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Productive characteristics of the grass *Digitaria umfolozi* subjected to defoliation frequencies

Características produtivas do capim *Faixa-Branca* submetido a frequências de desfolhação

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Abstract

An experiment was carried out to evaluate the dry matter production, total dry matter availability, daily dry matter accumulation rate, light interception, leaf area index, daily accumulation rate and dry matter availability of the morphological components (leaf blades, stems + sheaths and dead material), leaf/stem ratio, crude protein, neutral detergent fibre and acid detergent fibre of Faixa-Branca grass under seven defoliation frequencies (14, 21, 28, 35, 42, 49, and 56 days). Longer defoliation frequencies reduced the percentage of leaf blades and increased the percentage of stems + sheaths. The defoliation frequency positively influenced the availability of leaf blades, stems + sheaths, dead material and total dry matter. In the range of 42 days of defoliation, light interception reached 95%. At frequencies of 14 and 21 days of defoliation, the crude protein content of the leaves was above 20%. The highest utilization efficiency of Faixa-Branca grass is achieved when the forage is managed with cutting intervals of 40 to 46 days. Higher defoliation frequencies positively contribute to the increase in the number of total white band grass leaves and higher crude protein content of the leaf blades and stems + sheaths.
Key words: Crude protein. *Digitaria umfolozi*. Forage production. Light interception.

Resumo

Foi realizado um experimento com o objetivo de avaliar a produção de matéria seca, disponibilidade total de massa seca, taxa de acúmulo diária de matéria seca, interceptação luminosa, índice de área foliar, taxa de acúmulo diário e disponibilidade de matéria seca dos componentes morfológicos (lâmina foliar, colmo+bainha e material morto), relação lâmina/colmo, proteína bruta, fibra em detergente neutro e fibra em detergente ácido do capim Faixa-Branca submetido a sete frequências de desfolhação (14, 21, 28, 35, 42, 49, 56 dias). As frequências mais longas de desfolhação reduziram os percentuais de lâmina foliar e aumentaram colmo+bainha. A frequência de desfolhação influenciou positivamente a

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disponibilidade de lâmina foliar, colmo+bainha, material morto e matéria seca total. No intervalo de 42 dias de defoliation o capim faixa branca atingiu 95% de interceptação luminosa. Nas frequências de 14 e 21 dias de desfolhação os teores de proteína bruta das folhas foram acima de 20%. Verificou-se que a maior eficiência de utilização do capim Faixa-Branca é alcançada quando a forrageira é manejada com intervalos de corte de 40 a 46 dias. As maiores frequências de desfolhação contribui positivamente para o aumento do número de folhas totais do capim Faixa-Branca e apresentam maiores teores de proteína bruta das lâminas foliares e colmo+bainha.
Palavras-chaves: *Digitaria umfolozi.* Interceptação luminosa. Produção de forragem. Proteína bruta.

Introduction

In view of the need for increased productivity, Brazilian livestock producers have adopted new technologies, such as the use of new species and grass cultivars, new management practices and more intensive fertilization strategies. The potential of grasses is directly associated with their productive capacity and their adaptation to management, soil and weather conditions.

In recent decades, studies on the interaction between productivity and management goals in decision-making have intensified, which has resulted in the implementation of measures that lead to increased dry matter (DM) productivity, quality, animal performance and carrying capacity of the pastures with technologies able to increase the competitiveness of livestock systems based on forage mass production.

However, the response of forage plants to management depends mainly on the forage species, the form of forage utilization, the soil fertility and the weather conditions. Thus, forage management has led to changes in the production of biomass due to changes in the morphological and structural characteristics of forage plants, which has influenced DM production.

The genus *Digitaria* includes approximately 300 species of plants. Brazil has approximately 26 native *Digitaria* species, nine of which are unique, in addition to 12 exotic species distributed in the South, Southeast, Midwest and Northeast regions of Brazil, making Brazil the country in the Americas with the highest number of species of this genus (DIAS et al., 2007). However, the management of the genus has not been performed in accordance with its characteristics, which has led to a decrease in its use for pastures over time (FONSECA; MARTUSCELLO, 2010).

Aronovich et al. (1996) stated that plants of the genus *Digitaria* have properties recommended for intensive pasture-based production of milk and meat, and hybrids such as Survenola and Pentziana have good potential for animal production.

