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Nutritional value of tifton 85 bermudagrass at two cutting heights and different times of storage[1]

Valor nutricional do feno de capim tifton 85 sob duas alturas de corte e tempos de armazenamento

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Abstract

The goal of this study was to assess the dehydration curve and nutritional value of Tifton 85 bermudagrass at two cutting heights from ground level (4 and 8 cm) during 120 days of storage in a closed shed. The dehydration curve was determined using samples from the entire plant at eight different times. The experimental design consisted of randomized blocks with plots subdivided per times and five replicates. The second step consisted of assessing the nutritional value of the stored Tifton 85 bermudagrass in randomized blocks with plots subdivided per times and two treatments per plot: cutting height of four and eight centimeters from the ground, and five different times for the subplots, with five replicates. Dehydration of Tifton 85 bermudagrass at the two heights occurred in 48 hours, considered an ideal time for hay drying. The dry matter content responded quadratically to the time of storage of the two heights, only differing during baling and after 120 days of storage. Crude protein content had a quadratic behavior in the two cutting heights, with the smallest value after 30 days of storage (107.0 g kg^{-1}) and the largest after 90 days (147.8 g kg^{-1}) in the cutting height of eight centimeters. The ether extract exhibited a quadratic behavior in the two cutting heights, only differing after 90 days of storage. The neutral detergent fiber content had linear positive response according to the time of storage, with no difference between the cutting heights. For the neutral detergent fiber content in the two cutting heights, the quadratic regression model was the best fit to the data, differing between the heights after 30 and 60 days of storage. *In vitro* dry matter digestibility and *in vitro* cell wall digestibility values of the stored hay were lower than the values obtained at the time of cutting. Cutting performed at four centimeters from the ground was the most suitable for hay production due to higher dry matter production and nutritional value without difference between bailing treatments. Hay storage caused undesirable changes in the nutritional value, especially in fiber content and *in vitro* digestibility.

Key words: Bromatological composition. *Cynodon* spp. Dehydration.

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Resumo

O estudo objetivou avaliar a curva de desidratação e valor nutricional do feno de capim Tifton 85 sob duas alturas de corte em relação ao nível do solo (4 e 8 cm), durante 120 dias de armazenamento em galpão fechado. A curva de desidratação foi determinada utilizando amostras da planta inteira em oito tempos. O delineamento experimental foi em blocos casualizados com parcelas subdivididas no tempo, com cinco repetições. Na segunda etapa avaliou-se o valor nutricional do feno de Tifton 85 armazenado, para isto adotou-se o delineamento em blocos casualizados, em esquema de parcelas subdivididas no tempo, com 2 tratamentos alocados nas parcelas: altura de corte de 4 e 8 cm do solo e cinco tempos nas subparcelas, com cinco repetições. A desidratação do capim Tifton 85 ocorreu em 48 horas para as duas alturas de corte, sendo considerado um tempo ideal para secagem de feno. O teor de matéria seca respondeu de forma quadrática ao tempo de armazenamento do feno, nas duas alturas de corte, diferindo entre as alturas apenas no enfardamento e após 120 dias de armazenamento. O teor de proteína bruta apresentou comportamento quadrático, tanto para o corte a 4 cm, como para o corte à 8 cm do solo, apresentando aos 30 dias de armazenamento o menor valor (107,0 g kg-1) e o maior valor aos 90 dias de armazenamento (147,8 g kg-1), para corte à 8 cm do solo. O extrato etéreo apresentou comportamento quadrático, tanto para o corte à 4 cm, como para o corte à 8 cm do solo, diferindo entre as alturas apenas aos 90 dias de armazenamento. O teor de FDN apresentou resposta linear positiva em função do tempo de armazenamento, não diferindo entre as alturas de corte. Para o teor de FDA, em ambas as alturas de corte do capim Tifton 85, o modelo de regressão quadrático foi o que melhor se ajustou aos dados, diferindo entre as alturas aos 30 e 60 dias de armazenamento. Os valores de DIVMS e DIVPC do feno armazenado foram inferiores aos valores obtidos no momento do corte. O corte do capim realizado a 4 cm do solo é o mais indicado para produção de feno, visto maior produção de matéria seca e valor nutricional sem diferença entre os tratamentos no enfardamento. O armazenamento do feno causa alterações indesejáveis em seu valor nutricional, principalmente nos teores de fibra e digestibilidade in vitro.

Palavras-chave: Composição bromatológica. Cynodon spp. Desidratação.

