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Forage yield and nutritive value of *Panicum maximum* genotypes in the Brazilian savannah

Francisco Duarte Fernandes[1], Allan Kardec Braga Ramos[1], Liana Jank[2], Marcelo Ayres Carvalho[1], Geraldo Bueno Martha Jr.[3], Gustavo José Braga[1]*

[1]Embrapa Cerrados, BR 020 km 18 – 73310-970 – Planaltina, DF – Brazil.
[2]Embrapa Beef Cattle, Rua Radio maia, 830 – 79106-550 – Campo Grande, MS – Brazil.
[3]Embrapa Studies and Training, Pq. Estação Biológica, s/n – 70770-901 – Brasília, DF – Brazil.
*Corresponding author <gustavo.braga@embrapa.br>

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ABSTRACT: The narrow genetic variability of grasslands and the incidence of new biotic and abiotic stresses have motivated the selection of new *Panicum maximum* genotypes for use as forage for beef cattle in the Brazilian savannah. This study aimed to evaluate forage yield and nutritive value of *P. maximum* genotypes including 14 accessions (PM30 to PM43), four intraspecific hybrids (PM44 to PM47) and six cultivars (Aruana, Massai, Milênio, Mombaça, Tanzania and Vencedor), examining 24 genotypes over two years (2003 and 2004). Milênio cultivar was the genotype with the highest dry matter yield (DMY) in both years (18.4 t ha^{-1} and 20.9 t ha^{-1}, respectively) although it presented a high proportion of stems (~ 30 %). Genotypes that showed higher Leaf DMY in both years were the accession PM34 (14.7 t ha^{-1}) and the hybrid PM46 (14.0 t ha^{-1}), while Mombaça and Tanzania yielded 12.5 and 11.0 t ha^{-1}, respectively. Leaf organic matter digestibility and leaf DMY for PM40 and PM46 genotypes exceeded the mean (> 656 g kg^{-1} and > 11.7 t ha^{-1}, respectively). For this reason, PM40 and PM46 can be considered promising *P. maximum* genotypes for use as forage for grazing systems in the Brazilian savannah.

Introduction

The neotropical savannah known as Cerrado, located in the center of the Brazilian territory, presents 49 million hectares of cultivated pastures (Sano et al., 2007). Even though they are quite well adapted to general environmental conditions, their narrow genetic variability makes these pastures vulnerable to novel biotic and abiotic stresses. Examples of this are the emergent sap-sucking insect well-known as the sugarcane spittlebug (*Mahanarva* spp.), and a syndrome called 'sudden death' that have reached large areas of Marandu grass (*Brachiaria brizantha* Hochst. ex A. Rich. Stapf.) pastures in the Northern Brazilian territory, with a complex diagnosis usually related to temporarily flooded areas (Auad et al., 2010; Caetano and Dias-Filho, 2008). To expand the genetic diversity with highly productive species and to decrease the susceptibility of Brazilian pastures to upcoming stresses, new grass genotypes have undergone assessment by Brazilian research institutions (Sousa et al., 2011, Pessim et al., 2010, Resende et al., 2004).

As an alternative to *Brachiaria* spp., Guinea grass (*Panicum maximum* Jacq.) has been used for more intensive cattle production systems. It is recommended for regions where annual rainfall ranges from 800 to 1800 mm in well-drained soil and it requires medium to high soil fertility (Muir and Jank, 2004). Tanzania and Mombaça are the most planted Guinea grass cultivars in Brazil, both collected in Africa in the 1960s by ORSTOM (Office de la Recherche Scientifique et Technique d'Outre-Mer) and selected by EMBRAPA (Brazilian Agricultural Research Corporation) in the early 1990s. Currently, these two high-sized tufted grass cultivars are responsible for 10 % of the forage seed market in Brazil, but the incidence of the leaf fungus *Bipolaris maydis* (Nisik. Schoemaker) has reduced their demand, specifically for Tanzania (Euclides et al., 2010).

Besides selection from collected germplasm, hybridization is one of the most prominent alternatives applied in forage grass breeding. Hybridization efforts are possible for Guinea grass due to the existence of sexual and apomictic plants (Resende et al., 2004). Although polyploid species could display a great amount of meiotic abnormalities that affect pollen viability (Singh, 1993), recent analysis has demonstrated that certain intraspecific *Panicum* hybrids present a low level amount of meiotic abnormalities and high pollen viability can be expected (Pessim et al., 2010).

