Journal of Animal Production 29 (3), 18-28, 2017

Agronomic Behavior of *Cenchrus purpureus* Varieties Tolerant to Salinity

José Leonardo Ledea Rodríguez, Diocles Guillermo Benítez Giménez, Ramón Crucito Arias Pérez and Adania Guerra Manso

Jorge Dimitrov Center for Agricultural Research, Experimental Station of Pastures and Forages, Bayamo, Cuba

ledea@dimitrov.cu

ABSTRACT

A study was made at the Experimental Station of Pastures and Forages, at the Jorge Dimitrov Agricultural Research Institute to determine the effect of cutting age (60, 90, 120 days), and cultivar (CT-500 and CT-115) of new varieties of Cenchrus purpureus on some yield components . The effects of cutting age (3), cultivar (2), and their interaction (3 x 2), on yields and some agronomic variables were controlled by a randomized block design. Interaction did not to affect the morphological variables of leaves and stems, though it did affect plant height. The cultivars had significant differences ($P < 0.001$) for the ages of 60 and 90 days; whereas for the number of basal shoots and percent of dry matter in the whole plant, CT-115 was significantly higher at 60 and 120 days, respectively. The total growth rate and biomass duration significantly phased out at 90 days, in favor of CT-500. Both varieties showed potential for high dry matter production per hectare, and only differed ($P < 0.001$) from the 120 days in the forage areas with saline soils. These results must be considered as preliminary data for the design of a variety structure in saline forage areas.

Key words: *morphology, productivity, Cenchrus purpureus, Pennisetum purpureum*

INTRODUCTION

In Latin America, the ecosystems are changing due to the effects of climate change and inappropriate agricultural practices, which cause soil degradation in grazing areas that reduce production and persistence of pastures and forages (Pérez-Infante, 2013).

The same situation is produced in Cuba, also influenced by climatic change and annual rainfall occurrence, which along with the effects of temperature, solar radiation, long droughts and increasing salinization of soils, make pasture yields unstable throughout the year (Argentel, Yépez and de los Santos, 2016). These conditions are more striking in the eastern part of the country, with prolonged droughts, high evaporation, and precipitation/evaporation coefficient below 0.45, typical of arid regions (Benítez, Cisneros, Pérez-Infante and Nuviola, 2010).

The Cauto Valley is a plain irrigated by the Cauto River basin, in the east of Cuba. It spreads out 4.5 thousand km^2, covering regions of four Cuban provinces (Holguín, Tunas, Santiago de Cuba, and Granma), where 90% of local livestock raising takes place (Fajardo, 2008). The valley area that sits in the province of Granma extends from the borders of the Sierra Maestra Mountain Range in the south, to the Guacanayabo Gulf, and the borders of the coastal plains in the west; to Santiago de Cuba in the east; and Tunas, and Holguín in the north (Benítez *et al*., 2007).

The variability of atmospheric and meteorological changes promotes dynamic transformations in the direction of humid winds (ONEI, 2015). So rainfall is mainly produced in the northern coast of the region, causing a long seasonal drought in the valley. This phenomenon coincides with negative edaphic effects like, erosion (13.5%), low fertility (11%), poor draining (22.8%), and depletion of ground water sources (25%), whose overall impact are overlapped (Benítez, Cisneros, Pérez-Infante, and Nuviola, 2010). On top of it, salinization accounts for 38% of the area (Álvarez, 2009).

To stabilize forage production in Cuba under such extreme conditions, in 2000, a program to foster *Pennisetum purpureus* cultivars, resistant to droughts (CT-115), was initiated (Herrera *et al*., 2003). As a result, high salinity tolerant clones were generated. Herrera (2000), after molecular characterization of these plants through electrophoresis of more than five isoenzymatic systems, proved their variety condition, later corroborated for five generations with the same initial features.

Then, in 2011, the Center for Animal Science donated them to the Jorge Dimitrov Center for Agricultural Research, in order to broaden the existing germplasm, and to strengthen the main feed sources in fragile and degraded ecosystems in the Cauto Valley.

The aim of this study was to evaluate the agronomic behavior of varieties CT-500 and CT-115 at different cut ages during the rainy season, for the particular edaphoclimatic conditions of the Cauto Valley.

MATERIALS AND METHODS

Location and behavior of climatic factors in the experimental area

The study was made in the rainy season (May-October) in 2014. The experiments were carried out at the Experimental Station of Pastures and Forages, from the Jorge Dimitrov Center for Agricultural Research, in the province of Granma, Cuba. It is located on the 20º 18´13" north latitude, and 76º 39´ 48" west longitude.

