Utilization periods of stockpiled forage grasses established under dwarf coconut shading

Períodos de utilização de gramíneas forrageiras diferidas implantadas sob sombreamento de coqueiro-anão

Períodos de utilización de gramíneas forrajeras diferidas sembradas bajo la sombra de coco enano

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Abstract
The effects of utilization periods of stockpiled forage grasses established under shading of 25-year-old dwarf coconut (*Cocos nucifera*) in Parnaíba, Piauí, were evaluated. The experimental design was a randomized block design in split plots with three replications. The forage grasses: andropogon grass (*Andropogon gayanus* cv. Planaltina), digitaria grass (*Digitaria* sp.), marandu grass (*Urochloa brizantha*) and mombasa grass (*Megathyrsus maximus*) were allocated in the main plots, and the utilization periods (August, September, October and November), in the subplots. The stockpiled of forage grass pastures in integrated systems with dwarf coconut trees, in order to accumulate forage to feed the herds during the dry season, is a technically viable practice. Irrespective to the forage grasses evaluated, crude protein levels are insufficient to supply the minimum nutritional requirements of grazing beef or dairy cattle, so the animals must receive protein supplementation during the pasture utilization periods. The forage grasses most promising for stockpiled management were Marandu and Mombasa, allowing to reconcile high productivity with forage quality.
Keywords: Yield; Crude protein; Living matter/dead matter ratio; Semiarid; Silvopastoral system.

Resumo
Avaliaram-se os efeitos dos períodos de utilização de gramíneas forrageiras diferidas e implantadas sob o sombreamento de plantios de coqueiro-anão (*Cocos nucifera*) em Parnaíba, Piauí. O delineamento experimental foi blocos casualizados em esquema de parcelas divididas com três repetições, onde as gramíneas forrageiras: capim-andropogon (*Andropogon gayanus* cv. Planaltina), capim-digitaria (*Digitaria* sp.), capim-marandu (*Urochloa brizantha*) e capim-mombaça (*Megathyrsus maximus*) constituíram as parcelas principais e os períodos de utilização (agosto, setembro, outubro e novembro), as subparcelas. O diferimento de pastagens de gramíneas forrageiras em sistemas integrados com coqueiro-anão, de modo a acumular forragem para a alimentação dos rebanhos durante o período seco é uma prática tecnicamente viável. Independentemente das espécies de gramíneas cultivadas, os teores de proteína bruta são insuficientes para atender as necessidades nutricionais mínimas dos bovinos de corte ou leite em pastejo, devendo os animais receberem suplementação alimentar durante os períodos de utilização da pastagem. Das gramíneas avaliadas, o capim-Marandu e o Mombaça são os mais promissores, conciliando elevada produtividade com qualidade da forragem.
Palavras-chave: Produtividade; Proteína bruta; Relação material vivo/material morto; Semiárido; Sistema silvipastoril.

Resumen
Los efectos de los períodos de utilización de gramíneas forrajeras diferidas e implantadas bajo la sombra de plantaciones de coco enano (*Cocos nucifera*) fueron evaluados en Parnaíba, Piauí. El diseño experimental fue bloques al azar en un esquema de parcelas divididas con tres repeticiones. Los pastos forrajeros andropogon (*Andropogon gayanus* cv. Planaltina), digitaria (*Digitaria* sp.), marandu (*Urochloa brizantha*) y mombasa (*Megathyrsus maximus*) representaron las parcelas principales y los periodos de utilización (agosto, septiembre, octubre y noviembre) constituyeron las subparcelas. El diferimiento de pastos forrajeros en sistemas integrados con coco enano, con el fin de acumular forraje para alimentar los rebaños durante la estación seca es una práctica técnicamente viable. Independientemente de las especies de gramíneas evaluadas, los niveles de proteína cruda son insuficientes para satisfacer los requerimientos nutricionales mínimos de el ganado vacuno o lechero en pastoreo, y los animales deben recibir suplementos durante los períodos de utilización de las pasturas. De las gramíneas evaluadas, el pasto Marandu y Mombasa son los más promisorios, combinando alta productividad con calidad forrajera.
Palabras clave: Productividad; Proteína cruda; Relación materia viva/materia muerta; Semiárido; Sistema silvopastoral.

1. Introduction

The livestock represents one of the most important segments of agribusiness in Brazil (Carvalho & Zen, 2017). The activity presents unique conditions with regard to animal production, considering that the main forage resource for herd feeding, in the vast majority of farms, consists of native or cultivated pastures. In this context, from the point of view of herd feeding, pasture is the cheapest of all foods to produce and use. However, in most Brazilian physiographic regions there are two very distinct climatic seasons: the rainy season, characterized by humidity, temperature and luminosity, generally favorable for the growth of tropical forage grass, and the dry season, in which these factors are almost always adverse and limiting to animal production. As a consequence, there is a marked annual seasonality of forage production and animal performance, a behavior that occurs in most tropical pastures (Aroeira & Paciullo, 2004).

