

Dry matter digestibility of rhizoma perennial peanut (*A. glabrata*) grown for hay in the Caribbean¹

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ABSTRACT

The *in vitro* true dry matter digestibility (IVTDMD) of rhizoma perennial peanut (RPP) forage was evaluated in trials at Lajas (PI no. 276233, 262826, 262833, 262839, and cvs Florigraze and Arbrook) and Juana Díaz (PI no. 276233, 262839, and cv Florigraze), Puerto Rico. At both sites, the forage was cut at six-, nine-, and 12-wk harvest intervals (HI) in each of the four seasons of the year. The digestibility of the forage was not influenced by genotype. Mean IVTDMD across HI and season of growth was 64.3 and 62.5% in the Lajas and Juana Díaz trials, respectively. The IVTDMD decreased in a quadratic manner ($P < 0.01$) as HI increased from six to 12 weeks. The digestibility of forage harvested at six and nine weeks was similar, with a relative decline of 6.6 and 10.6% as HI increased from nine to 12 weeks in Lajas and Juana Díaz, respectively. Season of growth influenced IVTDMD ($P < 0.01$). In both trials, the highest digestibility was obtained in forage grown in summer. The effect of season of growth on IVTDMD was greatest in forage harvested at 12 weeks, and least in forage harvested at six weeks. The high digestibility reported among genotypes evaluated suggests they are a viable alternative for the production of high quality hay in the Caribbean tropics.

Key words: rhizoma perennial peanut, *in vitro* digestibility, tropical legume hay

RESUMEN

DIGESTIBILIDAD DE LA MATERIA SECA DE HENO DE MANÍ RIZOMA PERENNE (*A. GLABRATA*) COSECHADO EN EL TRÓPICO CARIBEÑO

La digestibilidad verdadera de la materia seca *in vitro* (DVMSIV) del maní rizoma perenne (MRP) fue evaluada en Lajas (núm. PI 276233, 262826, 262833, 262839 y los cvs Florigraze y Arbrook) y Juana Díaz (núm. PI 276233, 262839 y el cv Florigraze). En ambas localidades, el forraje se cortó a intervalos de seis, nueve y 12 semanas en cada una de las cuatro estaciones del año. La DVMSIV del forraje no fue afectada por el genotipo del MRP evaluado. Las medias fueron 64.3 y 62.5% para los MRP evaluados en Lajas y Juana Díaz, respectivamente. A medida que se alargó el intervalo de corte de seis a 12 semanas la DVMSIV se redujo ($P < 0.01$) en una forma cuadrática. En ambos estudios, la digestibilidad del forraje cosechado a las seis y nueve semanas fue similar; al aumentar de nueve a 12 semanas hubo una reducción relativa en la DVMSIV de 6.6 y 10.6% en Lajas y Juana Díaz,

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respectivamente. La estación de crecimiento afectó ($P < 0.01$) la DVMSIV. El forraje cosechado durante el verano tuvo la digestibilidad más alta en ambas localidades. El efecto de la estación de crecimiento fue mayor en el forraje cosechado a un intervalo de 12 semanas y menor en el forraje cosechado a las seis semanas de crecimiento. La alta digestibilidad de los genotipos evaluados sugiere que el MRP es una alternativa viable para la producción de heno de alta calidad en el trópico caribeño.

INTRODUCTION

One of the greatest limitations to dairy cattle production in the Caribbean tropics is the lack of high-quality forage that can be grown locally. Forage legumes stimulate higher feed intake and can support greater milk production than tropical grasses. At present there is no forage legume used for commercial hay production in the Caribbean Basin area. The legume that has shown the best potential for yield and quality in the tropics is rhizoma perennial peanut (RPP). In Puerto Rico, various accessions have been identified with potential for hay production (Valencia, 1993). Yearly dry matter yields of the best genotypes evaluated are between 25,000 and 35,000 kg/ha when harvested between six and nine weeks of regrowth and grown under irrigation.