Digitaria umfolozi (ARONOVICH et al., 1996; NAVARRO et al., 2005), also known as 'Survenola' or 'pangola peluda', is a hybrid obtained by crossing *Digitaria setivalva* Stent and *Digitaria valida* Stent at the University of Florida (Gainesville, USA) in 1965. In the agreste (sub-humid hilly region) and sertão (semiarid savannah) of the Brazilian Northeast region, *D. umfolozi* grass is also known as '*Faixa-Branca*' [white-band] grass and is used for animal production because of its nutritional qualities and because it grows well in these regions. However, although there is great interest of the productive sector for this forage there is a lack of technical information and data on its morphogenic, structural and productive characteristics, which could improve the management, zootechnical indices and use of *Faixa-Branca* grass in agriculture and livestock farming.

Producing the best responses in forage plants requires greater knowledge about the management and application of inputs to increase their productivity (MARCELINO et al., 2006). However, the recommendations for *Faixa-Branca* grass are made based on empirical knowledge. Therefore, this work aimed to evaluate the morphological and productive characteristics of *Faixa-Branca* grass subjected to different defoliation frequencies.

Materials and Methods

This experiment was conducted during the period of May to September 2009 in the Jorge Prado Sobral Experimental Station of Embrapa Coastal Tablelands, located in the municipality of Nossa Senhora das Dores in the state of Sergipe-SE in Brazil. The soil is a dystrophic cohesive Yellow Latosol, which is characteristic of the Coastal Tablelands of the Northeast region, and the experimental site is located at an altitude of approximately 200 m, with an average annual rainfall of 1,046 mm that is distributed predominantly in the period of May to September. The experimental soil was sampled in the 0-20 cm depth layer and presented the following chemical characteristics: pH in H_2O, 5.2; P, 5.18 mg/dm^3 (Melich 1); K, 148.75 mg/dm^3; Ca, 2.83 $cmol_c$/dm^3; Mg, 0.82 $cmol_c$/dm^3; Al, 0.13 $cmol_c$/dm^3; and organic matter, 4.24 g/$dm^{3.}$

This experiment used a randomized block design with three replicates. The experimental units consisted of 6 m^2 (3 x 2 m) beds for a total experimental area of 180 m^2 distributed in 21 beds, which were cultivated with *Faixa-Branca* seedlings planted at the beginning of the rainy season of 2009. The 21 beds were allocated in three blocks, with each block comprising seven beds. The beds were mowed to make them uniform at the end of June 2009, which left a 10-cm high residue.

After mowing the pasture, the experimental area was fertilized with 100 kg ha^1 of nitrogen as urea, 90 kg ha^1 of phosphorus as single superphosphate, and 80 kg ha^1 of potassium as potassium chloride. This procedure was performed based on the soil analysis to ensure that the initial residue targets were generated correctly and was not used again during the experimental period. The treatments were composed of seven defoliation frequencies (14, 21, 28, 35, 42, 49, and 56 days) of *Faixa-Branca* grass.

Four defoliations were applied for the 14-day treatment, two for the 21- and 28-day treatments and only one for the other treatments. During the experimental period, the following parameters were measured: DM production, total DM availability (TDMA), daily DM accumulation rate, light interception (LI), leaf area index (LAI), daily accumulation rate and DM availability of the morphological components (leaf blades, stems + sheaths and dead material) and leaf/stem ratio. An analysis of the crude protein (CP), neutral detergent fibre (NDF) and acid detergent fibre (ADF) content of *Faixa-Branca* grass was also performed.

To assess the TDMA, a forage sample was collected 10 cm from the ground, in a sampling design of 0.25 m^2 (50 x 50 cm) per experimental unit in each sampling. After the forage samples were collected, they were divided into two sub-samples (production and morphological composition). To obtain the morphological composition of *Faixa-Branca* grass, the sample was divided into green leaf blades, green stems (stems + leaf sheaths) and dead material (tillers and dead leaves), weighed, and then dried in a forced air oven at 65° C and weighed again.

The contribution of each morphological component (leaf blades, stems and dead material) to the total DM of each sample collected was used to estimate the availability of each component. The total DM production in the collected samples was estimated according to the agricultural method of differences described by Davies (1993). The DM accumulation rate was calculated as the DM accumulation divided by the cutting frequency.

