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Aspects related to production e storage of Tifton 85 bermudagrass hay with white oat IPR 126 and Guapa oversowing

Aspectos relacionados à produção e armazenamento do feno de Tifton 85 com sobressemeadura de aveia branca IPR 126 e Guapa

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Abstract

Structural characteristics, curve dehydration, dry matter production, chemical composition, occurrence of fungi, temperature in the storage of hay bales of Tifton 85 oversowing with long-cycle oat (IPR 126) and oats for short-cycle grains production (Guapa), were evaluated. For chemical composition, the experimental design used was randomized blocks, a split-plot overtime and 3 treatments (single Tifton 85, Tifton 85 with IPR 126 oat oversowing and Tifton 85 in association with Guapa white oat and 3 assessment periods (cutting, baling and 30 days of storage) with 5 repetitions. The dry matter production was higher in single Tifton 85 compared to associations with white oat. The largest stem diameter of guapa white oat contributed to reduce losses of water in the dehydration process, with the hay in this culture system being stored under 800 g kg^{-1} DM. It was found that the crude protein did not differ between cropping systems, but Tifton 85 hay showed high levels of acid detergent insoluble protein and higher levels of NDF and lignin. The occurrence of fungi was higher after storage predominating fungi of the genus *Penicillium*.

Key words: *Avena sativa*, storage fungi, *Penicillium* sp, neutral detergent insoluble protein

Resumo

Avaliou-se as características estruturais, curva de desidratação, produção de matéria seca, composição bromatológica, ocorrência de fungos, temperatura dos fardos no armazenamento do feno de capim tifton 85 sobressemeados com aveia branca de ciclo longo (IPR 126) e aveia branca para produção de grãos de ciclo curto (Guapa). Na composição bromatológica, o delineamento experimental foi de blocos casualizados com parcelas subdivididas no tempo com 3 tratamentos (tifton 85 solteiro, tifton 85 com sobressemeadura da aveia IPR 126 e tifton 85 em associação com aveia branca Guapa em 3 períodos de avaliação (corte, enfardamento e 30 dias de armazenamento), com 5 repetições. A produção de MS foi superior no tifton 85 solteiro quando comparado em associações com aveia. O maior diâmetro de colmo da aveia branca guapa contribuiu na redução das perdas de água por desidratação, sendo este

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feno armazenado com MS abaixo de 800g.kg^{-1}. Verificou-se que os teores de PB não diferiram entre as espécies, no entanto o tifton 85 apresentou maiores teores de PIDA, FDN e lignina. A ocorrência de fungos foi mais elevada após o armazenamento, predominando fungos do gênero *Penicillium*.
Palavras-chave: *Avena sativa*, fungos de armazenamento, *Penicillium* sp, proteína insolúvel em detergente neutro

Introduction

The summer pastures oversowing with winter annual species is a practice that has been adopted in some regions with the aim of improving the quality and forage production in winter, once the climate conditions favor the growth of tropical forage species only during spring/summer period with reduced quality and production in the fall/winter.

Moreira et al. (2006) defines the term oversowing to describe the practice of setting annual winter crops on a crop already formed by perennial species. This technique aims at increasing the forage production for grazing or hay production, without degrading or eliminating perennial species. According to Bertolote (2009), the implementation of this system should be in areas with irrigation or region presenting rainy winter, and one of the advantages of the oversowing technique is allow greater use of the area under cultivation.

Oats (*Avena* spp) is originated from ancient Asia being considered invasive plant of crops such as wheat and rye and expanded to Europe becoming an important food source for man and animals (MONTEIRO; MORAES; CORRÊA, 1996). Oats adapts to different regions of temperate and sub-tropical climate, being a tussock-forming species.

In oversowing systems the black oat has been the most used due to its tolerance to rust; however research conducted with white oat has shown better nutritional value of this species (NERES et al., 2011; CASTAGNARA et al., 2012) coupled with the market launch of cultivars more resistant to rust and longer cycle since most of white oat cultivars available in the market are intended for grain production.

Oliveira (2007) points out that few studies in the literature evaluates this association of summer perennial species with those annual from winter in terms of forage production, botanical composition, interaction between cultures and forage quality. Rodrigues, Avanza and Dias (2011) also high lights the need for more research in order to assess the technique.

Therefore, the objective of this work was to evaluate the oversowing technique of two oat cultivars on a field of Tifton 85, evaluating the dry matter production, dehydration curve, structural characteristics, nutritional value and fungi occurrence.

