Agronomic comparison of four *Panicum* hybrids and two cultivars at three cutting intervals in Puerto Rico[1]

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ABSTRACT

Three of the main problems associated with breeding guineagrass (*Panicum maximum* Jacq.), an important tropical forage, are seed shattering; low germination rate; and reproduction, which is by apomixis. Three hybrids were developed at the Tropical Agriculture Research Station (TARS) of the USDA-ARS, from sexual female plants and apomictic selections of guineagrass. In addition, an interspecific hybrid, BPIH104, was made from a cross between *Brachiaria purpurascens* Raddi and *Panicum coloratum* L. The four hybrids, common guineagrass, and Tobiata, an introduction from Brazil, were evaluated at 4-, 6-, and 8-wk cutting intervals (CI) during one year in a randomized split-plot design with four replications. Mean dry matter content (DMC), dry matter yield (DMY), crude protein yield (CPY), and plant height (PHt) increased ($P < 0.01$) from the 4- to the 8-wk CI, but mean crude protein concentration (CPC) decreased ($P < 0.01$). In vitro dry mater digestibility (IVDMD) decreased ($P < 0.01$) only from the 4- to 6-wk CI. DMC, CPY, and PHt were positively correlated, and CPC and IVDMD negatively correlated, with DMY. At the 8-wk CI, Tobiata and BPIH104 were the top yielders with annual yields equivalent to 43 and 41 t/ha, respectively. These and the other hybrids deserve further evaluation under grazing management in Puerto Rico.

Keywords: apomixis, interspecific hybrid, guineagrass hybrid, Tobiata

RESUMEN

Comparación agronómica de cuatro híbridos de Panicums y dos cultivares a tres intervalos de corte en Puerto Rico

Tres problemas importantes asociados con el cruzamiento de la yerba guinea (*Panicum maximum* Jacq.) son: la caída prematura de la semilla; pobre germinación; y su reproducción por apomixis. En la Estación de Investigaciones en Agricultura Tropical (TARS) se desarrollaron tres híbridos resultado del cruce entre plantas sexuales femeninas y selecciones apomícticas de la yerba guinea. Además, se logró un cruce interespecífico entre malojillo (*Brachiaria purpurascens* Raddi) y la yerba klein (*Panicum colora-*

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tum L.). Los cuatro híbridos, las yerbas guinea común y Tobiata, una introducción de Brazil, se evaluaron durante un año a intervalos de corte (CI) de 4, 6, y 8 semanas. El contenido de materia seca (DMC), rendimiento de materia seca (DMY), rendimiento de proteína cruda (PCY), y altura de la planta (PHt) promedio aumentaron ($P < 0.01$) del CI de 4 al de 8 semanas. Por otro lado, la concentración de proteína cruda (CPC) disminuyó ($P < 0.01$). La digestibilidad aparente in vitro (IVDMD) disminuyó ($P < 0.01$) sólo del CI de 4 al de 6 semanas. El DMC, CPC y PHt correlacionaron positivamente con el DMY mientras que CPC e IVDMD lo hicieron negativamente con respecto a DMY. Al CI de 8 semanas, Tobiata y BPIH104 fueron los mejores productores con rendimientos anuales equivalentes a 43 y 41 t/ha, respectivamente. Estos y los demás híbridos de *Panicum*, deben ser evaluados bajo pastoreo en Puerto Rico.

INTRODUCTION

Guineagrass (*Panicum maximum* Jacq.), an important tropical forage, reproduces by apomixis with pseudogamy, although sexual plants were discovered in populations of several introductions in Florida and Georgia by Smith (1972) and Burton et al. (1973). A sexual female, Tifton SPM92 (Hanna and Nakagawa, 1994), was utilized for the development of acid-tolerant guineagrass lines in Brazil (Hutton, 1989). The development of guineagrass hybrids using sexual female plants has not been reported.

