Seed Germination Characteristics of Two Woody Legumes (Retama and Twisted Acacia) From South Texas

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Abstract

The seed germination characteristics of retama *(Parkinsonia aculeata)* and twisted acacia *(Acacia schaffneri)* were investigated in relation to temperature and light regimes, substrate salinity, pH, osmotic potential, seed age, and seedling emergence. Seed germination of both species is restricted by impermeable seed coats. Soaking seeds of both species in concentrated sulfuric acid for 45 min increased germination. Retama seed germination was ≥87% at continous temperatures of 15 to 35° C and at alternating temperatures of 10–20, 15–25, and 20–30° C, while twisted acacia seed germination was ≥58% at constant temperatures of 15 to 30° C and at alternating temperatures of 10–20, 15–25, and 20–30° C. Light was not required for germination, and no dormancy mechanisms were observed. Viability of twisted acacia and retama seeds was not reduced after storage at room conditions for 2 years. Germination and radicle length were sensitive to osmotic potentials of polyethylene glycol solutions of 0.4 MPa and no germination occurred at 1.4 MPa. Germination of both species was only mildly depressed in aqueous solutions of 10 g/l NaCl; however, radicle elongation of both species was reduced at 5 g/l NaCl and severely inhibited at 10 g/l NaCl. The osmotic potentials of the NaCl solutions had little effect on germination, but they may have contributed to reduced radicle growth. Percent germination and seedling radicle length of both species were relatively tolerant of pH extreme. Twisted acacia seedling emergence was highest when the seeds were left exposed on the soil surface, whereas optimum retama seedling emergence occurred when seeds were covered with 1 to 7 cm of soil.

The South Texas Plains support one of the most diverse and difficult-to-manage brush problems in Texas. Among the diversity of woody plants found in this area are numerous species of the family Leguminosae. The genus *Acacia* is particularly prominent with 9 species occurring in this area (Correll and Johnston 1970). Twisted acacia, which spreads by seeds, is one of the most widespread *Acacia* species. It is a member of the mixed-brush complex *(Prosopis-Acacia)* and is highly adapted to both sandy loam and clay loam soils. Although twisted acacia has some value as a deer browse (Davis and Winkler 1968, Everitt and Drawe 1974), it can cause a serious brush problem on rangeland when it rapidly reinfests areas following initial brush control efforts (Box and White 1969, Scifres 1980, Hamilton and Scifres 1982).

Retama is a woody legume that is commonly associated with drainageways, lowland areas, and better upland sites of the South Texas Plains and Coastal Prairies (Smith and Rechenthin 1964, Scifres 1980). It is rarely eaten by wildlife or livestock, but it is occasionally grown as an ornamental (Vines 1960). Retama is considered a troublesome species, but it is less aggressive than twisted acacia and does not usually create a severe brush problem.

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There is a dearth of information on the reproductive potential of twisted acacia and retama. My objective in this study was to investigate the germination characteristics of twisted acacia and retama seeds in the laboratory to certain environmental factors encountered in the seedbed.

Materials and Methods

Retama seeds were randomly collected in August 1979 from several plant populations growing on a tight sandy loam range site (Aquic Paleustalfs) near Weslaco, Hidalgo County, Texas. Twisted acacia seeds were randomly collected from a sandy loam range site (Uridic Ustochrepts) near La Joya in Hidalgo County in November 1979. Only fully developed, undamaged seeds were used for germination experiments. The seeds were stored in cloth bags at room conditions (20 to 27° C, and 50 to 75% relative humidity). Most experiments were conducted when the seeds were less than 1 year old.

All experiments were conducted in small growth chambers with automatic temperature and fluorescent light (200 uE/m²/s) controls. Unless otherwise stated or unless temperature was an intended variable, experiments with retama were conducted at a constant temperature of 25° C, while twisted acacia experiments were conducted at a constant temperature of 20° C (median temperature where optimum germination occurred). An 8-hr light period was used in these experiments. An experimental unit was 10 seeds in a 15-cm petri dish that had 2 filter papers wetted with 20 ml of distilled water or an appropriate test solution. Experiments were designed as randomized complete blocks unless otherwise stated. Treatments were replicated 10 times, and each experiment was conducted twice. Seeds with 2-mm long radicles were considered as being germinated. The number of germinated seeds was recorded 14 days after the initiation of each experiment. Radicle lengths were recorded in selected experiments.

