Production of grazed tropical grasses in different agroecosystems in Puerto Rico. II. humid northern coastal plains[1]

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ABSTRACT

A field experiment was conducted near Barceloneta in the humid northern coastal plains of Puerto Rico to evaluate the production and persistence of 10 tropical grasses: *Cynodon* sp. Local, *Digitaria pentzii* Slenderstem, *C. nlemfuensis* Star, *C. plectostachyus* Star, *C. dactylon* Coastcross-1, *D. milanjiana* Pangola Soto, *Panicum maximum* Guinea, *P. maximum* Guinea USDA PI 259553, *P. maximum* Makueni and *D. decumbens* Transvala grazed at 3- to 5-week intervals for one and a half year. *P. maximum* USDA PI 259553 was the most productive grass, but during the 13 grazings in 1981-1982, it was not significantly different (P=0.05) from *C. plectostachyus* Star; *Cynodon* sp. Local, *D. pentzii* Slenderstem, *C. nlemfuensis* Star, *P. maximum* Makueni, and *D. decumbens* Transvala. Guinea and *D. milanjiana* Pangola Soto were the least productive (P=0.05). Results for 7 grazings from January to June 1983 again showed *P. maximum* USDA PI 259553 to be the most productive grass, although not significantly different (P=0.05) from *D. decumbens* Transvala, *C. dactylon* Coastcross-1 and *D. pentzii*. The production of *P. maximum* Makueni and *C. plectostachyus* Star was intermediate; *C. nlemfuensis* Star and Guinea were the least productive, and *D. milanjiana* Pangola Soto did not persist under intensive grazing (P=0.05). The total mean production of all grasses of 0.92 and 1.00 ton/ha/grazing, respectively, were related to rainfall distribution. The general mean in crude protein content of forage was higher during the drier months. Average production of all grasses in this experiment was lower than in a similar experiment at Corozal in the humid region of Puerto Rico, the relative difference varied among cultivars.

INTRODUCTION

The soils of the northern coastal plains are characterized by being less acid than those of the humid mountain region (1). They range from gently sloping to sloping, have medium natural fertility and are very well suited for pastures. At the present time this area sustains the most important milkshed in Puerto Rico, accounting for more than 50% of the total fresh milk produced.[3]

[1]Manuscript submitted to Editorial Board 30 April 1986.

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[3]Ramírez, A., 1984. Progress of the dairy industry in Puerto Rico. Presented at the Hill Farm Research Station, Louisiana State University, Homer, La. 71040.

Digitaria pentzii Slenderstem PI 11537 and *D. decumbens* Transvala PR PI 6439 are highly productive grasses under cutting (6, 8, 10, 13). Both grasses have also produced high yields and persisted well for 2 years under intensive grazing (3, 10, 15). *D. milanjiana* Pangola Soto is a highly productive grass in the humid mountain region when harvested by cutting (12), but it has not been evaluated for persistence under grazing.

Cynodon plectostachyus PR PI 11212, *C. plectostachyus*, PR PI 11487 and *C. nlemfuensis* var. *nlemfuensis* PR PI 2341 have been three of the most productive grasses under cutting management in different trials in the humid region (7, 8, 11, 14). In small plots *C. dactylon* Bermuda and *C. nlemfuensis* var. *nlemfuensis* produced high yields of forage and persisted under intensive grazing for 2 years in the mountain region (10). On the other hand, after 1 year of evaluation under clipping, *C. dactylon* cv. Coastcross-1 had been invaded by weeds (9).

Among *Panicum maximum* types, Guinea and USDA 259553 each produced over 40,000 kg/ha of dry forage with intensive cutting management in Gurabo (5), whereas Makueni PR PI 12917 has been as productive as Guinea under high levels of fertilization in the humid mountain region at Corozal (13). Guinea is among the highest producers of dry matter under grazing management (17) and Makueni has been one of the outstanding grasses in the region under grazing in small plots (10). These outstanding grasses need further evaluation in different regions of Puerto Rico to determine their performance under the complexity of grazing conditions in different agroecosystems.