The major weaknesses of guineagrass are seed shattering, low seed yield and poor germination rate. A relatively small percentage of harvested guineagrass is viable with a germination rate of only 5% being common (Vicente-Chandler et al., 1983). Poor seed production and low germination rate limit the extensive use of this excellent forage grass. Efforts to reduce seed shattering in guineagrass have been unsuccessful because of the lack of genetic material having this characteristic and also because of the difficulty encountered in hybridization. Kleingrass (*Panicum coloratum* L.) ($2n = 4x = 36$) is a source of genes with resistance to seed shattering in the Panicums (Young, 1986). The difference between the chromosome number of common guineagrass and that of kleingrass ($2n = 4x = 32$) makes it impossible to use kleingrass in a guineagrass breeding program. Paragrass or "malojillo" (*Brachiaria purpurascens* Raddi) ($2n = 4x = 36$) (Warmke, 1951) is extensively found in moist and poorly drained areas in the tropics and, if managed properly, can produce high-quality forage (Vicente-Chandler et al., 1983). Since kleingrass and paragrass have identical chromosome numbers, they offer an excellent opportunity for the development of new hybrids and possibly for the study of seed-shattering inheritance in the Panicums.

Native common guineagrass and many introductions of this species have been studied in Puerto Rico under cutting management (Méndez-Cruz et al., 1988; Ramos-Santana and Rodríguez-Arroyo, 1991 and

1994; Sotomayor-Ríos et al., 1971; Vélez-Santiago et al., 1982 and 1984; Vicente-Chandler et al., 1974), but no report has been made on the evaluation of guineagrass hybrids on the island.

The objective of this study was to compare the yield and quality of three guineagrass hybrids and one *Brachiaria* × *Panicum* hybrid to those of common guineagrass from Puerto Rico and Tobiata, a cultivar introduced from Brazil, at three cutting intervals (CI) in northwestern Puerto Rico.

MATERIALS AND METHODS

A one-year study beginning 18 January 1996 was conducted at the USDA-ARS Isabela farm in northwestern Puerto Rico. The soil is an Oxisol (Typic Hapludox) with a pH of 5.9, 2.0% organic matter, 143 mg/kg P, and 0.16 cmol/kg of K. Rainfall at Isabela follows a common pattern for the tropics with a marked dry season from December to March; however, moisture was not a limiting factor in this experiment since overhead irrigation was applied as needed.

The genotypes used were GH101, GH102, GH103, BPIH104, common guinea, and Tobiata. GH101 (guineagrass hybrid 101) was developed by crossing Tift SPM92 (Tifton sexual *Panicum maximum* 92) (female parent), a homozygous sexual guineagrass (Hanna, 1994), × a line obtained from guineagrass PI 259553 (male parent) also known as Puerto Rico Plant Introduction 3622 (PRPI 3622). Tift SPM92 is a short plant, reaching a height of less than 1 m, with a high leaf/stem ratio; it flowers throughout the year in Puerto Rico. Pl 259553 is a vigorous plant easily recognized by its tall growth, wide leaves, and by a horizontal mark or belt in the outer one-third of each leaf. It flowers throughout the year in Puerto Rico and produces excellent forage yields (Sotomayor-Ríos et al., 1971). GH102 was developed by crossing Tifton49 (Tift49) (female parent) (Hanna et al., 1973), a clone having sexual and apomictic plants with a high leaf/stem ratio, × CIAT 604 (male parent), a cultivar developed at the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. It is a tall, vigorous plant which produces high dry matter yields. GH103 was developed by crossing Tift49 × a line obtained from Pl 259553. BPIH104 (*Brachiaria* × *Panicum* interspecific hybrid 104) was developed at TARS by crossing paragrass (female parent) × kleingrass Pl 410177 (male parent) (Sotomayor-Ríos et al., 1994). The paragrass accession was collected at Mayagüez. It has vigorous running growth, with stems reaching a length of over 4 m, and generally roots at the nodes. It is widely used for forage in humid regions of Puerto Rico. Kleingrass Pl 410177 is a seed shattering resistant line obtained in 1991 from B. A. Young,

USDA-ARS, Temple, Texas (Young, 1986). These two tetraploids (2n = 4x = 36) produce abundant seed. Vegetative material of common guineagrass was collected at the Isabela USDA-ARS farm; and Tobiata, a guineagrass introduced from Brazil, donated by Alvaro Arias-Pedraza, Manager, Hacienda Las Carolinas, Salinas, Puerto Rico.

