

Agronomic comparison of dwarf and tall napiergrass in Puerto Rico¹

Antonio Sotomayor-Ríos,² Salvio Torres-Cardona,³
Adolfo Quiles-Belén³ and Wayne Hanna⁴

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ABSTRACT

Two tall and four dwarf napiergrasses (*Pennisetum purpureum* Schum.) were evaluated at three cutting intervals (CI) and at two locations. Overall dry matter yield (DMY) means of Merkeron and Merker (tall grasses) at the 45-, 65-, and 85-d CI (37.5, 48.8 and 52.8 t/ha/yr, respectively) were significantly higher ($P = 0.05$) than those of the dwarf grasses. Average DMY of the grasses increased 15% ($P = 0.05$) from the 45- to the 65-d CI. Overall mean crude protein concentration (CPC) of N75 and N127 (dwarf) at the 45- and 65-d CI surpassed ($P = 0.05$) those of the tall and most of the other dwarf grasses. In most instances the crude protein yield (CPY) of Merkeron and Merker exceeded ($P = 0.05$) those of the dwarf grasses. Merkeron and Merker plant heights ($P = 0.05$) were greater at all three cutting intervals. N75 (45-d CI), and N75 and N127 (65- and 85-d CI) had superior ($P = 0.05$) mean leaf:stem ratios. No difference ($P = 0.05$) in terms of in vitro dry matter digestibility (IVDMD) were observed among the six *Pennisetums*. The results of this study suggest that Merkeron and Merker could be recommended for use under cutting management and the dwarf grasses, especially N75 and N128, for grazing.

Key words: *Pennisetum purpureum*, cutting intervals, dry matter yield, crude protein yield, crude protein concentration

RESUMEN

Comparación agronómica de yerbas enanas y altas de Napier en Puerto Rico

Se evaluaron dos genotipos altos y cuatro enanos de Yerba Elefante (*Pennisetum purpureum* Schum.) a tres intervalos de corte (IC) en dos localidades. Los rendimientos de materia seca (RMS) promedio de Merkerón y Merker (yerba altas) a IC de 45-, 65-, y 85-d (37.5, 48.8 y 52.8 t/ha/año, respectivamente) resultaron significativamente mayores ($P = 0.05$) que los de las yerbas enanas. El RMS promedio de las yerbas aumentó 15% ($P = 0.05$) de 45- a 65-d. La concentración de proteína cruda promedio de N75 y N127 (enanas) a IC de 45-y 65-d superó ($P = 0.05$) a las yerbas altas y a las restantes yerbas enanas. En muchos casos los rendimientos de proteína cruda de Merkerón y Merker excedieron ($P = 0.05$) los de las yerbas enanas. La altura

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²Research Agronomist, USDA-ARS, Tropical Agriculture Research Station, Mayagüez, Puerto Rico 00681.

³Agronomist, USDA-ARS, TARS, Mayagüez, PR.

⁴Research Geneticist, USDA, ARS, Coastal Plain Exp. Station, Tifton, Georgia 31793.

de planta de Merkerón y Merker fueron superiores ($P = 0.05$) durante los tres IC. Las yerbas N75 (IC de 45-d) y N75 y N128 (IC de 65- y 85-d) registraron los valores más altos ($P = 0.05$) de razón hoja:tallo. No hubo diferencias significativas entre los seis *Pennisetums* en términos de digestibilidad aparente in vitro. Los resultados sugieren que las yerbas Merkerón y Merker pueden ser recomendadas para uso bajo corte y las yerbas enanas, especialmente N75 y N128 para pastoreo.

INTRODUCTION

Napiergrass or elephantgrass (*Pennisetum purpureum* Schum.), is a robust, high yielding, rhizomatous, vegetatively propagated perennial forage. It is native to Africa but well adapted to the tropics and subtropics. This grass can produce high-quality forage throughout the year in the tropics, but requires intensive management because of its rapid and tall growth habit. According to Vicente-Chandler et al. (1974), and on the basis of the results of numerous experiments conducted in Puerto Rico, napier is the highest-yielding grass under cutting management but has lower digestibility than other tropical grasses because of the high silica and moisture content of its leaves. Most farmers in the tropics utilize napiergrass as soilage for cattle feeding. However, with careful management, napier can be grazed effectively. Caro-Costas and Vicente-Chandler (1972) in Puerto Rico and Takahashi et al. (1966) in Hawaii reported excellent livestock performance on napiergrass under grazing management. The effect of three harvest intervals on yield and nutritive value of seven napiergrass cultivars was investigated at the University of Puerto Rico Corozal Substation by Vélez-Santiago and Arroyo-Aguilú (1981). They reported that as the grasses advanced in maturity from 30- to 45- and from 45- to 60-d harvest intervals, the DMY increased. However, as the fiber fraction increased, CPC and digestibility decreased. They concluded that forage grasses with a higher fibrous content exhibit lower CPC and digestibility.

