Seed Germination Characteristics of Three Woody Plant Species from South Texas

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Abstract

The seed germination of blackbrush *(Acacia rigidula)*, guajillo *(Acacia berlandieri)*, and guayacan *(Porlieria angustifolia)* was investigated in relation to temperature and various regimes of light; substrate salinity, pH, and osmotic potential; seed age; and site of seed source. Germination of blackbrush seed is restricted by an impermeable seed coat. Mechanical scarification or soaking seeds in concentrated sulfuric acid for 15 to 30 min increased blackbrush germination from 74 to 86%. Blackbrush, guajillo, and guayacan seed germination was best at about 25° C. Blackbrush seed germination was not reduced by alternating as opposed to constant temperatures but germination of guajillo and guayacan was generally lower under alternating temperatures. Light was not required for germination. No seed dormancy mechanisms were observed other than the hard seed coat of blackbrush, and seed viability was not significantly reduced after 1 year in storage at room conditions. Guajillo seed collected from plants growing on a sandy loam site had higher percent germination than those of plants growing on a more droughtly clay loam site. Germination of blackbrush and guayacan from different sites did not differ. Germination and radicle length of seedlings were relatively tolerant of extremes of pH. Guajillo germination was significantly reduced in a aqueous solution of 2,500 ppm NaCl. Germination of blackbrush seed was not affected by 10,000 ppm NaCl, but guayacan seed germination was reduced at this concentration. Radicle lengths of seedlings of all species were significantly reduced at 10,000 ppm NaCl. Seed germination and radicle length of all 3 species were progressively decreased by increasing moisture stress up to -12 bars. Emergence of blackbrush and guajillo seedlings was not dependent upon burial in the soil; germination and emergence were greatest on the soil surface or from a depth of 1 cm.

A great diversity of woody plant species is one of the most prominent characteristics of the Rio Grande Plain of southern Texas. Some 281 species are known to occur here (Lehmann 1975). Blackbrush, guajillo, and guayacan are 3 of the most abundant woody species found in southern Texas (Correll and Johnston 1970, Scifres 1980). Although all 3 species have some browse value for white-tailed deer *(Odocoileus virginianus)* and help provide wildlife habitat (Davis and Winkler 1968, Everitt and Drawe 1974, McMahan and Inglis 1974, Scifres 1980), they often present serious brush problems on rangelands. Blackbrush inhabits almost 4 million hectares of rangeland in south Texas, and guajillo infests about 3 million hectares (Smith and Rechenthin 1964); either species may exist as almost pure stands or they may be components of the mixed-brush complex *(Prosopis-Acacia)*. Guayacan seldom occurs in pure stands and is less aggressive than blackbrush or guajillo, but it is a common species in the mixed-brush complex (Smith and Rechenthin 1964, Scifres 1980). Little or no information is available concerning the reproduction potential of these species. My objective was to study the seed germination characteristics of blackbrush, guajillo, and guayacan plants as affected by simulated environmental factors.

Materials and Methods

Blackbrush and guajillo seeds were randomly collected from several plant populations growing on a sandy loam range site (Aridic Ustochrepts) in Jim Hogg County during June 1978 and 1979. Guayacan seeds were collected from a sandy loam site in Hidalgo County during September of the same years. Only fully developed, undamaged seeds were used for germination experiments. Most of the germination studies were conducted using seeds collected from these 2 sites unless stated otherwise. All seeds were stored at room temperatures (20 to 27° C) in cloth bags.

All germination experiments were conducted in small growth chambers with automatic temperature and fluorescent light controls. Unless otherwise stated or unless temperature was an intended variable, experiments were conducted at a constant temperature of 25° C with an 8-hr photoperiod. An experimental unit consisted of 10 or 20 seeds in a 9- or 15-cm petri dish containing 2 filter papers wetted with distilled water or appropriate test solution. The 9- and 15-cm dishes were wetted with 15 and 20 ml of solution, respectively. For blackbrush and guayacan seeds, 9-cm dishes were used; 15-cm dishes were used for the larger guajillo seeds. Experiments were designed as randomized complete blocks unless otherwise stated. Treatments were replicated 10 or 20 times, and each experiment was conducted at least twice. Seeds having 2 mm radicles were considered as germinated. The number of seeds germinated was recorded 14 days after initiation of each experiment. Radicle lengths were recorded in selected experiments.

