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Characterization of the yield and quality of five accessions of Cenchrus purpureus (Schumach.) Morrone

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ABSTRACT: The study was conducted at the horse rearing farm Los Limones, located in Jagüey Grande (Matanzas), in order to evaluate the yield of five accessions of *Cenchrus purpureus* (Schumach.). Morrone under production conditions. The treatments were the accessions king grass, OM-22, CT-169, Taiwán morado and CT-115. The plant height, total DM yield, leaf yield, stem yield, CP content, CF content and digestibility were measured. To analyze integrally the results a factorial analysis was made through principal components, using the Varimax method; for such purpose the accessions that had a similar performance from the impact indexes were analyzed and the cluster history and the association degree among the compared elements were taken into consideration. CT-169 and king grass were significantly higher ($p < 0{,}001$) in height than the other accessions. King grass showed significant difference in the total DM yield and in the stem yield with regards to the others, in the year as well as in the dry season. OM-22 and Taiwán morado achieved the highest CP percentage in the leaves and stems. From the productive point of view the best accessions were OM-22 and Taiwán morado, which showed a higher leaf proportion with regards to the total DM yield and stood out for their CP content and their acceptable digestibility. The performance in yield and quality of the accessions contributed to show the productive potentials of *C. purpureus* on the soils of the locality.

Keywords: digestibility, height, yield

INTRODUCTION

Cenchrus purpureus is largely extended throughout the tropical zone and is used as forage basis for feeding cattle, sheep and goats. However, belonging to the family of grasses, it has a limited nutritional value due to its low protein and energy content. Nevertheless, the *Cenchru*s varieties convert 23 % of the solar radiation they receive, value higher than that of energy sugarcane and the other grasses, and in their growth cycle they accumulate biomass until six months of age (Milera *et al*., 2010).

It has been observed that one hectare of CT-115 is capable of storing between 12 and 25 t of DM in the rainy season to be used in the dry season, with 90-120 resting days; while in the dry season the yields vary between 4 and 8 t DM depending on rainfall, the productive category of the soil and the establishment time of the pasture. The chemical and organic fertilization can modify this performance and renovate the vigor of the fields (Martínez *et al*., 2010).

Studies conducted in Cuba with other clones have shown that the improved *Cenchrus purpureus* varieties can have higher production and digestibility of their components (leaf, stem, whole plant); these varieties have lower content of lignin and cell wall.

Since 1981, the Institute of Animal Science (ICA, for its initials in Spanish) started to release varieties obtained by tissue culture or crossing (Martínez *et al*., 2010), as in the case of the varieties Cuba CT-115 (CT-115), Cuba CT-169 (CT-169) and the hybrid Cuba OM-22 (OM-22).

Taking into consideration these antecedents, the objective of this research was to evaluate the yield and quality of five *C. purpureus* accessions under production conditions, on a quartzitic Ferralitic Red soil.

MATERIALS AND METHODS

Location. The trial was conducted at the horse-rearing farm Los Limones, located between 22º 30’ and 22º 50’ North latitude and 88º 35’ and 88º 51’ West longitude, in the Jagüey Grande municipality, Matanzas.

Soil and climate characteristics. During the experimental period the annual rainfall was 1 213,4 mm, from which 90,8 % corresponded to the rainy season. The mean temperature value was 24,8 ºC.

The soil is classified as quartzitic Ferralitic Red, of acid pH (4,5-5,2), with an OM content of 2-5 %, low cation exchange capacity (< 20 cmol kg^{-1}), low natural fertility, and it shows a thick ironstone layer in its profile. The texture is deep clayey, the topography is flat, and it shows good internal and external drainage (Hernández *et al*., 1999).

Treatments and experimental design. The treatments consisted in five *C. purpureus* accessions (king grass, OM-22, CT-169, Taiwán morado and CT-115). A randomized block design with five replications was used, and the trial lasted for 16 months (four months of establishment).

Experimental procedure. The soil preparation was made though the conventional method; the land was furrowed every 1 m at 20 cm of depth and deep fertilization was applied at a rate of 0,5 t/ha, with the formula 0-20-30 (NPK). For planting certified vegetative seed from the germplasm bank of the ICA was used, with 90 days of age; twenty stems of three buds were placed in each furrow of 5 linear meters, with the tips overlaid (basal section with the top section), equivalent to 4-5 t/ha and twelve buds per linear meter.

Irrigation was applied in the dry season, in an interval of 15-20 days, with a norm of 250 m^3/ha.

The total surface was 1 330 m^2, with an experimental area of 625 m^2, distributed in 25 plots of 25 m^2, separated by 2 m between them. The trial started after the establishment cutting and 12 m^2 were harvested, once the edge effect was eliminated.

