absorption of water*

Water uptake tests using concentrations from 0 to 25 atm osmotic pressure indicate a decline in water uptake with increase in osmotic pressure (Fig. 4). In distilled water seeds increased in weight up to 202%, whereas at 25 atm the increase in weight equalled 164%. Inhibition of germination may thus be an osmotic affect.

### *Rate of germination*

Rate of germination and percentage of seeds germinated decreased with increased concentrations of NaCl (Fig. 5). In distilled water germination occurred after 4 days. Germination took place in 5 days in 4- and 8-atm solutions; however, in 16-atm solutions germination was delayed until the tenth day. Salts tested included NaCl (Fig. 5), $Na_2SO_4$, and $NaHCO_3$; all showed the same delay in germination rates.

### *Osmotic agents*

Experiments using $Na_2SO_4$ and $NaHCO_3$, NaCl and ethylene glycol indicate that all osmotic agents reduce total germination percentages with increased concentration (Fig. 6). There are no statistically significant differences in the action of the salts at 16 atm or higher. At 4 atm, ethylene glycol appeared significantly more inhibitory at $P = 0.01$. At 8 atm there is no statistically significant difference between the effects of $Na_2SO_4$ and NaCl or $NaHCO_3$ and ethylene glycol, but the effects of $NaHCO_3$ and ethylene glycol are more inhibitory than the chloride or sulfate salts of sodium.

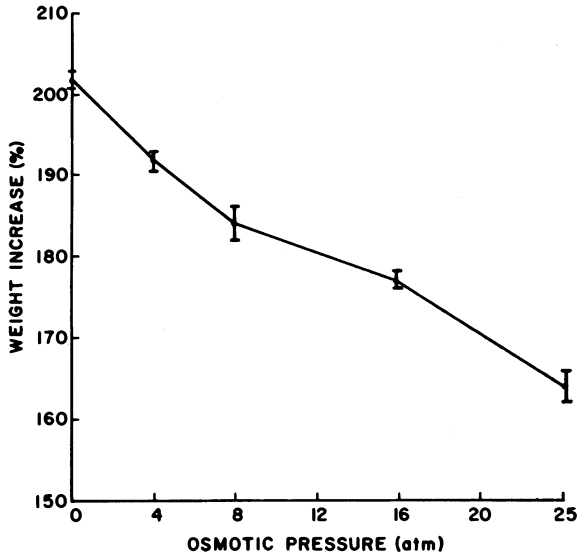


FIG. 4. Percentage increase in seed weight after soaking in distilled water and NaCl solutions of 0, 4, 8, 16, and 25 atm for 2 days. Vertical bars represent standard error.

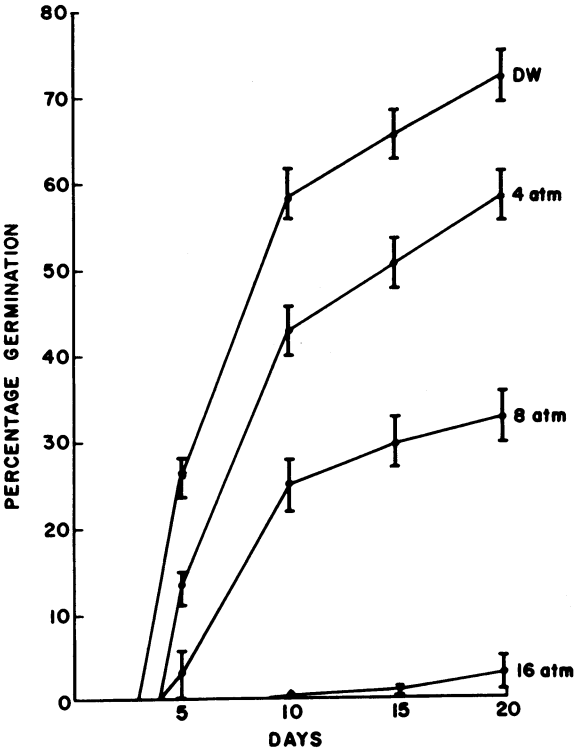


FIG. 5. Rate of *Iva annua* germination (%) at various NaCl concentrations. DW = distilled water. Vertical bars represent standard error.

