Seed germination characteristics of selected native plants of the lower Rio Grande Valley, Texas

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Abstract

Experiments were conducted to identify treatments that increased emergence of seeds of 24 woody plant species native to the lower Rio Grande Valley of southern Texas. Sulfuric acid (18.4M H_2SO_4) scarification significantly increased emergence of huisache *(Acacia smallii)*, huisachillo *(A. schaffneri)*, Texas ebony *(Pithecellobium flexicaule)*, tenaza *(P. pallens)*, tepeguaje *(Leucaena pulverulenta)*, retama *(Parkinsonia aculeata)*, and western soapberry *(Sapindus drummondii)*; treatments such as soaking in distilled water, gibberellic acid (0.3 or 1.4 mMol), or other scarification techniques were not as effective as acid. Fresh guajillo *(A. berlandieri)* seeds required no treatment, but 8-month-old seeds had higher emergence with acid scarification. Texas ebony emergence was higher from 10-month-old seed treated with acid than from fresh seeds. No pre-treatment seemed necessary for seeds of coral bean *(Erythrina herbacea)*, Texas persimmon *(Diospyros texana)*, sugarberry *(Celtis laevigata)*, granjeno *(C. pallida)*, pigeon-berry *(Rivina humilis)*, Texas baby-bonnets *(Coursetia axillaris)*, guajillo *(A. berlandieri)*, and lotebush *(Ziziphus obtusifolia)*. Results with blackbrush *(A. rigidula)*, Wright's acacia *(A. wrightii)*, rattlebush *(Sesbania drummondii)*, guayacan *(Guaiacum angustifolium)*, brasil *(Condalia hookeri)*, elbowbush *(Forestiera angustifolia)*, and anacua *(Ehretia anacua)* seeds were inconclusive. Plants of 16 woody species achieved mean heights of 25 cm in 45 to 150 days.

Keywords: seed treatments, scarification, brush

Less than 5% of the lower Rio Grande Valley of Texas remains in native brushland (U.S. Fish and Wildlife Service 1983). These brush communities provide critical habitat for numerous animal species. For this reason, the Texas Parks and Wildlife Department and the U.S. Fish and Wildlife Service are restoring native brush by planting native seeds and seedlings in formerly cultivated fields.

Propagation of native plants requires the development of proper handling methods for seeds and seedlings. Previous research on native plants of the lower Rio Grande Valley has been conducted in laboratory growth chambers, for example, fresh seeds of persimmon *(Diospyros texana)* germinated best (33 to 90%) without any treatment (Plowman and Munson 1983, Everitt 1984). Everitt (1983a) reported germination rates of 87 to 92% for guayacan *(Guaiacum angustifolium)* and 66 to 77% with fresh seed of guajillo *(Acacia berlandieri)*. Many other legume species have hard seed coats, and acid treatments have been used to increase germination of these species. Alaniz and Everitt (1978) obtained best results with Texas ebony *(Pithecellobium flexicaule)* by soaking seed in concentrated sulfuric acid (hereafter acid) for 30 to 45 minutes to get 80% germination. Maximum germination for huisache *(Acacia smallii)* was 65% with acid treatment from 45 to 60 minutes (Scifres 1974). Everitt (1983a, b) obtained 86% germination by soaking fresh blackbrush *(Acacia rigidula)* seeds in acid for 20 minutes, 58% with 45 minutes acid treatment of huisachillo *(Acacia schaffneri)* seeds, and 87% with acid treatment for 15 to 90 minutes of retama *(Parkinsonia aculeata)* seeds. Similarly, germination of rattlebush *(Sesbania drummondii)* seeds was improved by soaking in acid for up to 4 hours (Easton 1984). Acid scarification for 60 to 90 minutes followed by cold scarification for 90 days produced best results with western soapberry *(Sapindus drummondii)* seeds (Munson 1984). Seeds of other species, such as sugarberry *(Celtis laevigata)*, might undergo periods of dormancy that can be broken by prechilling (Bonner 1974, 1984). Fulbright et al. (1986a, b) used a combination of mechanical scarification, gibberellic acid, and heat/chill treatments to obtain 62% germination of granjeno *(Celtis pallida)* seeds; and gibberellic acid, moist pre-chilling for 2 weeks, and storage for 8 months as methods of improving germination of anacua *(Ehretia anacua)* seeds. Alaniz and Everitt (1980) obtained 40 to 60% germination of anacua seeds by soaking them in acid for 2 hours. The results, however, have not been tested in greenhouse and field structures.