The objective of the present investigation was to evaluate forage production and persistence of selected grass species adapted to the humid northern coastal plains of Puerto Rico subjected to grazing in small plots.

MATERIALS AND METHODS

The experiment was conducted on a private farm located near Barceloneta, lat. 18° 27′ N and long. 66° 33′ W, at an elevation of 4 m, in the humid northern coastal plains of Puerto Rico. Mean annual rainfall is 1360 mm, well distributed throughout the year, and mean daily temperature is 20 ° C, with seasonal variations of about 2° C.

The soil is an Islote clay (Typic Tropudalfs) with original pH 5.3, 80 p/m available P (Bray I) and 81 p/m exchangeable K in th top 15 cm. The soil was limed at a rate of 2,240 kg/ha 3 months before planting in May 1981 and 1 year later in May 1982.

A randomized block design with four replications and 10 grass cultivars (table 1) in 8x8 m plots was established August 1981. The grasses were fertilized with a 15-5-10 fertilizer at a rate of 1,600 kg/ha/year divided in four equal applications throughout he year.

All plots were cut initially at 10 cm above ground in October 1981, 2 months before grazing at 3- to 5-week intervals to a height of about 15 cm, with a group of 35 adult animals for a period of 1 to 2 days (mob grazing).

The forage offered in each plot was determined by sampling before and after grazing, with the pair quadrats method described by Rivera and Rodríguez (2). Green forage weight was determined in the field, and samples were dried at 55° C in a forced air oven for 48 hours to determine dry matter content. Monthly hand-picked forage samples were composited by replicates of each grass treatment, dried at 55° C in a forced air oven, ground in a Wiley mill to pass a 1-mm screen and analyzed for N content with a Technicon Autoanalyzer. Crude protein (CP) was calculated as N x 6.25. The procedure was repeated over 1.5 consecutive years with data from 13 grazing dates during the first year (1981 to 1982) and 7 for the following 6 months (1983). The experiment was discontinued because of deterioration of one of the cultivars by overgrazing.

RESULTS AND DISCUSSION

Panicum maximum USDA PI 259553 was the most productive grass under grazing during the first year of experiment in 1981-1982, although it was not significantly different (P=0.05) from *Cynodon plectostachyus* Star, *Cynodon* sp. Local, *Digitaria pentzii* cv Slenderstem, *C. nlemfuensis* Star, *P. maximum* Makueni, and *D. decumbens* Transvala (table 2). Guinea and *D. milanjiana* Pangola Soto were the least productive cultivars (P =0.05).

The average production of all grasses was related to rainfall distribution. The lowest average production per period for all grasses, 0.26 ton/ha (table 2), was from April 12 to May 10, which was a dry period in the

TABLE 1.—*Identification of grass cultivars*

Grass number	Species	USDA PI[1]	PR PI[2]
1	*Cynodon* sp. cv. Local	——	——
2	*Digitaria pentzii* cv. Slenderstem	300935	11537
3	*C. nlemfuensis* var. *nlemfuesis* cv. Star	——	2341
4	*C. plectostachyus* cv. Star	341818	11487
5	*C. dactylon* cv. Coastcross-1	255455	11504
6	*Digitaria malanjiana* cv. Pangola Soto	299699	6543
7	*Panicum maximum* cv. Guinea	——	——
8	*P. maximum* cv. Guinea	259553	3622
9	*P. maximum* cv. Makueni	349676	12917
10	*D. decumbens* cv. Transvala	299752	6439

[1]United States Department of Agriculture plant introduction number.
[2]University of Puerto Rico Agricultural Experiment Station plant introduction number.

