Seed Germination Characteristics of *Kochia scoparia*

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Abstract

Kochia *(Kochia scoparia)* seed germination was investigated in relation to various regimes of temperatures and light, salinity, pH, and osmotic potential. Germination was highest at cool to moderate temperatures. Percentage germination was ≥ 88% at continuous temperatures of 5 to 25 °C and at alternating temperatures of 5–15, 10–20, 15–25, and 20–30° C. Percentage germination was not higher at alternating than with constant temperatures. Light was not required for germination. Germination was not affected by 6 salts (NaCl, $CaCl_2$, $MgCl_2$, KCL, Na_2SO_4, and $MgSO_4$) at conductances up to 20 mmhos. Increasing conductances of NaCl and $CaCl_2$ solutions from 25 to 40 mmhos by 5 mmho increments progressively reduced germination. Germination was ≥40% in the 40 mmhos conductance of both salts. Kochia seed germination was highly tolerant of extremes of pH and was not reduced by simulated moisture stress until osmotic potential reached –8 bars. Seedling emergence for kochia seeds left exposed on the soil surface was significantly higher than those buried with soil.

Kochia *(Kochia scoparia)*, also known as railroad weed, ironweed, burning bush, fireweed, and belvedere, is an annual plant that is native to Eurasia. It was introduced to the United States as an ornamental in the early 1900's (Durham and Durham 1979), and has become naturalized in the central and western United States. Kochia has very leafy, erect, or ascending branches ranging from 3 to 15 dm tall (Correll and Johnston 1970). It produces small flower clusters in the axils of the leaflike but reduced bracts. The small seeds average about 1.0 mm in diameter.

Kochia is a highly palatable, nutritious, and productive forage species. Several cattle diet studies have reported high use and preference of kochia (Beck 1975, McClung et al. 1976, Vavra et al. 1977). Its protein content and digestibility are comparable with that of alfalfa (Bell et al. 1952, Sherrod 1971, Sherrod 1973). Sherrod (1971) reported that under dryland conditions in the Texas Panhandle, kochia had a dry matter yield of 11,327 kg/ha from a single cutting in mid-July. Preliminary studies conducted in New Mexico indicated that an irrigated and fertilized stand of kochia cut 4 times during the growing season had a total dry matter yield of nearly 26,000 kg/ha (Foster 1980). Despite kochia's attributes, Sperry et al. (1964) reported that its high oxalate content was possibly poisonous to livestock. However, Durham and Durham (1979) found no cattle poisoning by kochia in a continuous 5-year study.

Little information is available concerning kochia's reproductive potential. Lodhi (1979) investigated the autotoxic properties of kochia's phytotoxins on its germination and seedling growth. Our objective was to investigate effects of simulated environmental factors on germination characteristics of kochia seeds.

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Materials and Methods

Our fully developed, undamaged kochia seeds from a commercial source were used for germination experiments. Seeds were harvested from mature kochia plants during the fall of 1979. Most germination experiments were conducted when the seeds were less than 1 year old. Seeds were stored at room temperatures (20 to 27°C) in cloth bags throughout the study period.

All germination experiments were conducted in small growth chambers with automatic temperature and fluorescent light controls. Unless otherwise stated or if temperature was varied, experiments were conducted at a constant temperature of 15°C with an 8-hr light period. An experimental unit was 100 seeds in a 9-cm petri dish containing 2 filter papers wetted with 10 ml of distilled water or other test solution. Experiments were conducted with a randomized complete block design unless otherwise stated. Treatments were replicated from 4 to 10 times; each experiment was conducted at least twice. Data were pooled prior to statistical analyses. Seeds were considered to be germinated when radicles visibly protruded through the seed coat. The number of germinated seeds was recorded 10 days after initiation of each experiment.

Seeds were germinated under continuous temperatures in 5°C increments from 5 to 40°C (with an 8-hr light period), and alternating regimes of 5–15, 10–20, 15–25, and 20–30°C (16-hr low temperature, 8-hr high temperature with light). The petri dishes were randomized at each temperature regime. Light requirement was investigated by comparing germination in petri dishes covered with aluminum foil with germination in uncovered dishes. Germination tolerance to salinity was evaluated in aqueous solutions of six salts (NaCl, $CaCl_2$, $MgCl_2$, Na_2SO, and $MgSO_4$) at conductances of 0, 4, 6, 8, 12, 16, and 20 mmhos. Also, salt effects on germination "O" were evaluated with aqueous solutions of NaCl and $CaCl_2$ at conductances of 16, 20, 25, 30, 35, and 40 mmhos. The influence of substrate pH on germination was investigated by adding HCl and KOH to distilled water to give pH values of 2, 3, 4, 5, 6, 7, 8, 9, 11, and 12 (Mayeux and Scifres 1978).

