Effects of Temperature, Light, and Scarification on Germination of Brownseed Paspalum Seeds

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Abstract

Brownseed paspalum (Paspalum plicatulum Michx.) is an important forage grass in tropical and subtropical regions. This study investigated effects of temperature, light, and scarification on germination of seeds from Texas, Australia, South America, and Africa. Seed sources included PI-353399 (Ivory Coast), 'Bryan' (Australia), Paspalum plicatulum 600 (Columbia), and collections from De Witt and Hidalgo Counties, Texas. Untreated seeds and seeds scarified in 17 M sulfuric acid for 20 minutes were germinated under light (12 hours daily) and dark conditions at alternating temperatures of 5-15 (12 hours-12 hours), 10-20, 15-25, 20-30, 25-35, and 30-40° C for 28 days. Seeds from all sources showed similar responses to temperature for percent germination and corrected germination rate index (CGRI). Highest percent germination of Hildalgo seeds occurred at 20-30 and 25-35° C, while that of other sources occurred at 25-35 and 30-40° C. Maximum CGRI for most sources was at 30-40° C. Percent germination was generally higher in light than dark. Scarification increased percent germination and CGRI of De Witt. Hidalgo. PI-353399, and Bryan seeds. Our data indicate that brownseed paspalum seeds are adapted for warm-season germination.

Key Words: Paspalum plicatulum, corrected germination rate index, forage grasses, seed dormancy, tropical ecosystems

Brownseed paspalum (*Paspalum plicatulum* Michx.) is a native, warm-season, perennial bunchgrass found from North Carolina along the Gulf Coast to east Texas, and south to Argentina. The grass grows on poorly drained clay loam soils and on deep sandy soils (Leithead et al. 1971). In Texas, it provides fair grazing for livestock (Gould and Box 1965, Gould 1978). Cattle readily eat brownseed paspalum foliage after frost in the southern United States and it is one of the more palatable grasses in Florida (Grelen

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and Hughes 1984). Seeds of the grass are eaten by quail and wild ducks (Leithead et al. 1971). Two cultivars, Bryan (introduced from Puerto Rico) and Rodd's Bay (introduced from Guatemala), are grown for forage in Australia (Bisset 1975).

Requirements for germination of brownseed paspalum seeds are poorly documented. The objectives of this study were to investigate the effects of 6 alternating temperature regimes on germination of scarified and untreated seeds from Texas, Australia, South America, and Africa in the light and dark.

Materials and Methods

Brownseed paspalum seeds were collected by hand from native stands in De Witt and Hidalgo counties, Texas, in 1982. The Australian cultivar 'Bryan' (harvested in 1983) was obtained from a commercial source in Queensland, Australia; and *Paspalum plicatulum* 600 (PP600) seeds were obtained from Centro Internacional de Agricultura Tropical, Cali, Columbia (harvested in 1981). Accession PI-353399, originally harvested in Ivory Coast, was obtained from the USDA Plant Materials Center, Kingsville, Texas. Accession PI-353399 seeds used in the study were harvested in 1983 from a stand at Kingsville. The study was conducted in 1983.

Seeds were evenly distributed on blotter paper underlain by a layer of creped cellulose and placed in plastic boxes measuring 13.0 by 13.5 by 3.5 cm with tightly fitting lids (Fulbright et al. 1983). Seeds were treated with thiram [bis(dimethylthiocarbamoyl) disulfide] to minimize fungal growth. The substrata were moistened with 100 ml tap water (electrical conductivity 1.6 dS m⁻¹, ph 7.9) and remoistened when necessary. Four plastic boxes of 100 seeds per treatment were placed in a randomized, complete-block design within controlled environment chambers and each experiment was conducted twice.

Effects of temperature, light, and scarification on germination were determined by germinating scarified and untreated seeds under light and dark conditions at alternating temperatures of 5-15, 10-20, 15-25, 20-30, 25-35, and 30-40° C (12 hours dark-12

hours light). Seeds were scarified by soaking in 17 M sulfuric acid (H_2SO_4) for 20 minutes at 30° C. In pilot experiments, a 20-minute soak in H_2SO_4 increased germination of the De Witt County source. Following scarification, seeds were rinsed for 5 minutes in tap water and spread on paper towels to air dry for 24 hours at room temperature (Bonner et al. 1974). In the light treatment, cool-white fluorescent lights with an average photosynthetic photon flux density (PPFD) of $24 \,\mu$ mol m⁻²s⁻¹ were provided for 12 hours daily at the warmer temperature. Dark conditions were maintained by wrapping plastic boxes in 3 layers of aluminum foil. A green light (PPFD 2 to 3 μ mol m⁻²s⁻¹, wavelength 500 nm) was used for counts.