Pilot experiments on the seed germination of both retama and twisted acacia showed a low percent germination because of hard seed coats. Therefore, seeds were scarified by soaking in concentrated sulfuric acid (H_2SO_4) for various time periods and tested for germination at a constant temperature of 30° C. The seeds were acid-soaked for 0, 15, 30, 45, 60, and 75 min. Later studies were conducted for both species using seeds scarified for 45 min.

Seeds of both species were germinated under constant temperatures in 5° C increments from 5 to 40° C (8-hr light period, 16 hr darkness) and alternating temperature regimes of 5–15, 10–20, 15–25, and 20–30° C (16-hr low temperature in darkness, 8-hr high temperature with light). The petri dishes were randomized for each species at each temperature regime.

The effects of simulated moisture stress on seed germination were conducted at 20 and 25° C for twisted acacia and retama, respectively, using aqueous (distilled water) solutions of polyethylene glycol (PEG) 6000. The solutions were mixed after Michel and Kaufman (1973) to exert osmotic potentials of 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, and 1.4 MPa (1 MPa=10 bars). Distilled water was used for a control. The pH of these PEG solutions was 6.8. The petri dishes were placed on moist towels to help offset evaporation losses.

Salt tolerance of seed was evaluated with aqueous (distilled water) solutions of NaCl at concentrations 0, .25, .5, .75, 1, 2.5, 5, and 10 g/l as the germination media. The substrate's pH influence on germination was investigated by adjusting the pH of distilled water with HCl and KOH (Mayeux and Scifres 1978). Percent germination was evaluated with pH substrate values of 2, 3, 4, 5, 6, 7, 8, 9, 11, and 12.

The effect of age on viability of retama and twisted acacia seeds was investigated by comparing germinations at 1, 6, 12, 18, and 24 months after seed collection. Light requirement for seed germination was investigated by comparing the percent germination in petri dishes covered with aluminum foil with the percent germination in uncovered dishes.

The seed planting depth effects on retama and twisted acacia seed germination was studied in the greenhouse. Ten seeds of each species were planted in soil in large pots (16 cm diameter × 16 cm height). A potting mixture was used to prevent crusting. It had 3 parts sandy loam:one part peat moss:one part perlite. Seeds of both species were placed on the soil surface and also covered to depths of 1, 2, 4, 5, and 7 cm. Seedling emergence and height were recorded after 60 days.

Percentage germination and emergence data were transformed (Arcsin $\sqrt{\%}$) before statistical analyses. Data were pooled from the two studies conducted on each experiment prior to statistical analyses. Data were subjected to the analysis of variance and Student's *t*-test. An LSD was calculated in selected experiments (Steel and Torrie 1960). All statistical comparisons were made at $p=0.05$.

Results and Discussion

Retama and twisted acacia seeds are disseminated with hard seed coats that do not readily imbibe moisture (Fig. 1). After 14 days only 1% of the nontreated retama seeds germinated, whereas 5% of the nontreated twisted acacia seeds germinated. Hard seeds are common in several other woody legume species from south Texas (Scifres 1974, Alaniz and Everitt 1978, Everitt 1983). Soaking seeds of both species in concentrated H_2SO_4 for 15 min increased germination as compared with that of nontreated seeds, and soaking seeds for 30 min increased germination as compared with that of seeds soaked for 15 min. Retama seeds soaked for 45, 60, and 75 min had higher germination than those soaked for 30 min; however, germination percentages did not differ greatly among the three soaking periods. Twisted acacia seeds soaked for 45 min in H_2SO_4 had a higher germination percentage than those soaked for 30 min. Soaking twisted acacia seeds for 60 and 75 min did not improve the germination percentage over those soaked for 45 min. About 5% of the retama seeds and 25% of the twisted acacia had insect punctures or other imperfections and were not used in the germination trials. However, these factors may enhance imbibition and germination in nature.

