Short note [Nota corta]

INFLUENCE OF AGE AND CLIMATE IN THE PRODUCTION OF CENCHRUS PURPUREUS IN THE ECUADORIAN AMAZON REGION[1]

[INFLUENCIA DE LA EDAD Y EL CLIMA EN LA PRODUCCION DE CENCHRUS PURPUREUS EN LA REGION AMAZÓNICA ECUATORIANA]

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SUMMARY

The objective of this study was to establish the relationship between age and climatic elements and the performance indicators of *Cenchrus purpureus* vc. Maralfalfa. Sprouting ages at 30, 45, 60, 75 and 90 days were evaluated. A randomised block design was used and the variables green and dry matter yield of leaves and stems, total dry matter and dry matter production were measured. Second degree equations were established for age and the variables evaluated, as well as multiple linear curves to determine the relationship between climate factors and performance indicators; in the latter case, age was always used as an independent variable. The regression coefficients were higher than 0.96. The established regression equations explain the close relationship between age, performance, and climatic elements. These can be used to design efficient management systems of this variety. Age had a marked effect on the behaviour of the indicators evaluated, as performance increased. The established regression equations explain the close relationship between age, performance, and climatic elements. These can be used to design efficient management systems of this variety. It was concluded that age had a marked effect on the behaviour of the indicators evaluated, as performance increased.

Keywords: Age; humidity; grass; temperature; regression.

RESUMEN

El objetivo del presente trabajo fue establecer la relación de la edad y los elementos del clima con indicadores del rendimiento del *Cenchrus purpureus* vc Maralfalfa. Se evaluaron las edades de rebrote de 30, 45, 60, 75 y 90 días. Se empleó un diseño en bloques al azar y se midieron las variables, rendimiento de materia verde y seca de hojas y tallos, la producción total de materia en base seca y húmeda. Se establecieron ecuaciones de segundo grado para las variables evaluadas y la edad, así como lineales múltiples para determinar la relación entre los factores del clima y los indicadores del rendimiento, en este último caso siempre se empleó la edad como variable independiente. Los coeficientes de regresión fueron superiores al 0.96. Las ecuaciones de regresión establecidas explican la estrecha relación de la edad, el rendimiento y los elementos del clima. Estas pueden ser utilizadas para diseñar sistemas de manejo eficientes de esta variedad. La edad tuvo un marcado efecto en el comportamiento de los indicadores evaluados, a medida que aumentó el rendimiento. Las ecuaciones de regresión establecidas explican la estrecha relación entre la edad, el rendimiento y los elementos climáticos. Estos pueden utilizarse para diseñar sistemas de producción eficientes de esta variedad. Se concluyó que la edad tuvo un marcado efecto en el comportamiento de los indicadores evaluados, al aumentar el rendimiento.

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Palabras clave: edad; humedad; pasto; temperatura; regresión

INTRODUCTION

Pastures have been proven to be an appropriate source of feed for cattle, especially in tropical countries. This is due to the high number of species that can be used, the possibility of cultivating them all year round, the ability of the ruminant to use fibrous food, the species do not compete to be used as a food for human consumption and are usually an economic source (Herrera, 2006). However, the lack of good quality forage species adapted to the environmental conditions prevailing in different livestock areas is identified as one of the most limiting problems for livestock development (Sosa, 2004).

To mitigate this situation, great efforts have been made in the introduction of new species and varieties of higher yield and quality such as *Cenchrus purpureus* vc Maralfalfa in the Ecuadorian Amazon Region. However, the influence of age and climate on performance indicators is unknown. Therefore, the objective of this study was to establish the functional relationship between age and climate and different performance indicators in *Cenchrus purpureus* vc. Maralfalfa in the Ecuadorian Amazon Region.

MATERIALS AND METHODS

Study Area

The study was carried out at the Centre of Postgraduate Research and Conservation of Amazonian Biodiversity (CIPCA) belonging to the Universidad Estatal Amazónica (Amazon State University), located at 44 kilometres along the road between Puyo and Tena, in the Carlos Julio Arosemena Tola Canton, Napo Province, at an altitude of 584masl and with the following coordinates: 01 ° 14' 4.105 " S latitude and 77 ° 53 '4.27' 'W longitude.

The average rainfall in the province during the days of the experiment was 1426mm. The temperature in the shade was 23.40°C and 23.70°C in the sun and the average relative humidity of 83.80%.

Soil was classified as inseptisol, subtype Fluvaquentic Eutrudepts. A 1m deep trial pit was made to determine the limits, where limit "A" had a thickness of 15cm. Following on from that, we clearly distinguished two different colourations every 30cm, which became yellower and yellower. The chemical composition of the soil showed a pH of 5.50, organic matter of 26.8% and nitrogen level of 1.3%. his began with selecting the terrain, (regular topography and be free of excessive shade and watering). the removal of existing weeds and ground completely clearing was done manually. At the end of the preparation, the ground had the following characteristics: a length of 22 m and a width of 43 m, totalling 946 m^2. Each experimental unit had a rectangular shape of 5 m wide and 6m long with an area of 30 m^2. The units were separated by 1m-wide paths between each other and also between blocks.