Germinated seeds were counted daily for 28 days. Seeds were considered germinated when the coleoptile and radicle extended one-half the length of the seed. Percent germination was calculated on the basis of the percent live seed in each source:

% germination adjusted	=	$_{}$ % germination $ imes$ 100
for live seed		% live seed

Percent live seed in each source was determined by soaking seeds in a 0.1% 2,3,5-triphenyl tetrazolium chloride solution at 30° C for 3 hours (Grabe 1970). Germination rate index (GRI) was calculated as the summation of germination percentage for each day divided by the total number of days for germination (Maguire 1962). Corrected germination rate index (CGRI) was obtained by dividing GRI by the percent germination (adjusted for live seed) and multiplying by 100 (Evetts and Burnside 1972).

Response curve analysis was used to determine the relationship between temperature and germination for each source (Snedecor and Cochran 1967). Analysis of variance was used to determine if significant differences existed between light means and scarification means for each temperature and source. Differences discussed

Table 1. Response curve relationships for percent germination (adjusted for live seed) and 6 alternating temperatures for 5 sources of brownseed paspalum.

	Treatment							
	Li	ght	Dark					
Seed source	Untreated	Scarified	Untreated	Scarified				
De Witt Relationship R ²	Quadratic 0.82**	Quadratic 0.86**	Linear 0.57**	Quadratic 0.80**				
Hidalgo Relationship R ²	Quadratic 0.75**	Quadratic 0.97**	Quadratic 0.50**	Quadratic 0.93**				
PI-353399 Relationship R ²	Quadratic 0.67**	Quadratic 0.63**	Linear 0.60**	Linear 0.25**				
Bryan Relationship R ²	Quadratic 0.86**	Quadratic 0.85**	Quadratic 0.84**	Quadratic 0.90**				
PP600 Relationship R ²	Linear 0.78**	Quadratic 0.94**	Quadratic 0.89**	Quadratic				

^{**}Significant at the 0.01 level.

in the following section were significant at the 0.05 level of probability unless otherwise indicated.

Results

Brownseed paspalum seeds from 5 sources showed similar responses to temperature for percent germination and CGRI. Per-

Table 2. Effects of temperature (° C), light (12 hours daily), and scarification on percent germination (adjusted for live seed) of 5 sources of brownseed paspalum seeds.

			Temperature					
Seed source	Seed treatment	5–15	10–20	15-25	20-30	25-35	30–40	
De Witt	Light				-			
	scarified	0_{1}	30(9)	62(6)	67(23)	75(8)	88(10)	
	untreated	0	38(21)	59(16)	77(19)	90(15)	90(16)	
	Dark		, ,				` ,	
	scarified	7(5)	41(11)	67(8)	66(21)	70(5)	74(13)	
	untreated	0	11(10)	27(16)	46(22)	37(7)	58(28)	
Hidalgo	Light		, ,				` ,	
	scarified	0	51(9)	91(6)	103(5)	99(3)	95(9)	
	untreated	0	10(7)	40(12)	65(17)	74(14)	61(24)	
	Dark		• •	` '	` .	, ,	(- 7	
	scarified	1(2)	60(10)	81(11)	93(10)	95(9)	91(4)	
	untreated	0	11(8)	24(13)	40(21)	32(10)	27(14)	
PI-353399	Light		` '	` ,		` '	` '	
	scarified	0	76(8)	96(4)	70(34)2	91(10)	101(1)	
	untreated	0	55(30)	67(29)	72(28)	95(7) [°]	89(10)	
	Dark		` ,	` ,	` ′	` ,		
	scarified	39(42)	82(8)	96(5)	72(33)2	91(10)	99(5)	
	untreated	5(8)	26(15)	43(23)	56(35)	77(12)	71(14)	
Bryan	Light	` ,	` '	` '	, ,	` '	` ,	
	scarified	0	7(8)	57(8)	70(12)	73(11)	70(9)	
	untreated	0	3(2)	46(10)	61(11)	69(14)	72(6)	
	Dark						• •	
	scarified	0	25(7)	48(7)	62(15)	62(6)	68(7)	
	untreated	0	15(13)	31(12)	50(12)	56(7)	59(6)	
PP600	Light		• •	• •			. ,	
	scarified	0	4(4)	28(13)	66(11)	75(14)	74(11)	
	untreated	0	17(7)	72(8)	87(12)	85(7)	92(17)	
	Dark						. ,	
	scarified	0	13(9)	31(17)	57(12)	70(10)	53(14)	
	untreated	0	38(11)	65(17)	77(9)	87(7)	83(14)	