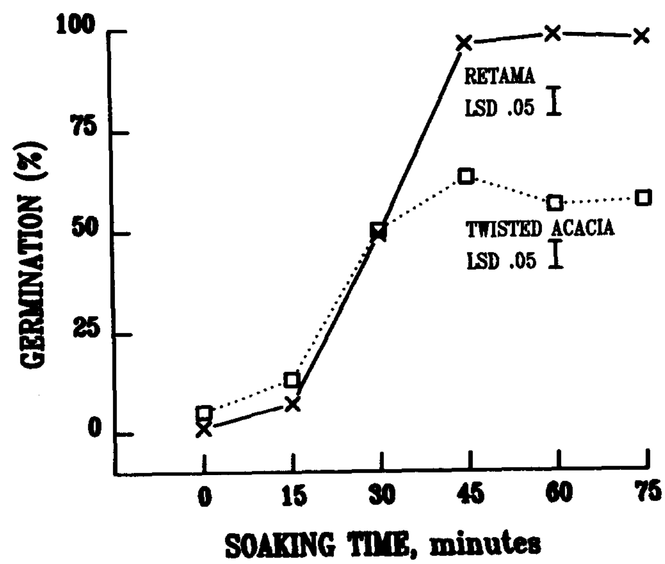

Fig. 1. *Percentage germination 14 days after soaking retama and twisted acacia seeds in concentrated H_2SO_4.*

Retama and twisted acacia seeds do not have specific temperature requirements for germination. Both species had similar germination patterns over a wide range of constant and alternating temperatures (Fig. 2). Retama seed germination was ≥87% at constant temperatures of 15 to 35° C and at alternating temperatures of 10–20, 15–25, and 20–30° C while twisted acacia seed germination was ≥58% at constant temperatures of 15 to 30° C and at alternating temperatures of 10–20, 15–25, and 20–30° C. Germination of both species either decreased abruptly or ceased at temperature extremes, but apparently retama seeds can germinate under higher temperatures than twisted acacia seeds. The temperature requirements for retama and twisted acacia seed germination are similar to those reported for other woody species from southern Texas (Everitt 1983).

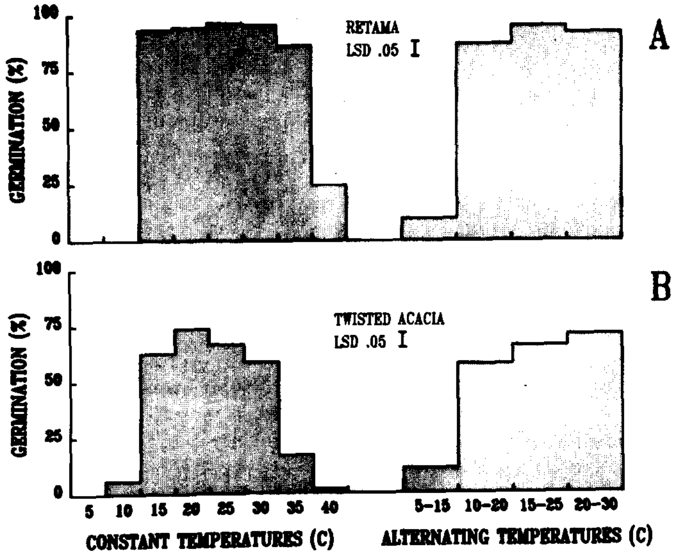

Fig. 2. *Average germination percentage of retama (A) and tiwsted acacia (B) seeds after 14 days exposure to 12 constant and alternating temperature regimes.*

Both germination and radicle length of retama and twisted acacia were sensitive to osmotic potentials of PEG solutions (Fig. 3). Percent germination of both species was suppressed at an osmotic potential of 0.4 MPa and was progressively reduced by increasing the osmotic potentials of the solutions. Germination of both species was severely inhibited at 1.0 MPa, and none of the seeds germinated at 1.4 MPa. Radicle lengths of both retama and twisted acacia had the same general trend as percent germination. These data suggest that retama and twisted acacia seed germination depend on adequate water availability. Thus, species establishment may be best during periods of high soil water availability. The highest rainfall in south Texas occurs in May and June, with another peak in September (National Oceanic and Atmospheric Administration 1974). Temperatures during these periods are generally mild and might also favor germination and seedling establishment.

