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Original

Agronomic Performance of *Cenchrus purpureus* vc. Cuba OM-22 in Venezuelan Plains

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ABSTRACT

Background: *Cenchrus purpureus* vc. Cuba OM-22 is a promising forage type for Venezuelan cattle raising, due to its high production and quality. **Aim:** To evaluate the agronomic indicators, and their relation to the plant age, and climatic elements, during the rainy and dry seasons.
Methods: A uniformity cut was established at the end of each period. Height, length, and width of the fourth pair of fully-open leaves and internodes, leaf content and stems, foliar area, and yields, were determined every 15 days, for 75 days, following a randomized block design with four replications. The values of variance analysis were compared, according to the test of multiple range comparison of means, and the regression equations were set up.
Results: The agronomic variables showed significant differences ($p<0.05$) with re-shoot age increase, having a marked effect on the percentage of leaves and stems. Multiple linear equations ($P<0.001$) ($R^2>0.90$) on yield and percentage of age-related leaves and stems, as well as for the mean and maximum temperatures, and precipitations, were set. The performance curve kept the logarithmic phase up to 75 days, when higher values were observed.
Conclusions: Age and the climatic elements showed a marked effect on the agronomic indicators. The regression models showed a high correlation between the variables studied with the maximum temperature, and precipitations.
Key words: climatic factors, forage, leaf, stem, production (*Source: AIMS*)

INTRODUCTION

Using pasture and forage in the right moment is one of the undertakings of current cattle farmers must fulfill adequately to achieve good productions from animals and production areas. All this

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and related knowledge will contribute to a more efficient use of these important resources of animal production systems (Santana *et al*., 2019).

In Venezuela, as in other countries with a tropical climate, biomass production is unstable throughout the year (Álvarez-Perdomo *et al.*, 2017); so, Oliveira *et al*. (2017) assure that due to its high yields, *Cenchrus purpureus* is a choice to cover the seasonal unbalances on the farms. Because of the recent introduction of varieties of that genus in Venezuelan territory, and poor knowledge of its performance, there is a need to evaluate the agronomic performance of *Cenchrus purpureus* vc. Cuba OM-22 at different cutting ages, as well as its relation to elements of the weather, in the conditions of a specific area in Portuguesa State.

MATERIALS AND METHODS

Location, climate, and soil of the experimental area: The research was done on Simon Bolivar Farm, from the Socialist Dairy Joined Venture of Alba, in Tucupido, municipality of Guanare, Portuguesa State, Bolivarian Republic of Venezuela. It is located on coordinates 8º 56 19.78 north latitude, and 69º 51 27.39 west longitude, 165 meters above sea level, in the mid-western area of the country. The study was conducted during the rainy and dry months. The weather is humid tropical, with a mean annual temperature of 28 ºC, and varying annual precipitations (1400-1900 mm). The rainy season takes place between May and October, and the dry season occurs between December and March. November and April are transition months (Foghin-Pillin, 2002 and INE, 2011). Table 1 shows the behavior of the climatic variables during the experimental period.

Table 1. Behavior of the climatic variables during the experimental period

	Rainy season			**Dry season**		
	June	**July**	**August**	**December**	**January**	**February**
Max. T. (ºC)	30.9	30.6	31.7	30.9	32.4	33.5
Mean T. (ºC)	26.6	26.3	25.9	26.7	27.5	28.2
Min. T. (ºC)	22.3	21.9	21.8	22.9	22.6	22.9
RT (%)	92.3	91.6	90.8	85	74	71
PE (mm)	227.2	230.4	231.9	63.7	8.9	3.6

Source: Airport Weather Station, Guanare, Portuguesa. Max. T: maximum temperature; Mean T.: mean temperature; Min. T.: minimum temperature; RH: relative humidity; PE: precipitation.

Soil features

The soil where the experiment took place, according to Mancilla (2002), is in the area of High Plains, originated by sedimentation plains, with a flat topography. The soils are classified as Entisol (World Soil Resources Reports, 2006), with a clayish texture and smooth slopes. Draining is appropriate, with natural fertility, low mineral changes, and little base loss. The chemical composition of the soil is shown in Table 2.

Table 2. Chemical composition of the soil in the experimental area

pH	E.C (dS/m)	O.M (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Text.	Sand (%)	Clay (%)	Lime (%)
5.6	0.05	2.18	2	30	418	83	FA.a	50.8	26.4	22.8

Source: Laboratory of Soil Analysis and Processing UNELLEZ-Guanare (2011).
E.C: Electric conductivity; OM: Organic matter; P: Phosphorus; K: Potassium; Mg: Magnesium; Text: Texture.