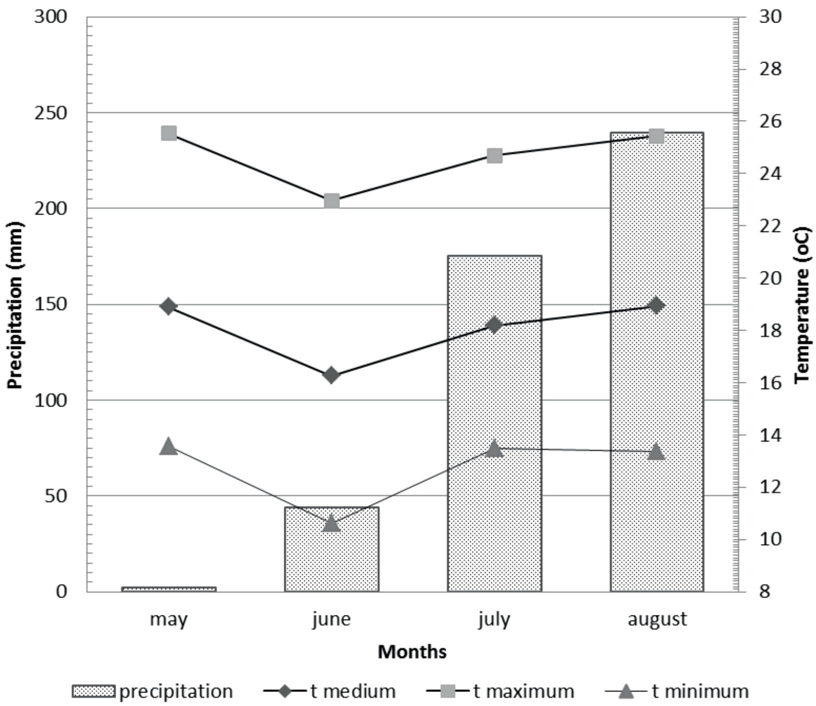
Material and Methods

The experiment was conducted on the property intended for hay production in Marechal Cândido Rondon with total production area of 30 acres of hay under the geographic coordinates 24^{o}33 '40''S latitude, 54^{o}04'12''W longitude and 420 m altitude. The local climate according to Koppen - Geiger is Cfa type, subtropical with well distributed rainfall throughout the year and hot summers. The mean temperature of the coldest quarter varies between 17 and 18 °C, between 28 and 29 °C in the hotter quarter and between 22 and 23°C annual. The normal mean annual total rainfall for the region ranges from 1600 to 1800 mm, with wetter quarter presenting totals ranging from 400 to 500 mm (CAVIGLIONE et al, 2000).

After sowing planting winter forage by oversowing, the climate conditions were unfavorable for germination (Figure 1), requiring the irrigation of experimental area using a tank truck totaling 15 mm (performed on June 3, 2011) of water. There was a frost on July 5 and 6, 2011 without harming the winter species; however in

Tifton 85 there were momentary losses through leaves chlorosis, but due to the presence of rhizomes this species had rapid regrowth after temperature rise and presence of moisture. During plants drying, climatic conditions were favorable (Figure 1, Table 1).

Figure 1. Weekly average temperatures of maximum, minimum and mean and rainfall during the months of forage growth.



Source: Elaboration of the authors.

Table 1. Climatic data for the dates regarding the cutting and drying of Tifton 85 hay.

Date	Temperature (°C)		
	Mean	Maximum	Minimum
08/31/2011	15.7	22.6	9.4
09/01/2011	15.6	25.3	8.3
09/02/2011	17.5	26.9	9.7
	Relative humidity (%)		
08/31/2011	56.6	94.0	23.0
09/01/2011	39.6	59.0	14.0
09/02/2011	46.6	67.0	20.0
	Dew point temperature (°C)		
08/31/2011	5.6	13.6	-0.8
09/01/2011	0.9	4.9	-4.5
09/02/2011	5.0	8.1	1.8
	Radiation (KJ/m^2)	Rain/dew (mm)	Wind (m/s)
08/31/2011	22463.457	0.0	5.8
09/01/2011	22767.210	0.0	4
09/02/2011	22758.981	0.0	5.3

Source: Experimental Farm Weather Station, Marechal Candido Rondon-PR, May/August, 2011.

