Influence of rainfall and temperature on biomass production of *Pennisetum purpureum* clones

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Biomass production performance of nine *Pennisetum purpureum* clones was evaluated in function of air temperature, rainfall and number of rainy days. The research was based on an experimental study developed at the Institute of Animal Science during the period 2009-2010 in a typical red ferrallitic soil without applying fertilization or irrigation. A completely randomized design was used and nine cuttings with four replications were practiced. Average yields of the two years of evaluation were 2.32 – 4.08 t/ha in the rainy period which were higher to those obtained in the dry period (0.75 – 1.36 t/ha). Yield had a decreasing tendency in time The highest significant correlations were achieved with the temperature (0.33-0.70) besides the number of rainy days. The coefficients of determination ranged between 58 and 80 %. It is concluded that forage production of *P. purpureum* was connected with the performance of the rainfall and temperature, and constitute a viable alternative for biomass production.

Key words: *without fertilization or irrigation, yield, climatic variables*

In pasture production the environmental natural conditions influence where this activity takes place. Climate is an essential component of the system. It is of vital importance to take into consideration the effect it exerts on the physiological processes originating plant growth and development. Febles *et al*. (2009) stated that the climate is one of the main sources from which seed production of high quality pastures is guaranteed and, consequently, biomass production, if it is considered that obtaining seeds is the first step of this practice.

One of the factors limiting animal production in the tropics of Latin America is the scarce availability and poor quality of forages, especially in areas of low natural fertility soils and with seasonal droughts (León *et al*. 2000). However, in Cuba, Pennisetum genus is of special interest, in view of its high luminous energy conversion possibility, excellent performance during establishment and high yield. This genus was introduced in our country in the the beginning of the 20th century and in the 80's in trials for obtaining genetic improvements for attaining biomass production and yield increases (Herrera *et al*. 2012). According to this, there are presently clones which have demonstrated tolerance to drought (Díaz 2009) and salinity (Álvarez 2009).

In view of the importance of this species for the development of the cattle plans of the country, this study aims at establishing the relationship between some climate factors and the yield performance of *P. purpureum* clones obtained biotechnologically in Cuba.

Materials and Methods

The experiment was developed during the period 2009-2010 at the Experimental Station of Pastures and Forages "Miguel Sistachs", of the Institute of Animal Science. A completely randomized design with nine cuttings and four replications was established. Nine clones of *Pennisetum purpureum* were used.

In a typical red ferrallitic soil without applying fertilization or irrigation, a uniformity cut was practiced at 10 cm at the beginning of the experiment. Later, the remaining cuttings were performed every 60 d in the rainy period and every 90 d in the dry season.

Yield (t/ha) was determined through total cutting in each treatment, after registering fresh weight of the total plot. The material collected was dried in an oven of air circulation at 65º C for 72 h. Yield and its components in dry basis were calculated, according to the methodology of Herrera (2006).

Climatic records, rainfall and mean temperature were collected (figure 1). Also, data of minimum and maximum temperatures as well as number of rainy days in each experimental cut were obtained. For confirming the normal distribution of data, Kolmogorov's-Snurbiv's test (Massey 1951) was used and for the homogeneity of variances the test of Bartlett (1937). A linear correlation analysis between yield (depending variable) and the climatic factors, rainfall, temperature and number of rainy dairy (independent variables) was made. The coefficients of correlation were reported.

From these results and according to the methodology proposed by Verdecia *et al*. (2012), linear multiple equations between yield and rainfall, temperatures and number of rainy days were established. For selecting the expressions of best adjustment the following elements were considered: highest coefficients of determination (R^2), high significance and significant term contribution, low standard errors of terms, standard errors of estimation and mean square of the error. Only those of best adjustment were reported.

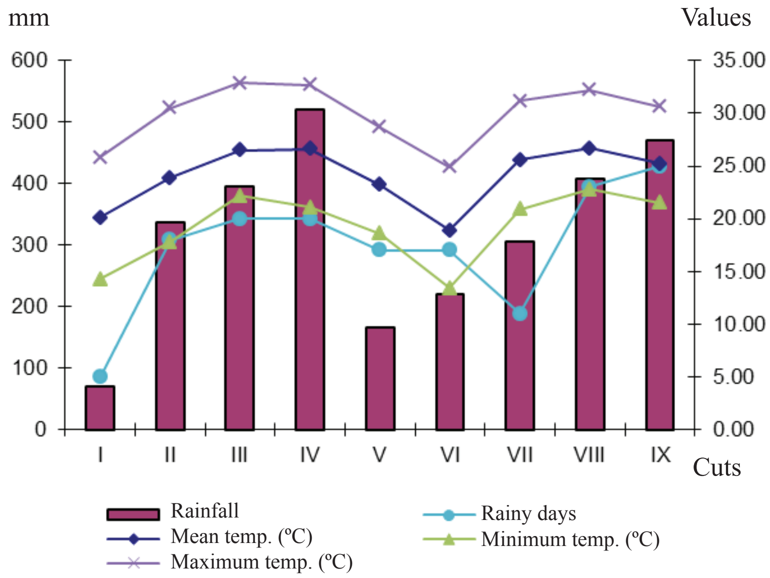

Figure 1. Climatic diagram of the studied period in the area of the Experimental Station of Pastures and Forages "Miguel Sistachs"