Initial experiments on the germination of blackbrush seeds revealed that their germination was low because of a hard seed coat. Therefore, seeds were soaked in concentrated H_2SO_4 (scarification) for various periods of time and tested for germination at a constant temperature of 30° C. The seeds were soaked in acid for 0, 5, 10, 15, 20, 25, or 30 min. Germination of acid-scarified seeds was compared with that of seeds with testas nicked with a file. Subsequent studies were conducted using seeds scarified for 20 min in H_2SO_4.

Seeds of all 3 species were germinated under continous temperatures in 5° C increments from 5 to 40° C. Seeds of each species were also studied in a separate comparison with continuous temperatures of 20, 25, and 30° C, and alternating regimes of 10–20, 15–25, and 20–30° C (16 hr low temperature, 8 hr high temperature with light). The petri dishes were randomized for each species at each temture regime.

Light requirement was investigated by comparing germination in petri dishes covered with aluminum foil with germination in uncovered dishes. As in all following experiments, light requirement was evaluated under the optimum temperature regime (25° C).

Tolerance of seeds to salinity was evaluated with aqueous solutions of NaCl at concentrations of 0, 250, 500, 750, 1,000, 2,500, 5,000, and 10,000 ppm (wt./vol.) as the germination medium. Solutions were formulated in distilled water. The influence of substrate pH on germination was investigated by adjusting the distilled water with HCl and KOH (Mayeux and Scifres 1978). Germination was evaluated with substrate pH values of 2, 3, 4, 5, 6, 7, 8, 9, 11, and 12.

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The effect of moisture stress on seed germination was evaluated by adjusting osmotic potentials of distilled water with polyethylene glycol (PEG) 6000, then using this solution as the germination medium. Tables of PEG 6000 concentration required to give selected osmotic potentials over a wide range of temperatures were developed by Michel and Kaufman (1973). Their results were used to prepare solutions ranging from 0 to −12 bars at 25° C.

Changes in seed viability (1978 collection) with increasing age were investigated by comparing germination at 1, 6, and 12 months after collection at constant temperatures of 25 and 30° C. Viability of seed collected in 1978 and 1979 was also compared. Viability of seeds from guajillo plants growing on a clay loam range site (Ustollic Camborthids) in Starr County was compared with that of seeds from plants on a sandy loam site in Jim Hogg County. Germination of seeds from guayacan plants growing on a shallow ridge site (Ustollic Paleorthids) in Jim Hogg County was compared with that of seeds from plants on a sandy loam site in Hidalgo County. Germination of blackbrush seeds from plants growing on a shallow ridge site in Starr County was compared with that of seeds from plants growing on a sandy loam site in Jim Hogg County.

The influence of planting depth on guajillo and blackbrush seeds was studied in the greenhouse. Ten seeds of each species were planted in large pots (16 cm diameter × 16 cm height). The potting mixture was three parts sandy loam: one part of sand to prevent crusting. Blackbrush seeds were placed on the soil surface or planted at depths of 0.5, 1.0, 1.5, 2.5, 3.5, and 5.0 cm. Guajillo seeds were placed on the soil surface or planted at depths of 1, 2, 3, 4, 6, and 8 to 10 cm. Seedling emergence and height were recorded at the end of 60 days.

Percentage germination and emergence data were transformed ($\text{Arcsin}\sqrt{\%}$) before statistical analyses. Data were subjected to analysis of variance and Student's *t*-test. Differences among means were compared with Duncan's multiple range test (Steel and Torrie 1960). All statistical comparisons were made at the .05 probability level.