The local climate classifies as relatively humid tropical (Barranco and Díaz, 1989). The station is located in an area where the high, mean, and low temperatures are 35.4, 27.1, and 20.3 ºC, during the rainy season; and 34.9, 24.8, and 14.8 ºC, in the dry season, respectively. In both seasons, relative humidity ranges between 77.8 and 72.7 %, respectively, with high evaporation values in the rainy season (216.2 mm), and in the dry season (191.9 mm) (Ledea, 2016). The behavior of precipitations during the study is shown in Fig. 1.

The soils are differentiated fluvisol (Hernández *et al*., 2015). Peña, Álvarez and Díaz (2002) in soil profile studies in the Cauto Valley found that 33.3% of negative effects were caused by salinization, with 100% in the location of the experimental station, with salinization levels between weak and mid-saline. The effective depth varies from deep (91-150 cm) to shallow (25-50 cm). It has poor draining, with a flat topography. Its natural fertility is within mid and low, with an acid pH. Table 1 shows the chemical traits.

Characteristics of the plant material used

The plant material for the seed banks was supplied by the Department of Pastures and Forages of the Animal Science Institute. The CT-500 obtained by tissue culture of CT-115 was used in the study; the latter was used as control. Both cultivars were established in 10 x 20 m lots (200 m^2), with 0.75 m among plants, and a meter between rows.

Treatment, design and statistical analysis

Factorial arrangement was made according to a randomized block design with four replicas, to evaluate the behavior of some agronomic variables and the yields of dry matter per hectare. Variance analyses were performed, using linear models to control the effects of re-shooting age (3), variety (2), and their interaction (3 x 2), with a total of 120 observations. For normal data distribution, the Kolmogrov-Smirnov test (Massey, 1951) was made; variance homogeneity was measured using the Bartlett test. The means were compared through the Newman-Keuls (Keuls, 1952). StatSoft 10.0., for Windos, was used. The mathematical model used in the analyses was,

Yijk=μ+Ri+ECj+Vk+ (EC x V)jk+eijk

Yijk=Variable response

μ: common constant for all the observations

Ri: effect of i-th replica (i=1, ….,4)

ECj: effect of j-th cutting age (j=1,…., 3)

Vk: effect of k-th variety (k= 1, 2)

(EC x V)jk: combined effect of j-th cutting age on k-th variety

eijk: random error ~ N (0, σ2e)

Experimental procedure

The seed banks used two inserted rows that coincided with every cutting age evaluated (60, 90, and 120 days). Sub-lots were formed (4.50 m long); each sub-lot had four replicas, and five plants were chosen for their respective cutting age in each variety. Cutting was made after measurements to estimate the yields of green matter. To achieve that, the edge effect was removed (the outer rows and 50 cm at both ends of every row). Normalization cut was made on March 2014 to achieve homogeneous experimental material. Then, the rows were plowed and 20 t.ha-1 of organic matter was applied to the soil.

Plant measurements

At cutting time, five plants were chosen per replica, and their leaves, stem, and dead materials, were removed, using stainless steel shears. Later, the methodology suggested by Herrera *et al*. (2003) was applied to measure plant height (from the base to the apical cone, using a meter ruler), the number of green leaves, percent of stems, and the number of basal shoots from the culm.

The fourth leaf was selected to measure length and width, according to Herrera (2006). The leaf width was estimated from the average of measurements made with a millimeter ruler to the base, mid, and apical segments, whereas the estimation of length started at the base and way up the apex (millimeter ruler). Stem thickness was estimated by measuring the fourth internode with a 0.05 mm gauge meter (СДЕЛАНО).

The percentage of green leaves and dead materials (DM%) were considered. Also included were the number of nodes and internodes, green stem percentage, dry matter yields per hectare, and the content of dry matter from leaves, stems, and whole plant. The leaf-stem-dead material ratio estimation required a sample of 200 g of green mass, from which the dry matter of each component was determined, according to Herrera (2006).

RESULTS AND DISCUSSION

Figure 2 shows the effect of cultivar interaction with cutting age on the Absolute Growth Rate (AGR), related to Biomass Duration (BD). The highest AGR value was observed at 120 days of cut for CT-115; it was common for the 90-day ages in the two varieties; and CT-500 at 120. The significantly low values were observed at 60 days for either variety, and differed from the rest of the age average evaluated. BD was significantly higher at 90 days for the CT-500, compared to CT-115; it was significantly different within its own averages at the 60 and 120-day cutting ages, and the CT-115 differed most at 60 and 90 days.

