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Nitrogen Fertilization and Cutting Frequency, Yield and Chemical Composition of Five Tropical Grasses[1]

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ABSTRACT

Five tropical forage grasses: Star (*Cynodon nlemfuensis*), Transvala digit (*Digitaria decumbens*), Pangola (*Digitaria decumbens*) and two Limpos (*Hemarthria altissima*, Bigalta and Greenalta), were cultivated without irrigation for 1.5 years at the Corozal Agricultural Experiment Substation to study the effects of 3 N fertilization levels and 3 harvest intervals (30, 45, and 60 days) on the green forage (GF), dry forage (DF), and crude protein (CP) yields and on the dry matter (DM), CP, P, and K contents. The soil is a Corozal clay (Ultisol). N levels, as $(NH_4)_2SO_4$, applied after each harvest, included low, 224; medium, 448; and high, 896 kg/ha/yr. P and K were applied at rates of 112 and 336 kg/ha/yr, respectively. DM content and DF and CP yields increased significantly with longer harvest intervals. The medium N level resulted in the highest CP yields, except in the case of Star grass, in which high N fertilization gave greater CP yield. Bigalta, Star, and Transvala digit cultivars exhibited the highest GF, DF, and CP yields. DF yields (means across the 3 harvest intervals and the 3 N levels) for Bigalta, Greenalta, Transvala, Star, and Pangola grasses were 35,421; 29,209; 31,699; 32,383; and 24,461 kg/ha/yr, respectively.

INTRODUCTION

Star (*Cynodon nlemfuensis* var. *nlemfuensis*), Coastcross 1 (*Cynodon dactylon* USDA PI 255455), Pangola (*Digitaria decumbens* Stent USDA PI 111110), Transvala digit (*Digitaria decumbens* USDA PI 299752), and Slenderstem digit (*Digitaria* spp. USDA PI 300935) grasses are among the most promising tropical forages, on the basis of clipping trials conducted in the central humid mountainous region of Puerto Rico (15, 16).

Considerable information is available on the response of Pangola (3, 10, 11, 17) and Star (2, 16) grasses to different N fertilization levels and harvest intervals. Superior performance of Transvala and Slenderstem cultivars over Pangola grass in dry forage (DF) yields at different growth

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stages was reported by Sotomayor-Ríos et al. (13, 14, 15). Transvala digitgrass is also identified as USDA PI 299601, 299608, 299837, and 364619 (1). Oakes and Sierra-Bracero (5) reported that Transvala digitgrass is more resistant to the yellow aphid (*Sipha flava*) attacks than Pangola grass. In Florida, Boyd et al. (1) reported that the Transvala cultivar is resistant to the Pangola stunt virus.

Two recent Limpo (*Hemarthria altissima*) grass cultivars (Greenalta USDA PI 299994 and Bigalta USDA PI 29995), released by the Florida Agricultural Experiment Station (7), were found to be highly productive at the Corozal Substation[3]. At present, there is no information in Puerto Rico on the response of these two new Limpograsses, nor of Transvala digitgrass, to different harvest intervals and N fertilization levels. Kretschmer Jr. and Snyder (4) indicated that the limpograsses, (Bigalta, Greenalta and Redalta) are of high productivity and that Bigalta responds well to N during the cool season. At present, these cultivars offer alternatives to commercially available tropical grasses.

The objective of this study was to compare the yield potential and the response to N fertilization levels of Limpo cultivars USDA PI 299994 and 299995 and of Transvala digitgrasses USDA PI 299752 with Pangola and Star grasses.

MATERIALS AND METHODS

The study was conducted over 1.5 years at the Corozal Agricultural Experiment Substation, where the mean ambient temperature during the experimental period was 24.8° C. Rainfall totalled 1962 mm during the first year (March 14, 1974 to March 14, 1975) and 496 mm during the 6 subsequent months (March 15, 1975 to September 15, 1975). The mean annual rainfall for the 10-year period, previous to 1974, was 1886 mm.