TABLE 2.—*Mean dry forage on offer of tropical grasses under grazing in the humid northern coastal plains at Barceloneta, Puerto Rico, 1981-1982*

Grass number	Grazing dates													Mean per grazing	Total per year
	Dec. 1 1981	Jan. 4 1982	Feb. 4 1982	Mar. 8 1982	Apr. 12 1982	May 10 1982	Jun. 7 1982	Jun. 28 1982	Aug. 2 1982	Aug. 31 1982	Sep. 27 1982	Nov. 1 1982	Nov. 30 1982		
	ton/ha														
3	1.88 a[1]	1.67 a	0.90 ab	0.91 abc	1.14 a	0.27 abc	1.59 ab	0.74 a	0.97 c	0.76 cd	0.48 bcd	0.60 a	0.26 f	0.94 abc	12.21 abc
2	1.77 ab	0.66 bc	0.87 ab	0.74 bc	1.40 a	0.34 ab	1.26 abc	0.93 a	1.39 bc	1,86 a	0.91 b	0.75 a	0.48 ef	1.03 abc	13.36 abc
5	1.74 ab	0.73 bc	0.34 b	0.71 bc	1.24 a	0.06 bc	1.32 abc	0.77 a	1.54 abc	0.87 bcd	0.95 b	0.64 a	0.65 de	0.99 bc	11.56 bc
6	1.32 bc	1.03 b	0.41 ab	1.00 abc	0.17 c	0.01	0.50 c	0.02 b	0.32 c	0.13 d	0.17 s	0.00 b	0.00 g	0.39 d	5.07 d
1	1.19 c	0.68 bc	1.17 ab	1.21 ab	1.28 a	0.24 abc	0.93 bc	0.74 a	0.72 abc	1.76 abc	0.24 cd	0.37 ab	1.15 ab	0.97 abc	12.68 abc
4	1.16 c	0.94 bc	0.85 ab	0.99 abc	1.27a	0.31 abc	215 a	0.99 a	1.92 abc	1.70 abc	0.63 bcd	0.47 a	0.86 bcd	1.10 ab	14.24 ab
10	0.99 c	0.77 bc	1.12 ab	1.38 a	0.96 ab	0.27 abc	1.73 ab	0.88 a	0.75 c	1.70 abc	0.81 bc	0.44 ab	1.01 bc	0.99 abc	12.91 abc
9	0.34 d	0.25 c	0.68 ab	0.73 bc	0.41 bc	0.32 abv	1.77 ab	0.74 a	2.34 ab	2.33 a	1.64 a	0.55 a	0.73 cde	0.99 abc	12.83 abc
8	0.25 d	0.29 c	0.99 ab	0.88 abc	0.68 abc	0.48 a	1.88 a	0.94 a	2.79 a	2.06 a	1.57 a	0.70 a	1.38 a	1.15 a	14.98 a
7	0.14 d	0.38 bc	1.11 ab	0.52 c	0.31 bc	0.23 abc	1.55 ab	0.73 a	2.60 ab	1.78 abc	0.62 bcd	0.31 ab	0.49 ef	0.83 c	10.79c
Mean	1.08	0.74	0.86	0.91	0.89	0.26	1.47	0.75	1.63	1.49	0.80	0.49	0.70	0.92	12.06

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

TABLE 3.—*Monthly rainfall at Barceloneta during the course of the experiment, 1981-1983*

Month	1981	1982	1983
	mm		
January	42	92	15
February	98	61	9
March	48	35	22
April	108	35	218
May	440	282	126
June	170	98	119
July 151	86	120	
August	139	72	116
September	132	124	77
October	90	63	
December	423	236	65
Total	1,991	1,331	1,111

region in 1982 (table 3). *P. maximum* USDA PI 259553 produced almost twice as much forage during this dry period (table 2), although it was not statistically different (P=0.05) from the other grasses except *C. dactylon* Coastcross-1, and *D. milanjiana* Pangola Soto.

During the rainy period from May 10 to June 7, 1982, all grasses were highly productive, except for *D. milanjiana* Pangola Soto, which continued to deteriorate under the intensive grazing. During the second part of the rainy season, from August 2 through September 26, 1982, (fig. 1), *P. maximum* USDA PI 259553 and Makueni continued to be the most productive grasses and *Cynodon* Local and *C. nlemfuensis* Star the least productive (P=0.05). Total production for the first year of *P. maximum* USDA PI 259553 and *Cynodon* Local was higher than that of the other grasses (P=0.05), but production of the former was more consistent throughout the year (table 2).

