Emergence and Survival of Honey Mesquite Seedlings on Several Soils in West Texas

DARRELL N. UECKERT, LYNNE L. SMITH, AND B.L. ALLEN

Abstract

Results from field and laboratory studies indicated that germination and emergence was adequate on soils that supported heavy densities, low densities, or no mesquite for establishment of dense populations of honey mesquite. Absence of honey mesquite or low densities of this species on soils where seeds are readily deposited by natural mechanisms could not be explained by soil chemical or physical properties that might inhibit seed germination or emergence of seedlings. In field studies, seedling emergence was not related to the density of honey mesquite presently growing on six range sites. At the end of the first growing season and at 1 year after planting, seedling survival was inversely related to density of honey mesquite. Two years after planting, seedling survival was not related to density of mesquite supported by the six soils. In this short-term study, competition with associated herbaceous vegetation overshadowed the effects of soil properties on survival of honey mesquite seedlings.

Honey mesquite (*Prosopis glandulosa* Torr. var. *glandulosa*) increases in abundance and invades certain range sites by means of seeds, which are transported by herbivores, wind, and water (Scifres and Brock 1970b). It is common, however, to see different soils within a pasture and under similar management supporting varying densities or no honey mesquite. The interactions of soil and other environmental factors on germination, emergence, and seedling establishment of honey mesquite are not well defined. An understanding of the factors which regulate infestation and reinfestation of rangeland by honey mesquite is needed by range managers for efficient management of this resource, and for wise planning of mesquite-control programs. This study was initiated to compare honey mesquite emergence and seedling establishment on several soils which support varying densities of this plant, and to attempt to determine if certain soil factors are inhibitory to emergence or survival of this plant.

Box (1961) reported that in the Texas Coastal Plains dense stands of running mesquite were usually associated with extremely fine-textured soils with slow permeability, poor drainage, and poorly aerated profiles (low porosity). He found that mesquite canopy cover was greatest on soils high in clay content, while mesquite density was greatest on clay loam sites. In a mesquite-buffalograss community, Box reported positive correlations of mesquite cover with litter and with soluble salts at 46 to 61 cm, and negative correlations with soil organic matter at 91 to 107 cm and with potassium at 91 to 107 cm. Mesquite cover in a chaparral-bristlegrass community was positively correlated with chlorides at 0 to 15 cm and with potassium at 46 to 61 cm. In a pricklypear-shortgrass community mesquite cover was positively correlated with phosphorus at 91 to 107 cm, and negatively correlated with soil organic matter at 46 to 61 cm.

Thomas and Young (1954) reported that in the western Edwards Plateau of Texas mesquite was more abundant on Tobosa clay soils than on four other associated soil series in their study area. The Tobosa soils occurred between the high swells and ridges (Ozona and Valera soils) and dry lake beds (Irion and Randall soils) and were moderately deep and clayey with heavier subsoils and less permeability than was found on the swells and ridges. Drainage on the Tobosa soils was slow, but water rarely stood on these soils after rains.

Welch (1968) reported that soil texture was the primary factor affecting mesquite distribution. He reported that mesquite seedlings could withstand soil moisture extremes and could survive severe drought if available moisture was reduced slowly.

Hudnall (1971) reported that whole soil soluble sodium was negatively correlated with honey mesquite canopy cover on moderately deep to deep calcareous soils on the High Plains of West Texas, while soil structure was positively correlated. He also found that $CaCO_3$ content in the A horizon and whole soil soluble Ca were significant in explaining variation in canopy cover of mesquite. For nonsaline soils, Hudnall reported that % clay in the A horizon, soluble Ca in the A horizon, and whole soil 15-bar moisture percentage explained most of the variation in honey mesquite canopy cover. Hudnall reported that honey mesquite density increased as soil maturity (judged by structural development, redistribution of $CaCO_3$, and horizonation) increased. He found high densities of mesquite on medium textured soils, while soils with low densities of mesquite or without mesquite tended to have extremes of sand or clay.

Methods

There were two aspects of this study: a laboratory study of seedling emergence and a related study of seedling emergence and survival in

Authors are associate professor and graduate research assistant, Range and Wildlife Management Department; and professor, Plant Soil Sciences Department, Texas Tech University, Lubbock 79409. Ueckert's present address is Texas A&M University Agricultural Research and Extension Center, Route 1, Box 905, San Angelo 76901.

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the field. Three locations studied by Hudnall (1971) were used in this study: (i) the Morgan Ranch, Andrews County, Texas; (ii) the Post-Montgomery Estate, Lynn County, Texas; and (iii) the 2S Ranch, Lynn County, Texas. These ranches were selected for study because different soil types within close proximity supported either low or high densities of honey mesquite or were void of honey mesquite plants. Soils from all three locations were used in the laboratory study. The two locations in Lynn County were used for the field study.

