doi: 10.17138/TGFT(9)249-255

Research Paper

Canopy characteristics of 'Mavuno' hybrid brachiariagrass and 'Marandu' palisadegrass harvested at different harvest intensities

Características del dosel de la pastura brachiaria *híbrida 'Mavuno' y la pastura 'Marandu' recolectadas a diferentes intensidades de cosecha*

LUAN F. RODRIGUES[1], JOAO M.B. VENDRAMINI[2], ANTONIO C. DOS SANTOS[1], JOSE C.B. DUBEUX JR[3], FABRICIA R.C. MIOTTO[1], LUCIANO F. SOUSA[1] AND NAYARA M. ALENCAR[1]

[1]*Departamento de Zootecnia, Universidade Federal do Tocantins, Araguaína, TO, Brazil.* uft.edu.br
[2]*Range Cattle Research and Education Center, University of Florida, Ona, FL, USA.* rcrec-ona.ifas.ufl.edu
[3]*North Florida Research and Education Center, University of Florida, Marianna, FL, USA.* nfrec.ifas.ufl.edu

Abstract

'Mavuno' is a newly released brachiariagrass (*Urochloa* hybrid) cultivar with limited information available in the literature. The objective of this study was to compare forage characteristics of this cultivar and 'Marandu' palisadegrass [*Urochloa brizantha* (Hochst. ex A. Rich.) R.D. Webster cv. Marandu] harvested at 2 different stubble heights during 2 growing seasons (January–April). The study was conducted in Araguaína, TO, Brazil in 2017 and 2018. Treatments were the factorial arrangement of 2 brachiariagrass cultivars, Mavuno and Marandu, harvested at 2 harvest intensities, 5 and 15 cm stubble height, distributed in a randomized complete block design with 4 replicates. Response variables were canopy height, forage accumulation, proportion of leaf, stem and dead material, and concentration of crude protein (CP) and in vitro digestible organic matter (IVDOM). Mavuno and Marandu did not differ (P>0.05) in forage accumulation (mean = 3,800 kg DM/ha/harvest) and IVDOM concentration (mean = 637 g/kg); however, Mavuno had lower CP concentration (101 vs. 110 g/kg), greater proportion of stems (16 vs. 13%) and less dead material (4 vs. 6%) than Marandu (P<0.05). Harvesting at 5 cm stubble height rather than 15 cm increased herbage accumulation per harvest (4,100 vs. 3,500 kg DM/ha) with decreased proportion of leaves (77 vs. 84%) and CP concentration (101 vs. 115 g/kg) (P<0.05). Our data suggest that Mavuno is a useful addition to the range of brachiariagrass cultivars for sowing in tropical regions and further studies are needed to evaluate the long-term persistence of Mavuno under different management practices in a range of environmental situations. While harvesting at 5 cm stubble height rather than 15 cm increased forage accumulation but reduced CP concentration, regardless of cultivar, longer-term effects on the stability of these pastures with these harvest frequencies and heights are open to question and studies should be continued for longer periods to assess longevity of stands under the 2 management strategies. Applying maintenance fertilizer during the growing season might have prevented the marked decline in dry matter accumulation as the season advanced and this hypothesis should be tested.

Keywords: Harvest severity, nutritive value, tropical pastures, *Urochloa* spp.

Resumen

"Mavuno" es un cultivar de pasto brachiaria (híbrido de *Urochloa*) recientemente liberado con información limitada disponible en la literatura. El objetivo de este estudio fue comparar las características del forraje de este cultivar y el pasto 'Marandu' [*Urochloa brizantha* (Hochst. Ex A. Rich.) R.D. Webster cv. Marandu] cosechado a 2 alturas diferentes de rastrojo durante 2 temporadas de crecimiento (enero–abril). El estudio se realizó en Araguaína, TO, Brasil en 2017 y 2018. Los tratamientos fueron el arreglo factorial de 2 cultivares de *Brachiaria*, Mavuno y Marandu, cosechados a

Correspondence: Joao M.B. Vendramini, Range Cattle Research and Education Center, University of Florida, Ona, FL 33865, USA.
Email: jv@ufl.edu