The soil type is a Corozal clay of the subgroup Aquic Tropudults (Ultisol). The original pH 4.6 was raised to approximately 5.4, by applying 5,040 kg of calcium carbonate per hectare as recommended by Riera (8).

The 5 grasses (table 1) were sprigged in October 1973 and evaluated initially on March 14, 1974, 5 mo after establishment. The experimental layout was a split-split plot design, with the 5 cultivars as the main plots and replicated 4 times; the harvest intervals (30, 45, and 60 days) as the sub-plots; and the N fertilization levels (low, 224; medium, 448; and high, 896 kg N/ha/yr) as the sub-sub-plots. Main plots were 4.57 × 9.14 m; sub-plots were 1.52 × 9.14 m; and sub-sub-plots were 1.52 × 3.05 m.

Ammonium sulphate $(NH_4)_2SO_4$ was the source of N. All plots also received 112 kg of P/ha/yr, applied in a single application as 46% superphosphate. Potassium, as KCl, was used at the rate of 336 kg/ha/yr. The annual amounts of N and K were divided into 6, 8, and 12 equal

[3] Unpublished data.

applications for the 60-, 45-, and 30-day harvest-interval treatments, respectively, and applied after each harvest. No irrigation was applied during the course of the experiment.

All grasses were harvested at approximately 8-cm height above the ground and weighed. Plot samples were taken, dried in a forced-air oven at 55° C, and ground in a Wiley mill[4] to pass through a 1-mm screen.

Dry matter (DM) was determined in all samples. For each harvest interval, samples were composited by harvests for each replication, and samples of each treatment were analyzed for P and K contents (9). Total N was determined with a Technicon Auto-Analyzer and crude protein (CP) was calculated as % N × 6.25.

The data for green forage (GF), DF, and CP yields and for DM content were subjected to analysis of variance and Duncan's multiple range test (12).

TABLE 1.—*Identification of the 5 forage grasses studied*

Grass species	USDA	PRPI[2]	Common name
Hermarthria altissima (Poir) (Stapf and C. E. Hubb.)	299995	6446	Bigalta Limpograss
Hemarthria altissima (Poir) (Stapf and C. E. Hubb.)	299994	6445	Greenalta Limpograss
Digitaria decumbens (Stent)	299752	6439	Transvala digitgrass
Cynodon nlemfuensis Vanderyst var. *nlemfuensis*	—	2341	Stargass
Digitaria decumbens (Stent)	111110	0560	Pangola digitgrass

[1] USDA plant introduction number.

[2] University of Puerto Rico Agricultural Experiment Station plant introduction number.

RESULTS AND DISCUSSION

Table 2 shows the annual GF, DF, and CP yields and DM content (means for 5 forage grasses, 3 harvest intervals and 3 fertilization levels). The highest GF yielder was Bigalta with 161,929 kg/ha/yr, outyielding significantly (P=.05) all the other grasses. The lowest GF yielder was Pangola with 105,510 kg/ha/yr. Bigalta presented the lowest DM content (23.61%), being significantly (P=.05) different from all other cultivars. No significant differences were observed between Bigalta, Transvala, and Star grasses, in DF yields (table 2). The lowest DF yielder was Pangola grass (24,461 kg/ha/yr). The CP yields ranged from 2,711 to 3,595 kg/ha/

[4] Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

yr for Greenalta and Star grasses, respectively. Bigalta and Transvala were not significantly inferior to Star in CP yields (table 2).

Mean GF and DF yields for the 30-day harvest interval (table 2 and fig. 1) differed significantly (P=.05) from those of the 45-day interval, and these in turn differed (P=.05) from those of the 60-day interval. Dry forage yields increased as harvest interval increased.

Mean GF, DF, and CP yields increased significantly (P=.05) from the low to the medium N fertilization levels (table 2). Between the medium and the high levels, there was no further increase in GF, whereas DF yield again increased significantly (P=.05). DM content was significantly (P=.05) less at the low and medium N levels than at the high N level.