Laboratory Study

The objective of the laboratory study was to determine the ability of mesquite to germinate and emerge under optimum conditions in soils supporting high densities, low densities, or no mesquite in the field. Soil samples were taken from the upper 30-cm increment, which was within the upper two horizons at all sites. At each of the three locations there were three levels of mesquite density: high density, low density, and no mesquite. Three bulk samples of soil from each honey mesquite density level were collected, thoroughly mixed, and used in the laboratory study. Soil types sampled within each location are shown in Table 1.

Table 1. Properties of selected soils of West Texas (weighted for the upper 30-cm increment) that were highly correlated with emergence of honey mesquite seedlings (from Hudnall 1971).

Ranch and soil type	Mesquite density	pH	Soluble Mg^{++}	% silt	Estimated structure grade
Morgan Ranch					
Ratliff loamy fine sand	none	7.9	3.2	4.1	1.21
Portales fine sandy loam	low	7.8	1.8	10.3	2.33
Blakeney fine sandy loam	high	7.9	0.7	11.2	2.33
Post-Montgomery Ranch					
Arch clay loam	none	8.0	3.3	22.6	1.29
Veal fine sandy loam	low	7.9	0.8	10.5	1.00
Portales fine sandy loam	high	7.4	1.5	17.9	2.17
2S Ranch					
Drake sandy clay	none	7.7	11.2	9.2	1.50
Veal fine sandy loam	low	8.0	2.5	10.2	1.25
Portales clay loam	high	7.9	3.6	28.6	4.00

In the laboratory, 819 mesquite seeds that had been mechanically threshed and scarified (Flynt and Morton 1969) were planted at a depth of 1.5 cm in the mixed soil samples from each mesquite density site. The germination and emergence trial was conducted under growth lights with a 12-hr photoperiod at a mean temperature of 30.5°C (87°F). Soil water content was maintained near field capacity and the seedlings were counted 7 days after the planting date for calculating emergence percentages. Differences between mesquite density sites within a location for total numbers of seedlings emerging were determined by Chi-square analyses. Variation in emergence within the soil was not evaluated. We selected soil properties (weighted for the upper 30 cm) (independent variables) for these nine soils (from Hudnall 1971) that we felt could affect germination and emergence (dependent variable). The independent variables included: ph, % $CaCO_3$,% gypsum, % saturation, electrical conductivity mmhos/-cm), soluble Ca^{++} (meq/l), soluble Mg^{++} (meq/l), soluble K^+ (meq/l), soluble Na^+ (meq/l), % sand, % silt, % clay, % available water at ⅓ Bar, % available water at 15 Bar, inches of available water, total stress at ⅓ Bar, total stress at 15 Bar, and estimated structure grade. Hudnall (1971) has discussed the general plant relationships for each of these variables. The data were analyzed by linear stepwise multiple regression (Snedecor and Cochran 1967) to determine the relationship of emergence of honey mesquite seedlings with these soil properties. Only those soil properties that were highly correlated with honey mesquite emergence, and which were linearly independent, including pH, soluble Mg^+, % silt, and estimated structure grade (all weighted for the upper 30 cm), were used in the final analysis (Table 1).

Field Study

The field study was conducted at the 2S and the Post-Montgomery Ranches, in Lynn County, Texas. The objectives of the field study were to compare emergence in the field with that in the laboratory and to compare seedling survival of honey mesquite in soils supporting various densities of mesquite, in the presence of competition from existing vegetation. On April 13 and 14, 1972, 36 mechanically shelled and scarified mesquite seeds were planted 15-cm apart and 1.5-cm deep in each of 14 rows on 30-cm spacings within each of the three mesquite density sites (500 seeds per site) at the two locations. The native vegetation was not disturbed. The planted areas were fenced with 4-cm mesh wire and barbed wire to minimize damage to seedlings by livestock, rodents, and lagomorphs.

Seedlings were counted on May 18 and emergence percentages were calculated. On August 2, 1972, May 21, 1973, and May 14, 1974, the live seedlings were counted on each site and percent survival was recorded.

Differences between mesquite density sites within each location for total numbers of seedlings emerging and for total numbers of live seedlings on each date were determined by Chi-square analyses. Variation in seedling emergence and survival within mesquite density sites was not evaluated.

