

Genotype Selection and Seeding Rate in Bahiagrass Establishment

PHILIP BUSEY

Bahiagrass (*Paspalum notatum* Flüggé) is a widely used roadside cover for the humid subtropics, but it can be slow and difficult to establish. Field tests were performed to determine optimum seeding rate and selection of genotype. Under weedy, nonirrigated conditions, Rapid Coverage Polycross (RCP-1) bahiagrass had higher establishment ratings in the second growing season than 'Pensacola' and 'Argentine.' For acceptable establishment, seeding rates of 17 and 12 g m⁻² (150 and 100 lb/acre) would be required for Argentine and RCP-1, respectively. Pensacola establishment was unacceptable at any seeding rate, up to 19 g m⁻² (170 lb/acre). Under weed-free conditions, and in the absence of millet (*Panicum* sp.) acceptable 2-month establishment required 13 and 16 g m⁻² (120 and 140 lb/acre) seeding rates, respectively, for Argentine and Pensacola. Under weed-free conditions, high (>13 g m⁻²) seeding rates conferred no advantage to long-term (9-month) performance. Millet interseeded with bahiagrass was deleterious to bahiagrass germination and subsequent establishment ratings. In spaced-plant evaluations, Rapid Coverage Polycross (RCP-2, or increase generation from RCP-1) had 12 percent and 61 percent faster lateral growth compared with Pensacola and Argentine, respectively. RCP-2 was superior to RCP-1 in visual coverage ratings. A dwarf bahiagrass, P3C1, which had shorter culms and finer texture than all other genotypes, had lateral growth equal to Pensacola.

Bahiagrass (*Paspalum notatum* Flüggé) turf is widely used on highway rights-of-way in the humid subtropics. There it provides erosion control and aesthetic benefits. Bahiagrass has higher root mass per ground area and a higher ratio of root to shoot mass than several other species of warm-season grasses, e.g., bermudagrass, centipedegrass, and St. Augustinegrass (1). It is well adapted to low fertility (2) and is resistant to seasonal drought. In the Republic of China, bahiagrass has reduced the annual soil loss to $1.5 \cdot 10^2$ g m⁻² compared with $1.56 \cdot 10^4$ g m⁻² (70 tons/acre) under clean culture (3).

Grass root systems are capable of increasing the shear resistance of soil, which is important for the stabilization of highway slopes. Roots of some grass species produce threefold increases in soil shear resistance within 7.5 months after seeding (4). Although bahiagrass contributes to safety and other environmental goals along southeastern United States highways, and elsewhere, its establishment from seeding is often a failure. Improved specifications for bahiagrass seeding are needed to reduce construction and maintenance expenses.

Beneficial seeding practices such as mulching improve seedling stands of several turfgrass species. Straw mulch is at least as adequate as, and easier to apply than, many other materials (5–7). Mulch can be broadcast and cut in cross-slope at 450 g m⁻² (2 tons/acre). Deep (9 to 25 mm, $\frac{3}{8}$ to 1 in.) drilling and packing (pressing in) of seed in soil provides optimum bahiagrass germination, especially in sand soils during dry

periods (8). Best bahiagrass establishment results from summer seedings [June through August (Busey, unpublished data)]. Postharvest dormancy is known to vary among bahiagrass genotypes (9–11) and may assist in the success of off-season seedings. Proper postseeding fertilization is important for bahiagrass establishment. A 9-week postseeding fertilization with 4.9 g of N m⁻² (44 lb of N per acre) significantly improves turf quality, compared to no fertilization, when evaluated 22 months after seeding (Busey, unpublished data).

Recommended bahiagrass seeding rates are 0.3 to 49.3 g m⁻² (2 to 436 lb/acre) (12–14), but 5.6 g m⁻² (50 lb/acre) is often used in highway grassing. It is not known which rate is optimum. Bahiagrass is comparatively slow in its log-phase growth (15), which may contribute to the difficulty of seed establishment and problems of competition from weeds. Bahiagrass is often seeded in combination with a fast-growing cover crop, such as millet (*Panicum ramosum* L.) or annual ryegrass (*Lolium multiflorum* Lam.), but poor results have been observed from the use of millet (Busey, unpublished observations).