In the final 6 months of the experiment, from January 3 to June 13, 1983 (table 4), *P. maximum* USDA PI 259553 continued to be the most productive grass, although it was not significantly different (P=0.05) from *D. decumbens* Transvala, *C. dactylon* Coastcross-1 and *D. pentzii.* The production of *P. maximum* Makueni and *C. plectostachyus* Star was intermediate; *C. nlemfuensis* Star and Guinea were the least productive, and *D. milanjiana* Pangola Soto did not persist under intensive grazing (P=0.05).

Again, average production of all grasses was related to rainfall distribution. The exceptionally high production in January 3, 1983, (table 4), followed very high rainfall in December 1981 (fig. 1). Thereafter, production decreased markedly in January, February and March 1983, a period of low rainfall and cool weather. During this period *D. decumbens* Tran-

TABLE 4.—*Mean dry forage on offer of tropical grasses under grazing in the humid northern coastal plains at Barceloneta, Puerto Rico, 1983*

Grass number	Grazing dates							Mean per grazing	Total per year
	Jan. 3 1983	Jan. 24 1983	Feb. 24 1983	Mar. 29 1983	May 3 1983	May 23 1983	Jun. 13 1983		
	ton/ha								
10	3.02 a[1]	1.68 a	1.13 ab	1.25 ab	1.45 bcd	0.17 bc	1.11 b	1.40 a	9.08 a
8	2.74 ab	0.41 cd	0.40 cd	0.93 abc	2.56 a	0.77 ab	2.12 a	1.43 a	10.01 a
9	2.72 ab	0.30 cd	0.37 cd	0.34 bcd	1.64 b	0.81 ab	1.45 ab	1.09 bcd	7.63 bcd
5	2.42 ab	0.88 bc	1.46 a	1.09 abc	1.32 bcd	0.51 abc	1.22 b	1.27 ab	8.88 ab
2	2.33 ab	1.06 abc	1.24 ab	1.38 a	1.11 cd	0.42 abc	0.60 bc	1.16 bc	8.15 abc
4	1.93 ab	1.34 ab	0.90 abc	1.05 abc	1.31 bcd	0.40 abc	0.79 bc	1.10 bcd	7.72 bcd
3	1.69 b	0.76 bcd	0.73 bc	0.49 abc	0.70 e	0.70 e	0.23 abc	0.77 e	5.43 e
7	1.65 b	0.23 cd	0.45 cd	0.18 cd	1.57 b	0.95 a	0.75 bc	0.83 de	5.79 de
1	1.51 b	0.73 bcd	0.78 bc	1.33 a	0.96 cde	0.13 bc	1.20 b	0.95 xde	6.64 cde
6	0.00 c	0.00 e	0.00 e	0.00 e	0.00 f	0.00 d	0.00 d	0.00 f	0.00 f
Mean	2.01	0.74	0.75	0.81	1.26	0.44	1.01	1.00	7.00