2 intensidades de cosecha, 5 y 15 cm de altura de rastrojo, distribuidos en un diseño de bloques completos al azar con 4 repeticiones. Las variables de respuesta fueron altura del dosel, acumulación de forraje, proporción de hoja, tallo y material muerto, y concentración de proteína cruda (PC) y materia orgánica digestible in vitro (IVDOM). Mavuno y Marandu no difirieron (P> 0.05) en la acumulación de forraje (media = 3,800 kg MS / ha / cosecha) y la concentración de IVDOM (media = 637 g / kg); sin embargo, Mavuno tuvo menor concentración de PC (101 vs 110 g / kg), mayor proporción de tallos (16 vs 13%) y menos material muerto (4 vs 6%) que Marandu (P <0.05). La cosecha a 5 cm de altura de rastrojo en lugar de 15 cm aumentó la acumulación de forraje por cosecha (4.100 vs 3.500 kg MS / ha) con una proporción menor de hojas (77 vs 84%) y concentración de PC (101 vs 115 g / kg) (P <0,05). Nuestros datos sugieren que Mavuno es una adición útil a la gama de cultivares de *Brachiaria* para la siembra en regiones tropicales y se necesitan más estudios para evaluar la persistencia a largo plazo de Mavuno bajo diferentes prácticas de manejo en una variedad de situaciones ambientales. Si bien la cosecha a 5 cm de altura de rastrojo en lugar de 15 cm aumentó la acumulación de forraje pero redujo la concentración de PC, independientemente del cultivar, los efectos a largo plazo sobre la estabilidad de estos pastos con estas frecuencias y alturas de cosecha están abiertos a cuestionamientos y los estudios deben continuar por más tiempo para evaluar la longevidad de las plantaciones bajo las 2 estrategias de manejo. La aplicación de fertilizantes de mantenimiento durante la temporada de crecimiento podría haber evitado la marcada disminución en la acumulación de materia seca a medida que avanzaba la temporada y esta hipótesis debería ser probada.

Palabras clave: Pastos tropicales, severidad de la cosecha, *Urochloa* spp., valor nutritivo.

Introduction

Brachiariagrasses (*Urochloa* spp.) are among the most commonly planted forage species in tropical regions, and Marandu palisadegrass [*Urochloa brizantha* (Hochst. ex A. Rich.) R.D. Webster cv. Marandu] has been one of the most frequently used cultivars in Brazil, representing approximately 35% of the total forage seed production in the country (Jank et al. 2011). Palisadegrass is primarily used in extensive grazing systems that are subjected to relatively low levels of inputs such as commercial fertilizer and liming (Miles et al. 2004). Despite the widespread use of palisadegrass, areas of Marandu have declined for unknown reasons in some regions of Brazil (Barbosa 2006). Therefore, new brachiariagrass cultivars need to be tested to potentially replace Marandu in those areas.

Mavuno is a hybrid brachiariagrass registered in Brazil (MAPA nº 30488) and was released as a commercial cultivar in April 2013. It originated from a cross between ruzigrass [*Urochloa ruziziensis* (R. Germ. & C.M. Evrard) Crins] and U. *brizantha*, that has been used for forage systems in tropical regions; however, there is limited scientific information available about Mavuno. Da Silva et al. (2020) observed that Mavuno had greater herbage accumulation and higher nutritive value than 'Tifton 85' bermudagrass (*Cynodon* spp.) and Jiggs bermudagrass [*Cynodon dactylon* (L.) Pers.] in Florida, USA, but had similar forage characteristics to 'Mulato II' brachiariagrass, which is also a *Urochloa* hybrid cultivar.

Harvest frequency and intensity are the most influential factors in terms of warm-season perennial grass herbage accumulation, nutritive value and persistence (Sollenberger and Burns 2001). In general, forage harvested at shorter stubble height could have decreased residual leaf area and root growth, which may limit the regrowth rate of the pasture (Inyang et al. 2010).

Depending on only limited numbers of brachiariagrass species and cultivars makes the livestock industry in tropical regions vulnerable to infestations by pests and diseases. Therefore, it is important to diversify the genetic sources of brachiariagrass to create more resilient grazing systems in different regions of the world. The objective of this study was to compare Marandu with the new Mavuno brachiariagrass under different harvest intensities in a tropical region. We hypothesized that Mavuno and Marandu would have similar forage accumulation and nutritive value.

