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RESEARCH PAPER

## Agronomic characteristics and chemical composition of *Gliricidia sepium* grown under different residual heights in different seasons

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### Abstract

**S.F. Silva, M.S. Carneiro, R.L. Edvan, E.S. Pereira, L.B. de Moraes. Neto, A.P. Pinto, and D. de A. Camilo. 2015. Agronomic characteristics and chemical composition of *Gliricidia sepium* grown under different residual heights in different seasons. Cien. Inv. Agr. 44(1): 35-42.** This research was conducted to evaluate the agronomic characteristics and chemical composition of *Gliricidia sepium* (Jacq.) Steud grown under different residual heights in different seasons. The experimental design used was a complete randomized block in a split-plot. The plots consisted of three residual heights (70, 90 and 110 cm), and the subplots were four seasons (fall, winter, spring and summer) with four replicates. There was no ( $P>0.05$ ) interaction between season and residual heights for agronomic characteristics. However, these features were influenced by the cutting season, with no significant effect ( $P>0.05$ ) on residual height. Significant effects ( $P<0.05$ ) were observed for dry matter, mineral matter, acid detergent fiber and ether extract in cutting seasons and residual height. *Gliricidia sepium* can be cut at a residual height of 70 cm, with better agronomic characteristics and chemical composition occurring in the fall.

**Key words:** Cutting management, harvest time, legumes, nutritional value, semiarid.

### Introduction

Choosing adapted and resistant forage species for the Brazilian semiarid region is a major challenge for producers, as irregular rainfall is the greatest obstacle to food production in the region. This causes

feedstock shortage during drought periods and increasing production costs due to the need of using supplements in diets (Ferreira *et al.*, 2009; Silveira, 2011). Temperature and humidity can also influence forage availability throughout the year, even in crops that show high resistance to annual water deficits.

represents an important commercial and economic alternative due to its adaptation to dry regions and multiple uses (Rangel *et al.*, 2011). This species has a high nutritional value, fast growth, high regeneration capacity, and high potential for forage production (Hurtato *et al.*, 2012).

The cutting intensity of forage affects regrowth, which is also influenced by the weather conditions at the time the cut is made. Forage production is seasonal in tropical regions, affecting both forage yield and quality (Costa *et al.*, 2013). Forage quality decreases as the plant matures, which usually matches the beginning of the dry season, increasing fiber and lignin contents and reducing crude protein. Given the low availability of forage in pastures in the Brazilian semiarid region, especially during the dry season, it is extremely relevant to study *G. sepium* throughout the year to evaluate its potential and implement better management.

This study was conducted to evaluate the agronomic characteristics and chemical composition of *G. sepium* under different residual heights in four different seasons.

## Materials and methods

The experiment was conducted in the Forage Sector of the Department of Animal Science at the Federal University of Ceará (UFC), Fortaleza, Ceará State. Fortaleza is located in the Coastal Zone, 21 m altitude, 3°43'02" S and 38°32'35" W. According to Köppen and Geiger (1928), the climate is *Aw*, tropical rainy, with rains concentrated in the summer and an average annual rainfall of 800 mm distributed from January to April.

An area of 600 m<sup>2</sup> was planted with 336 plants of *G. sepium*. The plantation was established in 2010 with approximately 3-cm-diameter and 20-cm-length stem sections spaced 1.0 × 1.5 m apart. Soil chemical analysis was conducted at

the Laboratory of Soils at the Federal University of Ceará (Table 1).

**Table 1.** Soil chemical characteristics of the experimental area.

H <sub>2</sub> O	pH						
	P	K	Ca+Mg	Al	Ca	Mg	Na
	— mg/dm <sup>3</sup> —		— cmol/dm <sup>3</sup> —				
6,1	9	70	3,5	0	1,9	1,6	8

Climatic data were gathered at the UFC's Weather Station, located approximately 600 m from the experimental site (Figures 1 and 2). A standardization cut was held on March 21, 2013 (the end of the summer solstice and the beginning of autumnal equinox), corresponding to the beginning of the rainy season. The soil was fertilized with 90 kg ha<sup>-1</sup> super phosphate (P<sub>2</sub>O<sub>5</sub>) and 60 kg ha<sup>-1</sup> of potassium chloride (K<sub>2</sub>O) with a single dose.