Cultivars "Argentine" and "Pensacola" are frequently used on highways. A proposed cultivar, RCP (Rapid Coverage Polycross) has been developed based on "general combining ability" (a genetic term) for rapid coverage ability (Busey and Henry, unpublished data). The comparative establishment of genotypes is not known. The objective of this study was to develop optimum seeding rates and selection of genotypes for bahiagrass establishment.

MATERIALS AND METHODS

Experiments were conducted at Fort Lauderdale Research and Education Center, Davie, Broward County, Florida. Field experiments were conducted on Hallandale fine sand, a siliceous, hyperthermic, Typic Psammaquent. Plots were occasionally spot treated with hydramethylnon (Amdro[®]) to control fire ants (*Solenopsis invicta* Buren), to facilitate data collection, but other pesticides were not used during the studies. Plots were free of preexisting bahiagrass and were individually broadcast-seeded from weighed allocations. Bahiagrass establishment was rated visually in field plots (10 = highest possible density, uniformity, and absence of weeds; 7 = acceptable; 1 = worst possible density, etc.), and other data were collected.

Experiment 1: Establishment under Weedy Conditions

Seven seeding rates of three bahiagrass genotypes (Argentine, Pensacola, and RCP-1) were seeded on 13 August 1986. Rates

TABLE 1 ESTABLISHMENT RATINGS OF BAHIAGRASS GENOTYPES AND SEEDING RATES UNDER WEEDY CONDITIONS

		<u>Evaluation time, days after seeding</u>					
		<u>First</u>	<u>Second growing season</u>				
		<u>season</u>					
Genotype		98	250	298	324	438	Mean
RCP-1		5.3 a ^z	5.6 a	6.1 a	6.7 a	6.7 a	6.3 a
Argentine		4.4 b	4.7 b	5.5 a	6.3 a	5.0 b	5.4 b
Pensacola		4.0 b	3.2 c	4.0 b	4.7 b	4.5 b	4.1 c
<u>Seeding rate</u>							
<u>g.m-2</u>		<u>pounds/acre</u>					
19.2	171	6.4 a	6.6 a	6.7 a	7.6 a	7.4 a	7.1 a
12.8	114	5.4 b	5.2 b	5.7 ab	6.7 ab	6.1 bc	5.9 b
8.5	76	4.9 bc	5.2 b	6.3 a	6.7 ab	6.5 ab	6.2 b
5.7	51	4.1 cd	4.1 c	5.1 bc	5.6 bc	5.0 cd	4.9 c
3.8	34	3.9 d	3.6 cd	4.6 c	5.3 c	4.4 de	4.5 cd
2.5	23	3.6 d	3.9 cd	4.6 c	5.2 cd	4.7 de	4.6 c
1.7	15	3.5 d	3.0 d	3.5 d	4.2 d	3.8 e	3.6 d
<u>Mean squares:</u>							
Genotype		18.5	59.4	50.5	24.0	29.1	49.9
Seeding rate		21.5	27.1	21.6	46.6	56.2	24.9
Error		1.5	1.5	1.7	1.8	1.7	1.4

^z Values are visual ratings, means of 6 replications;

10=maximum possible; 1=least. Values with a letter in

common are not significantly different by the Waller-

Duncan *k*-ratio *t*-test, *k*=100, *P* = ca. 0.05.