Material and Methods

The study was conducted at the Federal University of Tocantins, Araguaína, Brazil (07º5' S, 48º12' W; 277 masl), from January to April 2017 (Year 1) and December 2017 to April 2018 (Year 2). The experimental period chosen covered the growing season at the experimental location, where only infrequent and scarce rainfall occurs in the spring months (September–December). The soil type was Entisol (psamments, quartzipsamments). Initial soil characterization (0–20 cm horizon) indicated that mean pH was 5.3 and Mehlich-1 extractable P, K, Mg and Ca concentrations were 5, 20, 340 and 145 mg/kg, respectively. According to the Köppen climatic classification, the region has a tropical humid summer

with well-defined rainy and dry seasons, with average annual rainfall of 1,828 mm. The rainfall, minimum and maximum temperatures during the experimental period are presented in Table 1.

Treatments were the factorial arrangement of 2 brachiariagrass cultivars, Mavuno and Marandu, and 2 harvest intensities, 5 and 15 cm stubble height, distributed in a randomized complete block design with 4 replicates. The harvest intensity treatments provided a comparison between a moderate harvest stubble height (15 cm) and a short stubble height, which may modify production of the pasture due to limited residual leaf area (Giacomini et al. 2009).

Plot size was 3 × 3 m with 0.5 m alleys between plots and 1.0 m between blocks. On 16 January 2016, the existing vegetation in the experimental area was sprayed with glyphosate [N- (phosphonomethyl) glycine; Roundup Ultra 2, Monsanto Company, St Louis, MO, USA] at a level of 0.8 kg/ha, following which the seedbed was disked with a tandem disk until there was no remaining vegetation on the soil surface. Approximately 14 d after the soil preparation, seed was sown into the plots manually in rows 30 cm apart at a depth of 2 cm. The seeding rate for both grasses was 10 kg/ha, following the recommendation of the seed company (Wolf Seeds) for those cultivars and seed lots. Plots received 30 kg N, 13 kg P and 25 kg K/ha approximately 14 d after germination. Plots were clipped in January 2017 (Year 1) and December 2017 (Year 2) at the respective treatment stubble height, fertilized with 60 kg N, 6 kg P and 50 kg K/ha and evaluated every 28 d thereafter until April each year. The fertilizer sources were urea, simple superphosphate and potassium chloride and rates chosen were used to represent the limited fertilizer strategies used by producers in tropical and subtropical regions.

Measurements

Before each harvest, canopy height was measured using a calibrated stick at 5 random points per plot from ground level to the highest point reached by leaves or stems with no disturbance of the sward. An area of 0.75 m^2 was harvested manually and subsamples were dried at 55 ºC for 72 h and used to assess herbage accumulation, morphological composition and nutritive value. For determining morphological composition, a subsample was taken and manually separated into leaf, stem and dead material. The remaining forage on each plot was clipped at the same stubble height and removed from the plots after each harvest.

Tiller density and tiller mass were evaluated before the forage was harvested. The tillers in one 0.25 m^2 metal ring per experimental unit were counted and the data used to estimate tiller density/m^2. Tillers were harvested, dried at 55 ºC for 72 h and tiller dry mass was calculated.

A further subsample for nutritive value determination was taken, dried in the same way and ground to pass a 1 mm stainless steel screen in a Wiley mill (Model 4, Thomas-Wiley Laboratory Mill, Thomas Scientific, Swedesboro, NJ, USA). The nutritive value analyses were conducted on whole-plant samples (leaf + stem). In vitro digestibility of organic matter (IVDOM) was determined using the two-stage technique described by Tilley and Terry (1963) and modified by Moore and Mott (1974). The micro-Kjeldahl technique was used with a modification of the aluminum block digestion described by Gallaher et al. (1975) for N determination. Crude protein was estimated by multiplying N concentration by 6.25.

Statistical analysis

The data were analyzed using the PROC MIXED technique of SAS (SAS Institute Inc. 1996). Response

Table 1. Monthly rainfall, minimum and maximum temperatures during the experimental period in Year 1 and Year 2 in Araguaína, TO, Brazil (INMET 2018) and long-term average rainfall (1984–2018).

