FERTBIO 2012
A responsabilidade socioambiental da pesquisa agrícola
17 a 21 de Setembro - Centro de Convenções - Maceió/Alagoas

# Soil Macrofauna and its Relationship with Carbon and Nitrogen Contents UnderConservation Agriculture Systems in the Cerrado of Unaí, MG

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**ABSTRACT** –The area of study is located at Unaí, northwest of Minas Gerais state, in the Cerrado biome. The experiment is characterized by tillage regimes (conventional and no-till) and the presence (or not) of cover crops cultivated in intercropping with maize. Farming practices simulate those used in small scale farming conditions. Six treatments were studied: **CT** – Conventional; **NT** – No-tillage; **b** – *Brachiariaruziziensis*; **g** - *CajanusCajan*; **NT+b** – No-tillage + *B. Ruziziensis*; **NT+g** – No-tillage + *CajanusCajan*. An adjacent Cerrado (**CER**) and a pasture area (**PAT)** were sampled as a reference, totalizing eight areas. Macrofauna were collected using TSBF Method (Tropical Soil Biology and Fertility) and all individual were counted and separated in taxonomic groups. Comparing the abundance of individuals per treatment, a high variability was observed and the composition of the communities is related to the type of soil cover. The management systems under conservation agriculture (including no-till and use of cover crops intercropped) presents higher biodiversity than conventional tillage and the pasture. The abundance of individuals was higher in the pastures areas followed by no-tillage and *CajanusCajan*.

**Keywords:**no-tillage, cover crops, small scale farmers.

**INTRODUCTION -** Neotropical savannas cover 275 millions of hectares in the world, and 90% of them are located in Brazil. The "Cerrado" (250 millions of hectares) (Cole, 1986) forming the second largest Brazilian biome (23% of the territory). On Brazil, 39% of Cerrado lands are used, mainly by pasture (26%) and agriculture (10%) (Sano et al., 2008).

Conservation agriculture (CA) systems can be used with one commercial crop (soja, maize) without tilling the soil or intercropped with a recycling cover crop (from the genera *Brachiaria*, *Stylosanthes*, *Crotalaria and Cajanus*), which produces large amounts of biomass at the end of the rainy season and can still be used as non incorporated green manure or grazed on field (Scopel et al., 2004). Bernoux et al. (2006) have reported that in 2007 about 6 million ha of cropland were estimated to be under CA (no-till) in the Cerrado.

Conservation agriculture practices can increase crop production while reducing erosion and reversing soil fertility decline trough continual additions of fresh organic matter (crop residues and cover crops) stimulating SOM sequestration and biological activity in the root zone. However, its adoption encounters several major difficulties, such as development of new pests and diseases, and the need for farmers of greater technical knowledge. It also provides a low-cost option to mitigate global warming with reduction or elimination of soil tillage and increase soil organic carbon (Boddey et al., 2010).

Research conducted in Cerrado demonstrated that invertebrate communities seem to be best conserved in derived system from the Cerrado, with structure similar to that of the original system, such as pastures planted in savanna areas and tree-based systems in forest areas (Benito et al., 2004; Decaëns et al., 2004; Silva et al., 2006). However, increases in the intensity of agricultural practices and the establishment of continuous pastures or annual crops have caused important changes in the community structure, abundance and biomass of soil macrofauna.

The objective of this work was: (i) to assess the effects of cover crops (*CajanusCajan* and *Brachiaria ruziziensis*) cultivated intercropped with maize, on the abundance and diversity of the macrofauna and (ii) to verify the relationships between the macrofauna and carbon and nitrogen contents in the soil.

**MATERIAL AND METHODS -** The area of study is located at Unaí, northwest of Minas Gerais in the Cerrado biome. The study region is characterized by a sub-humid tropical climate, typical of the Brazilian Cerrado.

According to Köppen classification, the climate is Tropical wet and dry "Aw" (or savanna climate). The mean annual rainfall varies between 1200 mm and 1400 mm, with rain occurring between October to April, and the dry season, with duration of 5 to 6 months, coincides with the coolest months. The mean annual temperature is 24.4° C.