The soil of the experimental area is classified as Eutroferric Red Latossol (EMBRAPA, 2006) and has the following chemical characteristics: pH-$CaCl_{2:}$ 5.10, P (Mehlich): 21.08 mg dm^{-3}; K (Mehlich): 0.68 cmolc dm^{-3}, Ca^{2+} (KCl 1 mol L^{-1}): 6.21 cmolc dm^{-3}, Mg^{2+} (KCl 1 mol L^{-1}): 2.22 cmolc. dm^{-3}; Al^{3+} (KCl L^{-1} mol L^{-1}): .00 cmolc dm^{-3}; H+Al (ethyl 0.5 mol L^{-1}): 3.97 cmolc dm^{-3}, SB: 9.11 cmolc dm^{-3}; CTC: 13.08 cmolc dm^{-3} V: 69 65 %; organic matter (method Boyocus): 25.97 g dm^{-3}; Cu: 14.70 mg dm^{-3}; Zn: 10.40 mg dm^{-3}, Mn: 181.00 mg dm^{-3}; Fe: 23.20 mg dm^{-3}. The experiment was carried out in a field of *Cynodon* sp cv. Tifton 85 deployed for 6 years, with an area of 4.0 ha and it is intended only for hay production to marketing, which regularly receives swine slurry in the amount of 500 m^3 ha^{-1} year. In the manure analysis it was detected: Methodology flame AAS N: 1.75 g kg^{-1}, P: 0.06 g kg^{-1}, K: 0.10 g kg^{-1}, Ca: 3.30 g kg^{-1}; Mg: 1.00 g kg^{-1}, Cu: 1.00 mg kg^{-1}, Fe: 2.00 mg kg^{-1}, Mn: ND (not detected); Zn: 2.00 mg kg^{-1}.

The experimental design was randomized blocks with split-plot overtime, three tillage systems and three times of assessment with 5 repetitions: Tifton 85 single; Tifton 85 with long-cycle oat oversowing (*Avena sativa* IPR 126); Tifton 85 with white oat oversowing for grains (*Avena sativa* Guapa)

Sowing of winter forage was performed on octuber 5th, 2011, immediately after cutting the Tifton 85 for haymaking. 80 kg ha^{-1} of white oat seeds of each species was used. For sowing, a precision seeder by tractor for tillage with spacing of 0.17 m between rows, was used. The width of the plots corresponded to 4 passes of the tractor (2.38 m wide) totaling 9.52 m to 30 m in length, with a total area of 285.6 m^2. The germination of the plants was between 6 and June 8 and the urea application occurred on 06/15 with the dosages used: 100 kg ha^{-1} of nitrogen as urea (45% nitrogen).

The hay cut in the experimental field was carried out on August, 31, at 11h00 am after drying the dew with a mower conditioner by tractor, endowed with nylon free fingers for plant's mechanical conditioning (folding) at height of 5 cm above the soil. After cutting and mechanical conditioning, the forage remained in the field, exposed to the sun for dehydration. The baling occurred on September 1 at 3h00 afternoon. All treatments were made of rectangular bales with 10 kg mean weight. In the study of the dehydration curve, the experimental design was a randomized block with split-plot overtime being allotted in the plots three cropping systems and five sampling times and five replications in the sub plots. The sampling times corresponded to the following days and times of the dehydration period: 1st day (cut day): (0 time) 11h00 (time 6) 17h00, 2nd day: time (21) 08h00 (time 25) 12h00 (time 30) 17h00. After sampling each time the hay was stored in paper bags and subjected to drying in an oven with forced air for 72 hours at 55 °C for dry matter (DM) determination. From DM contents were obtained the dehydration curves.

The samples for determination of dehydration curves were performed at 8h00, 12h00 and 17h00 hours each day by collecting samples of approximately 300 g in each plot. After sampling, the samples were packed in paper bags and dried in an oven with forced air circulation at 65 °C for dry matter determination. Structural characteristics evaluation was performed as follows: for plants canopy height were collected measures at 10 points in each plot, with a graduated scale of 100 cm. In obtaining the stem diameter were taken 20 tillers and a caliper positioned before the first node. To determine the leaf / stem ratio, it was used the method of manual separation and drying, in which samples of 50 g were collected and separated into leaves and stems, which were placed in paper bags and submitted to drying at a temperature of 55 ºC for 72 hours in oven with forced ventilation. The leaf / stem ratio (F/C) was obtained from the ratio of the dry weight of leaves and dry weight of the stems.