Under most conditions the nutritive value of RPP is much higher than that of tropical grasses commonly grown in the Caribbean. The crude protein (CP) concentration of RPP hay ranges from 13 to 18%, depending on genotype, age at harvest, and season of harvest (Ruiz and Cancel, 2003; Romero et al., 1987). Crude protein concentrations of tropical grass hays can range from <5 to 16%. In Lajas, Puerto Rico, Ruiz and Cancel (2003) found the CP concentration of six genotypes to be 14.8% when averaged for three harvest intervals (HI: six, nine, and 12 weeks).

Cultivars Florigraze and Arbrook of rhizoma perennial peanut (RPP) have demonstrated high quality potential and excellent adaptability to subtropical areas in Florida. Romero et al. (1987) reported mean in vivo DM digestibilities of Florigraze RPP between 61.7 and 64.4% when fed to 300-kg Holstein heifers. Prine et al. (1981) reported in vitro organic matter digestibilities (IVOMD) for Florigraze RPP hay that averaged 66.6% over three years. Intake of organic matter (OM) from Florigraze hay has been reported to be similar to that of alfalfa hay by sheep (French et al., 1987) and greater than that of alfalfa hay by dairy heifers (Romero et al., 1987). When consumed by beef calves in a creep-grazing system, OM from Florigraze resulted in greater growth rate of calves and lower body weight loss of their dams in the period from calving to weaning than did that of bahiagrass (*Paspalum notatum*) pastures (French et al., 1987). Yearling steers grazing on pure Florigraze RPP achieved gains of 0.89 kg/d compared with only 0.24 kg/d on bahiagrass pastures (French et al., 1987).

Recently introduced RPP lines have demonstrated excellent adaptability to the tropical climate in Puerto Rico and greater yield potential than cultivars Florigraze and Arbrook (Ruiz et al., 2000). In addition to their excellent yield, they have a higher nutritive value than tropical grasses grown in the area. The determination of *in vitro* digestibility of these promising RPP lines will provide a good indication of their quality potential when grown in the tropics.

MATERIALS AND METHODS

Samples of RPP used in this study were obtained from established plots in trials conducted at the Lajas and Juana Díaz Substations of the Agricultural Experiment Station of the University of Puerto Rico, Mayagüez. At each location, plots were evaluated for a full year beginning March 1996 in Lajas, and January 1997 in Juana Díaz. Plots received supplemental irrigation to provide at least 2.5 cm of water each week.

In the Lajas study, four accessions USDA-TARS 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-week intervals. The arrangement of treatments used was a split-plot in space and time of a randomized complete block with four replications. Plots were split for HI, and split in time for each of the four seasons of the year as previously described (Ruiz et al., 2000). To reduce the number of analyses in the Lajas study, 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 as in the Lajas trial.

The forage samples in both trials were dried in a forced air oven at 60°C for 48 h. Subsequently, the dried RPP samples were ground through a 1-mm sieve and stored until analyzed. To determine *in vitro* true dry matter digestibility (IVTDMD) a Daisy II Rumen Fermenter (Ankom Technology, Macedon, NY)³ was used. In this procedure a 0.5-g subsample was introduced into an ANKOM 57 filter bag (95% of the open area has pores <30 microns in size) and incubated at 39.5°C for 48 h. Rumen fluid for the incubating solution was obtained from two fistulated Holstein cows fed a diet consisting solely of grass hay. Each duplicate subsample was incubated in rumen fluid from a different cow. After the end of the incubation period, sample bags were introduced

³Trade 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.

into ice water to stop fermentation and then rinsed in cold water in a washing machine. They were then placed in an ANKOM 200 fiber analyzer, where the procedure to determine neutral detergent fiber (NDF) was followed. Finally the bags were rinsed and dried in a forced air oven, and weighed to determine undigested DM.

Experimental data were analyzed by using the mixed procedure of SAS (Littell et al., 1991). To determine the significance of differences among main effects and interactions, the F-test was used. Comparisons of means were made by using the PDIFF option of SAS, and by orthogonal contrasts for pre-planned comparisons to determine differences among HI and among seasons of harvest. Whenever triple interactions are not discussed it is because these were not found to be significant ($P > 0.05$).