The experiment was installed in 2005, contained six treatments arranged in three completely randomized blocks. The treatments are characterized by different agricultural practices (conventional or no-tillage), and the presence or not of cover crops with maize (*Zea mays*). Six treatments were studied: **CT** – Conventional; **NT** – No-tillage; **b** – *Brachiaria ruziziensis*; **g -** *Cajanus Cajan*; **NT+b** – No-tillage+ *B. Ruziziensis*; **NT+g** – No-tillage+ *Cajanus Cajan*. An adjacent Cerrado (**CER**); and a pasture area (**PAT)** were sampled as references, totalizing eight areas. Individual plots measured 75 $m^2$ (15m by 5m), with exception of the plots with cover crops (treatment b and g) which were half the size measured 37.5 $m^2$.

**Sampling and analysis**

Macrofauna sampling was done using TSBF Method (Tropical Soil Biology and Fertility). The soil monoliths were extracted with 3 repetitions (blocks), and 2 replications in each plot. In addition, nearby Cerrado and pasture (*Brachiaria brizantha*), were sampled, making 4 repetitions in each one. Since in the experiment, two points were taken randomly in each plot; in the pasture and Cerrado, 4 points were taken in a transect with distances of 10m. Monoliths are divided in 3depths (0-10 cm, 10-20 cm and 20-30 cm) and the litter, totaling 176 samples (144 in the experiment + 32 for the Cerrado and pasture).

The fauna was sampled in the litter layer before soil blocks were excavated. Soil was hand-sorted in the field in order to collect macrofauna specimens, which were stored in a 45% alcohol solution, except for the earthworms that were preserved in 4 % formaldehyde.

All individuals were counted and identified at the morphospecies levels (i.e. morphologically identical groups of individuals) in the laboratory of EMBRAPA Cerrados at Brasilia, Brazil. Macrofauna data leads to calculate abundances, morphospecies richness index and frequencies for each sample. The Coleoptera group was subdivided into larvae and adults (CoL and CoA, respectively), because adults are considered to have different roles in soil function, acting as micropredators, litter transformers or "ecosystem engineers" (Lavelle, 1993). In the analysis, Hymneoptera and Formicidae were regrouped into Hymneoptera (Hym). The other groups found were Isoptera (Iso), Lepidoptera (Le), Hemiptera (He), Diptera (Di), Blattodea (B), Dermaptera (De), Myriapoda Diplopoda (Md), Myriapode Chilopoda (Mc), Chelicerata (Ch) and Oligochaeta (Oli). When specimen identification of larvae was impossible, theses were regrouped into "Others" label. Orthoptera presented less than 0.1% of population, so it was also regrouped with the "Others" label.

**Data Analysis**

Means were calculated per soil layer, in order to analyze vertical distribution of fauna in each treatment. Secondly, data from the different soil depths were put together in order to assess the fauna in the entire monolith and compare the management systems.

Total abundance ("n° ind"), diversity ("n° morphospecies") and Taxonomic Units (TU) were determined for each plot. The mean and standard error of the abundance in each morphospecies were calculated for each treatment. Theses parameters were also calculated for the 0-10cm horizon, because most of soil fauna and biological processes occurred in this horizon, at the interface between litter and soil functional domains.

The soil samples were analyzed by dry combustion after grinding and sieving at 0.2 mm, using a CHN 2400 Perkin-Elmer analyzer, to determine carbon (C) and nitrogen (N) contents.

**Statistical analysis**

Normality tests using SAS software, have been conducted (Shapiro-Wilk and Kolmogorov-Smirnov tests), in order to discover if parametric tests could be used. As most variables did not presented normal distribution, non-parametric test were performed. Then, t test was carried with ranked data in other to compare means (Wilcoxon test with 10% of probability). Correlations (Pearson) were also calculated in order to relate the variables.

Multivariate analyses were performed using R software, with the packages ADE4 and ADE4TkGUI (Chessel et al. 2004; Thiolouse et al., 2007). The principal component analysis (PCA) was performed in a matrix composed of six experiment treatment and Cerrado and Pasture versus biological and chemical variables (CoL, CoA, Hym, Iso, Le, He, Di, B, De, Md, Mc, Ch, Oli, Others, n° ind, n° TU, C, N, C/N, C 10, N 10, C/N 10).

