Response of tropical grasses to potassium fertilization in the humid coastal region of Puerto Rico[1]

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ABSTRACT

In 1982 and 1983 a field experiment was conducted in a Bayamón clay soil on a farm near Arecibo, Puerto Rico, to evaluate the effect of rates of K fertilization (0, 45, 136 and 272 kg/ha/year) on dry forage (DF), crude protein (CP) content and CP yields, K content and K uptake, and P, Ca, and Mg content. Six grasses (*Cynodon dactylon* cv. Coastcross-1, *Digitaria pentzii* cv. Slenderstem, *C. dotylon* cv. toño, *D. decumbens* cv. Transvala, *D. nlemfuensis* cv. Star and *D. decumbens* cv. Pangola) were cut at 45-day intervals. The mean DF yields of the first four grasses, 37,200 kg/ha, were significantly higher (P=0.05) than those of the other two in 1982. In 1983 the first grass was susceptible to weed infestation. The mean DF yields of the other grasses, 19,499 to 21,198 kg/ha, were significantly higher (P=0.05) than those of *C. nlemfuensis* cv. Star. The 136 and 272 kg/ha/year K rates produced significantly higher DF yields in 1982, but in 1983 only the highest rate had any signficant effect (P=0.05). The CP content of *D. decumbens* cv. Pangola, 12.29%, was significantly higher (P=0.05) than that of the others in 1982, but in 1983 *C. nlemfuensis* cv. Star showed a signficantly higher (P=0.05) CP content, 9.85%. Potassium rates did not have a significant effect (P=0.05) on CP content. CP yields were related to DF yields and followed similar patterns both years. The mean K content of all grasses was 1.75 and 1.53%; and K uptake was 603 and 299 kg/ha/year, in 1982 and 1983, respectively. These values were not significantly different (P=0.05) among species but they were significantly different (P=0.05) for the two highest K rates in 1982, and for the highest in 1983. The mean P content, 0.29%; Ca content, 0.46% and Mg content, 0.37%, were similar for all grasses and were not affected by K treatments.

INTRODUCTION

Potassium is limited for intensive forage production in the humid region of Puerto Rico (2). The sandy soils of the coastal plain are low in K content, and grasses harvested by cutting generally respond to applications of about 300 kg/ha/year (18). High yielding grasses in Puerto Rico take up as much as 600 kg/ha/year of K when grown with high N fertilization rates and harvested by cutting, but *Digitaria decumbens* cv. Pangola responded to only 200 kg/ha/year of K, whereas other grass species

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(17) responded to 400. In previous research at Arecibo, grasses harvested by cutting every 6 weeks on a Bayamón sandy clay soil (Typic Haplorthox) showed K deficiency symptoms, even though they were fertilized with 136 kg of K_2O. However, the *Cynodon* spp. appeared to be less affected by the deficiency. The K supplied naturally by this type of soil is usually less than 100 kg/ha/year (2); therefore, K deficiencies can be expected to occur after 1 year of intensive forage production. *Digitaria decumbens* cv. Pangola PR PI 0560 has been shown to be more productive than *Cynodon nlemfuensis* var. *nlemfuensis* cv. Star PR PI 2341 when cut at 60-day intervals, but it is more susceptible to virus disease and insect damage (9). However, in another experiment Star was more productive when cut at 30-day and 45-day intervals, whereas *Digitaria decumbens* cv. Transvala USDA PI 299752 was more productive than both grasses when cut at a 60-day interval (10). These results were confirmed by further experimentation under similar conditions, in which dry matter production of more than 30,000 kg/ha/year was obtained (11, 15).

Cynodon dactylon cv. Bermudagrass USDA PI 293611, *Cynodon dactylon* cv. Coastcross-1 USDA PI 255455 and *Digitaria pentzii* cv. Slenderstem USDA PI 300935 are also productive grasses with very high yields of dry matter. They have been evaluated in Puerto Rico when harvested by clipping (12, 13). However, the K requirement of such high yielding grasses has not been determined under intensive management systems in the humid coastal region of Puerto Rico.

The objectives of this research were to evaluate the effects of K fertilization on dry forage (DF) production and chemical composition of *Cynodon* and *Digitaria* grass species under clipping in the humid coastal region of Puerto Rico.