Forage production of the highest yielding Guinea grasses fertilized with 150 to 200 kg ha^{-1} of nitrogen is approximately 18 to 21 t ha^{-1} per year (Da Silva et al., 2009; Muir and Jank, 2004). Frequently, inadequate grazing management of these species results in excessive stem growth that decreases intake rate and cattle performance (Benvenutti et al., 2008). The use of small-sized *Panicum* spp. species like Massai could facilitate grazing management due to its higher leaf growth than stem growth. Although Massai is very much appreciated by farmers as it requires lower soil fertility than Mombaça and Tanzania (Volpe et al., 2008), it is recognized as a low nutritive *Panicum* (Brâncio et al., 2002). Availability of new cultivars and its use will decrease the vulnerability of Brazilian cultivated pastures. This study aimed to evaluate forage yield and nutritive value of *P. maximum* genotypes.

Materials and Methods

Experimental Field and Environmental Conditions

The experiment was carried out in Planaltina, Federal District, Brazil (15°35′ S; 47°42′ W, 993 m a.s.l.)

for two consecutive years (2003 and 2004). The climate at the site is Aw (tropical savannah) according to the Köppen-Geiger classification (Peel et al., 2007). Monthly rainfall, mean daily air temperature and historical averages for annual temperature and rainfall were recorded 600 m away from the experimental site (Table 1). The study was conducted in a clay soil (fine, mixed, isohyperthermic Rhodic Haplustox) with pH 5.0, organic matter content of 0.22 g kg^{-1} and phosphorus (P) content of 6.6 mg dm^{-3} (Mehlich-I) in the 0-0.2 m soil layer.

Panicum maximum Germplasm Sources

Treatments were 24 genotypes of *P. maximum*, categorized into three germplasm types (Cultivar, Accession or Hybrid): Aruana, Vencedor, Milênio, Mombaça, Tanzânia and Massai are cultivars; 14 accessions named PM30 to PM43 successively; and four non-natural intraspecific hybrids PM44 to PM47. Five genotypes were considered small-sized due to their lower maximum sward height (~ 0.74 m ± 0.224 m) – Aruana, Massai, PM31, PM44 and PM45 when compared to the others (~ 1.60 m ± 0.283 m). The accessions and germplasm used as a basis for hybridization were collected by ORSTOM (Office of Scientific Research and Technical Overseas) in East African savannas in 1967 and 1969. The male and female plants used in the hybridization belong to the *P. maximum* germplasm collection at Embrapa Beef Cattle (Brazilian Agricultural Research Corporation), located in Campo Grande (20°26′S; 54°38′W), in the state of Mato Grosso do Sul, Brazil, containing 426 apomictic tetraploid accessions and 417 sexual tetraploid plants.

Experimental Design

The experimental design was a randomized complete block design with three replications. Plots consisted of six rows of 4 m (0.5 m spacing) totaling area of 3 × 4 m (12 m^2). In Oct 2002, an equivalent dose of 1 t ha^{-1} of dolomitic lime was applied to the soil surface in the experimental area. Genotypes were seeded on 21 Nov 2002, at a rate of 3 kg ha^{-1} of viable seeds plus 28.4 kg ha^{-1} of P (Simple Superphosphate) placed in the rows. All plots were irrigated until complete germination had been achieved. On the 49th day after sowing, 50 kg ha^{-1} of Nitrogen (N) and 21 kg ha^{-1} of Potassium (K) were applied in the form of urea and potassium chloride, respectively.

In 2003, six cuts were made as follows: - 05 Feb 2003; 12 Mar 2003; 16 Apr 2003; 25 June 2003; 27 Oct 2003 and 01 Dec 2003. In 2004 a further new six cuts were made as follows: - 05 Jan 2004; 09 Feb 2004; 15 Mar 2004; 19 Apr 2004; 28 June 2004 and 12 Nov 2004. Consequently, experimental evaluations extended from Nov 2002 to Dec 2003 (375 days) and from Jan to Nov 2004 (347 days), referred to herein as Year 1 and Year 2, respectively.

The period from May until Oct was considered dry season, due to especially low rainfall. Urea and Potassium Chloride totaling 250 kg ha^{-1} of N and 207.5 kg ha^{-1} of K were split into five applications distributed equally throughout the year at post-harvest on every plot, except after the June cuts in Year 1 and Year 2; and the Nov cut in Year 2.