Introduction

The production and use of silage in Brazil started in the 1960s, with greater intensity in production systems of dairy cows. However, conserved fodder in the form of hay took longer to be used in the country, due to barriers such as the high production cost depending on the weather and price of resources (NERES; AMES, 2015).

Tifton 85 bermudagrass (*Cynodon* spp.) is a fodder grass developed at the Coastal Plain Experiment Station (University of Georgia – USDA), Tifton, State of Georgia, United States, by Burton et al. (1993). The cultivar originated from crossbreeding a South African species (PI 290884) with Tifton 68 bermudagrass, and stands out because of its high nutritional quality, low index of falling leaves, and the ease of regrowth at low cutting heights.

The western region of the State of Paraná, Brazil, has been characterized by a considerable growth of hay producers in recent years. Due to the great availability of liquid pig waste for fertilization of these areas, which solves an environmental problem of the region, combined with the climate of the region in summer, that allows rapid growth of plants, on average the harvests are performed every 28 days. Good quality hays feature high levels of crude protein and high digestibility, which can partly reduce the concentrated protein supplementation. Another advantage is that these products can be stored in different locations of the properties, in addition to the put option, which has been a sole source of income for many producers.

Conserved fodders may have their nutritional value changed during production and preservation, especially hay during drying, harvesting, and storage, directly affecting the chemical composition, intake, and digestibility (JOBIM et al., 2007).

Based on the above considerations, we conducted an experiment with the purpose of assessing the dehydration curve and the nutritional value of Tifton 85 bermudagrass (*Cynodon* spp.) at two cutting heights from the ground level (4 and 8 cm) during 120 days of storage in a closed shed.

Material and Methods

The experiment was conducted under field conditions in a property intended for the production of hay located in Marechal Cândido Rondon, State of Paraná, Brazil, with total area of 20 hectares for hay production. The geographical coordinates of the property were: latitude = 24°32' 49.7'' S; longitude = 54°01'46.4'' W; and altitude of 392 meters. According to the Köppen climate classification, the climate is subtropical (Cfa), with average temperature below 18 ºC in the coldest month (mesothermal) and average temperature above 22 ºC in the hottest month, with hot summers, infrequent frosts, and tendency of rainfall concentration in the summer months; however, without a defined dry season (CAVIGLIONE et al., 2000). The total average normal annual rainfall for the region ranges from 1,600 to 1,800 mm, with a more humid trimester ranging from 400 to 500 mm (IAPAR, 2006).

The soil of the experimental area was classified as Eutropherric Red Latosoil (EMBRAPA, 2013), with 650 g kg^{-1} of clay and the following chemical characteristics: water pH = 5.22; P (Mehlich) = 46.08 mg dm^{-3}; K (Mehlich) = 0.11 cmolc dm^3; Ca^{2+} (KCl 1 mol L^{-1}) = 6.37 cmolc dm^{-3}; Mg^{2+} (KCl mol L^{-1}) = 2.05 cmolc dm^{-3}; H+Al (0.5 mol L^{-1} calcium acetate) = 4.50 cmolc dm^{-3}; CTC = 13.03 cmolc dm^{-3}, V = 65.49%; Cu = 28.48 mg dm^{-3}; Zn = 33.37 mg dm^{-3}; Mn = 226.70 mg dm^{-3}; and Fe = 20.31 mg dm^{-3}. For the chemical analysis of the soil at a depth of 0 to 20 cm, the samples were dried in a forced-ventilation oven at 65 °C for 48 hours, characterized as kiln-dried fine earth passed through a 2 mm sieve. The analyses were conducted according to the methodology of the Agricultural Institute of Paraná (IAPAR) (PAVAN et al., 1992).

The area for Tifton 85 bermudagrass had been established eight years before our experiment and exclusively intended for hay production and predrying, using swine biofertilizer as the only source of fertilization. The biofertilizer had been produced through an anaerobic process, which had been treated in a Canadian biodigester model with continuous flow, capacity of 3,200 m^3, and hydraulic retention of 45 days. According to the Regulatory Instruction No. 17 of 18th June 2014, the use of waste was permitted provided that it was biostabilized, i.e., subjected to anaerobic fermentation in biodigesters.

Before cutting, we assessed the dry matter production and structural characteristics of the fodder. The production of dry matter was performed using metal frames of 0.25 m^2, which were randomly released in four different locations and cut at a height of four and eight centimeters from the ground. The samples were stored in paper bags and placed in a forced-ventilation oven at a temperature of 55 °C for 72 hours.

