

# Yield and nutritive value of hay from five tropical grasses at three harvesting intervals<sup>1</sup>

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## ABSTRACT

Five tropical grasses, *Cynodon dactylon* (coastcross), *Cynodon nlemfuensis* (star grass), *Cynodon plectostachyus* (callie), *Digitaria pentzii* (slenderstem), and *Panicum maximum* (guinea) PRPI 12917, were planted for hay production on a Vertisol soil with irrigation in the Lajas valley. On the basis of all factors studied, guinea, star grass and slenderstem, harvested at 45-day intervals (DI), are the best for hay production under adequate irrigation and fertilizer use in Vertisol soils in the southern coast of Puerto Rico. The forages were harvested at 35-, 45- and 55 DI. The highest yields of hay were obtained from guinea at 35- and 45 (2069 and 2901 kg/ha, respectively), and from slenderstem at the 55-DI (3397 kg/ha). The highest crude protein content was obtained with star grass at the 35-DI (18.6%) and with callie at 45- and 55-DI (14.0% and 11.5%, respectively). Crude protein yield at 35-DI was highest for star grass (356 kg/ha). At 45- and 55-DI slenderstem was higher (383 and 384 kg/ha, respectively). The highest digestion coefficients (DC) at the 45- and 55-DI were obtained with guinea (63.0 and 59.0, respectively), although not significantly different ( $P > 0.05$ ) from those of slenderstem and coastcross. At a 35-DI, coastcross averaged the highest DC (64.3%). The highest voluntary intake at the 35-DI was observed with coastcross (2.8% of body weight daily), but not more ( $P > 0.05$ ) than with slenderstem or star grass. At the 45- and 55-DI, the highest voluntary intake was observed with star grass and guinea (2.4% and 2.3% of body weight daily, respectively). The highest relative nutritive value (digestibility  $\times$  voluntary intake) was obtained with coastcross (1.81) at the 35-DI and with guinea at the 45- and 55-DI (1.51 and 1.36, respectively).

## INTRODUCTION

Forage programs used in most dairy and beef cattle operations in Puerto Rico are based on grazing or green chopping of various grass species, notably star grass, pangola, guinea, merker, and several native species. As in all tropical countries, seasonal variations in forage productivity and nutritive value are reflected in varying animal performance. During the seasons of maximum growth the forages produced in greater dry matter quantities are physiologically more mature at a given harvest

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interval, but used less efficiently by animals. These forages are often produced in excess of the herd demand and are wasted. Conversely, during periods of slow plant growth there is often insufficient forage to permit maximum intake by the animals. The result is greater reliance on concentrate feeds and higher production cost of milk and meat. Forage preservation is one obvious means of overcoming this seasonal imbalance between need and availability.

Preservation of surplus forage as hay, a standard procedure in many temperate countries, was little used in the past in Puerto Rico. However, commercial hay production on the island has gradually increased to the point of being an appreciable commodity; thus, research into optimum procedures for hay production and utilization is justified. Among the matters requiring investigation is selection of the most useful forage species (3,12), a choice which should be based on knowledge regarding yield, ease of field curing and nutritive value of the hay produced. Another key factor is harvest interval, with which forage yield varies directly, whereas nutritive value varies inversely (7,12).

Previous research into these questions has been conducted in Puerto Rico, but not under conditions comparable to those of commercial practice, since the forages were hand harvested (2,4,10). Therefore, the present experiment was initiated with the objective of evaluating hay produced mechanically from five grass species at three different harvest intervals. The criteria include dry matter and crude protein yields and contents, voluntary consumption by steers and *in vivo* digestibility.

#### MATERIALS AND METHODS

A three-hectare field subdivided into five equal plots was planted with the following grasses: *Cynodon dactylon* (Coastcross), *Cynodon nlemfuensis* (star grass), *Cynodon plectostachyus* (Callie), *Digitaria pentzii* (slenderstem), and *Panicum maximum* (guinea PRPI 12917). The study was conducted in the Lajas Valley in a Vertisol soil (very fine, montmorillonitic, isohyperthermic) which had a pH of 6.5 and was low in available phosphorus.

