Nutritive assessment of *Panicum maximum* cv. Mombasa in the climatic conditions of the Cauto Valley, Cuba

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In a random block design with six replicates, the influence of the regrowth age (30 to 75 d) and the climatic factors were evaluated in the nutritive quality of the pasture *Panicum maximum* cv Mombasa. The experiment was conducted in the trimesters January-February-March (dry season) and May-June-July (rainy season), on soil of the brown type with carbonate, without irrigation or fertilization. The highest correlations were between the indicators quality and age, mean temperature, maximum relative humidity and rainfall. The equations of linear regression during the rainy season had R^2 that varied between 0.97 and 0.99. DM, NDF, cellulose, hemicellulose, and *in situ* digestibility were outstanding. The lowest standard errors of estimation were obtained in NDF, cellulose, and hemicellulose. It is concluded that the regrowth age and the climatic conditions had marked effect on the nutritive value. Further studies on these indicators are recommended in different types of soils, in the edaphoclimatic conditions of the Cauto Valley, with the aim of having more information available.

Key words: *Panicum maximum, nutritive quality, climatic factors*.

In Cuba, as in the rest of the tropical and subtropical countries, the climatic conditions determine, up to great extent, the volume and quality of the biomass available in the pastures and forages. This constitutes a limitation for most of the cattle production systems in the dry season (Fernández *et al*. 2001)

Among the climatic conditions of the Cauto Valley, in the Granma province, the annual distribution of rainfall and the temperature variations have marked effect on the growth of the pasture species in the several periods of the year. This provokes a seasonal unbalance in the yields, besides limitations in the availability of forage during the dry season (Fernández *et al*. 2000).

Panicum maximum is a plant that adapts perfectly to the conditions of Cuba. It is probable that its production potential is affected by the climatic conditions prevailing in a certain area, when subject to repeated cuts and when the nutrients extracted according to the biomass production are not restored (Hernández *et al*. 2000). Thus, it is of great importance to deepen into the effect of the regrowth age and the climatic factors on the nutritive value of *Panicum maximum*, according to the various periods of the year. Also, it is necessary to describe the relations between these two elements and establish linear equations of multiple regression permitting to determine the different indicators of the nutritive value. By having more information on the construction of the model, the estimations will be more accurate.

The objective of this work was to determine the effect of the regrowth age and the climatic factors on the nutritive value of *Panicum maximum* cv. Mombasa in a brown soil with carbonate in the Cauto Valley.

Materials and Methods

Research area. The study was conducted in the facility for animal production devoted to research, at the Granma University. This facility is located at the Southeast area of the Cuba, in the Granma province, 17.5 km away from Bayamo city.

The cultivar of *Panicum maximum* cv. Mombasa was used in a prairie of two years of establishment. The study was carried out in January-February-March and May-June-July, during 2007-2008.

In January-February-March, the rainfall was of 83.7 mm. The mean, minimum and maximum temperature recorded values of 23.89; 18.28 and 31.41 ºC, respectively. The mean relative, minimum and maximum humidity was of 76.71, 43.92 and 97.13 %, respectively.

In May-June-July, the rainfall reached values of 309.88 mm. The mean, minimum and maximum temperature was on the order of 27.22, 22.23, and 35.17 ºC, respectively. The mean relative, minimum and maximum humidity had values of 79.25, 49.96 and 96.17 %, respectively. The soil was of the brown type with carbonate, according to Hernández (1999), with pH of 6.2. The content of P_2O_5, K_2O, and total N was of 2.4; 33.42 and 3 (mg/100g of soil), respectively, with 3.6 % of organic matter (Dirección Provincial de Suelos y Fertilizantes de Granma 2007).

Treatment and experimental design. A random block design was applied. The treatments were the regrowth ages of 30, 45, 60 and 75 d.

Experimental procedure. In each period, at the start of the evaluation, a uniformity cut was performed at

10 cm above the soil (January and May for each of the trimesters, respectively). Plots of 25 m^2 were limited, with 50 cm between them, for each of the regrowth ages. The field was not irrigated or fertilized during the experiment. The collection of samples was performed through the total cut of the plot in each treatment. For each of the repetitions, 200 g of material were collected, and later dried at 65 ºC in an air-forced oven for 72 h.

The percentage of DM, CP and silica was determined, according to the techniques of AOAC (2000). NDF, ADF and lignin were determined according to Goering and van Soest (1970).