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

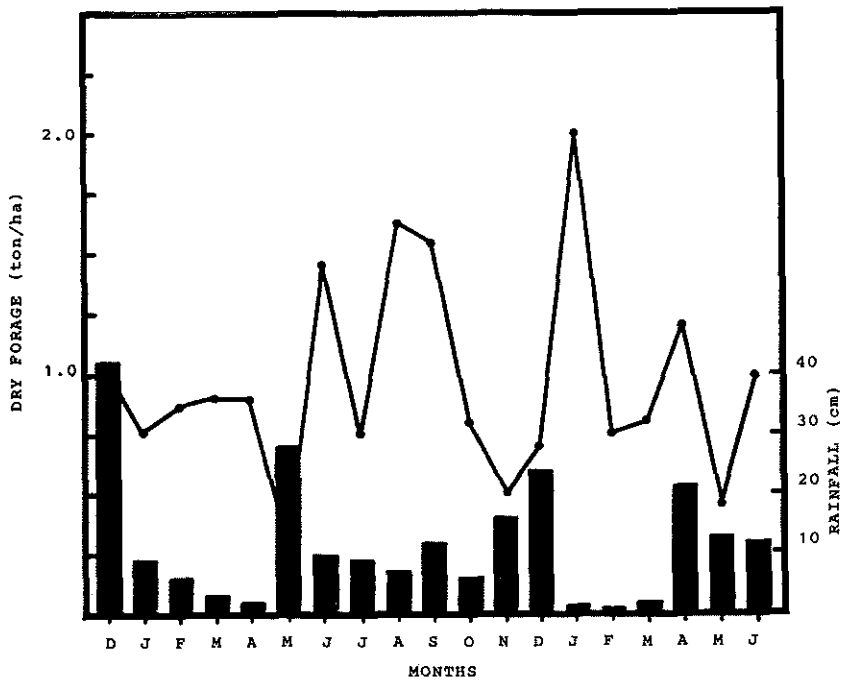

FIG. 1.—Seasonal dry forage on offer, mean for all grasses grazed in small plots every 3 to 5 weeks at Barceloneta, Puerto Rico, 1981 to 1983.

vala, *C. dactylon* Coastcross-1, *D. pentzii* Slenderstem, and *C. plectostachyus* Star were in general more productive than Guinea grass, unlike during the rainy season after March 29, 1983. The experiment was terminated after the June 13, 1983, grazing because of low production and deterioration of the stand in some plots. In general, production of all grasses in this experiment was lower than that observed in a similar experiment at Corozal, in the humid mountain region of Puerto Rico (9). This can be ascribed to lower production during the dry season at Barceloneta, but it varied among cultivars. For instance, the production of *P. maximum* Makueni was only 60% and that of *C. nlemfuensis* Star 80% of the production the one reported at Corozal, respectively (10); however, the production of *C. plectostachyus* was similar, and that of *D. pentzii* Slenderstem was higher in this experiment than the one at Corozal (10).

The mean CP content was similar for all grasses (table 5). *C. plectostachyus*, *C. nlemfuensis* var. *nlemfuensis* and the local cultivar of *Cynodon* sp. showed the higher CP content, 15.19, 14.52 and 14.57 %, respectively. The lowest CP content was found in *D. pentzii* cv. Slenderstem. In general, there was a tendency for a higher CP content associated with lower yields, and viceversa, except in November. There is a concentration or dilution effect, related to the amount of forage produced with similar N content in the soil which has been reported in previous experiments in the humid mountain region at Corozal (4, 16, 17).

Rainfall distribution is better and the dry season is shorter in the humid mountain region than in the northern coastal plains, and additional contribution factors may include differences in ambient temperatures during the dry season and in soil fertility. Nevertheless, *P. maximum* USDA PI 259553 is a cultivar highly productive in a number of different circumstances, i.e., under cutting in Gurabo (5), under grazing at Corozal (16) and as in the present investigation.

RESUMEN

Producción de gramíneas tropicales pastadas en diferentes ecosistemas agrícolas de Puerto Rico. II. Llanuras húmedas de la Costa Norte

En agosto de 1981 se estableció un experimento cerca de Barceloneta en las llanuras húmedas de la costa norte de Puerto Rico para determinar la producción y persistencia de 10 gramíneas tropicales pastadas en parcelas pequeñas. *Cynodon* local, *Digitaria pentzii* slenderstem, *C. nlemfuensis* estrella, *C. plectostachyus* estrella, *C. dactylon* coastcross-1, *D. milanjiana* pangola Soto, *Panicum maximum* guinea común, *P. maximum* USDA PI 259553, *P. maximum* makueni y *D. decumbens* Transvala se pastaron a intervalos de 3 a 5 semanas con un grupo de 35 animales adultos por un período de 1 a 2 días a una altura de 15 cm. a partir de diciembre de 1981 hasta junio de 1983. *P. maximum* USDA PI 259553 fue la más productiva en 13 apacentamientos el primer año de 1981 a 1982, con una media de

TABLE 5.—*Mean crude protein content of dry forage on offer of tropical grasses under grazing in the humid northern coastal plains at Barceloneta, Puerto, Rico, 1981-1983*