The evaluation of the canopy LI was performed at pre-cutting and at the time interval defined for each treatment using a photosynthetically active radiation (PAR) sensor, LP-80 AccuPAR, which records data on LI and LAI. In each experimental plot, four LI and LAI readings were taken to form a composite sample, and the average value was used for each evaluated treatment.

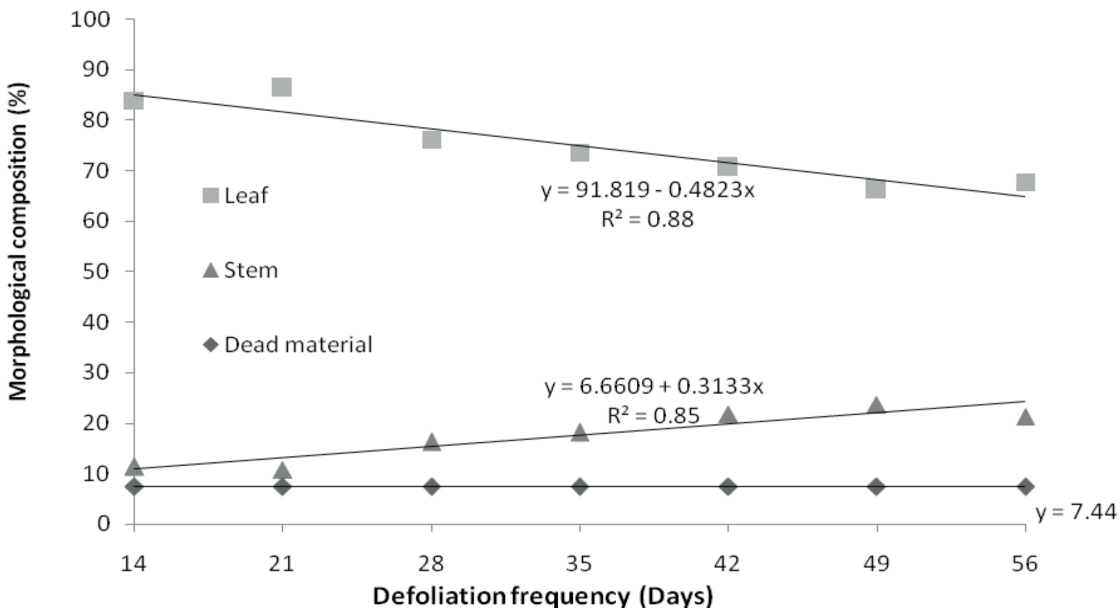
The samples used to calculate the DM availability of the *Faixa-Branca* morphological components were ground and dried at 105°C, and then, the chemical analyses of CP, NDF and ADF were performed according to methods described by Silva and Queiroz (2002). The CP content was estimated by multiplying the content of N by a factor of 6.25. The total N content was determined using the Kjeldahl method. The chemical analyses of *Faixa-Branca* grass were done in the Animal Nutrition Laboratory of the Embrapa Coastal Tablelands.

The data were subjected to statistical analysis according to the PROC ANOVA procedure of the SAS statistical package (SAS Institute, 2002), followed by a regression analysis when significant effects were observed ($P < 0.05$).

Results and Discussion

Morphological changes in the composition of the *Faixa-Branca* grass were observed when the grass was subjected to different defoliation frequencies. The percentage of leaf blades and stems + sheaths changed with the frequency of defoliation ($P < 0.05$), fitting a decreasing and increasing linear model, respectively (Figure 1). The *Faixa-Branca* grass leaf blades and stems + sheaths percentages showed opposite behaviours with the defoliation frequency; i.e., a longer defoliation period (56 days) resulted in a decreased percentage of leaf blades and an increased percentage of stems + sheaths. This behaviour was expected since both are complementary components of the lime matter "pool" of the pasture.

Figure 1. Morphological composition (%) of white stripped grass under different defoliation frequencies. F test 5%.



This different effect between the morphological components in relation to the defoliation frequency can be attributed to changes in the morphological characteristics related to the phenology of plants, which changes the leaf:stem and live:dead material ratios. Indeed, the stronger shading of lower leaves for longer defoliation intervals decreases their photosynthetic efficiency, which increases senescence and results in greater forage canopy heights (PEREIRA et al., 2012).