Clumps of about 7 cm in diameter of the six genotypes were planted 50 cm apart in four rows 10.7 m long. The distance between rows was 0.76 m. The following procedure was used for fertilizing and harvesting the individual plots: during the establishment period, each plot received 568 kg/ha of a commercial 15-5-10 fertilizer; after each cutting, plots were fertilized at an annual rate of 3,409 kg/ha of 15-5-10 divided into approximately 12, 8, and 6 applications, depending on the cutting interval. The center area of each subplot (3.6 × 0.7 m) was manually harvested at approximately 25 cm from ground level to determine yield. Green forage weight was determined in the field. Before each harvest, the height of 10 plants randomly selected from the plot was measured from the ground to the top leaf. Plot samples were dried to a constant weight at 55°C in a forced air oven, ground in a Wiley mill to pass through a 1-mm screen, and analyzed for nitrogen content by the standard micro-Kjeldahl procedure (A.O.A.C., 1980). Crude protein concentration (CPC) was calculated as %N × 6.25. In vitro dry matter digestibility (IVDMD) of the samples was determined by a two-stage technique (Tilley and Terry, 1963), and dry matter content (DMC) was determined.

The experimental design was a randomized complete block in a split-plot arrangement with four replications. It was analyzed as a split plot in time with genotypes as the main plots and CI of 4, 6 and 8 weeks as subplots, using the mixed procedure in SAS Version 6.11 for Windows (PC SAS) (SAS Institute, Inc., 1987). Treatment means were compared by Duncan's new multiple range test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Dry matter content and dry matter yield

All genotypes (G) cutting interval (CI) and G × CI were significant except G × CI for IVDMD (Table 1). The mean DMC of all genotypes increased ($P < 0.01$) from the 4- to the 8-wk CI (Table 2). The mean DMC of the 8-wk CI was higher ($P < 0.01$) than that of the 6-wk, which was higher ($P < 0.01$) than that of the 4-wk. GH101 had the highest ($P < 0.05$) DMC at the three CI. At both the 4- and 6-wk CIs, Tobiata and GH102 had the lowest ($P < 0.05$) DMC, but the DMC of GH102 was not significantly lower ($P < 0.05$) than that of common guineagrass. At the 8-wk CI, Tobiata had the lowest DMC ($P < 0.05$) among all genotypes.

TABLE 1.—*Analyses of variance (mean squares) of dry matter content (DMC), dry matter yield (DMY), crude protein concentration (CPC), crude protein yield (CPY), plant height (PHt), and in vitro dry matter digestibility (IVDMD) for six Panicums harvested at three cutting intervals in 1996 at Isabela, P. R.*

Source of variation	Degrees of freedom	DMC	DMY	CP	CPY	PHt	IVDMD
Genotype (G)	5	102.80**	18.24**	25.92**	11.80**	158.39**	17.54**
Cutting interval (CI)	2	461.73**	1,065.07**	565.97**	183.50**	1,445.98**	179.82**
G × CI	10	2.67**	2.46**	1.81*	1.85**	15.30*	1.43NS

*,** Significant at the 0.05 and 0.01 probability levels, respectively.
NS = Non significant.

TABLE 2.—*Mean dry matter content (DMC) and dry matter yield (DMY) of six Panicums harvested at three cutting intervals in 1996 at Isabela, P. R*

Genotype	DMC			DMY		
	4-wk	6-wk	8-wk	4-wk	6-wk	8-wk
	%			kg/ha		
GH101	21.6 a[1]	23.6 a	26.2 a	2,480 ab	3,869 c	5,410 c
GH102	18.0 c	20.3 de	23.0 c	2,334 b	3,792 c	5,975 bc
GH103	19.5 b	21.8 bc	24.0 bc	2,485 ab	3,971 c	5,927 bc
BPIH104	19.5 b	22.3 b	25.0 b	2,758 ab	4,340 ab	6,581 a
Common guineagrass	18.8 bc	21.3 cd	23.0 c	2,439 ab	3,974 bc	5,486 c
cv. Tobiata	17.7 c	19.9 e	20.8 d	2,954 a	4,747 a	6,337 ab
Mean	19.2 c[2]	21.5 b	23.6 a	2,575 c	4,116 b	5,953 a

[1]Means in the same column followed by one or more letters in common do not differ significantly at the 0.05 probability level.

[2]Overall means in the same row followed by a common letter do not differ significantly at the 0.01 probability level.