Plants were harvested for evaluation on June 21 (the end of autumn and the beginning of winter), September 21 (the end of winter and the beginning of spring), December 21 (the end of spring and the beginning of the summer) in 2013, and March 21 (the end of the summer and the beginning of autumn) in 2014. In all cuts, seven eligible plants, identified with colored ribbons per plot and per treatment, were evaluated according to their residual heights (70, 90 and 110 cm).

For growth analysis, the following nondestructive variables were measured: stem diameter at the ground level (STD), shoot diameter (SHD), number of shoots (NS) and plant growth (PG). For the stem and shoot diameter evaluation, a digital caliper was used measuring at a distance 5 cm from the ground and shoot base, respectively. Plant growth was measured from ground level to the highest branch using a graduated scale, and the residual height for each treatment was subtracted from this result. Leaf area index was calculated using a glass grid with known area which was placed over the leaves to count the number of squares contained inside the leaves borders.

At the beginning of each season, plants were cut with pruning shears according to pre-established residual heights. Collected material was weighed to obtain total mass of fresh forage for each treatment. Branches and leaves up to 1 cm in diameter were separated, and composite samples of approximately 500 g were retained to determine the chemical composition. Samples were dried in a forced air circulation oven at 65 °C for 72 h until achieving a constant weight. Dry samples were removed, weighed and ground in a Wiley knife mill with a 1-mm sieve and then stored in plastic containers.

Dry matter content was determined as well: crude protein (CP) in nitrogen distillers using the Kjeldahl method; ether extract (EE) using the Goldfish method; mineral matter (MM) in a muffle furnace at 600 °C; and neutral detergent fiber (NDF) and acid detergent fiber (ADF) using ANKOM equipment. Methods described in AOAC (1990) were used for the determination of DM, MM, CP and EE. NDF and ADF were determined according to Van Soest *et al.* (1991).

The experimental design was complete randomized blocks in a split-plot. Plots consisted of three residual heights (70, 90 and 110 cm) and subplots of 4 seasons (fall, winter, spring and summer) with four replicates. The data of agronomic character-

istics and chemical composition were submitted to analysis of variance (ANOVA). Means were compared by the Tukey test ( $P < 0.05$ ). Analysis was performed using the statistical software SAS version 9.0 (SAS Institute, 2002).

## Results and discussion

There was no interaction ( $P > 0.05$ ) between cutting seasons and residual height for the agronomic characteristics of *G. sepium*. However, they were influenced by the cutting season (Table 2). Plant growth during autumn was approximately three times higher than in spring. This result was similar to that found by Lopes *et al.* (2000), who evaluated morphophysiological characteristics of *Leucaena leucocephala* in two seasons (dry and rainy) and found a higher plant growth during the rainy season. The lower plant growth observed in spring was due to the low rainfall occurring in October, November and early December in 2013 (Figure 2).

Stem and shoot diameter (STD and SHD) were higher ( $P < 0.05$ ) in the winter when compared to other cutting periods (Table 2). It is worth noting that the rainfall preceding this cut occurred in June and July with little variation in temperature (Figures 1 and 2). This condition certainly favored

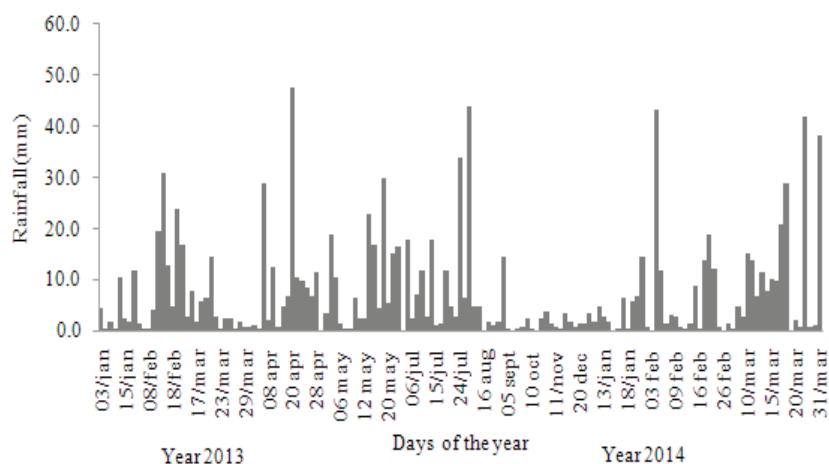


Figure 2. Rainfall recorded during the experiment in Fortaleza city, Ceará State.

accumulation of reserves in plants, allowing for an increase in STD and SHD. STD and SHD was registered in September, 2013 at 6.85 and 2.70 cm, respectively. These values were 2.5 and 3.4 times higher than those registered in the summer.

