Growth analysis of the *Pennisetum purpureum* cv. Cuba CT- 115 in the biomass bank technology

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To study the performance of some growth indexes of *Pennisetum purpureum* cv. Cuba CT – 115, when it is used as biomass bank, it was applied a completely randomized sampling design, with 15 repetitions, (bunches as experimental unit) .The treatments consisted on the re-growth age or grass rest . The culture growth rate (CGR), the net assimilation rate (NAR) and the specific foliar area (SFA) were determined to describe the growing of this cultivar. The culture growth rate was characterized, generally, by its gradual increase from 15 days, to get the maximum growth rate that was specific for each cycle and, from that moment on, began to decrease. The maximum productivity during the first year was reached at 71, 57 and 61 days of re-growth for cycles one, two and four, respectively. In the second year, it was obtained at 86, 46, 45, and 69 days of re-growth for cycles one, two, three and five, respectively. The specific foliar area did not vary in the first rest cycle with age in the first year, and decreased in the remaining cycles. The net assimilation rate shows specificity in its response pattern to the re-growth age in each rest cycle. It is concluded that CGR, SFA and NAR had specific response for each cycle, regarding the re-growth age and the climatic characteristics, and showed to be adequate indicators for the analysis of the growing of Cuba CT-115 cultivar. It is recommended the use of growth indexes of this grass as a tool for the management of biomass banks, as well as its utilization in the studies of other species of Pennisetum genre and in the design of other management options.

Key words: *grass, growth indexes, culture growth rate, net assimilation rate, specific foliar area*

In physiological terms, the growth is defined as the increase in size, volume and mass in the time (Hunt 1990). Due to the great number of variables used to explain the growth and development of plants, the time used for its determination, the variability presented by the variables, due to different environmental and management factors and, different indexes have been established to make the work and the interpretation of results easier.

The growth indexes, as Culture Growth Rate (CGR), Net Assimilation Rate (NAR), among others, constitute indicators that permit to describe quantitatively the growth. Its components are relatively simple and permit to analyze and compare the ability of vegetal species to growth and develop in a determined environment regarding time (Lamber *et al*.2008).

The *Pennisetum purpureum* cv. Cuba CT-115 constitutes an important contribution to the germoplasm of the Pennisetum genus. Its favorable characteristics, like less resistance to cut, low flowering, smaller than king grass, among others, permit its utilization in grazing and the application of biomass banks technology. This one has been well received by national and foreign producers because the use of this plant for grazing is an economical option that only demands a fence, a correct application of the rest time and technological discipline (Martinez 2010). However, there are only few basic studies that explain the grass growth in this technology.

The objective of this study was to analyze the performance of some growth indexes of the *Pennisetum purpureum* cv. Cuba CT-115 when it is used as biomass bank.

Materials and Methods

Treatments and design. The treatment consisted on the re-growth age or grass rest from the moment the animals exit the paddock (zero time) and according to the biomass bank technology. The rest time or growth cycles are represented in table 1. The duration is defined according to the biomass bank technology (Martinez and Herrera 2006). A completely randomized sampling design, with 15 repetitions (bunches as experimental unit) was applied because the area turned out to be homogeneous (Fortes *et al*.2007).

Procedure. The study was carried out for two years in the B dairy unit from the Institute of Animal Science, situated in San Jose de las Lajas municipality, Mayabeque province, between 22º 53 NL and 82º 02 WL, at 80 m a.s.l. (Anon1989). A paddock of 0.68 ha, planted with *Pennisetum purpureum* cv. Cuba CT- 115 was used in a brown gray springy soil (Hernandez *et al*. 1999), which presented a slightly acid pH and relatively low contents of N and K (table 2). A total of 15 bunches (experimental unit) were taken at random, immediately after grazing and every 15 days, up to complete each growth cycle according to table 1.

The behavior of some climatic factors during the two years of experimentation is shown in figure 1.In the experimental period, the months with lower accumulation of precipitations and mean temperature were November, December, January and February, with values inferior to 70 mm and 22 ºC, respectively.