The chemical composition of the hay was studied in a complete randomized block design in a split plot overtime with 3 treatments allocated to plots and three times in the subplots: cutting, baling and 30 days of hay storage, with 5 repetitions. In the shed storage, hay was housed in masonry airy shed, covered with clay tiles, brick-floored, where hay was arranged in stacks on wooden pallets with a height of 10 cm from the floor. In stored hay, the bales were opened for sampling at 30 days of storage. At the time of sampling, samples were collected for dry matter determination and fungi occurrence.

For dry matter content and chemical composition, samples of 300 g were collected, which were packed in paper bags and dried in an oven with forced air for 72 hours at 55 ºC. After drying the samples were ground in a Wiley type mill with 1 mm sieve and subjected to laboratory procedures for determination of crude protein (CP) according to AOAC (1990), neutral detergent fiber (NDF), acid detergent fiber (ADF) according to Van Soest and Robertson (1985), neutral detergent insoluble protein (NDIP, expressed in g kg of CP), acid detergent insoluble protein (ADIP, expressed in g kg^{-1} of CP), lignin (LAS) according to the methodology developed by Van Soest (1965), and hemicellulose and cellulose (SILVA; QUEIROZ, 2006).

The fungi were isolated by induction of mycelial growth in BDA culture medium by induced sporulation or direct isolation of signals (reproductive structures) of the pathogen from samples collected (FERNANDEZ, 1993; MENEZES; SILVA-HANLIN, 1997). Dilutions ranged from 10^1 to 10^5 and after incubation the colonies were counted using a Quebec colony counter being able to be counted the plates with 30 and 300 CFU (Colony Forming Unit) per Petri dish and the results in this assay were considered in 10^1 dilution.

From microscopic observation (stereoscope microscope), semi-permanent slides were prepared of all fungal structures found in both symptomatic materials and culture medium. These structures were transferred with the aid of a needle or stylus to a microscope slide with dye lactophenol blue cotton, covered with coverslip, sealed with enamel and observed under optical microscopy to identify the fungus, with the aid of specific identification keys (BARNETT; HUNTER, 1987; CARMICHAEL et al., 1980; GUARRO; GENÉ; STCHIGEL, 1999; SAMSON et al., 1995). The experimental design for the occurrence of fungi was a randomized block with split-plot overtime, three cropping systems and two collection times (cutting and storage).

During the storage period were monitored the room temperature in the shed and temperature (ºC) of bales by taking 3 points in each bale; being monitored 5 bales per treatment with skewer-type digital thermometer. Based on the observed data, the graph of temperature oscillation and temperature of the bales in the shed was elaborated.

Data were subjected to analysis of variance, and when found significance by the F test, the dry matter contents throughout the period of dehydration were studied by means of regression analysis, with the choice of the model that presented minimum significance of 5% by the T test and higher coefficient of determination (R^2). The structural characteristics, dry matter yield, bromatological composition were compared by the Tukey test at 5% probability.

The fungi discussion was based with descriptive analyses.

Results and Discussion

The higher dry matter production was observed in Tifton 85 single ($P<0.05$) surpassing the production of associations Tifton 85 + white oat (Table 2), as annual crops oversowing showed low yield due to low rainfall (May to June) in the establishment period (Figure 1) impairing the production of total dry matter of the association (789.20 g kg ha^{-1} of IPR 126 and 1180.00 g kg ha^{-1}). The low initial precipitation was reflected throughout the crop development, showing that the success in implementing this system depends not only on chemical attributes in the soil and seed quality, but favorable weather conditions or use of the irrigation system. The reduced growth of Tifton 85 when combined with oats was also certified by Neres et al. (2011), but according to the data obtained by the author, the oats in association with Tifton 85 promotes the increased nutritional value of forage intended to hay production.

Table 2. Dry matter production and structural characteristics of Tifton 85 and association with white oat.

Treatments	DM production (kg ha^{-1})	Plants Height (cm)	F/C	Stem diameter (mm)
Tifton 85	3550.60a	16.75c	0.99b	1.44bc
Tifton 85 + IPR 126	2625.80b	-----	-----	-----
Tifton 85+ Guapa	3021.80ab	-----	-----	-----
IPR 126 (tifton 85)	789.20d	31.20b	1.11a	1.76b
Guapa (tifton 85)	1180.80dc	46.40a	0.77c	2.96a
Tifton 85 (IPR)	1828.00c	14.60c	1.02ab	1.16c
Tifton 85 (Guapa)	1841.60c	16.60c	1.05ab	1.48bc
CV (%)	16.88	14.64	4.93	26.51