Results and Discussion

Yields (average of two years) of *P. purpureum* clones (table 1) show high variability in their performance, between them and between periods, with differences statistically significant. Data indicate that they are always higher in the rainy period. According to Rodríguez *et al*. (2011), this performance can obey to the fact that in the rainy period temperatures are higher, there is higher soil humidity and daylight duration. This propitiates that plants accumulate great amount of biomass expressing their growth potential and variability in a more dynamic and clear way. Clones e and g outstand. The c showed the highest value in the rainy period. However, in the dry period only attained a yield of 0.75 t/ha. Nonetheless, if the previous criteria are considered, this clone could be evaluated as promissory for a technology allowing the management of the difference between periods.

Table 1. Average DM yield of *P. purpureum* clones by period and total (t/ha/cut)

Clones	Period	
	Rainy	Dry
CT115	2.32[a]	1.23[ab]
a	2.50[a]	1.28[ab]
b	2.49[a]	1.13[ab]
c	3.84[c]	0.75[a]
d	2.54[ab]	1.05[ab]
e	4.08[c]	1.05[ab]
f	2.33[a]	1.02[ab]
g	3.49[bc]	1.36[b]
h	2.83[ab]	1.01[ab]
SE y Sig.	±0.356 ***	±0.198**

[a,b,c]Different letters indicate significant differences
**P < 0.01 and ***P < 0.001

P. purpureum cv. Cuba CT 115, used as control, showed an average yield per cut of 3.38 t/ha in the rainy period, reaching 26 t/ha of biomass in 180 d for the first year. This result agrees with Martínez (1995) in Cuba under similar conditions. Also it is in agreement with Herrera *et al*. (2007) on studying the effect of a growth promoter in this species. It must be considered that the previous result refers to studies with the whole plant and that the consumption of this pasture, according to the technology of biomass banks, only occurs in leaves and very young stems. However, Herrera *et al*. (2007) stated that if biomass is accumulated for a time longer than 120 d, more than 25 t DM/ha can be attained.

On carrying out a comparison of the performance of clones with the CT-115 (control), it was found that during the rainy period there are equal of superior results, thus they are considered potentially good biomass producers. From the statistical point of view, clones c, e and g surpassed their yield. This result is similar to that reported by Parra (2009) in a comparison of 13 clones of *P. purpureum* to the CT-115. In the dry period, there were no differences between clones and the control. Only c and g differed, favoring this latter.

DM yield throughout the cuttings (figure 2) is variable, but always decreasing. Clones a, b and f, together with the control (CT 115) showed an abrupt fall of their yield from the fourth cut. This coincides with the beginning of the second year of exploitation. On the contrary, c, d, e, g and h did not register a marked difference between the initial and final production. In h this tendency was

