Bermudagrass Establishment on High Sand-content Soils Using Various N–P–K Ratios

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Abstract. For drainage, turfgrass is often established on sand-based soils, which are typically nutrient-deficient and require supplemental fertilization. The objective of this study was to determine the optimum N–P–K fertilizer ratio for establishing bermudagrass from sprigs in sand. 'FloraDwarf' and 'Tifdwarf' bermudagrasses [*Cynodon dactylon* (L.) Pers. × *C. transvaalensis* Burt-Davy] were sprigged on a United States Golf Association (USGA) green [85 sand : 15 peat (v/v)] in Aug. 1996 at the Univ. of Florida's Envirogreen in Gainesville, Fla. 'TifEagle' bermudagrass was sprigged on a USGA green [85 sand : 15 peat (v/v)] and 'Tifway' bermudagrass [*C. dactylon* (L.) Pers.] was sprigged on native soil at Clemson Univ. in Clemson, S.C. in May 1999. Treatments consisted of fertilizer ratios of 1N–0P–0.8K, 1N–0P–1.7K, 1N–0.4P–0.8K, 1N–0.9P–0.8K, and 1N–1.3P–0.8K applied based on a N rate of 49 kg·ha⁻¹/week for 7 weeks. Growth differences were apparent among cultivars. A 1N–0P–0.8K or 1N–0P–1.7K ratio is insufficient for optimum growth of bermudagrass during establishment, even when planted on a soil high in P. Increased coverage rate with additional P was optimized at a ratio of 1N–0.4P at all four sites. Increased coverage with P was greatest on the sand-based greens, probably due to the very low initial P levels of the soils. On two of the sand-based greens, P in excess of a 1N–0.4P ratio decreased coverage rate.

Hybrid bermudagrasses are vegetatively propagated due to a lack of viable seed and to help ensure the turf remains true to its genetic type. Although bermudagrass is known for its vigor and heat and drought tolerance, newly planted sprigs lack a mature root system, rendering them susceptible to several problems during establishment such as drought stress, nutrient deficiencies, and weed encroachment. These problems and the desire to open a facility as soon as possible make rapid establishment a high priority for turfgrass managers.

Proper fertility is an important parameter for sprig establishment. Due to high turfgrass N requirements and soils that are typically nutrient deficient, N fertilizers are typically the most heavily applied during establishment. This practice is an attempt to supply optimum N fertility to facilitate rapid shoot growth and overcome losses of N due to leaching under irrigation. Excessive N fertility such as 62 kg·ha⁻¹/month has been shown to reduce bermudagrass establishment rates (Dudeck et al., 1985).

While N is applied in higher amounts than other nutrients, a balanced supply of nutrients is needed during turf establishment and for maintaining existing stands. Potassium plays a major role in plant water status and can affect leaf water potential and drought damage avoidance in bermudagrass (Miller and Dickens, 1997). Due to an underdeveloped root system during the establishment phase and the mobility of K in sands, adequate K fertilization appears to be beneficial. Bermudagrass rooting appears optimized with applications of K in a 1:1 ratio with N (Peacock et al., 1997). Higher numbers and longer stolon length have also been demonstrated with K fertilization at 49 kg·ha⁻¹/month during bermudagrass establishment (Trenholm et al., 1997). Phosphorous deficiency may occur during establishment due to limited rooting and relative P immobility in most soils.

Soil mixes used in golf green construction are typically deficient in N, P, and K, but native soils, often used for golf course fairways and sports fields, may contain sufficient levels of some nutrients. The construction of new research plots at the Univ. of Florida and Clemson Univ. provided opportunities to examine the effects of various fertilizer combinations to aid in the establishment of four bermudagrass cultivars. The objective of this

study was to determine the optimum ratio of N–P–K fertilizer for establishment of 'Tifdwarf', 'FloraDwarf', 'TifEagle', and 'Tifway' bermudagrasses on high sand-content soils and a native sandy loam.