The morphological characteristics of the leaf were determined, like its length and width, and the foliar area was determined. To determine the area of each leaf, the

Table1. Distribution of the rest cycles during the experiment

Rest cycles	Date	Duration, d
First Year		
Cycle1	December 2006-march 2007	90
Cycle 2	March-may 2007	60
Cycle 3	May-July 2007	60
Cycle 4	August-November 2007	105
Second Year		
Cycle 1	November 2007-february 2008	90
Cycle 2	February-April 2008	60
Cycle 3	May-june 2008	45
Cycle 4	June-august 2008	60
Cycle 5	September-December 2008	105

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

%	mg.100g^{-1}					pH
N	MO	Ca	Mg	P	K	
0.19	3.20	2.53	0.26	2.15	5.44	5.87

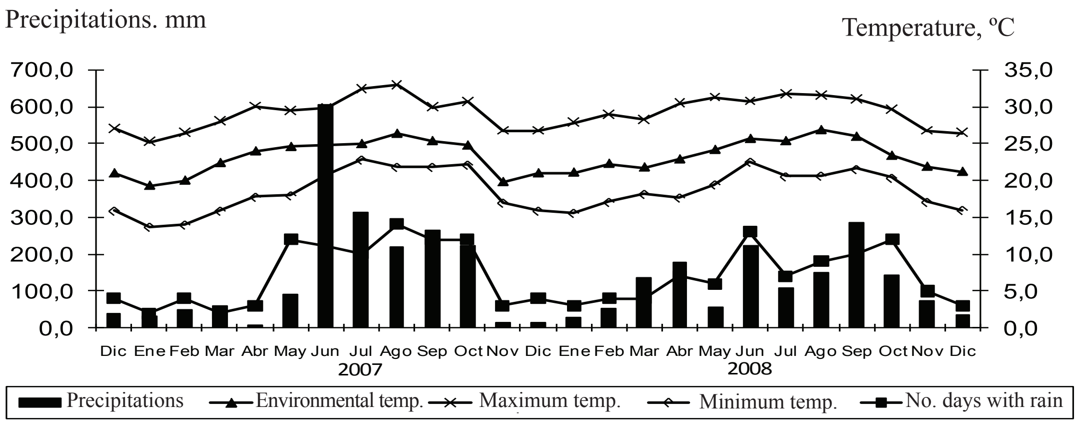


Figure1. Some climatic factors during the experimental period (December-2006 december-2008)

following expression was used:

AH=11.41+ 0.89(=0.09) L* A R=95.06** SE. =1.76

Where:

AH: foliar area

L: leaf length, cm (from the ligule to the apex)

A: leaf width (longitudinal middle point)

It was adjusted from the measuring of the real area in 70 representative leaves of different development stages of the plant. The gravimetric method in paper of homogeneous weight was used, according to Barrera *et al*. (2010).

The CGR, NAR, and SFA were determined according to the classic method of growth analysis, in accordance with Hunt (1990), starting from the dry mass, foliar area and time (re-growth age after grazing).

The age corresponding to the highest CGR was determined, when making the first derivative from the regression equation equal zero (Ross 2009).

Statistical analysis. Linear models were tested: linear, quadratic and cubic models, to study the relation between the re-growth age and the CGR, with the statistical software SPSS 15.5(Visauta 1998). The statistical criteria used in the selection of models of better fit were: parameter signification, determination coefficient (R^2), signification of the model and residues analysis.

Results and Discussion

The growth indexes that will be presented in this study provide information about growth performance of this variety in management conditions of biomass bank technology.

Figures 2 and 3 show the CGR that express the increase of dry mass per time unit, for the growth cycles of the technology and constitute an indicator of productivity. This index was characterized, in general, by its gradual increase, from 15 days of regrowth until getting the highest growth rate and started to decrease.

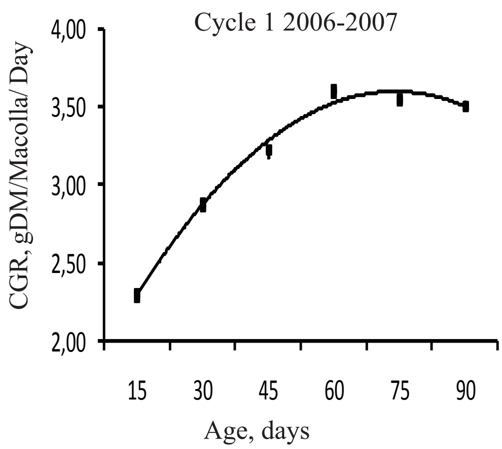
The highest productivity during the first year was reached at 71, 57 and 61 days of re-growth, in cycles one, two and four, respectively. And in the second year, the highest productivity was obtained at 86, 46, 45 and 69 days, in cycles one, two, three and five, respectively. This could indicate that, from the referred ages, the CGR did not increased, and the biomass accumulation, at these ages, is not biologically efficient.