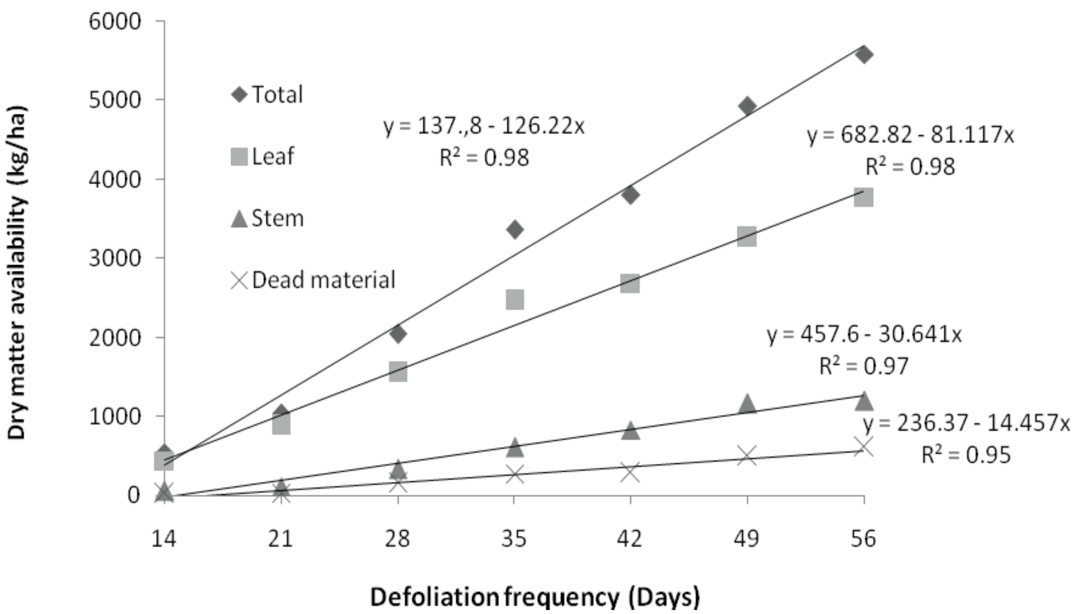
The increase in the percentage of the stem + sheath component in the forage canopy must be related to the increase in the morphological components. In grasses, the stem is not only involved in the translocation of assimilates to the leaves but also supports the spatial arrangement of the plant, which is important particularly in growth promotion periods. This probably explains the larger observed stem ratios as the defoliation frequency of the *Faixa-Branca* grass increased.

There was no effect of the defoliation frequency on the composition of the *Faixa-Branca* grass dead material ($P > 0.05$). The percentage of dead material in the pasture did not vary significantly during the experimental period and was on average 7.44%, which is considered low. The variations in the live:dead material ratio in the pasture are the result of the balance of dynamic and concomitant processes of growth and death/senescence of the tissues, which are differentially affected by agricultural and management practices. In addition, the presence of large amounts of dead material in the pasture can limit the use of the TDMA as an instrument to predict the DM consumption and the performance of animals in tropical pastures (SILVA et al., 2009); this fact was not observed in the present study.

With respect to the live and dead material, in general, there was participation of 92.66% and 7.44%, respectively, which demonstrated that there was little variation of these components with the defoliation frequency and confirmed the low presence of dead material (an indication of high efficiency of live forage production). However, this behaviour is not usually observed (PEDREIRA et al., 2009; CUTRIM JUNIOR et al., 2011) because a lower intensity of defoliation usually favours the passage of tillers from the vegetative phase to the reproductive one, which increases the contribution of the pseudostems and dead material to the forage production (MARCELINO et al., 2006).

The defoliation frequency influenced the availability of the leaf blades, stems + sheaths, dead material and total DM ($P < 0.05$), with all variables analysed fitting an increasing linear model (Figure 2).

Figure 2. Dry matter availability of total, leaf, stem and dead material of white stripped grass under different defoliation frequencies. F test at 5%.