**RESULTS AND DISCUSSION -** Concerning the assessment of soil macrofauna, a total of 2.317 individuals were sampled, distributed in 18 TU, on all the treatments.

The highest average soil fauna abundance occurred in the pasture (PAT) with 428 individuals (especially on 10-20cm soil layer); and the lowest in the conventional croppingsystem (CT) with only 147 individuals (Figure 1). No-till systems had intermediary abundances: NT in association with single cover crops had lightly lower abundances than NT. Nonparametric test showed significant difference between CT and all other systems.

The highest soil fauna diversity occurred in treatment b, with *Brachiaria ruziziensis* as a single crop, with 15 TU (only Diplopoda wasn't present); and the lowest diversity occurred in the pasture (PAT) with only 8 TU presents (figure 1). Regarding means of depths (0-30 cm), treatments with *Brachiaria ruziziensis* alone (b) and on no-till (NT) presents the larger diversity (11 TU), followed by those with *Cajanus* alone (g) and on the no-till maize crop (NT+g) with 10 TU presents. No Gasteropoda individual were found, and few Acarien, (other Chelicerate than Arachnida) and Orthoptera were observed. The most abundant TU were Isoptera, Formicidae, Coleoptera (especially larvae) and Oligochaeta, which are the "ecosystem engineers". According to Jones et al. (1994) ecosystem engineers are organisms that directly or indirectly modulate the availability of resources to other species, by causing physical state changes in biotic or abiotic materials. In so doing they modify, maintain, and create habitats.

The more superficial soil layer (0-10cm) tends to contains more individuals, and the abundance diminishes with the depth. Exceptions were PAT, CER and NT+g where the layer with more abundance was the 10-20cm depths. *Brachiaria ruziziensis* as a single crop was also an exception, due to one sample monolith that fell into an ant-hill, and that therefore should be considered as an outlier. The litter layer contained few individuals but with more diversity, and contained particular fauna: Coleoptera larvae, Arachnida and Orthoptera are more usually found in the litter than in other layers. Diversity also tends to diminished with the depth, resulting the layer 20-30cm be the less abundant and less diverse.

Comparing our results on the abundance of macrofauna with results obtained in other studies (Santos et al., 2008; Medeiros et al., 2009 ; Vendrame et al., 2009), data on density (individuals/$m^2$), a large variability in density of macrofauna for similar conditions of vegetation. It suggests that the biological composition is much related to the locality. Nevertheless, we can observe some trends: NT tends to show more macrofauna than CT, and less than pasture.

Even if different localities show strong differences in density of soil macrofauna, when comparing diversity, there is much more similarity. NT system without plant cover has in general more diverse macrofauna than conventional systems, as it was also observed bySantos et al. (2008). Our study shows that NT+ cover crops show even a more diverse macrofauna.These results show that the diversification of the agroecosystem tend to decrease abundance and increase diversity of insects as already demonstrated by Medeiros et al. (2009).

The principal components analysis (PCA) for biological and chemical data (Figure 2A) showed that the first two axis explained 40% of the variance (Axis 1 - 23% and Axis 2 - 17%). Axis 1 almost distinguished biological and chemical variables, with the exception of nº individuals and Isoptera variables. Indeed, it seems to create two contrary gradients of diversity and density of biological data, separating TU with very high abundance (Isoptera, that is the most responsible for n° ind), from the others which are the groups with low density but that assure higher diversity on the system. Thus Axis 1 separated the Cerrado and the pasture from all agricultural management systems. Axis 2 separated systems characterized by high C and N from those with high relation C/N, otherwise, seeing how variables influence the axis, the axis 2 should represent a gradient of nitrogen. Thus, Oligochaeta and Coleoptera Adults had strong influence on axis 2, associated to systems with higher nitrogen.

The multivariate analysis that we performed in this study clearly allowed distinguishing between CT of NT systems, and between Cerrado and pasture (Figure 2B). Within the different CA systems, the distinction was not so clear, indicating that the type of cover plant would be rather determinant than the type of tillage system, further considering that discriminant for cover plants separated both with high % of explanation.