Characteristics of the plant material

The plant material evaluated was *Cenchrus purpureus* vc. Cuba OM-22, with a high forage potential, which was introduced in Venezuelan territory as part of the Cuba-Venezuela Agreement. The seeds were provided by the Socialist Dairy Joined Venture of Alba, where the certified seed banks are ready for introduction, evaluation, and extension.

Treatment, design, and statistical analysis

A randomized block design was used, with four treatments (re-shooting ages of 30, 45, 60, and 75 days), and four repetitions. A 20 m^2 lot was used as experimental unit. The statistical analyses were performed with Statistica 10.0 (StatSoft, 2011), and the means were compared using Duncan's multiple comparison tests (1955). Correlation matrices were set up among the agronomic indicators and the climatic variables that characterized every experimental period.

Besides, multiple linear regression equations were set for these variables in the two periods, based on the correlation of indicators yield, and leaf and stem percentage. The selection considered high determination coefficients (R^2), and parameter significance level (Hocking, 1976).

Experimental procedure

The soil from the flat area portion with proper surface drainage was prepared conventionally without irrigation (plowing, harrowing, and furrowing). The area was planted in May, with four-month old agamic seeds, previously cut from three to five buds, which were inserted in the bottom of the furrow at 20 cm. Then they were covered with 10 cm of soil. The distance between furrows was 90 cm, and 60 cm between plants in lots of 20 m^2 of harvest area.

Each lot had four repetitions, and five plants were chosen for every age of the re-shoot. Then, an establishment cut was made between five and ten centimeters from the soil. The evaluation was started in June, following a year of establishment. Immediately after measurements, the material was cut and weighed using a 12 kg scale, with a 0.1 g deviation, to determine green and dry matter yields. The edge effect was considered.

Plant measurements

Determinations were made (cm) of the fourth fully open leaf; the length and diameter of the fourth internode, using a 0.05 mm caliper gauge; plant height from the base to the apex, using a millimeter rule; leaf and stem percentage (%), and foliar area (cm^2), according to the methodology described by (Herrera, García and Cruz, 2018).

RESULTS AND DISCUSSION

The values of the agronomic indicators in the rainy season (Table 3), increased with age, in general terms. As to height, differences were observed, with the highest value on day 75. The average was greater than the one reported by Ledea *et al.* (2017), on evaluation of varieties of Cenchrus in degraded ecosystems reported by Duarte *et al.* (2018), variety Roxo, in Brazil. For their part, the leaves showed a similar behavior, except at ages 45 and 60 days. The leaf-stem proportion reflected a greater ratio in the latter, from day 45 on, which was more striking as the plant aged, a normal process of the graminaceae.

Significantly, the increase of foliar area with aging corroborates the high photosynthetic capacity of this variety, higher than the one reported by Arango *et al.* (2017) on morphological evaluation of *Cenchrus clandestinus* in the high tropic of Colombia.

Ledea *et al.* (2018) evaluated three varieties of *Cenchrus purpureus* generated by tissue culture in the edaphoclimatic condition of Valle del Cauto, in the east of Cuba, and found similar results of leaf length at 60 and 75 days. It shows the morphological response of genus Cenchrus to the incidence of solar radiations common to the tropical belt, but even more striking in the tropic, particularly.

Leaf length is closely related to the climatic conditions of the area where pasture is grown (Sánchez-Santana *et al.*, 2019), which includes the irradiation level, light interception, precipitation, temperature, and wind velocity, which are other climatic variables linked to the physiology of the crop that also affect leaf morphology and the foliar area.

Table 3. Agronomic indicators of *Cenchrus purpureus* vc. Cuba OM-22 in the rainy season

Indicators	Re-shoot age, days					
	30	45	60	75	SE±	P
Ht, cm	118.5[a]	184.1[b]	221.9[c]	299.3[d]	6.15	0.004
LL, cm	55.8[a]	89.3[b]	90.0[b]	101.6[c]	1.73	0.006
LW, cm	2.8[a]	4.2[b]	4.1[b]	5.3[c]	0.08	0.002
IL, cm	3.3[a]	8.8[b]	9.7[b]	13.3[c]	0.34	0.005
ID, cm	2.1[a]	2.3[a]	2.3[a]	3.1[b]	0.05	0.02
LP, %	57.3[a]	37.9[b]	31.7[c]	21.2[d]	1.10	0.0001
SP, %	42.7[a]	62.1[b]	68.3[c]	78.8[d]	1.10	0.0005
FA, cm^2	156.6[a]	375.3[b]	368.3[b]	541.7[c]	12.67	0.004

[abcd] Unequal superindex values on the same row differ for $p<0.05$

Ht: Height; LL: Leaf length; LW: Leaf width; IL: Internode length; ID: Internode diameter; LP: Leave percentage; ST: Stem percentage; FA: Foliar area.