were 1.7 to 19.2 g of seed m⁻² (15 to 171 lb/acre) in a 1.5 × geometric series. The 21 resulting factorial combinations plus a control (nonseeded) treatment were replicated in six randomized complete blocks. Seed had been harvested by commercial growers in 1984 (Argentine and Pensacola bahiagrasses) or by hand in 1983 at the Fort Lauderdale Research and Education Center (RCP-1 bahiagrass). Seed were not scarified and were stored in a refrigerator (5°C). Tests done in 1984 by professional laboratories revealed proportions of pure, live seed (percent germination × percent pure seed) of 75 percent, 91 percent, and 90 percent for Argentine, Pensacola, and RCP-1, respectively; and 61 percent and 38 percent dormancy ("hard seed") for Pensacola and RCP-1, respectively. Because Argentine seed were hand-peeled, dormancy data were not available. A 1985 field study (Busey, unpublished data) revealed that acid scarification on these seed lots did not affect establishment. Thus, by the time the seed were used in the present study, they were effectively nondormant. Seeding rates were based on gross weight. Indi-

vidual seed weights were 2.58, 1.51, and 1.69 mg for Argentine, Pensacola, and RCP-1, respectively.

Plots were 1.5 m by 1.2 m (5 ft by 4 ft). Soil pH was 6.0 to 6.5, and plots were not irrigated, were mowed three times in the first year, and received no pest control. Before tillage, the field area had a dense stand of torpedograss (*Panicum repens* L.), a competitive, perennial grassy weed. Grass and weeds were mowed, and plots were rototilled to 16 mm (0.6 in.). Debris was removed, the area was leveled with a hand rake and broadcast-seeded, and seed were gently raked in. Plots were mulched with 454 g m⁻² (2 tons/acre) small-grain straw, and run over with a cultipacker. Plots were fertilized 5 weeks after seeding, with 5.0, 0.6, and 2.1 g m⁻² N, P, and K, respectively (44, 11, and 22 lb/acre of N, P₂O₅, and K₂O, respectively), with additional micronutrients, and 78 percent of the N was water soluble, primarily ammoniacal. Establishment ratings were taken on five dates of evaluation (3 to 15 months after seeding), and cultivars and seeding rates were compared by analysis of variance, within dates (Table 1).

TABLE 2 BAHIAGRASS GENOTYPE CHARACTERISTICS

Genotype	Unmown foliage height	Leaf width	Culm height	Culm number	Plant diameter	Visual cover rating ^z
	(mm)	(mm)	(mm)		(mm)	
RCP-2	144 c ^y	7.10 c	763 c	136 c	408 a	8.7 a
RCP-1	137 bc	6.71 b	752 c	135 bc	378 ab	8.0 b
Pensacola	129 b	7.00 bc	759 c	95 b	364 b	7.9 b
P3C1	108 a	6.30 a	544 a	162 c	362 b	6.3 c
Argentine	101 a	9.14 d	672 b	29 a	253 c	5.7 c
Mean squares:						
Genotype	6973	24.16	176740	54185	69706	30.5
Error	501	0.38	4743	4734	5015	1.5

^z Visual rating, 10=maximum possible; 1=least; 7=acceptable.

^y Values with a letter in common are not significantly different by the Waller-Duncan *k*-ratio *t*-test, *k*=100, *P* = ca. 0.05.

Because seeding rates and dates of evaluation were continuous variables, regression was a more appropriate means to study their effect than analysis of variance (16). Establishment ratings were estimated by a multivariate model, involving stepwise regression of linear effects, days after seeding, seeding rates, and quadratic and interactive sources of variation, for each genotype. To simplify the interpretation, four dates of evaluation (April through October 1987) were averaged as split plots in time, and genotype responses to log seeding rates were analyzed by using a linear model.

Experiment 2: Establishment Under Weed-Free Conditions

Red millet (*Panicum* sp.) and bahiagrasses were seeded together in various rate combinations on 25 August 1987. Seeding rates for each species were 0, 6.5, 12.9, 19.4, and 25.8 g m⁻² (0, 60, 120, 180, and 240 lb/acre), in all combinations, making 25 factorial treatment combinations. Treatments were repeated for two cultivars (Argentine and Pensacola) in three completely randomized replications; hence there were 150 plots. Seed of cultivars (1985 and 1986 harvests) were commercially scarified and fungicide treated and had a pure live seed proportion of 72 percent and 82 percent for Argentine and Pensacola, respectively. Seed weights were 3.09, 1.64, and 5.42 mg per seed for Argentine, Pensacola, and millet, respectively.