Month, year	Rainfall (mm)	Average rainfall (mm)	Max temperature (°C)	Min temperature (°C)
Year 1				
January 2017	292	257	30.7	21.4
February 2017	345	265	30.6	21.7
March 2017	252	286	31.0	22.0
April 2017	208	221	31.4	22.2
Year 2				
December 2017	256	227	30.5	22.4
January 2018	256	257	30.7	21.7
February 2018	345	265	30.3	22.3
March 2018	315	286	30.7	22.5
April 2018	124	221	32.0	22.0

variables were canopy height, forage accumulation, CP, IVDOM and leaf, stem and dead material proportions. Cultivar, harvest intensity, months and their interactions were considered fixed effects. Blocks and year were considered random effects. Month was analyzed as a repeated measurement and the covariance structure selected based on the least Akaike information criterion value. Normality of residues and homogeneity of variances were tested using conditional studentized residual plots. Treatments were considered different when P≤0.05 by LSD test. Main effects and interactions not discussed in the Results and Discussion sections were not significant (P>0.05). Main effects were not discussed if there was a significant (P<0.05) interaction with the respective independent variable.

Results

Canopy height differed between cultivars and harvest intensities, with no cultivar × harvest intensity interaction (Table 2). Mavuno was taller than Marandu at harvest and forage harvested at 15 cm was taller than that harvested at 5 cm. In addition, month of harvest had an effect on canopy height (Table 3), which declined progressively from January to April (P<0.05).

There were no differences in forage accumulation between cultivars (P>0.05), but pasture harvested at 5 cm accumulated more forage than that at 15 cm (P<0.05; Table 2). As reflected by differences in canopy height, forage accumulation declined progressively from January to April (P<0.05; Table 3).

While leaf proportion in harvested forage was similar for the 2 cultivars (mean = 80.5%), Marandu had less stem (13 vs. 16%) and more dead material (6 vs. 4%) than Mavuno (P<0.05) (Table 2).

There was a cultivar × harvest intensity interaction for tiller density (Table 4; P<0.05). Tiller density of both cultivars did not differ (370 tillers/m^2) when harvested at 5 cm, but Mavuno had greater (P<0.05) tiller density than Marandu when harvested at 15 cm (475 vs. 375 tillers/m^2). Tiller density declined as the season progressed for both harvest intensities but the differences were significant (P<0.05) only when harvested at 5 cm. Tiller mass was greater when harvested at 5 cm than when harvested at 15 cm (Table 2) and tiller mass declined progressively from January to April (P<0.05) (Table 3).

There were cultivar, harvest intensity (Table 2) and month effects on CP concentrations (Table 3) but no significant interactions among the variables. Mavuno had lower CP concentration than Marandu and forage

Table 2. Effects of brachiariagrass cultivars, Mavuno (*Urochloa* hybrid) and Marandu [*Urochloa brizantha* (Hochst. ex A. Rich.) R.D. Webster], and harvest intensity (5 and 15 cm stubble height) on canopy height at harvest, forage accumulation/harvest, proportion of leaf, stem and dead material, tiller mass and crude protein (CP) and in vitro digestible organic matter (IVDOM) concentrations in 2017 and 2018 (means for two years).

Parameter	Cultivar		Harvest consistency		s.e	P value		
	Mavuno	Marandu	5 cm	15 cm		cv.	Harvest height	cv. × Harvest height
Canopy height (cm)	31A[1]	28B	27b[2]	33a	0.71	<0.01	<0.01	0.34
Forage accumulation (kg DM/ha)	3,874	3,744	4,100a	3,500b	277	0.62	0.04	0.30
Leaf (%)	80	81	77b	84a	1.41	0.36	<0.01	0.83
Stem (%)	16A	13B	17a	12b	1.06	<0.01	<0.01	0.56
Dead material (%)	4B	6A	6a	4b	0.54	<0.01	<0.01	0.22
Tiller mass (g DM/m^2)	1.0	1.0	1.2a	0.9b	0.07	0.98	<0.01	0.96
CP (g/kg)	101B	110A	101b	115a	3.1	0.03	0.05	0.16
IVDOM (g/kg)	634	640	640	634	7.0	0.19	0.27	0.09

[1]Cultivar means followed by the same upper-case letters are not different (P>0.05).
[2]Harvest consistency means followed by the same lower-case letters are not different (P>0.05).