Results and Discussion

Scarification of Blackbrush Seed

Blackbrush seeds apparently do not readily imbibe moisture until the seed coats are broken because only 4% of the nontreated seeds germinated after 14 days (Table 1). Soaking seeds in concentrated H_2SO_4 for 5 min significantly increased germination as compared with that of untreated seeds, and soaking in H_2SO_4 for 10 min significantly increased germination as compared with that of seeds soaked for 5 min. Seeds subjected to mechanical scarification and those soaked in H_2SO_4 for 15, 20, 25, and 30 min had significantly higher germination percentages than those soaked for 10 min (74 to 86%); however, germination percentages did not differ significantly among these 5 treatments. About 20% of the blackbrush seeds that were collected had insect punctures or natural imperfections and were not used in germination experiments, but these factors may enhance moisture imbibition and allow subsequent germination in nature.

Table 1. Percentage germination 14 days after soaking blackbrush seeds in concentrated H_2SO_4 or mechanically scarifying the seed coat[1].

Soaking time (min)	Germination (%)
0	4 d
5	30 c
10	62 b
15	83 a
20	86 a
25	86 a
30	74 a
Mechanical scarification	77 a

[1] Means within a column followed by the same letter do not differ significantly at the 95% confidence level, according to Duncan's multiple range test.

Table 2. Average germination percentage of blackbrush, guajillo, and guayacan seeds after 14 days at 8 constant temperatures.[1]

Temperature regime (° C)	Species Blackbrush (%)	Guajillo (%)	Guayacan (%)
5	0 d	0 f	0 e
10	4 d	14 e	0 e
15	84 ab	66 bc	8 d
20	88 a	73 ab	61 b
25	90 a	77 a	87 a
30	86 ab	76 a	87 a
35	77 b	56 c	61 b
40	35 c	37 d	26 c

[1] Means followed by a common letter do not differ significantly at the 95% confidence level, according to Duncan's multiple range test.

Temperature

Germination of guayacan seed was suppressed at lower temperatures more than that of the *Acacia* species (Table 2). Guayacan seed did not germinate at 5 or 10° C, and the germination percentage at 15° C was significantly less than at 20° C. A few blackbrush and guajillo seed germinated at 10° C, and germination percentages at 15° C were 84 and 66%, respectively. Although blackbrush and guajillo seeds germinated well at temperatures from 15 to 35° C, both species germinated best at 25° C. Optimum germination of guayacan seed occurred at 25 and 30° C. Germination percentages of all three species were significantly lower at 40° C than at 35° C.

Germination percentages of blackbrush seed did not differ significantly among any of the 6 alternating and constant temperature regimes that were compared, but the highest germination occurred at 25° C (Table 3). Evidently temperature does not strongly regulate germination of this species. Germination of guajillo and guayacan seeds was significantly lower at alternating temperatures of 10-20 and 15-25° C than at the constant temperatures. Guajillo and guayacan seeds also germinated best at a constant temperature of 25° C.

Light

Germination percentages of all three seed species in darkness or in light did not differ (data not shown). These results agree with those reported for germination of honey mesquite *(Prosopis glandulosa)* seeds (Scifres and Brock 1972).

Salinity and pH

Percentage germination of guajillo and guayacan seeds was more adversely affected than blackbrush seeds by aqueous solutions of NaCl (Table 4). Increasing NaCl concentration from 1,000 ppm to 2,500, 5,000 and 10,000 ppm significantly reduced guajillo germination from 64% to 56, 47, and 34%, respectively. Guayacan seeds were more tolerant of NaCl than guajillo seed. Its germina-

Table 3. Average germination percentage of blackbrush, guajillo, and guayacan seeds after 14 days under various alternating and constant temperature regimes[1].