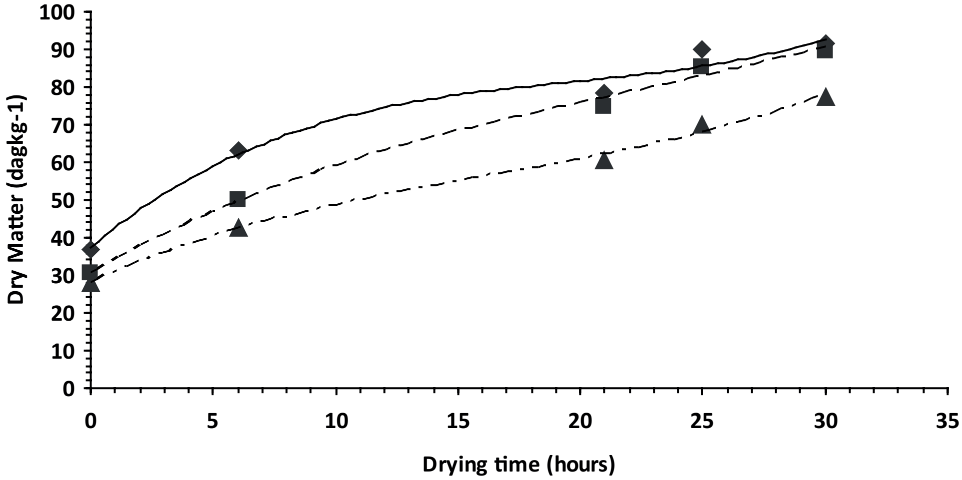
* Means followed by the same letter in the column do not differ by the Tukey test at 5% probability.
Tifton 85: Tifton 85; Tifton 85 + IPR 126: Tifton 85 oversowing with white oat IPR 126, Tifton 85 + Guapa: Tifton 85 oversowing with Guapa white oat.
Source: Elaboration of the authors.

The canopy heights were higher in oats (Table 2) according to the cespitose size because Tifton 85 has to be some estolonipherous species with keeper growth. The white oat IPR 126 Iapar launch in 2005 with suitability for grazing and long cycle has a characteristic of semi-prostate growth habit, thus presenting height of 31.30 cm compared to white oat guapa (46.40 cm) with cespitose growth habit. The Tifton 85 single and in combination showed no differences between heights averaging 15.98 cm.

The leaf/stem ratio of IPR 126 was the highest one (1.11 $P<0.05$) and that of Guapa was lowest ratio 0.77. The variable stem diameter is also one of important features in the dehydration process for producing hay fodder, since the larger the diameter, the greater the time required for dehydration. The stem diameter ranged between Tifton 85 and the oat cultivars with higher values in Guapa (2.96 mm) followed by IPR 126 (1.75 mm), being advised the use of conditioners in these cultivars, which, by causing injuries in the stem, accelerate the rate of dehydration. Stem diameter in Tifton 85 ranged from 1.16 to 1.48 mm and these values were considered ideal for a high rate of dehydration. The Tifton 85 had higher DM content (Figure 2) at cutting (378.06 g kg^{-1}) regarding the associations, which can be explained by the higher water content present in oats.

Tifton 85 and the association Tifton 85 + IPR 126 reached appropriate DM levels at the time of baling thus avoiding increasing the risk of DM losses, higher incidence of fungi and elevations of neutral detergent insoluble protein. However, the cultivation Tifton 85 + guapa in baling showed 775.06 g kg^{-1}, DM levels which increased after 30 days of storage.

Figure 2. Dry matter (Ŷ) of hay Tifton 85 (♦), Tifton 85 oversowing with IPR 126 white oat (■) and Tifton 85 oversowing with guapa white oat (▲) as depending on the drying time.



Source*:* Elaboration of the authors.

The crude protein contents did not differ between crops at cutting (Table 3), being lower than the expected in white oat + Tifton 85, once the white oat stands out for the high CP content and lower NDF and ADF. Neres et al. (2012), when evaluating the IPR 126 white oat under grazing obtained 230.7 g.kg^{-1} CP, 529.8 g.kg^{-1} NDF and 303.7 g kg^{-1} ADF in the first grazing. These low fiber contents can be attributed to the low development of white oat in the year assessed. Values of fiber increased in baling and storage. The neutral detergent insoluble protein did not differ between cropping systems in cutting and baling, but the Tifton 85 had higher levels in the storage ($P<0.05$) compared to the other treatments, showing that the hay undergoes changes in its composition. The acid detergent insoluble protein did not differ among cultures but it increased during baling in Tifton 85 hay ($P<0.05$) also remained in the storage. When compared to the steps, there was increased from cutting to baling and to storage.