The first comparison of tall and dwarf napiergrass cultivars was made by Hanna et al. (1993). They found that the dwarf cultivars yielded one-third as much plant material as the tall cultivars. The percentage of leaves was 60-76 for the dwarf and 43-46 for the tall cultivars. In a preliminary trial in Puerto Rico, Sotomayor-Ríos et al. (1993) compared the yield of standard napier and Merkeron with that of four dwarf napiergrasses based on five, four, and three cuttings at 45-, 65-, and 85-d CI, respectively. The dwarf napiergrasses yielded two-thirds as much as the two tall cultivars and had agronomic values which were higher than those reported by Hanna et al. (1993). Sollenberger et al. (1993) conducted three experiments during 1987-1991 to determine the factors underlying the high quality of Tifton N75 (Hanna and Monson, 1988), a cultivar later named 'Mott' (Sollenberger et al., 1989b), and to

assess the quality potential of napiergrass × pearl millet hybrids [*Pennisetum glaucum* (L.) R. Br.]. They concluded that the superior forage quality of Mott is due to its high leaf:stem ratio and to the proportion and distribution of tissues in the leaf lamina. Williams (1990) compared Mott to napiergrass × pearl millet hybrids. She suggested that the quality of Mott surpassed that of the hybrids probably because of Mott's improved leaf:stem ratio and possibly improved stem digestibility. Cultivar Mott has been extensively evaluated in Florida. Its potential as a high-quality forage for grazing was recognized in early 1980, when steer gains of nearly 1 kg/ha/d were reported (Boddorff and Ocumpaugh, 1986; Mott and Ocumpaugh, 1984).

With Mott, Knettle et al. (1990) conducted a 3-yr clipping trial using variable N rates, cutting frequencies, and stubble heights. They concluded that their best management was harvesting every eight to nine weeks to a 5-cm stubble, and fertilizing with 358 kg/ha of N. In a 2-yr study in Puerto Rico, Vélez-Santiago et al. (1983) found that the leaf:stem ratio of seven napiergrasses was higher during the short-day and dry-month periods, and lower during heavy rainfall periods. Vicente-Chandler et al. (1974), in another 2-yr study in Puerto Rico, reported decreases for leaf:stem ratio with harvest interval increases from 40 to 60 days.

This study compared the total DMY, CPY, CPC, plant height, leaf:stem ratio, and IVDMD of six napiergrasses: cultivars Merker and Merkeron (tall); and Mott (N75), N114, N127, and N128 (dwarf) at three CI and two locations.

MATERIALS AND METHODS

The six napiergrass cultivars were evaluated as forage crop material at two locations in western Puerto Rico for two years. Both locations were on USDA-ARS Tropical Agriculture Research Station farms, one at Isabela (18°30'N, 67°W) and the other at Mayagüez (18°7'N, 67°W). At Isabela the soil is an Oxisol (Typic Hapludox) with a pH of 5.0; at Mayaguez, the soil is an Ultisol (Typic Haplohumults) with a pH of 4.5.

Vegetative material (25 to 40 cm stem cuttings with 3-5 nodes) of Merker, Merkeron, N75, N114, N127, and N128 was planted at each location in August 1991. Merker cv was introduced into Puerto Rico from Mississippi by the University of Puerto Rico's Agricultural Experiment Station in 1934 (Vélez-Santiago et al., 1983). It has apparent resistance to eyespot disease caused by *Helminthosporium sacchari* (B. de Haan) Butl. (Vicente-Chandler et al., 1974). Merkeron (PI 531087) is an F₁ hybrid developed by Burton (1989), between a very leafy dwarf and a tall

selection of napiergrass. According to Burton (1989), "Merkeron napiergrass is an excellent example of valuable germplasm concentrated and preserved as a single perennial clone." The dwarf napiergrasses were selected from among a selfed progeny of Merkeron (Hanna and Monson, 1988) and were introduced into Puerto Rico in 1989 by the senior author. They have shorter internodes and are more leafy than the tall napiergrass and do not need to be cut after grazing.

