Effect of Three Harvest Intervals on Yield and Nutritive Value of Seven Napiergrass Cultivars[1]

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ABSTRACT

Seven Napier or elephant grass cultivars (*Pennisetum purpureum* Schum.) were evaluated at the University of Puerto Rico Corozal Agricultural Experiment Substation for 2 years to measure the effect of 30-, 45-, and 60-day harvest intervals on green forage (GF), dry forage (DF), and crude protein (CP) yields, leaf/stem ratio, and chemical composition.

As the grasses advanced in maturity from 30 to 45 and from 45 to 60 days, GF, DF, and CP yields increased in all cultivars. Significant ($P < .05$) differences occurred among cultivars as to GF, DF, and CP yields during the 2-year period. The highest DF yields were obtained by cultivars 13079, 13078, 7353, and 7350. Significant ($P < .05$) differences also occurred among cultivars as to GF and DF yields during the short-day and dry-month periods of the year. Leaf/stem ratio was higher during the short-day and dry-month periods, and lower during heavy rainfall periods. At the 45-day harvest interval, cultivar 13079 was highest in neutral-detergent fiber, acid-detergent fiber, and lignin contents, but lowest in CP and estimated digestibility contents.

INTRODUCTION

Many dairymen utilize Napier or elephant grass (*Pennisetum purpureum* Schum.) as soilage for cattle feeding in Puerto Rico. The variety Merker has been exclusively used due to its high yield, aggressiveness, persistence, and ability to compete with weeds under intensive fertilizer management. This grass is generally harvested every 50 to 60 days when its yield and nutritive value are rather high (15).

Napier grass has been thoroughly studied in Puerto Rico and other countries (1, 2, 3, 10, 14, 15, 17, 19, 20, 21, 22). Caro-Costas et al. (5) in Puerto Rico and Takahashi (18) in Hawaii reported excellent performance of this grass under grazing management. In 1954, Boneta-García (4) compared green forage (GF) yields of 6 *Pennisetum* cultivars at 3 different regions of Puerto Rico. Comparative cutting trials of elephant grass varieties were reported in other countries by Delgado *et al.* (6), Garrido-Virguez (7), Pereira et al. (11) and Zuñiga et al. (24).

This study was conducted in order to compare the yield of 6 *Pennisetum purpureum* cultivars with that of cultivar Merker at 30-, 45-, and 60-day harvest intervals in the humid mountainous region of Puerto Rico. Criteria considered were total and seasonal GF and dry forage (DF) yields, chemical composition, crude protein (CP) yields, leaf/stem ratio,

[1] Manuscript submitted to Editorial Board February 21, 1980

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and estimated digestible (EDDM), true (ETDDM), and apparent (EADDM) digestible dry matter values of the 7 cultivars.

MATERIALS AND METHODS

The experiment was conducted over a 2-year period (January 1975 to January 1977) at the Corozal Agricultural Experiment Substation on a Corozal clay of the sub-group Aquic Tropudults (Ultisol), with phosphorus (P), potassium (K), and magnesium (Mg) contents of 2.5, 196, and 3.1 p/m at the level of 20 cm of soil, respectively. Calcium carbonate was applied 2 months before planting to raise the pH from 4.8 to approximately 6.0 (12). After the first year, the soil was limed to a sustained pH of 6.0.

The following tabulation shows the identification of the 7 cultivars.

USDA PI[3]	*PR PI*[4]	*Other*
—	7350	—
285303	13079	—
300086	13078	—
—	7353	—
—	—	Merker
337620	11720	—
—	—	I-12

Three-month-old mature cuttings (3-bud pieces) were planted per row, with the double cane per row method. The experimental design was a randomized split plot, with the cultivars as main plots, each replicated 4 times, and 30-, 45-, and 60-day harvest intervals as the sub-plots. Main plots were 7.32 × 6.96 m and sub-plots 2.44 × 6.96 m. Sub-plots consisted of 4 rows 0.61 m apart. A 1.22-m alley was left between main plots.

All plots were fertilized at a rate of 4,484 kg/ha/yr with a commercial formula, analysis 15-5-10. The total annual fertilizer was divided into 12, 8, and 6 equal applications for 30-, 45-, and 60-day harvest intervals, respectively, and the corresponding amount applied after each harvest. All cultivars were harvested at approximately 5-cm height above the ground. The forage was weighed, sampled, dried at 60°C, and ground in a Wiley[5] mill to pass through a 1-mm screen.