MATERIALS AND METHODS

The experiment was conducted on a private farm near Arecibo, lat. 18° 28′ N and long. 67° 18′ W, in the humid coastal region of Puerto Rico, with a mean annual rainfall of 1375 mm, well distributed throughout the year, and a mean daily temperature of 25.4° C. The soil is a Bayamón clay (Typic Haplorthox), pH 5.0 with 18 p/m available P and 27 p/m exchangeable K in the top 20 cm. The soil was limed 2 months before planting to raise pH to approximately 6.6, according to the method described by Riera (7). A randomized split-plot design was used with four replications, in which grass cultivars were the main plots and K fertilizer treatments were the subplots. The grass cultivars are identified in the following tabulation. Potassium rates consisted of 0, 45, 136 and 272 kg/ha/year in 8 equal applications of potassium sulphate. All plots received N and P_2O_5 at a rate of 504 and 168 kg/ha/year, respectively.

Species	*USDA PI*[3]	*PR PI*[4]
Cynodon dactylon cv. Toño	293611	11212
C. dactylon cv. Coastcross-1	255455	11504
C. nlemfuensis var. *nlemfuensis* cv. Star	——	2341
Digitaria decumbens cv. Pangola	111110	0560
D. decumbens cv. Transvala	299752	6439
D. pentzii cv. Slenderstem	300935	11537

All grasses were harvested at a 45-day interval after an initial cutting at the end of 1981, 4 months after planting. The plots were harvested at approximately a 6-cm stubble. Green forage was weighed in the field, and samples were taken and dried at 55° C in a forced air oven for 48 hours, then ground to pass a 1-mm screen in a Wiley mill.

Dry matter content was determined in each individual sample. Subsamples were composited by replication in each harvest interval and analyzed for N, P, K, Ca and Mg. Crude protein content was computed as N × 6.25. Soil samples were taken at a 20-cm depth in each plot at the beginning and after each year of the experiment to determine pH, available P (Bray 1), and exchangeable K.

Analyses of variance and Duncan's multiple range test (8) were conducted each year for dry forage yield (DF), crude protein (CP) content and CP yield, K content and K uptake.

RESULTS AND DISCUSSION

The following tabulation shows the mean dry forage (DF) yields for each grass for all potassium fertilization rates combined for the first and second years of experimentation. The species response was significantly different (P=0.05) in both years. During the first year *Cynodon dactylon* cv. Coastcross-1, *Digitaria pentzii* cv. Slenderstem, and *C. dactylon* cv. Toño produced the highest yields and significantly surpassed (P=0.05) the other species, except *D. decumbens* cv. Transvala. The latter, in turn, was as productive as *C. nlemfuensis* cv. Star, but more productive than *D. decumbens* cv. Pangola.

Species	*First Year*	*Second Year*
	— *kg/ha* —	
Cynodon dactylon cv. Coastcross-1	38,533 a[5]	——[6]
Digitaria pentzii cv. Slenderstem	37,902 a	20,159 a

[3]United States Department of Agriculture plant introduction number.

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

[5]Means in the same column followed by the same letter do not differ significantly at the 5% probability level.

[6]Susceptible to weed invasion during the second year.

Cynodon dactylon cv. Toño	37,409 a	19,499 a
Digitaria decumbens cv. Transvala	34,957 ab	20,069 a
Cynodon nlemfuensis cv. Star	31,685 bc	16,564 b
Digitaria decumbens cv. Pangola	28,653 c	21,198 a

In the second year all the grasses showed similar DF yields, except for *C. nlemfuensis* cv. Star, which was significanly lower (P=0.05). The DF yields of all grasses studied over the 2-year period were similar to those previously reported for this region of Puerto Rico under similar cutting frequency and intensive management with high rates of N, P and K fertilization, either as chemical fertilizer or in combination with solid cattle manure (11, 12, 13, 14, 15, 17).

These results did not indicate any consistent difference in grass species in relation to response to K fertilization or susceptibility to K deficiency. These same results appeared in another report (16). The effect of K rates on the mean DF yields of all grasses, as shown in the following tabulation indicated that the first year the species response was significantly different (P=0.05) up to 136 kg/ha/year; but in the second year the difference was significant (P=0.05) only at the higher rate of 272 kg/ha/year. During neither year was there any significant interaction (P=0.05) among grass species and K rates of fertilization, since species were similar.

