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Forage Production and Nutritional Quality of Angleton climacuna (Dichanthium annulatum-Forssk-Stapf) for Hay, in La Dorada (Caldas)

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ABSTRACT

This study was made on the Rancho Claro Farm, municipality of Doradas (Caldas). The aim was to determine the effects of cutting age on forage production and nutritional quality of angleton climacuna (Dichanthium annulatum) used for hay production. The study was made in previously chosen grassland; 21 lots of 100 m^2 were prepared, and the cutting ages were set at random (40, 50, 60, 70, 80, 90, and 100 days). A completely randomized design was used with three replications per treatment. The age effect on production and quality was analyzed through analysis of variance and the Tukey´s test. Regression analysis and the Pearson test were made to determine correlation. Forage production was observed to vary between 5.8 and 23.6 T Ha^{-1} of FM. The highest protein value was observed 40 days later (7.9%), and it was higher than 5% until the 70^{th} day. The dry matter (DM) percent and neutral detergent fiber (NDF) increased with age; the highest contents were observed after 80 days. The crude energy (CE) values were similar in all the ages. Quality decreased with age, but forage production increased. It was concluded that forage production and quality can be determined at any age, provided that height and forage production values per m^2 are known at initial growth stages.

Key words: *chemical composition, growth, cutting age, pasture*

INTRODUCTION

Forage preservation has become an important alternative for ruminant supplementation at different times of the year, when food availability is reduced due to environmental factors, and increased fiber requirements under certain physiological conditions of high yielding dairy cows improves ruminal health (Kendall *et al.*, 2008; Zebeli *et al.*, 2012). In that context, the preservation of forage as hay has become an important strategy to incorporate new food sources with high fiber contents. This practice complements production management in many livestock raising systems in the country, thus making farms more competitive.

Forage angleton climacuna (Dichanthium annulatum-Forssk-Stapf) is a forage species originally from East Africa and India, which has been used as one of the main forages for hay production in Magdalena, Colombia, since it is a perennial graminaceae, with erect or semi erect growth, mid-high coverage, and high forage production (Lara-Mantilla, Oviedo-Zumauqué and Betancur-Hurtado, 2010). Besides, it can adapt well to the climatic and edaphological conditions of the region (Estrada, 2002).

Several studies have demonstrated that the nutritional quality of forage is reduced as plants mature, but plant growth increases dry matter levels, and, therefore, pasture productivity per area unit is raised to (Van Soest, 1994; Davis *et al.,* 2001; Roncallo, Sierra and Castro, 2012). In normal conditions, the harvest of angleton for haymaking takes place between 90 and 120 days, according to management, the fertilization scheme, and the environmental conditions. Additionally, the dry season and the ideal height of the plant should be synchronized, in order for the machines to perform optimum cuts. This factor can affect the nutritional quality of preserved forage (Tallowin and Jefferson, 1999).

Accordingly, the aim of this paper was to determine the forage production and nutritional quality of angleton climacuna (Dichanthium annulatum-Forssk-Stapf) harvested at different ages. Hence, it was important to know the optimum cutting time in normal conditions, in relation to nutrition and production.

MATERIALS AND METHODS

Location

The field works took place on Hacienda Rancho Claro Farm, in the municipality of La Dorada (Caldas), in the Magdalena region, Central Colombia, 190 m above sea level. The location has average precipitation values of 1 900 mm in the March-June and September-December periods, with 85% relative humidity, and 28 ºC average annual temperature. This area classifies as a dry tropical forest (bsT) (Holdridge, 1987).

Experimental design

A previously established grassland with angleton climacuna (Dichanthium annulatum-Forssk-Stapf) was chosen for the experiment. The 11 000 m^2 field was divided into 21 lots of 100 m^2 each; the distance between the lots was 1 m. The cutting ages for evaluation were assigned at random (40; 50; 60; 70; 80; 90 and 100 days) with three repetitions. The study area was isolated from the rest of the grassland by means of an electrically charged fence; then, a leveling cut was performed 10 cm high from the soil. A completely randomized design was used with three replications per treatment. The age effect on production and quality was analyzed through variance analysis and the Tukey´s test.