These effects are more pronounced in the Northeast region, where rainfall is irregular, with long periods of drought and poor distribution of rainfall (Magalhães, 2010). Some management practices can be adopted to reduce the negative effects of low forage availability in the dry season. Stockpiled is a technique that consists of set aside a certain pasture area at the end of the growing season, allowing the accumulated forage to be used in the dry period. It presents itself as a viable alternative to be used in semi-arid regions due to its low cost and easy execution (Costa et al., 2007; Rodrigues Junior et al., 2015; Manço, 2020).

In turn, livestock activity in general, despite its high economic relevance, has been identified as one of the main causes of environmental damage, notably deforestation and fires in the most Brazilian biomes. In this scenario, society and conservationist entities have demanded alternatives of less ecologically harmful livestock production. Among the alternatives, silvopastoral systems stands out. It consists of the combination of timber or fruit trees with pastures based animal production. Furthermore, these systems can ensure the stability and viability of agricultural systems, raise land productivity and multifunctionality, providing relevant ecological, economic and social benefits (Torquebiau etal., 2002; Magalhães et al., 2004; Andrade et al., 2018; Arciniegas & Flórez, 2018; Marenco, 2021; Gutiérrez Bermúdez & Mendieta Araica, 2022). Among the fruits grown in the Northeast region, coconut (*Cocos nucifera*) stands out, whose production exceeds 1.34 billion fruits, in a planted area of 211 thousand hectares (Jesus Junior et al., 2015). In the region, monoculture production systems predominate, however there is great potential for the establishment of silvopastoral systems (Azar, 2011; Salendu & Elly, 2014; Carvalho Filho et al., 2017; Osak et al., 2018; Oley et al., 2019). According to Pillai et al. (1980), in general, tropical forage grasses cultivated under coconut trees provide about 75% of the production obtained in single cultivation.

This work evaluated the effects of utilization periods on the yield and chemical composition of forage grasses stockpiled and established under dwarf coconut shading.

2. Methodology

The research was performed under field natural conditions using the quantitative method. As there are still gaps about the effect of the utilization periods on the productive performance of tropical forage grass stockpiled pastures under shading of 25-year-old dwarf coconut, the hypothetical-deductive method was chosen to be used (Pereira et al., 2018).

The work was carried out at the Unidade de Execução de Pesquisa (UEP), branch of Embrapa Meio-Norte, in the municipality of Parnaíba, Piauí State (03°05' S; 41°46' W and 46.8 m), semiarid region of the Northeastern Brazil (Sudene, 2017). According to the climate classification by Thornthwaite and Mather, the climate is C1dA'a'. This is characterized as dry sub-humid, megathermic, with a small water overplus and a potential evapotranspiration concentration of 29.7% in the quarter October, November and December. The climatological normal distribution of total annual precipitation between 1978 and 2014 was 1,033.5 mm (Bastos et al., 2016).

The soil of the experimental area was a Distrophic Yellow Latosol class, of medium texture, coastal caatinga phase and smooth flat relief (Melo et al., 2004). At the beginning of the experiment, the soil presented the following chemical characteristics: Organic Matter = 7.85 g/kg; pH (H_2O) = 5.73; P = 6.07 mg/dm^3; K = 0.14 cmol$_c$/dm^3; Ca = 1.69 cmol$_c$/dm^3; Mg = 0.59 cmol$_c$/dm^3; Na = 0.01 cmol$_c$/dm^3; Al = 0.04 cmol$_c$/dm^3; H + Al =1.83 cmol$_c$/dm^3; Sum of Bases = 2.43 cmol$_c$/dm^3; Cation exchange capacity = 4.26 cmol$_c$/dm^3, Bases Saturation = 57.02%; Aluminum saturation = 1.62%.

The rain was 1,215.2 mm during 2018. However, during the experimental period, from May to November, rainfall occurred irregularly, distributed as follows: May (67.9 mm), June (22.3 mm), July (15.1 mm); August (1.3 mm), September (0.0 mm), October (0.0 mm) and November (0.0 mm). Historically, the average maximum and minimum temperatures in the region are 36°C and 22°C, respectively. During the experiment, a minimum temperature of 23.9 °C, an average of 29.4°C and a maximum of 34.9°C were recorded.