Grass number	Grazing dates												Mean per grazing
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sept.	Oct.	Nov.	
4	20.75	17.62	15.50	16.75	9.87	18.37	14.25	11.75	15.87	14.12	15.37	12.12	15.19
3	20.00	17.87	16.37	18.87	8.62	20.00	14.25	11.25	16.25	11.62	10.37	8.75	14.52
5	19.62	14.25	12.00	13.25	10.25	20.00	12.00	10.00	15.25	9.62	10.62	10.50	13.11
6	18.75	20.12	15.00	14.12	11.00	19.50	14.00	12.12	15.50	12.00	10.62	12.12	14.57
9	18.75	14.37	13.12	11.62	11.12	24.12	9.87	7.37	13.37	10.50	10.75	8.25	12.77
7	18.00	15.00	12.12	12.87	6.75	23.37	14.87	12.62	16.12	9.37	11.25	13.00	13.78
8	17.62	14.25	11.00	12.62	11.62	20.87	13.20	12.40	13.62	10.75	9.62	13.12	13.39
2	16.50	16.87	12.62	9.37	10.37	20.75	11.87	11.62	11.37	7.87	8.37	8.00	12.13
1	15.00	16.62	15.00	17.25	14.25	17.00	13.37	11.19	14.25	14.12	15.00	11.37	14.57
Mean	18.33	16.33	13.64	14.08	10.43	20.44	13.07	11.19	14.62	11.10	11.33	9.92	13.78

[1]Means of 4 replications for two years.

1.15 ton./ha. de materia seca por intervalo de apacentamiento aunque no fue estadísticamente diferente (P=0.05) de *Cynodon plectostachyus* estrella, *Cynodon* sp. local, *Digitaria pentzii* slenderstem, *C. nlemfuensis* estrella, *P. maximum* makueni, y *D. decumbens* transvala. La guinea común y *D. milanjiana* pangola Soto fueron las menos productivas (P=0.05). La producción media de todas las gramíneas estuvo relacionada con la distribución de las lluvias; la mínima por período para todas las gramíneas, 0.26 ton./ha., ocurrió entre abril 12 y mayo 10, que correspondió a la época más seca en la región ese año. *P. maximum* USDA PI 259553 produjo casi el doble que las otras forrajeras durante este período seco, aunque no fue significativamente diferente (P=0.05) de las otras, con excepción de *C. dactylon* coastcross-1 y *D. milanjiana* pangola Soto. Durante el período más lluvioso, de mayo 10 a junio 7, 1982, todas las gramíneas fueron altamente productivas, excepto *D. milanjiana* Pangola Soto, la cual continuó deteriorándose y no resistió el apacentamiento intensivo. El contenido medio en proteína bruta del forraje fue mayor durante los meses más secos. Durante 6 meses del segundo año, de enero 3 a junio 13, 1983, *P. maximum* USDAPI 259553 continuó siendo la más productiva, aunque no fue significativamente diferente (P=0.05) de *D. decumbens* transvala, *C. dactylon* coastcross-1 y *D. pentzii* slenderstem. La producción de *P. maximum* makueni y *C. pectostachyus* estrella fue intermedia; *C. nlemfuensis* estrella y guinea común fueron las menos productivas (P=0.05) y *D. milanjiana* pangola Soto no persistió con un apacentamiento intensivo. De nuevo, la producción media de todas las gramíneas estuvo relacionada con la distribución de las lluvias. La producción excepcionalmente alta en enero 3 de 1983, estuvo relacionada con fuertes lluvias en diciembre de 1982. Luego la producción disminuyó marcadamente en enero, febrero y marzo de 1983, a causa de las pocas lluvias y posiblemente a temperaturas más bajas. Durante este período *D. decumbens* transvala, *C. dactylon* coastcross-1, *D. pentzii* slenderstem y *C. plectostachyus* estrella fueron en general más productivas que la guinea, a diferencia del caso durante la estación lluviosa después del 29 de marzo de 1983. El experimento se terminó en junio 13, de 1983 debido a la baja producción y deterioro de algunas parcelas. La producción media de todas las gramíneas en este experimento fue más baja que la observada en un experimento similar en Corozal en la región montañosa húmeda de Puerto Rico por la menor producción durante la estación seca, pero estas diferencias relativas variaron con las cultivares estudiadas.