Plots were 1.5 by 1.5 m (5 by 5 ft). The field area had been fumigated (methyl bromide) to control weeds. (Because of its high cost, soil fumigation would be inappropriate for highway use.) The pH was between 7.2 and 7.6. Plots were rototilled to a depth of 50 mm (2 in.), left rough, and seeded.

Plots were raked level, mulched with 450 g m⁻² (2 tons/acre) of small grain straw, and run over with a cultipacker. Plots were fertilized with 9.9, 1.1, and 4.1 g m⁻² of N, P, and K, respectively (88, 22, and 44 lb/acre of N, P₂O₅, and K₂O, respectively), with additional micronutrients, and 78 percent of the N was water soluble, mostly ammoniacal. This fertilizer was split into two application groups, applied at 3 and 6 weeks postseeding. Plots were irrigated 6 mm (0.25 in.) every other night, except during rainy periods, for the first 6 months. Seedling emergence and root and shoot biomass were determined 8 weeks after seeding with a 100-mm-(4-in.) diameter core randomly taken to a depth of 150 mm (6 in.) from one replicate of each treatment. Establishment ratings were taken visually at 2 and 9 months postseeding. Stepwise regression was used to develop a model for genotype response to seeding rates.

Experiment 3: Genotype Characteristics

Bahiagrass genotypes (Table 2) were compared in a spaced planting. RCP-2 consisted of the second-generation bulk increase (first generation from polycross nursery) of RCP-1. P3C1 consisted of the third-generation bulk of a dwarf population under selection. All seeds were germinated at the same time in a greenhouse, seedlings were transplanted in September 1987 to a temporary field area, and healthy plants of each genotype were again transplanted in December 1987 to a space-planted trial in the same areas as Experiment 2. Plots were irrigated every other night, except during rainy periods, for the first 3 months after seeding. There were 20 complete blocks, and plots were 1.2 by 1.2 m (3 by 3 ft).

In March 1988, each plant was measured for diameter lateral spread, unmown leaf height, and leaf width. Culm (seed-head) height at anthesis (mean of tallest three per plant) and number per plant were recorded weekly from 18 May through 28 June 1988. Because of the seasonally variable number of culms per plant, the culm height for each plot was the seasonal mean weighted for the number of culms produced during each week. Coverage was estimated visually in July 1988. Genotype means were compared by analysis of variance.

RESULTS

Experiment 1: Establishment Under Weedy Conditions

RCP-1 bahiagrass achieved higher establishment ratings than Argentine or Pensacola on most dates of evaluation (Table 1). Bahiagrass establishment was highly dependent ($r^2 = 0.56$, $P < 0.0001$) on days after seeding, seeding rates, blocks, cultivars, and several quadratic and interactive sources of variation. Predicted establishment ratings for treatment means were

$$Y_A = -2.77 + 0.362*B - 0.00736*B^2 + 0.0371*T - 0.0000542*T^2 \quad (1)$$

$$Y_P = -2.29 + 0.406*B - 0.01031*B^2 + 0.0205*T - 0.0000222*T^2 \quad (2)$$

$$Y_R = 1.17 + 0.155*B + 0.00060*B^2 + 0.0182*T - 0.0000189*T^2 \quad (3)$$

where

Y_A , Y_P , and Y_R = predicted second growing season establishment ratings for Argentine, Pensacola, and RCP-1, respectively,
 B = bahiagrass seeding rate (g m^{-2}), and
 T = time since seeding (days).

These formulae explained 78 percent, 89 percent, and 78 percent of the variance of treatment means for Argentine, Pensacola, and RCP-1, respectively. Longer intervals after seeding and higher seeding rates generally resulted in higher establishment ratings.

