# Cyclic behavior of soil quality in rotational land use systems of the Northeast of Pará state, Brazil

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## ABSTRACT

Slash and burn systems of the small scale farmers in the tropics are mostly lacking in stability due to soil degradation processes as loss of plant nutrients and decline of biological activity. The present work was done in the traditional cropping system with maize and cassava planted in mixed cropping and a spontaneously growing secondary vegetation which serves as fallow vegetation. Soil samples were taken in a field trial several times during cropping from burning until cassava harvest and in sites with 5 and 8 year-old secondary vegetation. The soil was analyzed for pH, C<sub>org</sub>, N<sub>t</sub>, P<sub>i</sub>, Ca, Mg, K, Al and biological (enzymatic) activities. For the statistical analyses a multivariate approach was used in order to characterize the condition of the soil on the base of a set of chemical and biological soil parameters. The graphical projection of the 1<sup>st</sup> and the 2<sup>nd</sup> function of a discriminant analysis reflects a cyclic behavior of the different phases of the land use system.

### RESUMO

Sistemas de derruba e queima do pequeno produtor nos trópicos estao muitas vezes ausente de estabilidade por causa dos processos de degradação do solo, como perdas de nutrientes e de atividades biológicas. Este trabalho foi realizado no sistema de plantio tradicional, caracterizado por um plantio de milho e mandioca em consorcio e uma fase de pousio com uma vegetação secundária. Amostras de solo foram tiradas várias vezes da queima à colheita da mandioca num experimento de campo e em áreas com vegetação secundária de 5 e 8 anos de idade. O solo foi analizado quanto ao pH, C<sub>org</sub>, N<sub>t</sub>, P<sub>i</sub>, Ca, Mg, K, Al e atividades biológicas (enzimáticas). Para análise estatística uma abordagem multivariavel foi usada para caracterizar as condições do solo à base de um 'pool' de parámetros químicos e biológicos do solo. A projeção das duas primeiras funções da análise de discriminação reflete um comportamento cíclico das diferentes fases do sistema de uso da terra.

#### ZUSAMMENFASSUNG

Slash and burn-Anbausysteme von Kleinbauern in den Tropen sind aufgrund von Prozessen der Bodendegradations wie Nährstoffverlusten und Abnahmen der biologischen Aktivität oftmals instabil. Die vorliegende Arbeit befaßt sich mit einem traditionellen Anbausystem mit Mais und Maniok in Mischkultur und einer spontan aufwachsenden Sekundärvegetation, die als Brachevegetation dient. Bodenproben wurden mehrmals in einem Feldversuch vom Brennen der Brachevegetation bis zur Maniokernte sowie auf Flächen mit einer 5- bzw. 8-jährigen Sekundärvegetation genommen. Die Bodenanalysen erfolgten auf pH, C<sub>org</sub>, N<sub>t</sub>, P<sub>i</sub>,

Ca, Mg, K, Al und biologische (enzymatische) Aktivitäten. Für die statistische Auswertung wurde ein multivariater Ansatz angewendet, um die Bodenbedingungen auf der Basis eines Pools von chemischen und biologischen Bodenparametern zu charakterisieren. Die graphische Projektion der ersten beiden Funktionen der Diskriminanzanalyse zeigt ein zyklisches Verhalten der verschiedenen Phasen des Landnutzungssystems.

## **INTRODUCTION**

Rotational land use systems are of importance to small scale farmers in tropical regions. During the fallow period of these systems the soil fertility status is restored to a level that allows the farmer to re-initiate a new cropping period of 1-2 years. However slash and burn systems are mostly lacking in stability due to soil degradation processes. These are loss of plant nutrients, deterioration of physical structure and decline of biological activity of the soil. A multivariate statistical approach was used in order to characterize the condition of the soil at particular sampling dates on the base of a set of chemical and biological soil parameters.

### **MATERIAL AND METHODS**

#### 1. The traditional cropping system

One of the most common cropping systems of the study region is maize (Zea mays) and cassava (Manihot esculenta) planted in mixed cropping. It is characterized by the rotation of the cropping and the fallow phase. The fallow vegetation - a spontaneously growing secondary vegetation ('capoeira') - is slashed by the farmer during the dry season (September - December) and burnt before the first rain. Maize is planted right after the beginning of the rainy season, cassava three weeks later. The fallow age is quite variable - it ranged between 4 and 10 years during the period of observation.

## 2. Field and lab work

The data was collected in a field trial and at two sites with 5 and 8 year-old secondary vegetation in the municipality of Igarapé Açu, 120 km east of Belém, Brazil. Soil samples were taken several times during cropping from right before burning until cassava harvest. Sampling depth was 0-10 cm. The soil was analyzed for pH (CaCl<sub>2</sub>), C<sub>org</sub>, P<sub>i</sub>, Ca, Mg, K and biological (enzymatic) activities.

#### 3. The statistical approach

The basic principal of the discriminant analysis is to comprise a multitude of variables by means of linear combination. The so-called discriminant function ('root') delivers the canonicle score for each observation. Calculating the mean of these individual canonicle scores leads to the group centroids. The difference between the centroids accounts for the distinctness of the particular groups. In this context the Squared Mahalanobis distance serves as a standardized measure. In order to prove the importance of the particular soil parameters for the discrimination of the groups (= phases of the cropping system), discriminant coefficients are calculated. They denote for each variable its partial contribution to the discriminant function(s). The higher the amount of the standardized coefficient the higher is the discriminatory importance of the respective parameter.

#### **RESULTS AND DISCUSSION**

The graphical projection of the 1<sup>st</sup> and the 2<sup>nd</sup> function of a discriminant analysis reflects a cyclic behavior in soil quality over the different phases of the land use system (Figure 1). Consequently, this curve could serve as a basis for the interpretation of agronomic management practices compared in the study. Deviation from the cyclical pattern observed in the traditional system might indicate a type of land use that helps to preserve the soil resources or predict spiraling degradation. The discriminant analysis also suggested the importance of particular soil parameters that were involved in the cyclical soil quality behavior: potassium,  $\beta$ -glucosidase, organic carbon (C<sub>org</sub>) and soil acidity (pH(CaCl<sub>2</sub>)) for the first root, calcium + magnesium and the acid phosphatase for the second root (Table 1). This information might help to understand what modifications in agronomic practices are necessary and, when adopted, whether they were successful or not.



Figure 1: Discriminant analysis of the traditional cropping system in Cumarú on the base of a set of chemical and biological soil parameters (0-10 cm)

	root 1	root 2
phosphatase, acid	-0.419	0.643
urease	-0.119	0.418
ß-glucosidase	0.731	-0.078
pH(CaCl <sub>2</sub> )	-0.649	0.503
Pi	0.454	-0.409
Corg	0.725	-0.259
Ca+Mg	0.283	-0.813
K	-1.270	0.177
Eigenvalue	34.103	13.461
cumul. propability	0.639	0.891

Table 1: Standardized coefficients for canonicle variables

## REFERENCES

Backhaus, K, Erichson, B, Plinke, W, Weiber, R, 1996: Multivariate Analysemethoden. Eine anwendungsorientierte Einführung. 8. Auflage, Springer, Berlin.