The maximum CGR was specific for each growth cycle and the highest grasSFAnd productivity was recorded in the rest cycles, developed during the rainy period (cycles 3-2007, 4-2007 and cycle 4-2008). Some studies showed that the forage growth rate could be limited by photo-assimilates supply, by the plant reserves or by the number, size and activity of the meristem (Perez *et al*. 2004 and Taiz and Zeiger 2010). All these factors that influence on the CGR are determined, in turn, by climatic factors. Therefore, the highest grasSFAnd productivity (CGR) was recorded during the rainy period, because precipitations, number of rainy days and superior temperature in this period (figure 1) could favor the plant metabolic activity and increase the photo-assimilates accumulation and biomass production.

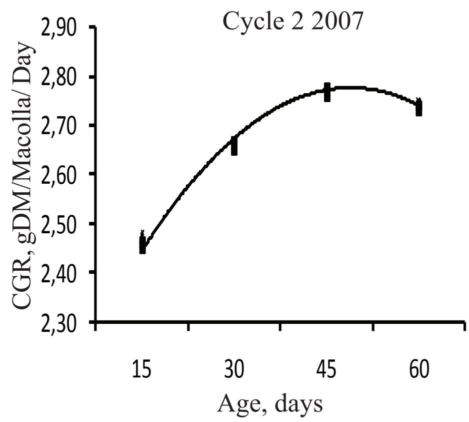
The SFA and the NAR were determined to complement the CGR.

The leaf area per unit of their dry weigh (SFA) did not vary in the first rest cycle, with age in the first year, and decreased in the other cycles. In the second year, it decreased in all cycles. Like in the previous index, each rest cycle showed a particular response pattern (figure4). Similar results were obtain and by Perez *et al*. (2004) in Bracharia hybrid cv. Mulato, where the specific foliar area was reduced as the plant grew, as a result of a higher individual weight of the leaf.

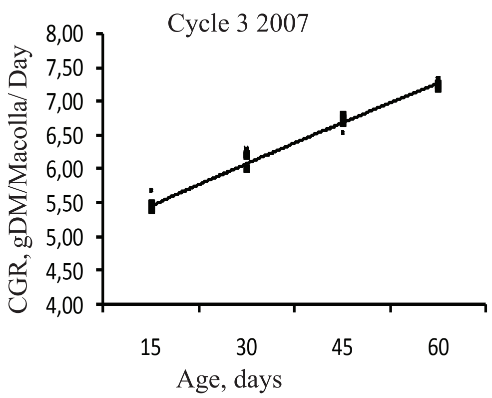
The reduction of the SFA is attributed to a change in the leaf structure, or to an increase in its concentration of nutrients or non structural carbohydrates. This reduction is the result of the plant incapacity to assign these compounds to the structural growth (Newton 1991). Leaves with less specific foliar area are denser and generally have a higher lignification, less cellular size,



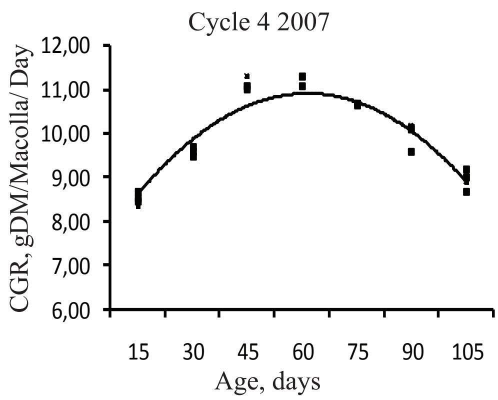
CGR = 1.516 + 0.057 (±0.005) Age
0.0004 (±0.00004) Age^2
R^2= 98.63** SE.= ±0.06