There were no significant differences between the crops in cutting but this reduced in the treatment Tifton 85 + IPR in baling and in Tifton 85 during storage. The opposite was observed with the hemicellulose that increased in Tifton 85 single and reduced in associations in the baling and storage. Lignin contents were higher in Tifton 85 single at the time of cutting and storage. Concerning to steps, there was increased lignin in Tifton 85 from cutting to storage.

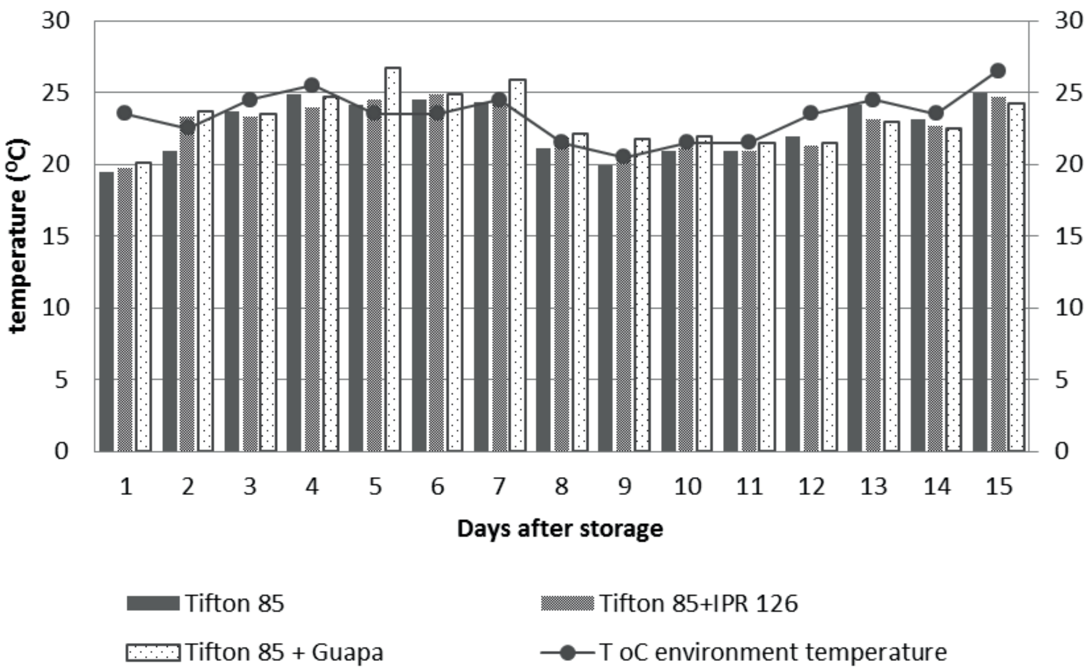
Table 3. Chemical composition of Tifton 85 at the time of cutting, baling and after 30 days of storage.

Crops	Dry matter (g kg^{-1})			Crude protein (g kg^{-1})			Neutral detergent insoluble protein (g kg^{-1} of CP)		
	Cutting	Baling	Storage	Cutting	Baling	Storage	Cutting	Baling	Storage
Tifton85	378.0aB	914.0aA	867.5aA	94.3C	110.8bB	129.9aA	417.0B	542.37A	608.2bA
Tifton85+ IPR	302.8bB	897.1aA	873.4aA	108.5B	127.5aA	126.2abA	385.5B	470.12B	584.1aA
Tifton 85+G	279.2bC	775.0bB	808.4bA	95.2B	110.2bA	113.9bA	363.0B	464.00A	451.3aAB
CV1(%)	3.13			3.92			14.35		
CV2(%)	3.49			8.11			12.60		
	Acid detergent insoluble protein (g kg^{-1} of CP)			Neutral detergent fiber (g kg^{-1})			Acid detergent fiber (g kg^{-1})		
	Cutting	Baling	Storage	Cutting	Baling	Storage	Cutting	Baling	Storage
Tifton 85	402.3B	687.6aA	699.8aA	8747.8aA	839.0aAB	794.2aB	558.2aA	503.4aB	416.1bC
Tifton85+ IPR	377.3B	538.7bA	568.5bA	720.1bA	634.0cB	674.0bB	506.1bA	412.7bB	492.2aA
Tifton 85+G	406.1B	535.5bA	599.2bA	762.1bAB	720.6bB	770.5aA	483.2b	489.5a	511.3a
CV1(%)	12.31			4.20			7,67		
CV2(%)	12.79			3.72			6,02		
	Cellulose (g kg^{-1})			Hemicellulose (g kg^{-1})			Lignin (g kg^{-1})		
	Cutting	Baling	Storage	Cutting	Baling	Storage	Cutting	Baling	Storage
Tifton 85	420.1A	392.2aA	283.4bB	328.6a	329.8a	385.3a	152.7aA	114.4B	126.9aAB
Tifton85+ IPR	384.0A	310.1bB	399.1aA	213.9b	221.3b	181.9c	122.1abA	102.5AB	93.0bB
Tifton+ G	381.8	388.9a	427.4a	278.8ab	231.1b	259.2b	101.4b	100.6	83.8b
CV1(%)	8.84			10.53			13.26		
CV2(%)	9.32			15.34			17.97		