At both locations, a complete fertilizer was applied at a rate of 84, 28, and 56 kg/ha of N, P, and K, respectively, at planting and after the 45-, 65-, and 85-d harvests. A randomized complete block design with a split-plot arrangement was used, with the forage cultivars as main plots and CI as subplots. Each main plot consisted of 12 rows 6 m long, spaced 0.9 m apart; the subplots were 3.6 × 6 m. Four replicates were used at each site. Immediately after planting, propazine [2-chloro-4,6-bis (isopropylamine)-s-triazine] was applied at a rate of 2.5 kg ai/ha to control weeds. Plots were irrigated as needed to prevent moisture stress. Plant height was measured (from the ground to the midpoint of the upper leaf blade) before each cutting using five plants at random from the middle of the subplot rows. Seventeen, 12, and 9 cuttings were made at 45-, 65-, and 85-d harvest intervals, respectively. Cuttings were made with a machete to a 10-cm stubble. The IVDMD samples were analyzed at the University of Puerto Rico, Mayagüez Campus, with the Tilley and Terry two-stage technique (Tilley and Terry, 1963). Leaf:stem ratio was calculated at each harvest. Leaf separations consisted of the leaf blade and the leaf sheath.

RESULTS AND DISCUSSION

Means for DMY, CPC, CPY, and plant height are presented for each CI in each location because of significant ($P = 0.05$) differences in them.

Sotomayor-Ríos et al. (1993) compared the DMY of tall and dwarf napiergrasses grown in Puerto Rico and found that the dwarf genotypes had two-thirds the yield of their tall counterparts. Hanna et al. (1993) compared dwarf [Mott (N75) and N129] with tall (Merkeron and N68) napiergrasses in Georgia and found that the dwarf napiers had only one-third the yield of the tall cultivars. In this study, the tall napiergrasses, Merker and Merkeron, had the highest ($P = 0.05$) DMY at the two locations and at each CI.

Dry matter yield

The average DMY of the six grasses was 12% higher ($P = 0.05$) at Mayagüez. The difference in DMY between locations could be attributed mainly to the rainfall pattern at the two sites. The Mayagüez site

received 635 mm more rain during the experiment than the site at Isabela (Table 1).

At Mayagüez (45-d CI), the dry matter yields of Merkeron and Merker (39.7 and 34.0 kg/ha/yr) were similar. Merkeron had a higher ($P = 0.05$) DMY than those of N75, N114, N127, and N128 (Table 1). The DMY of Merker was also higher ($P = 0.05$) than those of N75, N114, and N127 although similar to that of N128. At Isabela, Merkeron DMY (40.6 t/ha/yr) was superior ($P = 0.05$) to those of Merker and the dwarf grasses.

At Mayagüez (65-d CI), Merkeron and Merker dry matter yields (56.7 and 53.3 t/ha/yr) were higher ($P = 0.05$), and there was a greater difference between their DMY and those of the dwarf grasses. The DMY of N128 was higher ($P = 0.05$) than those of N127 and N75 but did not differ from that of N114. At Isabela, the 65-d CI DMY of Merkeron and Merker (43.2 and 42.1 t/ha/yr) exceeded ($P = 0.05$) those of the dwarf grasses.

At Mayagüez and Isabela (85-d CI), the DMY of Merkeron (53.7 and 56.3) and Merker (52.0 and 49.0 t/ha/yr) surpassed ($P = 0.05$) those of the dwarf grasses. At Mayagüez, the dry matter yields of N128 (39.9) and N114 (36.5 t/ha/yr) were not different but were superior ($P = 0.05$) to that of N127. The dry matter yields of Merkeron and Merker at Isabela (52.0 and 49.0 t/ha/yr) were greater ($P = 0.05$) than those of the dwarf grasses. N127 had the lowest DMY (18.5 t/ha/yr), and the DMY of N128 (37.8 t/ha/yr) was superior ($P = 0.05$) to those of the remaining dwarf grasses except that of N114.

The average DMY of the six grasses at both locations increased ($P = 0.05$) 15% from the 45- to the 65-d CI. Lengthening the CI from 65 to 85 days did not increase the DMY of the tall and dwarf grasses significantly. It appears that the total DMY of these grasses was at its maximum at the 65-d CI at both locations.

The mean DMY of Merkeron and Merker at the two sites was 38, 49, and 53 t/ha/yr at the 45-, 65-, and 85-d CI, respectively. On the other hand, the DMY of the dwarf grasses were lower and more consistent, with means of 30, 32, and 32 t/ha/yr, respectively. These yields are comparable to those of guineagrass (*Panicum maximum* Jacq.) and other well-known forages, which are mainly used under grazing management in Puerto Rico and elsewhere in the tropics (Sollenberger and Jones, 1989a; Vicente-Chandler et al., 1974).