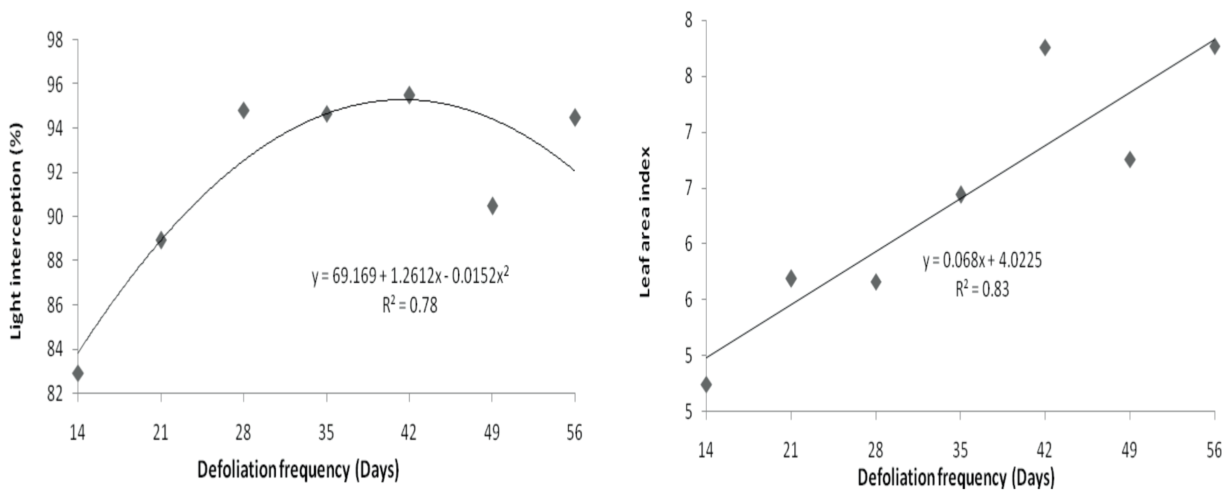
The increased availability of the *Faixa-Branca* forage grass during the study may be due to plant growth because as the defoliation frequency increases, the plants have more time to increase the leaf area, stems and dead material in the canopy.

The longer defoliation periods provided the highest amounts of leaf blades. It is possible that 56 days was not enough time for the tillers and leaf sheets to die. These results were positively reflected in the nutritional value of the forage, which also benefited from the smaller reduction in the leaf:stem ratio.

When analysing the average values of the leaf:stem ratio (average = 5.44), no significant differences were observed between the treatments ($P < 0.05$). This confirms that the defoliation frequency of 56 days was not sufficient to intensify the senescence process. It is possible that the number of live leaves per tiller and the lifespan of the leaves could be better measured for a defoliation period longer than 56 days. This demonstrates the need for in-depth studies evaluating the morphogenesis of *Faixa-Branca* grass because these studies are scarce in this forage plant.

The LI and the LAI varied as a function of the defoliation frequency, fitting a quadratic model and a linear model, respectively (Figures 3a and 3b). The increase in the LI and LAI with the defoliation frequency is in line with the results observed by Fagundes et al. (2012). Larger defoliation frequencies reduce the natural size of the plants, which results in LAI and LI. These changes alter the morphogenic characteristics of the grass, with the higher removal of the leaf tissues reducing the amount of photoassimilates available for the growth of new organs. Thus, as the defoliation frequency defoliation increases, the LAI and LI decrease (SANTOS et al., 2014).

Figure 3. Leaf area index and light interception of white stripped grass under different defoliation frequencies. F test, at 5%.



A B

The canopy LI values, which were recorded in the pre-cutting condition, reached the 95% target with the defoliation interval of 42 days and were favourable for defoliation frequencies less than 42 days. When LI reached 95%, there was a restructuring and reorganization of the leaf and stem components, which changed the structure of the pasture due primarily to elongation of the stem, and as a consequence, the LI changed. This can be observed in Figure 3 because as the defoliation frequency increases, there is a change in the morphological components of the canopy and the availability of the forage and its components (Figure 3).

The increase in the LAI with the longer period of defoliation is related to an increase in the availability of the leaf DM, which consequently increased the photosynthetic apparatus and the LI of the forage plants in the pasture. In the case of the lowest cutting frequency, the competition for light was low due to the frequent removal of the leaf area, which promotes the lower availability of forage and an LI below 95%.

The LI was positively associated with the LAI at the defoliation frequencies evaluated. For the frequencies above 42 days, where the LI value was above 95%, the plant exhibits elongation of the stems and increases the accumulation of dead material in the canopy base. It is possible that the increase in the LAI of the *Faixa-Branca* grass was related to the greater size of the leaf blades as the plants matured.

