THE JOURNAL OF AGRICULTURE
OF THE UNIVERSITY OF PUERTO RICO

Issued by the Agricultural Experiment Station of the University of Puerto Rico, Mayagüez Campus, for the publication of articles and research notes by staff members or others, dealing with scientific agriculture in Puerto Rico and elsewhere in the Caribbean Basin and Latin America.

VOL. 87 JANUARY AND APRIL 2003 No. 1-2

Chemical composition of rhizoma perennial peanut (*Arachis glabrata*) harvested for hay in the tropics[1]

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J. Agric. Univ. P.R. 87(1-2):1-18 (2003)

ABSTRACT

The effect of harvest interval (HI), six-, nine-, and 12-wk, and season of growth (winter, spring, summer, and fall) on crude protein (CP) and neutral detergent fiber (NDF) was studied with rhizoma perennial peanut (RPP) TARS line nos. 17033, 17050, 17052, and 17097 (PI nos. 276233, 262826, 262833, and 262839, respectively) and cv Florigraze and Arbrook at the Lajas Agricultural Experiment Substation. The same parameters were evaluated with PI nos. 276233, 262839, and cv Florigraze at the Juana Díaz Substation. The overall mean CP concentration for RPP, across HI and season of growth was 16.3 and 15.5% in the Lajas and Juana Díaz studies, respectively. In both trials, accession 17033 had the lowest (14.2%) and accession 17097 the highest (16.7%) CP values ($P < 0.05$). Harvest interval negatively influenced CP concentration ($P < 0.01$). An increase in HI from six to 12 weeks resulted in a reduction of CP from 17.3 to 15.5%, and from 16.5 to 13.7% in the Lajas and Juana Díaz studies, respectively. In the latter study the CP concentrations of forage harvested at six and nine weeks were similar. Differences in NDF among RPPs were significant ($P < 0.05$) in both trials. In both, accession 17033 had the highest (49.9%) and accession 17097 the lowest (48.1%) concentration. Increasing HI resulted in quadratic increases ($P < 0.01$) in NDF concentration. Results for the six-, nine- and 12-wk intervals were 47.8, 50.9, and 51.8% at Lajas and 45.8, 44.5, 52.0% at Juana Díaz, respectively. Season of growth did influence chemical composition of RPP; however, unlike the pattern observed in tropical grasses, the chemical composition of RPP was better in the seasons of greater forage yield (spring

[1]Manuscript submitted to Editorial Board 6 February 2003.

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and summer). These results show the excellent potential for high nutritive value of RPP when grown in the Caribbean tropics.

Key words: rhizoma perennial peanut, tropical legume hay, chemical composition

RESUMEN

COMPOSICIÓN BROMATOLÓGICA DEL HENO DE MANÍ RIZOMA PERENNE (*ARACHIS GLABRATA*) EN EL TRÓPICO

El efecto del intervalo de corte (IC), seis, nueve y 12 semanas, y época de crecimiento (invierno, primavera, verano y otoño) en la concentración de proteína cruda (PC) y fibra detergente neutro (FDN) en maní rizoma (MR) fue evaluado en dos estudios con parcelas divididas. En la Subestación de Lajas de la Estación Experimental Agrícola de la Universidad de Puerto Rico se evaluaron las accesiones 17033, 17050, 17052 y 17097 (núm. PI 276233, 262826, 262833 y 262839, respectivamente) y los cvs Florigraze y Arbrook; en la Subestación de Juana Díaz se evaluaron las accesiones 17033 y 17097 y el cv Florigraze. La concentración promedio de PC fue de 16.3 y 15.5% en los estudios de Lajas y Juana Díaz, respectivamente. En ambos estudios, la accesión 17033 tuvo la menor (14.2%) y la 17097 la mayor (16.7%) concentración de PC de los MR estudiados ($P < 0.05$). El IC influenció negativamente la concentración de PC en el forraje ($P < 0.01$). Un aumento en el IC de seis a 12 semanas resultó en una reducción de 17.3 a 15.5% en Lajas y de 16.5 a 13.7% en Juana Díaz, en este último la PC del forraje de seis y nueve semanas fue similar. Las diferencias de FDN entre MRs fueron significativas ($P < 0.05$) en ambos estudios. En ambos, la accesión 17033 mostró el valor más alto (49.9%) y la accesión 17097 el más bajo (48.1%). Un aumento en el IC resultó, en ambos estudios, en un aumento cuadrático ($P < 0.01$) de la FDN. Los valores para los IC de seis, nueve y 12 semanas fueron 47.8, 50.9 y 51.8% en Lajas y 45.8, 44.5 y 52.0% en Juana Díaz, respectivamente. La época de crecimiento influenció la composición bromatológica del MR; sin embargo, contrario al patrón observado en gramíneas, el valor nutritivo del MR es mejor en las épocas de mayor rendimiento (primavera y verano). Los resultados obtenidos indican el excelente potencial del MR para producir forraje de alto valor nutritivo en el Caribe.