Materials and Methods

A field study was conducted in Aug. 1996 at the Envirogreen located at the Univ. of Florida in Gainesville, Fla. 'FloraDwarf' and 'Tifdwarf' bermudagrasses were sprigged on a golf green [85 sand : 15 peat (v/v)] built to United States Golf Association (USGA) specifications (USGA Green Section Staff, 1993) using standard planting rates and procedures (McCarty, 2001). Experimental design was a randomized complete block with four replications of five treatments per cultivar for a total of 40 plots. Plot size was 0.8 m × 30 m. Treatments consisted of fertilizer ratios of 1N–0P–0.8K, 1N–0P–1.7K, 1N–0.4P–0.8K, 1N–0.9P–0.8K, and 1N–1.3P–0.8K applied based on an N rate of 49 kg·ha⁻¹/week. Fertilizers were applied in the forms of ammoniated phosphates, urea, triple superphosphate, and muriate of potash. Treatments were applied for 7 weeks. A field study was also conducted in Clemson, S.C., in May 1999 with 'TifEagle' bermudagrass sprigged on a USGA green [85 sand : 15 peat (v/v)] and 'Tifway' bermudagrass sprigged on native Cecil coarse sandy loam (clayey, kaolinitic, thermic Typic Kanhapludults). Experimental design was a randomized complete block with four replications of five treatments per cultivar for a total of 20 plots per cultivar. Plot size was 2 × 9 m. Treatments were identical to the Gainesville study and were applied for 7 weeks. Irrigation was supplied in both experiments as needed to maintain a high quality turf. Beginning 4 weeks after sprigging, 'FloraDwarf', 'Tifdwarf', and 'TifEagle' were maintained at a height of 3 mm by cutting with a reel mower three times per week, and clippings were removed. 'Tifway' plots were maintained by cutting with a reel mower at a height of 15 mm two times per week beginning 2 weeks after sprigging.

Data collected included soil analyses, visual ratings, and root/shoot dry weights. Soil samples were taken before sprigging and analyzed for P and K levels using an inductively-coupled plasma spectrophotometer (model 61E; Thermo Jarrell ASH Corp., Franklin, Mass.). Initial soil tests on 'Tifway' plots showed P at 65 mg·kg⁻¹, considered adequate, and K at 26 mg·kg⁻¹, considered deficient, and a pH of 5.9. The sand-based soils used for 'FloraDwarf'/'Tifdwarf' and 'TifEagle' initially contained P at 2.2 mg·kg⁻¹ and K at 1.0 mg·kg⁻¹ with a pH of 6.7, and P at 5 mg·kg⁻¹ and K at 5 mg·kg⁻¹ with a pH of 6.5, respectively. Visual ratings for grass coverage were recorded weekly and expressed as percentage of coverage (% coverage) on a scale of 0% to 100%. A weighted-mean cover rate for each plot was calculated by dividing the % coverage by the number of weeks for each rating, resulting in a mean cover rate. Four inch diameter grass plugs were taken to a depth of 8 inches at the conclusion of each

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experiment. Samples were divided into shoots and roots/rhizomes and dried in a forced-air oven at 75 °C for 48 h for dry weight comparisons. Data were analyzed using the SAS General Linear Model procedure (SAS Institute, 1987). Mean separations were performed using Fisher's LSD_{0.05}.

Results and Discussion

A Hartley's test for homogenous variances performed on the data sets showed that it was possible to combine data from the different sites for analysis. A grass × treatment interaction occurred for the cover rate data (Table 1). 'Tifway' had the highest cover rate, followed by 'TifEagle', 'Tifdwarf', and 'Floradwarf' (Table 2). For all four grasses, the 1N-0.4P-0.8K fertilizer treatment had the highest cover rates (Table 3), although 'Tifway' had a similar cover rate for the 1N-0P-1.7K treatment, probably due to adequate P levels in the native soil. 'FloraDwarf' and 'Tifdwarf' had lower cover rates for 1N-0.9P-0.8K and 1N-1.3P-0.8K treatments, while 'TifEagle' and 'Tifway' plots had similar cover rates for 1N-0.4P-0.8K, 1N-0.9P-0.8K, and 1N-1.3P-0.8K treatments (Table 3). This suggests that a 1N-0.4P-0.8K ratio is sufficient for establishment and higher P rates may not be beneficial or may be detrimental to establishment. Low cover rates for 1N-0P-0.8K and 1N-0P-1.7K treatments indicate the need for P during establishment (Table 3). Increased cover rates with sufficient P are similar to the findings of Juska (1959) with zoysiagrass. A 1N-0.8K ratio is also in agreement with the findings of Peacock et al. (1997) and Trenholm et al. (1997).