Before land preparation, weeds were killed with glyphosate (0.41% isopropylamine salt). The soil was disc-plowed, harrowed twice, land-planed and furrowed to a depth of 15 cm. The forages were planted from May to mid-June 1977. Vegetative material was placed in the furrows and partially covered with soil. Fertilizer of 15-5-10 analysis was broadcast at the rate of 545 kg/ha after planting. The area was sprayed with 7.5 kg/ha of the preemergent herbicide (Princep 80W)<sup>a</sup> and thereafter

<sup>a</sup>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.

irrigated by flooding, except in the case of buffel, where sprinkle irrigation was used. All plots were cut 11 October 1977, and a harvesting schedule was prepared for cutting at 35-, 45- and 55-day intervals. The haybine was adjusted to cut at 5 cm above soil surface. First scheduled harvests were in November at 35-day intervals and thereafter at indicated intervals over a period of 4.5 years until May 1982. Frequent rains from August through early October prevented hay making; therefore, to maintain cutting intervals, the forage was used as green chop feed during this period.

The cut forage was left in the sward for 2 or 3 days and raked into windrows. The latter were turned daily until ready for baling. In the event of rain, the curing period was prolonged. Moisture content of the harvested grasses in the field was measured at random spots with a 9-volt-DC moisture meter. The crop was baled at 18 to 20% moisture with a machine adjusted to make bales approximately 60 cm × 45 cm 38 cm.

From every baling for each grass, a sample of 10 to 15 bales/plot was weighed and recorded. The harvested forages were then stored for protection against unfavorable weather conditions and used within 6 weeks.

Following each harvest, a 15-5-10 fertilizer was broadcast at a rate of 715 kg/ha. Borders were kept free of weeds with glyphosate, and flooding irrigation was applied as required during growing intervals. Uniform samples were taken from random bales and were oven-dried at 60° C to determine moisture content. These were then ground in a Wiley mill through a 1 mm sieve.

Crude protein content of the hay samples, for all grasses at each cutting interval, was determined by the standard Kjeldahl procedure (1). Voluntary feed consumption and *in vivo* dry matter digestibility were determined for hay collected from one mid-experiment cutting. We used 340-390 kg Holstein steers placed in metabolic cages, according to the total collection procedure (5).

Data collected on green forage yield (GFY), dry matter yield (DMY), dry matter content (DMC) and crude protein yield (CPY) were statistically evaluated by analysis of variance, according to a complete randomized design with a 5 (grasses) × 3 (cutting intervals) × 5 (years) factorial arrangement of treatments. Data from the *in vivo* trials (voluntary intake, VI; dry matter digestibility, DMD; relative nutritive value, RNV) were subjected to analysis of variance according to a complete randomized design with a 5 (grasses) × 3 (cutting intervals) factorial arrangement of treatments, with four replicates (animals) per treatment. Treatment means were compared by Duncan's new multiple range test (14).

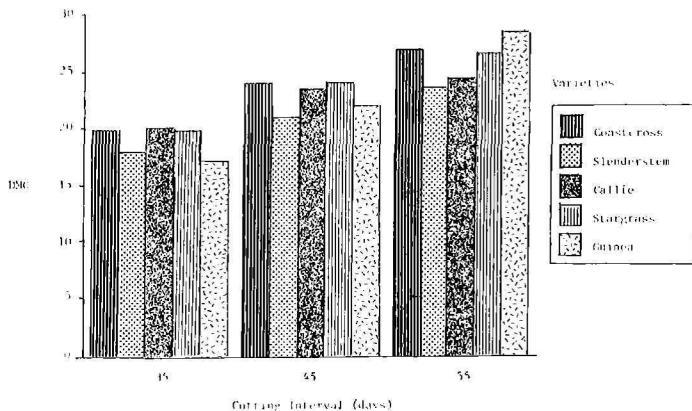


FIG. 1.—Average dry matter content (DMC) of five tropical forage grasses at three harvesting intervals (35-, 45- and 55-DI).