This behavior proved that CT-500 and CT-115 grew at completely different rates, so they accumulated DM at different speeds. It indicated that the innate features of each variety were the ones that differentiated the phenotypical responses observed in the rainy season. Uvidia, Leonard, Benítez and Buestan (2013) noted that it was caused by different environmental stimuli, when certain genes that promote specific activities were activated. If produced in concomitance with regulating and enzymatic factors, it could manifest very quickly, or not, which might have been present in the effect studied.

The AGR produced by CT-115 and CT-500 was lower than the results achieved by Rincón, Ligarreto and Sanjuanelo (2007), when they made individual evaluation of maize in association with naturalized pasture, and the pasture achieved by Uvidia, Leonard, Benítez, and Buestan (2013), in Amazon ecosystems (*Pennisetum purpureum* vc *Marafalfa*) for the fifth week (35 days), eighth (56 days), and twelfth (84 days), with 4, 5, 8, and 4 cm, respectively. These authors also stated that during the week of the highest active growth, the plant had the best DM yields. From week 12, stems and DM began to accumulate. However, figure 2 shows that this phenomenon lasted to 120 days, though it declined for the CT-500, but without significant differences from the former age, or by the CT-115 age for the 120 days.

Regarding plant height (Fig. 3), both varieties had significant higher values for the 120 days. The values for the rest of the ages were alternatingly similar for the varieties, though they differed in terms of individual age averages for the CT-115 and CT-500. The average for the 120 days was higher than the reports made by Cordoví, Ray, Nhatumbo, and Chimbalamala (2013), and Fernández, Viamonte, Fonseca, and Ramírez (2015) for *C. purpureus* varieties in degraded ecosystems under severe seasonal drought. However, they were lower than the results achieved by Ramírez (2010a) in varieties tolerant to droughts near the mountains, where the cultivars received the benefits of the local climate.

The precipitations had a marked influence on plant growth, especially on height. Figure 3 shows that the climate period in which the study took place, the precipitations were above the historical monthly means (Fig. 1). It caused a rise in soil salt solubility, which may have influenced positively on plant height (from 70 cm to more than 200 cm), regardless of the low specialization of graminaceae root systems (Rosenzweig *et al*., 2014). According to Argentel, Garatuza, Yépez, and de los Santos (2016), it is directly linked to root development, particularly root length (Nevo and Chen, 2010), as an important indicator to evaluate tolerance to salinity of various plant species.

Argentel, Garatuza, Yépez and de los Santos (2016) on evaluation of different wheat varieties in saline ecosystems in the east of Cuba, found that the plant height was closely linked to their root development. However, this phenomenon did not coincide with Hernández *et al*. (2003), who said that root development in the rainy season is reduced by a relocation of nutrients in the aerial parts of plants. Seemingly, plants tolerant to salinity modified root development, as a salinity compensating or adapting mechanism, so it must be inferred that CT-115 and CT-500 had a positive root development that facilitated a more efficient exploration of the environment they developed, and reached the heights shown in Fig. 3.

Plant height influenced its structure composition (Fig. 4). As the cutting age increased, the proportion of leaves in relation to stems was negatively inverted. Nevertheless, for the 60 days, CT-500 had an almost 50/50% proportion; for the other ages, the proportions were moved to the stems, which was not observed in CT-115, with more leaves than stems, for all the ages studied.

The CT-500 behavior was similar, as were the lower values achieved by Reyes *et al*. (2015) in sugar cane and CT-169, respectively, in grazing conditions throughout the two seasons. CT-115, however, had a similar behavior to the reports made by Roncallo, Sierra and Castro (2012), in Cenchrus purpureus, but better than the reports by Reyes *et al*. (2015). These structural modifications are related to the growing habit of graminaceae, and the incidence of climatic factors, and the plant´s capacity of response to the above-mentioned factors (Calzada *et al*., 2014).

These results coincided with the reports by Herrera (2006), Álvarez (2009), and Ramírez (2010b), regarding the high proportion of leaves of CT-115, especially caused by internode shortening, and the number of nodes produced (approximately 10). This allowed for higher nutrient yields in the leaves for animal consumption (11% dry protein) (Febles and Herrera, 2006). In that sense, Álvarez (2009) said that among pasture components, the leaves are the best source, because animals can consume the required nutritional elements for development, including large amounts of soluble components from the tissues of thin-wall cells filled with cytoplasm (Pérez Infante, 2013).