The structural characteristics contribute to the determination of the DM availability, forage quality, LI, LAI and access to forage by grazing animals, which affects ingestive behaviour. The TDMA as a function of the cutting intervals showed a significant positive linear effect ($P < 0.05$). Thus, when evaluating the behaviour of the TDMA in *Faixa-Branca* grass, significant increases in availability were observed with less frequent cutting.

Trindade et al. (2007) and Marcelino et al. (2006), working with *Marandu* grass, observed higher proportions of stems and dead material in pastures with approximately 100% LI. Similar results were found in this experiment, particularly as a result of the considerable accumulation of these components during the end of the regrowth period, after 95% LI was reached.

The daily DM accumulation rate of *Faixa-Branca* grass was significant ($P < 0.05$) for the evaluated cutting frequencies, and the data best fit a quadratic polynomial distribution.

The increase in the daily DM accumulation rate of *Faixa-Branca* grass was correlated with the defoliation frequency, leaf area and LI. Therefore, the grass, according to these variables and after derivation of the regression equation, showed maximum efficiency in terms of the daily DM accumulation rate for a defoliation frequency of 52 days in this study.

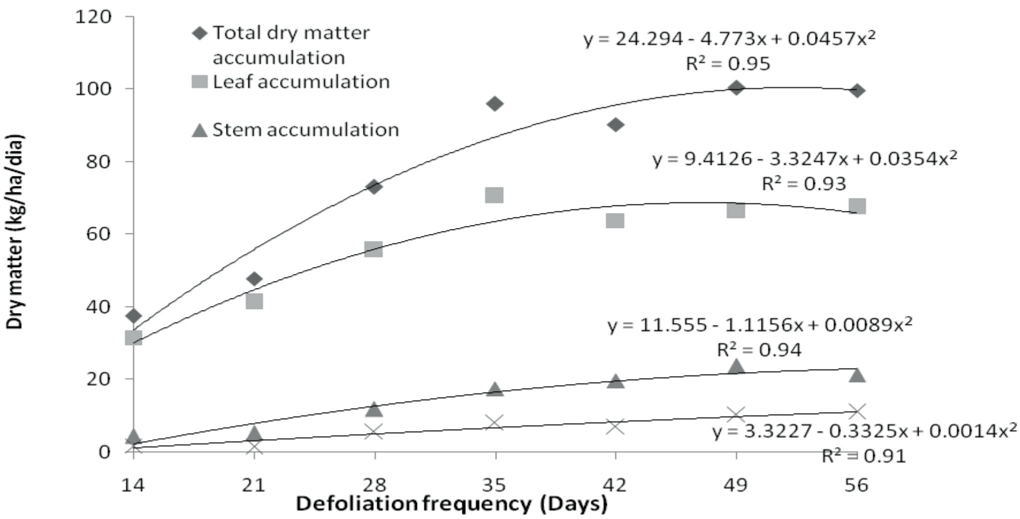
The regression analysis showed a quadratic effect ($P < 0.05$) of the defoliation frequencies on the daily accumulation rate of the leaf blades, with the maximum efficiency estimated at 42 days of defoliation according to the regression equation. After this defoliation frequency, there was a reduction in the daily accumulation rate of the leaf blades due to greater participation of the stems as the defoliation interval increased, where the reduction of leaf blades interferes with the forage canopy structure, LI, LAI and quality of the forage because the leaf blade is the more photosynthetically active and digestible component. The LI is key for the occurrence of photosynthesis and, therefore, the production of forage in the pasture. This is why the pastures with the greater LI (95%) and higher daily accumulation rate of leaf blades had greater accumulation of forage.

The daily accumulation rate of the total DM and leaf blades throughout the experimental period was greater in the *Faixa-Branca* grass with a defoliation frequency above 35 days. In these management conditions, there was greater LAI and forage harvest efficiency between defoliation frequencies of 40 and 55 days, which also had a positive effect on the production of the pasture DM. The larger number of cuttings in the pastures subjected to lower defoliation frequencies was not sufficient to compensate for the lower accumulation of forage per cutting frequency. The benefit of using higher defoliation intensities in terms of the accumulation of forage occurred in the pastures defoliated at 52 days. On the other hand, the effects of the defoliation frequency on the daily accumulation rate of the total DM differed for each cutting frequency studied.