INTRODUCTION

Rhizoma peanut (*Arachis glabrata*) is a perennial warm season legume with an excellent potential for forage production in the tropics. It was first introduced into the Caribbean in 1989 by the U.S. Department of Agriculture at the Tropical Agriculture Research Station in Mayagüez, Puerto Rico. Out of the 75 accessions initially introduced, four have been identified with the best potential for hay production. At Lajas, Puerto Rico, Ruiz et al. (2000) reported a mean yearly dry matter yield for the four promising accessions greater than 29,000 kg/ha, the best accession yielding over 36,000 kg/ha. Two of the accessions USDA-TARS 17033 (PI no. 276233), and 17097 (PI no. 262839) outyielded commercial cultivars Arbrook and Florigraze. Perennial peanut, unlike tropical grasses, has proven to be most productive when harvested at a short (6-wk), rather than at a longer (12-wk), harvest interval (HI). The

peanut plant is most productive during the long-day season; it shows a marked reduction in growth during late fall and early winter (December to February).

Florigraze rhizoma peanut has demonstrated a higher nutritive value than that of tropical grasses. Romero et al. (1987) reported CP concentrations of 14.9 and 14.0% for 6-, and 9-wk Florigraze. Ott (1989) found that in horses, Florigraze hay had a digestibility of 57.7% compared to only 45% for coastal Bermudagrass hay; the CP digestibility was also much higher (60.1 vs. 35.2%). Therefore, the potential for good nutritive value of the RPPs is promising. Determination of its chemical composition is important because the success of RPP as a hay crop will depend on its being of quality superior to that of tropical grass hay. This study was conducted to determine the chemical composition of four promising RPP accessions (17033, 17050, 17052, and 17097) when grown in the Caribbean.

MATERIALS AND METHODS

The RPP samples evaluated for chemical composition were obtained from two plot trials conducted at the Lajas and Juana Díaz Substations of the Agricultural Experiment Station of the University of Puerto Rico, Mayagüez. At both sites RPPs were planted in the month of February in a San Antón soil (fine-loamy, mixed, isohyperthermic Cumulic Haplustolls). Soil at the experimental sites had a pH of 7.7 at Juana Díaz, and approximately 7.5 at Lajas. Experimental sites received about 1,100 mm of rain annually; supplemental irrigation to supply plots with at least 2.5 cm of water per week was provided throughout the evaluation period.

At Lajas, samples of accessions USDA-TRAS 17033, 17050, 17052, and 17097 (PI no. 276233, 262826, 262833, and 262839, respectively) and commercial cultivars Florigraze and Arbrook were evaluated when harvested at six, nine, and 12 weeks beginning in March 1996. Treatments were arranged in a split-plot in space and time of a randomized complete block with four replications. Peanuts were assigned to 22.6 m^2 (3.7×6.1 m) whole plots. These were split for each HI, and split in time for each of the four seasons of the year. Within each HI, harvest dates were assigned to seasons according to the time when most of the plant growth occurred for that particular harvest date. Winter included harvests for a period when most of the growth occurred from January to March; similarly, spring from April to June; summer, from July to September; and fall, from October to December. To reduce the number of analyses, samples from blocks one and two, and three and four were combined so that treatment combinations were replicated only twice.

In Juana Díaz, samples of accessions 17033 and 17097 and cultivar Florigraze were evaluated when harvested at six-, nine-, and 12-week intervals beginning in January 1997. These two accessions were selected for this trial because they had shown greater yield potential than the other two accessions studied in Lajas. Florigraze, the most widely planted commercial cultivar, was used as a control for comparison purposes. The experimental layout was as in the Lajas experiment, with the difference that samples from each of the four replicates were analyzed.

Forage samples were dried in a forced air oven at 60°C for 48 h. Dried RPP samples were ground through a 1-mm sieve and stored for further analyses. Each sample was analyzed in duplicate. Crude protein was determined by using the Micro Kjeldahl (AOAC, 1984) method with a sample of between 0.14 and 0.16 g. Neutral detergent fiber (NDF) was determined by using the Ankom 200 Fiber Analyzer (Ankom Technology, Macedon, NY).[4] Approximately 0.5 g of sample was introduced in a nylon bag (Ankon F57; 95% of open area has pores <30 microns in size), sealed, and digested. Twenty-five bags were digested in 2000 ml of NDF solution for 60 minutes. Bags were washed in hot water, then in acetone; the bags were dried at 60°C for 48 h and weighed to determine NDF.

Experimental data were analyzed by using the mixed procedure of SAS (Littell et al., 1991). F-tests were used to determine the significance of main effects and interactions. Comparisons of means were made by using the pdiff option of SAS and orthogonal contrasts for preplanned comparisons among harvest intervals and season of harvest. Whenever triple interactions are not discussed it is because these were not found to be significant ($P > 0.05$).

RESULTS

Lajas Experiment

Crude Protein

The mean CP concentration of the six RPPs studied, when averaged across HI and season of growth, was 16.3%. The highest values were observed for accession 17097, which surpassed values ($P < 0.05$) of the commercial cultivars Arbrook and Florigraze (Table 1). Values for

[4]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 equipments or materials.

TABLE 1.—*Crude protein (CP) of accessions (USDA-TARS) 17033, 17097, 17050,17052 and cultivars Florigraze and Arbrook of rhizoma perennial peanut (RPP) harvested at six-, nine-, and 12-wk intervals during a full year in Lajas.*[1]

RPP	Harvest Interval (HI)			Mean[2]
	6-wk	9-wk	12-wk	
	---------- % CP ----------			
17033	15.44	14.09	13.63	14.39 c
17050	19.39	16.94	15.82	16.72 ab
17052	17.67	17.11	16.14	16.98 ab
17097	18.44	17.22	16.30	17.32 a
Florigraze	17.39	15.84	15.35	16.19 b
Arbrook	17.33	16.16	15.73	16.41 b
Mean[3]	17.28	16.23	15.49	

[1]Interaction HI*RPP is not significant.