#### RESULTS AND DISCUSSION

The highest dry matter content (DMC; fig. 1) was obtained from guinea at the 55-DI (28.3%). However, this amount was not significantly different ( $P > 0.05$ ) from that of stargrass or coastercross (26.4 and 26.9%, respectively). At the 35- and 45-DI values of DMC obtained from Callie, Coastercross and star grass (19.9, 19.8 and 19.8%, respectively and 23.4, 23.8 and 23.9%, respectively), were not different ( $P > 0.05$ ). Arroyo and Oporta (2) reported similar DMC from merker and guinea grass hay.

The highest dry matter yield (DMY; table 1) was obtained from slenderstem at the 55-DI (3400 kg/ha per cut), but this did not differ significantly ( $P > 0.05$ ) from the values for coastercross, star grass and guinea (3396, 3333 and 3280 kg/ha per cut, respectively). At the 35- and the 45-DI the highest DMY was obtained with guinea (2069 and 2901 kg/ha per cut, respectively), even though these yields were not significantly different from those of slenderstem (1949 and 2761 kg/ha per cut, respectively). Hay dry matter yield depends upon a number of factors. Inherent difference in yield capacity exist both among forage species and among different varieties of the same species, as shown by Vélez et al. (15) for guinea and buffel varieties, and Machado and Pedraza (6) for *Cynodon* sp. and *Digitaria* sp. A large variation in forage development was observed between cuttings within years. Schank et al. (11) compared tropical grass forage species and observed growth fluctuations, within the same variety, at different cutting intervals. The lowest DMY in this study was obtained with callie. This finding agrees with that of Rivera

TABLE 1.—Average dry forage yield (DRF) and crude protein yield (CPY) of five tropical forage grasses at three harvesting intervals (35-, 45- and 55-day)

Varieties	35-DI <sup>1</sup>		45-DI		55-DI	
	DRF	CPY	DFY	CPY	DFY	CPY
	kg/ha/cut	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha
Coastcross	1832 b <sup>2</sup>	262 a	2582	293 b	3397 a	339
Slenderstem	1949 a	294 a	2761 a	383 a	3400 a	384 a
Callie	1579 c	253 a	2143	300 b	2274 b	262
Stargrass	1921 ab	356	2833 a	336 a	3382 a	373 a
Guinea	2069 a	299 a	2901 a	372 a	3280 a	307
Mean	1870	294	2644	337	3146	325
Standard deviation	201	45	151	45	230	31

<sup>1</sup> Means per grass per harvest interval.

<sup>2</sup> Means in the same column followed by one or more letters in common do not differ significantly at the 5% probability level.

and Rodríguez (8), who reported callie as significantly inferior ( $P < 0.05$ ) in dry matter yields to five other grasses during several years of research. In Cuba, bermuda grass outyielded several *Digitaria* species in dry matter (3).

The 35-, 45- and 55-day harvesting intervals averaged 10.4, 8.1 and 6.6 cuttings per year, respectively, which, in turn, yielded an estimated pooled mean of 19.5, 21.4 and 20.9 tons of DFY, respectively (table 2). Similar trends were observed regarding estimated DFY at the 35- and 45-DI as guinea (21.7 tons) was followed in order by slenderstem (20.3 t), star grass (20.0 t), coastcross (19.1 t) and callie (16.5 t). At the 55-DI, Coastcross and star grass showed some degree of persistency in DFY, even though not at the expected rate. At this interval, guinea ranked fourth (21.8 t), whereas coastcross and star grass recovered and averaged higher DFY (22.5 t each) than at other intervals. Performance of Coastcross was retarded by weed invasion which competed greatly during the first 4 weeks of regrowth.