My objective was to develop or improve greenhouse germination techniques for 24 native woody plant species (Table 1). Treatments were based on known germination characteristics for seeds of different taxanomic groups. For example, seeds from families known for hard seed coats, such as Mimosaceae and Fabaceae, were subjected to scarification treatments. A secondary objective was to document the length of time needed for the seedlings to reach 25 cm in height, which is desired for field planting.

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Methods

Tests were conducted to determine if greenhouse emergence could be increased for these species (Table 1) using the following types of pre-sowing treatments: soaking in distilled water, soaking in gibberellic acid (0.3 or 1.4 mMol), or in acid (18.4M H_2SO_4), and other scarification techniques such as hot water, sandpaper and rock tumblers. I also tested the combined effects of seed ripeness and acid treatment on Texas ebony emergence. Experiments were done with seeds of various ages.

Seed Collection and Processing

Seeds were collected from local stands of native brush, primarily the Santa Ana National Wildlife Refuge near Alamo, Texas, between 1984 and 1985. They were collected directly from plants with the exception of anacua and cedar elm *(Ulmus crassifolia)*, which were swept off the ground. Seeds of leguminous species were extracted manually. Fruits of granjeno, sugarberry, brasil, anacahuita *(Cordia boisseri)*, and elbow bush *(Forestiera angustifolia)* were depulped for some treatments by rubbing manually against a wire mesh. Western soapberry seeds were removed from shells (pericarps). Seeds were stored in paper sacks on shelves at room temperature until 10 January 1985 and were stored in a refrigerator at 4° C after that date.

Experimental Design, Treatments, and Propagation Procedures

A randomized block design was used. Basic treatment types are listed in Table 2. Cedar elm fruits were planted in mulch collected from under the tree. Several unsuccessful exploratory treatments are not described in detail for sake of brevity. With the exception of

Table 1. Species selected for seed germination experiments.

Family	Scientific name	Common name
Ulmaceae	*Celtis pallida*	Granjeno
	Celtis laevigata	Sugarberry
	Ulmus crassifolia	Cedar elm
Phytolaccaceae	*Rivina humilis*	Pigeon-berry
Mimosaceae	*Acacia rigidula*	Blackbrush
	Acacia berlandieri	Guajillo
	Acacia smallii	Huisache
	Acacia schaffneri	Huisachillo
	Pithecellobium pallens	Tenaza
	Pithecellobium flexicaule	Texas ebony
	Luecaena pulverulenta	Tepeguaje
	Acacia wrightii	Wright's acacia
Caesalpinaceae	*Parkinsonia aculeata*	Retama
Fabaceae	*Erythrina herbacea*	Coral bean
	Sesbania drummondii	Rattlebush
	Coursetia axillaris	Texas baby-bonnets
Zygophyllaceae	*Guaiacum angustifolium*	Guayacan
Sapindaceae	*Sapindus drummondii*	Western soapberry
Rhamnaceae	*Condalia hookeri*	Brasil
	Ziziphus obtusifolia	Lotebush
Ebenaceae	*Diospyros texana*	Texas persimmon
Oleaceae	*Forestiera angustifolia*	Elbowbush
Boraginaceae	*Cordia boisseri*	Anacahuita
	Ehretia anacua	Anacua

granjeno, additional treatments were not tried if emergence exceeded 75% with no treatment. Emergence counts were made once or twice weekly.

In 1985, three replications of each treatment were located randomly in seedling trays (blocks) filled to 4 cm with a commercial potting mix which consisted of 85% peat moss and 15% vermiculite. There were 50 seeds in each replication. When seedlings were 1 to 10 cm tall, they were transplanted into a 3.8 by 3.8 by 25-cm cardboard tube filled with the same potting mix. Light intensity over the planting trays was 170 $\mu molm^{-2}s^{-1}$ (PAR) at 1530 hr on 27 June 1985 (10% of external conditions). The seedlings were transplanted to an area with light intensity of 450 $\mu molm^{-2}s^{-1}$ (27% of external). Seedling height was measured weekly in 1985 and also

Table 2. Basic treatments.