Plots were cut at 0.2 m level from the soil, discarding the 0.5 m lateral as borders. A forage subsample of 1.5 kg was picked, weighed and separated in leaf (green lamina), stem (culm plus leaf sheath) and dead material (brown leaves and brown stems). All samples were dried in the air oven-forced at 55 °C by 72 h. Annual dry matter yield (DMY) was considered as a sum of forage harvested in each cut for Year 1 and Year 2, as well as for annual leaf dry matter yield (Leaf DMY) and annual stem dry matter yield (Stem DMY).

Dried leaf blade samples were weighed, ground with a 2-mm screen in a Wiley mill and analyzed as to their nutritive value by near-infrared reflectance spectrophotometer (NIRS), as described by Marten et al. (1985). Data on reflectance of the samples, in the wavelengths 1100–2500 μm were stored in a spectrometer (model NR5000: NIRSSystems, Inc., USA) coupled to a microcomputer. NIRS was previously calibrated based on wet chemistry by the following procedures: organic matter (OM) and crude protein (AOAC, 1990); organic matter digestibility (as described by Tilley and Terry, 1963, modified by Moore and Mott, 1974); neutral detergent fiber and acid detergent fiber (as described in Van Soest et al., 1991). NIRS calibration was performed with 870 samples of tropical grasses, especially *Panicum maximum* and *Brachiaria* spp., originating a broad based equation. The coefficient of determination for nutritive value curves ranged from 0.87 to 0.99 and validation residues (difference between NIRS and reference procedure) were always lower than 5 %.

In Year 1, analysis for nutritive value was evaluated using samples from four cuts (5 Jan 2003, 12 Mar 2003, 16 Apr 2003 and 25 June 2003). In Year 2, the same

Table 1 – Monthly rainfall and temperature during experiment; and average monthly rainfall and temperatures from 1973 to 1995 in Planaltina, Federal District, Brazil.

Month	Rainfall				Mean temperature			
	2002	2003	2004	Avg.†	2002	2003	2004	Avg.†
	mm				°C			
Jan	207	204	323	283	22.3	22.4	21.7	22.3
Feb	125	359	445	204	21.9	22.7	21.4	22.5
Mar	74	182	300	232	22.8	21.7	21.9	22.7
Apr	63	37	153	105	22.7	22.4	21.8	22.3
May	19	9	19	30	21.5	20.6	21.5	21.2
June	0	0	5	6	20.5	20.5	19.7	20.4
July	3	0	0	7	21.2	19.6	19.1	19.8
Aug	19	29	4	14	22.3	21.6	21.4	21.5
Sept	41	18	0	44	23.0	23.3	24.2	23.1
Oct	32	23	72	151	25.4	23.4	23.9	23.2
Nov	98	134	92	189	23.1	22.3	23.0	22.6
Dec	151	164	190	240	22.9	23.4	22.2	22.2

†Average data of historical series (1973-1995).

analysis was evaluated using samples from three cuts (5 Jan 2004, 15 Mar 2004 and 28 June 2004).

Statistical Analysis

Data were evaluated in terms of the annual sum of quantity variables as dry matter yield (DMY). Nutritive value variables like crude protein (CP), organic matter digestibility (OMD), neutral detergent fiber (NDF) and acid detergent fiber (ADF) were evaluated as annual mean values. All variables were analyzed using Proc Mixed of SAS (Statistical Analysis System, version 6) with genotype, year and genotype × year as fixed effects whereas block effect was considered random. Years were tested as a fixed effect and a repeated measure because an effect on yield in a perennial experiment was expected. The means reported are least squares means and the effect of Genotype was assessed by Least Significant Difference by t test ($p < 0.05$). Linear correlation between variables was analyzed using Proc Corr of SAS (Statistical Analysis System, version 6).

Results and Discussion

Total DMY was affected by the effects of Year ($p < 0.001$), Genotype ($p < 0.001$), and Genotype × Year ($p = 0.002$; Table 2). Of the 24 genotypes evaluated, 20 presented higher DMY in Year 2 than Year 1, despite the longer period for the first year (28 days longer). DMY was 15.1 t ha^{-1} in Year 1 and 16.1 t ha^{-1} in Year 2. This increase could be due to rainfall that in the first year (2003) was lower than average (344 mm below average; Table 1) while in the second year (2004) was higher (101 mm above average), especially in Oct, Jan and Apr. Moreover, rainfall during the seeding development in Nov 2002 was insufficient and seedlings required irrigation.