The correlation circle demonstrated that biological and chemical variables were definitely linked, even more when considering that PCA performed with only biological variables resulted on the same general disposition, showing that chemicals ones (with smallest variances) wasn't dimming the biological, and its internal correlations. Interesting links are on the 3th quadrant: on the discriminant, it's where NT systems are placed, which would be linked the presence of Oligochaeta, Coleoptera (Larvae and Adult), and more nitrogen. Still, these systems are related to larger diversity and less density (generally abundance of Isoptera and Hymnoptera).

**CONCLUSIONS-** Comparing the abundance of individuals per treatment, a high variability was observed and the composition of the communities is related to the type of soil cover. The management systems under conservation agriculture (including no-till and use of cover crops intercropped) presents higher biodiversity than conventional tillage and the pasture. The abundance of individuals was higher in the pastures areas followed by no-tillage and *Cajanus Cajan*. The Isoptera group was related to higher C/N values. The abundance of the Oligochaeta was related to the areas with higher values of total carbon and nitrogen contents.

## REFERENCES

BENITO, N.P.; BROSSARD, M.; PASINI, A.; GUIMARÃES, M.F.; BOBILLIER, B. Transformations of soil macroinvertebrate populations after native vegetation conversion to pasture cultivation (Brazilian Cerrado). **Eur. J. Soil Biol.**, 40:147-154, 2005.

BERNOUX, M.; ET AL. Cropping systems, carbon sequestration and erosion in Brazil, a review. **Agro.Sust. Dev.**, 26:1-8, 2006.

BLANCHART, E.; BERNOUX, M.; SARDA, X.; SIQUEIRA NETO, M. ; CERRI, C.C. ; PICCOLO, M. ; DOUZET, J.M.; SCOPEL, E.; FELLER, C. Effect of direct seeding mulch-based systems on soil carbon storage and macrofauna in Central Brazil. **Agri.Consp. Sci.**, 72:81-87, 2007.

BODDEY, R.M.; ET AL. Carbon accumulation at depth in Ferralsols under zero-till subtropical agriculture.**Global Change Biology**, 16:784-795, 2010.

CHESSEL, D. ; DUFOUR, A.B. ; THIOULOUSE, J. **Taking into account groups of individuals: The ade4 package**. 7p. 2004a

COLE, M.M. **The savannas: biogeography and botany**. Academic Press., Londres, 1986. 438p.

DECAENS, T.; JIMENEZ, J.J.; BARROS, E.; CHAUVEL, A.; BLANCHART, E.; FRAGOSO, C.; LAVELLE, P. Soil macrofaunal communities in permanent pastures derived from tropical forest or savanna. **Agric. Eco.Environ.**, 103:301-312, 2004.

JONES, C.G.; LAWTON, J.H.; SHACHAK, M. Organism as ecosystem engineers. **Oikos**, 69:373-386, 1994.

LAVELLE, P.; BLANCHART, E.; MARTIN, A.; MARTIN, S.A. Hierarchical model for decomposition in terrestrial ecosystems - application tosoil of the humid tropics. **Biotropica**, 25:130-150, 1993.
MEDEIROS, M.A.; SUJII, E.R.; MORAIS, H.C. Effect of plant diversification on abundance of South American tomato pinworm and predators in two cropping systems. **Hortic. Bras.**, 27:300-306, 2009.

SANO, E.E.; ROSA, R.; BRITO, J.L.S.; FERREIRA, L.G. Mapeamento semidetalhado do uso da terra do Bioma Cerrado. **Pesq. Agro. Bras.**, 43:53-156, 2008.

SANTOS, G.G.; SILVEIRA, P.M.; MARCHÃO, R.L.; BECQUER, T.; BALBINO, L.C. Macrofauna edáfica associada a plantas de cobertura em plantio direto em um Latossolo Vermelho do Cerrado. **Pesq.Agro.Bras.**, 43:115-122, 2008.

THIOULOUSE, J.; DRAY, S. Interactive multivariate data analysis in R with the ADE4 and ADE4TkGUI packages.**Journ. Stat. Soft.**, 22:1–14, 2007.