¹Values in parentheses are standard deviations.

²Low values possibly resulted from an error during scarification.

cent germination of untreated seeds, except for PP600, showed a quadratic response to temperature in the light (Tables 1 and 2). Untreated PP600 exhibited a linear response to temperature in the light. In the dark, percent germination of untreated De Witt and PI-353399 increased linearly with increasing temperature, while seeds of the other sources exhibited quadratic responses. Percent germination of scarified seeds of all sources, except PI-353399, increased quadratically with increasing temperature in the light and dark. Scarified PI-353399 seeds showed a linear increase in percent germination with increasing temperature in the dark.

Highest percent germination, except for Hidalgo seeds, occurred at 25-35 and 30-40° C (Table 2). Highest percent germination of seeds from Hidalgo County occurred at 20-30° C and 25-35°. Lowest percent germination of all sources occurred at 5-15° C. The PI-353399 accession was the only source that showed appreciable germination (39%) at 5-15° C and that was with scarified seeds in the dark.

Corrected germination rate index of untreated De Witt and PI-353399 seeds increased quadratically with increasing temperature in the light and dark (Tables 3 and 4). Scarified and untreated Hidalgo seeds exhibited a quadratic response to temperature in the dark for CGRI. Corrected germination rate index increased linearly with increasing temperature for all other sources and treatments. Germination rates were highest at 30-40° C for most sources and treatments.

Percent germination was generally higher in the light than in the dark (Tables 2 and 5). The light × scarification interaction was significant (P<0.05) for percent germination of De Witt at temperatures above 5-15° C, Hidalgo at temperatures above 15-25° C, PI-353399 at all temperatures except 15-25° C, and Bryan at 30-40° C. The interaction resulted because percent germination of untreated seeds was higher in the light than in the dark, but germination of scarified seeds was similar under both conditions.

Table 3. Response curve relationships for corrected germination rate index (CGRI) and 6 alternating temperatures for 5 sources of brownseed paspalum.

	Treatment							
	Lig	ght	Da	ark				
Seed source	Untreated	Scarified	Untreated	Scarified				
De Witt								
Relationship <i>R</i> ²	Quadratic 0.94**	Linear 0.97**	Quadratic 0.96**	Linear 0.96**				
Hidalgo								
Relationship	Linear	Linear	Quadratic	Quadratic				
R²	0.93**	0.97**	0.95**	0.95**				
PI-353399								
Relationship	Quadratic	Linear	Ouadratic	Linear				
R ²	0.89**	0.93**	0.90**	0.92**				
Bryan								
Relationship	Linear	Linear	Linear	Linear				
R ²	0.81**	0.94**	0.77**	0.90**				
PP600								
Relationship	Linear	Linear	Linear	Linear				
R ²	0.99**	0.94**	0.94**	0.95**				

^{**}Significant at the 0.01 level.

Corrected germination rate index of De Witt, Hidalgo, PI-353399, and PP600 was higher in the dark than in the light at most temperatures (Tables 4 and 6). The CGRI of Bryan was similar in the light and dark.

Percent germination of scarified De Witt seeds was higher than

Table 4. Effects of temperature (° C), light (12 hours daily), and scarification on corrected germination rate index (CGRI) of 5 sources of brownseed paspalum.