In Year 1 several genotypes were classified as the most productive (Table 2), including cultivars, accessions and hybrids (Milênio, PM30, PM32, PM33, PM34, PM39, PM40, PM41, PM46 and PM47). In Year 2 only one genotype, Milênio, presented the highest DMY (20.9 t ha^{-1}). Aruana and PM43 were amongst the least productive genotypes in both years. Hybrids PM46 and PM47 did not repeat the same score in Year 2, but they presented similar DMY in both years. They yielded close to 17 t ha^{-1} per year, comparable to the highest yielding Guinea grass cultivars as reported in the literature (Muir and Jank, 2004; Da Silva et al., 2009). Mombaça pastures in a rotational stocking and fertilized system (195 kg ha^{-1} of N) produced 20 and 26 t ha^{-1} in a 411- day period, managed with 30 and 50 cm of post-graze sward height, respectively (Carnevalli et al., 2006).

When comparing the two most cultivated *P. maximum* in Brazil, Mombaça DMY was higher than Tanzania DMY in Year 1, but they yielded the same forage quantity in Year 2, because of an increase in Tanzania DMY. Used especially for cattle intensive systems, *P. maximum* cultivars in Brazil are considered high yielding, requiring fertilization to guarantee persistence and quality. Mombaça is usually recognized as more productive than Tanzania (20.5 vs. 14.4 t ha^{-1} per year; Cecato et al., 2000). Both need intensive grazing management, due to excessive growth of stems when there is no control of sward height (Da Silva et al., 2009).

Another *Panicum* cultivar used in Brazil is Massai that, despite its small size, presented a distinct DMY, specifically in Year 2 (18.9 t ha^{-1}). This tufted grass is considered less demanding in terms of soil fertility as compared with Mombaça and Tanzania (Volpe et al., 2008; Brâncio et al., 2003). According to Volpe et al. (2008), in a study conducted over 200 days in Campo Grande, MS, Massai pastures produced 5.9 and 8.0 t ha^{-1} of dry matter with 0 and 35 kg ha^{-1} of P in the sowing, respectively.

Leaf dry matter yield (Leaf DMY) was higher

Table 2 – Genotype, Year and Genotype × Year effects on total dry matter yield (DMY), stem dry matter yield (Stem DMY) and leaf dry matter yield (Leaf DMY) of *Panicum maximum* genotypes in 2003 (Year 1) and 2004 (Year 2).

Genotypes†	DMY		Stem DMY		Leaf DMY	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
	t ha^{-1}					
Aruana	12.9	11.1	6.7	4.2	6.0	6.7
Massai	14.6	18.9	2.4	3.8	11.6	14.9
Milênio	18.4	20.9	5.5	6.4	12.4	14.4
Mombaça	15.5	15.8	3.4	2.5	11.8	13.1
Tanzânia	12.5	15.3	2.3	2.9	9.7	12.2
Vencedor	13.5	13.9	4.1	2.9	9.0	10.9
PM30	16.8	17.1	4.7	4.8	11.7	12.2
PM31	14.6	17.3	1.8	3.4	12.4	13.8
PM32	17.2	16.5	3.7	3.6	13.2	12.9
PM33	16.0	16.5	2.9	3.5	12.4	12.9
PM34	17.1	17.6	2.2	2.5	14.3	15.0
PM35	15.0	16.0	3.3	3.6	11.1	12.2
PM36	13.8	17.0	3.4	4.0	9.9	12.8
PM37	15.4	15.6	4.1	3.5	11.0	11.8
PM38	14.2	16.2	4.8	4.9	9.2	11.2
PM39	16.8	16.0	3.1	2.6	13.2	13.2
PM40	16.5	17.3	3.6	2.6	12.5	14.5
PM41	17.1	17.4	4.3	3.8	12.2	13.3
PM42	10.9	14.2	2.3	2.9	8.2	11.1
PM43	12.5	12.6	5.1	4.2	7.4	8.3
PM44	13.0	14.9	3.5	3.9	9.2	10.9
PM45	13.0	13.5	2.9	1.9	9.8	11.5
PM46	17.4	18.0	3.9	3.0	13.1	14.8
PM47	16.5	17.5	4.4	4.0	11.7	13.4
LSD (d.f. = 94)‡	2.5	1.8	1.1	0.8	1.9	1.6
P						
Genotype	< 0.001		< 0.001		< 0.001	
Year	< 0.001		0.315		< 0.001	
Genotype × Year	0.002		< 0.001		0.019	