Crude protein concentration and crude protein yield

The average CPC of the dwarf grasses (11.4%) was higher than that of the tall grasses. At Isabela, the mean CPC of N127 (12.7%) and N75 (11.8%) surpassed ($P = 0.05$) the mean crude protein concentrations of

TABLE 1.—Mean dry matter yield, crude protein concentration, crude protein yield, plant height, leaf-stem ratio and in vitro dry matter digestibility of six *Pennisetums* at two locations during two years.¹

	Dry matter yield		Crude protein concentration		Crude protein yield		Plant height		Leaf:stem ratio		IVDMD %	
	t/ha/yr	t/ha/yr	%	%	t/ha/yr	t/ha/yr	m	m				
GRASS CUT EVERY 45 DAYS												
Merkeron	Mayagüez	Isabela	Mayagüez	Isabela	Mayagüez	Isabela	Mayagüez	Isabela	Mayagüez	Isabela	Mayagüez	\bar{X}
N75	39.7a	40.6a	10.2c	10.4b	4.0a	4.2a	1.6a	1.5a	0.9d	0.9d	57.8a	
N114	30.0c	31.6cd	11.4b	11.8a	3.4b	3.7b	1.1b	1.0b	2.2a	2.2a	59.1a	
N127	30.0c	30.0d	10.8a	10.8b	3.2b	3.2bc	1.2b	1.1b	1.2c	1.2c	59.0a	
N128	25.1d	25.1e	12.4a	12.7a	3.1b	3.2bc	1.2b	1.1b	1.8b	1.8b	58.2a	
Merker	33.3bc	30.8d	10.5c	10.7b	3.5b	3.3b	1.2b	1.2b	1.5b	1.5b	57.6a	
Mean	34.0ab	35.7bc	9.7c	10.3b	3.3b	3.7b	1.6a	1.4a	0.8d	0.8d	59.4a	
	32.0	32.3	10.8	11.1	3.4	3.6	1.2	1.2	1.6	1.6	58.5	
GRASS CUT EVERY 65 DAYS												
Merkeron	Mayagüez	Isabela	Mayagüez	Isabela	Mayagüez	Isabela	Mayagüez	Isabela	Mayagüez	Isabela	Mayagüez	
N75	56.7a	43.2a	6.5b	7.3cd	3.7a	3.1a	2.3a	2.3a	0.4d	0.4d	52.4a	
N114	32.6cd	29.8b	8.3a	8.7a	2.7b	2.6b	1.4c	1.3c	1.7a	1.7a	56.4a	
N127	38.7bc	29.8b	7.1b	9.5a	2.7b	2.8ab	1.8b	1.9ab	0.7c	0.7c	53.0a	
N128	28.6d	22.5c	8.0a	8.3b	2.3b	1.9c	1.6bc	1.5bc	1.6a	1.6a	55.7a	
Merker	39.9b	32.0b	7.5b	7.7bc	3.0b	2.5b	1.6bc	1.7b	1.2b	1.2b	51.8a	
Mean	53.3a	42.1a	6.8b	6.8d	3.6a	2.9a	2.3a	2.1a	0.7c	0.7c	55.4a	
	41.6	32.2	7.4	8.0	3.0	2.6	1.8	1.8	1.1	1.1	54.1	

¹Means in the same column followed by one or more letters in common do not differ significantly at the 5 percent probability level.

TABLE 1.—(Continued) Mean dry matter yield, crude protein concentration, crude protein yield, plant height, leaf:stem ratio and in vitro dry matter digestibility of six *Pennisetums* at two locations during two years.¹

	Dry matter yield		Crude protein concentration		Crude protein yield		Plant height	Leaf:stem ratio	IVDMD	
	t/ha/yr		%		t/ha/yr		m		%	
GRASS CUT EVERY 85 DAYS										
Merkeron	53.7a	52.0a	5.4a	6.0b	2.9a	3.1a	2.6a	2.7a	0.6b	50.6a
N75	31.3c	31.8c	6.8a	7.3a	2.1c	2.3b	1.5c	1.5c	1.1a	53.4a
N114	36.5bc	32.2bc	6.1a	6.1b	2.2bc	2.0c	2.2b	2.1b	0.4c	50.8a
N127	24.9d	18.5d	6.8a	7.4a	1.7d	1.4d	2.0b	1.6bc	1.3a	52.1a
N128	39.9b	37.8b	6.0a	5.8b	2.4b	2.2bc	1.9bc	2.0b	0.6b	50.7a
Merker	56.3a	49.0a	5.0a	5.3c	2.8a	2.6b	2.7a	2.6a	0.6b	51.4a
Mean	40.4	36.9	6.0	6.3	2.4	2.3	2.2	2.1	0.8	51.4