Four forage grasses were evaluated: andropogon grass (*Andropogon gayanus* cv. Planaltina), digitaria grass (*Digitaria* sp.), marandu grass (*Urochloa brizantha*) and mombasa grass (*Megathyrsus maximus*) and four utilization periods: August, September, October and November. The experimental design was randomized blocks in a split-plot scheme with three replications. The forage grasses constituted the main plots and the utilization periods the subplots.

The experimental plots were implanted at the beginning of the 2018 rainy season. The establishment fertilization consisted of doses equivalent to 50 kg ha^{-1} of P_2O_5, as the form of triple superphosphate and 40 kg ha^{-1} of K_2O, as the form of potassium chloride. The nitrogen fertilization (45 kg ha^{-1} as the form of urea) was in topdressing and split into two applications: one at sowing and the other 30 days later. The forage grasses sowing was carried out in February 2018, in rows spaced 0.4 m apart, under shading of 25-year-old dwarf coconut plants, spaced 8.5 m x 8.5 m and irrigated by microsprinkler. Only coconut plants received irrigation.

Grasses were stockpiled on May 23, 2018, and the utilization periods were August 1, September 5, October 10 and November 14, 2018. The defoliations were performed manually at a height of 10 cm above the ground for digitaria grass and 20 cm above the ground for the other grasses.

The green mass collected in the useful area was placed in paper bags and weighed on an analytical balance A sample was removed, weighed and dried in an oven with forced air circulation at 65°C for 72 hours, to estimate the production of green dry matter (GDM = total dry matter - dead matter) and determination of crude protein (CP) contents. In the Water-Soil-Plant Laboratory of Embrapa Meio-Norte/UEP of Parnaíba, CP contents were determined by the Kjeldahl method (AOAC, 2005). Data were analyzed using the statistical program Infostat (Di Rienzo et al., 2012).

3. Results and Discussion

No interaction (P>0.05) was observed between forage grasses and utilization periods for variable GDM productivity. Separately, there were also no significant differences for utilization periods (Table 1), whose average forage production were 4.81; 5.76; 5.26 and 5.40 t ha^{-1}, respectively, for August, September, October and November. These results are similar to those observed by Rodrigues Junior et al. (2015), under the same edaphoclimatic conditions, with marandu grass managed in full sun, stockpiled in May and used in July (5.79 t ha^{-1}), August (5.49 t ha^{-1}) and September (5.97 t ha^{-1}). It should be noted that, in order not to reduce voluntary intake and, consequently, affect animal performance, in stockpiled pastures, the forage supply must always be above the value considered critical by Mannetje and Ebersohn (1980), 2.0 t ha^{-1} of GDM.

Table 1. Green dry matter per hectare (GDM) of stockpiled tropical forage grasses, established under shading of 25-year-old dwarf coconut, as affected by utilization periods. Parnaíba, PI.

Grasses	Utilization Periods				
	August	September	October	November	Average
	-------------------- GDM (t ha^{-1}) ---------------------				
Andropogon grass	2.08	2.74	3.10	2.19	2.53 c
Digitaria grass	4.75	5.19	5.38	5.59	5.23 b
Marandu grass	5.56	7.74	6.28	7.09	6.67 a
Mombasa grass	6.84	7.39	6.28	6.76	6.82 a
Average	4.81 A	5.76 A	5.26 A	5.40 A	
CV	21.92				

- Means followed by different letters, uppercase in the lines and lowercase in the columns, differ from each other (P<0.05).
CV = coefficient of variation. Source: Research data

Analyzing the effect of grasses alone, marandu (6.67 t ha^{-1}) and Mombasa (6.82 t ha^{-1}) grasses showed higher forage yields (P<0.05) (Table 1). This situation was already expected, as these grasses have a high potential for forage production, when in favorable soil and climate conditions, and annual forage production can exceed 30 tons of GDM ha^{-1}, as a sum of several defoliations during growth season (Magalhães, 2010; Mochel Filho et al., 2016). Although, in this experiment, the forage production was lower than the one mentioned above. In the Minas Gerais´s savannas, Andrade et al. (2003) reported that Marandu and Mombasa grasses showed good forage production, exceeding 4.0 t ha^{-1} of GDM, when cultivated under eucalyptus (*Eucalyptus* spp.) shading. This can be considered as viable and good options for composing silvopastoral systems. It is important to highlight that in silvopastoral systems, under the treetops, forage grasses present a significant reduction in GDM production, as a consequence of changes in the quantity and quality of light, notably in terms of photosynthetically active radiation, the main input for the photosynthesis process (Costa et al., 2006; Bernardino & Garcia, 2009). Tropical grasses have a C_4 metabolic pathway and reach their maximum biomass production with high levels of luminosity (Rodríguez, 2002; Costa et al., 2004; Obispo et al, 2008; Silva, 2009; Soares et al., 2009).