RESULTS

Lajas Experiment

Differences in IVTDMD among the RPPs studied were not statistically significant at $P < 0.05$ (Table 1). Overall mean IVTDMD for the six RPPs studied was 64.35%. Only the value of accession 17097 deviated by more than 2% from this mean. As expected, length of HI had a significant ($P < 0.01$) quadratic effect on IVTDMD; the digestibility of RPP was similar at six- and nine-week intervals but declined in forage harvested at a 12-week interval. The digestibility of forage at the 12-wk HI

TABLE 1.—*In vitro true DM digestibility (IVTDMD) of accessions (USDA-TARS) 17033, 17097, 17050, 7052 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	
	-----% IVTDMD-----			
17033	65.10	64.35	60.10	63.18
17050	66.36	65.52	61.06	64.31
17052	66.24	66.81	60.21	64.42
17097	67.00	67.55	63.49	66.01
Florigraze	65.01	65.25	61.21	63.82
Arbrook	65.89	64.56	62.75	64.40
Mean ³	65.93	65.67	61.47	

¹Interaction RPP*HI was not significant at $P < 0.05$.

²Differences among means were not significant, $P < 0.05$.

³Decreased in a linear manner as HI increased from six to 12 weeks, $P < 0.01$.

was 6.6% lower than the mean digestibility of the six- and nine-wk forage. The effect of HI on IVTDMD was similar in all RPPs studied (interaction RPP × HI, NS $P > 0.05$).

Season of growth significantly influenced the digestibility of the RPPs evaluated ($P < 0.01$). In general, digestibility was highest during summer, lowest during fall, and similar during winter and spring (Table 2). In summer IVTDMD was 10% higher than in fall, and 5.1% higher than the mean of winter and spring. The effect of season of growth on IVTDMD was different among the RPPs studied (interaction season × RPP, $P < 0.01$). Only for accession 17033 and Arbrook was the effect of season of harvest similar to that of the main effect. For accession 17050, the digestibility was similar during winter, spring and fall, and highest during summer. The digestibility of accessions 17052 and 17097 was similar and highest during spring and summer, similar and lowest during winter and fall. For Florigraze, digestibility was similar during winter, spring and summer, and lowest during fall.

The effect of HI on IVTDMD was influenced by season of growth (season × HI, $P < 0.01$; Figure 1). The digestibility of RPP forage harvested at six and nine weeks was similar, and did not appear to change with season. On the other hand, the digestibility of the RPP forage harvested at a 12-wk interval was lowest in every season except during winter, when it was highest.

The interaction between season of growth and HI was influenced in a significant way by RPP genotype (triple interaction season × HI ×

TABLE 2.—*In vitro* true DM digestibility (IVTDMD) of accessions (USDA-TARS) 17033, 17097, 17050, 7052 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
	----- % IVTDMD -----			
17033	63.93	62.87	65.80	60.13
17050	63.17	62.85	68.82	62.43
17052	62.25	66.28	67.73	61.42
17097	64.45	67.22	67.95	64.43
Florigraze	65.37	65.23	66.62	58.08
Arbrook	65.25	62.80	68.70	60.85
Mean ²	64.07 b	64.54 b	67.60 a	61.22 c

¹Interaction season*RPP was significant at $P < 0.01$.