Table 3. Effects of month of harvest on canopy height and forage accumulation, plus crude protein (CP) and in vitro digestible organic matter concentrations (IVDOM) of brachiariagrass cultivars, Mavuno (*Urochloa* hybrid) and Marandu [*Urochloa brizantha* (Hochst. ex A. Rich.) R.D. Webster], harvested at 2 harvest intensities (5 and 15 cm stubble height) in 2017 and 2018 (means for two years).

Parameter	January	February	March	April	s.e
Canopy height (cm)	43a[1]	31b	24c	22c	1.05
Herbage accumulation (kg DM/ha)	5,660a	4,330b	2,980c	2,260c	438
Tiller mass (g/m2)	1.4a	1.1b	0.8bc	0.6c	0.12
CP (g/kg)	110ab	101b	119a	82c	0.53
IVDOM (g/kg)	620b	650a	638a	640a	0.83

[1]Means within rows followed by the same lower-case letter are not different (P>0.05).

Table 4. Harvest intensity × month effects on proportion of leaf, stem and dead material and tiller density in brachiariagrass cultivars, Mavuno (*Urochloa* hybrid) and Marandu [*Urochloa brizantha* (Hochst. ex A. Rich.) R.D. Webster], harvested in 2017 and 2018 (means for two years).

Harvest intensity (stubble height)	January	February	March	April	s.e
Leaf (%)					
5 cm	76bA	75bA	74bB	85aB	1.4
15 cm	76cA	79cA	87bA	94aA	
s.e.		1.8			
Stem (%)					
5 cm	22aA	21aA	15bA	12bA	1.0
15 cm	22aA	18aA	6bB	4bB	
s.e.		1.7			
Dead material (%)					
5 cm	3bA	4bA	11aA	5bA	0.5
15 cm	2bA	3bA	6aB	3bA	
s.e.		0.8			
No. of tillers/m^2					
5 cm	392aA	383aA	349bB	330cB	9
15 cm	401aA	411aA	406aA	383aA	
s.e.		9			

Within parameters, means within columns followed by the same upper-case letters and means within rows followed by the same lower-case letters are not different (P>0.05).

harvested at 15 cm had higher CP concentration than that harvested at 5 cm. Crude protein concentration was highest in March and lowest in April (P<0.05). Conversely, IVDOM was not affected by either cultivar or harvest height (Table 2) but was lower in January than in the remaining months (P<0.05) (Table 3).

Discussion

The greater canopy height for Mavuno than for Marandu was likely due to its greater proportion of stems and stem elongation resulted in forage with greater height. While Da Silva et al. (2020) observed that Mavuno had greater canopy height than Mulato II, Jiggs and Tifton 85 bermudagrass, the correlation coefficients of canopy height with forage accumulation and light interception were only r = 0.60 and r = 0.56, respectively, indicating that canopy height may not be an accurate indicator of forage accumulation. This finding was supported by results from our study because the 2 cultivars did not differ in forage accumulation despite Mavuno being taller than Marandu.

The decrease in canopy height and forage accumulation from January to April may be related to the fact that fertilizer was applied only at the beginning of the experimental period, considering that rainfall and temperature during the experimental period were relatively uniform (Table 1), except for April 2017, when rainfall was lower than in other months. In addition, there is a decrease in daylength from 12 h and 31 min to 11 h and 51 min from December to May, which has potential to decrease forage accumulation as well.

Harvesting at 5 cm resulted in greater forage accumulation than harvesting at 15 cm despite displaying lesser height at all stages. This reinforces the findings of Rodrigues et al. (2014), who harvested 'Xaraes' palisadegrass at different stubble heights (10, 20, 30, 40 and 50 cm) and observed an increase in herbage accumulation with decreasing stubble height.

The similar proportion of leaves in Mavuno and Marandu canopies (mean 80.5%) was likely the main factor leading to similar IVDOM for forage from the 2 grasses. While Mavuno had a greater proportion of stems than Marandu, it also had less dead material and the effects of these traits on IVDOM may have tended to cancel each other out. It is well reported in the literature that stems have greater concentrations of structural carbohydrates than leaves, and structural carbohydrates are generally less digestible than non-structural carbohydrates, which are commonly present at higher proportions in leaves (Chapman et al. 2014). It is also well documented that senescent material may have lost a significant proportion of cell contents, leading to decreased digestibility (Dubeux Jr et al. 2006).