The mean annual estimated CPYs (table 2) were 3.1, 2.6, and 2.2 tons for the 35-, 45- and 55-DI, respectively. The highest yield at the 35-DI was obtained with star grass (3.7 t), but values for slenderstem and guinea were similar to the mean. At the 45-DI, the highest expected CPY was 3.1 t for slenderstem, but at the 55-DI both star grass and slenderstem averaged 2.5 t. At these intervals the lowest estimated CPY were for guinea (2.2 and 2.0 t, respectively) and for callie (2.4 and 1.7 t, respectively):

#### Crude Protein Content and Yield

Mean crude protein content (CPC) of hays in this study were 15.6, 12.8 and 10.6% for the 35-, 45- and 55-DI, respectively (fig. 2). The

TABLE 2.—*Estimated annual dry matter and crude protein yields of five tropical forage grasses at three harvesting intervals (35-, 45- and 55-day)*

Varieties	35-DI		45-DI		55-DI		Mean DFY (Tons)	Mean (Tons)
	DFY (Tons)	CPY (Tons)	DFY (Tons)	CPY (Tons)	DFY (Tons)	CPY (Tons)		
Coastcross	19.1	2.7	20.9	2.4	22.5	2.2	20.8	2.4
Slenderstem	20.3	3.1	22.4	3.1	22.6	2.5	21.8	2.9
Callie	16.5	2.7	17.4	2.4	15.1	1.7	16.3	2.3
Stargrass	20.0	3.7	23.0	2.7	22.5	2.5	21.8	3.0
Guinea	21.7	3.1	23.5	2.2	21.8	2.0	22.3	2.4
Mean	19.5	3.1	21.4	2.6	20.9	2.2	20.6	2.6

tendency for CPC to decrease as harvesting interval increased was observed in all species studied and agrees with the findings of Gutiérrez et al. (4). At the 35-DI, the highest CPC (18.6%) observed in star grass. Callie (16.3%) surpassed ( $P < 0.05$ ) both coastcross (14.3%) and guinea (14.5%), but not slenderstem (15.1%), whereas the latter three did not differ from each other ( $P > 0.05$ ). At the 45-DI, the CPC of slenderstem (13.9%) and callie (14.0%) exceeded ( $P < 0.05$ ) that of coastcross (11.4%) and star grass (11.9%), but not guinea (12.8%). There were no differences ( $P > 0.05$ ) among the latter three. At the 55-DI callie, star grass and slenderstem were higher ( $P < 0.05$ ) in CPC (11.5, 11.3 and 11.0%, respectively) than coastcross (10.0%) and guinea (9.4%).

This study showed an average CPC of 12.2% for the three harvesting intervals in guinea. Arroyo and Oporta (2) compared chemical compo-

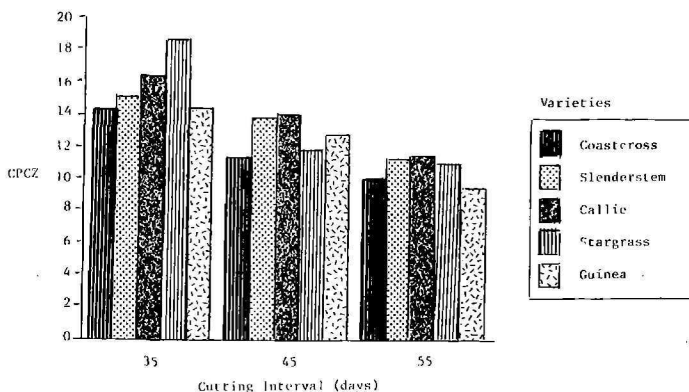


FIG. 2.—Average crude protein content (CPC) of five tropical grasses harvested at three harvesting intervals (35-, 45- and 55-DI).

nents of guinea and merker harvested at 30-, 45- and 60-DI and found that the average CPC of guinea (7.8%) was significantly lower ( $P < 0.05$ ) than the mean CPC of merker (9.1%). The average CPC obtained with slenderstem was 13.4%, which is considerably higher than that reported by Gutiérrez et al. (4) with pangola harvested at 30-, 45- and 60-DI (7.0%).