			Temperature					
Seed source	Seed treatment	5–15	10-20	15–25	20-30	25-35	30–40	
De Witt	Light							
	scarified	0_{1}	5.7(0.5)	9.9(1.2)	17.3(1.4)	23.1(1.1)	25.6(2.9)	
	untreated	0	5.5(0.9)	8.9(0.8)	14.6(1.6)	19.3(0.8)	19.8(3.3)	
	Dark							
	scarified	1.0(1.8)	8.2(0.5)	11.4(0.9)	19.6(1.6)	24.7(1.6)	28.3(2.4)	
	untreated	0 ` ´	7.8(1.1)	10.6(0.7)	16.9(1.3)	22.1(0.8)	22.6(2.1)	
Hidalgo	Light		• • •	` '				
- -	scarified	0	5.9(0.4)	10.8(0.6)	20.7(1.0)	28.2(1.5)	31.0(2.1)	
	untreated	0	5.2(0.6)	6.8(0.4)	13.0(2.0)	16.0(1.8)	17.6(2.1)	
	Dark		` '	` ,	` ,	. ,	, ,	
	scarified	0.4(1.2)	7.7(0.5)	12.5(1.1)	25.5(3.8)	28.4(1.6)	31.4(1.4)	
	untreated	0	5.6(0.9)	9.3(1.3)	15.0(1.0)	17.9(1.4)	20.4(3.6)	
PI-353399	Light	•		, ,	` ,	` ′	` ,	
	scarified	0	7.2(0.6)	15.1(0.7)	25.6(5.4)	31.1(1.2)	37.7(6.8)	
	untreated	Ö	6.4(0.7)	11.0(1.6)	16.5(4.1)	20.8(3.3)	19.8(3.3)	
	Dark	•	***************************************	,	` ,	` ,	` /	
	scarified	2.0(2.1)	10.2(0.5)	17.8(1.6)	26.3(5.7)	31.7(1.3)	38.9(7.3)	
	untreated	1.9(2.0)	8.7(1.0)	12.3(1.5)	18.1(3.4)	22.7(2.3)	23.7(3.8)	
Bryan	Light	()		` ,	` ,	` ´	` '	
•	scarified	0	3.1(2.0)	6.4(1.0)	13.2(1.0)	16.6(1.5)	20.5(3.5)	
	untreated	0	4.3(2.0)	5.4(0.5)	8.6(2.4)	12.2(2.5)	13.5(3.9)	
	Dark		` '	` ,	, ,		. ,	
	scarified	0	4.4(0.6)	6.5(0.9)	13.3(1.8)	16.5(1.8)	20.8(5.2)	
	untreated	0	4.3(1.3)	5.5(1.0)	8.4(3.2)	12.2(3.2)	12.4(3.1)	
PP600	Light	•		,	` ′	` ,	` ,	
	scarified	0	2.7(1.7)	5.6(0.5)	11.0(1.5)	13.8(0.8)	15.4(1.4)	
	untreated	0	3.6(0.4)	6.6(0.5)	12.6(0.7)	17.3(0.6)	20.4(0.6)	
	Dark		` ,	` ,			, ,	
	scarified	0	3.4(0.4)	6.0(1.3)	11.5(1.6)	14.9(0.8)	16.3(1.8)	
	untreated	Ö	4.4(0.3)	8.1(3.7)	14.0(1.1)	18.1(1.0)	20.7(2.4)	

¹Values in parentheses are standard deviations.

Table 5. P-values for the analyses of variance of the effects of light and scarification with concentrated H₂SO₄ on percent germination (adjusted for live seeds) of 5 sources of brownseed paspalum at 6 alternating (12 hours-12 hours) temperatures (° C). Separate analyses were done for each temperature and source combination.

Seed source and	Temperature						
treatment	5–15	10-20	15-25	20-30	25-35	30-40	
De Witt							
Light (L)	0.26	< 0.01	0.06	< 0.01	< 0.01	< 0.01	
Scarification (S)	0.26	0.03	< 0.01	0.11	0.05	0.24	
LXS	0.26	< 0.01	0.01	< 0.01	<0.01	0.02	
Hidalgo							
Light (L)	0.35	0.03	0.05	< 0.01	<0.01	< 0.01	
Scarification (S)	0.35	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
LXS	0.35	0.22	0.37	0.01	< 0.01	<0.01	
PI-353399							
Light (L)	0.03	< 0.01	0.24	< 0.01	< 0.01	< 0.01	
Scarification (S)	0.03	< 0.01	< 0.01	0.02	0.41	< 0.01	
LXS	0.04	< 0.01	0.24	0.03	< 0.01	<0.01	
Bryan							
Light (L)	•	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Scarification (S)	•	0.03	< 0.01	< 0.01	0.30	0.02	
LXS	•	0.30	0.25	0.66	0.77	0.01	
PP600							
Light (L)	•	< 0.01	0.57	0.02	0.66	0.02	
Scarification (S)	•	< 0.01	< 0.01	0.02	<0.01	< 0.01	
LXS	•	0.01	0.32	0.61	0.27	0.20	

Table 6. P-values for the analyses of variance for the effects of light and scarification with concentrated H₂SO₄ on CGRI of 5 sources of brownseed paspalum at 6 alternating temperatures (° C). Separate analyses were done for each temperature and source combination.

