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SHORT-TERM STUDY ON ^{13}CARBON DISCRIMINATION ON IRRIGATED TROPICAL PASTURE

G.B. Martha, Jr.[1,2], M. Corsi[1], P.C.O. Trivelin[2] and F. Queiroz, Neto[1]

[1]Universidade de São Paulo -ESALQ, Dept. Produção Animal, CP 9, Piracicaba, SP, Brasil, 13418-900, gbmartha@carpa.ciagri.usp.br

[2]Universidade de São Paulo – CENA, CP 96, Piracicaba, SP, Brasil, 13400-970.

Abstract

A better understanding of pasture ecosystem can be obtained through the use of ^{13}C discrimination technique. In this context, an experiment, assigned in a randomized complete block design with four replicates, was conducted to evaluate the Δ^{13}C (‰) discrimination, nitrogen (N) yield (kg N ha^{-1}), total nitrogen content (g kg dry matter (DM)$^{-1}$) and dry matter yield (kg DM ha^{-1}) on an irrigated Tanzania grass pasture (*Panicum maximum*, Jacq.) receiving increasing rates (0, 30, 60, 90 and 120 kg N ha^{-1} cut^{-1}) of N fertilizer during the summer. Dry matter yield, N yield and nitrogen concentration increased quadratically with increasing levels of N fertilizer ($P < 0,05$). On the other hand, Δ values tended to decrease linearly with increasing levels of N fertilizer ($P > 0,05$). Besides that, negative and significant correlations ($P < 0,05$) were evident between either Δ values and dry matter yield ($R = -0,4807$) and Δ values and N yield ($R = -0,5245$). Overall results allow to establish the following conclusions: 1) at lower N fertilizer inputs tropical pastures tended to show higher discrimination against ^{13}C though this effect might be associated with lower N concentrations in plant tissue that, in turn, might add inefficiency to the C4 photosynthetic pathway and 2) lower dry matter and N yields were associated with higher ^{13}C discrimination values. Conversely, higher dry matter and N yields were associated to lower ^{13}C discrimination values.

Keywords: ^{13}C discrimination, N fertilizer, tropical pasture

Introduction

The ratio between stable isotopes of organic and inorganic elements in nature generally indicates the type and rate of processes forming these components and the prevailing environmental conditions by the time these components were formed (Trivelin, 1999). In this context, stable isotope analysis has the potential to characterize and provide ecological informations about an environment. Very little information exists in literature regarding carbon (C) discrimination in intensively-managed tropical pastures, even though studies on this topic can provide further insights on the understanding of the complex interactions that characterize pasture systems, namely the effect soil use management has on the overall structure of the ecosystem and the rates and profiles of vegetation dynamics in these systems. Many different scenarios can be investigated in order to provide a better understanding of the ecosystem through ^{13}C discrimination technique but for intensively managed highly fertilized pasture systems it would be quite interesting to relate nitrogen (N) status/input of the system to discriminated ^{13}C. This paper reported preliminary results on ^{13}C isotope discrimination on an irrigated Tanzania grass pasture (*Panicum maximum*, Jacq.) receiving increasing rates of N fertilizers during the summer.

Material and Methods

The experiment was carried out at Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ/USP; 22º 42' S and 47º 38' W) during the summer (from January 12 to February 17/2000) and consisted of an irrigated (central pivot) Tanzania grass pasture (3.5 x 2.5 m plots) that received five rates of N (0, 30, 60, 90 and 120 kg N/ha) as ammonium sulfate. Lime, phosphorus, potassium and trace elements were corrected according to soil analysis. Treatments (N rates) were assigned in a randomized complete block design replicated four times. To determine the dry matter yield (DMY) (kg dry matter (DM) ha^{-1}) the forage was cut at a 30 cm-cutting height (two sampling areas of 0,25 m^2 each to form a composed sample) and samples collected in the field were oven dried (55º C) during a 48 h period, weighed and grounded. N concentration (NC) determination followed the Kjeldahl procedure and N yield (NY), i.e., kg N ha^{-1}, was obtained by the product between DMY and NC. Subsequently, samples were analyzed for $\delta^{13}C$ (‰) using an automated nitrogen and carbon analysis mass spectrometry (ANCA; Europa Scientific, model SL 20-20). Carbon isotope composition was expressed as $\delta^{13}C$ relative to that of the PDB standard with a precision of ± 0.02 ‰. The resulting $\delta^{13}C$ (‰) values were used to calculate isotopic discrimination (Δ) as indicated by Farquhar (1983). Data was first tested for homogeneity of variance and normality and the statistical package SAS System (1989) was used to perform the overall analysis of variance.