To obtain the diameter of the stems, we took ten tillers and, with the aid of a digital caliper, we measured the diameter of the stems before the first node. The height of the plants were measured using a graduated ruler in ten distinct points from the ground to the curvature of the last leaf.

Hay cuttings were carried out on 22nd March 2014 at 3:30 p.m., when the regrowth age of the Tifton 85 bermudagrass was 60 days. We used a mower conditioner with free swinging flail fingers, set to cut at four and eight centimeters from the ground. The turns were made after one, nineteen, and forty-four hours after cutting. The baling was carried out on 24th March 2014 at 3:30 p.m., and total time of drying in the field was 48 hours under favorable weather conditions for dehydration.

We produced rectangular bales of 12 kg that were stored in a masonry shed with side walls and windows for ventilation. The bales were placed on wooden pallets to prevent direct contact with the ground for 120 days.

The dehydration curve was determined through field collection of whole plant samples at eight different times. Time 0 corresponded to the sample collected before cutting at 3:30 p.m., and, on the other days, always at 8:00 a.m., 12:00 a.m., and 5:00 p.m. until the time of baling. The times assessed were: 0; 2.5; 16.5; 20.5; 25.5; 40.5; 44.5; and 48 hours after cutting. The samples were stored in paper bags and placed in a forced-ventilation oven at a temperature of 55 °C for 72 hours.

The experimental design consisted of randomized blocks with plots subdivided per times and five replicates. The main plots were the two cutting heights (4 and 8 cm), and the subplots were the times after cutting. The percentage values of dry matter at different times were assessed by means of regression, and the equation was chosen based on the determination coefficient and the significance of regression coefficients using the Student's *t*-test at 5% significance level. The comparisons between cutting heights were made using Tukey's test at 5% and the Sisvar version 5.3 software.

We collected samples from the baling (time 0) and the hay stored in the shed after 30, 60, 90, and 120 days of storage. After drying in a forced-ventilation oven at 55 °C for about 72 hours, the samples were ground in a Willey type mill (1 mm sieve) and subjected to laboratory procedures to determine dry matter content, crude protein, mineral matter, and ether extract according to the Association of Official Analytical Chemists (AOAC, 1990), neutral detergent fiber (NDF) and acid detergent fiber (ADF) according to Van Soest and Robertson (1985), *In vitro* dry matter digestibility (IVDMD) and *in vitro* cell wall digestibility (IVCWD) according to the technique described by Tilley and Terry (1963), adapted to the artificial rumen, as described by Holden (1999).

For the collection of the rumen fluid, we used a Jersey bull of approximately 500 kg, with a rumen cannula. To assess the IVDMD, the hay samples were weighed in the amount of 0.5 g and placed in jars containing rumen fluid and buffer solution. The material remained incubated for 48 hours and, at the end of that period, we added HC1-pepsin solution (1:10000) to the artificial fermenter in the proportion of 6.68 mL/sample. This material remained incubated for a further period of 24 hours. Subsequently, the bags were removed from the rumen fermenter and washed with distilled water until the total removal of adherent materials in the filter. To determine the IVCWD, the initial process was the same; however, the samples were taken when the first step of 48 hour-incubation was complete. Subsequently, the samples were washed and subjected to analysis of NDF according to Van Soest and Robertson (1985). The analyses were performed at the Laboratory of Animal Nutrition of the State University of West Paraná (UNIOESTE).

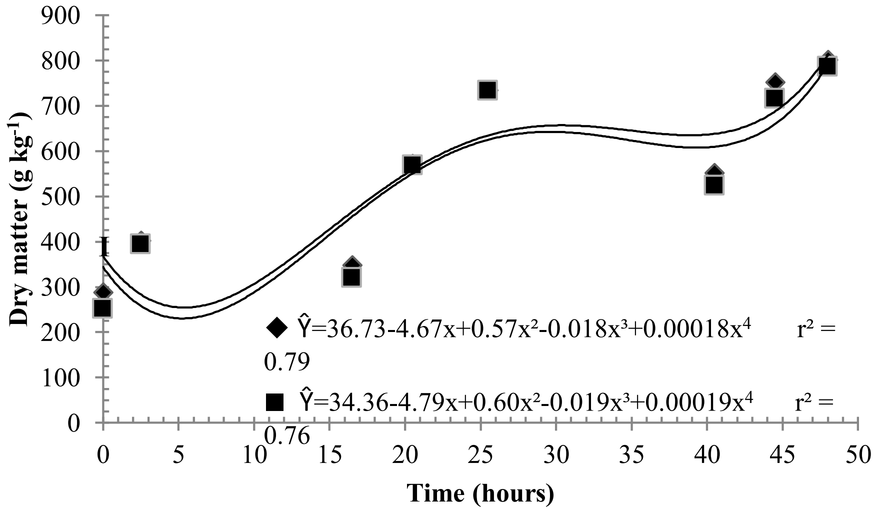
The nutritional value of hay was assessed using randomized blocks with plots subdivided at different times, with two treatments per plot, i.e., cutting height of four and eight centimeters from the ground; and five different times for the subplots, i.e., baling, 30, 60, 90, and 120 days of storage, with five replicates. The data were subjected to analysis of variance, and when the significance was determined by the F-test, we applied the Tukey's test at 5% probability level.