†Values presented are averages across three replications and six cuts for each year; ‡LSD least significant difference ($p < 0.05$) to 94 degrees of freedom (d.f.) by t test.

in Year 2 than Year 1 ($p < 0.001$), as was the case for DMY, and there were effects of Genotype ($p < 0.001$) and Genotype × Year ($p = 0.0192$; Table 2). In Year 1, Leaf DMY was 11.0 t ha^{-1}, while in Year 2 it was 12.4 t ha^{-1}. Genotypes PM32, PM34, PM39, PM40 and PM46 were the treatments with the highest Leaf DMY in Year 1. In Year 2, the only genotypes that repeated the same highest yield position were PM34, PM40 and PM46.

Stem dry matter yield (Stem DMY) was affected by Genotype ($p < 0.001$) and Genotype × Year ($p < 0.001$; Table 2). In Year 1, Stem DMY was higher for Aruana followed by Milênio, while in Year 2, Milênio presented the highest value. Considering the genotypes that produced more stems among the ones that produced more leaves, Milênio and PM41 presented Stem DMY higher than the mean (> 3.6 t ha^{-1}) in both years. Amount of stems relative to total DMY was 30 and 23 % for these two genotypes, respectively. On the other hand, in other genotypes with higher Leaf DMY but with Stem DMY below the mean (< 3.6 t ha^{-1}) such as Massai, PM31, PM32, PM34, PM39, PM40 and PM46, the amount of stems relative to DMY was 19, 22, 20, 14, 18, 18 and 19 %, respectively. The slight differences in Leaf DMY plus Stem DMY when compared to total DMY were due to the inclusion of dead material fraction (data not shown).

Massai produced a great amount of leaves to the detriment of stems, controlling the upright growth in contrast to the high-size tufted *P. maximum* cultivars like Milênio that usually yields a great amount of stems. For high yielding tropical grasses managed under intermittent stocking, use of targets such as sward height in the pre- and post-grazing helps to control the growth of stems that can be harmful to intake and cattle performance (Cunha et al., 2010; Benvenutti et al., 2008). For the same reason, continuous stocking management is not recommended for *P. maximum* because of its tendency towards heterogeneity in sward structure that results in patches with excessive stem growth, although Tanzania pastures had been assessed by continuous stocking systems too (Cano et al., 2004). So, the choice of productive species with a high proportion of leaves, a better quality plant component than stems is beneficial.

PM46 had 79 % of green leaves in the DMY, similar to Tanzania (78 %), Mombaça (80 %) and Massai (79 %), but higher than Milenio (68 %) and Aruana (54 %). In a study with regrowth periods of 30, 60 and 90 days, the proportion of leaves in total yield were 90, 71 and 45 % for PM46; 84, 77 and 47 % for Tanzania; 96, 82 and 51 % for Mombaça; 87, 77 and 70 % for Massai; and 92, 71 and 50 % for Milênio (Stabile et al., 2010). Even with 90 days of regrowth, the proportion of stems for Massai was lower than the others, although Milênio and Mombaça showed the highest absolute values of leaf yield. In Mombaça pastures managed by rotational stocking the proportion of stems in the total yield changed from 21 to 33 % as grazing frequency decreased (Silveira et al., 2010).

In terms of herbage mass (sampled at soil level), Massai presented high leaf/stem ratios ranging from 2 to 7 while for Mombaça and Tanzania these ratios varied between 2 to 4 throughout the year (Brâncio et al., 2003). Zanini et al. (2012) verified in pastures of Aruana a stem proportion of 26 % in pre-graze herbage mass. Although it produced lower Leaf DMY, PM45, a small sized genotype as well as Massai and Aruana, also presented a low proportion of stems relative to DMY – 19 %. Usually, a relative amount of plant components like leaf/stem ratio or percentage of leaves and/or stems impacts on ingestive behavior of cattle grazing. Evidently, for comparison purposes these data must always be accompanied by the absolute values, such as for PM46, that although it had the same proportion of leaves, it produced 22 % and 11 % more green leaves than Tanzania and Mombaça cultivars, respectively.