[2]Differences among means with different letters in the same column are significant, $P < 0.05$.

[3]CP decreased in a linear manner as HI increased from six to 12 weeks, $P < 0.01$.

accessions 17050 and 17052 were intermediate (16.9%) and similar to those of 17097, and to those of the two commercial varieties. Accession 17033 had the lowest CP concentration, 11.7% lower than that of the average of Arbrook and Florigraze. Harvest interval had a negative effect on CP concentration ($P < 0.01$). As the HI increased from six to 12 weeks, CP concentration of RPPs decreased linearly by a total of 1.8%. The effect of HI on CP was similar for all genotypes studied (no significant HI*RPP interaction).

The CP concentration in the RPP forage was affected in a significant manner ($P < 0.01$) by season of growth (Table 2). It was lowest and similar during winter and spring (averaging 15.5%), highest during summer, and intermediate during fall. The CP concentration of fall-grown forage was in relative terms 5.2% lower than that of summer-grown, and 7.4% higher than that of forage grown during winter and spring.

The effect of season on CP concentration was different among the RPP studied (interaction season × RPP, $P < 0.05$). For accessions 17033, 17052 and 17097 the CP concentration was lowest during winter and spring and highest during summer and fall (Table 2). For accession 17050 the CP value was lowest during spring (15.24%) and highest during winter, summer and fall (average of 17.24%). The two commercial varieties evaluated were affected in a different manner. For both Arbrook and Florigraze the CP concentration was highest during summer. However, for Florigraze the CP was lowest and similar during

TABLE 2.—*Crude protein (CP) of accessions (USDA-TARS) 17033, 17097, 17050, 17052 and cultivars Florigraze and Arbrook of rhizoma perennial peanut (RPP) harvested at six-, nine-, and 12-wk intervals in each season for a full year in Lajas.*[1]

RPP	Season			
	Winter	Spring	Summer	Fall
	% CP			
17033	13.58	14.20	14.98	14.79
17050	16.50	15.24	17.60	17.53
17052	15.68	15.67	18.23	18.33
17097	15.67	16.78	18.13	18.71
Florigraze	15.61	15.65	17.90	15.62
Arbrook	16.08	15.71	18.72	15.11
Mean[2]	15.52 c	15.54 c	17.59 a	16.68 b

[1]Interaction season*RPP is significant, $P < 0.05$.

[2]Differences among means with different letters in the same row are significant, $P < 0.01$.

fall, winter and spring; whereas for Arbrook values were lowest in forage grown in the fall.

Season of harvest modified the effect of HI on CP concentration (interaction season × HI, $P < 0.01$). In winter and spring, CP concentration was lowest for the forage harvested at 12 wk (Figure 1). On the other hand, combined summer and fall CP values of forage harvested at 9- and 12-wk intervals were similar (16.92 vs. 16.98%). In summer, the forage harvested at 9 wk had the lowest concentration, whereas it had the highest in the fall. Forage harvested at 6 wk had the highest CP concentration during winter, spring and summer; however, during fall, values were the lowest and similar to those of forage harvested at 12 wk.

Neutral Detergent Fiber

The overall mean NDF concentration of the six RPPs studied was 50.2% across HI and season of harvest. The highest mean concentration was observed in accession 17033 (Table 3). Values for accessions 17050 and 17052 were numerically lower but similar to that of 17033. On the other hand, Arbrook and Florigraze showed similar NDF concentrations that were less than that of accession 17033. The lowest NDF concentration among the RPPs studied, that of accession 17097, was relatively 4.2% lower than that of accession 17033.

Harvest interval affected the concentration of NDF in a positive and quadratic manner ($P < 0.01$). The concentration of the 6-wk RPP forage was the lowest. In relative terms it was 6.3% lower than that of the RPP harvested at a 9-wk HI. Thereafter the NDF concentration did not

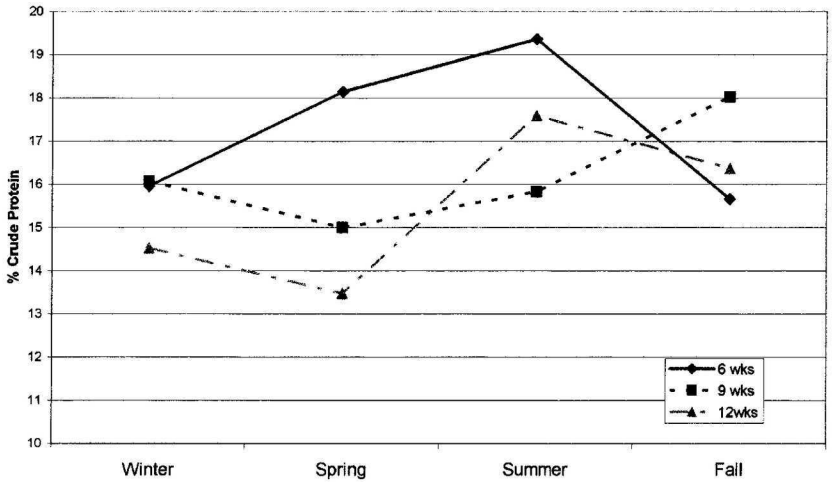

FIGURE 1. Average crude protein (CP) concentration of six RPPs (17033, 17050, 17052, 17097, 'Florigraze', and 'Arbrook') harvested at six, nine, and 12 weeks in each of the seasons of the year in Lajas.

increase in a significant manner when the HI increased from nine to 12 weeks. The effect of HI on NDF concentration was similar for all RPPs studied (no significant HI*RPP interaction).