The mean annual temperature during the 2 years was 76.0°C, 90.8°C maximum and 67.8°C minimum. During the first and second years, rainfall totalled 1,389 and 1,390 mm, respectively. The plots were not irrigated.

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

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

[5] 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.

DM was determined in all samples. For each harvest interval, samples were composited by replications. Each treatment was analyzed for total nitrogen (N) with a Technicon auto-analyzer and for P and K by the method of foliar diagnosis (13). CP was calculated as N × 6.25. Forty-five-day samples were analyzed for neutral-detergent fiber (NDF), acid-detergent fiber (ADF), lignin (L), and silica (Si) (8). Neutral-detergent soluble (NDS) content was calculated as the difference between 100 and NDF. Hemicellulose content was calculated as the difference between NDF and ADF. Digestibility values were calculated from Goering and Van Soest's summative equation (8):

$$\% \text{ estimated digestible dry matter} = 0.98\ (\% \text{ NDS}) + \% \text{ NDF}\ [180.8 - 96.6 \log_{10} (\% \text{ L}/\% \text{ ADF})\ 100],$$

$$\% \text{ estimated true digestible dry matter} = 0.98\ (\% \text{ NDS}) + \% \text{ NDF}\ [180.8 - 96.6 \log_{10} (\% \text{ L}/\% \text{ ADF})\ 100] - 3.0\ (\% \text{ Si}),$$

$$\% \text{ estimated apparent digestible dry matter} = 0.98\ (\% \text{ NDS}) + \% \text{ NDF}\ [180.8 - 96.6 \log_{10} (\% \text{ L}/\% \text{ ADF})\ 100\ ] - 3.0\ (\% \text{ Si}) - 12.9$$

Leaf/stem ratio was measured for the 45- and 60-day harvests in the second year. Before each harvest, 30 canes were taken at random for leaf/stem determinations.

The 2-year data for GF, DF, and CP yields and for DM and CP contents were subjected to variance analysis, with Duncan's multiple range test (16). A particular analysis was conducted in order to compare the DF yields at 45- and 60-day harvest intervals during the short-cool days of the year.

RESULTS AND DISCUSSIONS

Table 1 and figure 1 show mean GF, DF and CP yields and DM and CP contents of the 7 cultivars at the 30-, 45-, and 60-day harvest intervals during the 2-year period. At the 30-day harvest interval, the most productive as to GF, DF, and CP yields were cultivars 7350, 13079, 13078, 7353, and Merker. The least productive were cultivars 11720 and I-12. Cultivars I-12 and 11720 were lowest in DM but highest in CP content.

At the 60-day harvest interval, cultivars 13078, 7350, and 13079 produced the highest GF yields and outyielded significantly ($P < .05$) cultivars I-12, Merker, and 11720 (table 1). Highest DF yielders were cultivars 13078, 13079, 7350, and 7353. These were significantly ($P < .05$) different from cultivars Merker, I-12, and 11720.

Table 2 shows the mean values for GF, DF and CP yields and for DM, CP, P, and K contents for the 7 grasses. GF, DF, and CP mean yields increased significantly ($P < .05$) as harvest intervals increased from 30 to

45 and from 45 to 60 days. For DM content, significant differences ($P < .05$) were obtained only between 30 or 45 days and 60 days. CP content was significantly ($P < .05$) reduced from 30 to 45 days and from 45 to 60 days. Phosphorus and K contents diminished as harvest intervals increased. These values can be considered as normal, as reported by Vicente-Chandler et al. (20), and demonstrate that growth was not limited by these minerals.