* Means followed by same lowercase letter in row and uppercase letter in column do not differ by Tukey test at 5% probability.
Tifton 85: Tifton 85; Tifton 85 + IPR: Tifton 85 oversowing with white oat IPR 126, Tifton 85 + G: Tifton 85 oversowing with Guapa white oat.
Source*:* Elaboration of the authors.

The bales monitored during storage showed oscillations depending on the room temperature (Figure 3) and the treatments of grass Tifton 85 + Guapa presented temperature above room temperature at the 5th, 7th and 8th day, which may be due to the higher moisture content in time of baling. After the first week there were no peaks of rising temperatures of bales compared to the room temperature.

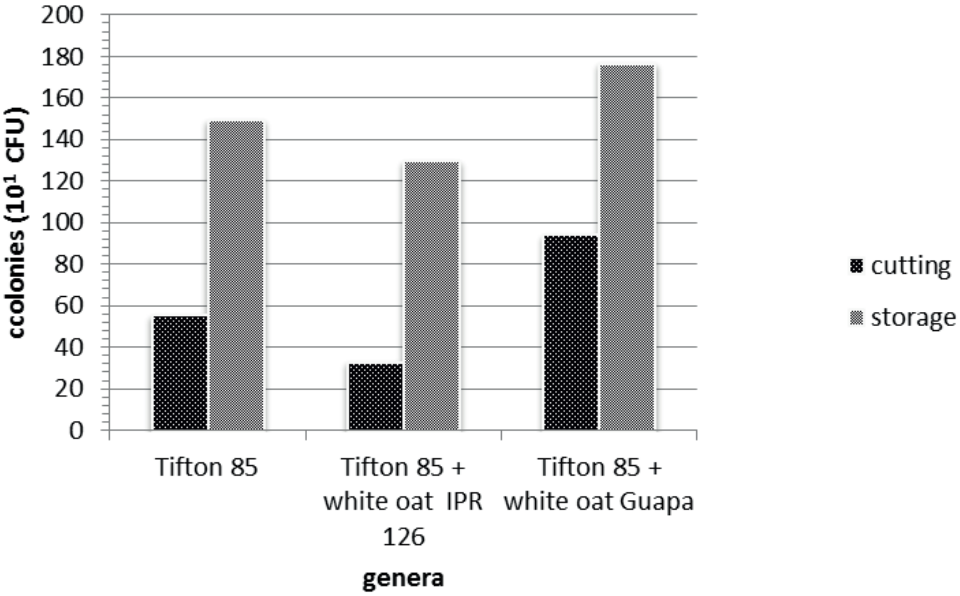
Figure 3. Values of room temperature inside the storage shed and temperatures of hay bales of Tifton 85 single and Tifton 85 with white oats.



Source: Elaboration of the authors.

The population of fungi was higher in storage when compared with the cutting (Figure 4). The genera that prevailed at the cutting were *Phoma* and *Fusarium* being typical field fungi (Figure 5).