TABLE 3.—*Neutral detergent fiber (NDF) of accessions (USDA-TARS) 17033, 17097, 17050, 17052 and cultivars Florigraze and Arbrook of rhizoma perennial peanut (RPP) harvested at six-, nine-, and 12-wk intervals during a full year in Lajas.*[1]

RPP	Harvest Interval (HI)			Mean[2]
	6-wk	9-wk	12-wk	
	---------- % NDF ----------			
17033	49.64	50.90	52.73	51.09 a
17050	48.31	50.83	52.91	50.68 ab
17052	47.97	51.06	52.45	50.50 ab
17097	46.03	49.74	51.00	48.92 c
Florigraze	48.03	51.00	51.24	50.09 b
Arbrook	47.14	51.70	50.66	49.83 cb
Mean[3]	47.85	50.87	51.83	

[1]Interaction HI*RPP was not significant.

[2]Differences among means with different letters in the same column are significant, $P < 0.05$.

[3]NDF increased in a quadratic manner as HI increased from six to 12 weeks, $P < 0.01$.

Season had a significant effect on NDF concentration ($P < 0.01$). The lowest concentration was observed for forage harvested in summer and the highest values for forage harvested in the fall (Table 4). Forage harvested during winter and spring had similar NDF concentration, with values being intermediate between those of summer and fall. The interaction between season and RPP was significant ($P < 0.05$). Accessions 17097 and 17033 deviated from the overall effect of season in that the NDF concentrations for forage grown in winter, spring, and fall were similar.

Season of harvest influenced the effect of HI on NDF concentration (interaction season × HI; $P < 0.01$). In fall, forage harvested at 12 weeks had by far the highest NDF concentration (Figure 2), while forage harvested at nine weeks had a greater concentration than that harvested at six weeks. In winter, the NDF concentration of forage harvested at the 9- and 12-wk intervals was similar (52.1%) and higher than that of the 6-wk interval (47.3%) RPP. In the spring, the NDF concentration was highest for the forage harvested at the 9-wk interval. Fiber concentration of the forage harvested at 12 weeks was intermediate, and that of forage harvested at six weeks was lowest. In summer, HI had no effect on NDF concentration; the mean across HI was 47.6%, which is similar to the average concentration of forage harvested at the 6-wk interval during winter, spring, and fall (47.7%).

Juana Díaz Experiment

Crude Protein

Differences in overall CP concentration, averaged across HI and season among accessions 17033, 17097, and cultivar Florigraze were statistically significant ($P < 0.01$). Crude protein, as a percentage of the DM, was similar (16.24%) in forage of accession 17097 and cultivar Florigraze (Table 5). Accession 17033 had a relative CP concentration, 14% lower than the average of the other two RPPs. An increase in HI from six to 12 weeks resulted in a quadratic ($P < 0.01$) decline in CP. Forage harvested at six- and nine-week intervals had a similar CP concentration, at about 16.3%. Crude protein concentration was lowest for the forage harvested at 12 weeks; it was 14.7% lower than the average of the forage harvested at six- and nine-week intervals. No significant interaction was found between RPP and HI with regard to CP concentration.

Season of growth influenced forage CP concentration in a significant way ($P < 0.01$). The highest CP concentrations were observed in forage grown during winter (Table 6). The lowest concentration was observed in summer forage, 15% less in relative terms than that grown in

TABLE 4.—*Neutral detergent fiber (NDF) of accessions (USDA-TARS) 17033, 17097, 17050, 17052 and cultivars Florigraze and Arbrook of rhizoma perennial peanut (RPP) harvested at six-, nine-, and 12-wk intervals in each season for a full year in Lajas.*[1]

RPP	Season			
	Winter	Spring	Summer	Fall
	% NDF			
17033	51.06	51.63	49.59	52.08
17050	50.47	51.23	48.69	52.34
17052	50.72	50.17	47.92	53.17
17097	50.85	49.54	45.54	49.77
Florigraze	49.96	49.32	46.77	54.33
Arbrook	50.16	49.27	47.34	52.56
Mean[2]	50.54 b	50.19 b	47.64 c	52.37 a

[1]Interaction season*RPP is significant, $P < 0.05$.
[2]Differences among means with different letters in the row are significant, $P < 0.01$.

winter. The average CP value of forages grown in spring and fall was intermediate, but higher ($P < 0.01$) in spring than in fall. The effect of season on CP concentration was different among RPPs (interaction