TABLE 2.—*Effect of forage grass, harvest interval, and fertilizer level on mean green forage, dry forage, and crude protein yields and on dry matter content*

Identification	Green forage yield[1]	Dry matter content	Dry forage yield[2]	Crude protein yield[2]
	kg/ha/y	%	*kg/ha/y*	*kg/ha/y*
Bigalta	161929 a[3]	23.61 d	35421 a	3092 ab
Greenalta	111331 bc	28.57 b	29209 b	2711 b
Transvala	128055 b	27.69 b	31699 ab	3315 ab
Star	114703 bc	30.70 a	32383 ab	3595 a
Pangola	105510 c	25.74 c	24461 c	2840 b
30-day	107611 b	26.37 c	27513 b	2375 c
45-day	128301 a	27.15 b	31872 a	3131 b
60-day	137006 a	28.25 a	32519 a	3825 a
224 kg N/ha/y	117311 b	25.36 b	24903 c	3031 b
448 kg N/ha/y	128055 a	25.48 b	30146 b	3262 a
896 kg N/ha/y	127552 a	30.95 a	36855 a	3037 b
Grand mean	124306	27.26	30635	3110

[1] Means per grass, per harvest interval, and per fertilizer level.

[2] Weighted means considering dry forage or crude protein yields at different seasons of the year.

[3] Means in the same column followed by one or more letters in common do not differ significantly at the 5% probability level.

Research conducted in the humid mountainous region (Ultisol soils) by Caro-Costas et al. (2, 3) and Vicente-Chandler et al. (17, 18) demonstrated that DF yields of Guinea (*Panicum maximum*) Star, Pangola, Congo (*Brachiaria ruziziensis*), and Carib (*Eriochloa polystachya*) grasses increased sharply up to 448 kg N/ha/yr, and then slowly from 448 to 896 kg/N/ha/yr. A similar response to N levels was reported for Pará grass (*Brachiaria purpurascens* (Raddi) Hnr.) and Bermuda grass (*Cynodon dactylon*) in Uganda by Olsen (6).

There was a significant (P=.05) increase in CP yield between the low and medium N levels, but then a decrease between the medium and high

N levels (table 2). However, CP yields obtained at the low and high N levels did not differ significantly.

Table 3 shows the mean DF and CP yields of the individual grasses at each of the three fertilization levels. At the low N fertilization level, Bigalta and Transvala were the highest GF yielders, being significantly different (P=.05) from Greenalta and Pangola grasses. Transvala and