The cuttings were performed every 60 days in the rainy season and every 90 days in the dry season, at 20 cm above the soil, and fertilization was applied after each cutting with a dose of 50 kg N/ha.

Measurements. Five plants were selected in each plot to measure height. The leaves and stems were packed separately to determine DM (%) in stove at 60 ºC, until reaching constant weight.

The dry samples were ground (in a Culatte Lyps mill, with a sieve of 1 mm diameter) and were stored in glass flasks with airtight closing, to be sent to the laboratory of analytical chemistry of the ICA, where the CP, DM and CF contents were determined; as well as the digestibility of the leaves and stems, according to AOAC (1995). In addition, the leaf, stem and total DM yield was calculated, per season and year.

Statistical analysis. A variance analysis was applied and for the mean comparison Duncan's (1955) test was used.

A principal component analysis was also made through the statistical model proposed by Torres *et al*. (2008), from which the following steps were developed:

a. With the obtained data of the studied variables in the five accessions the data matrix to be processed was constructed.
b. Testing of the application premises of the multivariate methods, using the correlation matrix.
c. Identification and selection of the importance order of the variables in the explanation of the yield variability.
d. Classification of the evaluations (varieties) according to the variables related to the yield, according to the criteria impact index and group formation.

The results obtained by developing the four above-listed steps allowed to define the better-performance group regarding yield.

The data processing was carried out with the statistical packages Infostat and SPSS 15.1 for Windows (Visauta and Martori, 2003).

RESULTS AND DISCUSSION

The height after one year of evaluation was significantly higher (p < 0,001) in CT-169, king grass and CT-115 than in the other accessions (table 1), result which coincides with the ones obtained by García (2011) when evaluating the growth dynamics in four *C. purpureus* cultivars. During the rainy season (RS), OM-22 and Taiwán morado, without differences between them, were significantly lower than CT-115 and king grass. In the dry season (DS), OM-22 reached the lowest height and differed from the other accessions.

A similar performance with regards to OM-22 during the DS was reported by García (2011). Likewise, Martínez (2012) stated that the stems of OM-22 stand out for having a low size in the dry season (85 cm with 90 days of regrowth).

Chamorro *et al*. (2011a), when evaluating during the dry season nine *C. purpureus* materials under the conditions of the warm valley of the Alto Magdalena, obtained at 45 days of regrowth the highest response in CT-115, which did not differ from CT-169, but it was higher than Napier and king grass.

Table 1. Plant height (cm).

Accession	Period		
	DS	RS	Annual
King grass	116,40^{bc}	147,40^{c}	135,08^{b}
OM-22	83,40^{a}	132,40^{ab}	112,96^{a}
CT-169	122,80^{c}	143,80^{c}	135,32^{b}
T. morado	103,00^{b}	127,80^{a}	118,20^{a}
CT-115	116,80^{bc}	140,80^{bc}	131,16^{b}
SE ±	4,48***	3,19*	3,16***

Values with different superscripts differ in the same column at $p < 0,05$ (Duncan, 1955)
*p<0,05 “””p<0,001

This performance of height in the DS could be due to the lower temperatures, to days of short duration and low light intensity and to lower rainfall, which are characteristic of this season.

The DM yield (table 2) was higher in king grass, which differed significantly from the other accessions, in the rainy season as well as in the annual total. This could be related to the largest height that this accession reached in such season, although without significant differences with regards to CT-169 and CT-115, and coincides with the results obtained by Wagner and Colón (2014).

In the DS no significant differences were found among the accessions; the yields were low and, according to Herrera and Ramos (2006), all seems to indicate that in this period there is a problem in the efficiency of light utilization or its conversion into chemical energy, which is expressed in the yields

Regarding the leaf yield (table 3), it was found that in the annual accumulated quantity king grass, without differing from OM-22, showed the highest value. In the DS no significant differences were observed among the accessions, and in the RS the highest yield was found in king grass, OM-22 and Taiwán morado, which differed significantly from the others.

According to Chamorro *et al.* (2011b), a higher amount of leaves in grasses is an indicator of the photosynthetic capacity and of a higher concentration of nutrients, which allows the plants higher productivity, for which it is a good indicator of yield.

Cultivar OM-22 is advisable for its high proportion of long and wide leaves, with regards to king grass; and, thus the material received by the animal with equal cutting age as this last cultivar shows a higher leaf proportion. In addition, the absence of hairs in the leaves of OM-22 allows manual cutting (Martínez *et al.*, 2010).

Regarding the stem yield in DM, in the rainy season and in the annual total (table 4) king grass was significantly higher ($p < 0,001$) than the other accessions, which did not differ among themselves. In the rainy season, the lowest yield was reached by Taiwán morado and CT-169, without differences between them.