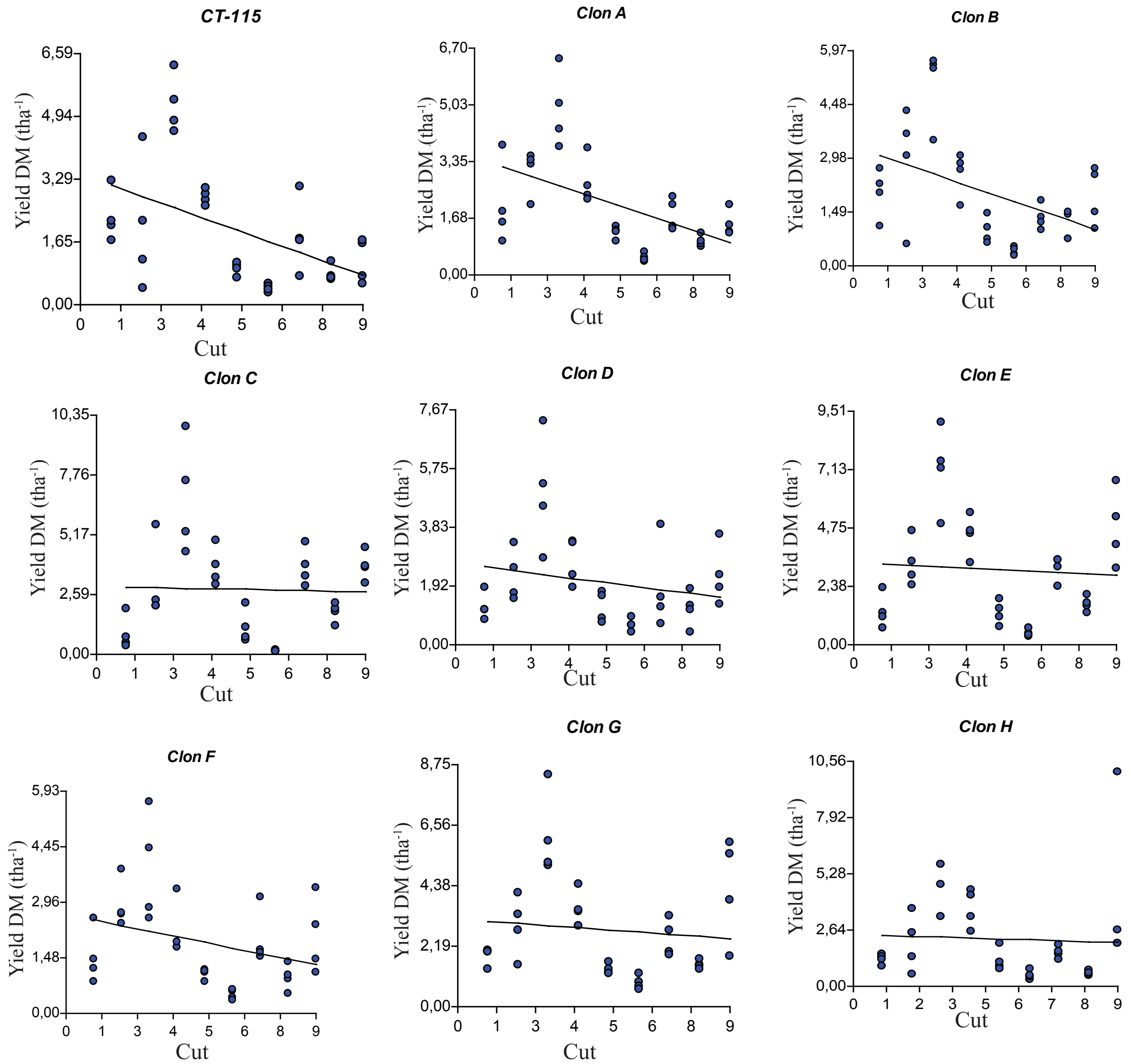

Figure 2. Yield tendency shown by Pennisetum clones throughout the time

shown with greater assertion, if taken into account that is was maintained constant during the whole experimental period. This performance can propose use alternatives, according to the productive purpose pursued.

In the analysis of correlations of the climatic factors and yield (table 2), the highest correlations were found with the minimum, mean and maximum temperatures, in the range from 0.40 to 0.70, although they were considered low and variables. The minimum temperatures were those of highest statistical significance. These results coincide with Ramírez *et al*. (2011), on studying *P. purpureum* cv. Cuba CT 169 in Cauto Valley in the Eastern region of Cuba, although the correlations reported were above 0.70.

In this study was also confirmed the statement of Baruch and Fisher (1998), who indicate that tropical grasses present a high sensibility to low temperature. Its negative effects on growth are evident between 0 and 15º C and, in some species at 20º C. Rainfall did not show significant correlations in any of the cases. The high variability of the data, expressed in the dispersion graphs (figure 2) could account for this result, since this was a field study without controlled conditions. In addition, during the experimental period there were damages provoked by several meteorological phenomena that took place in Cuba. However, the number of rainy days was significantly related to the performance of some clones (b and e). This result is considered logical and useful, if taken into account that the frequency of rainfall occurrence in a given period does not attain to maintain the adequate soil humidity levels for its development. This brings about that the plant by defect or by excess suffers a stress process.

According to Cuban conditions, this is one of the

Table 2. Correlation between the climatic factors and yield of *P. purpureum* clones

Clon	Tx	Tmin	Tmax	Pp	No of rainy days
CT115	0.36***	0.29	0.43***	0.22	-0.05
a	0.40**	0.31	0.48	0.27	0.03
b	0.40	0.33***	0.48**	0.32	0.12***
c	0.66	0.63	0.70	0.57	0.31
d	0.49	0.45	0.54	0.42	0.24
e	0.63	0.60**	0.68	0.62	0.37**
f	0.44***	0.37**	0.51	0.36	0.12
g	0.53	0.51***	0.57	0.53	0.33*
h	0.42	0.41***	0.45**	0.49	0.32***

factors affecting most pasture production, since during this dry season, only 25 to 30 % of the total pasture production of the year is attained, according to what was reported by Ramírez *et al*. (2010) in *P. maximum* cv. Likoni in the Eastern region of Cuba.