The greater proportion of stems in forage harvested at 5 than at 15 cm was expected because there is a greater proportion of stems in the bottom layers of warm-season forage canopies as reported by Vendramini et al. (2019) and Pontes et al. (2017).

Mavuno harvested at 15 cm had greater tiller density than Marandu, but there was no difference in tiller mass, indicating that Mavuno had less weight per tiller. The same trend was observed with harvest intensity because forage harvested at 5 cm had lower tiller density but greater tiller mass than forage harvested at 15 cm. Euclides et al. (2019) observed that increasing grazing intensity, i.e. grazing to a shorter stubble height, decreased persistence of palisadegrass. The greater decline in tiller density during the growth period when forage was cut at 5 cm rather than 15 cm in our study suggests that the more severe cutting height could result in reduced persistence of these pastures over time.

Mavuno has lower CP concentration than Mulato II under similar management systems and Da Silva et al. (2020) suggested that Mavuno may have an intrinsically lower CP concentration than other selected brachiariagrasses. The marked reduction in CP concentration observed in April was likely due to the run-down in soil N levels since no fertilizer was applied after commencement (~90 d) plus limited rainfall during April (Table 1).

The slight increase in stem proportion in the forage harvested at 15 cm failed to decrease IVDOM of forage as the stems produced were relatively immature (28 days). While we expected Mavuno to have greater IVDOM than Marandu, there was no difference in IVDOM between the cultivars. Both Mavuno and Mulato II are hybrids of ruzigrass and palisadegrass, and among the brachiariagrass species ruzigrass is known to have consistently highest digestibility (Barnard 1969; Rosa et al. 1983). The harvest intervals employed and fertilizer management used in this study may have negated the potential differences in IVDOM between Mavuno and Marandu.

In summary, the absence of marked differences in performance between Mavuno and Marandu during the study suggests that Mavuno is a suitable option for broadening the range of brachiariagrass genetic resources in tropical regions. However, Mavuno had greater canopy height and proportion of stem in the canopy, and lower CP concentration than Marandu, when harvested at a fixed harvest frequency of 28 d. While harvesting at 5 cm stubble height rather than 15 cm increased herbage accumulation but reduced CP concentration, regardless of cultivar, longer-term effects on the stability of these pastures with these harvest frequencies and heights are open to question and studies should be continued for longer periods to assess longevity of stands under the 2 management strategies. Applying maintenance fertilizer during the growing season might have prevented the marked decline in dry matter accumulation as the season advanced and this hypothesis should be tested.

Further studies are warranted to evaluate the effects of additional abiotic and biotic factors on production and survival of Mavuno in a range of environmental situations.

Acknowledgments

We thank the CAPES foundation for sponsoring the assistantship of the first author's Ph.D. program.

References

(Note of the editors: All hyperlinks were verified 28 May 2021).

Barbosa RA. 2006. Morte de pastos de braquiarias. 1st Edn. Embrapa Gado de Corte, Campo Grande, MS, Brazil. bit.ly/3jY1Twi

Barnard C. 1969. Herbage plant species. Australian Herbage Plant Registration Authority, CSIRO, Canberra, ACT. Australia.

Chapman DF; Lee JM; Waghorn GC. 2014. Interaction between plant physiology and pasture feeding value: a review. Crop and Pasture Science 65:721–734. doi: 10.1071/CP13379

Da Silva HMS; Vendramini JMB; de Oliveira FCL; Soares Filho CV; Kaneko M; Silveira ML; Sanchez JMD; Yarborough JK. 2020. Harvest frequency effects on herbage characteristics of 'Mavuno' brachiariagrass. Crop Science 60:1113–1122. doi: 10.1002/csc2.20046

Dubeux Jr JCB; Sollenberger LE; Vendramini JMB; Stewart RL; Interrante SM. 2006. Litter mass, deposition rate, and chemical composition in bahiagrass pastures managed at different intensities. Crop Science 46:1299–1304. doi: 10.2135/cropsci2005.08-0262