CGR = 2.175 + 0.023 (±0.002) Age –
0.00022 (±0.00003) Age^2
R^2= 98.97 * SE. = ±0.01

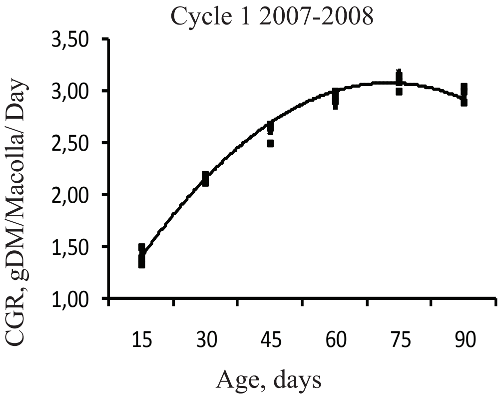


CGR = 4.945 + 0.039(±0003) Age
R^2=97.91** est. SE = ± 0.11

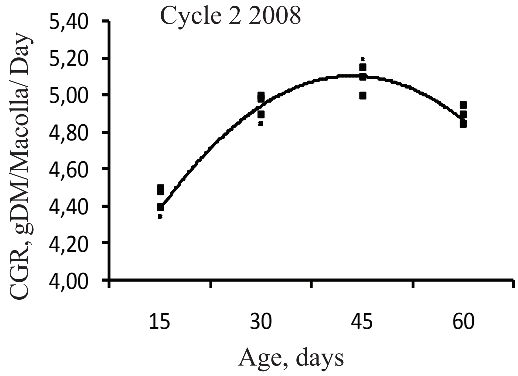


CGR = 6.41 + 0.16 (±0.03) Age-
0.0013 (±0.0002) Age^2
R^2=85.48** est. SE= ±0.44

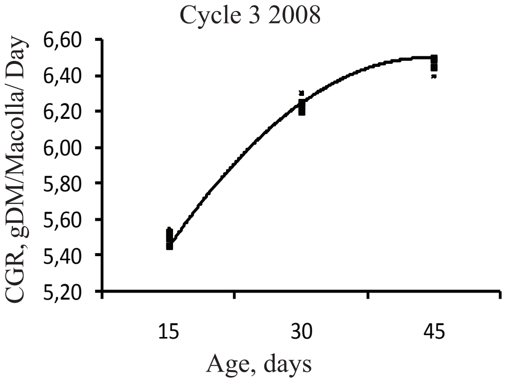
Figure 2. Culture growth rate in the first year of evaluation (2006 -2007)



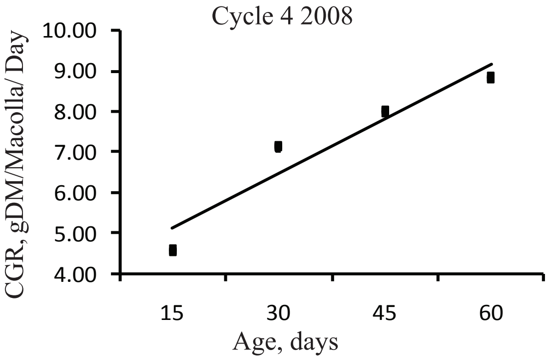
$CGR = 0.413 + 0.069(\pm0.004)\ Age - 0.00045\ (\pm0.00004)\ Age^2$
$R^2 = 99.49^{**}$ est. SE = ±0.05



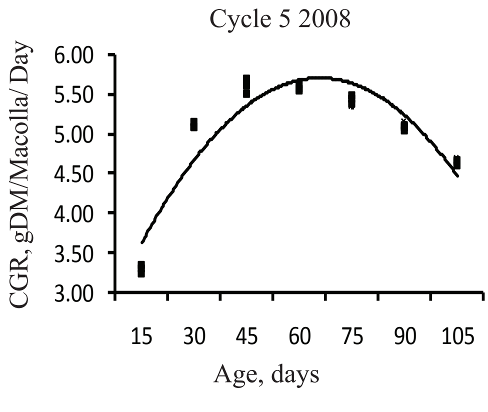
$CGR = 3.682 + 0.064(\pm0.004)\ Age - 0.00072\ (\pm0.00005)\ Age^2$
$R^2 = 99.19^{*}$ est. SE = ±0.024



