Carbon Accumulation in Soils under *Brachiaria* Pastures in the Atlantic Forest Region of the South of Bahia, Brazil

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CARBON ACCUMULATION IN SOILS UNDER *BRACHIARIA* PASTURES IN THE ATLANTIC FOREST REGION OF THE SOUTH OF BAHIA, BRAZIL

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Abstract

The objective of this study was to investigate the change in carbon stocks in soil following deforestation of the Atlantic forest in the South of Bahia State (Brazil) and replacement with productive pastures of *Brachiaria humidicola* either in monoculture or with the introduction of the forage legume *Desmodium ovalifolium.* Carbon stocks in the 0-30 cm layer were 44.5 Mg ha^{-1} under the original forest and found to be approximately 42 Mg ha^{-1} C 10 years later. At this time pastures of *B. humidicola* with or without the presence of *D. ovalifolium* were formed and grazed continuously for a further nine years until 1997. To 30 cm depth, C stocks increased during this time to 49.3 Mg ha^{-1} in the grass-only pasture and 52.4 Mg ha^{-1} in the mixed pasture which suggests that the presence of the legume enhanced C accumulation under the *Brachiaria* pastures. Analysis of the ^{13}C abundance of samples taken to 100 cm depth in 1997 revealed that there was significant accumulation of organic matter derived from the *Brachiaria* to a depth of 50 cm in the soil and this material was of high C:N ratio (22-27).

Keywords: Tropical forest, *Brachiaria humidicola, Desmodium ovalifolium,* Pastures, Soil carbon accumulation, Soil organic matter

Introduction

Along the Atlantic coastal region of Brazil from Rio de Janeiro, north to the State of Rio Grande do Norte, at least 20 Mha of Atlantic forest has been replaced by pastures of *Brachiaria*. Several studies in the Amazon region have shown that deforestation initially causes a decrease in soil organic matter (SOM) levels but if *Panicum* or *Brachiaria* pastures are established and maintained in a productive state, after some years SOM levels increase and eventually often surpass the levels originally under the forest (Neill et al., 1997). However, similar studies do not appear to have been performed in the Atlantic forest region.

In this study analyses of total C and ^{13}C isotope abundance of the SOM were utilised to investigate the changes in soil C stocks under both grass-only *B. humidicola* and mixed *B. humidicola*/*Desmodium ovalifolium* pastures established in the Atlantic forest region of the south of Bahia State and grazed continuously for 9 years by beef cattle at 3 different stocking rates.

Material and Methods

1. Site: Estação de Zootecnia do Extremo Sul da Bahia (CEPLAC), Itabela, Bahia. (16°39'S, 39°30'W). Soil: Typic Paleudult (0-20 cm: pH 5.5; Ca^{2} 2.2; Mg^{2+} 0.2; K^{+} 0.1; Al^{3+} 0.1 $cmol_c$/kg); P (Mehlich-1) 2.0 mg/kg. Climate: Humid tropical (Annual rainfall 1300 mm, Mean monthly temperatures range from 19 to 29°C).

2. Grazing experiment: Experiment was planted in 1987 in an area originally deforested in nearly 1977, and was grazed continuously from 1988 to 1996. *B. humidicola* in

monoculture (BH) and mixed *B. humidicola/D. ovalifolium* (BHDO), each under the stocking rates of 2, 3 and 4 animals/ha with 3 replicates were arranged in a completely randomized design. Three crossbred Zebu-Brahman steers were introduced into paddock of 1.5, 1.0 or 0.75 ha for respective three stocking rates. More details of this study were given in Rezende et al. (1999).

3. Fertilisation: At sow (1987): 12.5 kg ha^{-1} K (potassium chloride) and 22 kg ha^{-1} P (single superphosphate). Maintenance: 6 kg ha^{-1} K and 11 kg ha^{-1} P applied every 1 to 2 years.

4. Sampling: In 1988 composite soil samples (20 sub-samples) were taken from each paddock at 5 cm layers to 25 cm depth. This sampling was repeated in 1994 at 0-5, 5-10 and 10-30 cm depth layers. Finally in February 1997, composite soil samples were taken from 0-5, 5-10, 10-15, 15-20, 20-30, 30-40, 40-50, 50-60, 60-80 and 80-100 cm depth layers. Composite samples (4 sub-samples) were taken from three profiles (50 m apart) in the neighbouring forest at the same depth for chemical analyses and bulk density measurements.

