Potential of *Stylosanthes guianensis* as a Forage Crop in the Humid Mountain Region of Puerto Rico[1]

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ABSTRACT

The potential of *Stylosanthes guianensis* var. Endeavor as a forage crop was evaluated in an Ultisol of the humid mountain region of Puerto Rico. The effects of P and K fertilizers on yield of dry forage (DF), and contents of crude protein (CP), P and K in its leaves and stems were examined. All plots were initially fertilized with N at the rate of 56 kg/ha. The P and K, as triple superphosphate and potassium sulfate, respectively, were tested at three levels (P: 0,98 and 196; K:0, 186 and 372 kg/ha) divided into 10 applications, one after each harvest during the 764-day cropping period.

Yields of DF and CP were not affected by P and K, but in two of the ten harvests, percent CP was highest from plots treated with 98 kg/ha/yr of P and zero K treatment; over all harvest percent CP was higher in this treatment than in either the non-fertilized nor the zero P and 372 kg/ha K treatment. Total DF yields were high, from 21.0 to 24.0 metric tons/ha. Data on DF and CP suggest that *S. guianensis* is a potentially valuable forage crop for the low fertility Ultisols of the humid region.

INTRODUCTION

Endeavor stylo (*Stylosanthes guianensis* cv, Endeavour), one of the new and most promising legumes for the tropics (6), is adaptable to a wide range of soils. Adult plants are vigorous and can be harvested continuously from about 4-6 months after planting to about 6 years, which is considered the maximum period of economic production. Stylo fixes substantial quantities of atmospheric N under conditions of low soil fertility without prior inoculation (15) since the nodulating organism is present in most soils. According to Harding (6), it is a high yielding forage legume that grows well in association with other grasses such as *Brachiaria decumbens*, *Digitaria decumbens* and *Paspalum coryphaeum*. Stylo-grass associations have been reported to produce remarkable increases in carrying capacity of pasture and weight gains of animals (15).

In general, *Stylosanthes* grows well under low fertility conditions (5, 13), but *S. humilis* and *S. guianensis* have reportedly responded to P under certain conditions. Ortega (9) reported that application of 131 kg of P/ha/yr to a clay soil increased DF yields from 2.5 metric tons/ha/yr

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in the control to 9.6 metric tons/ha/year. Other researchers compared the forage potential between stylo and other forages (6, 8, 15).

For many years these scientists at the University of Puerto Rico Agricultural Experiment Station have been introducing and evaluating many legumes. Most are apparently unsuitable for intensive management systems. Among these legumes, only tropical Kudzu (*Pueraria phaseoloides*) has been tested extensively under grazing conditions (12, 17).

We designed our study to evaluate the potential of *Stylosanthes guianensis* as a forage crop under conditions in the humid mountain region of Puerto Rico, the effect of P and K on the yields of DF and CP, and on the content of P and K in var. Endeavour when grown in pure stands during a 764-day period.

MATERIALS AND METHODS

The experiment was conducted at the Corozal Substation, located at 213 m above sea level. The soil is a Corozal clay, Aquic Tropudults (7). The soil of this region was described by the USDA-Soil Conservation Service[3] and the climate by Capiel and Calvesbert (3). We applied lime to raise the pH from 4.5 to 6.0, according to the method of Riera (10).

Seed was scarified in concentrated sulfuric acid for 6 minutes and drained in running water for 10 minutes. At planting time about 56% of the seed germinated in petri dish tests.

The design was a randomized complete block with four replicates. Plots were 6.1 × 6.1 m with rows spaced 0.6 m apart. An alley of 0.9 m was left between plots.

Immediately after planting (October 23, 1973) all plots received a blanket application of N as ammonium sulfate at a rate of 56 kg/ha. Phosphorus was applied as triple superphosphate and K as potassium sulfate. The corresponding amount for each treatment was applied in five equal applications per year after each of ten harvests. The P and K treatments, in kg/ha, were as follows: 1 = 0 P - 0 K; 2 = 0 P - 372 K; 3 = 98 P - 0 K; 4 = 98 P - 372 K; and 5 = 196 P - 186 K.

The legume was harvested by machete. Harvest 1 was 135 days after planting (March 7, 1974); and harvest 10, November 26, 1975. Forage was cut about 20 cm above ground, weighed and removed from all plots. Samples were dried at 63°C and ground to pass through a 1 mm screen.