The mean dry matter yield (DMY) of all genotypes increased ($P < 0.01$) from the 4- to the 8-wk CI. Cutting at 4 wk resulted in a mean yield of 2,575 kg/ha compared to 4,116 and 5,953 kg/ha for the 6- and 8-wk CI. Mean yield of the 4-wk treatment was about 63% of that of the 6-wk and about 43% of that of the 8-wk CI. The 6-wk treatment had about 69% of the yield of the 8-wk CI. Genotype yield differences were not significant ($P < 0.05$) at the 4-wk CI except for GH102, which had lower DMY ($P < 0.05$) than that of cv Tobiata. At the 6-wk CI, the top-yielding genotypes were Tobiata (4,747 kg/ha) and BPIH104 (4,340 kg/ha). The yield of BPIH104, was, however, not different ($P < 0.05$) from that of common guineagrass (3,974 kg/ha). At the 8-wk CI, BPIH104 had higher ($P < 0.05$) DMY (6,581 kg/ha) than all other genotypes except Tobiata. The DMY of GH101, GH102, GH103 and common guineagrass was not different ($P < 0.05$). The mean DMY across genotypes at the three CIs was excellent and equivalent to annual yields of 33.6, 35.8, and 38.8 t/ha. Numerous experiments conducted in Puerto Rico with common guineagrass harvested every 40 and 60 days have demonstrated that about 26 and 32 t/ha can be obtained with an annual application of 3 t/ha of 15-5-10 fertilizer (Vicente-Chandler et al., 1983). In this study, the annual DMY of common guineagrass was about 35 and 36 t/ha when harvested at the 6- and 8-wk CI, respectively, and was about 83.4% of that of the highest producer (BPIH104) at the 8-wk CI. The superior total DMY production of BPIH104 and Tobiata was more evident at the 6- and 8-wk than at the 4-wk CI (Table 2).

Crude protein concentration and crude protein yield

The mean crude protein concentration (CPC) of all genotypes decreased ($P < 0.01$) from the 4- to the 8-wk CI (Table 3). Cutting at four weeks resulted in a mean CPC of 12.5% compared to 9.4 and 8.3% for the 6- and 8-wk CI. At the 4-wk CI, the CPC of GH102 (13.6%) and GH103 (13.5%) was higher ($P < 0.05$) than that of the remaining genotypes. At the 6-wk CI, the mean CPC of GH102 (10.2%), GH103 (10.0%) and common guineagrass (9.7%) was higher ($P < 0.05$) than that of GH101 and BPIH104 (8.6%) but similar to that of Tobiata (9.4%). Common guineagrass had the highest CPC at the 8-wk CI (9.0%), although it was similar to that of the remaining genotypes except GH101 (7.3%). Across CIs, the CPC of GH102 and GH103 was similar, and these two genotypes showed the sharpest decline in CPC (13.6 to 8.7, and 13.5 to 8.8%) (Table 3).

The mean crude protein yield (CPY) across genotypes increased ($P < 0.01$) with an increase in the CI. Cutting at 4 wks resulted in a mean CPY of 310.0 compared to 391.9 and 494.6 kg/ha for the 6- and 8-wk CI, respectively. The 4-wk treatment yielded about 79 and 63% of the CP in the 6- and 8-wk treatments, respectively, whereas the 6-wk treatment yielded about 79% of the 8-wk treatment's CP. No differences ($P < 0.05$) among genotypes in terms of CPY were found at the 4-wk CI. At the 6-wk CI, the CPY of the genotypes was similar except that of Tobiata, which was superior ($P < 0.05$) to that of GH101. At the 8-wk CI, the

TABLE 3.—*Mean crude protein concentration (CPC) and crude protein yield (CPY) of six Panicums harvested at three cutting intervals in 1996 at Isabela, P. R.*

	CPC			CPY		
Genotype	4-wk	6-wk	8-wk	4-wk	6-wk	8-wk
	%			kg/ha		
GH101	11.8 b[1]	8.6 b	7.3 b	281.0 a	331.2 b	393.1 b
GH102	13.6 a	10.2 a	8.7 ab	316.2 a	387.8 ab	517.7 a
GH103	13.5 a	10.0 a	8.8 a	327.3 a	384.7 ab	523.4 a
BPIH104	11.7 b	8.6 b	8.0 ab	306.5 a	371.3 ab	524.1 a
Common guineagrass	12.5 b	9.7 a	9.0 a	286.7 a	377.5 ab	496.9 a
cv. Tobiata	11.9 b	9.4 ab	8.1 ab	342.6 a	438.8 a	512.1 a
Mean	12.5 a[2]	9.4 b	8.3 c	310.0 c	391.9 b	494.6 a

[1]Means in the same column followed by one or more letters in common do not differ significantly at the 0.05 probability level.