In order to determine the *in vitro* and true digestibility, the protocol recommended for the incubator DaisyII® was followed, (ANKOM Technology, Fairport, NY-USA). The samples were incubated for 48 h in the DaisyII® for the *in vitro* digestibility, the temperature was of 39.2 ± 0.5 °C, with constant circular agitation. After the incubation, the bags were washed with cold water to halt the fermentation and they were dried in air-forced oven at 105 °C/1 h. Later, the NDF was determined to find out the real feed digestibility.

The *in situ* digestibility, at 72 h of incubation, was determined according to the method of the rumen bag, as described by Orskov *et al*. (1980).

Statistical analysis and calculations. Linear correlation analysis was performed for the quality indicators (dependent variables), age and climate elements (independent variables) for each of the varieties in each seasonal period. Only the R^2 were reported.

Out of the results, the multiple linear equations were established for DM, CP, silica, NDF, ADF, ADL, cellulose, hemicellulose, cell content, DMIVD, true digestibility, ISDMD, age and climatic factors. For each seasonal period, only those of best fit were reported.

In order to select the expressions of best fit, it was considered: high coefficient of determination (R^2), high significance, significant supply of the terms and low coefficients of indetermination (1- R^2), standard errors of the terms, standard errors of estimation and mean square of the error.

For all the coefficients of correlation, the classification of high was used, when they were superior to 0.80 ($P < 0.001$), which was determined by being the basis for later analysis. In all the instances the procedure was as by Herrera (1981) and the statistical software Statistica 7.0 was applied for Windows (2007).

Results and Discussion

In general, the high correlations in May-June-July (table 1) were reflected between the variables under study and the age, the minimum and mean temperatures, the mean relative and maximum humidity and the rainfall. The performance was different with the maximum temperatures and the minimum relative humidity. Except the true digestibility (TD), the rest of the indicators was related to the rainfall and the regrowth age. Cellulose was that manifesting high correlations with the maximum temperatures.

In January-February-March (table 2), there were high correlations with the age, positive and negative; the mean and maximum temperatures; the maximum relative humidity and the rainfall. The performance was different in the minimum temperature, the minimum relative and the mean humidity.

Multiple linear equations were established permitting to determine DM, CP, silica, NDF, ADF, ADL, cellulose, hemicellulose, cell content, DMIVD, true digestibility and DMISD, out of the climatic factors and the age.

The equations obtained in May-June-July (table 3) had R^2 that varied between 0.97 and 0.99. DM, NDF, cellulose, hemicellulose, cell wall digestibility and *in situ* digestibility were outstanding. The lowest standard errors of estimation were obtained in NDF, cellulose, and hemicellulose.

During January-February-March (table 4), the values of R^2 ranged from 0.89 to 0.99, with the best performances for DM, CP, silica, ADF, ADL, cellulose, hemicellulose, DMIVD, true digestibility and ISD and coefficients of 0.99. This evidenced the relation between the indicators evaluated and the climatic factors.

The climate is the group of the meteorological conditions that tend to be seen in one region. It is the result from the combination of various physical properties of the atmosphere (temperature, humidity, winds, radiations, electric state) that last for a period of time (Herrera and Ramos 2006).

When establishing the relations between the climatic factors (rainfall, temperature, and relative humidity), there were high negative correlations of CP, hemicellulose, cell content, true digestibility, DMIVD, and DMID in the rainy and dry season. This could be determined by the age increase and, thus, by the plant growth. More water is accumulated and the stem fraction increases, having smaller amount of crude protein and larger amount of cell wall components. Thus, the digestibility and the cell wall diminish. The opposite occurred for the cell content components, especially for the NDF, ADF, ADL and silica. This provoked negative effect on the digestibility and the cell content (Juárez *et al*. 2009 and Homen *et al*. 2010).

The influence of the rainfall on the performance of these morphological, biochemical and physiological processes, related to the growth and the quality of the pastures, depends on multiple factors that are closely associated with the environment, the soil, the humidity and the fertility and the species. The literature reports that the growth of the pastures is related to the soil humidity. It, at the same time, varies according to the amount and distribution of the rainfall, the structure and the slope of