Yields of GF, DF and CP were calculated for each harvest. Nitrogen and P were determined by the Technicon microanalyzer (11). Potassium was analyzed with a Beckman DU flame spectrophotometer.

During the experimental period (October 23, 1973 to November 26,

[3] Detailed Soil Survey and Descriptive Legends of the Agricultural Experiment Station Farms, University of Puerto Rico, Mayaguez Campus, USDA Soil Conservation Service, Caribbean Area, 1968.

1975), rainfall totalled 3,571 mm. Mean annual temperature was 23.8°C. Supplemental irrigation was applied only until all plots were established. Data were subjected to analysis of variance, and significant differences were identified with Duncan's multiple range test.

RESULTS AND DISCSSION

Table 1 gives data on yield, DM, CP and rainfall for each harvest period. In 9 out of 10 crops, the fertilizer treatments did not significantly alter GF and DF. Average percent DM was highest for crop 3 (33%) which received the least amount of rainfall and lowest for crop 10 (17%) which received a high amount of rainfall (565 mm). The DM did not differ significantly among treatments for any harvest.

Percent CP differed significantly among treatments only for harvests 5, 6, and 10. In harvest 5 and 6 percent CP was highest from the application of 98 kg/ha of P and zero K. Percent CP was highest in crop 1, probably because of the initial application of N.

Table 2 shows total yields, CP, P and K contents of forage for each treatment over the 10 harvests. The GF yield was highest with treatment 2 (zero P and 372 kg/ha/yr of K), 17% more than the control (treatment 1). The DM contents of the 5 treatments were very similar. Yields of DM and CP did not differ signficantly among treatments. On an annual basis, CP yields from the control plots (1.7 metric tons/ha) were comparable with those reported by Caro-Costas et al. (4) from a pure stand of Napier grass (i.e. 2.0 metric tons/ha/yr) that was cut every 2 months and fertilized at a rate of 336 kg of N/ha/yr, even though in this study the plots received only an initial application of 56 kg/ha of N fertilizer for a 764-day cropping period.

In treatment 3 (98 kg/ha/yr of P and zero K) N content in plant tissues was significantly higher than that in treatments 1 and 2 (table 2). Plant P content was significantly higher in treatment 5 than in treatments 1 and 2. Increased P contents in *Stylosantheses humilis* and *Stylosanthes guianensis* var. Endeavour with increased P levels were reported by Gates (5) and Ortega (9), respectively. A reduction in P contents in different *Stylosanthes guianensis* accessions with increasing level of K was reported by Brolman and Sonoda (2). In our tests average K content in plant tissues was similar for the five treatments. The lowest K content, 2.997, is not considered deficient (2). The fact that total DF yields throughout the experimental period did not increase with K levels probably could be explained by the high soluble K in the soil for this crop. Abruña et al. (1) reported that Humatas soil, a similar upland Ultisol, released large quantities of K, averaging 260 kg/ha, during the first year. After that K removal dropped off sharply to an average of about 90 kg/ha yearly which was sustained during the subsequent 3 years. It can be estimated that at least 630 kg of K (21,010 × .03) was removed from the control plots during the 10 harvests. Soil samples analyzed after harvest 10 contained the following amounts of soluble K:

Treatment, kg/ha		*Soluble K, kg/ha*
0 P	0 K	336
0 P	372 K	672
98 P	0 K	384
98 P	372 K	652
196 P	186 K	540

The final amount of soluble K (i.e. 336 kg/ha) in the control plots suggests that even after 10 harvests soluble K was adequate in this unfertilized soil. This fact might account for the lack of response to K applications in this experiment.

The DF yield (5.7 metric tons/ha) was highest in harvest 4, from July 9 to September 9, 1974. During this fast growth period, the plants received 466 mm of rainfall. The DF yield (2.7 metric tons/ha) was much lower from harvest 5 (September 10–November 26, 1974) when the plants were flowering; rainfall was 843 mm. In harvest 6 (November 27, 1974–February 12, 1975) DF yield declined to 0.7 metric tons/ha; rainfall was 309 mm. The period from November to March is characterized by dry, rather cool days, and the tropical grasses grow slowly, as previously reported (14, 17). The short cool days from November to February at Corozal and the fact that the legume was flowering could explain the yield decline in harvest 6. Rainfall apparently is important during the long days. The DF yield increased to 1.1 metric tons/ha in harvest 7 (February 13–April 11, 1975) when the plants received 162 mm of rainfall but declined sharply at harvest 8. The DF yield for this growth period (April 12 to July 29, 1975) was only 0.6 metric ton/ha and rainfall was only 191 mm.