1. No treatment.
2. Soaking in distilled water 3 to 7 hours or 47 to 49 hours.
3. Soaking in 100 mg/l or 500 mg/l gibberellic acid for 3 to 7 hours or 47 to 49 hours with an aerator.
4. Soaking in acid (18.4M H_2SO_4) for 1 to 120 minutes.
5. Soaking in acid (18.4M H_2SO_4) for 1 to 120 minutes followed by soaking in distilled water 3 to 7 hours.
6. Other scarification methods such as rubbing lightly with coarse sandpaper for 2 minutes, placing in boiling water and letting cool 5 to 6 hours (or 47 to 49 hours), or placing seeds in a tumbler with crushed rock for 1 to 60 minutes.

weekly in 1986 for seedlings of granjeno, huisache, huisachillo, and western soapberry until mean heights were 20 to 30 cm.

Based on results in 1985, calculations of minimum sample size for α = 0.5 and β = 0.20 (Kirk 1982) suggested that 5 to 10 replications of each treatment would be necessary. In 1986, therefore, procedures were changed so that there were 8 replications of each treatment, and each replication placed on a separate table (block) in the greenhouse. There were 32 seeds in each replication. Seeds were sown directly into the cardboard tubes, one seed per tube, and the same potting mix used. A 75% shade cloth over the exterior of one portion of the greenhouse was replaced with a 50% shade cloth; light intensity varied at each table, and ranged from about 300 $\mu molm^{-2}s^{-1}$ (18% of external) to 600 $\mu molm^{-2}s^{-1}$ (36% of external at mid-afternoon during several measurements in June 1986.

During both years, the plants were watered once every other day for 5 minutes with overhead spray stick sprinklers. Sodium and calcium concentrations in samples of the water supply (March 1985, July and August 1986) varied from 265 to 281 mg/l, and 45 to 97 mg/l, respectively, with total salts estimated at 1,128 to 1,289 mg/l. Two grams of slow-release fertilizer (18-7-10 + 1% Fe) were placed on the soil surface when seedlings were about 5 cm tall.

Data Analyses

Analyses of variance (ANOVA) and Tukey's HSD multiple comparison tests were used to identify significantly different ($P \leq 0.05$) treatment means, unless emergence was highest under no treatment. Multiple comparison tests were not used to compare graded levels of acid treatment (Petersen 1977).

Results

Germination of Families

Ulmaceae

Highest emergence of sugarberry occurred with pretreatment of depulped seeds (Table 3). With granjeno, emergence was higher if the pulp was not removed (Table 3). There was no enhancement of emergence from soaking seeds of these 2 species in 1.4 mMol gibberellic acid for 5 hours.

Emergence rates of cedar elm were low (<10%). Planting seeds in mulch from under the tree significantly ($P \leq 0.05$) increased emergence from 3 to 9%.

Phytolaccaceae

Emergence from 5-month-old pigeon-berry *(Rivina humilis)* seed planted in May 1985 was 79% after 43 days. No pregermination treatment of seeds was necessary. No emergence was obtained from 3-year-old seeds.

Mimosaceae

Scarification of Texas ebony seeds increased emergence (Tables 3 and 4). Emergence was 78% after acid treatment for 60 minutes. The best alternative scarification method was with crushed rock for 5 minutes (29% emergence). It was superior ($P \leq 0.05$) to boiling water (3%) or placing in water in an oven at 38° C for 6 hours (6%). Emergence was higher ($P \leq 0.05$) for 10-month-old Texas ebony seed that had been soaked in acid for 30 minutes (88%) than for seeds from green pods, either with or without scarification (48% and 35%, respectively) (Table 5).

Emergence was similar among treatments for 10-month-old seed of tenaza *(Pithecellobium pallens)* (Table 3). Seed from the same collection planted a year later had 45% emergence with acid treatment for 10 minutes, but no emergence without treatment; the threshold for acid treatment was about 5 minutes (Table 4).

Scarification of the seed coat improved emergence of several *Acacia* species. Huisache and huisachillo seeds both required scarification (Table 3), and highest emergence (97 and 73%, respectively) was with 120 minutes of acid treatment for both species. The threshold for acid scarification was 60 minutes for huisache. Scarification in acid (1 minute) or by sandpaper (2 minutes) doubled emergence of 8-month-old seeds of Wright's acacia *(Acacia wrightii)* (Table 3). No scarification was needed with fresh guajillo seeds, while those planted 7 months after collection had higher emergence with 1 minute of acid treatment (Table 3). Treating seed of blackbrush with acid for 15 minutes followed by soaking in distilled water for 5 hours produced 33% emergence, similar to emergence (24%) without treatment (Table 3).