LITERATURE CITED

1. Acevedo, G., 1982. Survey of Arecibo area of northern Puerto Rico. USDA Soil Conservation Service.
2. Rivera, E. and J. Rodríguez, 1980. Forage yield of five grasses under intensive grazing management in the humid region of Puerto Rico, *J. Agric. Univ. P. R.* 64 (3): 259-63.
3. Rodríguez, J., E. Rivera and J. Vicente-Chandler, 1980. Productivity of four intensively managed grasses under grazing management in the humid hill region of Puerto Rico, *J. Agric. Univ. P. R.* 64 (2): 236-46.

4. Soldevila, M., 1980. Effect of rotation length in pangola pastures upon the liveweight gain of growing Holstein heifers, *J. Agric. Univ. P. R.* 64 (2): 243-46.
5. Sotomayor-Ríos, A., A. Acosta-Matienzo and J. Vélez-Fortuño, 1971. Yield comparison and plant character correlations of 16 *Panicum* accessions, *J. Agric. Univ. P. R.* 55 (2): 174-83.
6. ——, —— and ——, 1973. Evaluation of seven forage grasses at two cutting stages, *J. Agri. Univ. P. R.* 57 (3): 173-8.
7. ——, F. J. Juliá and J. A. Arroyo-Aguilú, 1974. Effects of harvest intervals on the yield and composition of 10 forage grasses, *J. Agric. Univ. P. R.* 58 (4): 448-55.
8. ——, J. Vélez-Santiago, S. Torres-Rivera and S. Silva, 1976. Effect of three harvest intervals on yield and composition of nineteen forage grasses in the humid mountain region of Puerto Rico, *J. Agric. Univ. P. R.* 60 (3): 294-309.
9. Tergas, L. E., J. Vélez-Santiago and D. Vera de Saldaña, 1986. Response of tropical grasses to potassium fertilization in the humid coastal region of Puerto Rico, *J. Agric. Univ. P. R.* 72 (1): 00.
10. ——, ——, and ——. 1986. Productivity of tropical grasses under grazing in different agroecosystems in Puerto Rico. I Humid mountain, *J. Agric. Univ. P. R.* 72 (1): 00.
11. Vélez-Santiago, J. and J. A. Arroyo-Aguilú, 1983. Nitrogen fertilization and cutting frequency, yield and chemical composition of five tropical grasses, *J. Agric. Univ. P. R.* 67 (2): 61-69.
12. —— and ——, 1984. Comparison of six *Stylosanthes* cultivars and *Digitaria milanjiana* in the humid mountain region of Puerto Rico, *J. Agric. Univ. P. R.* 68 (4): 355-64.
13. —— and ——, 1984. Influence of two fertilizer levels on forage and crude protein yields of seven tropical grasses, *J. Agric. Univ. P. R.* 68 (4): 471-78.
14. ——, A. Sotomayor-Ríos and S. Torres-Rivera, 1979. Effects of three harvest intervals and two fertilizer rates on the yield and HCN content of ten *Cynodon* cultivars, *J. Agric. Univ. P. R.* 63 (1): 35-44.
15. Vicente-Chandler, J., J. Rodríguez and F. Abruña, 1972. Effects of two heights and three intervals of grazing on the productivity of heavily fertilized Pangola grass pastures, *J. Agric. Univ. P. R.* 56 (2): 110-14.
16. ——, R. Caro-Costas, F. Abruña y S. Silva, 1983. Producción y utilización intensiva de las forrajeras en Puerto Rico, Esta. Exp. Agric. Univ. P. R. Bol. 271.
17. ——, F. Abruña, R. Caro-Costas, J. Figarella, S. Silva and R. W. Pearson, 1974. Intensive Grassland Management in the Humid Tropics of Puerto Rico, Agric. Exp. Stn. Univ. P. R. Bull. 233.