Sample collection

When the proper cutting age was reached, four randomized samplings were made in each lot. The frames used (0.25 m^2 were placed in each lot by transecting. To determine plant growth behavior (PG), plant height (cm) was measured from the stem to the last meristematic apex. The production of green forage (GFP t/ha^{-1}) and bales (BP $unit/ha^{-1}$) were also determined, assuming a weight of 12 kg and 5% waste due to transformation processes, and 13% humidity (Suttie, 2003). The grass was cut 5 cm from the soil, then it was weighed in the field, using a scale, and it was stored in airtight plastic bags. The bags were frozen and transported to the integrated laboratory of animal nutrition, biochemistry, and pastures and forages, at the Faculty of Agricultural Sciences, University of Antioquia. Then 1 kg of forage was placed in a forced air stove at 60 ºC, for 48 h. Later, the material was weighed again to determine the contents of dry matter. The samples were stored in labeled glass flasks for later chemical analysis.

A chemical analysis of crude protein (CP) was made using the micro Kjeldahl method (AOAC, 2012). Crude energy (CE) was determined using a calorimetric pump. The content of neutral detergent fiber (NDF) was determined according to the technique suggested by Van Soest (1994).

Statistical analysis

A fix balanced completely randomized experimental design was applied, with three repetitions per treatment. The treatments were based on the cutting ages, at 40, 50, 60, 70, 80, 90, and 100 days.

The cutting age effect on the production parameters and nutritional quality of the pasture were determined through analysis of variance (ANOVA), comparison of the average effect per treatment through the Tukey´s test (5% significance), validation of normality assumptions, descriptive analysis per treatment, and correlation and simple regression analysis, regarding age as the independent variable. SAS (Statistical Analysis System, version 8.02) (SAS 2001) was used for data analysis.

RESULTS AND DISCUSSION

Growth and production of forage

The growing habit and graminaceae development are two factors that directly affect forage production. They are important indicators to evaluate grass productivity in tropical conditions. Table 1 shows forage growth and production parameters of angleton climacuna (*Dichanthium annulatum*) harvested at different ages. Forage growth showed no significant differences ($P<0.05$) between the successive periods evaluated. The differences turned more evident as forage age increased. A similar behavior was observed for GFP and BP. Variables PG, GFP, and BP were largely affected by the harvest age, with top values of 61.9 cm, 23.6 t/ha^{-1}FM, and 1 220 $units/ha^{-1}$, respectively. These results were influenced by the local precipitation, which hindered progressive and constant growth of forage, and became a negative factor that affected productivity improvements per area unit.

The results found in growth and production behaviors followed the same patterns as the ones reported by Cruz (1996) in the French Antilles; Ramírez, González-Rodríguez, García-Dessommes and Morales-Rodríguez (2005) in México; Sultan *et al.* (2008) in Pakistán, Lara-Mantilla *et al*. (2010), Laredo and Ardila (1984) in the north Colombian coast; Sultan and Kundu (2010) in India, and Roncallo, Sierra and Castro (2012) in the Colombian Caribbean. However, the values of PG, GFP, and BP were higher than the ones found in this study. It is important to consider that forage growth is determined by the quality of the soil, and by the precipitation behavior. Medina (2016) said that forage growth is limited by soil compacting, erosion, lack of humidity, and deficiencies in draining and fertility, which affect biomass production directly in grazing systems. Mechanical aeration is a positive practice to improve forage productivity in tropical conditions (Lascano *et al.*, 1998; Estrada, 2002). In the current paper, the edaphic conditions and rainfall did not favor forage productive behavior, which led to the assumption that under ideal production conditions, forage can achieve higher values than the ones found.