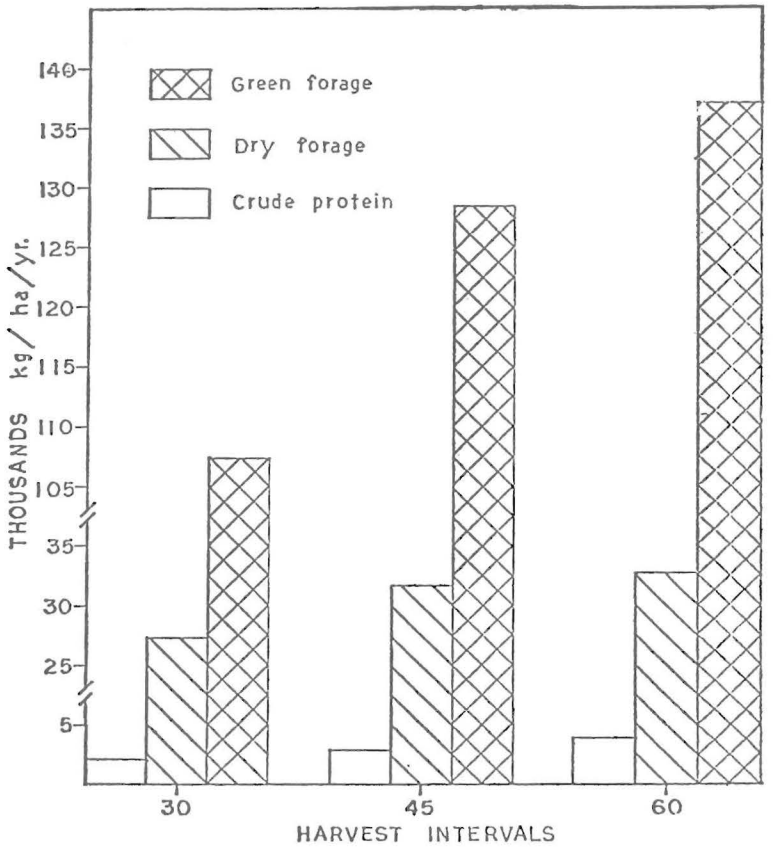

FIG. 1.—Mean green forage, dry forage, and crude protein yields of 5 tropical grasses at 30-, 45-, and 60-day harvest intervals.

Star grasses were the highest CP yielders with 3,453 and 3,365 kg/ha/yr, respectively, Greenalta being significantly lower (P=.05), with 2,521 kg/ha/yr.

At the medium and high N fertilization levels (table 3), Bigalta DF yield was significantly (P=.05) superior to all of the others, except Star.

Transvala, Star and Bigalta grasses were the best CP yielders at the

TABLE 3.—*Mean green forage, dry forage, and crude protein yields of 5 tropical grasses at 3 fertilization levels*

Grass species	224 kg N/ha/y		448 kg N/ha/y		896 kg N/ha/y	
	Dry forage yield[1, 2]	Crude protein yield[1, 2]	Dry forage yield	Crude protein yield	Dry forage yield	Crude protein yield
	kg/ha/y					
Bigalta	27099 a[3]	2940 ab	35379 a	3381 ab	43785 a	2951 b
Greenalta	22127 b	2521 b	29579 b	2877 b	35921 b	2735 b
Transvala	28439 a	3453 a	30677 b	3377 ab	35983 b	3117 b
Star	25133 ab	3365 a	31348 ab	3688 a	40668 a	3730 a
Pangola	21718 b	2879 ab	23746 c	2983 b	27921 c	2657 b
Grand mean	24903	3031	30146	3262	36855	3037

[1] Means for three harvest intervals.

[2] Weighted means considering dry forage or crude protein yields at different seasons of the year.

[3] Means in the same column followed by one or more letters in common do not differ significantly at the 5-% level.

TABLE 4.—*Mean crude protein, phosphorus, and potassium content of 5 tropical grasses at 3 fertilization levels*

Grass species	224 kg/ha/yr			448 kg/ha/yr			896 kg/ha/yr		
	Crude protein	Phospho-rus	Potas-sium	Crude protein	Phospho-rus	Potas-sium	Crude protein	Phospho-rus	Potas-sium
				%					
				30 days					
Bigalta	9.38	.27	3.25	10.63	.28	3.17	11.88	.27	3.18
Greenalta	10.00	.24	2.69	11.25	.23	2.87	12.50	.22	2.81
Transvala	10.00	.30	3.00	11.88	.28	3.06	14.38	.25	3.36
Star	11.88	.31	3.04	13.13	.30	3.28	15.00	.28	3.17
Pangola	11.25	.27	2.98	13.13	.25	3.23	16.25	.25	3.61
Mean	10.50	.28	2.99	12.00	.27	3.12	14.00	.25	3.23
				45 days					
Bigalta	8.13	.20	2.82	9.38	.21	2.74	11.25	.21	2.48
Greenalta	8.75	.20	2.57	9.38	.19	2.53	15.63	.19	2.51
Transvala	8.75	.23	2.72	10.63	.22	2.74	13.13	.21	3.05
Star	10.00	.25	2.60	11.25	.24	2.75	13.13	.22	2.73
Pangola	10.00	.24	2.71	12.50	.22	3.04	15.00	.22	3.31
Mean	9.13	.22	2.68	10.63	.22	2.76	13.63	.21	2.82
				60 days					
Bigalta	5.63	.14	2.38	6.88	.16	2.31	8.13	.16	2.42
Greenalta	6.88	.16	2.40	7.50	.16	2.41	8.13	.16	2.32
Transvala	6.88	.19	2.42	8.13	.17	2.36	10.63	.16	2.49
Star	7.50	.20	2.53	8.75	.19	2.57	10.00	.18	2.55
Pangola	7.50	.16	2.36	8.75	.16	2.39	11.88	.16	2.96
Mean	6.88	.17	2.42	8.00	.17	2.41	9.75	.16	2.55
Grand mean	8.84	.22	2.70	10.21	.22	2.76	12.46	.21	2.87