The agronomic indicators in the dry season (Table 4) behaved as in the rainy season. Leaf percentage was high at 30 days of re-shooting ($p<0.05$); however, it dropped considerably with aging, having differences in all the treatments, which may be related to physiological mechanisms of response that the plant developed due to the lack humidity for solute transportation and the development of new structures (Herrera, García and Cruz, 2018; Álvarez *et al*., 2019).

Table 4. Agronomic indicators of *Cenchrus purpureus* vc. Cuba OM-22 in the dry season.

Indicators	Re-shoot age, days					
	30	45	60	75	SE±	P
Ht, cm	83.5^{a}	112.3^{b}	151.3^{c}	117.3^{d}	3.69	0.003
LL, cm	62.8^{a}	80.0^{b}	95.5^{c}	105.8^{d}	1.68	0.009
LW, cm	2.9	2.9	3.9	3.8	0.06	0.1
IL, cm	2.8^{a}	2.9^{a}	3.4^{a}	6.0^{b}	0.12	0.02
ID, cm	1.6^{a}	2.2^{b}	2.1^{b}	2.4^{b}	0.04	0.03
LP, %	69.1^{a}	46.7^{b}	39.7^{c}	24.9^{d}	1.55	0.0001
SP, %	30.9^{a}	53.3^{b}	60.3^{c}	75.1^{d}	1.55	0.0002
FA, cm^2	188.0^{a}	235.7^{a}	379.4^{b}	401.1^{c}	9.80	0.001

^{abcd} Unequal superscript values on the same row differ for $p<0.05$
Ht: Height; LL: Leaf length; LW: Leaf width; IL: Internode length; ID: Internode diameter; LP: Leave percentage; ST: Stem percentage; FA: Foliar area.

Likewise, Álvarez *et al.* (2019) found similar results to this research during the dry season in Valle del Cauto, Cuba. However, some indicators were lower for the same age of re-shooting. Moreover, Reyes-Pérez *et al.* (2019) evaluated productivity and quality of two varieties of *Cenchrus purpureus* (Morado and Maralfalfa) in the area of Mana, Ecuador, and they found that the best leaf stem ratio was established during the early age of re-shoot, as in this study.

When the ratios were established among the yield indicators, age, and climatic factors (Table 5), the multiple linear regression equations were adjusted for the rainy season of all the productive variables with age, maximum temperatures, and precipitations, using R^2 coefficients above 0.96.

Whereas, for the dry season, multiple linear regression equations were adjusted in terms of yields (t DM ha^{-1}) to age, maximum temperatures, and precipitations (R^2 0.99). To determine the leaf and stem percentage, the mean and maximum temperature values, and age were adjusted to R^2 values above 0.94.

Table 5. Better fit adjustment models of *Cenchrus purpureus* vc. Cuba OM-22 in the rainy and dry seasons

Indicator	Equation	R^2
	Rainy season	
Yields (tDM/ha)	505.37+0.62(±0.07)A-17.06(±1.65)Max T+0.16(±0.006)PE	0.99
Leaves (%)	508.5-0.61(±0.07)A-14.66(±1.75)Max T+0.04(±0.06)PE	0.96

Stems (%)	-408.5+0.61(±0.07)A+14.65(±1.75)Max T-0.04(±0.07)PE	0.96
Dry season		
Yields (tDM/ha)	122.91+0.67(±0.05)A-4.16(±0.43)Max T-0.63(±0.17)PE	0.99
Leaves (%)	503.14-0.61(±0.06)A+13.34(±3.12)Max T-33.24(±7.12)Mean T	0.94
Stems (%)	-464.06+0.62(±0.06)A-13.24(±3.13)Max T+33.16(±3.14)Mean T	0.96

P<0.001. A: age; Max T: maximum temperature; PE: precipitations; Mean T: mean temperature; R^2: Determination coefficient.

In both seasons, the parameters were significant. The variability explained by the models was high, and similar, with determination coefficient above 90%. This indicates the precision of the models suggested to explain the biological process. It had greater variability (CME and SE±) in the rainy season compared to the dry season in terms of yields. This behavior occurs thanks to the fact that in the former, soil moisture is higher, which makes the plant express its highest productive potential, and gather high quantities of biomass (Martínez and González, 2017; Uvidia-Cabadiana *et al*., 2018, and Reyes-Pérez *et al.*, 2019).