The number of shoots (NS) in the summer was higher than in other seasons. This must have occurred as a result of increased rainfall in January, February and March prior to the cut, as the summer is considerably rainy in this region, as shown in Figures 1 and 2. However, Perrando and Corder (2006), evaluating *Acacia mearnsii* in Rio Grande do Sul State Brazil, observed higher plant regrowth occurring during the winter and spring (September and December), seasons of less oscillation between temperature and precipitation, thus favoring growth. A higher NS occurred in

the summer when the 4th cut was conducted, and an average of 31.33 shoots per branch were recorded. This number was lower than that found by Edvan *et al.* (2014) when managing *G. sepium* with a residual height of 90 cm and a cutting frequency of 90 days, when 42 shoots per branch were recorded during the summer.

It was observed that the leaf area index (LAI) was higher ( $P<0.05$ ) in autumn. A higher rainfall in the previous months to the cut may have contributed positively to this result. Chaves *et al.* (2007) verified similar results assessing *Eucalyptus grandis* canopy, where the LAI was higher in the rainy season, presenting a quick plant recovery after the cut at the beginning of the rainy season. Precipitation is the main climatic variable influencing plant growth in Brazil, especially in

**Table 2.** Agronomic characteristics of *Gliricidia sepium*, plant growth (PG), stem diameter (STD), diameter of the shoots (SHD), number of shoots (NS), leaf area index (LAI), total mass of fresh forage (TMFF), and total mass of dry forage (TMDF) according to seasons and residual height.

Variables	Seasons				
	Fall 2013	Winter 2013	Spring 2013	Summer 2014	SD
PG (m)	0.81a	0.38bc	0.26c	0.46b	0.23
SD (cm)	2.06c	6.85 <sup>a</sup>	4.10b	2.74c	2.11
DS (cm)	0.83b	2.07 <sup>a</sup>	1.07b	0.68b	0.37
NS	22.83c	23.83bc	25.16bc	31.33a	4.49
LAI (m <sup>2</sup> )	1.13a	0.19c	0.72b	0.48bc	0.39
TMFF (t.ha <sup>-1</sup> )	13.13a	5.86b	4.89b	7.96b	3.67
TMDF (t.ha <sup>-1</sup> )	3.49a	1.65b	1.24b	1.94b	0.98
	Residual Height				SD
	70 cm	90 cm	110 cm		
PG (cm)	0.46	0.53	0.44		0.10
SD (cm)	3.66	4.07	4.09		0.24
DS (cm)	1.17	1.17	1.14		0.10
NS	23.12	26.43	27.81		2.41
LAI (m <sup>2</sup> )	0.68	0.70	0.51		0.10
TMFF (t.ha <sup>-1</sup> )	8.16	7.83	7.89		0.17
TMDF (t.ha <sup>-1</sup> )	2.20	2.11	1.92		0.14

Means with different letters in the line significantly different ( $P<0.05$ ) by Tukey test. SD: standard deviation.

regions close to the equator, because temperature is nearly constant throughout the year, except in the extreme South.

The highest yield of total mass of fresh forage (TMFF) and total mass of dry forage (TMDF) was 13.13 and 3.49 t ha<sup>-1</sup> (Table 2), respectively, and registered in autumn. Previous rainfall and an average of 12 h of sunlight per day may have contributed to these higher values. Gomez *et al.* (2002) stated that *G. sepium* is very demanding in terms of sunlight, as observed in this study that under ideal conditions of water supply and solar radiation, plants presented elevated yield for TMFF and TMDF.