The regression analysis detected a quadratic effect of the defoliation frequencies on the daily accumulation rate of the stem DM. According to the equation obtained, the maximum efficiency was obtained at 62 days, which is above the defoliation frequencies studied herein. Stem development increased the daily accumulation rate of the DM but, in contrast, interfered with the canopy structure, which had negative effects on the forage quality by reducing the leaf:stem ratio, a characteristic that exhibits direct relationships with LI and LAI.

When analysing the daily DM accumulation rate of the dead material, there was a linear variation (0.0107) with the reduction in the defoliation frequency (Figure 4). Thus, as the cutting interval increased, there was increased participation of the dead material in the DM accumulation. It is important to highlight that increases in the cutting interval, without adjustments in the use of forage, favours the senescence of the components and hence the accumulation of the dead material in the pasture.

Figure 4. Dry matter accumulation rate of total, leaf, stem, and dead material (kg/ha/day) of the white stripped grass under different defoliation frequencies. F test, at 5%.



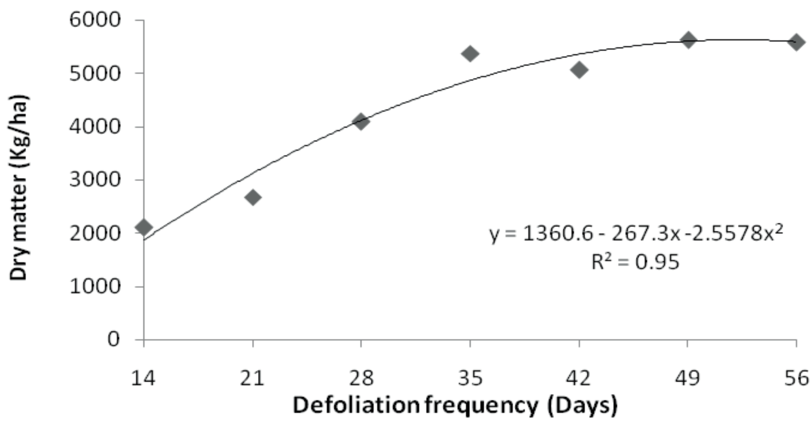
According to Zanine et al. (2011), the accumulation of DM in pastures subjected to larger cutting intervals is not enough to compensate for the smaller forage accumulation and the high DM accumulation rates in pastures managed under smaller cutting intervals and with 95% LI, which contributes to greater grazing intensity and efficiency of the forage harvest. Although these authors work with Guinea grass, the response of the plant to management was compatible with the results of this experiment.

The total accumulation of *Marandu* forage grass is higher for longer defoliation intervals; however, this is due to greater participation of the stems and dead material in the forage produced, which compromises the efficiency of the utilization of the forage produced (DIFANTE et al., 2011). These results are in agreement with the response of the *Faixa-Branca* grass obtained herein.

By studying the dynamics of growth and forage production of *Trachypogon plumosus* under different soil fertility correction levels and regrowth ages, Costa et al. (2016) observed that the absolute and average growth rates should be equivalent to maximize the net accumulation of forage and avoid losses by senescence as a result of the shading of the lower leaves.

A quadratic effect for the production of the *Faixa-Branca* DM was observed, with an estimated maximum efficiency at 52 days of defoliation (Figure 5). DM production is dependent on leaf blades and stems; however, the production of DM changed with the frequency of defoliation, which indicates the importance of studying this characteristic because it is directly related to the TDMA of forage.

Figure 5. Dry matter yield (kg/ha) of the white stripped grass under different defoliation frequencies. F test, at 5%.

