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Evaluation of Seven Forage Grasses at Two Cutting Stages[1]

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INTRODUCTION

Milk and beef production presently are the most important agricultural enterprises of Puerto Rico in terms of total gross income. According to figures published by the Agricultural Experiment Station (1) in 1970 there were about 806,000 acres of pastures and rangeland in Puerto Rico and the value of dairy production then was approximately 71 million dollars.

Improved pastures in grasses such as Guinea (*Panicum maximum* Jacq.), Pangola (*Digitaria decumbens* Stent), Merker (*Pennisetum purpureum* Schumach.) and lately Star (*Cynodon nlemfuensis* var. *nlemfuensis* formerly known as *C. dactylon*) and *C. plectostachyus* (K. Schum.) (Pilger)) have contributed greatly to the success of the dairy and beef industry in Puerto Rico during the last several decades (3,26). Since its introduction to Puerto Rico in 1946 (2) Pangolagrass has enjoyed great popularity among farmers mostly because of its excellent growth, palatability, and quick recovery after grazing. Total acreage of Pangola in Puerto Rico at present is estimated over 100,000 acres.[3] This grass is, however, very seriously affected by a stunting virus disease already spread in Suriman (7); it also is heavily attacked by various insects especially during the dry winter months which considerably reduces its yield (12). The Plant Breeding Department of the Agricultural Experiment Station of the University of Puerto Rico, Mayagüez Campus, at Río Piedras has introduced and tested many forage species in the last decade. Results from field experiments conducted in Puerto Rico indicate that grass species belonging to the

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[3] Estimates by the Agricultural Extension Service of the University of Puerto Rico and the Department of Agriculture, Commonwealth of Puerto Rico.

genera *Digitaria, Brachiaria, Pennisetum, Panicum* and *Cynodon* are promising; many of these grasses could easily serve as substitutes for Pangola in a pasture program (2,3,4,5,6,13,16,17,18,19,20,21,22,23, 24,25,26).

The present study was undertaken to compare the yield performance of six forage grass introductions, four *Brachiarias* and two *Cynodons*, with Pangolagrass, each cut at a 60-day interval and at the optimum stage for harvest.

An attempt was made to answer the following questions: (a) Is the 60-day harvest interval the best method to evaluate tropical grasses for total yield and protein content? (b) How does the evaluation of grasses at the optimum stage for harvest using visual estimates compare with the 60-day harvest interval?

TABLE 1.—*Identification of seven forage grasses evaluated at Gurabo, Puerto Rico and their Plant Introduction (PI) number*[1]

Grass number	Species—field identification	Plant introduction number		Common name or variety
		USDA PI	PR PI	
1	*Brachiaria brizantha* Stapf	—	1525	Signal
2	*Brachiaria* cf. *mutica* (Forsk.) Stapf	299499	6451	Tanner
3	*Brachiaria ruziziensis* Germain C. Evrard	247404	5366	Congo
4	*Brachiaria brizantha* Stapf	255346	5909	Signal (glabrous)
5	*Cynodon dactylon* (Camus) Harlan et de Wet	288218	8991	Var. *coursii*
6	*Cynodon nlemfuensis*	—	2341	Star var. *nlemfuensis*
7	*Digitaria decumbens* Stent	111110	—	Pangola

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

MATERIALS AND METHODS

The seven forage grasses included in this investigation (table 1) were planted by cuttings or rootstocks at the Gurabo Substation on a Mabí clay with a pH ranging from 4.5 to 5.5. The design was a randomized split plot with 4 replications. Each plot was 7 feet by 20 feet, separated from adjacent plots by 5-foot pathways. A complete 14-4-10 fertilizer was applied at a rate of 500 pounds per acre after each cutting at the 60-day interval and at the optimum stage for harvest. The grasses cut at the 60-day interval received a total of 3,000 pounds of fertilizer per acre per year while the grasses cut at the optimum stage for harvest received additional applications according to the harvest schedule (table 2). Overhead irrigation was applied at the rate of ½ to 1 inch each time, whenever necessary during dry spells. The experiment was conducted over a 2-year period.