Potassium rates	*First Year*[7]	*Second Year*[7]
kg/ha	*— kg/ha —*	
0	33,691 c[8]	19,045 b
45	34,495 bc	19,223 b
136	35,724 a	19,246 b
272	35,517 ab	20,477 a

The mean DF yields in this experiment were higher at lower rates of K than those reported for *C. nlemfuensis* at a K rate of 672 kg/ha/year (1). Also the present responses were less than those found in this region by other investigators (16). However, the K rates in their experiment were much higher. Differences in natural soil fertility among different soils in the experimental sites explain part of these differences in grass response.

The crude protein (CP) content of forage was significantly different (P=0.05) among species in both years of the experiment (table 1), but rates of K fertilization had no significant effect (P=0.05) in either year

[7]Mean for six and five grasses during the first and second years of experiment, respectively.

[8]Means in the same column followed by the same letter do not differ significantly at the 5% probability level.

TABLE 1.—*Mean crude protein content and yield of crude protein of tropical grasses with potassium rates in a Bayamón clay soil at Arecibo, Puerto Rico, 1982-1983*

Species	First year		Second year	
	C.P.	Yield	C.P.	Yield
	%	*kg/ha*	%	*kg/ha*
Cynodon dactylon cv. Coastcross-1	10.21c[1]	3,928a	—[2]	—
Digitaria pentzii cv. Slenderstem	9.98c	3,773ab	7.78b	1,656a
Cynodon dactylon cv. Toño	9.97c	3,726ab	8.10b	1,580a
Digitaria decumbens cv. Transvala	10.69bc	3,728ab	7.96b	1,591a
Cynodon nlemfuensis cv. Star	11.21b	3,544b	9.85a	1,622a
Digitaria decumbens cv. Pangola	12.29a	3,512b	8.04b	1,626a

[1] Means in the same column followed by the same letter do not differ significantly at the 5% probability level.

[2] Invaded by weeds during the second year.

(table 2), nor was there any significant interaction (P=0.05) between species and K rates.

During the first year the CP content of *D. decumbens* cv. Pangola was significantly higher (P=0.05) than that of *C. nlemfuensis* cv. Star, which in turn was similar to *D. decumbens* cv. Transvala, but significantly higher (P=0.05) than those of the other grasses. The following year only *C. nlemfuensis* cv. Star showed a significantly higher (P=0.05) protein content compared to the other grasses. The mean CP yields for all grasses and rates of K fertilization were 3,700 and 1615 kg/ha for the first and second years of experiment, respectively (tables 1 and 2). CP yields were closely related to DF yields and followed the same pattern of response among species and rates of K fertilization discussed above. A number of similar results are reported in the literature in regard to CP content and CP yields for these grasses when intensively managed under cutting and heavily fertilized with N, P and K in the humid region of Puerto Rico (11, 12, 13, 14, 15, 17). The mean K content and K uptake

TABLE 2.—*Effect of potassium rates on the mean crude protein content and crude protein yield of tropical grasses in a Bayamón clay soil at Arecibo, Puerto Rico, 1982-1983*

Potassium rates	First year[1]		Second year[1]	
	CP	Yield	CP	Yield
kg/ha/year	%	*kg/ha*	%	*kg/ha*
0	10.85 n.s.[2]	3611 b[2]	8.52 n.s.	1607 ab
45	10.49	3602 b	8.45	1613 ab
136	10.63	3759 ab	8.14	1549 b
272	10.91	3835 a	8.29	1691 a

[1] Mean for six and five grasses during the first and second years of experiment, respectively.

[2] Means in the same column n.s. or followed by the same letter do not differ significantly at the 5% probability level.

for all grasses was 1.75 and 1.53%, and 603 and 299 kg/ha, during the first and second years of the experiment, respectively (table 1). There was no significant difference (P=0.05) among species. The effects of K rates were significant (P=0.05) for both parameteers during both years (table 2), but there was no significant interaction (P=0.05) among species and K rates. The 136 and 272 kg/ha/year rates were equally effective and both were significantly higher (P=0.05) than the lower rates during the first year. During the second year there was a significant response (P=0.05) only at the higher K rate. The mean K content of the grasses was similar to that previously reported with the same species under similar conditions in the region (12, 13, 15).