[2]Overall means in the same row followed by a common letter do not differ significantly at the 0.01 probability level.

CPY of the genotypes was similar, except that of GH101, which had lower ($P < 0.05$) CPY.

Plant height and IVDMD

Mean plant height (PHt) increased ($P < 0.01$) as the CI increased (Table 4). Cutting every 4 wk resulted in a mean PHt of 73 cm compared to 99 and 124 cm for the 6- and 8-wk CI, respectively. The 4-wk mean compares favorably with a mean PHt of 57 cm for 11 Panicums harvested every 30 days at Corozal, Puerto Rico (Ramos-Santana and Rodríguez-Arroyo, 1991). At the 4-wk CI, the height of the tallest plant, BPIH at 90 cm, was greater ($P < 0.05$) than that of the remaining genotypes. At the 6- and 8-wk CI, BPIH104 and Tobiata were taller ($P < 0.05$) than the remaining genotypes with heights of 117 and 111 cm at 6 wk and 141 and 140 cm at 8 wk. Common guineagrass mean PHt at the 4- and 6-wk CI was 73 and 98 cm, respectively. Ramos-Santana and Rodríguez-Arroyo (1991) reported mean PHt values in Puerto Rico of 60 and 100 cm for this grass harvested at 30 and 45 days, respectively. The mean IVDMD was higher ($P < 0.01$) for all genotypes at the 4-wk CI. Cutting at the 4-wk interval resulted in a mean IVDMD of 63.2% compared to 55.0% for the 6- and 8-wk CI. There were no differences ($P < 0.05$) in IVDMD among genotypes at each CI.

Previous studies with forage sorghum [*Sorghum bicolor (L.)* Moench] conducted at TARS (Torres-Cardona et al., 1986) showed a significant correlation between PHt and yield. In this study, highly

TABLE 4.—*Mean plant height (PHt) and in vitro dry matter digestibility (IVDMD) of six Panicums harvested at three cutting intervals in 1996 at Isabela, P.R.*

	PHt			IVDMD		
Genotype	4-wk	6-wk	8-wk	4-wk	6-wk	8-wk
	cm			%		
GH101	68 cd[1]	95 b	104 c	66.4 a	57.1 a	55.7 a
GH102	62 d	92 b	129 b	65.2 a	57.6 a	55.9 a
GH103	67 cd	83 c	106 c	64.2 a	55.4 a	56.3 a
BPIH104	90 a	117 a	141 a	61.1 a	50.8 a	56.2 a
Common guineagrass	73 bc	98 b	125 b	60.0 a	53.5 a	51.5 a
cv. Tobiata	78 b	111 a	140 a	62.3 a	55.5 a	56.8 a
Mean	73 c[2]	99 b	124 a	63.2 a	55.0 b	55.0 b

[1]Means in the same column followed by one or more letters in common do not differ significantly at the 0.05 probability level.

[2]Overall means in the same row followed by a common letter do not differ significantly at the 0.01 probability level.

significant ($P < 0.01$) correlations were found between DMC and DMY (0.52), CPY and DMY (0.81), and PHt and DMY (0.76). On the other hand, negative correlations ($P < 0.01$) were found between CPC and DMY (-0.55) and IVDMD and DMY (-0.35). This finding suggests that Panicums selected for characters such as DMC, CPY, and PHt may give breeders higher forage yields.

The four hybrids, common guineagrass, and Tobiata all excelled in one or more of the six traits studied. GH101 had more DMC ($P < 0.05$) than the other genotypes, and Tobiata and BPIH104 were among the top yielders throughout the experiment. Because of their superiority in terms of total yield and other traits, Tobiata and BPIH104 warrant further grazing management evaluation in Puerto Rico.

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