Irrespective to forage grass, for the LM/DM ratio, the best period of pasture utilization (P<0.05) was recorded in August (Table 2). This can be caused by the shortest time between stockpiled (May) and pasture use (70 days) for later evaluations, 105 days, 140 days and 175 days for the September, October and November evaluations, respectively.

Table 2. Ratio living matter/dead matter (LM/DM) of stockpiled tropical forage grasses, established under shading of 25-year-old dwarf coconut, as affected by utilization periods. Parnaíba, PI.

Grasses	Utilization Periods				
	August	September	October	November	Average
	---------------------- LM/DM ----------------------				
Andropogon grass	5.02	1.85	1.82	2.10	2.69 a
Digitaria grass	1.77	1.56	1.40	1.64	1.59 b
Marandu grass	4.10	3.06	3.37	2.34	3.21 a
Mombasa grass	3.90	2.74	2.72	2.63	2.99 a
Average	3.70 A	2.30 B	2.33 B	2.18 B	
CV (%)	33.89				

- Means followed by different letters, uppercase in the lines and lowercase in the columns, differ from each other (P<0.05).
CV = coefficient of variation. Source: Research data

The LM/DM ratio is a parameter of great relevance in the choice of forage for stockpiled, so it is strongly influencing the diet selection by ruminants (Euclides et al., 2000). Dead material, in large quantities, may limit the voluntary intake of grazing animals (Rosales & Pinzón, 2004; Santos et al., 2004). In this experiment, andropogon, marandu and Mombasa grasses presented the highest values (P<0.05) for the LM/DM ratio (Table 2).

For the CP levels, no interaction was detected between forage grasses and utilization periods (Table 3). Isolated, a significant effect (P<0.05) was registered for the CP levels for the utilization periods evaluated. When the pasture was used in August, the protein levels were higher in relation to the other utilization periods. This behavior could be predicted, since the grasses stockpiled in August were used earlier, compared to the other months. As the grass plant matures, there is a reduction in cellular content and, consequently, a decline in CP levels (Magalhães et al., 2009; Cajas-Girón et al. 2012, González et al., 2014; Valbuena et al., 2016; Fontinele et al., 2022), as observed in this work. In general, in silvopastoral systems, pastures tend to have better nutritional value, showed higher CP contents than conventional pastures (Souza et al., 2007, Barragán-Hernández et al., 2019). This fact was not observed in this experiment, possibly due the long rest period for the grasses defoliation.

Table 3. Crude protein (CP) contents of stockpiled tropical forage grasses, established under shading of 25-year-old dwarf coconut, as affected by utilization periods. Parnaíba, PI.

Grasses	Utilization Periods				
	August	September	October	November	Average
	------------------------ CP (%) ------------------------				
Andropogon grass	6.56	4.88	3.33	3.35	4.53 c
Digitaria grass	8.14	6.74	5.71	5.70	6.57 a
Marandu grass	6.95	6.33	5.97	5.92	6.29 a
Mombasa grass	6.56	4.69	5.56	5.01	5.46 b
Average	7.05 A	5.66 B	5.14 B	4.99 B	
CV (%)	12.99				

- Means followed by different letters, uppercase in the lines and lowercase in the columns, differ from each other (P<0.05).
CV = coefficient of variation. Source: Research data.

Analyzing only the effect of the forage grass, the highest levels of CP were recorded by digitaria grass (6.57%) and marandu grass (6.29%) (P<0.05) followed by Mombasa grass (5.46%) and andropogon grass (4.53%). In ruminants' nutrition, CP values below 7% are not desirable for a forage grass, and may affect rumen fermentation, due to the reduction in microbial activity caused by nitrogen deficiency, reduction in voluntary intake and in the forage digestibility coefficient, according to Minson (1984), Van Soest (1994), Silva et al. (2002) and Medeiros and Marino (2015). In this experiment, irrespective to forage grass, this criterion would not be attained. In stockpiled pastures, the forage chemical composition is probably the most limiting factor for animal productivity. Therefore, management actions should be adopted to improve the voluntary intake and digestibility of stockpiled pastures, such as protein supplementation for animals, especially during the dry season (Detmann et al., 2004; Soares et al., 2015),

4. Conclusions

The stockpiled of forage grass pastures in integrated systems with dwarf coconut trees is a technically viable practice, in order to accumulate forage to feed the herds during the dry season.

Irrespective to the forage grasses evaluated, crude protein levels are insufficient to supply the minimum nutritional requirements of grazing ruminants, mainly beef or dairy cattle, so the animals must receive protein supplementation during the pasture utilization periods.

The most promising forage grasses for stockpiled management were Marandu and Mombasa, allowing to reconcile high yield with forage quality.

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