Results and Discussion

DMY, NY and NC all increased quadratically with increasing levels of N fertilizer ($P < 0,05$), reaching a maximum (inflexion) point at 83,2, 82,6 and 100 kg N ha^{-1}, respectively (Table1). NY was positively related to DMY while both DMY (-0,4807) and NY (-0,5245) were negatively related to Δ (P < 0,05; Table 2). Δ values are within the typical range found in tropical grasses (Trivelin, 1999), yet this variable weakly responded to increasing levels of N fertilizer (Table 1). However, a linear non-significant tendency of higher discrimination against ^{13}C in tropical pastures at lower N fertilizer inputs was evident and seems feasible to admit that, at least in part, the high NC (even in control plots) rendered poorer correlations between NC and Δ (Table 2). In this context, NC response pattern to increasing levels of N fertilizer might suggest that plants receiving lower N fertilizer rates tend to be at a lower N status that, in turn, could have negatively contributed to the photosynthetic process (higher ^{13}C discrimination), probably reflecting a reduced partitioning of carboxylase activity to ribulose-1,5-biphosphate carboxylase relative to phosphoenolpyruvate carboxylase in these “low N status” C4 plants as proposed by Meinzer & Zhu (1998). Meinzer & Zhu (1998) argued that this fact seems to indicate that the associated increase in bundle sheath leakiness to CO_2 and decline in quantum yield (in conjunction with an extra energy cost to the plant, because ATP is required for regeneration of phosphoenolpyruvate carboxylase) may have been attributable largely to a decline in C3 cycle activity in the bundle sheath relative to C4 cycle activity in the mesophyll.

Overall, observations generated in this short-term experiment revealed that the use of ^{13}C discrimination technique can be a powerful tool in assessing nitrogen and carbon fluxes in soil-pasture systems. At lower levels of N nutrition (lower N fertilizer inputs) tropical pastures tended to show higher discrimination against ^{13}C, though this effect might be associated with lower N concentrations in plant tissue that, in turn, might add inefficiency to the C4 photosynthetic pathway. The absence of significant responses in this regard could be a consequence of sampling procedure that is more complex with cespitous clumpy growth habit forages than on swards forming pastures (Mannetje, 1987). Evaluations of ^{13}C discrimination, under different nitrogen fertilizer scenarios and/or different pasture managements, can contribute considerably to the better understanding of the mechanisms governing pasture systems and studies of this kind should be encouraged.

References

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Table 1 - Equations relating several variables to nitrogen fertilizer rates.

Equations	R^2	CV (%)	P-value
Dry matter yield (kg DM ha^{-1}); $= 3528 + 78{,}2\,x – 0{,}465\,x^2$	41,97	24,96	0,0169
Nitrogen yield (kg N ha^{-1}); $= 54{,}7 + 1{,}8 – 0{,}011\,x^2$	49,65	26,62	0,0058
N concentration (g N kg DM^{-1}); $= 15{,}8 + 0{,}08\,x – 0{,}0004\,x^2$	78,03	4,07	0,0001
$\Delta = 4{,}3 – 0{,}003\,x$	10,76	9,39	0,1839

Table 2 - Correlation matrix among several variables as a result of increasing rates of nitrogen fertilizer.

Variable	Dry matter yield	Nitrogen conc.	Δ value
Dry matter yield	-	-0,1495	-0,4807
	-	(0,5669)	(0,0435)
Nitrogen yield	0,9777[1]	0,0080	-0,5245
	(0,0001)[2]	(0,9758)	(0,0255)
Nitrogen concentration	-	-	-0,3007
	-	-	(0,2408)

[1] Correlation; [2] P-value.