Regarding the residual height, no significant differences were observed ( $P>0.05$ ) for agronomic characteristics (Table 2). This result attests to the adaptation and resistance that plants present under different cutting management. It could also be noticed that residual heights of 70 to 110 cm provided higher growth for *G. sepium*. Edvan *et*

*al.* (2014) stated that a residual height of 60 cm was not appropriate for this species. In relation to the chemical composition, an interaction ( $P<0.05$ ) was observed between residual height and cutting season for NDF, CP and OM contents (Table 3). No interaction effect ( $P>0.05$ ) was verified for DM, MM, ADF and EE contents.

Higher levels of NDF were registered in the winter and spring for all residual heights (70, 90 and 110 cm). According to Duarte (2012), NDF concentration is the parameter that seems to be most influenced by the low amount of water in the soil, decreasing the amount of carbon incorporated into the cell wall and increasing fiber content. The high NDF content suggests a reduction in the nutritional value of the forage for ruminants, indicating that *G. sepium* would probably have its nutritional value reduced during this season.

In contrast, lower NDF values were observed in the fall for a residual height of 70 cm and in the summer for residual heights of 70 and 90 cm. These heights

**Table 3.** Mean values of neutral detergent fiber (NDF), crude protein (CP) and organic matter (OM) in *Gliricidia sepium* at different times in relation to residual height.

Residual height	Seasons				SD
	Fall 2013	Winter 2013	Spring 2013	Summer 2014	
NDF (% DM)					
70 cm	54.82bB	63.79aA	63.44aA	54.35bC	5.21
90 cm	60.94aA	64.08aA	64.65aA	60.35aB	2.17
110 cm	62.23aA	62.32aA	64.38aA	65.33aA	1.53
CP (% DM)					
70 cm	20.66aA	22.76aA	18.65aA	22.31aA	2.12
90 cm	16.23bA	21.40aA	20.63aA	22.92aA	2.87
110 cm	20.34aA	21.81aA	18.54bA	24.73aA	2.61
OM (% DM)					
70 cm	80.30bB	84.86aA	81.71bA	81.26bA	2.34
90 cm	84.38aA	85.42aA	81.47abA	80.36bA	2.38
110 cm	84.08aA	84.30aA	82.47aA	81.59aB	1.30

Means with different lowercase letters in line (residual height x seasons) and different capital letters in column (seasons x residual height) are different ( $P<0.05$ ) by Tukey test. SD: standard deviation.

were influenced by rainfall during the seasons, but this was not observed for those managed at a residual height of 110 cm, probably because these plants retained major supporting structures.

Higher levels of CP were registered in winter and summer for all residual heights (70, 90 and 110 cm). This was mainly due to well-distributed rainfall in the previous months little variation (Figure 1), which may have favored a higher accumulation of cellular content in the plants. It is worth mentioning that values for CP in this study for plants managed at 70 cm residual height, even with minimal rainfall during a season, for example in December 2013, averaged 18%, according to Van Soest (1994), this value is higher than those suitable for ruminants needs.

Higher levels of OM were registered ( $P < 0.05$ ) in the winter for all residual heights (70, 90 and 110 cm) (Table 3). This result may be related to the higher DM content and lower MM content observed in this season (Table 4), as OM content is proportional to the levels of DM and MM. A significant effect was observed ( $P < 0.05$ ) for DM, MM, ADF and EE for cutting seasons (Table 4). Higher DM content was observed for plants submitted to cut in the winter, which may be an effect of high rainfall and temperature indices in

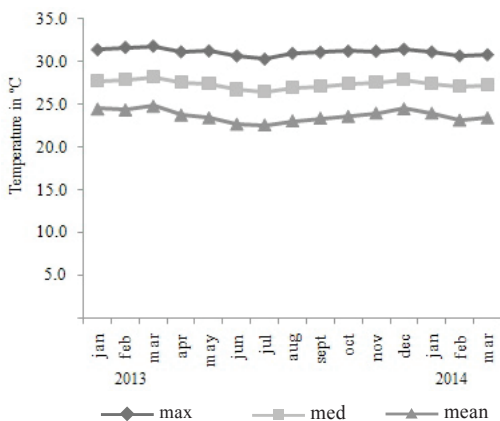
previous months. Plants managed in the spring showed a higher percentage of MM, differing from the other seasons. Low rainfall registered in September and November 2013 may have affected concentrations of this nutrient in the plants.