Nutritional quality

The nutritional quality of forage is a determining factor regarding the productive performance of the animals that consume it. The results are shown in table 2. CP had significant differences ($P<0.05$) when the forage cutting age increased; the prevalent trend was, the older the cutting age, the lower amounts of CB produced. This behavior decreased until 70 days, when the protein value was higher than 5%, thus meeting the minimum protein requirements for ruminants in tropical systems (NRC, 2001; Ørskov, 1982; Poppi and McLennan, 1995). DM and NDF had significant differences ($P<0.05$), in relation to the ages evaluated, with increasing values as age was older. The maximum values observed for DM and NDF were 51.7 and 84.6%, respectively. The lowest NDF percents were observed before 70 days. These results were similar to others reported by Lara-Mantilla, Oviedo Zumaqué and Betancur Hurtado (2010); Laredo and Ardila (1984) in the north Colombian coast; Cruz (1996) in the French Antilles; Ramírez *et al.* (2005) in México and Sultan *et al.* (2008), in Pakistan. The nutritional quality of forage was directly affected by the cutting age. This behavior was associated to a thickening of the cell wall, which generated lower deposits of easily digested protein and energy in the protoplasm, drastically affecting the nutrient contents with the growth of plants (Van Soest, 1994; Davis *et al.*, 2001).

Relation between forage production and nutritional quality

The cutting age is an important factor in forage quality. The longer the plant is exposed to adverse environmental factors (rain, wind, solar radiation), the greater the growth of the cell wall is, which limits the contents of other essential nutrients in the diet of ruminants (Kendall *et al.*, 2008). Table 3 shows the correlation between forage production and nutritional quality.

An inversely negative relation was observed in the parameters associated to yields (PG, GFP, and BP), the components of the cell wall (NDF), and DM, in relation to forage CP. Likewise, a positive relation was observed in the PG, GFP, and BP in comparison to DM and NDF. These results indicated that as pasture grows, the DM contents increase due to a gradual enlargement of the cell wall; therefore, the CP levels decrease. In that sense, other studies have demonstrated an inverse relation between forage production and nutritional quality, expressed in terms of digestibility and CP contents in *Dichantium* sp species. (Davis *et al.*, 2001; Ramírez, González-Rodríguez, García-Dessommes and Morales-Rodríguez, 2005; Lara-Mantilla, Oviedo Zumaqué and Betancur Hurtado, 2010).

The CE contents did not affect any variable evaluated, probably because ruminants use energy based on forage digestibility (Menke *et al.*, 1979; Poppi and McLennan, 1995). The above should be considered for hay-making, since production and quality must synchronize to achieve optimum results at cutting. Upon evaluating the relation between growth, production, and the nutritional quality of pastures, a common point was observed for variables CP, DM, and NDF, between 60 and 80 days (Fig. 1), which suggests that within that age range forage must be cut to achieve more than 4% protein.

It is also important to implement management practices that optimize forage growth to improve quality and production per hectare in the local livestock companies. The utilization of chemical fertilization and irrigation systems may be a viable technical and economic alternative to improve the indicators analyzed. Cruz (1996) pointed out that the *Dichanthium aristatum* varieties responded well to nitrogen fertilizers (more than 7 t/ha^{-1} on the 40^{th} day of age) when fertilization was applied after the tenth day of cutting.

Table 4 shows the linear regression equations, which included age as an independent variable. These results allow for field predictions of production and quality, if at least one of the PG (cm), GFP (t/ha^{-1}), BP ($units/ha^{-1}$), DM (%), or NDF (%) values is known.

CONCLUSIONS

Dichanthium annulatum (Forssk.) Stapf used for hay-making should be harvested before 60 days of age in order to make optimum use of the nutritional values of the plant. However, the productive and nutritional behaviors of this species must be further studied under fertilization conditions.

The nutritional quality parameters decreased with plant age; therefore, it is important to design strategies that maximize growth with higher productivity rates, and ensure that the harvested hay is high quality and fulfills the animal feeding requirements.