Potassium contents of 1.0 to 1.5% of the DF have been associated with high yields of tropical grasses in the region. Higher content is considered luxurious consumption of potassium by these grasses (18). These guidelines were based on data from the tall grasses *Pennisetum purpureum* cv. Napier and *Panicum maximum*. In the present investigation the highest DF yields in both years were associated with 1.80 to 1.98% K content in DF (table 2). This finding suggests higher critical K levels for stoloniferous species, such as *Cynodon* and *Digitaria* spp., than those of tall grasses. González and Torriente (4) also found in Cuba that the critical K level for *C. dactylon* cv. Coastcross-1, 2.60%, was higher than those of *P. maximum* and *Cenchrus ciliaris*.

The mean K uptake for all species (table 1) was higher during both years than the K removal reported by Abruña et al. (2) for similar soils in the region. The uptake of K by the forages during both years (table 2) was much higher than the fertilizer K applied in all treatments and higher than those reported in the literature (1, 18). Apparently, either the K-supplying power of the Bayamón clay soil is higher than anticipated or the forage species in the present study were more efficient in utilizing available K in the soil profile of this deep soil of better natural mineral content than in sandy clay soils.

On the other hand, the significantly higher DF yields related to higher K rates (table 2) seemed to be associated with higher rates of exchangeable K in the topsoil for each year individually (table 3). Therefore, exchangeable K in the soil was related to DF yields as was found by Abruña et al. (2). Less than 25 p/m K might indicate a marginal level for high DF yields under intensively managed systems with these species when compared with an initial exchangeable K level of 18 p/m (table 3). Table 3 also shows that the K rates did not affect soil pH in the topsoil the first year. However, pH decreased with time faster at higher K rates, probably because of more extraction of cations by higher DF yields, in addition to the residual acidity of nitrogen fertilization. Available P was not affected by K rates, but showed an accumulative increase associated with P throughout the experiment.

TABLE 3.—*Mean potassium content and potassium uptake of tropical grasses with potassium rates in a Bayamón clay soil at Arecibo, Puerto Rico, 1982-1983*

Species	First year		Second year	
	K	Uptake	K	Uptake
	%	kg/ha	%	kg/ha
Cynodon dactylon cv. Coastcross-1	1.62 n.s.[1]	628 n.s.	—[2]	—
Digitaria pentzii cv. Slenderstem	1.90	719	1.49 n.s.	322 n.s.
Cynodon dactylon cv. Toño	1.67	622	1.75	340
Digitaria decumbens cv. Transvala	1.62	517	1.19	240
Cynodon nlemfuensis cv. Star	2.00	644	1.85	310
Digitaria decumbens cv. Pangola	1.73	492	1.39	283

[1] Means in the same column do not differ significantly at the 5% probability level.
[2] Invaded by weeds the second year.

The mineral composition of the grasses showed no important differences among species in either year, except perhaps for *C. nlemfuensis* cv. Star, which had a higher P content both years, and *D. decumbens* cv. Transvala, which was higher in Ca content in both years (table 4). There was a tendency in all species for a decrease in Mg content from the first to the second year of the experiment, a fact which might be related to a decrease in Mg content in the soil under intensively managed systems and lower yields of DF during the second year of the experiment. The forage P, Ca and Mg contents in the present investigation were higher than those reported in the literature for other tropical grasses in Puerto Rico (3), but they were still approximately adequate to meet the dietary requirements for both beef and dairy cattle, more so in the case of Mg (5, 6).

TABLE 4.—*Effect of potassium rates on the mean potassium content and potassium uptake of tropical grasses in a Bayamón clay soil at Arecibo, Puerto Rico, 1982-1983*

Potassium rates	First year[1]		Second year[1]	
	K content	Uptake	K content	Uptake
kg/ha/year	%	*kg/ha*	%	*kg/ha*
0	1.49 b[2]	502 b	1.28c	249 c
45	1.60 b	549 b	1.44 bc	273 bc
136	1.89 a	660 a	1.61 b	308 b
272	1.98 a	703 a	1.80 a	368 a

[1] Mean for six and five grasses during the first and second years of experiment, respectively.
[2] Means in the same column followed by the same letter do not differ dignificantly at the 5% probability level.