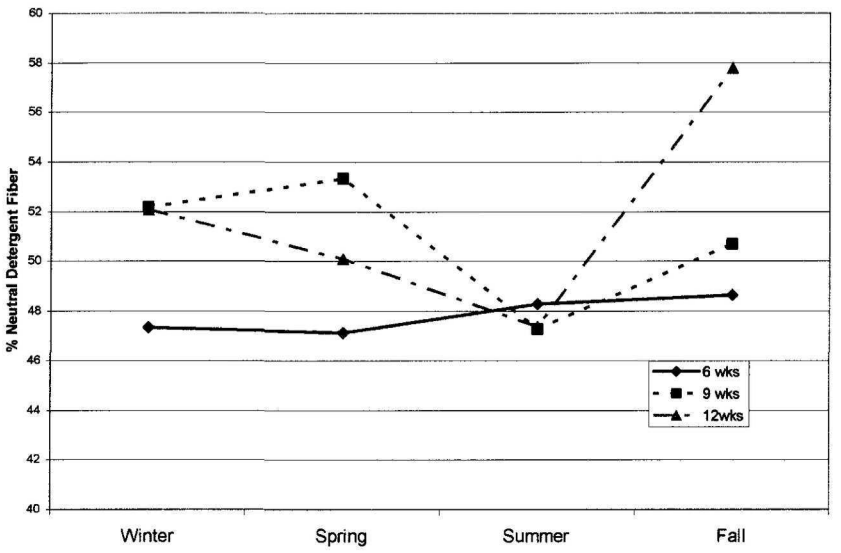

FIGURE 2. Average NDF concentration of six RPPs (17033, 17050, 17052, 17097, 'Florigraze', and 'Arbrook') harvested at six, nine, and 12 weeks in each of the seasons of the year in Lajas.

TABLE 5.—*Crude protein (CP) of accessions (USDA-TARS) 17033, 17097, and cultivar Florigraze or rhizoma perennial peanut (RPP) harvested at six-, nine-, and 12-wk intervals during a full year in Juana Díaz.*[1]

RPP	Harvest Interval (HI)			Mean[2]
	6-wk	9-wk	12-wk	
	---------- % CP ----------			
17033	14.99	14.65	12.10	13.91 b
17097	16.90	16.64	14.67	16.07 a
Florigraze	17.79	17.01	14.43	16.41 a
Mean[3]	16.55	16.10	13.73	

[1]Interaction HI*RPP is not significant.
[2]Differences among means with different letters in the same column are significant, $P < 0.01$.
[3]CP decreased in a quadratic manner as HI increased from six to 12 weeks, $P < 0.01$.

season × RPP, $P < 0.05$). In forage of accession 17033 the lowest CP concentration was observed in fall, not summer, as observed for the main effect of season. For accession 17097 the CP concentration in forage grown in fall and spring was similar, whereas in cultivar Florigraze it was similar during winter and spring.

Season of growth significantly influenced the effect of HI on CP concentration of RPP forage (interaction season × HI; $P < 0.01$). In forage harvested at a 12-week interval, the CP concentration declined from winter to summer (Figure 3). In forage harvested at a nine-week interval, season appeared to have the least effect on CP concentration; however, there was a tendency for CP to increase from spring to fall. In contrast, in forage harvested at a six-week interval there was a ten-

TABLE 6.—*Crude protein (CP) of accessions (USDA-TARS) 17033, 17097, and cultivar Florigraze of rhizoma perennial peanut (RPP) harvested during the four seasons of the year in Juana Díaz.*[1]

Season	RPP			Mean[2]
	17033	17097	Florigraze	
	---------- % CP ----------			
Winter	15.17	17.23	17.70	16.70 a
Spring	13.94	16.34	17.23	15.84 b
Summer	13.46	14.42	14.73	14.20 d
Fall	13.09	16.28	15.98	15.12 c

[1]Interaction season*RPP is significant, $P < 0.05$.
[2]Differences among means with different letters in the same column are significant, $P < 0.01$.

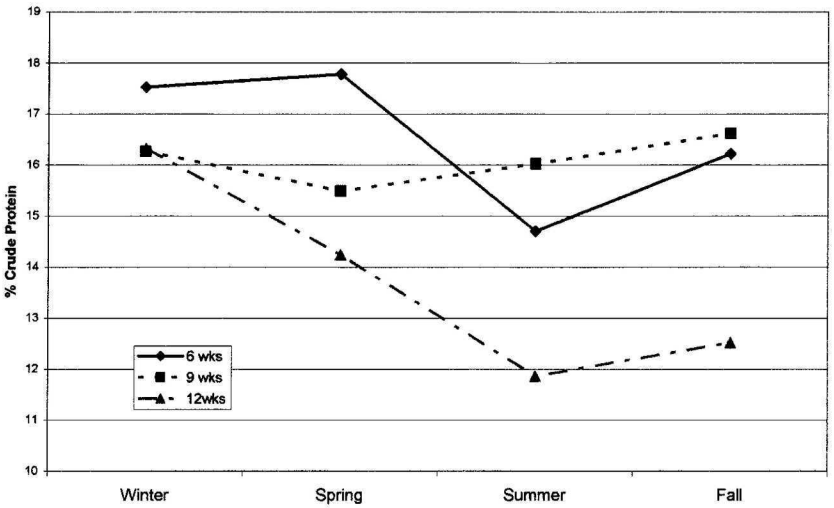

FIGURE 3. Average crude protein (CP) concentration of three RPPs (17033, 17097, and 'Florigraze') harvested at six, nine, and 12 weeks in each of the seasons of the year in Juana Diaz.

dency for a reduction in CP in summer. The highest CP concentration was observed in forage harvested at a six-week interval and grown in winter and spring. The concentration in forage grown in these seasons was similar and averaged 17.6%. On the other hand, during summer and fall the CP concentration of forage harvested at a nine-week interval was higher than that of forage harvested at a six-week interval.