Sowing

The cutting and transport of propagating material took place one day before sowing. It was brought from a prairie established about 3 years ago. The cuttings were selected and cut from the middle part of the Maralfalfa cane (stem) with 3 knots, with a length between 0.30 and 0.50 m and weight between 40 and 70 g.

The selected cuttings were planted or sown by placing a stake at a distance of one metre in the furrows of the plots. A disinfection of the vegetative material was carried out using Vitavax at a rate of 10 g/L of water through a fumigation pump in order to avoid the attack of possible pests or diseases.

A count of the number of cuttings was made in each experimental unit with its corresponding weight and identification by individual cards for each experimental unit. After the establishment of 150 days, a cut of uniformity was made

Sampling

The yield was measured at different sprouting ages by cutting 1 m^2 from each experimental unit. The total weights, leaf-stem ratio and dead material were weigh by means of a digital weighing machine.

Treatments, experimental design and experimental Measurements

A randomised block design with three replicates was used to evaluate sprouting ages at 30, 45, 60, 75 and 90 days.

The measurements observed were: green matter yield of leaves (GMYL) and of stems (GMYS), total green matter production (TGMP), dry matter yield of leaves (DMYL) and of stems (DMYS) and total production of dry matter (TPDM).

At the beginning of the evaluation in each period, a cut of uniformity was made to 20 cm of the soil (during the time period of the experiment). 25 m^2 plots corresponding to sprouting ages were delimited (30, 45, 60, 75 and 90) with 50 cm per side to act as borders. The area was neither irrigated nor fertilised during the experiment. The plots constituted 96 % of the pasture to be evaluated.

The yield was determined by the total cut of the plot in each treatment. The botanical composition was taken into account when expressing the yield of the variety under study. After the green weight of the total plot, the leaves and green stems were separated, weighed individually according to Herrera (2006a), dried in an air-circulating oven for 72 hours at 65 ºC and this allowed us to determine their yield in DM. For this, 200 g of each sample was used with 4 replicates per treatment.

Statistical Analysis and Calculations

The data was analysed using ANOVA; the "Statistica version 8.1" system for Windows was used. To verify the normality of the data, the Kolmogorov Smirnov test and the Newman-Keuls test were used to determine differences between the means.

The regression equations (linear, quadratic, cubic, logarithmic and Gompertz) were analyzed and the descending method was used to establish the functional relationship between yield and age, as well as between yield and climate. For the selection of the best fit equation we considered a high R^2 value, a high significance, a low standard deviation of elements and estimation, a smaller mean squared error, significant contribution of equation elements and a low indetermination coefficient ($1 - R^2$).

RESULTS AND DISCUSSION

The green matter yield increased with age ($P<0.05$) and a quadratic regression equation was adjusted; the highest values were reached at 90 days. Dry matter production increased with age ($P<0.05$), and a quadratic regression equation was adjusted; the highest value was reached at 90 days, exceeding 19 tons (Figure 1).

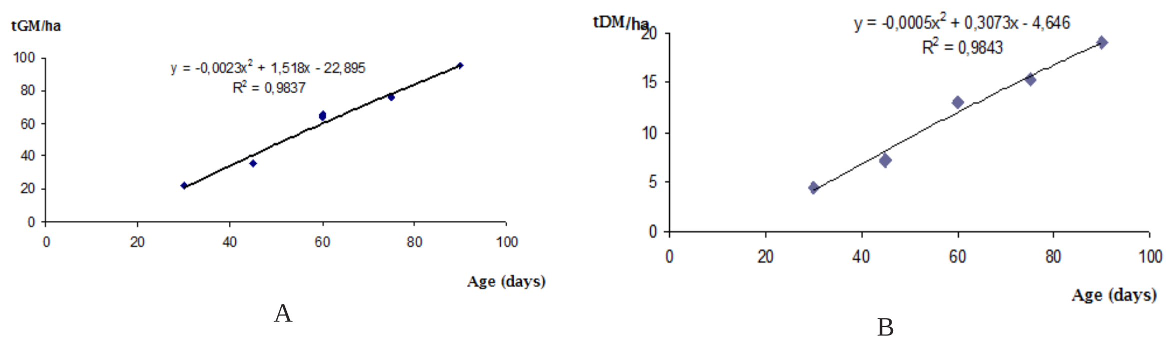

Figure 1: Effect of sprouting age on the total yield of green matter (A) and dry matter (B) (t) of *Cenchrus purpureus* vc. Maralfalfa

Recent studies by Rodríguez et al. (2014) reported linear, quadratic and cubic regression equations by establishing the functional relationship between age and dry matter yield in the *Pennisetum* species in the western region of Cuba. These results are similar to those obtained in this study, although the species are different and the experimental conditions as well. Other studies (Ramírez et al., 2010 and 2012) showed second degree equations for *Pennisetum purpureum* vc CT 169 and *Megathyrsus maximus* in rainy and less rainy seasons respectively, although it is necessary to point that the experimental conditions are different, since annual rainfall in the Ecuadorian Amazon Region exceeds 4500 mm, demonstrating the ecological plasticity of this genus.