Tepeguaje seeds also required scarification for optimum results

Table 3. Emergence (%) in response to pre-sowing treatments.

Species	Seed Coll.	Seed Sown	Days after sow[1]	Treatments[2]: Control	Dist. water soak	Gibb. acid (mMol) 0.3	Gibb. acid (mMol) 1.4	Acid scarific.[3]	Other
			days	Emergence (%)					
Anacua	6–86	7–86	175	22b		27ab(4h)	32a(4h)	16b(135m)	
Blackbrush	7–84	5–85	23	24	19	24		27(15m)	33(acid 15m+water 5h)[4]
Coral bean	7–84	6–85	62	50	29	37		49(2m)	
Granjeno with pulp	8–86	8–86	19	77a			79a(5h)		<33b(depulped)
Guajillo	6–85	6–85	13	96	92(4h)	91(4h)		90(2m)	
Guajillo	11–85	6–86	13	29b			38ab(5h)	44a(1m)	
Huisache	7–85	5–86	46	11b	14b(6h)			95a(90m)	10b(boil water)
Huisachillo	10–85	7–86	42	2b				73a(120m)	
Rattlebush	7–84	6–85	34	12	11	12		14(2m)	11(sandpaper 2m)
Retama	7–86	10–86	7	8b	8b(4h)			51a(45m)	
Sugarberry depulped	7–86	8–86	54	73a	58b(5h)	63ab(5h)	63ab(5h)		<59b(with pulp)
Tenaza	7–84	6–85	23	25a	20a(7h)	26a(7h)		42a(2m)	24a(sandpaper 2m)
Tenaza	7–84	10–86	10	0b				45a(10m)	
Tepeguaje	7–84	3–85	81	5b				13ab(2m)	28a(boil water)
Tepeguaje	7–85	10–85	90	33b	37b(6h)	34b(6h)		82a(10m)	50b(boil water)
Tepeguaje	7–85	6–86	41	26b				73a(10m)	84 (acid 15m)
T. baby-bonnet	5–85	6–85	18	25	12	11			
T. ebony	8–85	11–85	40	3b	6b(6h)	5b(4h)	4b(4h)	78a(60m)	29ab(rock 5m)
T. ebony	8–85	6–86	66	64b				88a(30m)	
T. persimmon	7–84	3–85	68	55ab	72a(50h)	22bc(49h)		70a(1m)	77a(sandpaper 2m)
T. persimmon	7–84	6–86	34	36	34(3h)	33(3h)		34(1m)	28(boil water)
W. acacia	7–84	3–85	75	13	16			27(1m)	29(sandpaper 2m)

[1]Number of days after sowing that cumulative emergence data are presented.
[2]h = hours; m = minutes; treatment means followed by the same letter (within row) were not significantly different ($P>0.05$).
[3]Emergence less when followed by soaking in distilled water, except blackbrush as noted.
[4]Blackbrush seeds rubbed lightly with coarse sandpaper for 2 minutes had 25% emergence.

Table 4. Emergence (%) in response to pre-sowing acid (18.4M (H_2SO_3) treatment of seeds.

Species	Seed Coll.	Seed Sown	Days after sow[1]	0	1	2	5	10	15	20	30	45	60	75	90	105	120	135	180
				Concentrated sulfuric acid (minutes)															
			days	% emergence															
Huisache	7–85	5–86	46	11							26	44	92	80	95	94	97		
Huisachillo	10–85	7–86	42	2							4	38	58		50		73		
Retama	7–86	10–86	7	8					35			51			47		40		
Tenaza	7–84	6–85	23	25		42													
Tenaza	7–84	10–86	10	0	1	4	39	45		32									
Tepeguaje	7–84	3–85	81	5		13													
Tepeguaje	7–85	10–85	90	33	24	37	72	82											
Tepeguaje	7–85	6–86	41	26			56	73	84	78	73		74						
T. ebony	8–85	11–85	40	3							67	71	78						
T. ebony	8–85	6–86	66	64							88								
T. persimmon	7–84	3–85	68	55	70														
T. persimmon	7–84	6–86	34	36	34	27	25	19											
W. soapberry	10–85	6–86	57	17								67	70		47		71		69

[1]Number of days after sowing that cumulative emergence data are presented.