Results and Discussion

The total time of drying in the field was 48 hours for the two cutting heights assessed, without exceeding seven days, because, according to Collins (1995), this is the time limit for the production of hay with suitable quality for animal consumption. At the time of baling, dry matter content of Tifton 85 bermudagrass was within the desired range, averaging 793.6 g kg^{-1}, i.e., around 800 g kg^{-1}. This value avoids increasing the risk of dry matter loss and the occurrence of fungi that can harm the quality of hay.

The behavior of the dehydration curve followed the fourth-degree polynomial model, similar to that described by Calixto Júnior et al. (2007), who assessed stargrass hay (*Cynodon nlemfuensis* Vanderyst). We observed that the dehydration rate oscillated during the drying period, i.e., between zero and 48 hours. This fact was due to overnight dew which rehydrated the fodder mass (Figure 1). However, it could be observed that the moisture gained during the night was quickly lost in a few hours of sunshine.

Figure 1. Dehydration curve of Tifton 85 bermudagrass at cutting heights of 4 cm (♦) and 8 cm (■) with respect to hours after cutting.



I = significant according to Tukey's test (5%). CV1: 2.16%; CV2: 4.05%.

There was effect (p <0.05) between the heights only at the moment of cutting (time 0). With respect to baling, the two cutting heights exhibited similar dry matter content; however, the dry matter content of the hay cut at eight centimeters from the ground was less than 800 g kg^{-1}, i.e., 785.8 g kg^{-1}.

The diameter of the stem is an important feature in the dehydration process of hay production, because, according to Jobim et al. (2001), it is negatively related to the dehydration rate of hay. The diameter of the stems of Tifton 85 bermudagrass at the time of cutting had an average of 1.45 mm. This value was similar to that found by Ames et al. (2014), who assessed the same fodder and obtained a high rate of dehydration, showing stem diameters between 1.16 and 1.48 mm.

The bromatological composition before cutting (Table 1) had protein content of 159.6 g kg^{-1} at eight centimeters, and 108.1 g kg^{-1} at four centimeters. These values were used to allow the analysis of possible changes in the composition of stored bales with respect to the cutting times.

At the time of cutting, the Tifton 85 bermudagrass cut at four centimeters from the ground exhibited a dry matter production of 5,487 g kg^{-1}, whereas at eight centimeters the production was 2,721 g kg^{-1}.

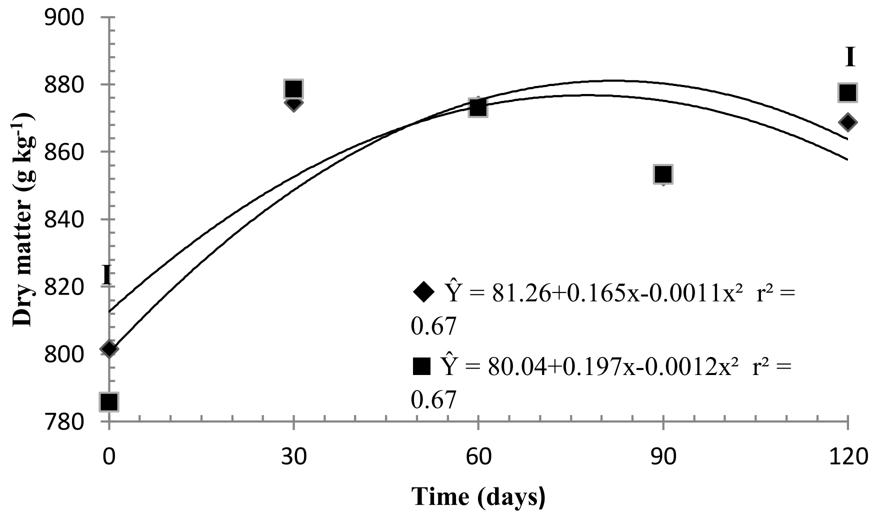
The dry matter content of Tifton 85 bermudagrass responded quadratically (p <0.05) to the storage time of the two cutting heights (Figure 2), differing only in baling and after 120 days of storage. However, it is important to note that the variations in the levels of dry matter during storage can be explained by changes in climatic conditions during this period. According to Raymond et al. (1978), hay has a hygroscopic property, i.e., it can absorb and lose water, and, consequently, the relative humidity affects the moisture content of the fodder stored. The maximum value found was after 75 and 82 days of storage in the two cutting heights, respectively.