TABLE 1.—*Effect of harvest interval on the mean green forage, dry forage, and crude protein yields and on the dry matter and crude protein contents of 7* Pennisetum *cultivars at 3 harvest intervals*

Identification	Green forage yield[1]	Dry matter content	Dry forage yield	Crude protein content	Crude protein yield
	Kg/ha/y	%	*Kg/ha/y*	%	*Kg/ha/y*
			30-day grasses		
7350	127,986a[1]	14.56	18,634a	14.67 c	2,723a
13079	121,981ab	15.32	18,684a	14.23 c	2,667a
13078	117,379ab	14.54	17,074a	14.16 c	2,438ab
7353	112,812ab	14.57	16,437a	15.80 b	2,606a
Merker	92,979abc	14.54	13,518ab	16.73ab	2,261abc
11720	72,035 bc	13.54	9,758 b	17.42a	1,676 bc
I-12	58,695 c	14.33	8,412 b	17.86a	1,498 c
			45-day grasses		
7350	182,671ab	14.17	25,883 abcd	11.42 b	2,946 bc
13079	210,642a	15.49	32,634a	11.36 b	3,718ab
13078	202,194a	14.95	30,231ab	11.47 b	3,464ab
7353	203,571a	14.59	29,703abc	13.12a	3,897a
Merker	135,194 b	14.84	20,071 d	12.90a	2,606 c
11720	166,222ab	13.95	23,185 cd	12.67a	2,941 bc
I-12	179,924ab	14.28	25,690 bcd	13.01a	3,358abc
			60-day grasses		
7350	303,342a	17.52	53,167a	7.76 c	4,150ab
13079	293,791a	18.60	54,640a	7.99 bc	4,404ab
13078	326,034a	17.49	57,038a	8.09 bc	4,572ab
7353	274,589ab	18.86	51,785a	9.12ab	4,759a
Merker	234,340 b	18.56	43,510 b	8.84abc	3,845 b
11720	234,040 b	17.07	39,954 b	9.48a	3,787 b
I-12	238,755 b	17.62	42,081 b	9.36a	3,950ab

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

Table 3 shows total GF and DF yields and DM content for 3 harvests from October 3, 1975, to February 17, 1976, for 45-day grasses, and from September 4, 1975, to March 3, 1976, for 60-day grasses. Cultivars 13078 and 13079 presented highest GF and DF yields at 45 days, significantly ($P < .05$) different from those of cultivar Merker. At 60 days, cultivar 13078 outyielded significantly ($P < .05$) all other cultivars in GF. However,

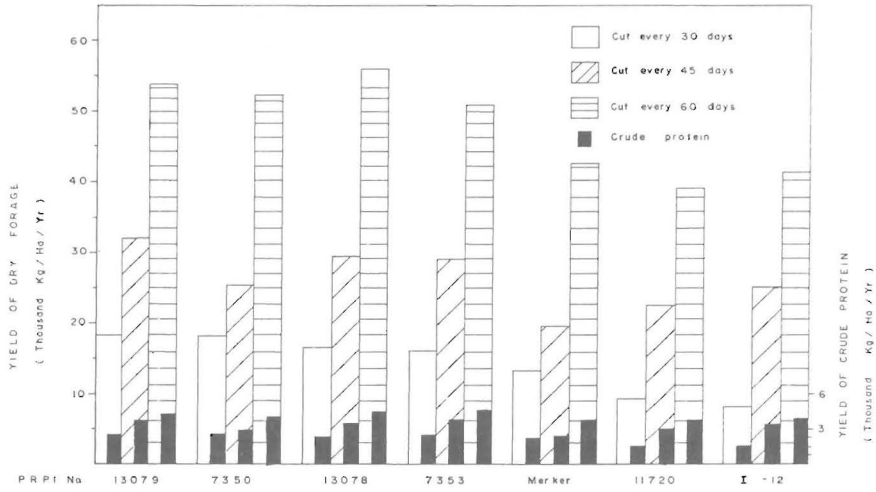

FIG. 1.—Dry forage and crude protein yields of seven Napiergrass cultivars at 30-, 45- and 60-day harvest intervals.

TABLE 2.—*Mean green forage, dry forage, and crude protein yields; and dry matter, crude protein, phosphorus, and potassium contents of* 7 Pennisetum *cultivars at 3 harvest intervals*

Item and unit of measurement	Harvest interval (days)			Mean
	30	45	60	
Green forage yield per ha per year, kg	100,552c[1]	182,917b	272,127a[2]	185,199
Dry matter, percent	14.49b	14.61b	17.96a	15.69
Dry forage yield per ha per year, kg	14,645c	26,771b	48,882a	30,099
Crude protein, percent	15.84a	12.28b	8.67c	12.26
Crude protein yield per ha per year, kg	2,267c	3,276b	4,210a	3,251
Phosphorus, percent	.32	.29	.23	.28
Potassium, percent	4.23	3.96	3.27	3.82

[1] Means of 7 cultivars.