Herrera (2008) in studies on the basic principles of plant physiology, reported the best correlations on relating the number of rainy days, the maximum temperatures higher than 27 ºC and minimum temperatures of 15 ºC, with physiological growth elements. This relationship attained to be explained through the performance pattern of these indicators.

The analysis of linear multiple regression (table 3) evidenced that the coefficients of determination were in the range from 58 to 80 %, which determines, to a great extent, the responsibility of the climatic variability in the yield variability of the pasture. The adjustment was always statistically significant at 5 % confidence. The adjustments corresponding to the equations of first order, referred to the varieties c, e and a were similar to those reported by Verdecia *et al*. (2012) in *P. maximum* cv. Mombaza studies. Also they agree with Homen *et al*. (2010) on assessing the performance of *P. maximum* vc. common, Tanzania and Likoni, with the inclusion of the parameters of age and relative humidity. However, in studies of Cóndor (2012) coefficients of determination higher than 92 % are reported on studying this relationship in *P. purpureum* cv. CT 169 in Granma province, Cuba. In this same analysis it is confirmed that rainfall is the climatic element that less contribution makes to yields, with values of 0.01 and 0.02 and only in one case, of 0.08.

It is concluded that forage production of clones of *P. purpureum* constitutes a viable alternative for biomass

Table 3. Linear multiple equations for different clones of *P. purpureum*

Clon	Linear multiple regression equation	SE ±	MSE	R^2 Sign.	R^2 Aj.
CT-155	Yield = -13.11 – 6.96 (±0.93)a + 2.12 (±0.38)b + 4.94 (±0.57)c -0.02(±0.01)d + 3.8E-5(±8.3E-6) d^2 - 0.20 (±0.01) e	0.77	0.59	80***	75
a	Yield = -15.98 – 5.42 (±0.86)a + 1.40 (±0.34)b + 4.21 (±0.52)c – 0.02 (±0.01) d + 2.7E-5 (±7.6E-6) d^2 - 0.11 (±0.05)e	0.71	0.50	79***	75
b	Yield = -14.71 – 6.36 (±0.99)a + 1.80 (±0.40)b + 4.68 (±0.60)c – 0.02 (±0.01)d + 3.5E-5 (±8.8E-6)d^2 - 0.1 (±0.05)e	0.82	0.67	75***	70
c	Yield = -10.24 - 6.51(±1.41)a + 2.39(±0.58)b + 4.20(±0.83)c + 0.01(±0.004)d - 0.28(±0.08)e	1.26	1.58	72***	67
d	Yield = - 10.26 – 5.83 (±1.21)a + 1.87 (±0.48)b + 4.01 (±0.73)c - 0.01(±0.01)d + 2.5E-5 (±1.1E-5)d^0 - 0.12 (±0.7)e	0.99	0.99	64***	56
e	Yield = -8.14 - 6.71 (±1.41)a + 2.39 (±0.60)b + 4.27 (±0.85)c + 0.01(±0.004)d - 0.27(±0.08)e	1.30	1.68	70***	65
f	Yield = -9.90 - 3.79 (±1.04)a + 1.04 (±0.42)b + 2.85 (±0.63)c – 0.01 (±0.01)d + 1.2E-5 (±9.2E-6)d^2 - 0.10 (±0.06)e	0.85	0.73	58***	49
g	Yield = -4.31- 6.01 (±1.39)a + 2.17 (±0.58)b + 3.71 (±0.81)c + 0.01 (±0.004)d - 0.22 (±0.08)e	1.24	1.53	60***	54
h	Yield = -15.40 - 1.60 (±0.46)a + 2.26 (±0.82)b +7.03 (±1.63)c – 0.08 (±0.02)d + 0.0001 (±3.2E-5)d^2 + 5.57 (±2.13)e - 0.40 (±0.15) e^2 +0.01 (±0.0019)e^3	1.49	2.21	58***	46

Terms of the equation. a: mean temperature, b: minimum temperature, c: maximum temperature, d: rainfall, e: number of rainy days

***$P \leq 0.001$

production under the conditions of this study. The relationships established through the correlations of the climatic parameters and the yield of clones allowed establishing greater influence of minimum, mean and maximum temperatures in this performance. Also, it was confirmed that the number of rainy days has greater contribution that rainfall.

Unquestionably these clones increase the available germplasm of *P. purpureum* and could serve as basis for subsequent studies of genetic improvement from different ways, as the classic genetics, the biotechnological and the physical and chemical mutagenesis. It is recommended to confirm these relationships for each seasonal period, in view of the existing difference in the performance of the studied indicators. It is suggested to search for a predictive model from the results obtained and to evaluate the performance of the same varieties under different animal management systems and in other tropical grass species.

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