A simpler, linear regression of genotype second-growing-season establishment on log-transformed seeding rates (Figure 1) resulted in

$$Y_A = 2.879 + 1.446*\ln(B) \quad (4)$$

$$Y_P = 1.701 + 1.384*\ln(B) \quad (5)$$

$$Y_R = 4.497 + 1.021*\ln(B) \quad (6)$$

These formulae explained 62 percent, 68 percent, and 52 percent of the variance of treatment means for Argentine, Pensacola, and RCP-1, respectively. According to these formulae, seeding rates of 17 g m^{-2} (150 lb/acre) for Argentine and 12 g m^{-2} (100 lb/acre) for RCP-1 would be required to achieve

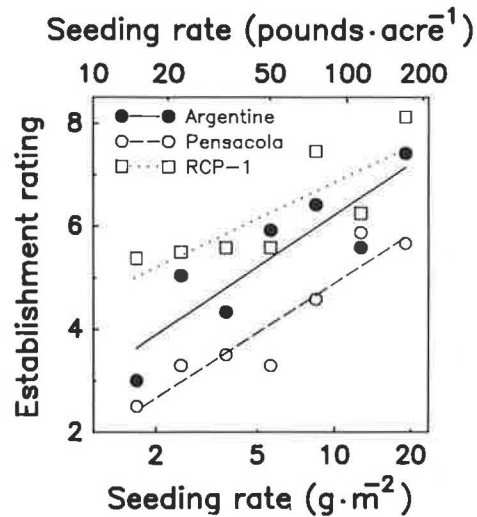


FIGURE 1 Bahiagrass establishment response to bahiagrass genotype and seeding rate under weedy conditions: second growing season.

acceptable (rating ≥ 7.0) establishment in the second growing season. Pensacola would not achieve acceptable establishment at any seeding rate within the range of rates tested. The higher establishment ratings of RCP-1 bahiagrass compared with Argentine and Pensacola (Figure 1) were most noticeable at low seeding rates.

Experiment 2: Establishment Under Weed-Free Conditions

Higher emergence of seedlings was observed for Pensacola than for Argentine ($5,220$ vs. $2,620 \text{ m}^{-2}$). Considering the smaller seed size for Pensacola compared with Argentine, and the differing pure live seed proportions, this calculated to comparable germinations for Pensacola and Argentine, 69 percent and 65 percent, respectively. The millet seeding rate had a deleterious effect on bahiagrass germination percentages and reduced bahiagrass germination by about one-third over the range of millet seeding rates used.

Early (2-month) bahiagrass establishment ratings were highly determined ($r^2 = 0.74$ and 0.80 for Argentine and Pensacola, respectively) by bahiagrass seeding rate (Figure 2), millet seeding rate (Figure 3), and second- and third-order interactions:

$$Y_P = 1.05 + 0.579B - 0.0128B^2 - 0.031BM + 0.000484BM^2 + 0.000527B^2M \quad (7)$$

$$Y_A = 1.10 + 0.628B - 0.0129B^2 - 0.290BM + 0.000375BM^2 + 0.000553B^2M \quad (8)$$

where

Y_P , Y_A = predicted second growing season establishment ratings for Pensacola and Argentine, respectively,

B = bahiagrass seeding rate (g m^{-2}), and

M = millet seeding rate (g m^{-2}).

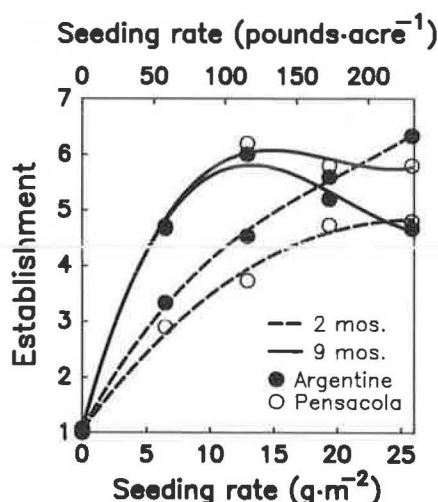


FIGURE 2 Bahiagrass establishment response to bahiagrass genotype and seeding rate under weed-free conditions.