The CP concentration of RPP forage was affected ($P < 0.01$) by the three-way interaction among season, RPP, and HI (Figure 4). Forage of accession 17033 had the lowest concentration of CP during winter, spring, and fall; however, during summer its CP concentration when harvested at a nine-week interval was higher than that of accession 17097. Furthermore, the CP concentration of forage from accession 17033 was similar to that of Florigraze when harvested at a 12-wk interval. The effect of HI on CP appeared to be linear for all three RPPs during spring but curvilinear during summer and fall. In winter, HI appeared to have no effect on CP concentration of accession 17097, whereas it had a quadratic effect on Florigraze and an inverse linear effect for 17033. During summer and fall, there was a tendency for the CP concentration to be higher in forage harvested at a nine-week interval than in that harvested at six- and 12-week intervals for accession 17097 and Florigraze. For accession 17033, this trend was observed in summer but not in fall.

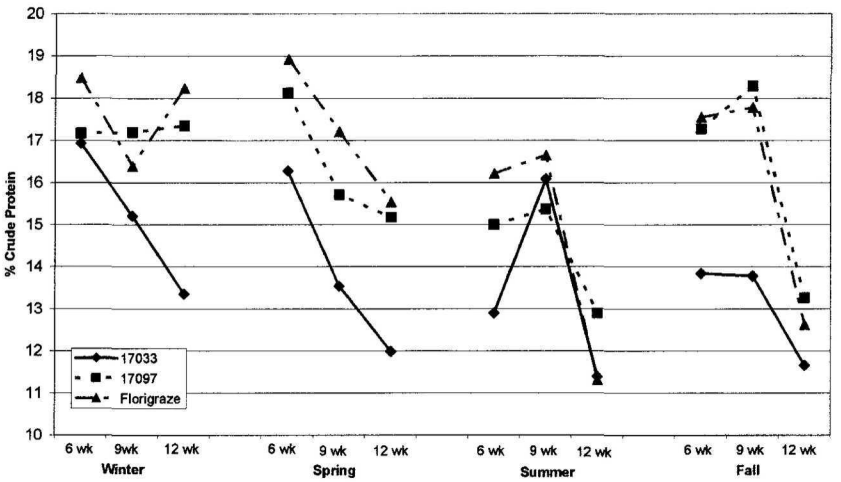

FIGURE 4. Crude protein of forage from RPP accessions 17033, 17097, and cultivar Florigraze harvested at six, nine, and 12 weeks in each of the seasons of the year in Juana Diaz.

Neutral Detergent Fiber

The mean NDF concentration of accessions 17033, 17097 and cultivar Florigraze across HI and season of growth was 47.42%. The NDF concentration of accession 17097 was similar to that of Florigraze (46.97%) and less ($P < 0.05$) than for accession 17033 (Table 7). An increase in HI from six to 12 weeks resulted in a quadratic increase ($P < 0.01$) in the concentration of NDF. The concentration was similar in the six- and nine-week forage; 15.1% less, relative to the average in the 12-week forage. The effect of HI on NDF concentration was not similar for all RPPs (interaction HI × RPP, $P < 0.05$). In forage of accessions 17033 and 17097 the NDF concentration declined from the six- to the nine-week interval, whereas in Florigraze it was similar at both of these harvest intervals. Even though NDF concentration in forage harvested at the six- and nine-week intervals was lowest for cultivar Florigraze, at the 12-week interval the concentration was lowest for accession 17097. At a six-week HI, NDF concentration of accessions 17033 and 17097 was similar, but at a 12-week interval it was similar for accession 17033 and cultivar Florigraze.

Season significantly influenced ($P < 0.05$) the NDF concentration of peanut forage. The lowest NDF concentration was observed in winter; the highest, in fall (Table 8). In relative terms, it was 23.3% higher in fall than in winter. For forage grown during spring and summer the

TABLE 7.—*Neutral detergent fiber (NDF) of accessions (USDA-TARS) 17033, 17097, and cultivar Florigraze or rhizoma perennial peanut (RPP) harvested at six-, nine-, and 12-wk intervals during a full year in Juana Díaz.*[1]

RPP	Harvest Interval (HI)			Mean[2]
	6-wk	9-wk	12-wk	
	---------- % NDF ----------			
17033	47.67	45.18	53.15	48.67 a
17097	46.50	44.39	50.88	47.25 b
Florigraze	43.30	43.84	51.86	46.33 b
Mean[3]	45.83	44.47	51.96	

[1]Interaction HI*RPP is significant, $P < 0.05$.
[2]Differences among means with different letters are significant, $P < 0.05$.
[3]NDF increased in a quadratic manner as HI increased from six to 12 weeks, $P < 0.01$.

NDF was intermediate, although higher in spring than in summer. The interaction between season and RPP was not significant.