Consequently, significant differences were achieved for structural behavior, in terms of dry matter percentage from the whole plant (Fig. 5). CT-500 significantly accumulated more dry matter from the whole plant at the 120-day cut, which differed ($P < 0.001$) from its own averages at the 60-day cut; CT-115 behaved similarly at the 60 and 90-day cuts. The values for the 90 and 120 days for CT-500 and CT-115 were not significant ($P \geq 0.05$) regarding the highest value. This value was higher than the one achieved by Cordoví, Ray, Nhatumbo and Chimbalambala (2013), in three varieties of *C. purpureus* in semi arid conditions south of Mozambique; whereas the DM yields of CT-115 and CT-500 (Fig. 6) were higher than the values achieved by Fernández, Viamonte, Fonseca, and Ramírez (2015), when they evaluated two varieties of *C. purpureus* tolerant to droughts in both seasons. They also were higher than the results reported by Valles de Mora, Castillo, and Berna (2016), when they evaluated ten tropical graminaceae in the two seasons, in Tlapacoyan, Veracruz, Mexico.

Regardless of this behavior, CT-115 was significantly better than CT-500 in DM yields.ha-1, at 150 days; this value differed from the rest of the averages observed for the ages studied for both CT-115 and CT-500. No significant differences were observed for the other ages ($P > 0.05$) in terms of DM.ha-1 accumulation.

Despite the previous differences, dry matter yields were not affected by soil salinity, with an electric conductivity of 0.047, 0.10, and 0.05 dS.m-1, in saturated patches 0-20, 20-40 and 40-60 cm deep, respectively (Ledea, 2016). In that sense, Schroeder *et al.* (2013), explained that when saturated conductivity patches were over 3.6 dS.m-1, the crops experimented yield drops, due to difficulties in processes that determined osmotic adjustment. Accordingly, Argentel, Garantuza, Yépez, and de los Santos (2016), said that the accumulation of dry matter in saline soils depends a great deal on the plant´s water relations, and the regulation capacity of the variable, through active accumulation of inorganic osmolites and ions. This effect could have been stimulated by the occurrence of precipitations.

The amount of basal shoots generated by a plant was closely linked to the productive behavior. Fig. 7 shows the cultivar-cutting age ratio for the variable. However, the 60 and 90-day averages did not show any significant statistical differences ($P > 0.05$). The opposite was observed for CT-115 at 120 days.

The number of basal shoots was lower than the values reported by Díaz (2007), at different re-shooting ages (86, 112, and 154 days), and the ones reported by Martínez *et al.* (2010) when they evaluated Cuba CT-169 and OM-22 in the rainy season. The behavior observed in Fig. 7 owed mainly to the mobilization of reserve substances within the plant, to generate basal shoots. At 60 days, CT-500 had more soluble carbohydrates that were mobilized over basal shooting (Ayala, 1990), which occurred when the stem began to age, suggesting faster maturation of the variety. However, maturation of CT-115 was identified at 90 days, then it dropped at 120 days, due to the end of growth and mobilization of carbohydrates into the roots to ensure re-shooting (Fortes, 2014).

CONCLUSIONS

The cultivars had significant differences (P < 0.001) for the 60 and 90 cutting ages, whereas for the number of basal shoots, and dry matter percentage from the whole plant, CT-115 was significantly higher at the 60 and 120 days, respectively. The absolute growth rate and biomass duration were significantly phased out at 90 days, favoring CT-500. Both varieties showed a production potential for dry matter per hectare, and only differed (P<0.001) for the 120-day age in forage areas with saline soils.

RECOMMENDATIONS

These results should be considered as preliminary data for the design of varietal structures in forage areas with low salinization. Also, new varieties generated by tissue culture should be submitted to evaluation in areas with higher salinization levels.

REFERENCES

ÁLVAREZ, Y. (2009). *Evaluación inicial de nuevas variedades de Pennisetum purpureum con tolerancia a la salinidad en el Valle del Cauto*. Tesis de Maestría, Universidad de Granma. Cuba.

ARGENTEL MARTÍNEZ, L.; GARATUZA PAYÁN, J.; YÉPEZ GONZÁLEZ, E. A., & DE LOS SANTOS, S. (2016). Evaluación de la tolerancia de variedades mexicanas de trigo a la salinidad, a través de indicadores fisiológicos, bioquímicos y agronómicos, cultivadas en Cuba en condiciones de campo. *Cultivos Tropicales*, *37* (1), 91-101.

AYALA, J. R. (1990). *Plantación y establecimiento. King grass. Plantación, establecimiento y manejo en Cuba*. La Habana, Cuba: Ed. EDICA, Instituto de Ciencia Animal.

BARRANCO, G. y DÍAZ, L. R. (1989). *Clima. Nuevo Atlas Nacional de Cuba*. Cuba: Inst. Geogr. ACC, ICGC, MINFAR.

BENÍTEZ, D, G.; CISNEROS, M.; PÉREZ-INFANTE, F.; NUVIOLA, Y. (2010). *El Balance alimentario para los rebaños en pastoreo*. Holguín, Cuba: Ed. ARGRAF.