The yield of king grass in the year coincides with the one obtained by Martínez (2012), and was

Table 2. Dry matter yield (t/ha).

Accession	Period		
	DS	RS	Annual
King grass	15,28	21,88^{c}	37,16^{b}
OM-22	11,16	19,20^{b}	30,36^{a}
CT-169	13,12	17,16^{a}	30,28^{a}
T. morado	10,66	16,68^{a}	27,34^{a}
CT-115	11,18	18,12^{ab}	29,30^{a}
SE ±	1,49	0,61***	1,40*

Values with different superscripts differ in the same column at $p<0,05$ (Duncan, 1955)
*p<0,05 ***p<0,001

Table 3. Leaf yield (DM, t/ha).

Accession	Period		
	DS	RS	Annual
King grass	5,38	9,14[b]	14,52[b]
OM-22	5,86	7,98[b]	13,84[ab]
CT-169	5,34	7,32[a]	12,66[a]
T. morado	4,94	7,50[ab]	12,44[a]
CT-115	5,00	7,12[a]	12,12[a]
SE ±	0,56	0,25*	0,56**

Values with different superscripts in the same column differ at p<0,05 (Duncan, 1955)
*p<0,05 **p<0,01

Table 4. Stem yield (DM, t/ha).

Accession	Period		
	DS	RS	Annual
King grass	8,92	13,72[c]	22,64[b]
OM-22	5,32	9,82[b]	15,14[a]
CT-169	8,12	9,50[ab]	17,62[a]
T. morado	6,64	8,26[a]	14,90[a]
CT-115	7,36	9,78[b]	17,14[a]
SE ±	0,95	0,37***	0,89***

Values with different superscripts in the same column differ at p<0,05 (Duncan, 1955)
***P<0,001

slightly lower than the one reached by this same author in the dry season.

Table 5 shows the performance of protein, fiber and digestibility of the leaves in the five *C. purpureus* accessions. The cv. Taiwán morado showed significant difference ($p < 0,001$) in the protein content and the digestibility, in the two seasons. The fiber content during the rainy season was similar to that of CT-169 and king grass, without difference between them.

According to Martínez (2004), the international reports indicate that in *C. purpureus*, with regrowths between 30 and 40 days old, the crude protein ranges in the leaves are between 12 and 14 %. Similar values were obtained in this work, but with 15 days less of regrowth.

Regarding the stems, their quality was lower in both seasons in all the accessions, with regards to that of the leaves (table 6).

Table 5. Leaf quality (%).

Accession	CP DS	CP RS	CF DS	CF RS	DIG. DS	DIG. RS
King grass	9,79[a]	8,99[a]	33,69[ab]	36,88[abc]	53,02[b]	50,89[b]
OM-22	11,43[bc]	10,76[b]	38,62[c]	35,84[a]	51,68[ab]	49,87[ab]
CT-169	12,04[c]	10,86[b]	33,90[b]	37,95[c]	50,10[a]	48,64[a]
T. morado	12,69[d]	11,70[c]	31,91[a]	37,26[bc]	56,07[c]	55,51[c]
CT-115	11,32[b]	8,61[a]	38,61[c]	36,67[ab]	51,58[ab]	51,67[b]
SE ±	0,21***	0,25***	0,59***	0,38**	0,03***	0,25***

Values with different superscripts in the same column differ at p<0,05 (Duncan, 1955)
**p<0,01 ***p<0,001

Table 6. Stem quality (%).

Accession	CP DS	CP RS	CF DS	CF RS	DIG. DS	DIG. RS
King grass	5,66^{a}	3,86^{a}	37,63^{ab}	40,72^{c}	46,96^{b}	47,91^{b}
OM-22	6,83^{b}	6,93^{c}	36,85^{a}	37,31^{a}	42,44^{a}	46,33^{a}
CT-169	5,56^{a}	6,71^{c}	40,81^{c}	39,50^{b}	43,67^{a}	47,43^{b}
T. morado	7,15^{b}	6,44^{c}	37,43^{ab}	43,43^{d}	45,96^{b}	47,27^{ab}
CT-115	5,45^{a}	5,53^{b}	39,25^{bc}	39,61^{b}	46,11^{b}	47,38^{b}
SE ±	0,18***	0,20***	0,71*	0,34***	0,41***	0,32**

Values with different superscripts in the same column differ at p<0, 05 (Duncan, 1955)

*p<0, 05 **p<0,01 ***p<0,001

Ramos-Trejo *et al*. (2013) state that one disadvantage of OM-22 is its low protein content; however, in this study it was over 10 % and did not differ from the one found in king grass. To increase the protein of this accession, an alternative can be its association with a legume.