Euclides VPB; Montagner DB; Macedo MCM; de Araujo AR; Difante GS; Barbosa RA. 2019. Grazing intensity affects herbage accumulation and persistence of Marandu palisadegrass in the Brazilian savannah. Grass and Forage Science 74:450–462. doi: 10.1111/gfs.12422

Gallaher RN; Weldon CO; Futral JG. 1975. An aluminum block digester for plant and soil analysis. Soil Science Society of America Journal 39:803–806. doi: 10.2136/sssaj1975.03615995003900040052x

Giacomini AA; da Silva SC; Sarmento DOL; Zeferino CV; Souza Junior SJ; da Trindade JK; Guarda VA; Nascimento Junior D. 2009. Growth of marandu palisadegrass subjected to strategies of intermittent stocking. Scientia Agricola 66:733–741. doi: 10.1590/S0103-90162009000600003

INMET (Instituto Nacional de Meteorologia). 2018. September 25. inmet.gov.br/portal

Inyang U; Vendramini JMB; Sellers B; Silveira MLA; Lunpha A; Sollenberger LE; Adesogan A; Paiva LM. 2010.

Harvest frequency and stubble height affects herbage accumulation, nutritive value, and persistence of 'Mulato II' brachiariagrass. Forage and Grazinglands 8:1–7. doi: 10.1094/FG-2010-0923-01-RS

Jank L; de Valle CB; Resende RMS. 2011. Breeding tropical forages. Crop Breeding and Applied Biotechnology 11:27–34. doi: 10.1590/S1984-70332011000500005

Miles JW; do Valle CB; Rao IM; Euclides VPB. 2004. Brachiariagrass. In: Moser LE; Burson BL; Sollenberger LE, eds. Warm-Season (C_4) grasses. Agronomy Monograph 45. ASA, CSSA, SSSA, Madison, WI. p. 745–784. doi: 10.2134/agronmonogr45.c22

Moore JE; Mott GO. 1974. Recovery of residual organic matter from in vitro digestion of forages. Journal of Dairy Science 57:1258–1259. doi: 10.3168/jds.S0022-0302(74)85048-4

Pontes LS; Baldissera TC; Giostri AF; Stafin G; dos Santos BRC; Carvalho PCF. 2017. Effects of nitrogen fertilization and cutting intensity on the agronomic performance of warm-season grasses. Grass and Forage Science 72:663–675. doi: 10.1111/gfs.12267

Rodrigues RC; Lana RP; Cutrim Jr. JAA; Sanchês SSC; Galvão CML; de Sousa TVR; Amorim SEP; de Jesus APR. 2014. Accumulation of forage and sward structure of Xaraés grass subjected to intensity of cuts. Revista Brasileira de Saúde e Produção Animal 15:815–826. (In Portuguese) doi: 10.1590/S1519-99402014000400002

Rosa B; Rocha GP; Silva HL. 1983. Consumo voluntario e digestibilidade aparente de feno *Brachiaria decumbens* Stapf e *Brachiaria ruziziensi*s Germain et Evrard em diferentes idades de corte. Anais das Escolas de Agronomia e de Veterinaria 13:5–27. bit.ly/37Puiis

SAS Institute. 1996. SAS user's guide. Release version 6. SAS Institute, Cary, NC, USA.

Sollenberger LE; Burns JC. 2001. Canopy characteristics, ingestive behaviour and herbage intake in cultivated tropical grasslands. In: Proceedings of the 19th International Grassland Congress, São Pedro, SP, Brazil. p. 321–327.

Tilley JMA; Terry RA. 1963. A two-stage technique for the in vitro digestion of forage crops. Grass and Forage Science 18:104–111. doi: 10.1111/j.1365-2494.1963.tb00335.x

Vendramini JMB; Sollenberger LE; Leite de Oliveira FC; Herling VR; Gomes VC; Sanchez JMD; Yarborough JK. 2019. Herbage characteristics of continuously stocked limpograss cultivars under stockpiling management. Crop Science 59:2886–2892. doi: 10.2135/cropsci2019.05.0299

(Received for publication 30 April 2020; accepted 8 May 2021; published 30 September 2021)