BENÍTEZ, D.; RAMÍREZ, ALINA.; DÍAZ, MARGARITA.; RAY, J.; GUERRA, J. y VEGAS, A. (2007). Comportamiento de machos vacunos en un sistema racional de pastoreo en el Valle del Cauto. *Rev. Cubana Cienc. Agric.*, *41* (3), 227-230.

CALZADA-MARÍN, J. M.; ENRÍQUEZ-QUIROZ, J. F.; HERNÁNDEZ-GARAY, A.; ORTEGA-JIMÉNEZ, E. y MENDOZA-PEDROZA, S. I. (2014). Análisis de crecimiento del pasto maralfalfa (*Pennisetum* sp.) en clima cálido subhúmedo. *Revista mexicana de ciencias pecuarias*, *5* (2), 247-260.

CORDOVÍ, E.; RAY, J. V.; NHATUMBO, S. y CHIMBALAMBALA, A. (2013). Comportamiento de tres especies del género *Pennisetum purpureus* en clima semiárido del sur de Mozambique. *Granma Ciencia*, *17* (3), 1-6.

DÍAZ, D. (2007). *Evaluación agronómica de nuevas variedades Pennisetum purpureum en condiciones de sequía el Valle del Cauto*. Tesis de maestría, Universidad de Matanzas, Cuba.

FAJARDO, H. (2008). La innovación tecnológica en la producción pecuaria en la provincia de Granma: Una necesidad impostergable. *Rev. Granma. Ciencia*, *12* (1), 12-16.

FEBLES, G. y HERRERA, R.S. (2006). *Introducción y características botánicas. Pennisetum purpureum para la ganadería tropical*. La Habana, Cuba: Ed. EDICA.

FERNÁNDEZ, M. J.; VIAMONTE, I. M.; FONSECA, N. y RAMÍREZ, A. (2015). Evaluación de dos cultivares de *Pennisetum purpureum* tolerantes a la sequía en la región de Cauto Cristo, Granma, Cuba. *Rev. Ciencia y Tecnología Ganadera*, *9* (1), 23-29.

FORTES, D. (2014). *Comportamiento de algunos indicadores morfofisiológicos y de calidad de Pennisetum purpureum vc. Cuba CT-115 utilizado como banco de biomasa*. Tesis de Doctorado, Instituto de Ciencia Animal, Cuba.

HERNÁNDEZ, L.; RODRÍGUEZ, I.; CRESPO, G.; SANDRÍNO B y FRAGA, S. (2003). *Los componentes de la fitomasa subterránea en diferentes pastizales de la provincia de La Habana*. II Foro latinoamericano de Pastos y Forrajes, Instituto de Ciencia Animal, La Habana, Cuba.

HERNÁNDEZ, A.; PÉREZ, J. M.; BOSCH, D.; RIVERO, L. y CAMACHO, I. (2015). *Nueva versión de la clasificación genética de los suelos de Cuba*. Ciudad de La Habana, Cuba: Instituto de Suelos, Ministerio de la Agricultura, AGRINFOR.

HERRERA, R. S. (2006). *La fisiología vegetal y los pastos*. Conferencias curso de pastos, ICA, La Habana, Cuba.

HERRERA, R. S. (2000). *Obtención de plántulas de Pennisetum purpureum con resistencia a la sequía y salinidad mediante técnicas biotecnológicas*. La Habana, Cuba: CITMA-ICA.

HERRERA, R. S.; CHAPLE, Z.; CRUZ, A. M.; ROMERO, A. y GARCÍA, M. (2003). Obtención de plántulas de *Pennisetum purpureum* resistentes a la sequía y salinidad. Nota técnica. *Rev. Cubana de Cienc. Agríc.*,*37* (2), 89-93.

KEULS, M. (1952). The use of the "studentized range" in connection with an analysis of variance. *Euphytica*, *1* (2), 112-122.

LEDEA, J. L. (2016). *Caracterización químico nutritiva de nuevas variedades de Cenchrus purpureus tolerantes a la sequía en el Valle del Cauto*. Tesis de Maestría, Universidad de Granma, Cuba.

MASSEY, F. J. (1951). The Kolmogorov-Smirnov test for goodness of fit. *Journal of the American statistical Association*, *46* (253), 68-78.

MARTÍNEZ, R. O.; TUERO, R.; TORRES, V., & HERRERA, R. S. (2010). Models of Biomass Accumulation and Quality in Varieties of Elephant Grass, Cuba CT-169, OM – 22 and King Grass during the Rainy Season in the Western Part of Cuba. *Cuban J. Agric. Sci.*, *44* (2), 187.