5. Analyses: All soil samples were sieved to 4 mm to remove roots and other debris and ground to <100 mesh using a roller mill. Total C was determined on 200-250 mg aliquots using a Leco Model CHN 600. Total_N content was determined on 1 g aliquots using semi-micro Kjeldahl digestion followed by steam distillation using an automatic titration/distillation unit (Tecator Kjeltec model 3100, Höganäs, Sweden) as described by Urquiaga et al. (1992). The ^{13}C isotopic abundance of the soil samples were determined on nearly 20 mg aliquots using a continuous-flow isotope-ratio mass spectrometer (Finnigan DeltaPlus mass spectrometer coupled to the output of a Carlo Erba EA 1108 total C and N analyser – Finnigan MAT, Bremen, Germany).

The proportions of soil organic C derived from the forest vegetation (fC_{For}) and from the *Brachiaria* (fC_{Br}) in each layer were estimated from the ^{13}C abundance of the soil samples ($‰_{PDB}$) from the following equation:

$fC_{For} = (\delta^{13}C_{Past} - \delta^{13}C_{Br})/(\delta^{13}C_{For} - \delta^{13}C_{Br})$ ....Eqn. 1

where $\delta^{13}C_{Past}$ and $\delta^{13}C_{For}$ are the ^{13}C abundance of the same layer of soil under the pasture and forest, respectively and $\delta^{13}C_{Br}$ is the ^{13}C abundance of *B. humidicola* litter.

Results and Discussion

Soil C and N content under the pastures was not significantly affected either by stocking rate or its interaction with pasture type. Shortly after establishment of the pastures in 1988, the soil C stock (0-30 cm) under the grass-only and mixed pastures were estimated to be 43.7 and 41.8 Mg ha^{-1} , respectively and marginally lower than that under the neighbouring forest (44.5 Mg ha^{-1}). After six years of grazing (1994) the C stocks showed an significant ($P<0.05$) increase to 47.2 and 49.8 Mg ha^{-1}, although, as soil bulk density was not estimated at these first two samplings, the increase may have been partly caused by soil compaction owing to cattle treading. A further three years of grazing (1997) showed further non-significant increases in soil C stocks to 49.3 Mg C ha^{-1} in the grass-only pasture and 52.4 Mg ha^{-1} in the mixed pasture which suggests that the presence of the legume enhanced C accumulation under the *Brachiaria* pastures.

The proportions of soil C in each layer calculated from the ^{13}C data showed that under the grass-only pasture approximately 37 % of C derived from the forest vegetation in the 0-5 cm layer was lost since the original deforestation in nearly 1977 (Fig. 1). The losses of forest derived C from the 5-10 and 10-30 cm layers in the same period were 19.5 and 13 %, respectively. After the establishment of productive, well-managed pastures in 1987/8, the C derived from the *Brachiaria* replaced the lost forest-derived C and in 1997 the soil C stock (0-30 cm) was significantly higher than in 1988, and showed continuing trend to increase. At the final sampling of the experiment in 1997 in the 0-100 cm layer of soil under the mixed grass-legume pasture the C stock (97.2 Mg ha^{-1}) was higher ($P < 0,095$) than in the grass-only pasture (92.2 Mg ha^{-1}. The ^{13}C data indicated that there was no significant input of *Brachiaria* residues below 60 cm depth (Fig 2). Because of the significant proportion of *Brachiaria*-derived C in the top 30 cm of the soil in the grass-only pasture it was possible to calculate the C:N ratio of the organic matter derived from the *Brachiaria*, and this was found to be between 22 and 27.

The results of this study in the Atlantic forest region of the south of Bahia confirm those of most similar studies conducted in the Amazon, that after deforestation soil carbon stocks in the 0-30 cm layer are reduced. After 9 years of establishment of well-managed *B. humidicola* pastures at this site C stocks showed and increase to above that of the original forest and this appeared to be due to the high C:N ratio of the *Brachiaria*-derived organic matter. The incorporation of a legume into the pasture further stimulated C accumulation.