Green forage yields per plot were obtained after each harvest and samples were sent to the Central Analytical Laboratory of the Río Piedras Agricultural Experiment Station for dry weight and protein content determinations.

All plots were harvested at a 60-day interval and at the optimum stage for harvest. Visual estimates of forage volume and maturity on each grass were used as criteria for determining the latter stage. It was considered that plants had reached an optimum stage for harvest when flowering, yellowing of the leaves at the basal part of the plants began to appear and the grasses had attained a reasonable forage volume as compared to the adjacent plots which were harvested every 60 days.

TABLE 2.—*Total number of harvests at the optimum stage for harvest, longest, shortest and average cutting interval*

Grass number	Total number of harvests	Cutting intervals		
		Longest	Shortest	Average
		Days	*Days*	*Days*
1	13	70	45	55.5
2	13	67	45	55.5
3	13	70	45	55.5
4	13	70	42	53.6
5	13	70	42	53.6
6	14	67	41	51.6
7	13	75	42	55.5

GENERAL DESCRIPTION OF THE SEVEN GRASSES STUDIED

Signalgrass (*Brachiaria brizantha* Stapf.) is a vigorous grower capable of producing large yields of palatable, nutritious forage. It has been recommended by Rivera-Brenes et al. (17) as a substitute for Pangola and Guinea grass in Puerto Rico. This grass is susceptible to leaf burn damage when fertilized broadcast due to its pubescence; it also is sometimes attacked during springtime in Puerto Rico by the fall armyworm (*Spodoptera frugiperda* Smith & Abbot). Signalgrass propagation is by cuttings, rootstocks and occasionally by seed. A field description of this grass, and its agronomic behavior as compared to Guineagrass (*Panicum maximum* Jacq.), was given by Sotomayor-Ríos et al. (18).

Tannergrass (*Brachiaria* cf. *mutica* (Forsk.) Stapf.) is a vigorous, rapidly spreading plant which spreads by means of stolons. The leaves and stems are glabrous and succulent when young. An undetermined species of *Helminthosphorium* occasionally attacks the leaves. Propagation is entirely by cuttings; it does not produce viable seed in Puerto Rico. A cytological and taxonomic description of this grass was made by Sotomayor-Ríos et al. (20).

Congograss (*Brachiaria ruziziensis* Germain C. Evrard) is a vigorous high yielding plant (23) resembling Signalgrass in its morphology. The leaves and stems are pubescent. Propagation in Puerto Rico is by cuttings or rootstocks although seed has been brought from Australia for experimental purposes. A cytological and taxonomic description of this grass was made by Sotomayor-Ríos et al. (20).

Glabrous (*Brachiaria brizantha* Stapf.) also resembles Signalgrass in its morphology. Distinctive features separating this grass from Signal are: Absence of pubescence, darker green color of young leaves and erect growth habit. It is a coarse and more erect grass than either Signal or Congo. Culms are 200 cm. high or more and these form well-defined, relatively large tussocks. The stems seldom root at the nodes, thus outward spread by rooting stems is practically absent. Propagation is by seed and rootstock division. Seed production in Gurabo is low but spontaneous seedlings have been observed. When mature, the leaf texture is tough and scabrous. No diseases or insect pests have been observed on this grass.

Cynodon dactylon var. *coursii* was introduced from the United States by the Plant Breeding Department of this Station in 1965; it has been described taxonomically by Harlan et al. (8). This bermuda grass is a vigorous grower which spreads by means of creeping stolons often rooting at the nodes.