NEVO, E. y CHEN, G. (2010). Drought and Salt Tolerances in Wild Relatives for Wheat and Barley Improvement. *Plant, Cell & Environment*, *33* (4), 670-685.

ONEI (2015). *Anuario estadístico de Cuba 2014*. Territorio. Cuba: Oficina Nacional de Estadística e Información. Retrieved on January 12, 2015, from http://www.one.cu/anuarioestadisticodecuba2014.

PEÑA, F. H.; ÁLVAREZ, A. y DÍAZ, E. (2002). IV Clasificación de los suelos del Valle del Cauto. *Rev. Granma Ciencia*, *6* (3), 56-60.

PÉREZ-INFANTE, F. (2013). *Ganadería eficiente*. La Habana, Cuba: Editorial: Asociación Cubana de Producción Animal.

RAMÍREZ, A. (2010a). *Caracterización y tipificación de las fincas ganaderas en ecosistemas montañosos del macizo Sierra Maestra*. Tesis de Doctorado, Instituto de Ciencia Animal, Cuba.

RAMÍREZ, J. L. (2010b). *Rendimiento y calidad de cinco gramíneas en el Valle del Cauto*. Tesis de Doctorado, Instituto de Ciencia Animal, Cuba.

REYES, J. J.; PADILLA, C.; MARTÍN, P. C.; GÁLVEZ, M.; REY, S.; NODA, A. y REDILLA, C. (2015). Consumo de forrajes tropicales por vacas lecheras, mestizas Siboney, manejadas en condiciones de estabulación. *Avances en Investigación Agropecuaria*, *19* (1), 31-40.

RINCÓN, Á.; LIGARRETO, G. y SANJUANELO, D. (2007). Crecimiento del maíz y los pastos (*Brachiaria sp.*) establecidos en monocultivo y asociados en suelos ácidos del piedemonte llanero colombiano. *Agronomía Colombiana*, *25* (2), 264-272.

RONCALLO, B.; SIERRA, A. M. y CASTRO, E. (2012). Forage Yield of Cutting Grass and Effect on Compositional Quality and Yield of Milk in a Dry Caribbean. *Revista Corpoica Ciencia y Tecnología Agropecuaria, 13* (1), 71-78.

ROSENZWEIG, C.; ELLIOTT, J.; DERYNG, D.; RUANE, A. C.; MÜLLER, C.; ARNETH, A.; *et al.* (2014). Assessing Agricultural Risks of Climate Change in the 21st Century in a Global Gridded Crop Model Intercomparison. *Proceedings of the National Academy of Sciences*, *111* (9), 3268-3273.

SCHROEDER, J. I.; DELHAIZE, E.; FROMMER, W. B.; GUERINOT, M. L.; HARRISON, M. J.; HERRERA-ESTRELLA, L. *et al.* (2013). Using Membrane Transporters to Improve Crops for Sustainable Food Production. *Nature*, *497* (7447), 60-66.

UVIDIA, H.; LEONARD, I.; BENÍTEZ, D. y BUESTAN, D. (2013). Dinámica del crecimiento de la Maralfalfa (*Pennisetum* sp.), en condiciones de la Amazonia Ecuatoriana. *Revista Amazónica Ciencia y Tecnología, 2* (1), 14-18.

VALLES DE LA MORA, B.; CASTILLO, E. y BERNAL, H. (2016). Rendimiento y degradabilidad ruminal de la materia seca y energía de diez pastos tropicales cosechados a cuatro edades. *Mex. Cienci. Pec., 7 (2),* 141-158.

.

