Crops production in a fire-free system for land preparation in the northern Brazilian Amazon

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Abstract
Fire is traditionally used by smallholders for land preparation in the Brazilian Amazon but burning fallow vegetation has many disadvantages that lead to soil degradation. A fire-free system, based on slash-and-mulch of fallow vegetation, has been studied as alternative for site preparation. The technique was considered feasible in the region of eastern Brazilian Amazon, even with the inputs of inorganic fertilizers. However, is very important to verify if a fire-free land preparation system is also feasible in other regions of the Brazilian Amazon. The aim of this study was to evaluate the fire-free system in the Mucajai region of northern Amazon in Brazil. Crop production was measured as a result of lime and low doses of fertilizers applied on the surface of mulch layer. In the first cropping period an intercropped system was evaluated simulating a strategy that will guarantee the diversity of products in the smallholdings. However, the combination between rice and corn was not adequate because while lime and fertilizers application improved rice yield, corn yield decreased due to competition. Both in first and second cropping periods, inorganic fertilizer application was essential to ensure higher grain production. Inorganic fertilizers were much more effective in association with liming.

Key Words
Tropical agriculture, alternatives to slash-and-burn, mulch technology, lime, fertilization.

Introduction

In a large area of the Brazilian Amazon, the agriculture in smallholdings is based on the slash-and-burn method of fallows, a low economical value technique for land preparation. However, it has several disadvantages which are related to nutrient and biomass losses. Moreover, Brazil experienced extreme drought conditions during the periods of 1997–1998 and 2005–2006. Those dry seasons have contributed to the increase of fires that put into risk the human health, the private properties, the forest landscapes, and the national infrastructure (Holdsworth and Uhl 1997; Cochrane and Schulze 1998; Nepstad *et al.* 1999; de Mendonça *et al.* 2004). The agricultural system of slash-and-burn, also known as shifting agriculture, considers the regenerative potential of fallow vegetation. At the beginning the site is prepared by cutting and burning fallow vegetation, followed by a cropping stage of approximately 2 years, and a fallow phase when native vegetation reclaims the site (Davidson *et al.* 2008). Some studies have documented positive correlations between fallow period and subsequent crops production (Swamy and Ramakrishnan 1988; Silva-Forsberg and Fearnside 1997; Kato *et al.* 1999; Bruun *et al.* 2006), but the growing human population is increasing pressures on the limited agricultural land, resulting in shorter fallow periods (Sanchez *et al.* 2005). The combination of slash-and-burn method and the shortening of fallow periods might contribute seriously to land degradation.

To overcome these problems some studies have been done to evaluate alternative management techniques. The system based on slash-and-mulch of fallow vegetation, also known as mulch technology, has been considered advantageous in many aspects, mainly because mulch layer protects the soil, conserves soil moisture, suppresses weed growth, and supplies soil with organic matter and plants nutrients (Thurston, 1997). However, some management solutions still need to be found to make this land preparation system feasible for small-holders. In the first cropping period, immediately after land preparation, nutrients are not readily available and the slowly decomposing wood mulch does not provide nutrients as readily as do the ashes of burned fallow (Denich *et al.* 2005). The fire-free system demands inorganic nutrient to ensure crops production and probably the inputs are necessary not only in the first cropping period, but also in the subsequent cropping periods aiming to replace nutrients removed by crops harvest. An adequate low-input pattern in the fire-free land preparation system can be reached by application of low amounts of mineral and organic fertilizers, associated with crops rotation and soil organic matter decomposition.

The mulch technology was considered profitable, both financially and socially, in the Bragantina region of

eastern Amazon in Brazil (Bowman *et al.* 2007). However, differences between regions in the vast area of Brazilian Amazon brought the need to evaluate the mulch technology in other regions. The aim of this study, which was carried out in the Mucajai region of northern Amazon in Brazil, was to evaluate crops production as a result of liming and low doses of fertilizers applied on surface of mulch layer in a fire-free land preparation system. Grains yields were evaluated during two cropping periods after slash-and-mulch fallow vegetation.

Methods

Site description

This research was conducted at the Embrapa Roraima experimental station, which is located in the municipality of Mucajai ($60^o58'W$; $2^o23'N$) in the Brazilian state of Roraima. The climate is tropical rainy, with dry period from December to March, and annual precipitation of 1900 -2000 mm. The characteristics of the top 0.2m of the soil of the site are: pH (H_2O) 5.5, soil organic matter 3.2%, available P (Mehlich extract) 0.68 mg/kg, effective CEC 3.5 $cmol_c$/kg, K 0.06 $cmol_c$/kg, Ca 1.0 $cmol_c$/kg and Mg 0.4 $cmol_c$/kg.

Site preparation

A 4-year-old fallow area was prepared for planting during the beginning of the rainy season of 2006. Fallow vegetation was cut and mulched using a chopper attached to a forestry tractor (Figure 1).

Figure 1. Fallow vegetation mulching using a chopper attached to a forestry tractor.

Experimental design and treatments

Four replications of the split-plot experimental design were used. Two treatments were chosen for the main plot – lime (1 t/ha) or no lime, while for the sub-plot three. Two cropping periods were considered; at the beginning of the first cropping period (FCP), during the rainy season of 2006, corn was sowed intercropped with rice and at the start of second cropping period (SCP), beginning of 2007, cowpea (*Vigna unguiculata*) was sowed. The fertilizer levels of the first cropping period (FCP) were 80-80-90-70 kg/ha (1), 50-60-50-40 kg/ha (2) and 0-0-0-0 kg/ha (3) of N, P_2O_5, K_2O and S. The fertilizer levels of the second cropping period (SCP) were 60-100-100-200 kg/ha (1), 30-50-50-70 kg/ha (2) and 0-0-0-0 kg/ha (3) of N, P_2O_5, K_2O and S. The size of each plot was 10m x 12m and the nutrient sources for seedbed fertilization were ammonia sulphate, simple superphosphate and potassium chloride. Nutrient sources for sidedressed fertilization were ammonio sulphate and potassium chloride. In the first cropping period "Sol da manhã" corn was planted in double rows 1.0 m apart, with four rows of "Coringa" rice planted in between. Rice spacing was 0.3 m within and between rows. In the second cropping period only cowpea (*Vigna unguiculata*) was planted with spacing between rows of 0.8 m.