(Table 3). Soaking 9-month-old tepeguaje *(Luecaena pulverulenta)* seeds in water brought to boiling temperature and cooled for 48 hours, increased emergence from 5% for the control to 28%. In a subsequent experiment, soaking 3-month-old seeds in acid for 10 minutes increased emergence from 33% for the control to 82%. This treatment produced better results than boiling water or 2 minutes in acid ($P\leq0.01$) (Tables 3, 4). In a later experiment with 11-month-old seeds, best results were with acid treatment for 15 minutes (Table 4).

Caesalpinaceae

Emergence of retama seedlings was higher ($P\leq0.05$) with acid treatment of 45 minutes (51% instead of 8% for the control) (Tables 3 and 4).

Fabaceae

Acid scarification did not significantly ($P\leq0.05$) increase emergence of seeds tested of this legume family. Emergence from untreated seed was 25% for Texas baby-bonnets *(Coursetia axilla-*

Table 5. Effect of seed-ripeness and acid treatment on Texas ebony emergence.

Seed age	Pod color	Treatment	Mean emergence[1]
			%
10 months	Brown	Acid 30 min	88
10 months	Brown	No treatment	64
<1 month	Green	No treatment	48
<1 month	Green	Acid 30 min	35

[1]Treatment means were all significantly different ($P<0.05$) from other treatment means.

ris), 12% for rattlebush, and 50% for coral bean *(Erythrina herbacea)* (Table 3).

Zygophyllaceae

Soaking 10-month-old seeds of guayacan in distilled water for 3.5 hours produced twice the number of seedlings compared to untreated seeds. Emergence was low (6 to 12%). Emergence was 34% with 250 untreated 2-month-old seed planted in September 1986.

Sapindaceae

Acid scarification for 45 minutes or more significantly ($P\leq0.05$) increased emergence of western soapberry (Table 4). Highest emergence (71%) was with acid scarification for 120 minutes. Cold stratification for 90 days (Munson 1984) did not increase emergence (e.g., 60 minutes acid—70%, with pre-stratification—57%).

Rhamanaceae

Mean emergence was 95% in 3 trials with fresh, depulped seed of lotebush *(Ziziphus obtusifolia)*. Results were poor (emergence <6%) with 8-month-old seed of brasil.

Oleaceae

Results were also poor (emergence <5%) with 8-month-old seed of elbowbush. Emergence was 1 to 3% better with whole fruit than depulped seeds. A few thousand untreated seeds of elbowbush from the same collection were scattered on a mist table (1/2 peat moss, 1/2 perlite) in late June 1985 (not part of an experiment); hundreds of seedlings emerged in September and October.

Ebenaceae

Emergence obtained with 10-month-old seeds of Texas persimmon that had been scarified with coarse sandpaper for 2 minutes was 77% compared to 55% for the control (Table 3). Emergence was highest (36%) with no treatment in a second experiment 14 months later with seed from the same collection (Table 3). Emergence decreased with increasing length of acid treatment (Table 4).

Boraginaceae

Anacua seeds soaked in 1.4 mMol gibberellic acid had highest emergence (Table 3). Anacahuita seeds that were 11 months of age produced 21 plants from 30 seeds.

Seedling Height Growth

Seedling height growth was variable (Table 6). Seedlings generally required 45 to 150 days to achieve 25 cm height. Some species such as guajillo, tenaza, and rattlebush had fast initial growth. Rattlebush continued with rapid growth, reaching 25 cm in 45 days, and eventually 2.5 m. Other species, such as tepeguaje, increased growth dramatically once daytime temperatures stayed above 30° C (photoperiod also increased). Other plants, such as Texas baby-bonnets, guayacan, and Texas persimmon grew slowly. Height growth measurements indicated that most seeds need to be sown in the greenhouse at least 90 days, and in some cases 150 days, before field planting.

Table 6. Time (days) till mean seedling height of 5, 10 and 25 cm[1] for 16 species (— indicates not measured).

Species	Date planted	Height (cm) 5	10	25
		days		
Blackbrush	Jun 85	40	50	110
Coral bean	Jun 85	—	18	73
Granjeno	Aug 86	—	—	70
Guajillo	Jun 85	8	18	90
Guayacan	May 85	70	—	—
Huisache	May 86	—	—	52
Huisachillo	Jul 86	—	—	80
Rattlebush	Jun 85	—	20	45
Sugarberry	Jun 85	27	—	70[2]
Tenaza	Jun 85	15	50	90
Tepeguaje	Mar 85	45	60	80
T. baby bonnets	Jun 85	25	40	150
Texas ebony	Aug 85	—	—	90
T. persimmon	Mar 85	80	100	150
W. soapberry	Jun 86	—	—	80
Wright's acacia	Mar 85	18	40	70

[1]Estimated by interpolation because seedling heights were not measured daily.
[2]Seeds sown in August 1986 produced plants with mean height of 40 cm in 77 days.