Results and Discussion

Laboratory Study

Emergence of honey mesquite seedlings was significantly higher in soils that supported either no mesquite or low densities of mesquite than in soils that supported a high density of mesquite (Table 2). Differences in emergence between soils supporting various densities of mesquite, although statistically significant ($P<0.05$), were very small and are not believed to be of biological or ecological importance. However, these data indicate that soil physical or chemical properties that inhibit germination or emergence of honey mesquite were not present in any of the nine soils studied. In years of sufficient precipitation, germination and emergence should be adequate on all of the sites studied to permit the establishment of honey mesquite.

Table 2. Percent emergence of honey mesquite in laboratory trials in soils supporting three densities of mesquite at three locations in West Texas.

Location	Soil type	Mesquite density	Percent emergence
Morgan Ranch	Ratliff loamy fine sand	none	86.4 a[1]
	Portales fine sandy loam	low	82.8 b
	Blakeney fine sandy loam	high	80.6 b
Post-Montgomery Ranch	Arch clay loam	none	80.0 ab
	Veal fine sandy loam	low	82.2 a
	Portales fine sandy loam	high	77.9 b
2S Ranch	Drake sandy clay	none	86.3 a
	Veal fine sandy loam	low	86.1 a
	Portales clay loam	high	82.2 b

[1] Values for each location followed by similar letters are not significantly different at the 5% significance level.

Stepwise multiple regression indicated that mesquite seedling emergence increased as pH and concentration of soluble Mg^{+} increased, and decreased as the proportion of silt in these nine soils increased. However, the equation[1] was not considered to be of value because of the narrow range in emergence percentages attained (Table 2) under the optimum conditions utilized in the laboratory study.

Field Study

In the field study, emergence and seedling survival varied between sites within both locations. At the Post-Montgomery Ranch, emergence was the greatest (47%) on the Portales fine sandy loam which supported a high density of mesquite, and lowest (17.4%) on the Veal fine sandy loam, which supported a low density (Table 3). The Arch clay loam, which was void of mesquite, supported an intermediate level of emergence (40.6%). At the 2S Ranch, seedling emergence was highest (45.2%) on the Drake sandy clay, which was void of mesquite, and lowest (34.2%) on the Veal fine sandy loam, which supported a low density of mesquite. Emergence was intermediate (38.8%) on the Portales clay loam, which supported a high density of mesquite (Table 3). These results did not show the same trends for emergence as were seen in the laboratory study (Table 2).

Precipitation and temperatures were adequate at both field locations for germination of honey mesquite seeds during the spring of 1972. Sites within each location were in close proximity (within 0.8-km radius), thus precipitation did not vary significantly between sites. The two ranches were also in close proximity (within 19-km radius), thus temperatures were similar between locations. Scifres and Brock (1970a) have demonstrated that honey mesquite seeds germinate most favorably at 29.5°C and reported that soil temperatures usually reach 25.6°C to 26.7°C in the upper 10 cm (4 in) around April 5 to 24 on the High Plains of Texas. Thus the requisites for honey mesquite germination would be met when spring rains occur during this period. Our field data substantiate the results from the laboratory study, that soil physical or chemical properties that inhibit germination or emergence of honey mesquite were not present in the soils studied. Emergence was adequate on all six sites for establishment of dense populations of honey mesquite. Under field conditions, the level of honey mesquite seedling emergence was not related to the density of mesquite presently supported on these six soils. Variation in percent emergence of honey mesquite seedlings between sites was not related to cover of existing vegetation, thus it is not felt that an interaction of plant cover with soil temperatures affected germination or subsequent emergence, although data on soil temperatures were not taken.

Drought conditions prevailed during most of the growing seasons of 1972, 1973, and 1974; thus conditions for mesquite seedling establishment and survival were sub-optimal at the six sites studied. These conditions provided an excellent opportunity to study the survival of honey mesquite seedlings during drought conditions. At the end of the 1972 growing season (4 months post-planting) and at the beginning of the 1973 growing season (13 months post-planting), seedling survival followed a similar trend at both locations, with survival being highest on the sites void of mesquite, intermediate on sites supporting low densities of mesquite, and lowest on sites supporting high densities of mesquite (Table 3).

[1] The regression equation, $Y = 26.40 + 7.35 X_1 + 0.52 X_2 - 0.21 X_3$, where X_1 = pH; X_2 = soluble Mg^{++}; and X_3 = % silt (all weighted for the upper 30 cm), accounted for 77% of the variation ($R = 0.88$) ($P<0.05$) in emergence of honey mesquite seedlings.

Table 3. Percent emergence and percent survival of honey mesquite seedlings in field studies on six mesquite density sites at two locations in Lynn County, Texas.