Stargrass was introduced into Puerto Rico in 1957 as *Cynodon plectostachyus* (K. Schum.) (Pilger). Two strains were introduced; Puerto Rico Plant Introduction Number (PRPI No.) 2341 and 2342.[4] Field tests conducted at Gurabo, Puerto Rico by Sotomayor-Ríos et al. (21) showed that dry matter and protein yields of PRPI 2341 were superior to those of PRPI 2342. Absence of pubescence in PRPI 2342 is a distinguishing character separating these two strains. Stargrass PRPI 2341 has been propagated extensively in Puerto Rico in the last decade, at present being one of the most outstanding forages; it is considered to have a great pasture purpose potential in Puerto Rico (5). Caro-Costas et al. (3,4,5) refer to Stargrass as *C. dactylon*; however, in a written communication to the senior author, Dr. Jack R. Harlan of the University of Illinois indicated that

[4] Plant Breeding Department, Annual Report Agr. Exp. Sta., Univ. P.R., 1958.

this grass is *C. nlemfuensis* var. *nlemfuensis*. Stargrass PRPI 2341 is a vigorous grower and a rapidly spreading plant that develops long, stout, trailing, rooting runners which sometimes attain several meters in length, and tufted, flowering stems 60 to 100 cm. tall, often rooting at the nodes. This grass produces a very dense cover in a relatively short period of time. At certain times of the year, especially during the rainy season, the leaves are attacked by larvae of the moth *Marasmia similis* (Von Hedemann).

Pangolagrass (*Digitaria decumbens* Stent) is a vigorous plant which has been utilized by farmers for many years since its introduction to Puerto Rico 3 decades ago (2). This grass, described morphologically (9,12) has been extensively studied agronomically here and elsewhere (6,7,11,13,16, 17,19,21,22,25,26).

OPTIMUM HARVEST STAGE

Maximum dry matter yields are obtained when grasses are cut near maturity; at this stage the nutritive value and digestibility is comparatively low. Both protein and mineral content are low while lignin is high. As forage grasses mature there is also a high stem-to-leaf ratio; stems tend to be higher in lignin and lower in protein. In the Tropics, these relations have been studied in Trinidad by Paterson (14,15) and in Puerto Rico by Vicente Chandler et al. (23,24).

To decide the optimum stage for harvesting forage grasses, a compromise must be reached between the high yields associated with longer cutting intervals and the more nutritious forage obtained with more frequent harvests. According to McDonald, as cited by Vicente Chandler et al. (26), the digestibility of grasses decreases by 0.48 percent per each additional day of increase in cutting interval, starting at 85-percent digestibility with very young grasses. It follows then that the digestibility at a 40-day interval amounts to $85 - (0.48 \times 40) = 65.8$ or 66 percent, and similarly 56 percent for a 60-day interval and 42 percent for a 90-day interval. Vicente Chandler et al. (26) thus determined the highest yields of digestible dry matter are obtained when Pangola, Para and Guinea are cut at a 60-day interval and Napier at a 90-day interval.

Grasses, like most other plants, respond to seasonal and climatic variations. In Puerto Rico, the field studies of Vicente Chandler et al. (23,24,25), Caro Costas et al. (6) and Rivera-Brenes et al. (16) show that grass forage yields during the winter months are about half those during the remainder of the year due to day lengths and lower temperature factors which influence early flowering. Hence, Vicente Chandler et al. (26) recommend a 40- to 60-day cutting interval for Pangola, Para and Guinea grasses, using the shorter intervals during the warm rainy months and the longer interval during the dry winter months.

Frequent clippings at short intervals eventually weakens the vigor of grasses thus diminishing their yields, a practice which restricts root growth and lowers the carbohydrate reserves stored in root tissues. Hunt (10), working with perennial rye grass, found that shoots increased tenfold over a period of 5 months with a 30-day clipping interval than with a 10-day interval and roots, which showed a considerable increase in weight under the 30-day interval showed an actual loss in weight under the 10-day interval. The deleterious effect of frequent harvests upon the vigor of rootstocks is most evident when periods of unfavorable weather follow a cutting and plants need most of their reserves to promote new growth. The immediate advantage of more nutritive forage with shorter cutting intervals thus must be weighed against the long term deleterious effect upon plant vigor and future yields.