Usually recommended for sheep grazing systems, cultivar Aruana produced approximately half the leaf DMY as compared with the other genotypes (Table 2). It was influenced by its continuous flowering during the year, favoring stem DMY. In this case, a higher cutting frequency could reduce stem accumulation, which can be also be influenced by the pre-determined stubble height. Cecato et al. (2000) verified that Mombaça and Aruana did not show any differences for leaf DMY when stubble height was reduced from 0.40 to 0.20 m, in contrast to Tanzania that showed higher leaf yield at lower stubble height. Aruana also produced 74 % less leaves than Mombaça and Tanzania, regardless of stubble height. As a whole, a stubble height of 20 cm mimics a more intensive grazing management in a well-fertilized *P. maximum* pasture, a desirable aspect for evaluating germplasm capability.

There were effects of Year ($p < 0.05$), Genotype ($p < 0.001$) and interaction Genotype × Year ($p < 0.001$) on ADF (Table 3). Mean values for Year 1 and Year 2 were 362 and 365 g kg^{-1}, respectively. In Year 1 genotypes with lower ADF were PM43, Vencedor and Aruana whereas in Year 2, Vencedor was the only one with the lowest ADF. On the other hand, genotypes with the highest ADF in the first year were PM31, PM34, PM35 and PM37. In the second year, genotypes with the highest ADF were Massai, PM30, PM31, PM35, PM37 and PM41.

For NDF there were effects of Genotype ($p < 0.001$), Year ($p = 0.002$) and Genotype × Year ($p = 0.011$). Mean values for Year 1 and Year 2 were 737 and 731 g kg^{-1}, respectively. Genotypes with the highest NDF in Year 1 were Massai, Milênio, Mombaça, PM31, PM32, PM37, PM41 and PM44. In Year 2 Massai, PM31, PM37 and PM41 presented again the highest NDF values. The lowest values for NDF in Year 1 were observed in a group of 12 genotypes, including cultivars (Aruana and Tanzânia), accessions (PM30, PM33, PM34, PM36, PM39, PM40, PM42 and PM43) and hybrids (PM45, PM46 and PM47). The only genotype with the lowest NDF value in Year 2 was Vencedor that presented a value lower than the Year

Table 3 – Genotype, Year and Genotype × Year effects on acid detergent fiber (ADF), neutral detergent fiber (NDF), crude protein (CP) and *in vitro* organic matter digestibility (OMD) of *Panicum maximum* genotypes in 2003 (Year 1) and 2004 (Year 2).

Genotypes†	ADF		NDF		CP		OMD
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	
	g kg^{-1} dry matter						
Aruana	329	346	737	754	179	147	676
Massai	379	385	755	744	150	123	631
Milênio	361	361	744	723	168	147	647
Mombaça	371	369	743	731	144	124	628
Tanzânia	360	361	732	728	162	138	680
Vencedor	330	327	716	681	171	145	706
PM30	370	387	716	725	156	125	665
PM31	388	390	765	747	140	120	617
PM32	373	366	744	722	142	130	630
PM33	354	363	733	733	163	141	661
PM34	398	360	742	732	143	130	642
PM35	389	390	739	733	145	124	620
PM36	353	356	736	729	171	148	670
PM37	399	398	749	755	144	128	641
PM38	368	367	741	742	146	131	646
PM39	348	348	731	720	147	135	650
PM40	338	346	723	722	156	140	677
PM41	373	383	749	739	162	132	641
PM42	359	364	726	738	161	138	676
PM43	322	345	712	721	172	135	679
PM44	368	374	744	742	154	130	625
PM45	357	368	737	740	167	137	662
PM46	356	349	732	715	162	148	690
PM47	355	354	716	733	164	139	673
LSD (d.f. = 94)‡	12.8	12.8	22.4	17.6	14.6	12.7	28.2
P							
Genotype	< 0.001		< 0.001		< 0.001		< 0.001
Year	0.013		0.002		< 0.001		< 0.001
Genotype × Year	< 0.001		0.011		0.012		0.139

†Values presented are averages across three replications (four cuts for Year 1 and three cuts for Year 2); ‡LSD least significant difference ($p < 0.05$) to 94 degrees of freedom (d.f.) by t test.

2 mean. As expected, there was a positive correlation between NDF and ADF (0.57; $p < 0.001$).