Received: 7-12-2017
Accepted: 7-20-2017

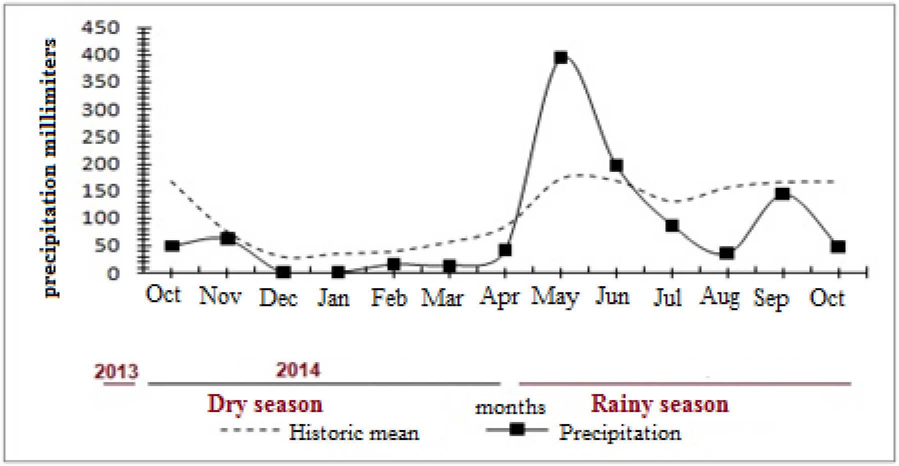
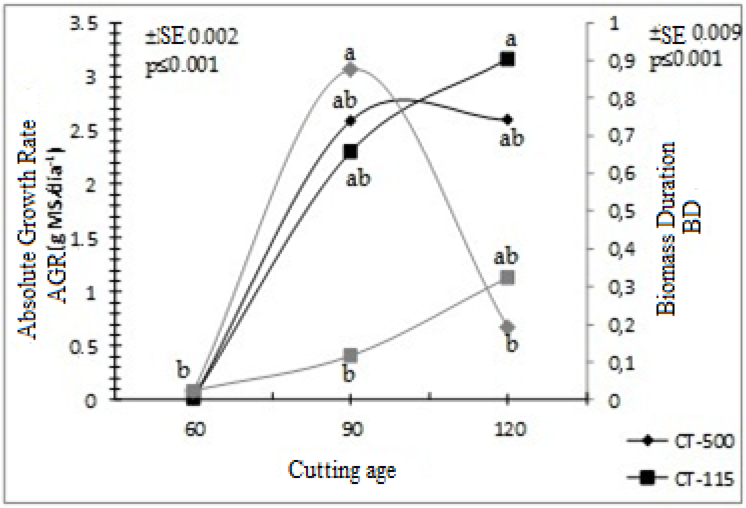


Fig. 1. Behavior of precipitations between October 2013 and October 2014

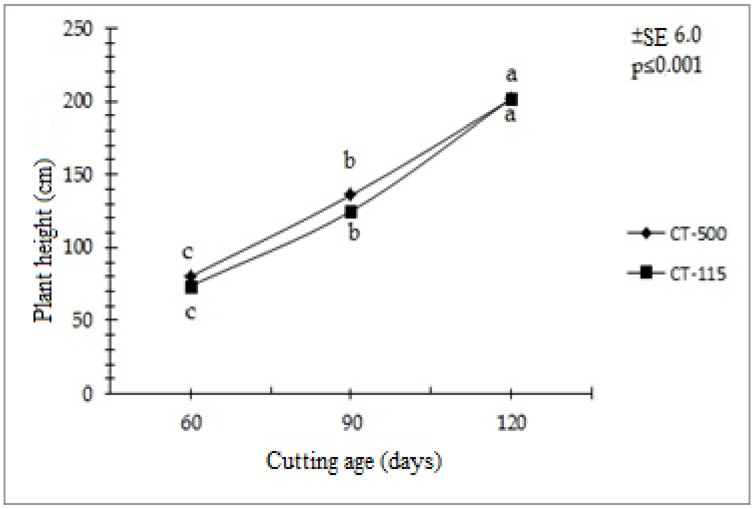
Table1. Chemical cmposition of the soil used for the study

pH		Mg/100 g of soil		OM %	Total soluble salts %
KCl	H_2O	P_2O_5	K_2O		
4.7	6.3	2.2	7.3	2.10	0.439



[ab] Different letters within the same age differ for P<0.001, according to Newman Keuls (StatSoft 2010)

Fig. 2. Effect of cultivar-cutting age interaction on the absolute growth rate (in black), related to biomass duration (in gray)



ab Different letters within the same age differ for P<0.001, according to Newman Keuls (StatSoft 2010)<