TABLE 3.—*Comparison of total forage and protein yields of seven grasses cut at a 60-day harvest interval*

Grass number	Yield of green forage per acre yearly[1]	Grass number	Yield of dry forage per acre yearly	Grass number	Yield of crude protein per acre yearly
	Tons/acre		*Tons/acre*		*Tons/acre*
4	72.78 A	4	19.85 A	4	1.40 A
1	69.93 A	1	16.87 B	1	1.20 B
3	69.50 A	7	16.44 B	7	1.09 B C
7	69.05 A	3	16.08 B	6	1.06 B C
2	53.20 B	5	14.48 C	5	1.01 C
5	49.17 B C	6	13.72 C D	3	1.01 C D
6	45.24 C	2	12.17 D	2	.83 D

[1] Means followed by the same letter are not significantly different at the 0.05-level of probability.

RESULTS AND DISCUSSION

During the 2-year period and at the optimum stage for harvest, the grasses were cut 13 times, except Stargrass which was cut 14 times (table 2). The shortest cutting interval of 41 days corresponds to Stargrass while the longest of 75 days corresponds to Pangola.

At the 60-day cutting interval no significant differences were noted among the three Brachiarias (*glabrous Signal, Signal, Congo*) and Pangola in terms of total green forage per acre per year when these grasses were grown with complementary irrigation during a 2-year period at the Gurabo Substation. These grasses outyielded the two Cynodons and Tannergrass at the 5-percent level (table 3). The highest yielding grass in terms of total dry forage was glabrous Signal with 19.85 tons per acre per year, which outyielded each of the other grasses tested at the 5-percent level. The grass yielding least was Tannergrass with 12.17 tons of dry forage per acre per year. The annual crude protein yields of the seven grasses also are shown in table 3. Protein yields varied from 1.40 to 0.83 tons per acre per year. Glabrous Signal produced the most crude protein per acre per year, outyielding the others at the 5-percent level.

No significant differences were observed among Congo, Pangola, glabrous Signal and Signal grasses in terms of total green forage per acre per year at the optimum stage for harvest. These selections in turn outyielded the other grasses under test at the 5-percent level (table 4). The total dry forage yields ranged from 18.84 to 13.35 tons per acre per year. Glabrous Signal outyielded the other six grasses at the 5-percent level. The least dry forage producer was Tannergrass. The crude protein yields ranged from

TABLE 4.—*Comparison of the total forage and protein yields of seven grasses cut at the optimum stage for harvest*

Grass number	Yield of green forage per acre yearly[1]	Grass number	Yield of dry matter per acre yearly	Grass number	Yield of crude protein per acre yearly
	Tons/acre		*Tons/acre*		*Tons/acre*
3	70.40 A	4	18.84 A	4	1.54 A
7	69.90 A	7	17.30 A B	5	1.26 B
4	69.62 A	1	15.87 B	6	1.25 B
1	67.04 A	5	15.84 B	7	1.24 B
2	59.47 B	3	15.71 B	1	1.24 B
5	50.30 C	6	13.75 C	3	1.11 B C
6	43.54 D	2	13.35 C	2	1.03 C

[1] Means followed by the same letter are not significantly different at the 0.05-level of probability.

1.54 to 1.03 tons per acre per year (table 4). Glabrous Signal outyielded the other grasses at the 5-percent level.