Location	Mesquite density	Percent emergence	Percent seedling survival[2] Aug., 1972	May, 1973	May 1974
Post-Montgomery Ranch	none	40.6a[1]	37 a	24 a	5 a
	low	17.4 b	29 ab	20 ab	17 b
	high	47.0 c	24 b	14 b	5 a
2S Ranch	none	45.2 a	48 a	13 a	4 a
	low	34.2 b	26 b	4 b	2 ab
	high	38.8 b	3 c	0 c	0 b

[1] Values within a column for each location followed by similar letters are not significantly different at the 5% significance level.
[2] Based on number of seedlings that emerged.

Only 3% of the mesquite seedlings survived their first summer on the Portales clay loam soil (supporting a high density of honey mesquite) at the 2S Ranch, and all of the seedlings had died on this site by the beginning of the 1973 growing season (Table 3). At 13 months post-planting, seedling survival was still significantly higher on the 2S Ranch site void of mesquite as compared to the site supporting a low density of mesquite. At 25 months post-planting the trend was similar, but the difference was not significant. This trend held for the three sites at the Post-Montgomery Ranch at 13 months post-planting, but at 25 months post-planting survival was significantly higher on the low-density mesquite site than on the other two sites. Seedling survival was equal on the Post-Montgomery Ranch site void of mesquite and that supporting a high density of mesquite at 25 months post-planting (Table 3).

We believe that the effect of existing herbaceous vegetation on the sites studied overshadowed the effects of soil properties on survival of honey mesquite seedlings during this field study; thus regression analyses to relate emergence and survival in the field with soil properties were not conducted. The site supporting a high density of mesquite at the 2S Ranch was also supporting a dense stand of tobosagrass (*Hilaria mutica*) (Table 4). We believe that the high mortality of young mesquite seedlings on this site resulted from competition with this very drought-tolerant mid-grass. Similarly, the low survival of seedlings on the site supporting high densities of mesquite on

Table 4. Cover ratings for major plants on six sites in Lynn County, Texas (from Hudnall 1971).

Plants	Honey Mesquite Density: Post Montgomery Ranch none	low	high	2S Ranch none	low	high
Aristida spp.	1[1]	3				
Bothriochloa saccaroides	1					
Bouteloua curtipendula	1	2				
Bouteloua eriopoda		2				
Bouteloua gracilis	5	2	3		3	1
Buchloe dactyloides	2	3	3	2		1
Distichlis stricta	1					
Hilaria mutica						6
Panicum obtusum	1					
Schedonnardus paniculatus				3		
Sporobolus airoides				6	1	1
Tridens pilosus	1					
Condalia obtusifolia						1
Yucca glauca		3				
Croton pottsii	1					
Atriplex canescens						1

[1] 1 = 1–5%; 2 = 6–10%; 3= 11–20; 4 = 21–30%; 5 = 31–50%; 6 = 51–75%

the Post-Montgomery Ranch was possibly due to competition for soil moisture from the dense stand of buffalograss (*Buchloe dactyloides*) and blue grama (*Bouteloua gracilis*) (Table 4). Scifres and Brock (1970b) reported that honey mesquite seedling survival was greater in tobosagrass rangeland than in buffalograss rangeland at 2 months post-planting on experimental plots near Spur, Texas. Differences in precipitation between years could possibly account for this discrepancy between the two studies.

Periodic short-term and long-term droughts are common in this region of the southern Great Plains. Honey mesquite seed undoubtedly germinate readily and emerge in most soils of this region when spring rains occur. We feel that competition from exisiting herbaceous vegetation plays a major role in limiting the establishment of honey mesquite seedlings during short-term drought. However, during long-term droughts when density and vigor of herbaceous vegetation are severely reduced, mesquite seedlings may readily become established on many soils in the absence of competing vegetation. The subsequent survival of these seedlings is determined by the availability of soil water, which is a function of numerous soil properties, as well as competition from associated vegetation. Native rodents, insects, and low winter temperatures are also important factors influencing survival of mesquite seedlings (Paulsen 1950).

Conclusions

Germination and emergence of honey mesquite seedlings is probably adequate on most rangeland soils in the southern High Plains of Texas, where a seed source is present, in years of adequate spring and summer rainfall, to permit the establishment of dense populations of this plant. However, soil factors, such as available water, and ecological factors, such as competition, probably result in moisture stress and subsequent seedling mortality on many soils, which may explain why some range sites have no mesquite or low densities of mesquite.

Competition with existing herbaceous vegetation may overshadow the effects of soil properties on seedling survival during some years. Thus, during short-term droughts a good stand of grass seems to play a major role in limiting the establishment of honey mesquite seedlings.

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