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

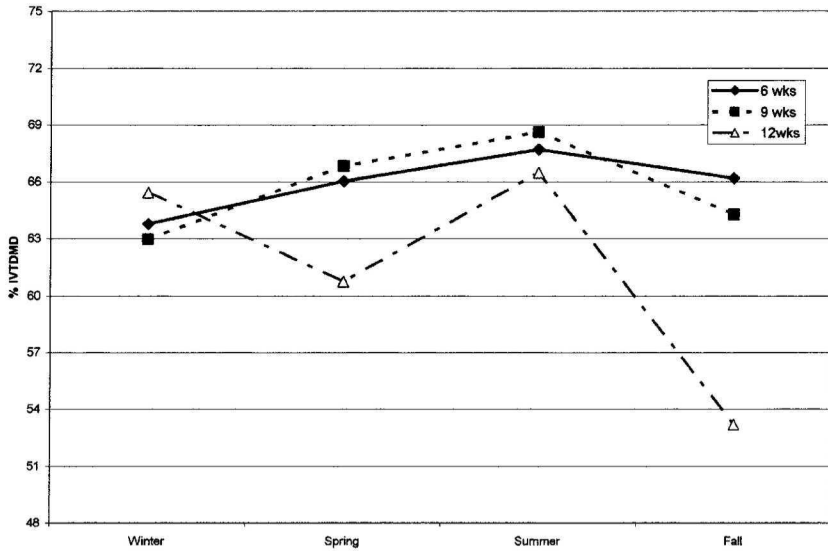


FIGURE 1. Average in vitro true digestibility of six RPPs harvested at six, nine, and 12 weeks in each of the four seasons of the year in Lajas.

RPP, $P < 0.05$). Differences in digestibility due to HI and RPP genotype appeared to be smallest during summer and greatest during fall (Figure 2). In winter, there was a tendency for a quadratic effect of HI on IVTDMD. For accession 17097 and cultivars Arbrook and Florigraze the tendency was for an increase as HI increased. For accession 17052, IVTDMD decreased as HI increased, whereas for accessions 17033 and 17050, values were similar at six- and 12-wk and lowest at the nine-wk interval. During spring, the tendency in all RPPs was for a quadratic decline. In this season, the digestibility of the forage harvested at six- and nine-week intervals was similar in all RPPs except for 17052 and Arbrook. For these two RPPs the digestibility of the forage harvested at nine-week interval was highest. In fall, accessions 17050 and cultivars Arbrook and Florigraze showed a tendency for a linear decline as HI increased; this observation was not made in any other season. For forage harvested at nine and 12 weeks there was a strong tendency for IVTDMD to decline from summer to fall, with the exception of forage from accessions 17050 and 17097 when harvested at nine weeks. The digestibility of RPP harvested at a 12-wk interval declined from winter to spring, with the exception of that of accession 17052. With the 12-wk interval, the digestibility of RPP increased sharply from spring to summer in all RPPs except accession 17097, in which it remained the same.

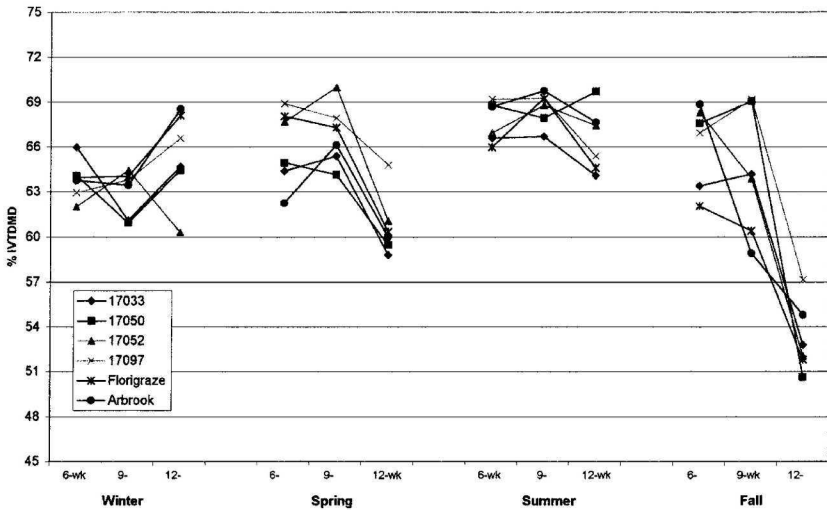


FIGURE 2. In vitro true DM digestibility of accessions 17033, 17050, 17052, 17097, and cvs Florigraze and Arbrook harvested at six, nine, and 12 weeks in each of the four seasons of the year in Lajas.

Juana Díaz Experiment

The mean IVTDMD of RPP samples of accessions 17033, 17097, and cultivar Florigraze across HI and season of growth was 62.48%. Analysis of the data indicated no difference in IVTDMD among RPPs (Table 3). Harvest interval significantly affected the IVTDMD of RPP ($P < 0.01$). As the HI increased from six to 12 weeks there was a quadratic decline in IVTDMD. The digestibility of forage harvested at six and nine weeks was similar, averaging about 64.8%, whereas in forage harvested at 12 weeks it declined by 10.6% relative to that at a nine-wk interval. The effect of HI on the IVTDMD was similar in the three RPPs studied (interaction RPP \times HI, NS $P > 0.05$).