Table 1. Bromatological composition of Tifton 85 bermudagrass at two cutting heights.

Cutting height	DM	MM	CP	EE	NDF	ADF
		---------------------g kg^{-1}----------------------				
4 cm	287.6	64.8	108.1	25.4	714.2	355.4
8 cm	252.2	63.4	159.6	30.8	697.6	283.1

DM = dry matter; MM = mineral matter; CP = crude protein; EE = ether extract; NDF = neutral detergent fiber; ADF = acid detergent fiber.

Figure 2. Dry matter content of Tifton 85 bermudagrass at cutting heights of 4 cm (♦) and 8 cm (■) with respect to time of storage (days).



I = significant according to Tukey's test (5%). CV1: 0.63%; CV2: 0.55%.

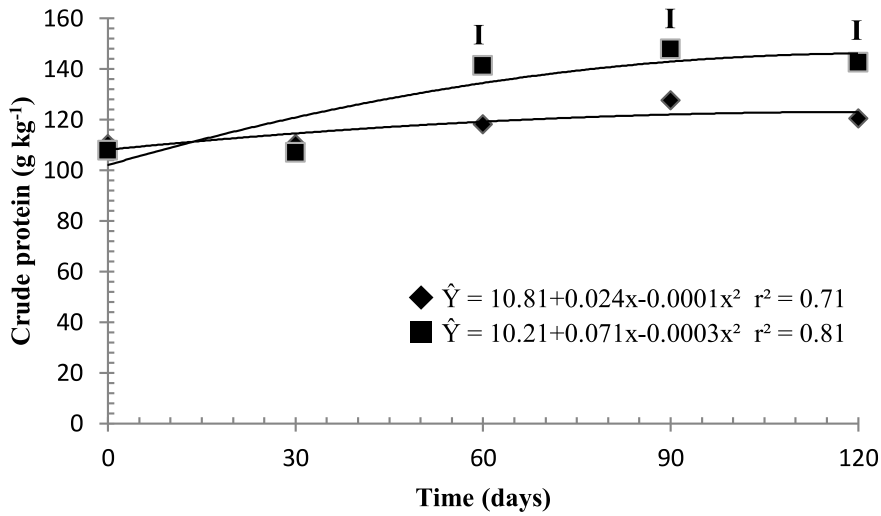
When we assessed the times of storage, the content of mineral matter did not exhibit any difference (p >0.05), and the average was 65.5 and 65.9 g kg^{-1} in the two cutting heights, respectively.

The crude protein content exhibited a quadratic behavior (p <0.05) in the two cutting heights. The lowest value occurred after 30 days of storage (dry matter = 107 g kg^{-1}) in the hay cut at eight centimeters from the ground. The highest value was found after 120 and 118 days of storage in the hay cut at four and eight centimeters from the ground, respectively. There was a difference between the cutting heights after 60 days of storage, and the hay cut at eight centimeters exhibited a greater increase in crude protein concentration (Figure 3).

This increase in protein content during storage was probably due to the development of microorganisms in the hay. Martinez et al. (2010) studied Tanzania grass inoculated with different concentrations of the pathogen *Bipolaris maydis* (helmintosporium) and found crude protein values that ranged from 68 to 172 g kg^{-1}, indicating that the occurrence of the disease led to significant increase in the content of crude protein in the leaves.

According to Goodman et al. (1986), the increase in total nitrogen content can be in part attributed to the synthesis by the pathogen, resulting in the increase of nucleic acids, which are proteins used for growth of hyphae and spores.

Figure 3. Crude protein content of Tifton 85 bermudagrass at cutting heights of 4 cm (♦) and 8 cm (■) with respect to time of storage (days).