Small-sized genotypes, especially PM31, Massai and PM44 presented values of ADF and NDF above the mean, a result expected for Massai. For PM45, fiber results were slightly lower than the other small sized genotypes. Brâncio et al. (2002) concluded that Massai leaves presented ADF (442 g kg^{-1}) slightly higher than Mombaça and Tanzania (431 g kg^{-1}), due to the higher lignin (64 *vs.* 80 g kg^{-1}). In a study with *P. maximum* cultivars at two cutting heights in Maringá, PR, ADF values of Mombaça and Tanzânia were 420 and 417 g kg^{-1}, respectively; while NDF values were 715 and 726 g kg^{-1}, respectively (Machado et al., 1998). Probably results were higher in this study because of the presence of green stems in the forage analyzed.

Stabile et al. (2010) evaluated selected *P. maximum* genotypes (Massai, Milênio, Mombaça, Tanzânia, PM39, PM40, PM41, PM44, PM45, PM46 and PM47) in Campo Grande, MS, and they did not verify differences for ADF and NDF in leaves. Mean values for NDF were 750 and 767 g kg^{-1} for 30 and 60 days of defoliation intervals, respectively. For ADF, values were 382 and 408 g kg^{-1}, respectively, higher than values observed in this study.

Results for crude protein (CP) of leaves showed effects of Genotype ($p < 0.001$), Year ($p < 0.001$) and Genotype × Year ($p = 0.012$; Table 3). Mean values for Year 1 and Year 2 were 157 and 135 g kg^{-1}, respectively. Aruana, Milênio, Vencedor, PM36, PM43 and PM45 presented the highest values for CP in Year 1 (Table 3). Tanzânia, PM39, PM40, PM42, PM46 and PM47 joined with the six highest CP genotypes in Year 1 as the highest CP in Year 2. According to Machado et al. (1998) Tanzânia CP during the year was 121 g kg^{-1} at the two cutting heights evaluated.

There were effects of Genotype ($p < 0.001$) and Year ($p < 0.001$) on OMD. Aruana, Tanzânia, Vencedor, PM40, PM43 and PM46 presented the highest values of OMD. In Tanzânia pastures managed with four sward heights (0.2, 0.4, 0.6 and 0.8 m) OMD of leaves decreased linearly from 740 to 670 g kg^{-1} as sward height increased (Cano et al., 2004). As expected, OMD showed a high negative correlation with ADF (-0.67; $p < 0.001$) and moderately negative with NDF (-0.37; $p < 0.001$) and a positive correlation with CP (0.80; $p < 0.001$). Occasionally it could be assumed that a low dry matter yield results in a high nutritive value, but the negative correlation of OMD with Leaf DMY was not so high (-0.31; $p < 0.001$). As a result, specific genotypes had digestibility and leaf yield above the mean, the reverse also being true. PM46, for example, showed values above the mean for digestibility and Leaf DMY simultaneously, the same occurring in PM47 and PM40 (Figure 1).

Considering the four quadrants formed by the mean values between leaf DMY and leaf OMD association (Figure 1), most of the genotypes are in the quadrant with low digestibility and high dry matter yield (i.e. PM34) or in the quadrant with high digestibility and low dry matter yield (i.e. Vencedor). On the other hand, PM37, PM38 and PM44 showed values below the mean for digestibility and leaf yield at the same time. Forage digestibility is related to intake rate, and affects animal performance positively. In addition, leafy swards provide more suitable intake conditions in view of the characteristics of animal ingestive behavior (Benvenutti et al., 2008). Both these features must be considered in the selection of new forage grasses for grazing systems, since it is possible to breed, or to select forages, for higher DM digestibility without affecting DM yield as discussed by Stabile et al. (2012). Grouping genotypes of *P. maximum* based on green forage yield, *in vitro* digestibility of stem NDF and sward morphological composition, Stabile et al. (2010) in a short term experiment, found PM39 and PM47, an accession and a hybrid, respectively, to be the most promising genotypes.