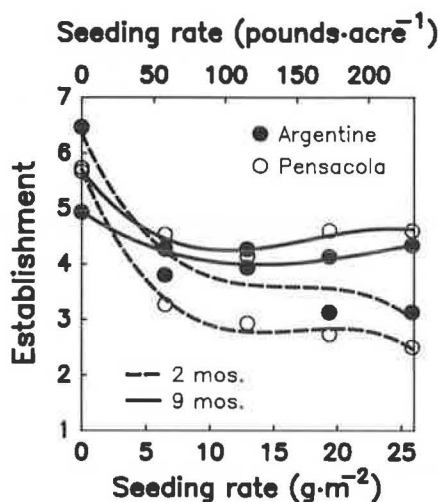


FIGURE 3 Bahiagrass establishment response to millet seeding rate under weed-free conditions.

Acceptable early bahiagrass establishment (rating ≥ 7) was predicted only for high bahiagrass seeding rates (13 g m^{-2} , 120 lb/acre , for Argentine; and 16 g m^{-2} , 140 lb/acre , for Pensacola) and where no more than 2 g m^{-2} (17 lb/acre) millet would be used. In the range of acceptable seeding rates, millet would always be deleterious.

Bahiagrass stand dry weights were highly associated with visual establishment ratings. Argentine and Pensacola revealed a similar relationship between establishment rating and stand dry weight (data not presented). Acceptable 2-month establishment (rating ≥ 7) was associated with stand dry weights $\geq 110 \text{ g m}^{-2}$ (980 lb/acre). Argentine achieved higher stand dry weights than Pensacola. Each increase of 1 g m^{-2} millet seed would require a 3 g m^{-2} increase in bahiagrass seed to compensate for the deleterious effects of millet.

The 9-month establishment ratings revealed a dramatic curvilinear relationship (Figure 2). Maximum bahiagrass establishment was predicted for both Argentine and Pensacola in the bahiagrass seeding rate range, $10\text{--}15 \text{ g m}^{-2}$ ($90 \text{ to } 130 \text{ lb/}$

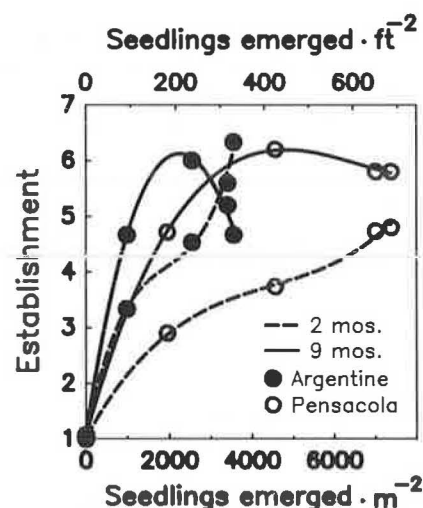


FIGURE 4 Bahiagrass establishment response to bahiagrass seedling emergence under weed-free conditions.

acre) and higher rates were deleterious. The deleterious effect caused by millet was less conspicuous for the 9-month rating (Figure 3) than for the 2-month rating.

The most predictive criterion of bahiagrass establishment was seedling emergence (Figure 4). Maximum 9-month establishment ratings were observed at 2,000 and 4,000 emergent seedlings m^{-2} for Argentine and Pensacola, respectively. These seedling densities resulted in marginal establishment (rating about 6), and higher densities were not beneficial.

Experiment 3: Genotype Characteristics.