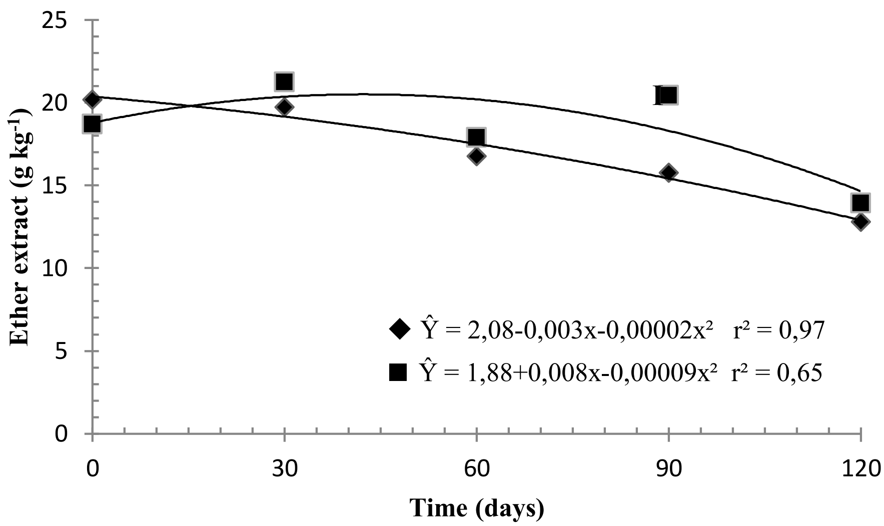


I = significant according to Tukey's test (5%). CV1: 2.76%; CV2: 2.77%.

Wunsch et al. (2007) assessed the bromatological composition of fodder in grasslands of the State of Rio Grande do Sul, Brazil, and found increased crude protein concentration after 90 days of storage in comparison to the concentration at the time of cutting. According to Rotz and Abrams (1988), the increase in crude protein levels of stored hay may be related to the loss of non-protein nitrogenous compounds.

The ether extract exhibited a quadratic behavior (p <0.05) in the two cuttings (4 and 8 cm) (Figure 4). The average was 17.1 and 18.5 g kg^{-1} in the Tifton 85 bermudagrass cut at four and eight centimeters from the ground, respectively. A difference between the heights was only observed after 90 days of storage.

Figure 4. Ether extract content of Tifton 85 bermudagrass at cutting heights of 4 cm (♦) and 8 cm (■) with respect to time of storage (days).

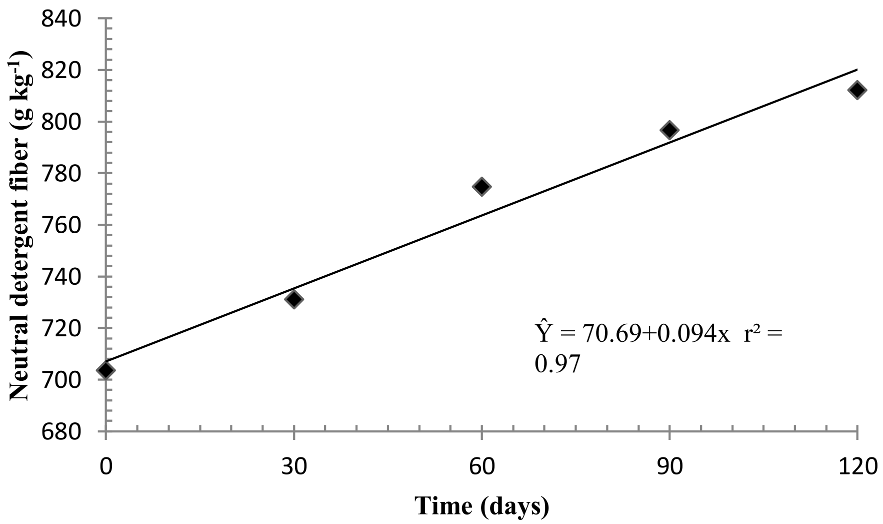


I = significant according to Tukey's test (5%). CV1: 5.27%; CV2: 9.5%.

According to Church (1988), most fodders have a small amount of ether extract in their composition, reaching up to 35 g kg^{-1} in the dry matter. This is a positive factor since bovines are tolerant up to levels of 70 g kg^{-1} in dry matter of the total diet.