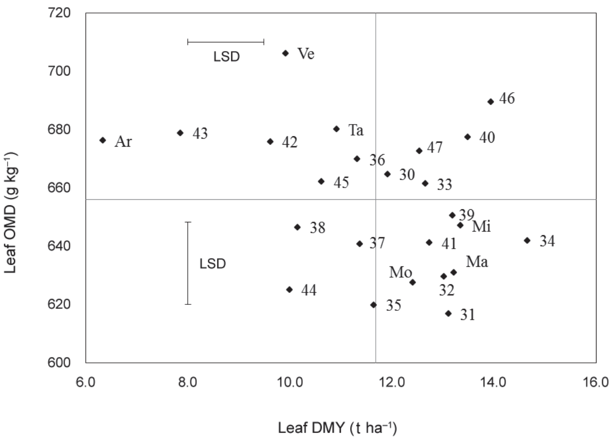

Figure 1 – Scatter plot of annual leaf dry matter yield (DMY) and *in vitro* organic matter digestibility (OMD) over two years of 24 genotypes of *Panicum maximum* (Ar = Aruana; Ma = Massai; Mi = Milênio; Mo = Mombaça; Ta = Tânzania; Ve = Vencedor; means named with the numbers refer to accessions PM30 to PM43; hybrids are named as PM44 to PM47). Overall mean values of leaf DMY and leaf OMD are indicated by solid lines. LSD Least significant different (p < 0.05).

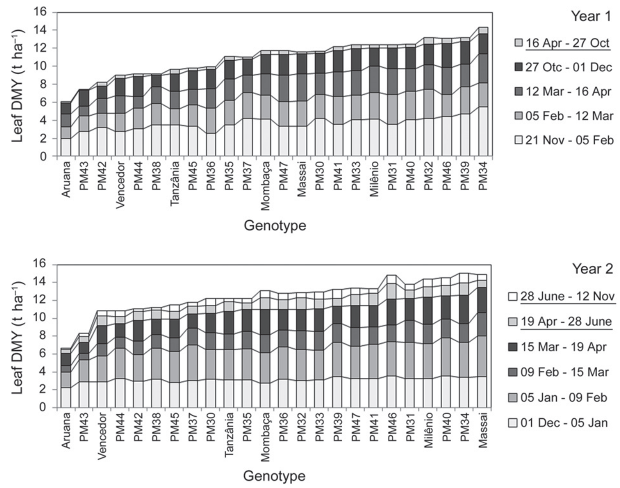

Figure 2 – Leaf dry matter yield (DMY) of 24 genotypes of *Panicum maximum* during Year 1 (2003) and Year 2 (2004) subdivided in periods relative to each cut with the exception of the period of 16 Mar 2003 to 27 Oct 2003 that corresponds to two cuts. The underlined periods relate to the dry season period. The genotypes in absciss axis are listed in rising order according to leaf yield in the wet season periods.

In addition to nutritive value and leaf yield, a more constant forage growth on a yearly basis is appreciated for tropical grasses. The production concentration in the wet season is excessively high in Central Brazil, reaching around 70 to 90 % (Pedreira et al., 2005), since dry periods last five to six months per year (Table 1). In particular, *P. maximum* species are known for their high yield concentration during the wet season. The higher yield in 2004 (Year 2) as compared with 2003 (Year 1) can be partly explained by a higher yield in the June and Oct cuts (dry season) in this same year, as can be seen for all genotypes (Figure 2).

It is possible that a variation in rainfall and a likely extra development of root system in the second year after sowing influenced the results. While in 2003, rainfall during the entire dry season (May to Oct) was only 79 mm, in 2004 it was 100 mm. At the same time, in Apr 2003 rainfall was only 37 mm while in Apr 2004 it was 153 mm. Tanzânia in Year 1 and PM46 in Year 2 were the genotypes with the highest proportion of leaf yield during the dry season – 5 and 18 % respectively. Some genotypes like Massai and PM31 despite having Leaf DMY above the mean presented lower values in the dry season, especially in Year 2 – 10 and 11 %, respectively.

The only remarkable difference between the most productive accessions and hybrids with the main *P. maximum* cultivars used in Brazil (Mombaça and Tanzânia) relative to yield concentration in a wet season was due to the positive performance of PM46 in Year 2. However, this concentration of forage yield in the wet season is still very high, making necessary other resources such as stockpiling, supplements and mixed grass-legumes pastures to ensure the food supply for the dry season.

Among all accessions and hybrids evaluated, PM40 and particularly PM46 can be used as forage in grazing systems due to its suitable characteristics in terms of nutritive value, annual leaf yield and dry season leaf yield, since they were superior to the main *P. maximum* cultivars cultivated in the Brazilian savannah, especially Mombaça and Tanzânia. Considering these benefits, an effort to undertake more evaluations must be made to provide complete information about these genotypes in terms of seed production, pests and disease resistance and soil mineral nutrition. Moreover, these genotypes should be tested in grazing trials with the aim of evaluating animal performance and plant persistence. Beyond this, specific targets of sward structure in terms of sward height pre and post-graze must be tested to improve the management of these species so as to enhance animal productivity in the farm.

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