Season of growth affected IVTDMD of RPP in a significant ($P < 0.01$) manner. The digestibility was lowest and similar during winter and spring (59.12%), and highest during summer (Table 4). In fall the digestibility of RPP forage was higher than in winter and spring but lower than in summer. The effect of season on IVTDMD was similar in the three RPPs studied (interaction season \times RPP, NS $P > 0.05$).

The effect of HI on digestibility was influenced significantly by season of harvest (interaction season \times HI, $P < 0.01$). In winter the digestibility of forage harvested at six- and 12-week intervals was similar and greater than that of nine-week-old forage (Figure 3). In spring,

TABLE 3.—*In vitro true DM digestibility (IVTDMD) 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 Diaz.*¹

RPP	Harvest Interval (HI)			Mean ²
	6-wk	9-wk	12-wk	
	-----% IVTDMD -----			
17033	65.95	63.38	58.95	62.75
17097	65.35	63.42	57.91	62.23
Florigraze	66.29	64.19	56.89	62.46
Mean ³	65.86	63.66	57.92	

¹Interaction RPP*HI was not significant at $P < 0.05$.

²Differences among means were not significant, $P < 0.05$.

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

the digestibility of nine and 12-week forage was similar (55.27%) and lower than that of six-week forage (66.49%). The digestibility of RPP harvested at a nine-week interval was highest in summer, and in fall was similar to the digestibility of forage harvested at a six-week HI. The forage harvested at six- and 12-wk intervals deviated from the general pattern observed for season. During summer and fall, the IVTDMD was lowest for the RPP forage harvested at a 12-week interval. The digestibility of forage harvested at a six-week interval tended to increase from winter to summer, remaining high in fall. In forage harvested at a 12-week interval the digestibility was highest during summer (66.09%); however, unlike forage harvested at six and nine weeks, it was lowest (49.27%) in fall.

TABLE 4.—*In vitro true DM digestibility (IVTDMD) of accessions (USDA-TARS) 17033, 17097, and cultivar Florigraze of rhizoma perennial peanut (RPP) harvested during the four seasons of the year in Juana Diaz.*¹

Season	RPP			Mean ²
	17033	17097	Florigraze	
	-----% IVTDMD -----			
Winter	60.58	58.63	58.49	59.24c
Spring	59.18	59.67	59.17	59.01c
Summer	69.16	69.96	70.02	69.71a
Fall	62.08	61.64	62.15	61.96b

¹Interaction season*RPP was not significant at $P < 0.05$.

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

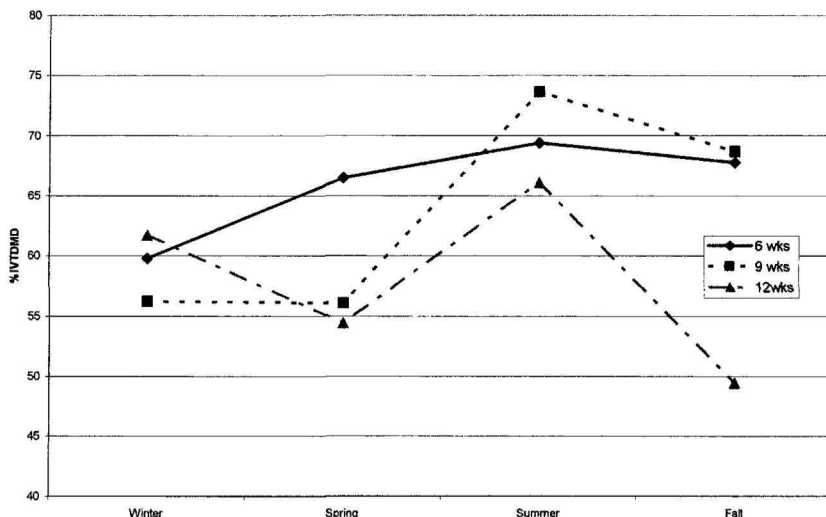


FIGURE 3. Average in vitro true digestibility of six RPPs harvested at six, nine, and 12 weeks in each of the four seasons of the year in Juana Diaz.