### *Seedling growth*

Sodium chloride was more inhibitory to seedlings than ethylene glycol (Fig. 7). This re-

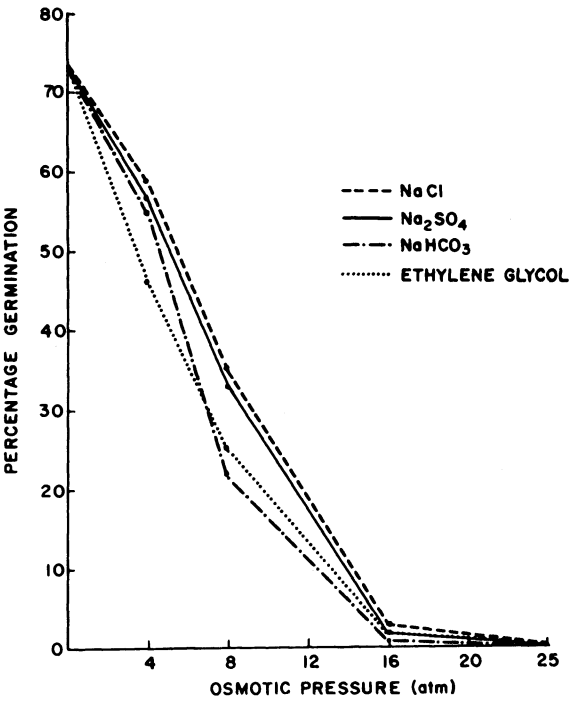


FIG. 6. Percentage germination of *Iva annua* at varied osmotic pressures after 20 days.

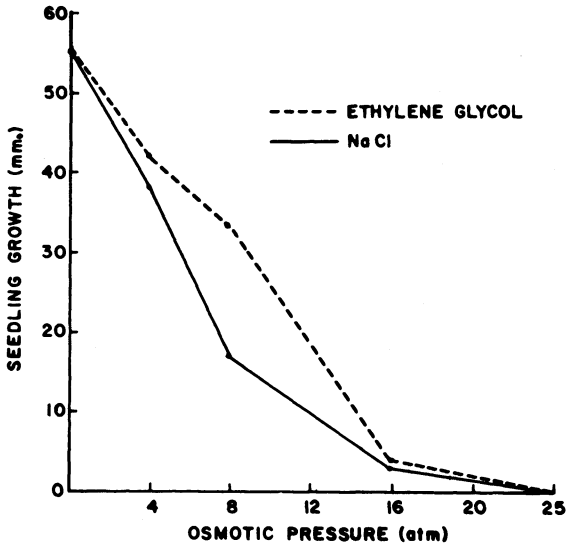


FIG. 7. Seedling length (mm) of *Iva annua* at varied osmotic pressures of NaCl and ethylene glycol after 25 days.

sponse, different than the germination experiment (Fig. 6) indicates, may be the result of a nutrient deficiency in the medium. Preliminary experiments indicate that seedling growth will take place in up to 8 atm NaCl solutions, but not beyond this point. These results agree well with the limits of salt tolerance found for germinating seed (Fig. 6).

## DISCUSSION

Several investigations have shown that the chief effect of excess salts on seed germination is osmotic (MacKay and Chapman 1954, Ungar 1962, Seneca 1969). There appears to be no permanent toxicity induced by NaCl which prevents seeds from germinating as in alfalfa (Uhvits 1946). Data reported here for *Iva annua* support the view that the chief effects of excess salts is not an ion toxicity (Fig. 3, 6). The reduction in germination which takes place with increased salt concentrations is not a permanent inhibition. With a dilution of salts, recovery rates are obtained which are equal to control germination under comparable conditions. This tolerance of *I. annua* to salinities up to 23% NaCl permits survival during dry periods, when the salinity hazard rises (Ungar 1968), and during periods of temporary flooding with highly saline waters. After rainfalls have leached or diluted these excess salts, *I. annua* will still be capable of germinating. Germination in early spring, when soils are generally wetter and the evaporating power of the air is reduced, also facilitates *I. annua* growth.

Low temperature treatments do not permanently hamper germination, and the 15°C temperature for optimum germination is close to the 11°C average daily temperature for April 1964, the year in which seeds were collected. The ability to germinate at lower temperatures also has survival value for a species which germinates early in the growing season. Interactions have been observed here between temperature and salinity that are similar to those reported by Ahi and Powers (1938), Binet and Combes (1961), and Ungar (1967*a*) for other species, that is, a general decrease in germination and apparent salt tolerance above the optimum value. *I. annua* shows greatest salt tolerance at 15°C and lowest at the extremes, 5°C night–10°C day and 35°C thermoperiods. Germination of *I. annua* seeds is thus apparently limited to early in the growing season. No need for light was found, and so the chief mechanism stimulating germination is probably a thermal one (Ungar, *unpublished data*).

The occurrence of *I. annua* in soils averaging 0.5–0.7% total salts indicates that it is not one of the most salt-tolerant species. Germination and preliminary plant growth studies indicate that the species could be limited to areas of moderate salinity and that it is at the upper limits of its distribution in these moderately saline soils.

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