¹Means in the same column followed by one or more letters in common do not differ significantly at the 5 percent probability level.

the remaining grasses. These results are comparable to the findings of Vélez-Santiago and Arroyo-Aguilú (1981), who reported a CPC which ranged from 11.1 to 13.0% for seven *Pennisetums* harvested at a 45-d CI in Puerto Rico. At Mayagüez (65-d CI), the CPC of dwarf grasses N75 (8.3%) and N127 (8.0%) were higher ($P = 0.05$) than those of the remaining grasses. At Isabela, the CPC of dwarf grasses N114 (9.5%) and N75 (8.7%) were higher ($P = 0.05$) than those of the other grasses.

At Mayagüez (85-d CI), the mean CPC of the grasses was 6.0%, and there were no differences ($P = 0.05$) among them for this trait. At Isabela, the mean CPC of N127 (7.4%) and N75 (7.3%) were superior ($P = 0.05$) to those of the remaining grasses.

At Mayagüez and Isabela (45-d CI), the CPY of Merkeron (4.0 and 4.2 t/ha/yr) surpassed ($P = 0.05$) those of the remaining grasses. At Mayagüez and at the 65-d CI, the CPY of Merkeron and Merker (3.7 and 3.6 t/ha/yr) were higher ($P = 0.05$) than those of the remaining grasses. However, at Isabela no differences were determined among Merkeron, Merker and N114 CPY. At Mayagüez (85-d CI), Merkeron and Merker CPY (2.9 and 2.8 t/ha/yr) were superior ($P = 0.05$) to those of the dwarf grasses, whereas at Isabela, Merkeron CPY (3.1 t/ha/yr) exceeded ($P = 0.05$) those of the remaining grasses. The interaction of grass \times CI was significant. The mean CPY decreased 3.5, 2.8, and 2.4 t/ha/yr for the 45-, 65-, and 85-d CI, respectively.

Plant height and leaf:stem ratio

At both locations and at the three CI, Merkeron and Merker plant heights were superior ($P = 0.05$). Most of the dwarf grasses had similar heights, although N75 was the shortest of the group. In addition to plant height, the principal differences between the tall and dwarf grasses were leafiness, and, in most cases, CPC. According to Bogdan (1977), the main limitations to using napiergrass in pastures are its tall growth and low leaf:stem ratio. N75 is the only dwarf napiergrass cultivar which has been extensively evaluated in Florida, where beef steer gains of nearly 1 kg/d have been reported (Sollenberger et al., 1993). The leaf:stem ratio of the napiergrasses in this study ranged from 0.8 to 2.2 at the 45-d CI. N75's leaf:stem ratio, 2.2, was superior ($P = 0.05$) to that of each of the remaining grasses. As the CI increased, the leaf:stem ratio of the grasses decreased. At the 65-d CI, it was 0.4 to 1.7 and, at the 85-d CI, 0.4 to 1.3. N75 and N127 had higher leaf:stem ratios than the other grasses. Boddorff and Ocumpaugh (1986) compared Mott with pearl millet (*Pennisetum americanum*) \times tall napiergrass hybrids in Florida. These authors reported in vitro organic matter disappearance (IVOMD) of 716 g/kg with 68% leaf for Mott,

whereas the corresponding values for the pearl millet hybrids were 701 g/kg IVOMD with 33% leaf. They concluded that since grazing animals select leaves, it would be advantageous to use the dwarf napiergrass because the leaf blade content was nearly double that of the tall hybrids at any time. Williams (1990) suggested that the advantage of Mott over napier \times millet hybrids was probably due to its improved leaf:stem ratio and possibly its improved stem digestibility.

In vitro dry matter digestibility

The IVDMD of the six grasses was similar for the three CI at the two locations: it ranged from 57.6 to 59.4 (45-d), 51.8 to 56.4 (65-d), and 50.6 to 53.4% (85-d). As the CI increased the overall IVDMD mean of the grasses at the two locations decreased: 58.5 (45-d), 54.1 (65-d), and 51.4% (85-d).

The results of this study suggest that tall grasses such as Merkeron and Merker could be recommended for use under cutting management rather than for grazing. The dwarf grasses, especially N75 and N128, can be utilized under both cutting and grazing management.

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