The difference in terms of total green, dry forage, and crude protein yields per acre per year between the 60-day and the optimum stage for harvest for each of the seven grasses is shown in table 5. No significant difference was observed between the 60-day interval and the optimum stage for harvest in terms of total green forage yield per acre per year for all grasses except Tanner. The yields of Tannergrass in terms of total green forage per acre per year at the optimum stage for harvest were significantly better than those obtained at the 60-day interval. The dry forage yields per acre per year of Tanner and *C. dactylon* var. *coursii* at the optimum stage for harvest were significantly superior to those obtained at the 60-day harvest interval (table 5). The annual crude protein yields per acre per year for all the grasses except Tanner were significantly superior at the

TABLE 5.—*Yield differences between the 60-day harvest interval and the optimum stage for harvest of seven forage grasses during a 2-year period*

Grass number	Annual green forage yields				Annual dry forage yields				Annual crude protein yields			
	60-day interval	Optimum stage for harvest	Difference between harvests	Significance of the difference	60-day interval	Optimum stage for harvest	Difference between harvests	Significance of the difference	60-day interval	Optimum stage for harvest	Difference between harvests	Significance of the difference
	Tons/acre	*Tons/acre*			*Tons/acre*	*Tons/acre*			*Tons/acre*	*Tons/acre*		
1	69.93	67.04	−2.89	N.S.[1]	16.87	15.87	−1.00	N.S.	1.20	1.24	0.04	N.S.
2	53.20	59.47	6.27	* *[2]	12.17	13.35	1.18	*[3]	.83	1.03	.20	* *
3	69.50	70.40	.90	N.S.	16.08	15.71	−.37	N.S.	1.01	1.11	.10	*
4	72.78	69.62	−3.16	N.S.	19.85	18.84	−1.01	N.S.	1.40	1.54	.14	* *
5	49.17	50.30	1.13	N.S.	14.48	15.84	1.36	*	1.01	1.26	.25	* *
6	45.24	43.54	−1.70	N.S.	13.72	13.75	.03	N.S.	1.06	1.25	.19	* *
7	69.05	69.90	.85	N.S.	16.44	17.30	.86	N.S.	1.09	1.24	.15	* *
Average	61.27	61.47	.20	N.S.	15.66	15.81	.15	N.S.	1.09	1.24	.15	* *

[1] N.S. = Not significant.
[2] * * = Significant at the 1 percent-level.
[3] * = Significant at the 5 percent-level.

optimum stage for harvest when compared to the 60-day harvest interval. A graphic representation comparing the annual dry forage yields and crude protein content of the seven grasses when cut at the 60-day harvest interval and at the optimum stage for harvest is shown in figure 1. The crude protein content at the 60-day harvest interval ranged from 7.7 to 6.3 percent while at the optimum stage for harvest it ranged from 9.1 to 7.1 percent. Stargrass had the highest crude protein content both at the 60-day harvest interval and the optimum stage for harvest with 7.7 and 9.1 percent, respectively (fig. 1).

This experiment showed that the green and dry forage yields of the seven grasses, with few exceptions, were very similar when they were cut at a 60-day interval or at the optimum stage for harvest. A significant increase in total crude protein yield in all grasses except one was observed, however, when they were cut at the optimum stage for harvest as compared to the 60-day harvest interval. The additional fertilizer added at the optimum stage for harvest, as compared to the amount applied at the 60-day harvest interval, and that many of the grasses were cut at a shorter harvest interval (table 2), could account for the significant increase in the total protein yields obtained with the former method. Forage produced at