Temperature regime (° C)	Species Blackbrush (%)	Guajillo (%)	Guayacan (%)
Alternating 10–20	90 a	48 d	20 d
Alternating 15–25	91 a	63 c	50 c
Alternating 20–30	88 a	70 b	76 b
Constant 20	86 a	69 b	75 b
Constant 25	93 a	76 a	92 a
Constant 30	90 a	73 ab	88 a

[1] Means followed by a common letter do not differ significantly at the 95% confidence level, according to Duncan's multiple range test.

Table 4. Percentage germination and radicle length of seedlings of blackbrush, guajillo, and guayacan after 14 days exposure to various NaCl concentrations[1].

NaCl Concentration ppm	Germination (%)			Radicle Length (mm)		
	Blackbrush	Guajillo	Guayacan	Blackbrush	Guajillo	Guayacan
0	93 a	67 a	91 a	38.2 bc	48.3 a	36.6 ab
250	91 ab	68 a	88 ab	49.9 a	56.1 a	34.5 bc
500	88 ab	65 a	87 ab	46.0 ab	53.6 a	35.0 bc
750	89 ab	66 a	84 ab	45.7 ab	53.8 a	40.2 ab
1,000	84 abc	64 a	90 ab	41.3 b	55.5 a	45.5 a
2,500	83 bc	56 b	87 ab	32.6 c	46.5 a	42.4 ab
5,000	75 c	47 c	82 b	13.8 d	47.7 a	26.7 c
10,000	75 c	34 d	61 c	4.7 e	32.2 b	9.5 d

[1] Means within a column followed by the same letter do not differ significantly at the 95% confidence level, according to Duncan's multiple range test.

tion was not significantly reduced until a concentration of 10,000 ppm NaCl was reached. Blackbrush germination percentages were not severely reduced by salinity, but seedling radicle lengths were significantly reduced at the two highest NaCl concentrations. Radicle elongation of both guajillo and guayacan seedlings was significantly reduced by 10,000 ppm NaCl.

Germination percentages of all three species were significantly reduced at both pH 2 and pH 12 as compared with germination percentages at other pH values (Table 5). Germination at pH 2 was significantly lower than at pH 12. None of the blackbrush seeds germinated at pH 2 as compared with 33% at pH 12. Radicle elongation seemed more sensitive than germination to pH at less extreme conditions. Similar effects of hydrogen ion concentrations on early vigor of goldenweed (*Isocoma* spp.) seedlings have been reported (Mayeux and Scifres 1978).

Substrate Osmotic Potential (Moisture Stress)

Decreasing moisture availability was simulated by adjusting the osmotic potential of the germination media. Seed germination progressively decreased with decreasing moisture availability in all 3 species (Table 6). Percentage germination of blackbrush and guajillo seed was significantly reduced at –2 bars simulated moisture stress, whereas guayacan was significantly reduced at –4 bars. However, some seed of all species germinated at –12 bars tension. Guayacan seeds were apparently less affected by increased moisture stress than those of blackbrush and guajillo. Radicle lengths of seedlings of all 3 species followed the same general trend as germination, but guayacan seedlings appeared to be more severely inhibited by moisture stress than did blackbrush and guajillo seedlings. This was in contrast to guayacan's generally better germination under increased moisture stress, as compared to the other species.

Age and Site Effects

A comparison of germination of seeds of each species about 1 month after collection with germination after storage for 6 to 12 months showed no change in viability (data not shown).

The germination percentage of guajillo seeds collected from plants growing on the sandy loam site (73%) was significantly

Table 5. Percentage germination and radicle length of seedlings of blackbrush, guajillo, and guayacan after 14 days exposure to solutions of various pH[1].