The yield of leaves had a similar response pattern when related to age (Table 1). This is an indicator that allows one to establish the composition of the total yield of the plant, since the leaves show: a) a high probability of increasing the photosynthetic process, b) a greater possibility of substance production for growth, c) a better accumulation of reserves for sprouting, d) a higher quantity of nutrients in the leaves than in the stems, and e) that the animal consumes more leaves than stems (Bayble et al., 2007).

The highest yield of leaves during the first weeks of sprouting can be attributed to the appearance of new offspring and the plant's need to create the substances necessary for its development (Herrera et al., 2008). However, its decline as age increases is associated with increased stem thickness and length (Romero et al., 1998). However, the study done in Mexico by Beliuchenko and Febles (1980) in *Cenchrus purpureus* v Maralfalfa differ from the aforementioned comments and the results of this research: they obtained values of yield of leaves when the cutting ages were higher than 120 days (3.90 t/ha[1]), which is similar to the behaviour of the species evaluated here, but at 75 days of sprouting.

On the other hand, the green and dry matter yield of stems increased with plant age, which amongst other aspects could be due to an increase in structural carbohydrates (cellulose and hemicellulose) as well as lignin, although they were not measured in this experiment. However, other causes could be: water availability, development of the plant root system and time of year; these can produce morphological changes such as a decrease in foliar laminae and an increase in basal bundles (Cárdena et al., 2012). Nevertheless, it is important to note that in the Ecuadorian Amazon Region, climatic conditions are very similar throughout the year, which means a rapid plant growth, a response to what happened in this study.

Table 1. Relationship between sprouting age and phenological indicators in *Cenchrus purpureus* v Maralfalfa.

Variable	a	b	EE±	c	EE±	R^2	$1-R^2$	CMe	EE±
GMYL	-21.19	1.3	0.17	-0.01	0.001	0.81	0.19	4.28	2.07
GMYS	-1.75	0.21	0.14	0.008	0.001	0.99	0.01	2.91	1.70
DMYL	-4.24	0.26	0.03	-0.002	0.0001	0.81	0.19	0.17	0.41
DMYS	-39.9	0.04	0.02	0.002	0.0001	0.99	0.01	0.11	0.33

R^2 all at $p<0.001$. a = independent factor, b = rainfall for GMYS and DMYL, c = rainfall for the rest. Green matter yield of leaves (GMYL) and of stems (GMYS), dry matter yield of leaves (DMYL) and of stems (DMYS). CMe error square

Other studies, which evaluated the forage production of four germplasm of *Pennisetum purpureum* (Valenciaga et al, 2012) report values similar to those shown in this study. Yields were found for the maralfalfa grass (11.19 t/ha-1 stalk) maintaining an average growth rate of 113 $kg/ha^1/day^{-1}$. Values obtained here at the age of 75 days denote that the experimental conditions were different, which shows the adaptation of this genus to different ecosystems.

The results of the correlation analysis between the climatic variables suggest that there are correlations between the productive indicators and the climatic variables (Table 2). The relationships established between the productive indicators (GMYS, TPGM, DMYS and TPDM) and the rainfalls indicated the close dependence between these variables.

Research in Cuba conducted by Herrera and Ramos (2006), Ramirez (2010) and Ramírez et al. (2012) reported similar behaviour in Napier, king grass and *Pennisetum purpureum* v. CT 169, respectively, and reported in the first two cases that as the irrigation standard increased, the relationship between irrigation standard and yield declined. Note that in the Ecuadorian Amazon Region, annual rainfall exceeds 4500mm and can reach 6000 mm, with a monthly distribution that exceeds 300mm. This factor can contribute to the good development of this species, which by its behaviour shows the ecological plasticity that it has.