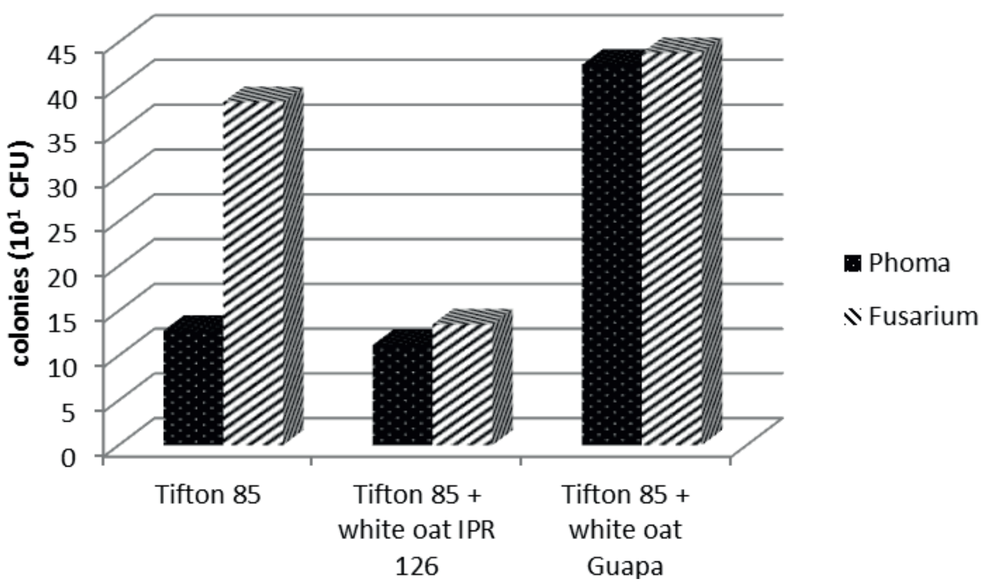
Figure 4. Total count of fungi before cutting and after 30 days of hay storage.



Source*:* Elaboration of the authors.

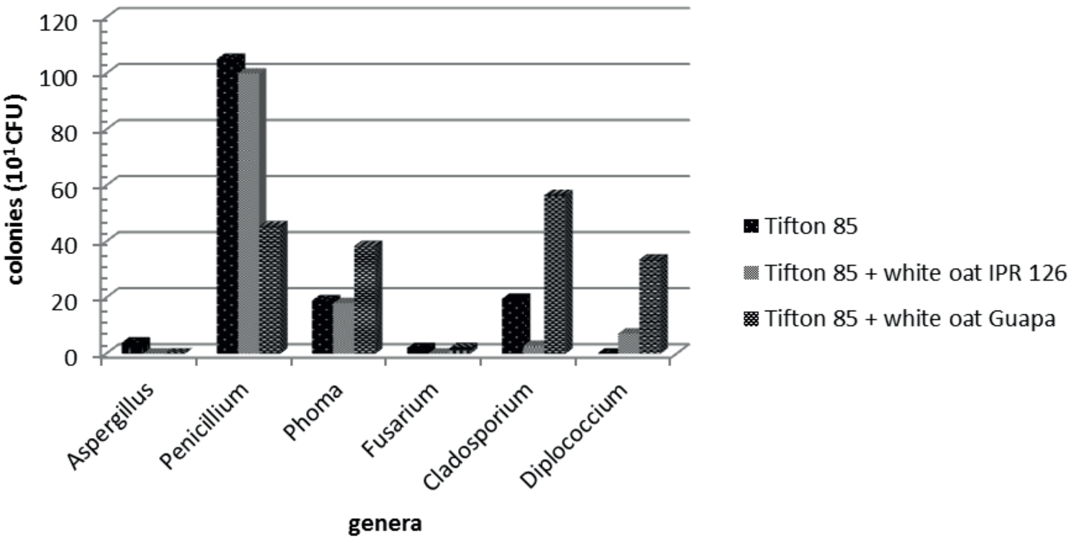
After storage the most common species of fungi genera were *Penicillium,* fungus typical of storage, followed by the genus *Phoma* and *Cladosporium* and, in the treatment Tifton 85 + Guapa also *Diplococcium* (Figure 6). In the treatment Tifton 85 + Guapa there was predominance of *Cladosporium* compared to *Penicillium* and in all treatments there was low occurrence of *Aspergillus.*

Figure 5. Count colonies of fungal genera present (CFU g10[1]) before cutting the forage.



Source*:* Elaboration of the authors.

Figure 6. Count of fungi genera (CFU g10[1]) in Tifton 85 hay 30 days after storage.



Source*:* Elaboration of the authors.

Conclusions

The success of oversowing cool season species in areas of production of Tifton 85 hay depends on climatic factors prevailing in the year. The oat oversowing in areas of Tifton 85 does not increase the dry matter production, but further improvements in the nutritional value of the hay produced with lower neutral detergent fiber and lignin contents.

The occurrence of fungi in hay stored with suitable levels of dry matter should be further studied in view of the occurrence of the genus *Penicillium*.

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