There was a grass × treatment interaction influence on shoot weight, but root weight was affected by grass only (Table 1). These differences are probably due to variations in site conditions and shoot responses among cultivars. 'Tifway' had the highest shoot weights, followed by 'FloraDwarf' and 'Tifdwarf', which had similar shoot weights (Table 2). 'FloraDwarf', 'Tifdwarf', and 'TifEagle' had highest shoot weights with the 1N-0.4P-0.8K treatments (Table 3). 'FloraDwarf' and 'Tifdwarf' shoot weight responses were similar to cover rate, suggesting P as limiting and a 1N-0.8K ratio as optimum (Table 3). 'TifEagle' had highest shoot weight with 1N-0P-1.7K, 1N-0.4P-0.8K, 1N-0.9P-0.8K, and 1N-1.3P-0.8K treatments, suggesting that P did not limit shoot growth in the presence of increased K levels (Table 3). 'Tifway' shoot weights were highest with 1N-0P-0.8K, 1N-0P-1.7K, 1N-0.9P-0.8K, and 1N-1.3P-0.8K treatments (Table 3). This is probably due to the inherent higher levels of P and K found in the native loamy-sand soil.

Root weights were different due to grass, but not affected by P or K (Table 1). 'TifEagle' had the highest root weights followed by 'Tifway', 'Tifdwarf', and 'Floradwarf' (Table 2). These differences may be attributed to growth differences, which have been shown among bermudagrass cultivars (Dudeck et al., 1985).

In conclusion, a 1N-0P-0.8K or 1N-0P-

Table 1. Mean squares from analysis of variance of cover rate, shoot weight, and root weight following seven weeks of bermudagrass establishment.

Source of variation	df	Mean square		
		Cover rate	Shoot wt	Root wt
Grass	3	430.01**	3.79**	28.66**
Rep (Grass)	12	3.59**	0.34	1.67**
Treatment	4	61.63**	3.04**	0.36
Grass × Treatment	12	9.17**	1.35**	0.59
Error	48	0.69	0.2	0.52
Total	79			

**Significant at $P < 0.01$.

Table 2. Mean cover rate, shoot weight, and root weight following seven weeks of establishment for 'FloraDwarf', 'Tifdwarf', 'TifEagle', and 'Tifway' bermudagrass.

Grass	Cover rate % coverage/wk	Shoot wt (g)	Root wt (g)
FloraDwarf	8.96 d ^a	2.21 b	0.81 d
Tifdwarf	10.10 c	2.09 b	1.05 c
TifEagle	11.12 b	1.55 c	3.30 a
Tifway	19.17 a	2.60 a	2.56 b

^aWithin columns, means followed by the same letter are not significantly different according to Fisher's LSD_{0.05} test.

Table 3. Mean cover and shoot rates at five fertilizer ratio treatments seven weeks after establishment of 'FloraDwarf', 'Tifdwarf', 'TifEagle', and 'Tifway' bermudagrass.

Grass	Fertilizer N-P-K	Cover rate % coverage/wk	Shoot wt (g)
FloraDwarf	1N-0P-0.8K	6.55 c ^a	1.44 c
	1N-0P-1.7K	5.81 c	1.16 c
	1N-0.4P-0.8K	13.02 a	3.71 a
	1N-0.9P-0.8K	9.96 b	2.20 b
Tifdwarf	1N-1.3P-0.8K	9.75 b	2.53 b
	1N-0P-0.8K	7.77 c	1.84 b
	1N-0P-1.7K	7.33 c	0.93 c
	1N-0.4P-0.8K	13.49 a	2.75 a
TifEagle	1N-0.9P-0.8K	10.86 b	2.62 a
	1N-1.3P-0.8K	11.06 b	2.34 ab
	1N-0P-0.8K	8.42 b	1.15 b
	1N-0P-1.7K	8.42 b	1.34 ab
Tifway	1N-0.4P-0.8K	12.56 a	1.50 ab
	1N-0.9P-0.8K	13.55 a	1.87 a
	1N-1.3P-0.8K	12.65 a	1.89 a
	1N-0P-0.8K	17.47 c	2.64 ab
	1N-0P-1.7K	20.50 a	2.69 a
	1N-0.4P-0.8K	19.38 ab	2.04 b
	1N-0.9P-0.8K	19.07 b	2.81 a
	1N-1.3P-0.8K	19.41 ab	2.85 a

^aWithin grasses and variables, means followed by the same letter are not significantly different according to Fisher's LSD_{0.05} test.

1.7K ratio is insufficient for optimum growth of bermudagrass during establishment, even when planted on a soil high in P. Increased coverage rate with additional P was optimized at an ratio of 1N-0.4P at all four sites. Increased coverage with P was greatest on the sand-based greens, probably due to the very low initial P levels of the soils. On two of the sand-based greens, P in excess of a 1N-0.4P ratio decreased coverage rate.

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