Retama and twisted acacia germination was not severely affected in aqueous solutions of NaCl up to 10 g/l (Fig. 4). Percent germination of retama seed was slightly reduced at 5 g/l NaCl and further suppressed at 10 g/l, but it remained greater than 80% in the 10 g/l solution. Twisted acacia seed germination was only

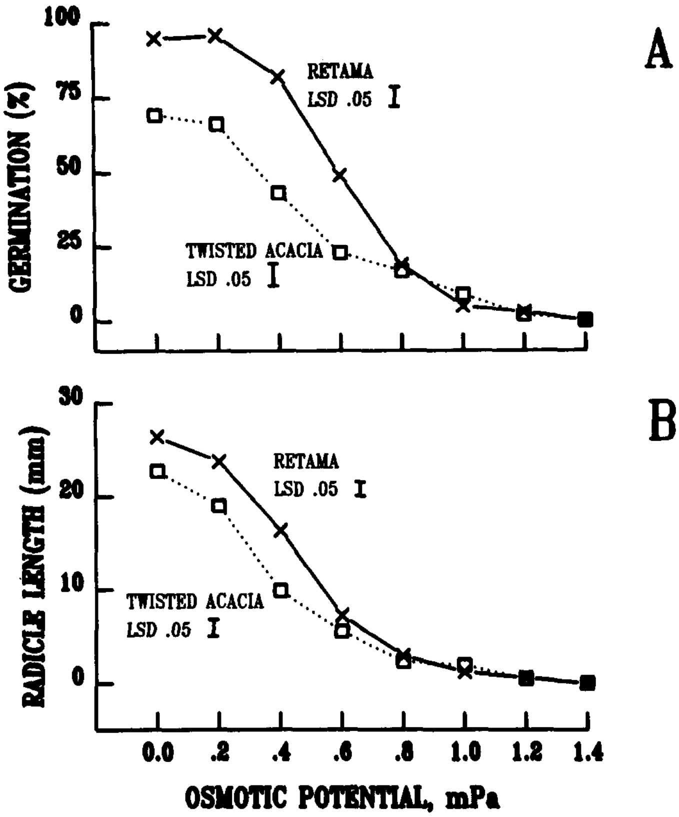

Fig. 3. *Retama and twisted acacia percentage seed germination (A) and radicle length (B) after 14 days exposure to germination media of various osmotic potentials.*