According to Gris *et al.* (2008), minerals play an important role in the animal organism, being essential for production and maintenance. Mineral content may vary in plants according to the period of cut and their vegetative stage. Higher ADF content was verified in autumn and winter (Table 4). The EE content in the winter was higher than other cuts. Low rainfall recorded before this cut in June, July and August 2013 may have promoted an increase in the percentage of EE.

No significant differences were observed ( $P > 0.05$ ) for the percentages of DM and ADF for residual heights of 70, 90 and 110 cm (Table 4). However, it was observed that the residual height of 70 cm presented a higher percentage of MM followed by 90 and 110 cm.

For percentages of EE, the highest value was obtained on a residual height of 110 cm, probably related to the greater height, which may have contributed to an increase in concentration of reserves in the plant, consequently affecting this component. According to Bakke *et al.* (2010), differences in the chemical composition of *Leguminosae* are closely related to the genetic characteristics of each plant, such as differential absorption of nutrients and conversion of photosynthetic metabolites, climate and soil conditions, or even different stages of leaf maturity.

In Northeast Brazil, where seasons are not well defined, differences for the variables evaluated in the seasons were mainly affected by variations in precipitation, as the temperature is almost constant during the year (Figure 1). This region is characterized by two distinct periods where *G. sepium*. presented differences in development and composition, a rainy season (summer and fall) with fast growth and high nutritional value, and a



**Figure 1.** Minimum, average and maximum temperature (monthly average) during the experimental period (2013–2014) in Fortaleza city, Ceará State.



**Table 4.** Mean values of dry matter (DM) mineral matter (MM) acid detergent fiber (ADF) and ether extract (EE) in *Gliricidia sepium* according to seasons and residual height.

Variables	Seasons				SD
	Fall 2013	Winter 2013	Spring 2013	Summer 2014	
DM (%)	28.18b	30.92 <sup>a</sup>	25.40c	24.54c	2.89
MM (%)	6.28b	6.57b	8.41a	6.19b	1.04
ADF (%)	43.90a	42.98 <sup>a</sup>	42.47b	40.60b	1.39
EE (%)	3.51c	6.16 <sup>a</sup>	4.55b	5.19ab	1.11
	Residual Height			SD	
	70 cm	90 cm	110 cm		
DM (%)	27.47	27.11	27.20	0.18	
MM (%)	7.49a	6.78ab	6.32b	0.58	
ADF (%)	40.56	43.43	43.47	1.66	
EE (%)	4.49b	4.45b	5.62a	0.66	

Means with different lowercase letters in line are significantly different ( $P < 0.05$ ) by Tukey test. SD: standard deviation.

dry season (winter and spring) with slow growth and low nutritional value, where plant growth is defined by the total precipitation.

*Gliricidia sepium* should be managed with a residual height of 70 cm. The season where *G. sepium* showed higher dry matter production, plant growth and better chemical composition was autumn.

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### Resumen

S.F. Silva, M.S. de S. Carneiro, R.L. Edvan, E.S. Pereira, L.B. de M. Neto, A.P. Pinto, y D. de A. Camilo. 2017. Características agronómicas y composición química de *Gliricidia sepium* cultivadas bajo diferentes alturas residuales en diferentes estaciones del año. Cien. Inv. Agr. 44(1): 35-42. Este estudio tuvo como objetivo evaluar las características agronómicas y la composición química de *Gliricidia sepium* manejado con diferentes residuos en diferentes estaciones del año. El diseño estadístico fue de bloques al azar en parcelas divididas. Los residuos incluyeron tres diferentes alturas (70, 90 y 110 cm) y las subparcelas incluyeron cuatro estaciones del año (otoño, invierno, primavera y verano), con cuatro repeticiones. No hubo interacción ( $P > 0.05$ ) entre la estación y la altura de residuo en las características agronómicas de *G. sepium*. Sin embargo, estas características fueron influenciadas por el tiempo de corte. Efectos significativos ( $P < 0.05$ ) se obtuvieron para la materia seca promedio, cenizas, fibra detergente ácido y extracto etéreo. *G. sepium* puede ser manejado dentro de la altura residual de 70 cm, con mejores características agronómicas y composición química en la estación de otoño.

**Palabras clave:** Legumbres, manejo de corte, semiárido, tiempo de corte, valor nutritivo.

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