It is argued that water is the essential component of plant cells and that almost all metabolic processes depend on its presence. In addition, water is required for the maintenance of turgor pressure and the diffusion of solutes in and between the cells; it supplies the hydrogen and oxygen that are involved in the photosynthetic process, which permits the reaffirming of the high correlations with several of the variables, both in performance and chemical composition measurements (Lösch, 1995)

The effect of rainfall on the behaviour of these morphological, biochemical and physiological processes related to the growth and quality of pasture depends on multiple factors that are closely associated with the environment, the soil and its moisture and with plant species. In this sense, literature affirmed that the growth of grasses is a function of the available moisture in the soil and that this, in turn, varies depending on the amount and distribution of precipitation, structure and slope of the soils, the radiation and temperature values, as well as the area covered by vegetation (Del Pozo, 2004). The relationship between the climatic variables of dew point and both the productive and chemical indicators reflect the relationship between humidity and rainfall, since the latter have a close correspondence with the former. By taking into account the results of the correlations, multiple linear equations were established to estimate the GMYL, GMYS, TPGM, DMYL, DMYS and TPDM based on the climatic factors. In all cases, age was used as an independent variable (Table 3). The linear multiple equations presented coefficients higher than 0.96 for all variables evaluated. The CMe values and the standard deviations of the estimation were low, providing, amongst other aspects, the reliability of the established expressions (Table 3).

Table 2. Matrix of correlation of the elements of the climate with the indicators of the performance

Variable	Total rainfall	Outdoors temperature	Temperature in the shade	Thermal sensation	Dew point	Relative humidity
GMYL	-0.61**	-0.16	0.02	-0.03	0.38	0.83**
GMYS	0.92***	-0.90***	-0.96***	-0.95***	-0.96***	-0.47*
TPGM	0.62**	-0.98***	-0.95***	-0.96***	-0.78**	-0.07
DMYL	-0.61**	-0.16	0.02	-0.03	0.37	0.83**
DMYS	0.92***	-0.90***	-0.96***	-0.95***	-0.96***	-0.47*
TPDM	0.62**	-0.98***	-0.95***	-0.96***	-0.78**	-0.07

*p<0.05 **p<0.01 ***p<0.001. Green matter yield of leaves (GMYL) and of stems (GMYS), total green matter production (TGMP), dry matter yield of leaves (DMYL) and of stems (DMYS) and total production of dry matter (TPDM).

Table 3. Simple linear models in *Cenchrus purpureus* vc Maralfalfa

Variable	a	b	EE±	c	EE±	d	EE±	R^2	$1-R^2$	CMe	EE±
GMYL	-4.92	1.44	0.08	-0.07	0.004			0.96	0.04	0.93	0.96
GMYS	1211	1.025	0.03	-14.67	2.62			0.99	0.01	3.89	1.97
TPGM	1022	1.92	0.14	-12.41	0.27	-0.047	0.008	0.99	0.01	2.87	1.69
DMYL	-0.98	0.29	0.016	-0.015	0.0009			0.96	0.04	0.03	0.18
DMYS	240.5	0.20	0.006	-2.91	0.50			0.99	0.01	0.14	0.38
TPDM	220.27	0.09	0.009	-2.65	0.14	0.006	0.0005	0.99	0.01	0.01	0.11

R^2 all at p<0,001 a = independent factor, b = rainfall for GMYS and DMYL, d = humidity for the rest, c = rainfall for the rest. Green matter yield of leaves (GMYL) and of stems (GMYS), total green matter production (TGMP), dry matter yield of leaves (DMYL) and of stems (DMYS) and total production of dry matter (TPDM). (CMe) error square

This demonstrates the reliability of the model, since the method of all possible regressors was used for its construction (Chacin, 1998). Literature reflected the use of mathematical equations to predict biomass production for tropical, temperate and some semi-arid vegetation types (Návar et al., 2001). At present, the number of studies using climate factors in mathematical expressions to explain the behaviour of production and other indicators of pasture is not extensive in the literature published in Ecuador.

Higher regression coefficients (greater than 0.93) were found in more recent studies in the species *Pennsiteum purpureum* vc CT 169 using multiple linear equations, where the yield and chemical composition and minerals P and Ca were related to climatic variables. These authors used mainly rainfall and relative humidity in their models, although the experimental conditions were different, which reaffirms the high correlation between these variables and supports the results of this study (Ramírez et al., 2014).

On the other hand, other studies, which established multiple linear equations to relate climatic variables and age, with the yield and chemical composition of the species *Megathysrus maximus*, achieved high coefficients and great adjustments when they used humidity and rainfall in their models. This is similar behaviour to that found in this work (Ramírez et al., 2011). The green matter yield increased with age (P<0.05) and a quadratic regression equation was adjusted; the highest values were reached at 90 days. Dry matter production increased with age (P <0.05), and a quadratic regression equation was adjusted; the highest value was reached at 90 days, exceeding 19 tons.

CONCLUSIONS

Age had a marked effect on the behaviour of the indicators evaluated, as performance increased. The established regression equations explain the close relationship between age, performance, and climatic elements. These can be used to design efficient management systems of this variety.

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