The effect of moisture stress on seed germination was evaluated by adding polyethylene glycol (PEG-6000) to distilled water for the substrata—PEG-6000 concentrations required to give osmotic potentials over a wide range of temperatures are given by Michel and Kaufman (1973). We prepared solutions ranging from 0 to –16 bars at 15°C.

The influence of soil coverage on emergence of kochia was studied in the greenhouse. One hundred seeds were planted in small pots (13 cm diameter × 13 cm height). The potting mixture was 3 parts sandy loam: 1 part sand to prevent crusting. Seeds were placed on the soil surface and at a depth of 3 mm. Since kochia seeds are very small, they were planted at a shallow depth. Each treatment was replicated 10 times and the experiment was conducted twice. Seedling emergence was recorded at the end of 21 days.

Percentage germination and emergence data were transformed ($\text{Arcsin}\sqrt{\%}$) before statistical analyses. Data were analyzed by analysis of variance or Student's *t*-test. Means were compared with Duncan's multiple range test (Steel and Torrie 1960). Student's

t-test was used to compare surface vs. buried and light vs. no light while Duncan's test was used for multiple treatment mean comparisons. All interpretations were made at the 0.05 probability level.

Results and Discussion

Temperature and Light

Germination of kochia seeds was ≥ 88% at constant temperatures of 5 to 25°C and at alternating temperatures of 5–15, 10–20, 15–25, and 20–30°C (Table 1). The highest germination occurred at constant temperatures of 10 and 15°C. Germination was significantly lower at 30°C than at 25°C and was decreased to 30% at 35°C. Only 11% of the seed germinated at 40°C. Evidently, high constant temperatures inhibit kochia seed germination. Our findings support those of Durham and Durham (1979), who reported that under field conditions kochia seeds start germinating in February in the Texas Panhandle. Mean daily temperatures in February for the Texas Panhandle range from 5 to 7°C (National Oceanic and Atmospheric Administration 1974).

Table 1. Percentage germination of kochia seeds after a 10-day exposure to 12 constant and alternating temperature regimes.[1]

Temperature (C)	Germination (%)
Constant 5	92 ab
Alternate 5–15	92 ab
Constant 10	94 a
Alternate 10–20	93 ab
Constant 15	94 a
Alternate 15–25	90 bc
Constant 20	92 ab
Alternate 20–30	89 c
Constant 25	88 c
Constant 30	74 d
Constant 35	30 e
Constant 40	11 f

[1]Means within a column followed by the same letter do not differ significantly at the (95%) probability level.

The percentage of kochia seeds that germinated in darkness (90%) did not differ significantly from that of seeds exposed to daily 8-hr periods of light (92%). Apparently light is not required for germination.

Salinity Effects

Salinity had no effect on kochia seed germination at concentrations that gave a conductance up to 20 mmhos for any of the 6 salts (Table 2). Na_2SO_4 inhibited germination numerically but not significantly at a concentration that gave a conductance of 20 mmhos. Since either Na or Ca is usually the dominant cation in saline soils (Ryan et al. 1975), we further tested kochia seed germination in NaCl and $CaCl_2$ substrates with their conductances ranging from 16 to 40 mmhos. These salts had similar effects on germination as their concentrations were increased (Table 3). Their germination was significantly lower at 25 than at 20 mmhos. Increasing conductance by 5 mmho increments from 25 to 40 mmhos progressively reduced germination. Nevertheless, 45 and 40% germination occurred with NaCl and $CaCl_2$ solutions, respectively, when their conductance was 40 mmhos, suggesting that kochia can be established on soils with a wide range in salinity. Our findings are in close agreement with those of Francois (1976), who reported that *Kochia prostrata* was also highly salt tolerant.

Table 3. Percentage germination of kochia seeds after a 10-day exposure to sodium chloride and calcium chloride solutions with conductances ranging from 16 to 40 mmhos.[1]

Conductance[2] (mmhos/cm)	% Germination NaCl	% Germination $CaCl_2$
16	91 a	90 a
20	89 a	90 a
25	76 b	82 b
30	66 c	72 c
35	48 d	57 d
40	45 d	40 e

[1]Means within a column followed by the same letter do not differ significantly at the 95% probability level.
[2]Conductance can be converted to ppm by 640 × mmhos.

Hydrogen Ion, Moisture Stress, and Planting Depth

Kochia seed germination was only slightly reduced at pH 2 and 12 as compared with germination at intermediate hydrogen ion concentrations (Fig. 1). Apparently, kochia seed can germinate under either extreme acid or alkaline conditions.