TABLE 5.—*Soil pH, phosphorus, and potassium changes in a Bayamón clay soil with potassium rates at Arecibo, Puerto Rico, 1982-1983*

Potassium rates	Initial year[1]			End first year[2]			End second year[3]		
	pH	P	K	pH	P	K	pH	P	K
kg/ha/year		*p/m*			*p/m*			*p/m*	
0	6.83	19	16	6.50	36	22	6.20	37	15
45	6.84	18	18	6.60	32	25	6.09	34	16
136	6.69	18	16	6.40	34	33	5.85	33	20
272	6.77	18	17	6.42	39	45	5.82	36	24

[1] Mean of 4 replications at 0-20 cm soil depth after liming and before planting.
[2] Mean of 4 replications for six grass plots at 0-20 cm soil depth.
[3] Mean of 4 replications for five grass plots at 0-20 cm soil depth.

TABLE 6.—*Mean mineral content of tropical grasses with potassium rates in a Bayamón clay soil at Arecibo, Puerto Rico, 1982-1983*

Species	First year			Second year		
	P	Ca	Mg	P	Ca	Mg
			%			
Cynodon dactylon cv. Coastcross 1	0.26	0.43	0.43	—[1]	—	—
Digitaria pentzii cv. Slenderstem	0.23	0.44	0.55	0.29	0.43	0.39
Cynodon dactylon cv. Toño	0.27	0.46	0.36	0.31	0.41	0.27
Digitaria decumbens cv. Transvala	0.27	0.58	0.38	0.29	0.48	0.25
Cynodon nlemfuensis cv. Star	0.35	0.47	0.39	0.37	0.46	0.32
Digitaria decumbens cv. Pangola	0.26	0.49	0.46	0.28	0.38	0.29

[1] Invaded by weeds the second year.

RESUMEN

Respuesta de gramíneas tropicales a la fertilización con potasio en la costa húmeda de Puerto Rico

En 1982 y 1983 se estudió en un suelo arcilloso Bayamón de una finca cerca de Arecibo, Puerto Rico, el efecto de la fertilización con potasio (0, 45, 136 y 272 kg./ha. y año) sobre el rendimiento de forraje seco (DF), el contenido en proteína bruta (CP) y el rendimiento de CP, el contenido en K y Ca, absorción de K y contenidos en P, Ca y Mg en el forraje seco de las 6 gramíneas (*Cynodon dactylon* cv. coastcross-1, *Digitaria pentzii* cv. slenderstem, *C. dactylon* cv. Toño, *D. decumbens* cv. transvala, *C. nlemfuensis* cv. estrella y *D. decumbens* cv. pangola) cortadas a intervalos de 45 días. Las medias de forraje seco de las primeras 4 gramíneas, 34,957 a 38,533 kg./ha., fueron significativamente más altas (P = 0.05) que las de las otras dos en 1982, pero en 1983 la primera fué susceptible a las malezas, y las medias para las otras, 19,499 a 21,198 kg./ha., fueron significativamente más altas (P = 0.05) que la de *C. nlemfuensis* cv. estrella. La aplicación de 136 y 272 kg./ha. y año de K produjeron rendimientos de DF más significativos (P = 0.05) en 1982, pero en 1983 solamente la aplicación más alta tuvo un efecto significativo (P = 0.05). El contenido en CP de *D. decum-*

***bens* cv. Pangola, 12.29%, fue más significativo (P=0.05) que el de las otras especies en 1982; pero en 1983 *C. nlemfuensis* cv. estrella mostró un contenido en CP, 9.85%, más significativo (P=0.05). Los valores de K no tuvieron un efecto significativo (P=0.05) en el contenido en CP. Los rendimientos de CP estuvieron relacionados con los rendimientos de DF y siguieron patrones similares en ambos años. El contenido medio en K, 1.75 y 1.53%, y la absorción de K, 603 y 299 kg./ha. y año, en 1982 y 1983, respectivamente, no fué significativamente diferente (P=0.05) en ninguna especie, pero si significativamente diferente (P=0.05) en las dos aplicaciones más altas de K en 1982 y del contenido más alto en 1983. Los contenidos medios en P, 0.29%; Ca, 0.46%; y Mg, 0.37%, fueron similares en todas las gramíneas y no se afectaron por los tratamientos de K.**

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