Sampling and analysis

Grain yield was assessed in the central rows, excluding 1.0 m at all sides of sub-plots, and comprising an experimental area of 80 m^2. It was corrected to standard moisture of 13%, and extrapolated to one hectare. Results were analysed statistically using Genstat package (version 11.1 VSN International Ltda), and analysis of variance ($\alpha = 0.05$) was conducted using ANOVA procedure for split-plot design. Means were separated using the least significant differences procedure.

Results

During the first cropping period, the corn yield was decreased which was associated with both liming and intermediate fertilizer level (Figure 2). The reduction of corn yield is justified by the intercropping system, mainly because rice production in this treatment was high causing competition between corn and rice. The combination of the different crops contributes to improved yield and therefore it is an important tool for profitability for land preparation system in smallholdings. However, competition can reduce crop production if the choice of species is not adequate. The crop combinations between cassava and beans, and cassava and corn resulted in high productivity (Mburu *et al.* 2006). Probably, cassava has a growth habit more adequate for combination with species like corn. No differences were observed for corn and rice yields regarding fertilizer levels 1 and 2, however the yields were greater when compared with treatments on which fertilizers were not applied (Figure 2). Some authors have described that in mulched fields, the fertilizing effect was observed only in a prolonged cropping period after the mulch had decomposed and the nutrients released, showing that fertilization is essential during the earlier part of the cropping period (Kato *et al.* 1999; Denich *et al.* 2004). The analysis of total grain production (corn and rice) in the first cropping period (Table 1) and the analysis of cowpea yield in the second cropping period (Figure 3) reveal that the highest evaluated fertilizer level resulted in highest grain yield mainly when lime was applied. Usually, liming had favourable effects in weathered soils, by reducing soil acidity and toxic alluminium, improving plants root system, and consequently, improving nutrients uptake by plants.

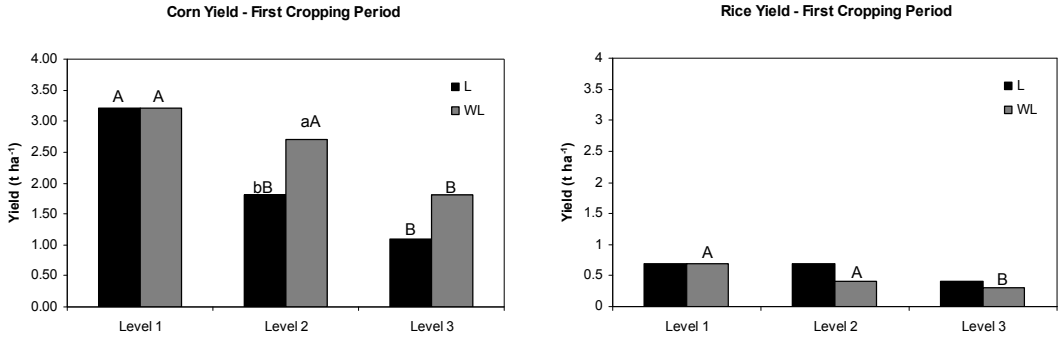

Figure 2. Means of corn and rice yields in the first cropping period of slash-and-mulch land preparation system. Fertilizer levels to the first period (kg/ha of N - P_2O_5 - K_2O - S): 1) 80-80-90-70; 2) 50-60-50-40; 3) 0-0-0-0. Different capital letters indicate significant differences within fertilizer levels. Different lower case letters indicate significant differences within lime application.

Table 1. Means of grains yield (corn+ rice) in the first cropping period.

	Corn and rice yield t/ha		
	1†	2†	3†
L††	3.9	2.5	1.6
WL††	3.9	3.1	2.1
LSD (P=0.05)		1.0	
CV (%)		20	

† Fertilizer levels to the first period (kg/ha of N - P_2O_5 - K_2O - S): 1) 80-80-90-70; 2) 50-60-50-40; 3) 0-0-0-0.
†† L – liming; WL: without liming

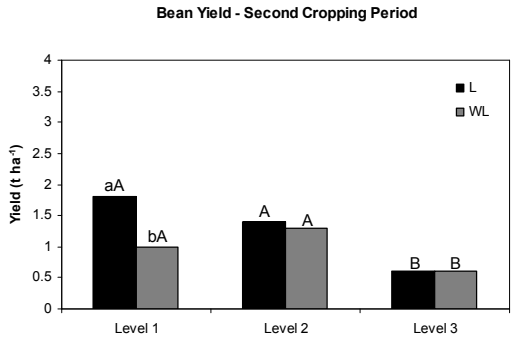

Figure 3. Means of cowpea (bean) yield in the second cropping period of slash-and-mulch land preparation system. Fertilizer levels to the second period (kg/ha of N - P_2O_5 - K_2O - S): 1) 60-100-100-200; 2) 30-50-50-70; 3) 0-0-0-0. Different capital letters indicate significant differences within fertilizer levels. Different lower case letters indicate significant differences within lime application.

Conclusion

Low levels of fertilizers applied in association with lime can improve crop production in northern Brazilian Amazon in a fire-free system for land preparation.

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