The NDF content exhibited a positive linear response (p <0.05) depending on the time of storage, and did not differ between the cutting heights (Figure 5). The NDF content in the baling process ranged from 702.7 to 813 g kg^{-1} of dry matter after 120 days of storage in the hay cut at four centimeters, and 704.2 to 811.2 g kg^{-1} after 120 days of storage in the hay cut at eight centimeters. Those values are considered high, but observed in tropical fodders (NERES et al., 2011).

Figure 5. Neutral detergent fiber content of Tifton 85 bermudagrass at cutting heights of 4 and 8 cm with respect to time of storage (days).



CV1: 1.86%; CV2: 2.72%.

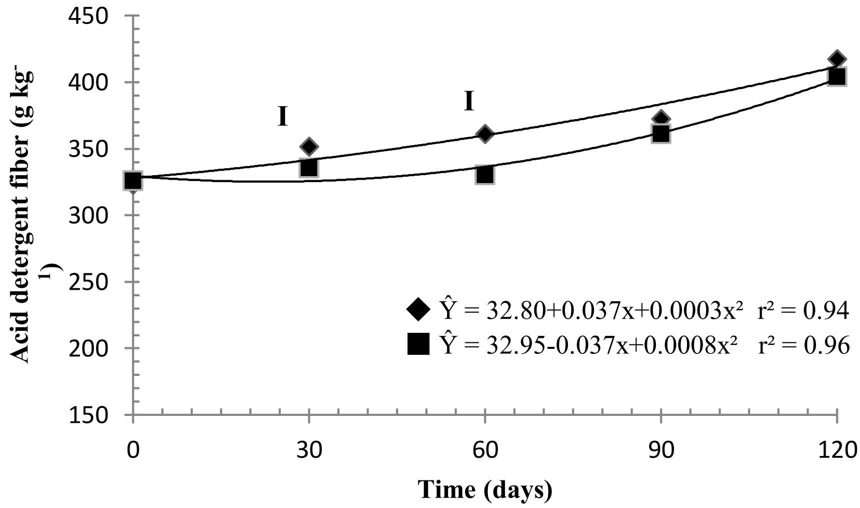
According to Van Soest (1965), percentages above 600 g kg^{-1} of NDF exhibit negative correlation with fodder consumption, which is caused by the decreased rate of fodder passage through the digestive tract of the animals.

The results found for NDF in the present study were similar to those found by Castagnara et al. (2011) in Tifton 85 bermudagrass. The NFD values obtained by these authors were higher 30 days after baling in comparison to levels observed at the moment of cutting and baling.

The NDF and ADF values are subject to variations depending on any change that occurs in the content of cellulose, hemicellulose, and lignin. The increase in NDF content in response to storage can be attributed to a higher consumption of soluble carbohydrates.

With respect to ADF content in the two cutting heights of Tifton 85 bermudagrass, the quadratic regression model was the best fit to the data (Figure 6), differing between the two heights after 30 and 60 days of storage. The lowest value was found at the time of baling in the hay cut at four centimeters from the ground, with a value of 322.9 g kg^{-1} of dry matter. On the other hand, the highest value was observed after 120 days of storage in the hay cut at eight centimeters, with a value of 417.2 g kg^{-1}.

Figure 6. Acid detergent fiber of Tifton 85 bermudagrass at cutting heights of 4 cm (♦) and 8 cm (■) with respect to time of storage (days).



I = significant according to Tukey's test (5%). CV1: 3.39%; CV2: 3.23%.

Changes in ADF values between the baling process and the storage period may be associated with changes in fibrous components and dry matter losses that naturally occur during hay storage (BUCKMASTER et al., 1989).

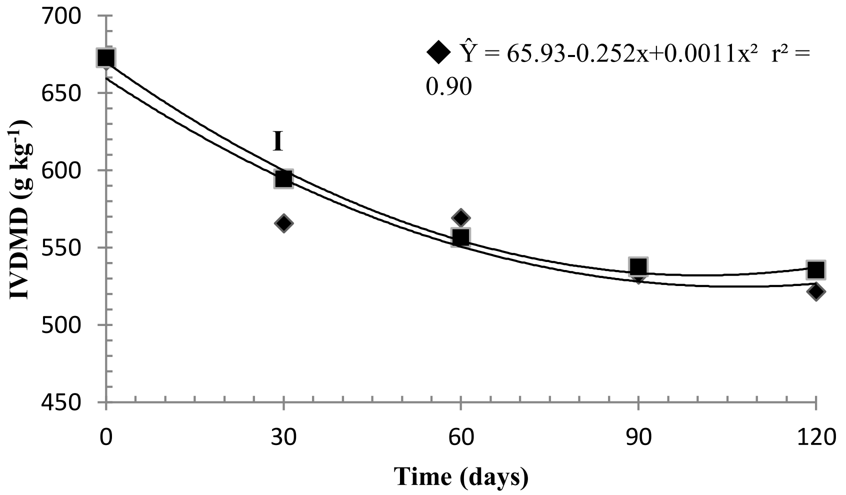
The average values of ADF were 365 and 351.3 g kg^{-1} in the hay cut at four and eight centimeters, respectively. These values were lower than those found by Gonçalves et al. (2002), who obtained an average ADF content of 458.5 g kg^{-1} in grasses of the genus *Cynodon* after 63 days of regrowth.