#### Nutritive value

Mean dry matter digestion coefficients (DMDC) observed across all cutting intervals were 62.3%, 59.5%, and 56.0% for 35-, 45- and 55-DI, respectively (table 3). All four of the other species were superior ( $P < 0.05$ ) to callie in DMDC at all cutting intervals (table 3). At 35-DI the highest digestibility was that of coastcross (64.3), whereas at both 45- and 55-DI that of guinea was highest (63.1 and 59.2, respectively). At the latter two cutting intervals guinea surpassed ( $P < 0.05$ ) star grass, but not coastcross or slenderstem.

Gutiérrez et al. (4) found that digestibility of pangola hay (51.8%) was higher than that of star grass hay (50.2%). Arroyo and Oporta (2) reported no dry matter digestibility differences between guinea (48.4%) and merker hay (51.9%), however, significant differences were observed among harvesting intervals of 30, 45, and 60 days (54.6, 47.6 and 48.2%, respectively).

In ranking of hays of the different species according to voluntary intake relative to body weight VI was inconsistent at different harvest intervals (table 3). At 35-DI, the highest VI, that of coastcross (2.82), surpassed ( $P < 0.05$ ) that of Callie (2.32) and guinea (2.35), but not that of slenderstem (2.42) or star grass (2.49). At 45-DI and 55-DI, coastcross was no longer outstanding in VI, but rather almost equal to the overall mean. Star grass had the highest VI (2.43) at 45-DI, but was not outstanding at the other two harvest intervals. Guinea was the leading species at 55-DI (2.30) and a close second at 45-DI (2.40), but below average (2.35) at 35-DI. Slenderstem was slightly below the overall mean of VI at each of the three harvest intervals and callie more so. Yazman et al. (16) reported reduced dry matter intakes (DMI) of star grass hay harvested at 45-DI (1.8% LVW) relative to that harvested at 30-DI (2.3% LVW) and attributed this to wide differences in CPC (12.8 vs 9.4%). Gutiérrez et al. (4) found higher DMI of pangola hay (1.79% liveweight (LVW)) than that of star grass hay (1.50% LVW). However, differences in DMI were not significant in hay harvested at 30-, 35- and 60-DI (4).

#### Relative nutritive value

The relative nutritive value (RNV) is a term suggested by Rohweder et al. (9). It is the daily consumption of digestible dry matter as a percentage of LVW, and expresses as a single figure overall forage quality when

TABLE 3.—Mean digestion coefficient (DC), voluntary intake (VI) and relative nutritive value (RNV) of five tropical forage grasses cut at three harvesting intervals and field cured as hay<sup>1</sup>

Varieties	35-DI			45-DI			55-DI		
	DC	VI	RNV	DC	VI	RNV	DC	VI	RNV
	%			%			%		
Coastcross	64.3 a <sup>2</sup>	2.82 a	1.81 a	60.8 ab	2.33 ab	1.42 ab	58.8 a	2.19 b	1.29 a
Slenderstem	62.7 a	2.42 ab	1.52 bc	60.2 ab	2.29 bc	1.38 b	57.3 ab	2.13 b	1.22 b
Callie	57.6 b	2.32 b	1.34 bcd	54.3 c	2.20 c	1.20 c	51.8 c	2.08 c	1.08 c
Stargrass	63.3 a	2.49 ab	1.58 ab	59.0 b	2.43 a	1.44 a	55.4 b	2.14 b	1.18 b
Guinea	63.6 a	2.35 b	1.49 bcd	63.1 a	2.40 ab	1.51 a	59.2 a	2.30 a	1.36 a
Mean	62.3	2.48	1.55	59.5	2.33	1.39	56.5	2.17	1.23
Standard deviation	3.06	0.46		3.18	0.13		3.36	0.11	

<sup>1</sup> Means per harvest interval.