RCP bahiagrass (generations RCP-1 and RCP-2) had rapid lateral spread (Table 2). RCP-2 was faster spreading than Argentine and Pensacola and equal to or faster than RCP-1. These rates indicated that no decline in fitness had occurred during advance of generations. RCP-1 was not different from Pensacola in any respect. RCP bahiagrass was relatively tall (unmown height) compared with other genotypes and about the same texture (leaf width) as Pensacola. The dwarf bahiagrass, P3C1, had moderate coverage rate and was superior to Argentine, but not different than Pensacola. The dwarf had significantly finer leaves and shorter culm height than all other genotypes and had unmown height as short as Argentine. The dwarf, P3C1, also had the largest number of seedheads. These results are encouraging evidence of breeding progress for rapid coverage and dwarf habit.

CONCLUSIONS AND RECOMMENDATIONS

These studies, in combination with a review of previous work, result in a model and a method for bahiagrass establishment. Bahiagrass has slow biomass accumulation (15), poor seedling competition, and slow vegetative spread. Successful establishment may be viewed as a process of developing sufficient biomass reserve to endure cool and dry periods, when bahiagrass growth ceases. Everything must be done to gently promote the bahiagrass, while using proper timing of practices (e.g., mowing and fertilization) to deter weed encroachment but not injure the bahiagrass. Millet (*Panicum* spp.), because

of its deleterious effects, should not be used at high rates, although it has commonly been used as a companion crop. The effect of millet is so deleterious that it should be further studied for possible allelopathy, which might be operable at low seeding rates.

Genotype selection is important in bahiagrass establishment. Argentine and RCP-1 had superior establishment compared with Pensacola. From 13 to 17 g m⁻² (120 to 150 lb/acre) Argentine seed would be needed, depending on conditions, and 16 g m⁻² (140 lb/acre) Pensacola would be needed under weed-free conditions. RCP-1 can be planted at 12 g m⁻² (100 lb/acre), even under weedy conditions, to achieve acceptable establishment. RCP-1 and RCP-2 have an advantage because they have faster lateral growth rates than Argentine, based on spaced plant evaluations. Higher bahiagrass seeding rates are beneficial, especially in weedy conditions, and their effect is most apparent in the first season of growth. Seeding rates needed to achieve acceptable establishment in the second season and in weed-free conditions may be reduced considerably with no reduction in ultimate establishment ratings.

The effectiveness of proper seeding rate and genotype selection is dependent on other practices that have been found to be effective. Seeding should be done during warm, rainy months; no supplemental watering is needed. Seed should be distributed evenly, incorporated 9 to 25 mm ($\frac{3}{8}$ to 1 in.) deep, mulched with small-grain straw at 450 g m⁻² (2 tons/acre), and firmly rolled after seeding to create good seed to soil contact. If there is any slope, the mulch should be cut in across slope with blunt coulters (5).

Seeded areas should be fertilized to provide maximum nutrient release to young seedlings. Soluble nitrogen sources can be used but should be in a complete formulation, including micronutrients (iron, especially). The application of fertilizer postseeding is more expensive than fertilization at the time of planting because it requires a second visit to the site by the grassing contractor. About 4.5 g of N m⁻² (40 lb of N per acre) is effective, and higher rates should not be used in any single application. Regular mowing should be initiated as soon as weeds begin to shade the bahiagrass seedlings (about 6 weeks), but mowing height must not be less than 80 mm (3 in.).

Inspection 3 to 9 weeks after seeding (assuming warm weather and adequate soil moisture) should reveal a minimum of 1,000 to 2,000 seedlings m⁻² (100 to 200 per ft²), although this is not a guarantee of successful longterm establishment, if other procedures are not followed. One should be unable to take a step without touching a seedling. Seedlings should produce one leaf per week of growth, and a major onset of tillering (development of basal offshoots) and development of thick roots should be observed 8 weeks after seeding. Seedling stands may subsequently be observed to go into 1 or more weeks of wilt, and still survive, but they remain tender and susceptible to shading by weeds and scalping. Until seeded areas are 1 year old, a secure basis for their acceptance cannot be made.