We observed that the IVDMD and IVCWD values of the stored hay were lower than the values obtained at the time of cutting (p <0.05) (Figures 7 and 8). Ames et al. (2014) obtained similar results observing a decrease in IVDMD values from 526 g kg^{-1} at the time of cutting to 415 g kg^{-1} 30 days after baling in Tifton 85 bermudagrass cut during the winter. The decrease in IVDMD during storage can be attributed to the higher concentration of NDF and ADF observed in comparison to the concentration observed during the baling process.

There was a difference in IVDMD content (p <0.05) between the two heights only after 30 days of storage. The IVDMD content of the hay cut at eight centimeters was 594 g kg^{-1}, whereas the content observed in the hay cut at four centimeters was 565.5 g kg^{-1}.

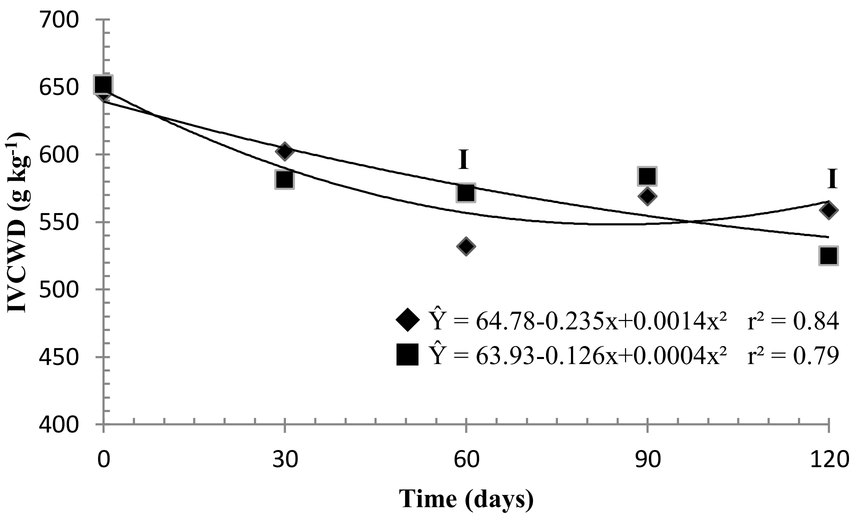
The IVCWD exhibited a quadratic behavior (p <0.05) in the two cutting heights (4 and 8 cm) (Figure 8). The difference between the two heights was observed after 60 and 120 days of storage. The results found for IVCWD in the present study were similar to those found by Cecato et al. (2001) in Tifton 85 bermudagrass cut after 70 days of regrowth, with an average value of 645.3 g kg^{-1}.

Figure 7. *In vitro* dry matter digestibility of Tifton 85 bermudagrass at cutting heights of 4 cm (♦) and 8 cm (■) with respect to time of storage (days).



IVDMD = *in vitro* dry matter digestibility; I = significant according to Tukey's test (5%). CV1: 3.32%; CV2: 3.45%.

Figure 8. *In vitro* cell wall digestibility of Tifton 85 bermudagrass at cutting heights of 4 cm (♦) and 8 cm (■) with respect to time of storage (days).



IVCWD = *In vitro* cell wall digestibility; I = significant according to Tukey's test (5%). CV1: 2.97%; CV2: 3.71%.

Conclusions

Tifton 85 bermudagrass cut at four and eight centimeters from the ground only exhibited differences in dry matter levels at the time of cutting.

The hay cut at four centimeters from the ground was the most suitable for fodder production, aiming at increased dry matter and nutritional value with no difference between the bailing treatments.

Hay storage caused undesirable changes in nutritional values, especially with respect to *in vitro* fiber content and digestibility.

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