Table 1. Matrix of correlation of *Panicum maximum* cv. Mombasa in May-June-July

Variables	Age	Minimum temp.	Mean temp.	Maximum temp.	Minimum RH	Mean RH	Maximum RH	Rainfall
DM	0.97	0.90	0.98	0.71	-0.36	-0.89	-0.97	0.89
CP	-0.97	-0.95	-0.97	-0.86	0.55	0.87	0.88	-0.98
Silica	0.99	0.89	0.97	0.86	-0.58	-0.95	-0.88	0.96
NDF	0.99	0.95	0.99	0.77	-0.41	-0.89	-0.97	0.94
ADF	0.95	0.94	0.97	0.69	-0.31	-0.83	-0.98	0.89
ADL	0.93	0.94	0.95	0.61	-0.20	-0.77	-0.99	0.85
Cellulose	0.87	0.81	0.84	0.99	-0.83	-0.87	-0.64	0.96
Hemicellulose	0.99	0.95	0.99	0.84	-0.51	-0.92	-0.93	0.97
Cell content	-0.98	-0.94	-0.99	-0.76	0.41	0.89	0.96	-0.93
DMIVD	-0.98	-0.93	-0.99	-0.78	0.44	0.89	0.95	-0.94
True digestibility	-0.49	-0.68	-0.57	-0.02	-0.44	0.20	0.78	-0.38
DMISD	-0.99	-0.96	-0.99	-0.77	0.41	0.88	0.96	-0.95

Tabla 2. Matrix of correlation of *Panicum maximum* cv. Mombasa in January-February-March

Variables	Age	Minimum temp.	Mean temp.	Maximum temp.	Minimum RH	Mean RH	Maximum RH	Rainfall
DM	-0.98	-0.70	0.90	0.89	-0.71	-0.71	-0.81	0.95
CP	-0.99	0.56	-0.95	-0.96	0.82	0.83	0.88	-0.95
Silica	0.99	-0.51	0.98	0.97	-0.82	-0.83	-0.93	0.97
NDF	0.97	-0.41	0.97	0.96	-0.84	-0.86	-0.93	0.94
ADF	0.98	-0.38	0.99	0.98	-0.83	-0.86	-0.97	0.97
ADL	0.94	-0.77	0.85	0.84	-0.66	-0.65	-0.75	0.92
Cellulose	0.92	-0.16	0.98	0.96	-0.84	-0.89	-0.99	0.90
Hemicellulose	-0.96	0.34	-0.99	-0.97	0.84	0.87	0.97	-0.94
Cell content	-0.95	0.39	-0.95	-0.94	0.82	0.84	0.91	-0.91
DMIVD	-0.99	0.58	-0.96	-0.95	0.79	0.80	0.90	-0.97
True digestibility	-0.86	0.88	-0.73	-0.72	0.50	0.49	0.62	-0.86
DMISD	-0.99	0.57	-0.96	-0.94	0.75	0.77	0.91	-0.99

Table 3. Multiple equations of *Panicum maximum* cv. Mombasa in May-June-July

Variables	a	b	SE±	c	SE±	d	SE±	R^2	Mean square	SE±
DM	-227.9	0.241	0.033	9.233	2.239	-0.049	0.003	0.99***	0.035	0.188
CP	8449.5	0.41	0.107	-55.38	11.39	-71.88	14.81	0.97***	0.100	0.317
Silica	-78.24	0.097	0.013	2.437	0.902	-0.013	0.005	0.98***	0.034	0.184
NDF	-352.7	0.015	0.003	15.87	0.221	-0.012	0.0003	0.99***	0.0003	0.018
ADF	-98.98	0.130	0.015	5.990	1.242	-0.024	0.0043	0.97***	0.076	0.276
ADL	-530.9	-0.13	0.032	20.29	2.219	-0.010	0.0032	0.98***	0.035	0.187
Cellulose	204.4	0.035	0.004	-6.771	0.290	0.026	0.0004	0.99***	0.0006	0.024
Hemicellulose	93.80	0.056	0.004	-1.844	0.318	0.011	0.0019	0.99***	0.0024	0.065
Cell content	166.15	-0.25	0.022	-5.996	1.747	0.027	0.0061	0.98***	0.1514	0.389
DMIVD	211.5	-0.30	0.039	-7.198	3.077	0.0319	0.0108	0.97***	0.469	0.685
True digestibility	4742.7	1.917	0.090	-178.4	6.117	0.027	0.0088	0.98***	0.266	0.515
DMISD	344.42	-0.29	0.0158	-13.14	1.248	0.0356	0.0441	0.99***	0.077	0.278

R^2 all at $P < 0.001$. DM= a+b*age-c*meanT+d* rainfall, CP= -a-b* age +c*maxT+d* rainfall, Silica= -a+b* age +c*meanT+d* rainfall, NDF= a+b* age +c*minT, ADF= -a+b* age +c*meanT+d* rainfall, ADL= a+b* age -c*menT+d* rainfall, Cellulose= a- b* age +c*maxT-d*maxRH, Hemicellulose= -a-b* age +c*maxRH, cell content= a-b* age, DMIVD= -a-b* age +c*meanT-d*rainfall, TD= -a-b*age+c*meanT-d*rainfall, DMISD= -a-b*age+c*MeanT-d*rainfall