ACKNOWLEDGMENTS

This is Florida Agricultural Experiment Station Journal Series 9909. The Florida Department of Transportation (FDOT) was

the primary sponsor of study. G. L. Henry, Bureau of Environment, FDOT, was the coordinator. The South Florida Water Management District supported the dwarf bahiagrass development. Ideas and seed were provided by two of the leading producers of Florida bahiagrass seed, K. F. Payne and F. Tomkow. The seed analysis was made possible by W. R. "Buddy" Vaughan, Florida Department of Agriculture and Consumer Services; and C. Jake Hulsey, Hulsey Seed Laboratory, Decatur, Ga. B. J. Center, R. Moriones, and M. C. Vempala provided expert technical assistance. P. Mislevy critically reviewed this manuscript and provided insightful comments.

REFERENCES

1. A. S. Laird. A Study of the Root Systems of Some Important Sod-Forming Grasses. *University of Florida Agricultural Experiment Station Bulletin* 211, 1930.
2. E. R. Beaty and J. D. Powell. Growth and Management of Pensacola Bahiagrass. *Journal of Soil and Water Conservation*, Vol. 33, 1978, pp. 191-193.
3. S. Jean and T. Juang. Effect of Bahia Grass Mulching and Covering on Soil Physical Properties and Losses of Water and Soil of Slopeland (First Report). *Journal of the Agricultural Association of China (Taipei)*, Vol. 105, 1979, pp. 57-66.
4. L. J. Waldron and S. Dakesian. Effect of Grass, Legume, and Tree Roots on Soil Shearing Resistance. *Soil Science Society of America Journal*, Vol. 46, 1982, pp. 894-899.
5. A. P. Barnett, E. G. Diseker, and E. C. Richardson. Evaluation of Mulching Methods for Erosion Control on Newly Prepared and Seeded Highway Backslopes. *Agronomy Journal*, Vol. 59, 1967, pp. 83-85.
6. J. B. Beard. A Comparison of Mulches for Erosion Control and Grass Establishment on Light Soil. *Michigan State University Agricultural Experiment Station Quarterly Bulletin*, Vol. 48, 1966, pp. 369-376.
7. B. L. Schmidt, G. S. Taylor, and R. W. Miller. Effect of Corn Steep Liquor for Erosion Control and Vegetative Establishment on Highway Backslopes. *Agronomy Journal*, Vol. 61, 1969, pp. 214-217.
8. G. W. Burton. The Establishment of Bahia Grass. *Journal of the American Society of Agronomy*, Vol. 32, 1940, pp. 545-549.
9. G. W. Burton. Scarification Studies on Southern Grass Seeds. *Journal of the American Society of Agronomy*, Vol. 31, 1939, pp. 179-187.
10. J. M. Gamboa and D. N. Guerrero. Escarificación del Zacate Bahía, *Paspalum notatum* Flüggé, para Acelerar su Germinación. *Agricultura Técnica*, Vol. 2, 1969, pp. 445-449.
11. R. C. Williams and B. C. Webb. Seed Moisture Relationships and Germination Behavior of Acid-Scarified Bahiagrass Seed. *Agronomy Journal*, Vol. 50, 1958, pp. 235-237.
12. C. G. Chambliss and D. W. Jones. *Bahiagrass*. University of Florida Cooperative Extension Service Circular 321B, 1981.
13. G. B. Killinger, G. E. Ritchey, C. B. Blickensderfer, and W. Jackson. *Argentine Bahia Grass*. Florida Agricultural Experiment Station Circular S-31, 1951.
14. S. Smith. *Bahiagrasses for Florida Lawns*. University of Florida Department of Ornamental Horticulture, Fact Sheet 6, Fort Lauderdale, 1975.
15. P. Busey and B. J. Myers. Growth Rates of Turfgrasses Propagated Vegetatively. *Agronomy Journal*, Vol. 71, 1979, pp. 817-821.
16. V. Chew. Uses and Abuses of Duncan's Multiple Range Test. *Proc. Florida State Horticultural Society*, Miami Beach, Vol. 89, 1976, pp. 251-253.