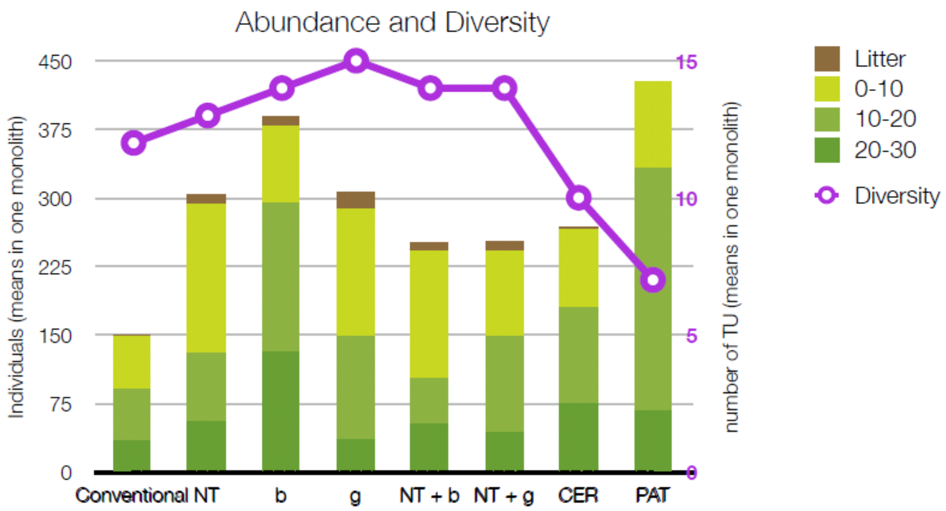


**Figure 1 -** Means of abundance (density in bars) and diversity (number of taxonomical units in points) in each land use system. Abundance values are presented according to the depth.

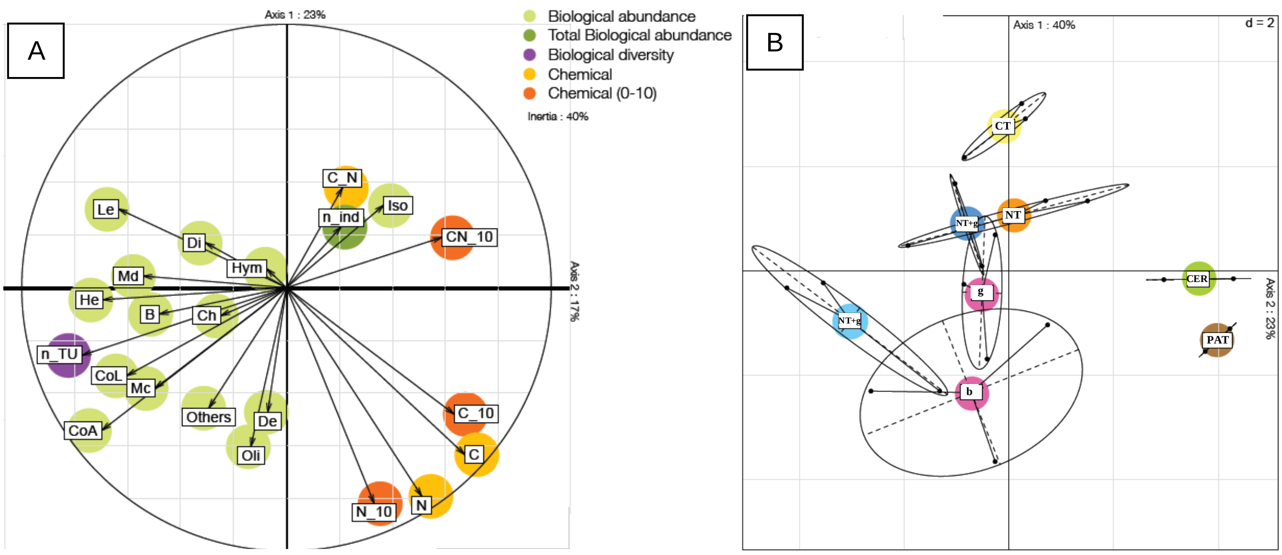


**Figure 2 -** Diagram of the principal component analysis for biological and chemical data (A) and discriminant analysis for management systems (B).