[2] Means in the same row followed by one or more letters in common do not differ significantly at the 5-percent probability level.

DF yields of cultivar 13078 and 13079 were significantly ($P < .05$) different f rom cultivars I-12, 11720, and Merker only.

Table 4 shows the leaf/stem ratio for the 7 cultivars at the 45- and 60-day harvest intervals during 1976. At 45 days, high leaf/stem values corresponded to the period of low rainfall from May 18 to August 16, 1976. Also high leaf/stem values occurred during the short-day period from January 3 to February 16, 1976. Low leaf/stem values occurred

TABLE 3.—*Total green and dry forage yields and dry matter content for 3 harvests at 2 harvest intervals during the short-day and dry-month periods of 1975–76*

Identification	Green forage yield[1]	Dry matter content	Dry forage yield
	Kg/ha	%	*Kg/ha*
		45-day grasses	
13078	120,447a[1]	13.10 bc	15,809ab
13079	119,248a	14.95a	17,790a
I-12	102,555ab	12.99 c	13,341 bc
7353	97,038ab	14.57a	14,138abc
7350	93,482ab	13.55 bc	12,667 bc
11720	93,299ab	12.94 c	12,073 bc
Merker	72,685 b	14.10ab	10,221 c
		60-day grasses	
13078	199,166a	14.97 c	29,667a
13079	163,332 b	16.82ab	27,472a
I-12	135,047 c	17.51ab	23,652 b
7353	132,456 c	19.50a	25,847ab
7350	149,372 bc	17.41ab	26,006ab
11720	126,776 c	16.98ab	21,549 b
Merker	128,016 c	18.38ab	23,529 b

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

TABLE 4.—*Values for leaf/stem ratio (green weight) for the 7* Pennisetum *cultivars at 45 and 60 days of growth and of rainfall per period*

Harvest date	Leaf/stem ratio[1,2]							Rainfall per period
	I-12	Merker	7350	7353	11720	13078	13079	
								Cm
				45-day grasses				
1/3–2/16/76	.81	.81	.80	.79	.82	.80	.82	13.6
2/17–4/2/76	.65	.61	.74	.79	.70	.74	.70	21.0
4/3–5/17/76	.64	.63	.66	.67	.70	.67	.70	22.1
5/18–7/1/76	.81	.87	.82	.73	.82	.71	.82	3.7
7/2–8/16/76	.81	.71	.88	.88	.93	.89	.93	9.9
8/17–10/4/76	.66	.62	.65	.62	.70	.71	.70	22.3
10/5–11/14/76	.55	.50	.52	.48	.50	.60	.50	34.0
11/15–1/3/77	.67	.64	.66	.66	.65	.65	.65	12.5
Mean	.70	.67	.72	.70	.73	.72	.73	17.4
				60-day grasses				
1/2–3/2/76	.71	.66	.65	.71	.71	.81	.71	21.7
3/3–5/3/76	.63	.58	.60	.64	.66	.63	.60	28.6
5/4–7/1/76	.49	.55	.61	.61	.61	.63	.68	10.0
7/2–9/1/76	.61	.62	.64	.63	.67	.72	.73	13.0
9/2–11/3/76	.47	.43	.31	.38	.41	.51	.53	51.0
11/4–1/3/77	.58	.48	.41	.47	.59	.67	.41	14.6
Mean	.58	.55	.54	.57	.61	.66	.61	23.2

[1] Mean values of 4 replicates per grass.
[2] Stem includes the sheath.

during the period of maximum rainfall; i.e., from October 5 to November 14, 1976. A similar pattern for leaf/stem values was observed for the 60-day harvest interval data. Increases or decreases in leaf/stem values of 13 elephant cultivars have been reported by Garrido-Virguez (7), with increases or decreases in the rainfall distribution throughout the year. Decreases have also been reported for leaf/stem ratios by Vicente-Chandler et al. (23), as harvest interval increases from 40 to 60 days.