Hence, Rojas and Guerra (2010), and Herrera *et al.* (2017) claimed that the growth of pasture may be described through mathematical functions that predict the behavior of height and biomass production. They allow for evaluation and simple classification of the productivity of a species in a given area.

During the evaluation and prediction of the productive performance of *Cenchrus purpureus* vc. Bermuda grass, with different cutting frequencies, and nitrogen fertilization levels, Márquez *et al.* (2007) found that they fit a mix non-linear regression model, and another model of categorical regression. In this research, R^2 accounted for 70.67% of total yield variability, a lower value than this work. However, Ramírez (2010) modulated the accumulated DM yields of Cenchrus varieties, and other graminaceae, and found better fit models.

Importantly, Herrera, García, and Cruz (2016; 2018), on evaluation of the effect of the cutting frequency and nitrogen fertilization on the productive behavior of cross Elefante and Bermuda grass, through quadratic linear regressions, achieved determination coefficients that varied between 85 and 99%, similar to the ones found in this work, in the two seasons.

Figure 1 shows the evolution of dry biomass production depending on age.

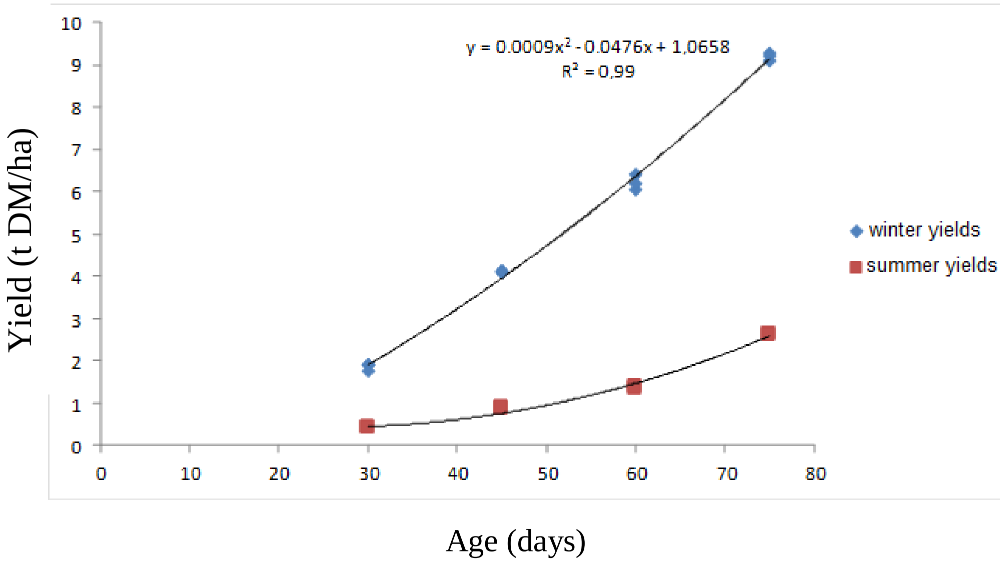

Figure 1. Yields of *Cenchrus purpureus* vc. Cuba OM-22 in the two seasons

During the rainy season, this variety underwent the highest growing speed, expressed in the production of biomass, which coincided with the logarithmic phase of the pasture, in relation to a positive balance between photosynthesis and respiration, similar to Herrera, García and Cruz (2016), and Reyes-Pérez *et al.* (2019). The lowest forage productivity was observed in the dry season, which was determined by the high temperatures, low soil moisture, and shorter days. However, Ramírez (2010), in Valley of Cauto, found similar results in a study of five recently introduced graminaceae at different cutting ages.

The forage accumulation curves help understand and make decisions in relation to other crops under specific conditions (Cruz *et al.*, 2017; Ray *et al.*, 2018). In this particular variety, proper use may generate and help implement programs that favor identification of parameters of economic and productive interest, which cannot be overlooked when a decision should be made to foster productivity.

CONCLUSIONS

Age and the elements showed a marked effect on agronomic indicators. The regression models showed a high relation of the variables studied with the maximum temperature, and precipitations.

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AUTHOR CONTRIBUTION

Conception and design of research: YAB, JRR, DVA, YAB, RRB, RHG. Data analysis and interpretation: YAB, JRR, RRB, DVA, RHG, YAB. Redaction of the manuscript: YAB, JRR, DVA.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.