It has been considered that the two factors with the highest incidence on the zootechnical response in ruminants are voluntary intake and digestibility. Taking this into consideration, an analysis was made of digestibility in the leaves, stems and plants. The results were similar to the ones obtained by Chamorro *et al*. (2011a) for Napier grass.

Taking into consideration that it is difficult to identify the best accession through independent variables, a factorial analysis by means of principal components was carried out using the Varimax method (table 7), to determine the impact index and form the groups. This index has been used in the country to measure the impact of the introduction of Cuba CT-115 in the Livestock Genetic Enterprise of Mayabeque (Rodríguez *et al*., 2014) and to characterize the factors that influence milk production in farms of the Ciego de Ávila province (Martínez-Melo *et al*., 2013).

Table 8 shows the impact of the two components selected in the variables for the estimation of yield, when different accessions are evaluated. To explain each case the selection of the variables that appear in table 7, in which those that were represented in

Table 7. Variability of the principal components according to the Varimax method.

Variable	CP1	CP2
Total yield (t/ha)	0,903	0,429
Leaf yield (t/ha)	0,989	-0,116
Stem yield (t/ha)	0,780	0,614
Plant height (cm)	0,071	0,994
Proper value	2,41	1,56
Explained variance (%)	60,19	39,06
Accumulated variance (%)	60,19	99,25

Table 8. Impact of the variables.

Accession	Imp CP1	Imp CP2
King grass	1,51172	0,71447
OM-22	0,53252	-1,37864
CT-169	-0,52298	0,76270
T. morado	-0,74510	-0,75720
CT-115	-0,77616	0,65867

CP1 as well as in CP2 are observed, should also be mentioned.

According to the impact indexes expressed in table 8, in king grass the variables total yield and leaf yield were more efficient, that is, it is in this accession where the variables of CP1 were better expressed; while Taiwán morado and CT-115 represented the accessions with the worst performance for total yield and leaf yield (CP1).

The variable plant height, which is related to the CP2 (table 8), showed the highest effect in accessions CT-169 and king grass; while in this same component the effect was negative for OM-22, from which it is deduced that in this accession such variable was worst expressed.

From the impact indexes (table 8) the existence of accessions with similar performances was analyzed, so that the responses of the studied variables allowed to estimate, as a whole, the pasture yield.

In the clustering process the cut was made for a certain value of the dissimilarity coefficient (table 9), which originated the classification of the yield and the group formation.

To decide the cut the clustering history was examined and the rule of selecting the coefficient when the successive values among the clustering steps showed a sudden jump, was applied.

The average values of the variables related to yield, for each group, are shown in table 10.

In group I the highest average value was found for the variables total yield, stem yield and plant height; the first is among the ones identified in CP1 as having the highest variability, just like height, which was related to CP2. Table 8 shows that the highest positive value of the impact index (Imp CP1) was observed in king grass; while this same accession and CT-169 showed the best performances for Imp CP2; they are both accessions belonging to group I.

Group II included the accessions which not only had lower height, but that also showed the lowest total yield and stem yield values (table 10). This group includes OM-22, accession which showed the highest negative value for the impact index in CP2, component related to the variable height. OM-22 as well as Taiwán morado (group 2) showed negative values of the impact index in the two components (table 8).

According to the results of the statistical analysis, group I, formed by the accessions king grass, CT-169 and CT-115, showed a better performance of the variables related to the estimation of plant yield; nevertheless, group II, with a lower result, was integrated by accessions with higher leaf percentage (45,4 % for II and 40,5 % for I, respectively), besides showing higher quality. In this sense, the CP values of OM-22 were higher than the ones found by Ramos-Trejo *et al*. (2013) when using a higher dose of nitrogen fertilization, which endorses this accession as promising for the conditions under which the evaluation was conducted. Also Miranda *et al*. (2012) stated that this accession is adapted to the hydric stress and to the conditions without irrigation, without fertilization, on soils of low natural fertility.

CONCLUSIONS

From the productive point of view the best accessions were OM-22 and Taiwán morado, which showed a higher proportion of leaves with regards to the total DM yield and stood out for their CP content and acceptable digestibility.

The performance in yield and quality of the accessions contributed to show the productive potentials of the genus *Cenchrus* in the local soils.

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Table 9. Groups formed by the cluster analysis.

Dissimilarity coefficient	Group	Accessions
1,05	I	King grass CT-169 CT-115
	II	OM-22 T. morado

Table 10. Average values and deviations of the variables related to the yield for each formed group.

Group	Total yield (t/ha)		Leaf yield (t/ha)		Stem yield (t/ha)		Height (cm)	
	x	DS	x	DS	X	DS	x	DS
I	32,27	4,30	13,07	1,27	19,10	2,77	133,90	2,01
II	28,85	2,19	13,10	0,99	15,60	1,27	115,55	3,75

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