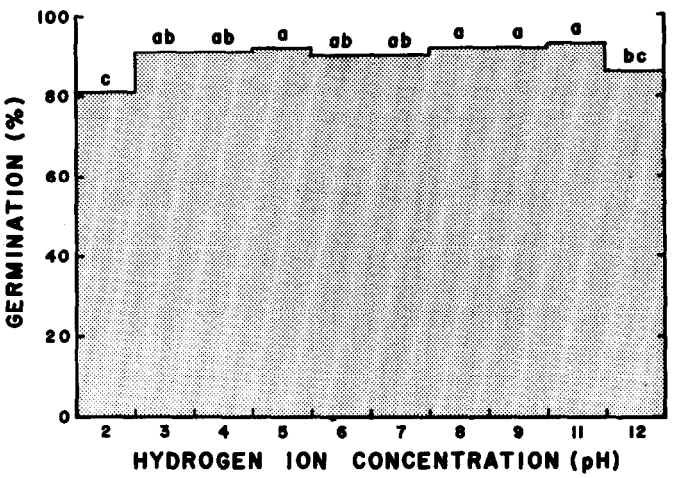

Fig. 1. *Percentage germination of kochia seed after 10-days' exposure in aqueous solutions of various pH. Plateaus designated with the same letter are not significantly different at the 95% probability level, according to Duncan's multiple range test.*

Table 2. Percentage germination of kochia seeds after a 10-day exposure to various salt solutions with conductances up to 20 mmhos for each of 6 different salts.[1]

Conductance[2] (mmhos/cm)	% Germination NaCl	$CaCl_2$	$MgCl_2$	KCl	Na_2SO_4	$MgSO_4$
0	90 a	90 a	90 a	94 a	97 a	95 a
4	90 a	91 a	89 a	92 a	97 a	94 a
6	89 a	90 a	89 a	93 a	93 ab	95 a
8	92 a	89 a	89 a	95 a	89 bc	88 a
12	90 a	92 a	91 a	93 a	92 ab	85 a
16	92 a	92 a	94 a	92 a	95 ab	92 a
20	86 a	89 a	92 a	88 a	82 c	90 a

[1]Means within a column followed by the same letter do not differ significantly at the 95% probability level.
[2]Conductance can be coverted to ppm by 640 × mmhos.

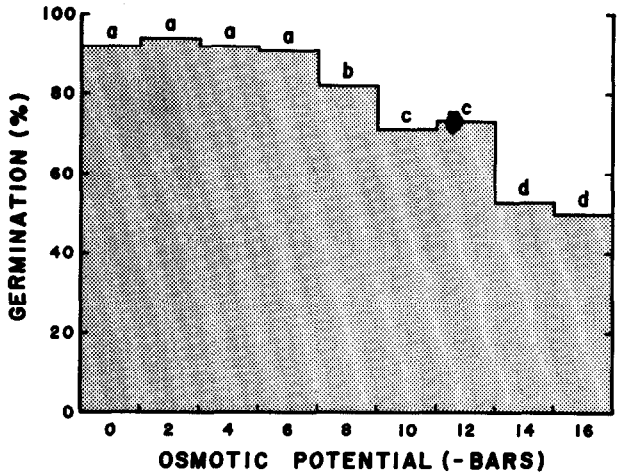

Fig. 2. *Percentage germination of kochia seed after 10-days' exposure in germination media of various osmotic potentials. Plateaus designated with the same letter are not significantly different at the 95% probability level, according to Duncan's multiple range test.*

Kochia seed germination was not reduced until the osmotic potential of the media reached -8 bars (Fig. 2). The germination percentages at -10 and -12 bars were significantly lower than at -8 bars. Germination was further reduced as the moisture tension was increased to -14 and -16 bars. However, there was 50% germination at -16 bars. Thus kochia seed germination was not severely affected by moisture stress.

The seedling emergence percentage for kochia seeds left exposed on the soil surface (74%) was significantly higher than for those planted at a depth of 3 mm (57%). Apparently, seedling emergence is inhibited by seed burial. Emergence is probably inhibited because of the small size of seed since absence of light has no detrimental effect on germination.

Conclusions and Management Implications

Kochia seed germination is favored by cool to moderate temperatures. Therefore, field planting should probably be done in January or February in the southwestern United States to give good germination and seedling establishment. No seed dormancy was observed for kochia seed. Although germination in the fiel depends on the interaction of the physiological system of the see with actual environmental parameters in the seedbed, the ability c kochia seed to germinate under extremes in moisture tension, pH and salinity indicates that it may be adapted to a variety of so conditions.

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