Table 4. Multiple equations of *Panicum maximum* cv. Mombasa in January-February-March

Variables	a	b	SE±	c	SE±	d	SE±	R^2	Mean square	SE±
MS	269.7	0.214	0.0058	-10.87	0.3831	0.0406	0.0029	0.99***	0.008	0.0896
PB	-39.99	-0.164	0.0160	1.759	0.4846	0.0213	0.0061	0.99***	0.023	0.154
SI	-9.410	0.0567	0.0025	0.538	0.1658	0.0085	0.0012	0.99***	0.0015	0.0388
FND	55.32	0.0787	0.0041	0.560	0.2377			0.95***	0.085	0.2925
FAD	-181.5	0.014	0.0032	8.916	0.2125	0.019	0.0016	0.99***	0.0024	0.0497
LAD	147.5	0.110	0.0057	-6.383	0.3744	0.0172	0.0028	0.99***	0.0076	0.0876
CEL	482.0	-0.020	0.0016	1.639	0.0995	-5.199	0.0656	0.99***	0.0010	0.0319
HCEL	-184.4	-0.041	0.0075	2.305	0.4162			0.97***	0.0611	0.2473
CC	34.65	-0.073	0.0053					0.89**	0.1936	0.440
DIVMS	-160.6	-0.439	0.0212	9.835	1.395	-0.046	0.0107	0.99***	0.106	0.326
DV	-698.6	-0.431	0.0103	33.61	0.680	-0.119	0.0052	0.99***	0.0253	0.159
DISMS	-96.95	-0.319	0.011	7.253	0.7244	-0.168	0.0055	0.99***	0.0287	0.169

R^2 all at P < 0.001. DM= a+b*age-c*meanT+d* rainfall, CP= -a-b* age +c*maxT+d* rainfall, Silica= -a+b* age +c*meanT+d* rainfall, NDF= a+b* age +c*minT, ADF= -a+b* age +c*meanT+d* rainfall, ADL= a+b* age -c*menT+d* rainfall, Cellulose= a- b* age +c*maxT-d*maxRH, Hemicellulose= -a-b* age +c*maxRH, cell content= a-b* age, DMIVD= -a-b* age +c*meanT-d*rainfall, TD= -a-b*age+c*meanT-d*rainfall, DMISD= -a-b*age+c*MeanT-d*rainfall

the soils, values of radiation and temperature and area covered by the vegetation (Del Pozo 2004, Juárez and Bolaños 2007 and Jiménez *et al*. 2010).

Santos *et al*. (2011) stated that the quality and productivity of the pastures is affected by environmental factors, such as the temperature, the light, and the rainfall, besides the intrinsic to each plant. The temperature and the water availability limit the correct growth and the quality of the pastures. Besides, they change their morphological, physiological, and biological structure.

The studies of Estrada (2004) and Ramírez (2010) reported results similar to those of this work. These authors noted high positive correlations of the species *Panicum maximum* with the mean and maximum temperatures in the CP indicators. They also noted high negative correlations of the temperature with the CP, which evidenced decline in the pasture quality by increasing the temperature.

The reference about the influence of the climatic factors on the quality of this species was reflected in the equations of multiple regression, established to determine the different quality indicators. This indicated that the processes occurring in the plant were affected when there were sudden changes in the climatic conditions and rise in the regrowth age, due to the close relationship of these factors and the age with the plant metabolism.

During the study, all the indicators were related to the indicators with the climatic factors and the age in each period of the year. The best expressions (R^2 higher than 0.95, P < 0.001 and low mean squares of the error, coefficient of indetermination and standard error of estimation) were obtained when the rainfall, the mean temperature and the age were included. This confirmed the previous results.

Ramírez (2010) and Homen *et al*. (2010), when studying the performance of *Panicum maximum* cv. common, Tanzania and Likoni, obtained the best expressions by including the rainfall, the temperatures, and the relative humidity.

It is concluded that the regrowth age and the climatic conditions characterizing each period of the year exert a marked effect on the nutritive value. The equations of linear multiple regression account for the relation between the different indicators of the nutritive value, the rainfall, the mean temperature, and the age.

Studies about the regrowth effect on the physiology and the quality indicators of *Panicum maximum* are recommended in exploitation conditions in different types of soil, in a way that its utilization can be recommended according to the edaphoclimatic conditions of each area of the Cauto Valley.