Discussion

No treatment seemed necessary for fresh seeds of sugarberry (depulped), granjeno (whole fruit), lotebush (depulped), pigeonberry (whole fruit), or 10-month-old coral bean seeds. The first 4 drupe-producing species are thought to be some of the most important wildlife food plants. Results with depulped granjeno seeds (33% emergence) were similar to those obtained by Fulbright et al. (1986b). Retaining the pulp when planting fresh granjeno seeds appears to be beneficial, and the complex set of pre-sowing treatments recommended by Fulbright et al. (1986b) unnecessary.

Leguminous species, especially of the family Mimosaceae, required scarification for high emergence rates. These included Texas ebony, tenaza, huisache, huisachillo, Wright's acacia, tepeguaje, and retama. Hard seed coats seem to be the major impediment to rapid germination. I obtained higher emergence with soaking seeds in acid for longer periods than recommended previously for 3 of these species. Alaniz and Everitt (1978) obtained maximum germination (80%) for Texas ebony after soaking seeds in acid for 30 to 45 minutes. Emergence increased up to 78% after 90 minutes soaking in my experiment, the longest period I tried with that species (Table 4). Similarly, with huisache Scifres (1974) obtained highest germination after 45 to 60 minutes of acid soaking, and with huisachillo Everitt (1983b) had best results after 45 minutes of this treatment, while emergence continued to increase up to 120 minutes in my experiments with these species, the longest period evaluated (Table 4). Results with retama were similar to those of Everitt (1983b).

Nokes (1986) suggested that early harvest of seeds that were mature, but had not completely hardened their seed coats, might be a way of avoiding scarification treatment. This was not advantageous with Texas ebony because emergence was higher with 10-month-old acid-scarified seeds (Table 5). Nokes also noted that immature seeds often produced weak and spindly seedlings or failed to germinate altogether.

Results of seed scarification and soaking in water were mixed with other legumes. Age of the seed (10 months) may have been a reason for low emergence of blackbrush and rattlebush in my experiments. I did not obtain significantly higher emergence of blackbrush with 15 minutes of acid treatment as Everitt (1983a) had with fresh seed of that species. Acid treatment for 2 minutes did not improve emergence of rattlebush (Table 4), but a much lengthier soak of 4 hours recommended by Easton (1984) was not evaluated. Results with fresh guajillo seeds were similar to those of Everitt (1983a) (no treatment was necessary), but acid treatment for 1 minute increased emergence ($P \leq 0.05$) of 5-month-old seed. This suggested that the seed coat of guajillo might harden with time. Emergence of Texas baby bonnets was low (25%) and further experimentation is needed with that species, especially since it is considered a rare plant (Lonard et al. 1989).

Everitt (1984) stated that fresh seeds of Texas persimmon germinated well without treatment, and viability was not reduced after storage under room conditions for 2 years. Mild scarification and soaking in distilled water had positive effects on emergence of 8-month-old seeds, and no treatment was necessary with 23-month-old seeds (Tables 3 and 4). Emergence of untreated seeds dropped by 35% over that period suggesting loss of viability.

Low emergence was obtained for cedar elm, guayacan, anacua, brasil, and elbowbush, and further experimentation is needed with these species. Emergence results with guayacan and anacua were much lower than that obtained in some laboratory germination tests (Alaniz and Everitt 1980, Everitt 1983a). Fulbright et al. (1986a) did not obtain superior germination of anacua seeds with acid scarification as did Alaniz and Everitt (1980), and plant growers have reported mixed results (pers. commun.). Anacua, brasil, and elbowbush seem to have complex dormancy mechanisms that need to be identified. Cedar elm seeds appear to have very low viability, and time of collection and sowing are probably important.

Many growers have reported trouble growing anacahuita (pers. commun.). My results with depulped 11-month old seed were good (70%), although the sample size of 30 was small. Anacahuita seeds might have immature embryos when the fruits first drop and may require a long period of after-ripening before germination can occur.

Several species, such as lotebush, might germinate readily at seed drop, but if stored or if conditions are otherwise unfavorable, may undergo dormancy for an extended period. Other researchers (J. Everitt, pers. commun.) have had low success growing lotebush from stored seed. Seed viability may also differ considerably from plant to plant with some of these species.