<sup>2</sup> Means in the same column followed by one or more letters in common do not differ significantly at the 5% probability level.



fed as the only energy source. On the basis of this information, hay was graded from 1 to 5 when RNV ranged from 1.40 to 0.83 (9). In a draft report hay classification standards for Puerto Rico were formulated, by a designated committee. On the basis of preliminary data (7). The grades suggested were PR 1, 2, 3, and 4 corresponding to RNV 1.20, 1.19 to 0.99, 0.98 to 0.80 and 0.80, respectively. The mean RNV obtained in this study were 1.55, 1.39 and 1.23 for the forages harvested at 35-, 45- and 55-DI, respectively (table 2). RNV ranged from 1.81 on Coastercross harvested at 35-DI to 1.08 on Callie harvested at 55-DI. At 45- and 55-DI, guinea provided the highest values of RNV. On the basis of proposed local grades, the hays utilized in this study could be graded between PR 2 and PR 1. The most important factors to be considered upon deciding which forage species to use for hay production are yield performance and RNV. Star grass, Coastercross and slenderstem provided the best RNV at the 35-DI; guinea, Star grass and Coastercross were the best at 45-DI; and guinea and Coastercross were best at the 55-day cutting interval.

On the basis of yield performance, nutritive value, and crude protein content, the 45-day harvesting interval was the best overall for hay production among all of the species studied. All factors considered, guinea, stargrass and slenderstem harvested at 45-DI can be recommended as the best alternatives presently available for hay production under conditions of irrigation and high fertilizer application in Vertisol soils on the south coast of Puerto Rico.

#### RESUMEN

##### Rendimiento y valor nutritivo del heno de 5 yerbas tropicales a 3 intervalos de corte

En un suelo Vertisol en la zona suroeste de Puerto Rico se sembraron cinco gramíneas forrajeras: *Cynodon dactylon* (Cross 1), *Cynodon nlemfuensis* (estrella), *Cynodon plectostachyus* (Callie), *Digitaria pentzii* (pangola fina), y *Panicum maximum* (guinea, PRPI 12917); se cosecharon a intervalos de 35, 45 y 55 días y el forraje se henificó. Los rendimientos más altos de heno se obtuvieron con guinea a intervalos de 35 y 45 días (2069 y 2901 kg./ha./corte, respectivamente), pero al intervalo de 55 días pangola fina produjo más (3397 kg./ha./corte). El contenido más alto en proteína bruta se obtuvo con estrella al intervalo de 35 días (18.6%) y en Callie a los intervalos de 45 y 55 días (14.0% y 11.5%, respectivamente). El rendimiento en proteína bruta a intervalo de 35 días fue más elevado en estrella (336 kg./ha./corte) y a los intervalos de 45 y 55 días lo fueron en pangola fina (383 y 384 kg./ha./corte, respectivamente). El coeficiente de digestión (DC) más alto al intervalo de 35 días se obtuvo con Cross 1 (64.3). A los intervalos de 45 y 55 días, el DC más alto se obtuvo con guinea (63.0 y 59.0, respectivamente), pero al compararlos con los de pangola fina y Cross 1 la diferencia no fue significativa. El consumo voluntario mayor a intervalo de 35 días se obtuvo en Cross 1 (2.82% de peso vivo diariamente

(PV), pero las diferencias no fueron significativas ni con pangola fina ni con estrella. A los intervalos de 45 y 55 días el consumo voluntario más alto fue con estrella y guinea (2.43 y 2.30% PV, respectivamente). El valor nutritivo relativo más alto (digestibilidad  $\times$  consumo voluntario) se obtuvo con Cross 1 (1.81) a intervalos de 35 días, y con guinea a intervalos de 45 y 55 días (1.51 y 1.36, respectivamente). A base de los factores estudiados, guinea, estrella y pangola de tallo fino, cosechadas a intervalos de 45 días, son las mejores para la producción de heno con riego y abonamiento adecuado en suelos Vertisol en la costa sur de Puerto Rico.

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