Season of harvest modified the effect of HI on NDF concentration (interaction season × HI, $P < 0.01$). The NDF concentration of RPP forage harvested at a 12-wk interval was the highest in every season except during winter, when it was lower than that of 9-wk forage and similar to that of the 6-wk forage (Figure 5). For both the 6- and 12-wk-old forage there was a tendency for NDF concentration to increase from winter to fall. On the contrary, the forage harvested at a nine-week interval showed a tendency for NDF concentration to decrease from winter to summer, increasing slightly again in fall. The lowest NDF concentration during summer and fall was that of forage harvested at

TABLE 8.—*Neutral detergent fiber (NDF) of accessions (USDA-TARS) 17033, 17097, and cultivar Florigraze of rhizoma perennial peanut (RPP) harvested during the four seasons of the year in Juana Díaz.*[1]

Season	RPP			Mean[2]
	17033	17097	Florigraze	
	---------- % NDF ----------			
Winter	43.65	43.37	43.03	43.35 d
Spring	48.58	47.23	45.41	47.07 b
Summer	47.44	45.15	44.80	45.80 c
Fall	54.99	53.27	52.11	53.46 a

[1]Interaction season*RPP is not significant.
[2]Differences among means with different letters in the same column are significant, $P < 0.05$.

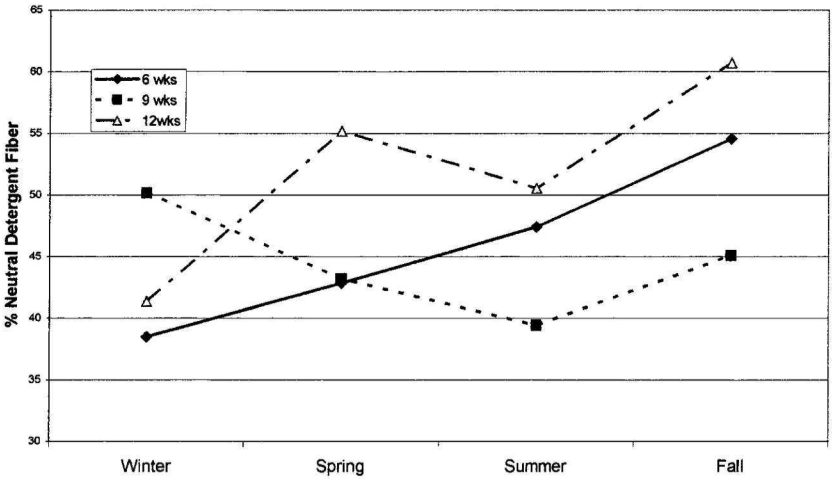

FIGURE 5. Average NDF concentration of three RPPs (17033, 17097, and 'Florigraze') harvested at six, nine, and 12 weeks in each of the seasons of the year in Juana Diaz.

nine weeks. Furthermore, in forage grown in winter and spring the lowest concentration was that of forage harvested at six weeks.

DISCUSSION

Crude Protein

Accession 17033 had the lowest CP concentration among the RPPs studied in both experiments. It was 14.0 and 14.3% lower relative to the average of accession 17097 and Florigraze at Lajas and Juana Díaz, respectively (Tables 1 and 5). The lower concentration could be explained in part by the higher yield of DM, which exceeded by at least 11% the average of accession 17097 and Florigraze (Ruiz et al., 2000). Furthermore, plants of accession 17033 have longer stems and appear to have a greater proportion of stems in relation to leaves than the other RPPs. The fact that RPP stems have a lower concentration of CP than leaves could explain part of the differences observed among RPPs.

The overall CP concentration of accession 17033, averaged across location, HI, and season, was 14.1%. Even though this was the lowest concentration among the RPPs studied, it is approximately 83% higher relative to the average concentration of six tropical grasses harvested at a similar stage of growth (Vicente-Chandler et al., 1974). In the Juana Díaz experiment the CP concentration of accession 17097 and Florigraze was similar. However, in the Lajas study CP concentration

of accession 17097 was higher than that of Florigraze, in spite of greater DM yield of accession 17097 compared to that of Florigraze (Ruiz et al., 2000).

In both experiments, an increase in HI from six to 12 weeks resulted in a reduction of CP in the forage. In comparative terms, the decline was 10.3 and 17.0% in Lajas and Juana Díaz, respectively. However, the differences in CP in the Juana Díaz experiment for the six- and nine-week forage were not significant (quadratic decline $P < 0.01$). In general, in accessions 17033, 17097, and Florigraze, when averaged across experiments, the relative decline in CP concentration from six to nine weeks was only 5.4% (16.82 to 15.91%). In contrast, tropical grasses showed a decline of approximately 21% (9.92 to 7.87%) when HI increased from 45 to 90 days (Sotomayor-Ríos et al., 1974). In another study (Vicente-Chandler et al., 1974), six tropical grasses (Napier, guinea, Carib, pangola, star, and congograss) receiving 1,700 kg/ha of 15-5-10 fertilizer showed a relative decline in CP concentration of 40% when HI increased from 40 to 90 days. Therefore, the observed decline in CP as the plant matures is at least two times greater for tropical grasses than for RPP forage.

The combined CP concentration of the six grasses at 40, 60, and 90 days of regrowth was 9.6, 7.7, and 5.7%, respectively (Vicente-Chandler et al., 1974). At six-, nine-, and 12-week intervals the CP concentration for accession 17033, the accession with the lowest CP value, was 15.2, 14.4, and 12.8%, respectively. Thus, the evidence suggests that RPP has considerably higher concentration of CP than tropical grasses, particularly for more mature forage (12-wk HI).