DISCUSSION

No significant differences in IVTDMD were observed among RPP genotypes evaluated in either of the two trials. Mean digestibility values were higher in the Lajas than in the Juana Díaz experiment, primarily because of the lower digestibility of the forage harvested at 12 weeks in Juana Díaz. The digestibility of accessions 17033, 17097 and cv Florigraze harvested at 12 weeks was 6.35% higher in Lajas. The overall mean digestibilities observed in these trials agree with values reported by Prine et al. (1981) for Florigraze RPP. These authors reported in vitro organic matter digestibilities that averaged 66.6% over three years in Florida. Harvest interval affected IVTDMD similarly in these two experiments. The digestibility of RPP at six and nine weeks was similar, averaging approximately 65.23% between experiments for accessions 17033, 17097, and cv Florigraze. At a 12-week HI the digestibility declined significantly when compared to values observed for forage harvested at six- and nine-wk intervals. When averaged for both experiments, the digestibility of RPP harvested at 12 weeks declined by 8.4% relative to that at six and nine weeks.

Contrary to what has been observed for RPP at the six- and nine-week HI, the digestibility of tropical grasses declines significantly over a similar interval of increasing maturity. Méndez-Cruz et al. (1988) re-

ported a relative decline of *in vivo* DM digestibility of 9.3% when the HI of five tropical grass hays increased from 35 to 55 days. In another trial, Mandebvu et al. (1998) reported a relative decline in IVDMD of 12.99% for 'Tifton 85' Bermudagrass hay when the HI increased from 3.5 to 7.0 wk. Therefore, over the range of HI most commonly used for hay production in the Caribbean (<9 wk) the digestibility of RPP hay will be higher than for tropical grasses and will decline at a slower rate with an increase in HI. Rhizoma perennial peanut will therefore provide more flexibility than grasses in terms of determination of harvest dates, thus allowing more variability regarding management and weather considerations without the digestibility of the hay being affected significantly.

In both experiments, the digestibility of harvested RPP forage was highest when growth occurred during summer. This finding is important because at every HI, RPP yield was highest in summer (Ruiz et al., 2000). The digestibility of forage grown during winter and spring was similar within trials; however, mean value in these seasons was intermediate (between that of summer and fall) in Lajas and lowest (compared with that of summer and fall) in Juana Díaz. The digestibility of RPP grown in fall was similar in both experiments, averaging 61.59%. Overall, summer is the season when the greatest yield of DM is produced. Thus, the greatest yield of digestible nutrients can also be expected in summer. During spring the yield of DM is comparable to that in summer, but the digestibility of the forage is lower.

The effect of season of growth on IVTDMD of RPP forage seems to be greater for forage harvested at a 12-week HI, particularly during spring and fall, when digestibility, compared to that of forage harvested at six and nine weeks, is much lower than that during winter and summer (Figures 1 and 2). Forage harvested at six weeks appears to have been affected the least by season of growth. Forage harvested at nine weeks behaved similarly to that harvested at six weeks in Lajas; however, in Juana Díaz its digestibility during winter and spring was lower than that of six-week forage.

The IVTDMD of the RPPs appeared to be independent of DM yield and chemical composition. Accession 17033 had the highest DM yield (Ruiz et al., 2000) and NDF concentration, and lowest CP concentration (Ruiz and Cancel, 2003) among the RPPs evaluated. In tropical grasses these characteristics are associated with lower digestibility of the forage. However, the digestibility of forage of accession 17033 was similar to that of the other RPPs evaluated. This similar digestibility in spite of a greater NDF concentration might be associated with greater digestibility of the NDF fraction in accession 17033.

When evaluated for hay production under tropical conditions, RPP produced excellent DM yields (Ruiz et al., 2000). These are comparable to yields of tropical grasses, with the advantage that the forage of peanut is of better chemical composition and higher digestibility. This potential for high quality hay does not seem to be influenced by yield of the RPP genotype when harvested before nine weeks or during summer. Thus, RPP appears to be an excellent and viable alternative for the production of better quality hay than that of grasses in the tropics.

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