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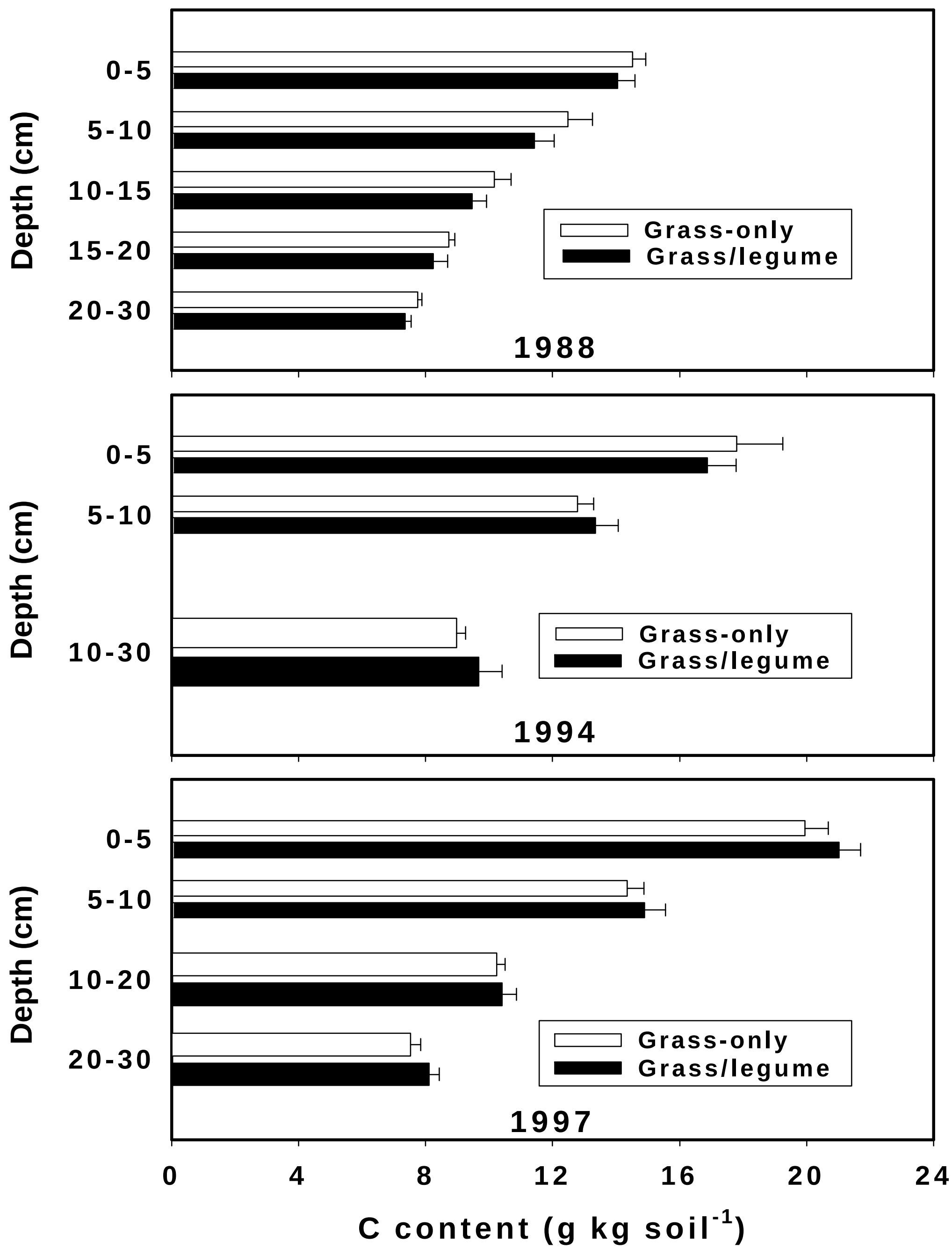

Figure 1 - Soil carbon content (0-30 cm) under *B. humidicola* (grass-only) and mixed *B. humidicola*/ *D. ovalifolium* (grass/legume) pastures at the establishment (1988) and during grazing period (1994 and 1997)