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Table 1. ***Growth and production of Dichanthium annulatum*** **(Forssk.) Stapf for hay production in La Dorada (Caldas)**

Cutting age days	PG Mean ± ET (cm)		GFP Mean ± ET (T ha^{-1}FM)		BP Mean ± ET (Unit ha^{-1})	
40	20.4 ± 0.9	a	5.87 ± 1.1	a	166 ± 20.9	a
50	24.0 ± 0.3	a	7.29 ± 0.7	a	167 ± 5.9	a
60	30.0 ± 2.2	ab	12.58 ± 3.1	b	342 ± 28.2	ab
70	42.0 ± 1.9	cb	14.53 ± 0.8	bc	487 ± 47.1	b
80	45.8 ± 2.1	c	19.42 ± 2.6	cd	778 ± 77.1	c
90	53.9 ± 2.8	cd	19.96 ± 1.4	d	911 ± 122.1	c
100	61.9 ± 1.6	d	23.60 ± 1.0	d	1220 ± 83.9	d

Unequal letters in the columns represent statistical significance (P<0.05)
PG: Plant growth (cm); GFP: Green forage production (T ha^{-1}MF); BP: Bale production (units/ha^{-1})

Table 2. Nutritional quality of *(Dichanthium annulatum)* (Fprssk) Stapf for hay production in La Dorada (Caldas)

Cutting age (days)	DM Mean ± ET (%)		CP Mean ± ET (%)		NDF Mean ± ET (%)		CE Mean ± ET (Mj)	
40	22.9 ± 0.8	a	7.9 ± 0.4	a	60.5 ± 0.3	a	16.182 ± 148	a
50	27.6 ± 0.3	ab	7.2 ± 0.7	a	67.0 ± 7.5	abc	16.010 ± 140	abc
60	28.5 ± 2.2	b	5.2 ± 0.8	b	65.2 ± 2.5	bc	15.592 ± 188	c
70	33.6 ± 1.9	c	5.2 ± 0.4	b	76.5 ± 8.5	abc	15.952 ± 144	abc
80	40.0 ± 2.1	d	3.8 ± 0.6	cb	81.1 ± 11.9	cb	15.632 ± 199	bc
90	45.5 ± 2.8	e	3.6 ± 0.4	cb	78.3 ± 6.3	abc	16.071 ± 143	ab
100	51.7 ± 0.8	f	3.2 ± 0.8	c	84.6 ± 4.9	c	16.048 ± 198	abc

Unequal letters in the columns represent statistical significance (P<0.05)
DM: Inclusion percent of dry matter; CP: Inclusion percent of crude protein; NDF: Inclusion percent of neutral detergent fiber; CE: Mega Joules of crude energy

Table 3. Correlation matrix between production and growth, and the nutritional quality of *(Dichanthium annulatum)* (Forssk) Stapf used for hay production in La Dorada (Caldas)

	PG	GFP	BP	DM	CP	NDF
GFP	+ 0.95 <0.0001					
BP	+ 0.96 <0.0001	+ 0.97 <0.0001				
DM	+ 0.91 <0.0001	+ 0.89 <0.0001	+ 0.96 <0.0001			
CP	-0.88 <0.0001	-0.90 <0.0001	-0.88 <0.0001	-0.87 <0.0001		
NDF	+0.75 0.0001	+0.75 <0.0001	+0.74 <0.0001	+0.70 0.0004	-0.75 <0.0001	
CE	-0.07 0.7722	-0.18 0.4545	-0.01 0.9925	+0.14 0.5570	+0.18 0.4296	+0.02 0.9036

PG: Plant growth (cm); GFP: Green forage production (Ton GF ha^{-1}); PP: Bale production (units/ha^{-1}), DM Inclusion percent of dry matter; CP: Inclusion percent of crude protein; NDF: Inclusion percent of neutral detergent fiber; CE: Mega Joules of crude energy