pH	Germination (%)			Radicle length (mm)		
	Blackbrush	Guajillo	Guayacan	Blackbrush	Guajillo	Guayacan
2	0 d	28 d	26 c	0 f	16.8 d	3.2 e
3	85 a	54 b	86 a	34.0 d	31.4 c	8.3 d
4	83 ab	60 ab	85 a	48.8 ab	56.1 a	29.4 bc
5	89 a	65 a	83 a	43.4 bc	53.1 ab	31.0 b
6	89 a	61 ab	88 a	50.5 a	52.8 ab	29.2 bc
7	88 a	65 a	85 a	48.4 ab	61.3 a	33.7 ab
8	90 a	67 a	80 a	46.3 ab	53.3 ab	32.2 ab
9	87 a	62 ab	85 a	45.3 ab	51.0 ab	36.3 a
11	75 b	60 ab	86 a	39.1 cd	43.9 b	25.8 c
12	33 c	41 c	68 b	10.1 e	23.4 cd	9.1 d

[1] Means within a column followed by the same letter do not differ significantly at the 95% confidence level, according to Duncan's multiple range test.

Table 6. Percentage germination and radicle length of seedlings of blackbrush, guajillo, and guayacan after 14 days exposure to germination media of various osmotic potentials[1].

Osmotic potential (–bars)	Germination (%)			Radicle length (mm)		
	Blackbrush	Guajillo	Guayacan	Blackbrush	Guajillo	Guayacan
0	88 a	66 a	87 a	41.6 a	49.4 ab	32.2 a
2	75 b	54 b	83 a	21.9 b	54.0 a	10.3 b
4	53 c	35 c	68 b	23.3 b	41.2 b	7.7 c
6	53 c	30 cd	60 bc	16.7 c	42.5 b	5.7 cd
8	41 d	23 de	55 c	11.6 d	27.5 c	5.3 cd
10	32 d	22 e	45 d	8.4 de	19.2 cd	4.3 d
12	19 e	13 f	32 e	5.9 e	9.8 d	3.3 d

[1] Means within a column followed by the same letter do not differ significantly at the 95% confidence level, according to Duncan's multiple range test.

Table 7. Percentage seedling emergence and seedling height 60 days after planting blackbrush and guajillo seeds at various depths in soil in the greenhouse[1].

Blackbrush			Guajillo		
Planting depth (cm)	Emergence (%)	Height (mm)	Planting depth (cm)	Emergence (%)	Height (mm)
0	60 ab	34.8 a	0	65 a	80.7 a
0.5	51 bc	34.7 a	1.0	62 ab	60.5 b
1.0	72 a	34.1 ab	2.0	65 a	57.6 bc
1.5	35 d	29.5 b	3.0	50 bc	50.4 bc
2.5	40 cd	24.3 c	4.0	47 c	48.3 cd
3.5	26 d	20.7 c	6.0	19 d	37.4 de
6.0	5 e	9.6 d	8–10	17 d	35.8 e

[1] Means within a column followed by the same letter do not differ significantly at the 95% confidence level, according to Duncan's multiple range test.

greater than those collected from plants on the clay loam site (59%) (data not shown). Neither site had especially adverse soil conditions, but the clay loam contained more calcium and was drier. Germination percentages of blackbrush and guayacan seeds collected from plants growing on the sandy loam site did not differ significantly from those collected from plants on the shallow ridge.

Planting Depth

Seedling emergence was best when blackbrush seeds were planted a depth of 1 cm, but the emergence of seeds left exposed on the soil surface did not differ significantly from those planted at depths of 0.5 and 1 cm (Table 7). Seed planting depths from 0 to 1.5 cm had little effect on the vigor of blackbrush seedlings.

Optimum numbers of guajillo seedlings emerged when seeds were either left exposed on the soil surface or planted 2 cm deep. Few guajillo seedlings emerged when seeds were planted deeper than 4 cm. Guajillo seedlings from exposed seed were more vigorous than those from seeds plants in the soil.

Conclusions

Data from this study indicate that blackbrush, guajillo, and guayacan can tolerate a wide range of simulated environmental factors during germination and early seedling establishment. Narrow limits or restrictive requirements for germination were not observed. Although germination in the field depends on the interaction of the physiological system of the seed with actual environmental parameters in the seedbed, the ability of seeds and seedlings of these species to withstand extremes in moisture, temperature, pH, and NaCl concentrations may help account for their abundance and distribution.

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