At the 45-day harvest interval (tables 1 and 5), cultivar 13079 presented the highest NDF, ADF, and L contents but the lowest CP and estimated digestibility contents. Cultivar 7353 had the lowest L content but the highest estimated digestibility contents. As fiber fractions increase, CP and digestibility contents decrease. Forage grasses, with a higher fibrous content, tend to exhibit lower CP and digestibility contents. Kayongo-

TABLE 5.—*Chemical composition and estimated digestibility values of 7* Pennisetum *cultivars at 45 days of growth*

Identification	NDF[1]	NDS	ADF	H	L	Si	EDDM	ETDDM	EADDM
				%					
I-12	67.90[2]	32.10	39.08	28.82	8.41	2.07	66.80	60.59	47.69
Merker	67.23	32.77	37.52	29.71	8.26	2.08	66.46	60.22	47.32
7350	68.02	31.98	39.47	28.55	8.39	2.48	67.09	59.65	46.75
7353	68.14	31.86	39.81	28.33	8.22	2.26	67.87	61.09	48.19
11720	67.07	32.93	38.15	28.92	8.48	2.52	66.27	58.71	45.81
13079	70.73	29.27	41.49	29.24	9.18	2.40	64.66	57.46	44.56
13078	70.24	29.76	39.27	30.97	8.82	1.85	64.46	58.91	46.01
Mean	68.48	31.52	39.26	29.22	8.54	2.24	66.23	59.52	46.62

[1] NDF, neutral-detergent fiber; NDS, neutral-detergent solubles; ADF, acid-detergent solubles; H, hemicellulose; L, lignin; Si, silica; EDDM, estimated digestible dry matter; ETDDM, estimated true digestible dry matter; EADDM, estimated apparent digestible dry matter.

[2] Means of 4 replicates per grass.

Male et al. (9) demonstrated that differences in chemical composition and estimated digestibility do exist among grasses grown under the same environmental and agronomic conditions. They obtained a significant variation among CP and fibrous contents (ADF and cellulose) in Pennisetum cultivars, suggesting that there may be a possibility of genetic improvement for tropical grasses.

After the first year, the stands of the 7 cultivars were greatly reduced on 30-day plots. This decrease suggests that the 30-day harvest interval is too short. It was observed that the least affected plots, by frequent harvests, were those of cultivars 7350 and 7353.

During the rainy season, a high degree of infestation, caused by *Piricularia grisea* (CKe) Sacc., and known as gray spot disease, appeared on cultivars Merker, 11720, and I-12 harvested every 30 days. It was

observed that cultivars 13078, 13079, 7350, and 7353 exhibited resistance to this disease.

It can be concluded that cultivars 7350, 13079, 13078, and 7353 were the most productive as to GF, DM, and CP yields at the 30-, 45-, and 60-day harvest intervals. Cultivars 13078 and 13079 outyielded cultivar Merker as to GF and DM during the short-day period from September 1975 to March 1976. These cultivars also showed a high degree of resistance to the gray spot disease during the rainy season. A 30-day harvest frequency is not recommended for stand persistency and survival.

RESUMEN

Se determinó el efecto de los intervalos de corte de 30, 45 y 60 días en los rendimientos de forraje verde, forraje seco y proteína bruta y en la razón de hoja a tallo y de composición química de siete cultivares del pasto elefante (*Pennisetum purpureum* Schum.) durante 2 años, en la Subestación Experimental de Corozal de la Universidad de Puerto Rico, que está localizada en la región húmeda montañosa de Puerto Rico.

Según se alargaron los intervalos de corte de 30 a 45 y de 45 a 60 días, los rendimientos de forraje verde, forraje seco y proteína bruta aumentaron en todos los cultivares. Se obtuvieron diferencias significativas ($P < .05$) entre cultivares en los rendimientos de forraje verde, forraje seco y proteína bruta durante los 2 años del estudio. Los cultivares 7350, 7353, 13078 y 13079 presentaron los mayores rendimientos de forraje seco. Se obtuvieron también diferencias significativas ($P < .05$) entre cultivares en rendimientos de forraje verde y forraje seco durante los períodos de días cortos y meses secos. La razón de hoja a tallo fue mayor duante los períodos de días cortos y meses secos y menor durante el período de lluvia intensa. A los 45 días de crecimiento, el cultivar 13079 fue el máximo en contenidos de fibra neutrodetergente, fibra ácidodetergente y lignina y menor en proteína bruta y coeficientes de digestibilidad estimada.

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