$CGR = 4.39 + 0.091(\pm0.004)\ Age - 0.0010\ (\pm0.0003)\ Age^2$
$R^2 = 99.75^{**}$ est. SE = ± 0.03



$CGR = 3.75 + 0.09\ (\pm0.02)\ Age$
$R^2 = 86.72^{**}$ est.SE = ±0.67



$CGR = 2.23 + 0.11\ (\pm0.02)\ Age - 0.0008\ (\pm0.0002)\ Age^2$
$R^2 = 86.53^{**}$ est. SE= ±0.36

Figure 3. Culture growth rate in the second year of evaluation (2007- 2008)

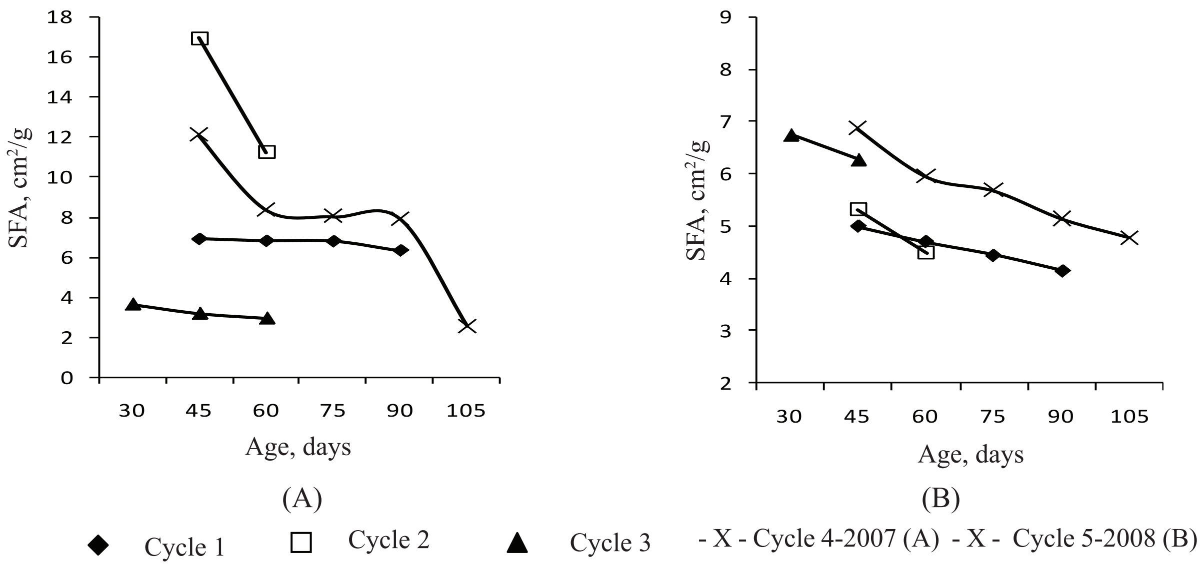


Figure 4. Specific foliar area in the first (A) and second (B) year of study

low content of humidity and low nitrogen concentration (Castro *et al*. 2000). This corresponds to the highest re-growth ages.

This leaf structural characteristic could cause the reduction in the grassland productivity at highest re-growth ages because when the plant shows thicker leaves there is a possibility of intercepting less radiation, and as a consequence, a minor production of assimilates occurs, which can be used for growth. In that respect, Ribaski (1999) reported that a higher SFA involves an increase in the light intersection capacity of the plant. May be, this is a way for increasing the photo-synthetically active surface, and assures a more efficient use in low lighting intensity.

The NAR expresses the net gain of assimilates, mainly photosynthetic, by the unit foliar area in time. This indicator showed particular performance in each cycle, as well as the pattern that followed regarding the re-growth age. The NAR practically did not vary during the first year in cycle 1, between 30 and45 days of re-growth. Nevertheless, from this moment, it decreased drastically up to 60 days, to continue its descend up to 90 days. The same response pattern was presented in cycle 3 up to 60 days. In cycle 2, it barely varied between 45 and 60 days, while in cycle 4, there was a slight increase up to 60 days, for later decreasing (figure 5A).