The high yields of *S. guianensis* are encouraging. The DF and CP yields from the control plots 10.1 and 1.7 metric tons/ha/year, respectively, are about 64% and 71% of those from the best bermuda grasses (15.8 and 2.4 metric tons/ha/yr) when cut every 30 days and grown under intensive fertilization in the same region (16). Besides its potential for good yields of DF and CP, *S. guianensis* could probably be useful in mixtures with grasses such as *Panicum* and Brachiarias. The plant could also be a useful legume in restoring N levels in some of our tropical soils.

RESUMEN

Un experimento para evaluar el potencial de *Stylosanthes guianensis*, cv. Endeavour en la zona central montañosa de Puerto Rico y determinar el efecto de varias dosis de P y K sobre los rendimientos de forraje seco,

TABLE 1.—*Yield and crude protein content of* Stylosanthes guianensis *grown over a period of 764 days at Corozal*

Treatment number[1]	Date and number of crop									
	3-7-74 1	5-7-74 2	7-8-74 3	9-9-74 4	11-26-74 5	2-12-75 6	4-11-75 7	7-29-75 8	9-10-75 9	11-26-75 10
					Green forage (t./ha)					
	NS	NS	NS	NS		NS	NS	NS	NS	NS
1	2.8	4.7	9.2	28.0	10.9 b[2]	1.9	3.6	2.5	10.0	16.8
2	2.5	5.2	10.0	26.0	19.9 a	3.1	4.3	2.8	11.0	20.7
3	2.9	5.0	9.7	28.0	10.0 b	3.1	3.8	1.3	11.3	18.2
4	2.4	4.8	9.9	27.4	10.6 b	2.2	3.3	1.7	11.1	22.4
5	2.3	5.5	9.2	27.1	9.3 b	2.5	4.0	2.0	8.9	21.7
$\bar{X}$	2.6	5.0	9.6	27.3	12.1	2.6	3.8	2.1	10.5	20.0
					Dry matter content (%)					
	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
1	22	30	34	22	23	28	28	30	24	17
2	24	26	34	21	21	28	29	29	22	17
3	22	26	31	20	22	28	31	29	23	15
4	22	26	32	22	22	28	29	29	21	16
5	20	28	33	21	23	30	30	28	22	19
$\bar{X}$	22	27	33	21	22	28	29	29	22	17
					Dry forage (t/*ha*)					
	NS	NS	NS	NS		NS	NS	NS	NS	NS
1	0.6	1.4	3.1	6.0	2.5 b	0.5	1.0	0.8	2.4	2.8
2	0.5	1.4	3.4	5.3	4.3 a	0.9	1.3	0.8	2.5	3.6
3	0.6	1.3	3.0	5.5	2.2 b	0.8	1.2	0.4	2.5	2.8
4	0.6	1.2	3.2	6.0	2.3 b	0.6	1.0	0.5	2.3	3.4
5	0.5	1.6	3.0	5.6	2.1b	0.8	1.0	0.5	2.0	4.2
$\bar{X}$	0.6	1.4	3.0	5.7	2.7	0.7	1.1	0.6	2.3	3.4

					Crude protein (%)					
	NS	NS	NS	NS		NS	NS	NS	NS	NS
1	23.75	19.97	17.31	16.31	17.47 b	20.47 b	16.62	16.28	16.03	17.13 a
2	23.94	20.12	16.44	16.44	17.44 b	19.50 b	16.44	16.78	16.12	15.44 c
3	25.22	20.43	17.56	17.38	19.72 a	21.20 a	16.44	17.91	16.81	17.47 a
4	25.34	20.53	16.25	17.03	17.40 b	19.53 b	16.75	17.28	17.12	16.13 bc
5	24.09	19.16	17.41	16.62	17.72 b	19.06 b	16.88	18.06	17.15	16.66 ab
$\bar{X}$	24.46	20.04	16.99	16.75	17.95	19.95	16.62	17.26	16.25	16.56
					Crude protein (t/ha/yr)					
	NS	NS	NS	NS		NS	NS	NS	NS	NS
1	0.144	0.274	0.519	0.954	0.448 b	0.111	0.162	0.113	0.328	0.481
2	0.129	0.272	0.558	0.877	0.749 a	0.170	0.209	0.132	0.395	0.553
3	0.163	0.272	0.529	0.968	0.432 b	0.183	0.194	0.64	0.425	0.486
4	0.142	0.250	0.519	1.023	0.398 b	0.118	0.163	0.80	0.393	0.553
5	0.112	0.297	0.517	0.938	0.371 b	0.146	0.171	0.94	0.339	0.686
$\bar{X}$	0.138	0.273	0.528	0.952	0.480	0.146	0.180	0.97	0.376	0.552
Rainfall (mm)	555	155	123	466	843	309	162	191	203	565