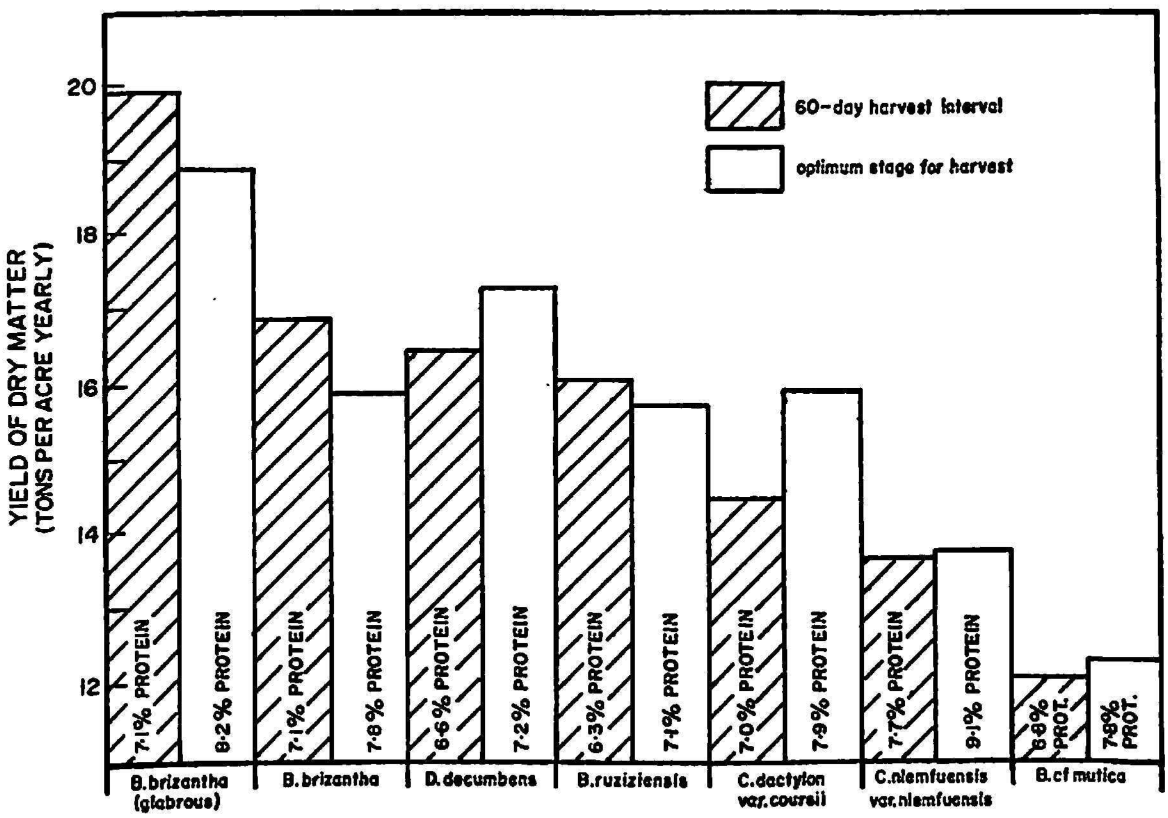

Fig. 1.—Dry forage yields and crude protein content of seven grasses cut at a 60-day harvest interval and at the optimum stage for harvest during a 2-year period.

the optimum stage for harvest apparently could be of superior quality, as indicated by the higher protein yields obtained.

Excellent yields were obtained from all the grasses tested when cut either at the 60-day harvest interval or at the optimum stage for harvest. Of the grasses tested, glabrous Signal (*Brachiaria brizantha*) produced most; 19.85 tons of dry forage per acre per year at the 60-day harvest interval and 1.54 tons of crude protein per acre per year at the optimum stage for harvest.

SUMMARY

Seven forage grasses, i.e., Tanner (*Brachiaria* cf. *mutica*), a bermuda grass selection (*Cynodon dactylon* var. *coursii*), glabrous Signal (*Brachiaria brizantha*), Signal (*Brachiaria brizantha*), Congo (*Brachiaria ruziziensis*), Star (*Cynodon nlemfuensis* var. *nlemfuensis*) and Pangola (*Digitaria decumbens*) were cut at a 60-day harvest interval and at the optimum stage for harvest during a 2-year period at the Gurabo Substation. It was considered that plants had reached the optimum stage for harvest when flowering and yellowing of leaves at the basal parts of the plant began to appear and the grasses had attained a reasonable forage volume as compared to adjacent plots harvested every 60 days.

At the 60-day harvest interval, the top yielder was the glabrous Signal; this grass produced 72.78, 19.85 and 1.40 tons of total green, dry forage, and crude protein per acre per year, respectively. Signalgrass was second best with 69.93, 16.87 and 1.20 tons of green, dry forage and crude protein per acre per year, respectively. At the optimum stage for harvest, the top yielder in terms of total green forage per acre per year was Congograss with 70.40 tons. The best dry forage and crude protein yielder was glabrous Signal with 18.84 and 1.54 tons per acre per year, respectively. Pangolagrass was second best in terms of total green and dry forage per acre per year with 69.90 and 17.30 tons, respectively.