The salinity of the water in the greenhouse was a concern because salts can stunt seedling growth (Everitt et al. 1977, Salisbury and Ross 1985). Laboratory experiments, however, indicate many plants of the Lower Rio Grande Valley have high tolerances of salts before germination is reduced significantly, varying from 2,000 mg/l for guajillo to more than 10,000 mg/l for blackbrush (Everitt 1983a). Salts might accumulate to toxic levels if plants are stored in the greenhouse for long periods without flushing by rain.

In general, highest emergence was achieved with fresh, mature seeds. With 8- to 10-month-old seeds, 50% and better emergence was obtained with Texas ebony, huisache, huisachillo, tepeguaje, coral bean, western soapberry, Texas persimmon, and anacahuita. Storage techniques must be developed for other species if seeds are to be collected in the summer and not planted in fields until fall and winter during cooler and wetter conditions.

Literature Cited

Alaniz, M.A., and J.H. Everitt. 1978. Germination of Texas ebony seeds. J. Rio Grande Valley Hortic. Soc. 32:95-100.

Alaniz, M.A., and J.H. Everitt. 1980. Germination of anacua seeds. J. Rio Grande Valley Hortic. Soc. 34:75-80.

Bonner, F.T. 1974. *Celtis* L. Hackberry. p. 411-416. *In:* Seeds of woody plants in the United States. USDA Agr. Handb. No. 450. Washington, D.C.

Bonner, F.T. 1984. Germination test for sugarberry *(Celtis laevigata* Willd.). Newsletter Assoc. Official Seed Analysts 58:24-26.

Easton, E.F. 1984. Drummond rattlebox *(Sesbania drummondii)* germination as influencd by scarification, temperature, and seeding depth. Weed Sci. 32:223-225.

Everitt, J.H. 1983a. Seed germination characteristics of 3 woody plant species from south Texas. J. Range Manage. 36:246-249.

Everitt, J.H. 1983b. Seed germination characteristics of 2 woody legumes (retama and twisted acacia) from south Texas. J. Range Manage. 36:411-414.

Everitt, J.H. 1984. Germination of Texas persimmon seed. J. Range Manage. 36:411-414.

Everitt, J.H., A.H. Gerbermann, and J.A. Cuellar. 1977. Distinguishing saline from non-saline rangelands with skylab imagery. Photogrammetric Engineering and Remote Sensing 43:1041-1047.

Fulbright, T.E., K.S. Flenniken, and G.L. Waggerman. 1986a. Methods of enhancing germination of anacua seeds. J. Range Manage. 39:450-453.

Fulbright, T.E., K.S Flenniken, and G.L. Waggerman. 1986b. Enhancing germination by spiny hackberry seeds. J. Range Manage. 39:552-554.

Kirk, R.E. 1982. Experimental design: Procedures for the behavioral sciences. 2 ed. Brooks/Cole Publ. Co.

Lonard, R.I., J.H. Everitt, and F.W. Judd. 1989. Woody Plants of the Lower Rio Grande Valley, Texas. N.A. Browne, illustrator. Texas Memorial Museum Press, Austin, Tex. (In press).

Martin, R.E., R.L. Miller, and C.T. Cushwa. 1975. Germination respondes of legume seeds subjected to moist and dry heat. Ecology 56:1441-1445.

Munson, R.H. 1984. Germination of western soapberry as affected by scarification and stratification. HortScience 19:712-713.

Nokes, J. 1986. How to grow native plants of Texas and the Southwest. Texas Monthly Press, Austin, Texas.

Petersen, R.G. 1977. Use and misuse of multiple comparison procedures. Agron. J. 69:205-208.

Plowman, R.D., and R.H. Munson. 1983. Seed dormancy in Texas persimmon (*Diospyros texana* Scheele). Plant Propagator 29:14-15.

Salisbury, F.B., and C.W. Ross. 1985. Plant physiology. 3rd edition. Wadsworth Publ. Co., Inc., Belmont, Calif.

Scifres, C.J. 1974. Salient aspects of huisache seed germination. Southwest. Natur. 18:383-392.

U.S. Fish and Wildlife Service. 1983. Land protection plan: Lower Rio Grande Valley National Wildlife Refuge. U.S. Fish & Wildlife Serv., Albuquerque, N. Mex.