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References

Ankom Technology. Procedures for fiber and *in vitro* analysis. Available: <http://www.ankom.com> [Consulted: 16/11/04]

AOAC. 2000. Official Methods of Analysis. 17th Ed. Ass. Off. Anal. Chem. Washington, D.C.

Del Pozo, P. P. 2004. Bases ecofisiológicas para el manejo de los pastos tropicales. Anuario Nuevo. Universidad Agraria de La Habana, Cuba. Available: <http://www.produccionbovina.com/produccion_y_manejo_pasturas/pastoreo%20sistemas/30-bases_ecofisiologicas_manejo_pasturas_tropicales. htm.> [Consulted: 23/09/09]

Estrada, J.E. 2004. Efecto de la temperatura sobre la producción y el contenido de proteína cruda y fibra neutro detergente de *Panicum maximum* vc. Tobiatá, *Digitaria eriantha* vc. Transvala y *Brachiaria híbrido* vc. Mulato. Proyecto Especial de Ingeniero Agrónomo en Ciencia y Producción Agropecuaria. Zamorano, Honduras. 11 pp. Available:<http://www.zamo-oti-02.zamorano.edu/tesisinfolib/2004/T1972.pdf> [Consulted: 15/02/2010]

Fernández, J.L., Benítez, D.E., Gómez, I., Cordoví, E. & Leonard, I. 2001. Dinámica del crecimiento del pasto *Brachiaria radicans* vc. Tanner en las condiciones edafoclimáticas del valle del Cauto en la provincia Granma. Cuban J. Agric. Sci. 35:399

Fernández, J.L., Benítez, D.E., Gómez, I., Tandrón, I. & Ray, J. 2000. Effect of regrowth age on the yield of *Brachiaria purpurascens* cv. Aguada in Cauto Valley in Cuba. Cuban J. Agric. Sci. 34:257

Goering, M.K. & van Soest, P.J. 1970. Forage fiber analysis (apparatus, reagents, procedures and some applications). Agricultural, USDA. Washington DC. 379 pp.

Hernández, A. 1999. Nueva versión de la clasificación genética de los suelos de Cuba. Instituto de Suelos. Academia de Ciencias de Cuba. La Habana, Cuba

Hernández, D., Carballo, M. & Reyes, F. 2000. Reflexiones sobre el uso de los pastos en la producción sostenible de leche y carne de res en el trópico. Pastos y Forrajes 23: 269

Herrera, R. S. 1981. Influencia de la fertilización nitrogenada y edad de rebrote en la calidad del pasto bermuda cruzada (*Cynodon dactylon* vc. Coast Cross). PhD Thesis. Instituto de Ciencia Animal, La Habana, Cuba

Herrera, R.S. & Ramos, N. 2006. Factores que influyen en la producción de biomasa y calidad. In: *Pennisetum purpureum* para la ganadería tropical. Ed. Instituto de Ciencia Animal. La Habana, Cuba. p.79

Homen, M., Entrena, I., Arriojas, L. & Ramia, M. 2010. Biomasa y valor del pasto Guinea *Megathyrsus maximus* (Jacq) B.K. Simon & S.W.L. Jacobs, gramalote¨ en diferentes períodos del año en la zona de bosque húmedo tropical, Barlovento, Estado de Miranda. Zootec. Trop. 28:255

Jiménez, O., Granados, L., Oliva, J., Quiroz, J. & Barrón, M. 2010. Calidad nutritiva de *Brachiaria humidicola* con fertilización orgánica e inorgánica en suelos ácidos. Arch. Zootec. 59:561

Juárez, J. & Bolaños, E. 2007. Las curvas de dilución de la proteína como alternativas para la evaluación de los pastos tropicales. Universidad y Ciencia 23:81

Juárez, A., Cerrillo, M., Gutiérrez, E., Romero, E., Colín, J. & Bernal, H. 2009. Estimación del valor nutritivo de pastos tropicales a partir de análisis convencionales y la producción de gas *in vitro*. Téc. Pec. Méx. 47:55

Orskov, E.R., Hovell, B.D. & Mouid, F. 1980. Uso de la técnica de la bolsa de nylon para la evaluación de los alimentos. Prod. Anim. Trop. 5:213

Ramírez de la Ribera, J. 2010. Rendimiento y calidad de cinco gramíneas en el Valle del Cauto. PhD Thesis. Universidad de Granma. Bayamo. p. 100

Santos, M.C.S., Lira, M.A., Tabosa, J.N., Mello, A.C.L. & Santos, M.V.F. 2011. Responce of Pennisetum clons to periods of controlled hidric restriction. Arch. Zootec. 60:31

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