During the second year, there was an intense decrease between 45 and 60 days of re-growth during cycles one and five. From that moment on, it continued to decrease but in a less marked manner. In cycle three, it also decreased, while in cycle 2 it was constant (figure 5B). In general, during this year, the lowest values were obtained, compared to the first year.

In cycles one and three of the first year, it was evident that the net gain of assimilates decreased and it seems that the production was not enough to fulfill the plant needs for growing and developing. However, in cycle 2 the NAR showed a low increase that was interrupted by a short growth period. In cycle four, with the fast growth produced between 45 and 60 days, assimilates needs

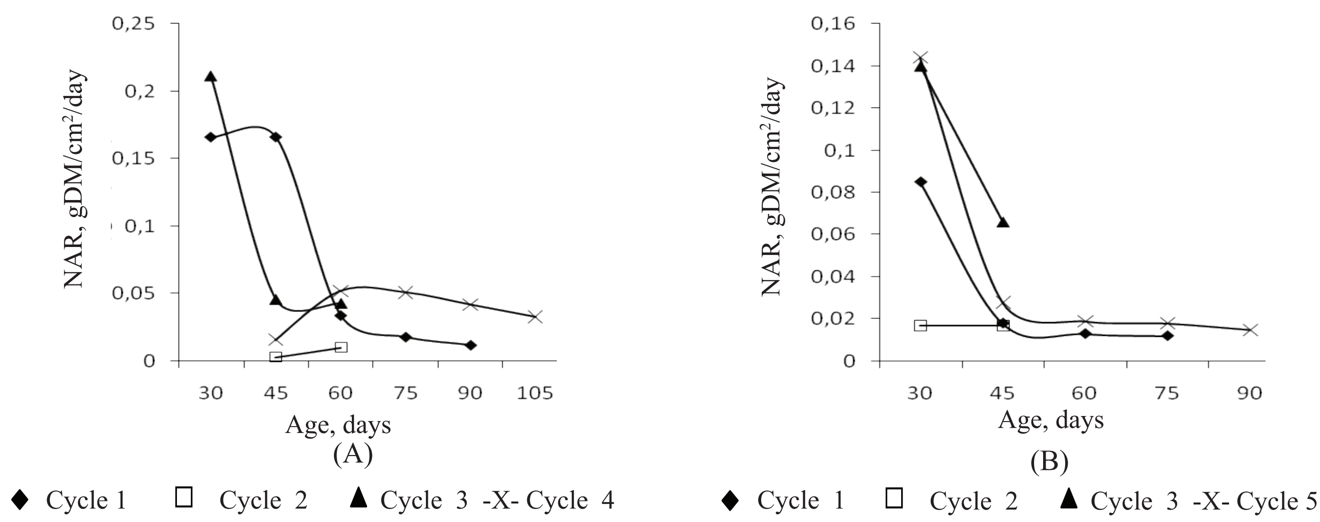


Figure 5. Net assimilation rate in the cycles of the first(A) and second (B) year

were tried to be filled, which was not achieved because it started to decrease at 60 days. This behaviour was produced, maybe, at the expense of the increase of the foliar area with the re-growth age, but with reductions in the SFA.

This response pattern was repeated in the second year, but NAR values were high due, probably, to the high availability of nutrients coming from its recycling and the higher precipitations (figure 1) occurred during the dry period. In general, the NAR was reduced at the highest re-growth age in all cycles, probably because the increase of the leaf age, joined to the self-shadowing of the plant inferior leafs, reduces the photosynthetic efficiency. In that respect, Andrade *et al*. (2005) reported that the reduction of NAR with the development is owed to a decrease in the photosynthetic rates, more than to the increase of the plant respiratory loss. As a consequence, the CGR is also reduced, at high ages. Barrera *et al*. (2010) informed that the NAR shows high values in the first development stages of the plant, stage in which there is more exposition to the total radiation, condition that becomes the opposite in more advanced stages in the plants growth.

It is concluded that the CGR, SFA and NAR had specific response for each cycle, according to the re-growth age and the climatic characteristics, and showed to be adequate indicators for the growth analysis of Cuba CT- 115 in the biomass bank technology. It is recommended the implementation of growth indexes of this grass, as a tool for the management of biomass banks and its use in researches of others species of Pennisetum genre, as well as the design of other management options.

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Received: November 15, 2012