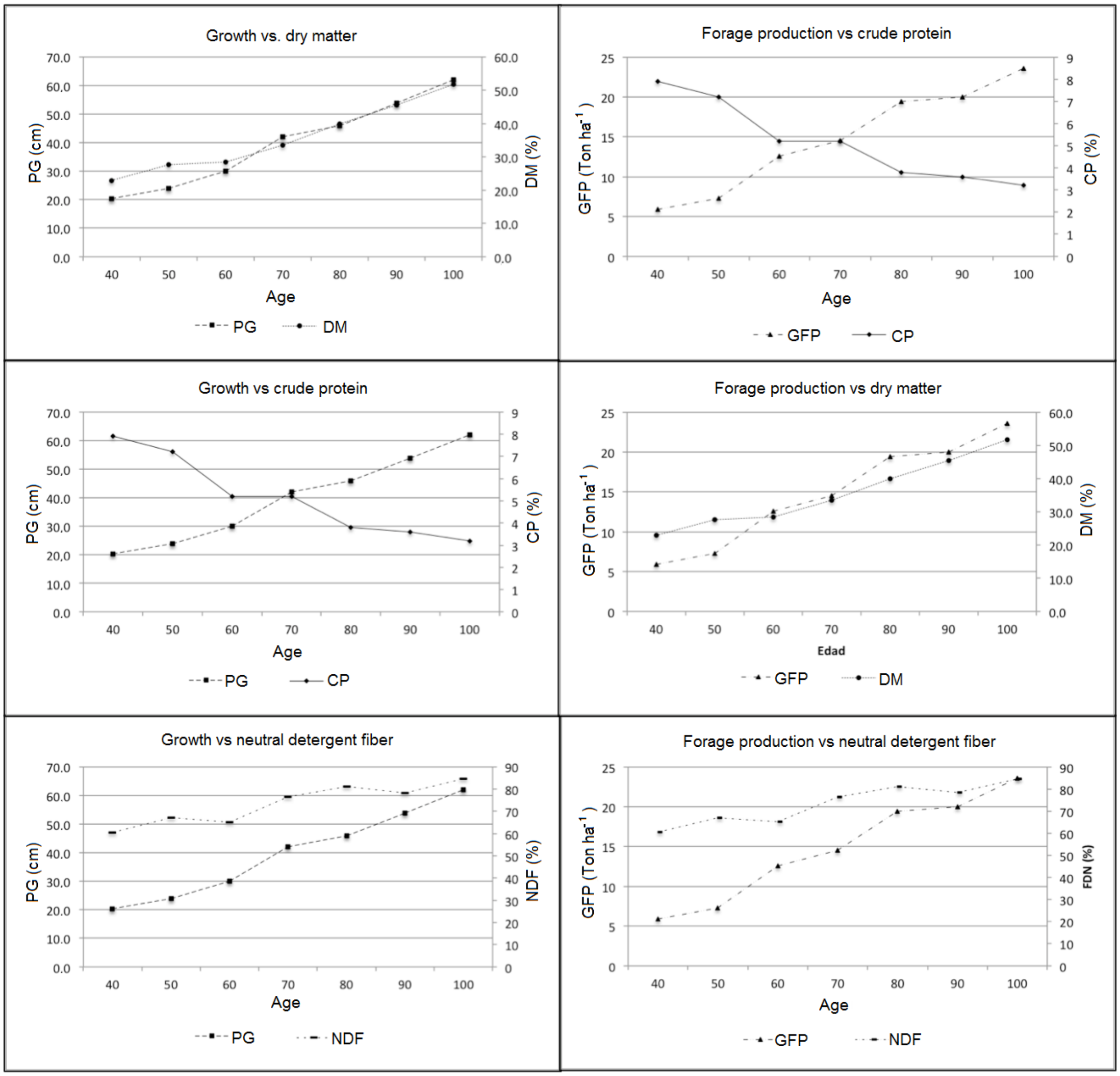

Fig. 1. Relation of growth, production, and nutritional quality of *Dichanthium annulatum)* (Forssk.) Stapf used for hay production in La Dorada (Caldas)

Table 4. Parameters of simple regression of *Dichanthium annulatum* (Forssk.) Stapf used for hay production in La Dorada (Caldas)

Variable	Intercept	Slope	Determination coefficient
PG (cm)	-10.3	0.714	0.908
GFP (T ha^{-1})	-6595.7	304.9	0.919
BP (T ha^{-1})	-68903	1 815.6	0.920
DM (%)	3.88	0.454	0.862
CP (%)	10.7	-0.078	0.799
NDF (%)	45.6	0.396	0.609

PG: Plant growth (cm); GFP: Green forage production (Ton GF ha^{-1}); PP: Bale production (units/ha^{-1}), DM: Dry matter percent; CP: Crude protein percent; NDF: Neutral detergent fiber percent.