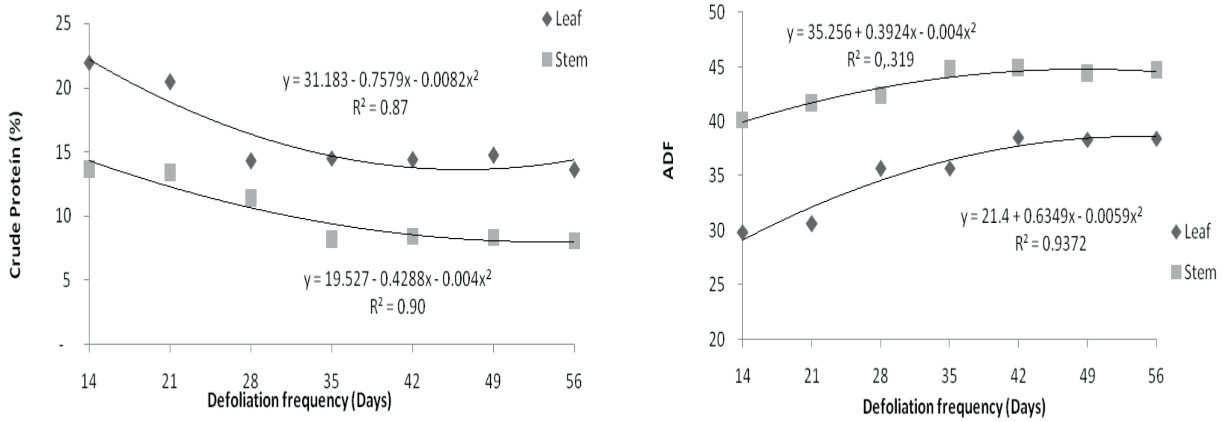


The increase in DM production can be attributed to the greater period between defoliations and, consequently, the greater accumulation of pseudostems and dead material, which affected the nutritional value of the forage. Therefore, in some cases, the benefits provided by higher forage matter production can be compensated by higher accumulation of dead material and stems, which is considered forage loss and results in lower nutritional value, greater rest periods and a lower number of grazing cycles.

The analysis of variance of the CP content of the leaf blade and stem components presented a significance correlation ($P < 0.05$) with the defoliation frequency and showed a quadratic effect. High levels of CP were observed in the grass leaves, with significance differences, at the initial defoliation frequencies (14 and 21 days), which decreased ($P < 0.05$) concomitantly with the reduction in defoliation frequency (Figure 6).

Higher defoliation frequencies of *Faixa-Branca* grass led to the emergence of new growth in the pasture and high levels of CP; however, over the experiment, decreases in the defoliation frequency led to increased elongation of the stem, reduction in the leaf:stem ratio, lignification, an increase in the percentage of dead material and/or the dilution effect of this nutrient in the forage mass produced, which explains the decrease in the CP levels of the grass.

Figure 6. Crude protein (CP) and acid detergente fiber (ADF) leves of the white stripped grass under different defoliation frequencies. F test, at 5%.



Different forage species and cultivars with 60 days of age presented CP levels for *Digitaria decumbens* of 11% (VALENTE et al., 2011). When evaluating oats and ryegrass subjected to different cutting times and N levels, Cassol et al. (2011) obtained CP levels of 27%. Similar CP levels were observed in the *Faixa-Branca* grass subjected to a defoliation frequency of 56 days, which demonstrates the maintenance of the quality of the grass throughout the study and its importance as forage.

When studying the levels of NDF for the leaf and stem components of *Faixa-Branca* grass, a similar pattern of variation was observed in response to the different defoliation frequencies; however, these results were not significant ($P > 0.05$). In contrast, the ADF levels for the same components presented significant variance ($P > 0.05$) and a quadratic effect, with an increase in ADF content being observed for leaves after 42 days and for stems after 35 days of defoliation. This shows similarity with the grass studied.

Larger CP values and smaller NDF and ADF values were obtained in the grasses with cutting frequencies of 21 days or less. As the age of the plant increased, there was an increase in the cell wall proportion, which coincided with the decreased NDF and ADF values and the low CP content. The NDF and ADF values for the leaf and stem components were high, which indicating that *Faixa-Branca* grass is a subtropical grass, and as such, cell wall thickening is a relevant characteristic. However, the variation in the levels was not as high as the grass developed. The high levels of NDF presented in this study can reduce the consumption of forage; however, good levels of CP are present in the grass.

The increase in the levels of fibre and decrease in CP content between the results of this study and the study by Bauer et al. (2008) were attributed to differences between the species and genotypes, the stages of development, the environmental conditions and the management practices.

The genus *Digitaria* tends to quickly decrease its quality after 5-6 weeks, and this can partially be explained through the reuse of the plant protein, which is achieved through nitrogen compound migration from the senescent tissues to the organs of the meristematic tissues (VENECIANO et al., 2006).

Conclusion

Higher defoliation frequencies positively contribute to an increase in the total number of leaves of *Faixa-Branca* grass, and a defoliation frequency higher than 46 days is not recommended.

Younger *Faixa-Branca* grass plants present greater levels of CP in the leaf blades and stems + sheaths.

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