[1] 1 = 0 P and 0 K; 2 = 0 P and 372 kg/ha K; 3 = 98 kg/ha P and 0 K; 4 = 98 kg/ha P and 372 kg/ha K; 5 = 196 kg/ha P and 186 kg/ha K.

[2] In each column means followed by the same letter do not differ significantly (P = .05), according to Duncan's multiple range test. NS = Non significant.

TABLE 2.—*Yield, crude protein and chemical composition of* Stylosanthes guianensis *grown over 764 days at Corozal*

Treatment number	P	K	Green forage yield	Dry matter content	Dry forage yield	Crude protein yield	Crude protein content	Average percent composition (dry basis)		
								N	P	K
			mt/ha	%	*t/ha*		%	%	%	%
				NS	NS	NS				NS
1	0	0	90.4 b[1]	25.75[2]	21.0	3.5	17.14 b	2.742 b	0.270 b	3.007
2	0	372	105.6 a	25.27	24.0	4.0	16.52 b	2.642 b	0.262 b	3.140
3	98	0	93.2 ab	24.63	20.4	3.7	18.56 a	2.970 a	0.305 ab	3.065
4	98	372	95.8 ab	24.68	21.1	3.6	17.49 ab	2.797 ab	0.295 ab	3.042
5	196	186	92.7 ab	25.39	21.3	3.7	17.72 ab	2.835 ab	0.317 a	2.997

[1] Data are means for four replicate plots and include 10 crops. In each column means followed by one or more letters in common do not differ significantly (P = .05), according to Duncan's multiple range test.

[2] NS = Non significant.

de proteína bruta y su composición quimica se realizó en un suelo Ultisol de dicha región. El experimento se extendió por 764 dias consecutivos. Las dosis de P y K variaron de 0 a 196 y 372 kg/ha y año, respectivamente.

Ni el abonamiento con P ni con K aumentaron significativamente el contenido de materia seca, el rendimiento de forraje seco y el rendimiento de proteína bruta en la producción total (10 cosechas), o sea, desde el 23 de octubre de 1973 hasta el 26 de noviembre de 1975.

Parece ser que a mayor pluviosidad más altas son las producciones de forraje seco. En el primer año la producción media más altas, 5.7 Tm/ha se obtuvo en el corte 4 (9 de julio al 9 de septiembre de 1974), el cual coincidió con unos de los períodos más lluviosos, o sea 466 mm. En el segundo año la producción más baja, 0.6 Tm/ha se reflejó en la octava cosecha, comprendida del 12 de abril et 29 de julio de 1975, en uno de los períodos más secos (191 mm). La sequnda producción más baja, 0.7 Tm/ha tuvo lugar en los días cortos del año cuando las plantas estaban en plena floración.

Los rendimientos de proteína bruta total no se afectaron significativamente por las dosis de P y K. Esta varió de 3.5 (parcelas control) a 4.0 Tm/ha y año en los 764 días de duración del experimento.

El contenido en P del tejido foliar aumentó significativamente con las aplicaciones de P, variando de 0.27% para el tratamiento control a 0.32% para la aplicación de 196 y 186 kg P y K/ha y año, respectivamente. El contenido en K del tejido foliar no aumentó significantivamente con las aplicaciones de K.

De los datos del estudio que aqui se informa se desprende que esta leguminosa tiene un magnífico potencial como productora de forraje seco y proteína bruta (CP). Su potencial de producción anual en términos de proteína bruta alcanzó un 71% del logrado por los mejores tipos de pastos Bermuda disponibles en Puerto Rico cuando éstos se cosechan cada 30 días y se abonan intensivamente en la región húmeda montañosa.

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