Seed source and			Tempe	erature		
treatment	515	10-20	15-25	20-30	25–35	30-40
De Witt			*******			
Light (L)	0.17	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
Scarification (S)	0.17	0.36	0.05	< 0.01	< 0.01	< 0.01
LXS	0.17	0.66	0.82	0.95	0.17	0.94
Hidalgo						
Light (L)	0.35	< 0.01	< 0.01	< 0.01	0.02	0.07
Scarification (S)	0.35	< 0.01	< 0.01	<0.01	< 0.01	< 0.01
LXS	0.35	< 0.01	0.24	0.10	0.09	0.03
PI-353399						
Light (L)	0.04	< 0.01	0.02	< 0.01	0.04	< 0.01
Scarification (S)	0.29	0.01	< 0.01	< 0.01	< 0.01	< 0.01
LXS	0.43	0.10	0.24	0.30	0.25	0.03
Bryan						
Light (L)	•	0.18	0.53	0.91	0.90	0.41
Scarification (S)	•	0.25	< 0.01	< 0.01	< 0.01	< 0.01
LXS	•	0.17	0.96	0.72	0.75	0.41
PP600						
Light (L)	•	0.05	0.20	0.04	< 0.01	0.47
Scarification (S)	•	0.03	0.07	0.01	< 0.01	< 0.01
LXS	•	0.84	0.49	0.15	0.79	0.49

that of untreated seeds in the dark but not in the light (Tables 2 and 5). Scarified Bryan and Hidalgo seeds had higher percent germination than untreated seeds at most temperatures. For PI-353399, percent germination of scarified seeds was similar to or higher, depending on temperature regime, than that of untreated seeds in the light. In the dark, scarified seeds exhibited higher percent germination. Scarified De Witt, Hidalgo, PI-353399, and Bryan seeds also germinated more rapidly than untreated seeds at most temperatures (Tables 4 and 6). Scarification reduced percent germination and CGRI of PP600.

Discussion

Texas sources of brownseed paspalum appear adapted for germination during the summer. Average daily minimum and maximum temperatures above 20 and 30° C, respectively, occur in May, June, July, August, and September in south Texas (NOAA 1972). Environmental conditions most favorable for establishment of brownseed paspalum probably occur in May, June, and September, which are peak rainfall months in south Texas (Gould 1975). Australian, African, and South American sources also appear to be adapted for germination during warm seasons.

Our results agreed with specifications of Low (1981) that light

should be provided for testing germination of brownseed paspalum. Several other *Paspalum* species apparently require light for maximum germination. Low (1981) indicated that light should be used for testing seeds of 4 *Paspalum* species commonly planted in Australia.

Differences among seed sources in the effect of scarification with 17 M H₂SO₄ probably resulted from differences in dormancy. Dormancy may have varied because of differences in seed age, environmental conditions during seed development and seed storage, or ecotypic variation. Our results indicate that scarification with H₂SO₄ is a potential presowing treatment to increase germination of dormant brownseed paspalum seeds.

Gamboa and Guerrero (1969) found that H₂SO₄ scarification separated the lemma and palea and increased germination of Bahia grass seeds. Brownseed paspalum caryopses are tightly enclosed in the lemma and palea and H₂SO₄ possibly increased germination through effects on the lemma and palea. However, H₂SO₄ scarification also causes biochemical changes in seeds (McDonald and Khan 1983). Tischler and Young (1983) concluded that H₂SO₄ may destroy or solubilize germination inhibitors in the seed coat of the caryopsis or in the lemma and palea of kleingrass (Panicum coloratum) and thus its effect is at least partially independent of scarification. Further research is needed to determine causes of dormancy in brownseed paspalum seeds.

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