Fig. 3. Effect of cultivar-cutting age interaction on plant height

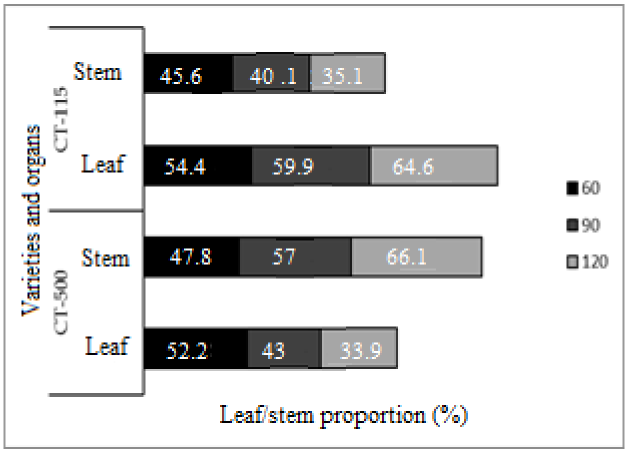
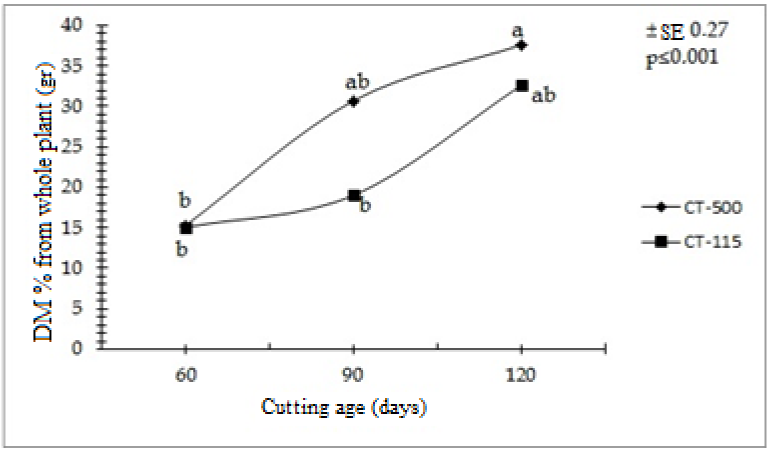
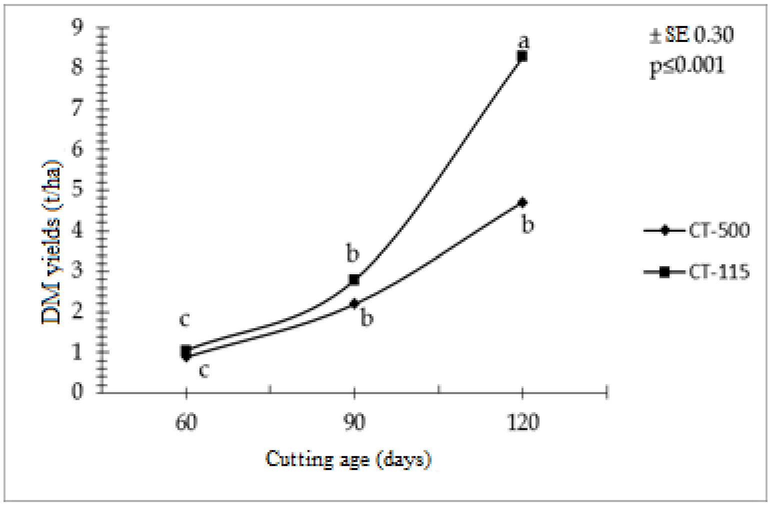


Fig. 4. Effect of cultivar-cutting age interaction on leaf-stem ration



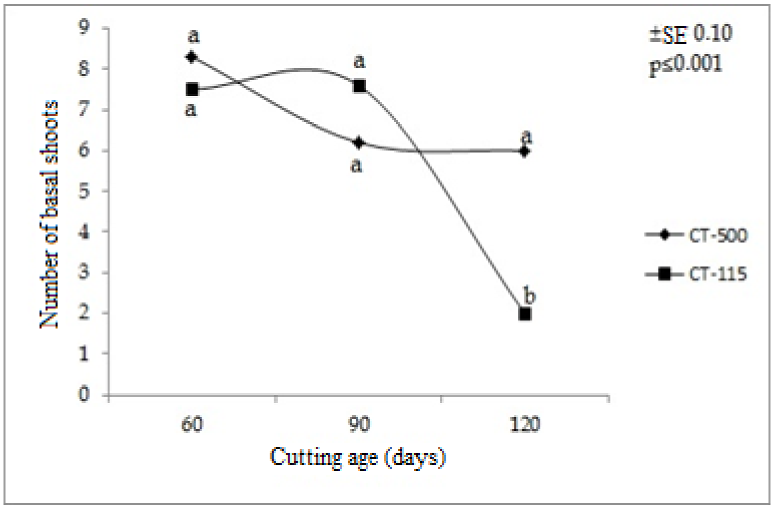
[ab] Different letters within the same age differ for P<0.001, according to Newman Keuls (StatSoft 2010)ab

Fig. 5. Effect of cultivar-cutting age interaction on the percent of dry matter from whole plant



[a, b, c] Different letters within each age differ for P<0.05, according to Newman Keuls (StatSoft 2010)

Fig. 6. Effect of cultivar-cutting age interaction on yields of *DMt/ha^{-1}*



[ab] *Different letters within the same age differ for P<0.05, according to Newman Keuls (StatSoft 2010)*

Fig. 7. Effect of cultivar-cutting age interaction on the number of basal shoots