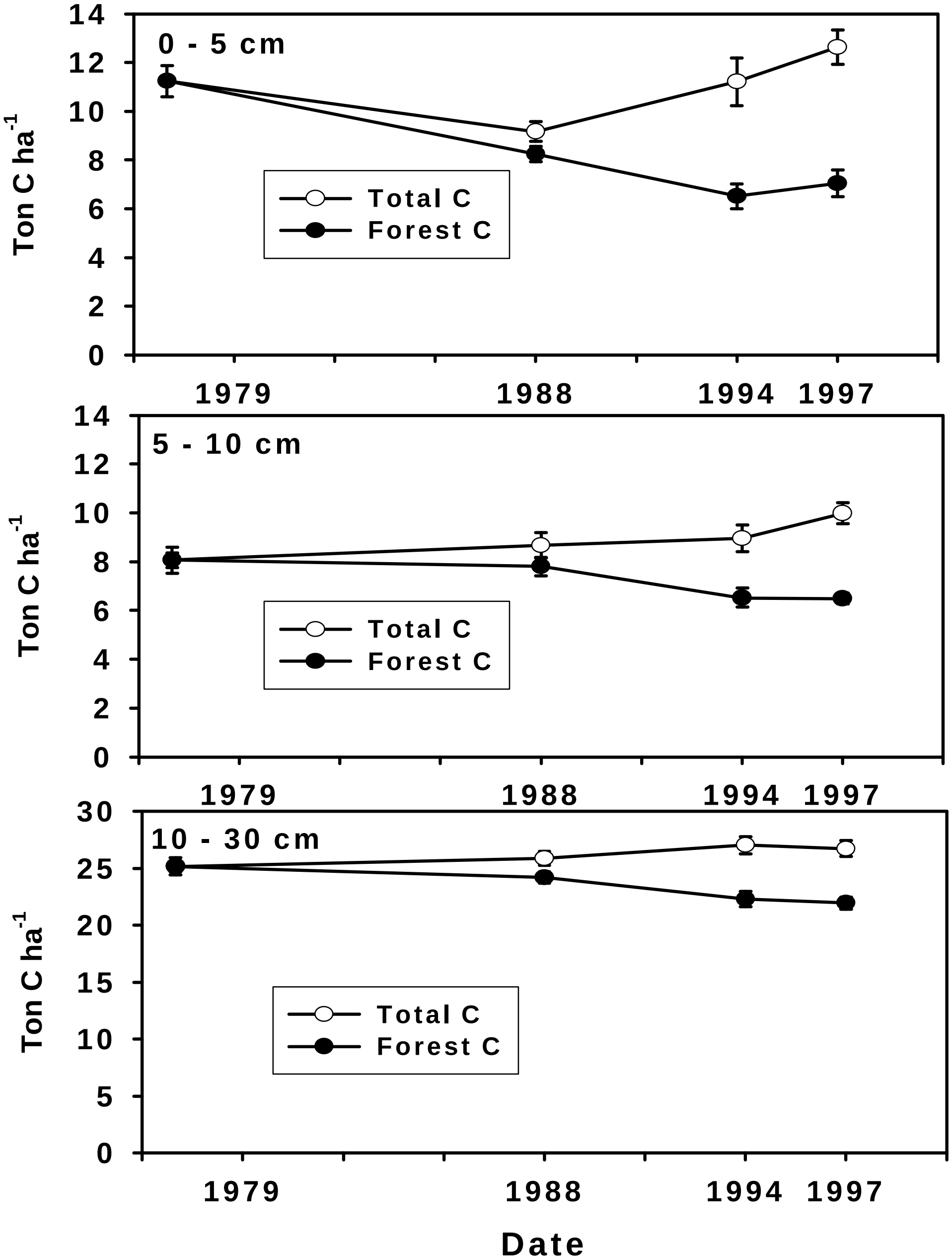

Figure 2 - Soil carbon content (0-30 cm) derived from forest and *Brachiaria at* deforestation (1977) and at the establishment of *B. humidicola* pastures (1987) and during grazing period (1988 and 1997). Values are means of 3 stocking rates and 3 replicates