The green forage yields of the grasses studied, except Tannergrass, were similar when cut at the 60-day harvest interval as compared to the optimum stage for harvest. The annual dry forage yield also was similar at the two cutting stages, except Tannergrass and *C. dactylon* var. *coursii*. Significantly higher protein yields were obtained at the optimum stage for harvest in all forages with the exception of Signalgrass.

Glabrous Signal (*Brachiaria brizantha*), USDA PI 255346, was the top dry forage yielder of the seven grasses studied. This grass produced about 20 tons of dry forage (73 tons of green forage) containing 7.1 percent of protein and about 19 tons of dry forage (69 tons of green forage) containing 8.2 percent of protein, at the 60-day harvest interval and at the optimum stage for harvest, respectively.

RESUMEN

En pruebas realizadas en la Subestación de Gurabo, siete yerbas forrajeras, Tanner (*Brachiaria* cf. *mutica*), una selección de yerba bermuda (*Cynodon dactylon* var. *coursii*), Signal-glabra (*Brachiaria brizantha*), Signal (*Brachiaria brizantha*), Pangola (*Digitaria decumbens*), Congo (*Brachiaria ruziziensis*) y Estrella (*Cynodon nlemfuensis* var. *nlemfuensis*), se cortaron a intervalos de 60 días y en su estado óptimo de cosecha, por un período de 2 años. Se consideró que las plantas habían llegado a su estado óptimo de cosecha al florecer y cuando las hojas de la base se tornaban amarillas; además, cuando las yerbas mostraban un volumen de forraje razonable al compararse estas plantas con las parcelas adyacentes que se cortaban cada 60 días.

Cuando el corte se hizo a intervalos de 60 días la yerba Signal-glabra fue la mejor productora con 72.78, 19.85 y 1.40 toneladas de forraje verde, forraje seco y proteína cruda por acre por año, respectivamente. La yerba Signal ocupó el segundo lugar como productora con 69.93, 16.87 y 1.20 toneladas de forraje verde, forraje seco y proteína cruda por acre por año, respectivamente.

Cuando el corte se hizo al llegar la yerba a su estado óptimo de cosecha, la mejor productora en términos de forraje verde total fue la yerba Congo con 70.40 toneladas por acre por año. La mejor productora en términos de forraje seco y proteína cruda total fue la Signal-glabra con 18.84 y 1.54 toneladas por acre por año, respectivamente, siguiéndola en turno la yerba Pangola con 69.90 y 17.30 toneladas de forraje verde y seco por acre por año, respectivamente.

La producción anual de forraje verde de todas las yerbas con la excepción de la Tanner fue similar cuando se cortaron cada 60 días al compararse con el corte en su estado óptimo de cosecha. La producción anual de forraje seco de todas las yerbas fue similar en ambos tipos de corte con la excepción de las yerbas Tanner y *C. dactylon* var. *coursii*. La producción anual de proteína cruda cuando las yerbas se cortaron en su estado óptimo de cosecha fue significativamente superior a la producción obtenida cuando las yerbas fueron cortadas a intervalos de 60 días, con excepción de la yerba Signal.

La yerba Signal-glabra (*Brachiaria brizantha*) USDA PI 255346 fue la mejor productora entre todas las yerbas estudiadas, en términos de forraje seco. Esta yerba produjo alrededor de 20 toneladas de forraje seco (73 toneladas de forraje verde) con un contenido de 7.1 por ciento de proteína cada 60 días y alrededor de 19 toneladas de forraje seco (69 toneladas de forraje verde) con un contenido de 8.2 por ciento de proteína en su estado óptimo de cosecha.

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