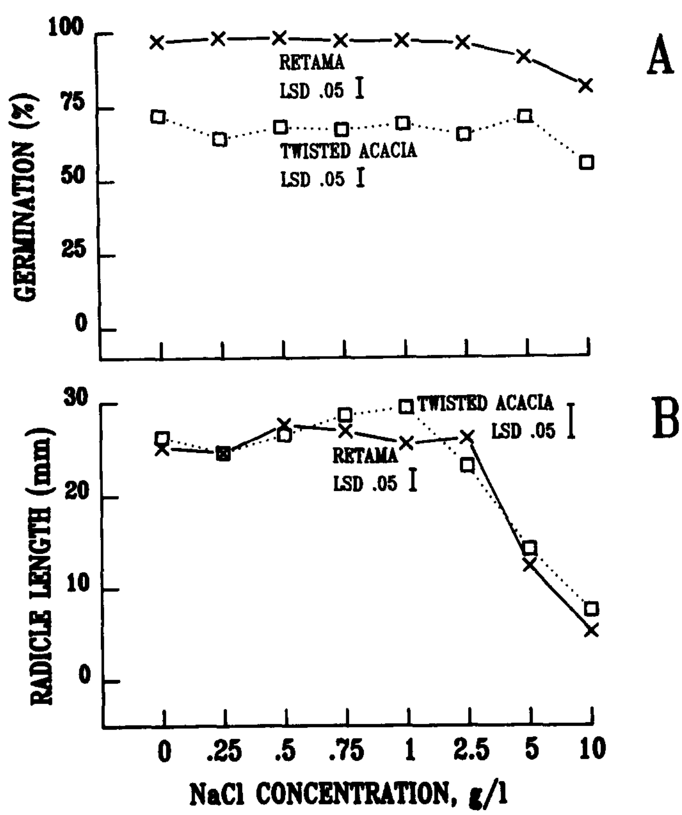

Fig. 4. *Retama and twisted acacia percentage seed germination (A) and radicle length (B) after 14 days exposure to various NaCl concentrations.*

slightly inhibited in the 10 g/l NaCl solution. Radicle elongation of both species was more sensitive to salinity than percent germination. Radicle lengths of both species were suppressed by increasing the NaCl concentration from 2.5 to 5 g/l. Both species had another reduction in radicle length when salt concentration was increased from 5 to 10 g/l. Soil salinity probably has little influence on the seed germination and establishment of retama and twisted acacia. Sodium chloride is the dominant salt in the saline soils of south Texas, and salt concentration in the upper 30 cm of these soils is usually lower than 10 g/l (Fanning et al. 1965, Everitt et al. 1982). Everitt et al. (1982) reported the electrical conductivity in the upper 30 cm of these soils ranged from 6.9 to 12.6 mmhos/cm (salt concentration of 4.4 to 8.1 g/l).

Seed germination in saline soils is affected by both direct ion effects and osmotic interference with imbibition (Uhvits 1946). Richards (1954) presented the relationship between osmotic potential and concentrations of various salts. As described elsewhere (Mayeux 1982), this information can be used in conjunction with germination response to osmotic potentials of PEG solutions to determine if the osmotic potentials of the salt solutions had any effect on seed germination and seedling vigor of retama and twisted acacia. Percent germination and seedling radicle lengths of retama and twisted acacia in 10 g/l concentrations of NaCl were 81% and 5.2 mm, and 55% and 7.5 mm, respectively (Fig. 4). The osmotic potentials of these solutions is about 0.6 MPa. Percent germination and seedling radicle lengths of retama and twisted acacia in PEG solutions of 0.6 MPa were 49% and 7.2 mm, and 23% and 5.5 mm, respectively (Fig. 3). Based on this comparison, the osmotic potentials of the NaCl solutions had little effect on germination of these species. However, seedling radicle length of the 2 species were similar for the 2 solutions. Whether the similarity in radicle lengths is the result of the osmotic potential of the NaCl solutions or direct ion effects is confounded.

Retama and twisted acacia seeds germinated uniformly over a broad range of pH values (data not shown). Retama seed germination was 93% at pH values ranging from pH 3 to 11 while twisted acacia seed germination was ≥67% at these same values. Germination in both species was suppressed at pH 12 (37 and 50% germination for twisted acacia and retama, respectively), and germination essentially stopped for both species at pH 2. Radicle lengths of retama and twisted acacia seedlings followed similar trends to germination, but were more sensitive to less extreme pH conditions. Optimum radicle length of twisted acacia seedlings occurred at pH 7. Soil pH may not be an important factor to determine retama and twisted acacia distribution, since both species germinated over a wide range of pH values. These findings agree with those reported for numerous other troublesome species of woody plants from southern Texas (Scifres 1974; Mayeux and Scifres 1978; Everitt 1983).

Retama seedling emergence is apparently favored by seed covering. The percent emergence for retama seeds left exposed on the soil surface was lower than for seeds covered with soil at depths ranging from 1 to 7 cm (Fig. 5). Seedling emergence was only mildly depressed at a planting depth of 7 cm as compared with the 1 to 5 cm planting depths. Seed planting depths from 0 to 7 cm had little effect on retama seedling height. Twisted acacia emergence from seeds left exposed on the soil surface was higher than for seeds planted at depths ranging from 1 to 7 cm. In general, twisted acacia's percent emergence and seedling height were reduced by increased seed planting depth. These findings agree with those reported for other species of *Acacia* from south Texas (Everitt 1983).