Season of growth affected CP concentration; however, the effects observed were not similar in the two experiments. At Lajas, CP concentration was highest in summer, and higher in fall than in winter and spring. At Juana Díaz, it was highest in winter, and higher in spring than in summer and fall. At this location winter was particularly dry and windy and the irrigation water appeared to have been distributed unevenly among experimental plots. Dry matter yield and plant height were lowest during winter, characteristics that favor high CP concentration in the plant (Ruiz et al., 2000). On the other hand, in Lajas during winter and early spring peanut plants experienced leaf drop due to leaf scorch caused by *Leptosphaerullina crassica*, particularly for the forage harvested at 12 weeks. The authors have no clear hypothesis to explain the discrepancies in CP concentration between experiments as affected by season of the year. Accession 17033 deviated from the overall observed pattern in that the CP concentration in forage grown in spring was similar to that of forage grown in summer in both trials.

The interaction of season × HI affected CP significantly in both experiments; however, the observed results were not similar between experiments. Only for forage harvested at a 9-wk interval was the effect of season on CP concentration similar at both locations. At nine weeks RPP experienced less change in CP concentration due to season than forage harvested at six and 12 weeks.

Neutral Detergent Fiber

In both experiments, the NDF concentration was higher in forage of accession 17033 than in that of accession 17097 and Florigraze, comparatively 3.2 and 3.9% in Juana Díaz and Lajas, respectively. Although small, these differences were statistically significant at both locations ($P < 0.05$). The NDF concentration of accession 17097 was lower than that of Florigraze in the Lajas study, but similar to that of Florigraze in Juana Díaz. The range of NDF concentrations (43 to 53%) observed for RPPs in both experiments agree with those reported for early- to mid-bloom legume hay (Rohweder et al., 1978) and are considerably lower than the values for tropical grasses (61.5 to 74.6%) cited by the same authors.

Ruiz et al. (1995) reported a range in NDF concentrations for *Cynodon nlemfuensis* (stargrass), *Brachiaria purpurascens* (paragrass), and *Panicum maximum* (guineagrass) mixed pasture that was between 66.4 and 74.1% when harvested at an average of 30 days to a residual height of 15 cm. Mandebvu et al. (1998) reported an average concentration of 83% for 'Tifton 85' Bermudagrass hay harvested at seven weeks of regrowth. When averaged across HI and season, the NDF concentration of peanut hay of accessions 17033 and 17097 and of commercial cultivar Florigraze was 48.7%. This concentration is far lower than the lowest values reported for tropical grass hays (Rohweder et al., 1978). This finding is important because the NDF analysis provides a good estimate of the slowly digestible and indigestible fractions of the forage. Thus, in general, the lower the NDF concentration of the forage, the higher its digestibility and intake potential (Van Soest, 1982).

In both trials, HI affected NDF concentration, which increased in a quadratic manner over the intervals from six to 12 weeks. In the Lajas experiment, the NDF concentration in the forage harvested at nine and 12 weeks was similar and greater than for the forage harvested at six weeks. However, the relative difference observed in NDF concentration between the six- and 12-week forage was only 4%. At Juana Díaz, the values observed in the forage harvested at six and nine weeks were similar and less than those in the forage harvested at 12 weeks. In this trial, the relative difference in NDF concentration between the six- and

12-week forage was greater (7.5%) than at Lajas. When averaged across location and RPP, the NDF concentration was 46.9, 47.5, and 51.8% for forage harvested at six, nine, and 12 weeks, respectively. Arroyo-Aguilú and Oporta-Téllez (1980) reported average NDF concentrations of 71.0, 75.4, and 76.5% for Napier (*Pennisetum purpureum*) and guinea grasses harvested at 30-, 45-, and 60-day intervals, respectively. Pangola digitgrass averaged 72.8, 72.4, and 74.2%. Gutiérrez-Vargas et al. (1978) reported that stargrass averaged 77.0, 77.7, and 76.9% when harvested at 30-, 45-, and 60-day intervals, respectively. Mandebvu et al. (1998) reported values of 79.3 and 83.0% for 'Tifton 85' Bermudagrass hay harvested at 3.5- and 7-wk intervals. Thus, tropical grass hays, even when harvested at immature stages of growth (30 to 40 days), have much higher concentrations of NDF than even mature (12-week) RPP forage.

The NDF concentration in RPP forage was highest at both sites when it was harvested during the fall season. At this time of the year, growth of RPP slows considerably thus resulting in a relative reduction in DM yield of between 33 and 63% compared with that of summer (Ruiz et al., 2000). In both trials, the NDF concentration was lower during summer than fall and spring. The interaction of season × HI affected NDF concentration of RPPs in both experiments; however, the observed effect was different between them. One reason for the observed differences could be the low NDF concentration during winter and spring in forage harvested at six and 12 weeks in Juana Díaz. These results suggest that the forage harvested in summer, the season of greatest DM yields, is also of better quality than that harvested in fall and spring, and that RPP thus offers a maximum harvest of both hay and nutrients.

The data on CP and NDF concentration in this experiment clearly show the excellent potential for high quality of RPP grown in the Caribbean tropics. When averaged across experiments, RPP, and HI, the concentration of CP and NDF was 15.7 and 48.7%, respectively. These results, particularly those of NDF, suggest that the nutritive value of RPP in most circumstances would be better than that of the highest quality tropical grass. Given its good adaptability to the tropical environment and its high yield potential, RPP constitutes a viable alternative for the production of high quality hay in the tropics.

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