medium N level (table 3), whereas Star was best at the high N level, outyielding significantly (P=.05) all of the remaining cultivars. CP yields did not differ significantly among the rest of the cultivars at this level. On the basis of DF and CP yields, the high N level appears to be best for Star grass and the medium N level best for the other 4 grasses.

Table 4 shows the CP, P, and K contents for the five grasses at each N fertilization level and harvest interval. Forage CP content invariably increased as N fertilization increased, irrespective of the grass species or harvest interval. Bigalta tended to be the lowest in CP content and Pangola the highest. Forage CP content decreased as harvest interval increased, with the sole exception of 45-day Greenalta grass at the high N level. P content tended to decrease as harvest interval increased from 30 to 45 and from 45 to 60 days of age (table 4). In only one case P content was lower than 0.16%, this was in Bigalta at the low N level and the 60-day harvest interval. Thus, there was little evidence of deficiency of this nutrient in the forages throughout the experimental period (19). K content was consistently above 2.3%, indicating that forage yields were not limited by a lack of this mineral in the soil. According to Vicente-Chandler et al. (19), K contents of 1.0 to 1.5% are associated with high forage yields. Above this level, there is a tendency for "luxury" consumption of K.

RESUMEN

Se cultivaron cinco gramíneas tropicales: Estrella (*Cynodon nlemfuensis*), Transvala (*Digitaria decumbens*), Pangola (*Digitaria decumbens*) y dos Limpo (*Hemarthria altissima*, Bigalta y Greenalta), en la Subestación Experimental Agrícola de Corozal para medir durante 1.5 años los efectos de tres niveles de fertilización nitrogenada y de tres intervalos de corte (30, 45 y 60 días) en los rendimientos de forraje verde, forraje seco y proteína bruta y en los contenidos de materia seca, nitrógeno, fósforo y potasio. El suelo es un Ultisol, el cual no se regó.

Los niveles de nitrógeno, como sulfato amónico, aplicados después de cada corte, consistieron de 224 (nivel bajo), 448 (nivel mediano) y 896 (nivel alto) kg/ha y año, respectivamente.

El contenido de materia seca y los rendimientos de forraje seco y proteína bruta aumentaron significativamente al alargarse el intervalo de corte. Con el nivel mediano de N se lograron los mayores rendimientos de proteína bruta, excepto en el caso de Estrella, donde el nivel alto de fertilización produjo un mayor rendimiento de dicha fracción.

Las cultivares Bigalta, Estrella y Transvala produjeron los rendimientos más altos de forraje verde, forraje seco y proteína bruta. Los rendimientos de forraje seco (promedios globales para los tres intervalos de corte y los tres niveles de fertilización) de las cultivares Bigalta, Greenalta,

Transvala, Estrella y Pangola fueron 35,421, 29,209, 31,699, 32,383 y 24,461 kg/ha y año, respectivamente.

El contenido de proteína bruta aumentó según aumentaron los niveles de N, indenpendientemente de las cultivares o los intervalos de corte. Los valores medios obtenidos en el forraje para P y K fueron de .21 a .22% y de 2.70 a 2.87%, respectivamente, los cuales pueden considerarse normales y adecuados.

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