Evidently, light exposure was not the factor that partially inhibited surface-sown retama seed germination. In a separate experiment, the percentage of retama and twisted acacia seeds germinated in light did not differ from those germinated in darkness (data not shown). However, seedlings germinated in darkness had unfolded cotyledons in contrast to fully expanded cotyledons for seedlings germinated in light. This agrees with reports for several other species of woody plants from southern Texas (Scifres

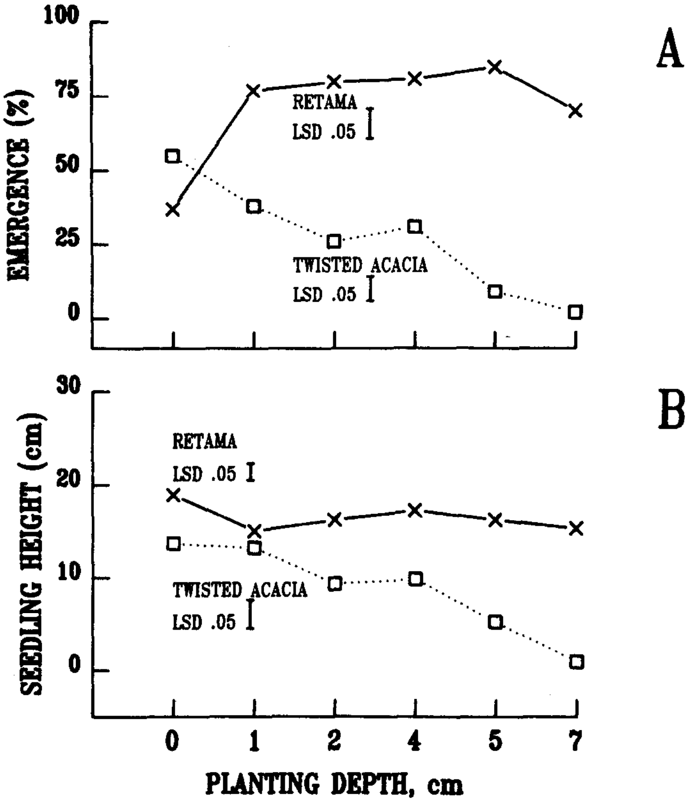

Fig. 5. *Percentage seedling emergence (A) and seedling height (B) 60 days after planting retama and twisted acacia seeds at various soil depths in the greenhouse.*

1974, Whisenant and Ueckert 1981, Everitt 1983), and supports the findings of Mayer and Poljakoff-Mayber (1975), that large seeds do not require light for germination.

A comparison of seed germination of both species about 1 month after collection with germination after storage for 6, 12, 18, and 24 months showed no changes in viability (data not shown).

Conclusions

Retama and twisted acacia seed germination characteristics are similar. Both species are disseminated with hard seeds that inhibit water imbibition. Thus, seeds probably may not germinate readily in nature until the seed coats are made permeable by insects, vertebrate seed eaters, or weathering. Under laboratory conditions, germination of both species was promoted by soaking seeds in concentrated H_2SO_4 acid from 45 to 75 min. Germination in both species was favored by mild temperatures. Retama and twisted acacia seed germination was not severely inhibited by high NaCl levels or pH extremes; however, radicle length was slightly restricted by these conditions. The osmotic potentials of the NaCl solutions had little effect on germination of either species, but they may have suppressed radicle length. Both species appeared to be very sensitive to osmotic potentials of PEG solutions, indicating that adequate soil moisture is probably essential for seed germination and seedling establishment. No after-ripening or seed dormancy mechanisms were observed for either species. Data presented in this study may provide information on the physiological interaction of seeds and seedlings of retama and twisted acacia with environmental parameters encountered in the seedbed.

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