Fire-free alternatives to slash-and-burn for shifting cultivation in the Eastern Amazon region: The role of fertilizers

Osvaldo R. Kato[1], Maria S. A. Kato[1], Maurício M. Parry[3], Manfred Denich[2] and Paul L. G. Vlek[2]

[1] EMBRAPA Amazônia Oriental- Belém-PA-Brazil, [2] Zentrum für Entwicklungsforschung, Universität Bonn- Bonn-Germany, [3] Supported by CNPq- Belém-PA-Brazil

ABSTRACT

The objective of this study was to evaluate alternatives to burning of the slashed fallow vegetation of different age on crop production in the Northeast of Pará State, Brazil. Burning and mulching of fallow biomass was compared in a cropping sequence of rice, cowpea and cassava, with and without NPK fertilizer. Without NPK, fallow duration is important only with slash-and-burn technology, where reducing the fallow period from 10 to 4 years caused a 30% reduction in rice yields. If NPK are applied, fallow period beyond 4 years appear to have little effect on yields, irrespective of the land preparation method. Not-burning, without NPK caused yield reductions of 47 and 76% with rice, and 40 and 100% with cowpea after 4 and 10 years of fallow, respectively. The application of NPK raised yields from around 0.67 t ha-1 to over 2.4 t ha-1 for rice, from around 0.1 t ha-1 to over 1.5 t ha-1 for cowpea and from around 15.2 t ha-1 to over 27.8 t ha-1 for cassava. Cassava yields were least affected by fire-free land preparation.

RESUMO

O objetivo deste estudo foi avaliar diferentes métodos de preparo de área em capoeira de diferentes idades, na produção das culturas no Nordeste do Pará, Brazil. Queima e não queima foram comparados em uma sequência de arroz, caupi e mandioca, com e sem fertilização NPK. Sem fertilizante, a duração do pousio é importante somente com a tecnologia de derruba e queima, pois a redução do período de pousio de 10 para 4 anos causou uma redução de 30% na produção do arroz. Se fertilizantes são aplicados, o pousio de 4 anos parece causar um pequeno efeito na produção, independente do método de preparo de área. Não queima causou uma redução na produção do arroz de 47 e 76%, do caupi de 40 a 100% após 4 e 10 anos de pousio, respectivamente. A aplicação de fertilizante aumentou a produção de 0.67 t ha^{-1} para acima de 2.4 t ha^{-1} para o arroz, de 0.1 t ha^{-1} para 1.5 t ha^{-1} para caupi, e de 15.2 t ha^{-1} para 27.8 t ha^{-1} para mandioca. Produção de mandioca foi pouco afetada (0 e 18%) pela não queima da vegetação de pousio.

ZUSAMMENFASSUNG

Ziel der Untersuchung war es, alternative Methoden der Flächenvorbereitung in unterschiedlich alten Bracheflächen anhand der Kulturpflanzenerträge im Nordosten des Bundesstaates Pará, Brasilien, zu bewerten. Die Anbausysteme mit Brennen und mit Mulchen wurden in einer Fruchtfolge mit Reis, Bohnen und Maniok, gedüngt und nicht-

gedüngt (NPK), miteinander verglichen. Das Brachealter war lediglich im 'slash and burn' Anbausystem ohne Düngung von Bedeutung, wo der Reisertrag nach der 4jährigen Brache gegenüber der 10jährigen Brache um 30 % abnahm. Wenn Dünger ausgebracht wird, hat eine Brachedauer von mehr als 4 Jahren scheinbar keine Ertragswirkung mehr, unabhängig von der Methode der Flächenvorbereitung. Der Verzicht auf das Brennen führte ohne Düngung zu Ertragseinbußen bei Reis in Höhe von 47 bzw. 76 % und bei Bohnen von 40 und 100 % nach 4 bzw. 10jähriger Brache. Die Applikation von NPK-Dünger führte zu einer Ertragssteigerung bei Reis von 0,67 t ha^{-1} auf über 2,4 t ha^{-1}, bei Bohnen von 0,1 t ha^{-1} auf 1,5 t ha^{-1} und bei Maniok von 15,2 t ha^{-1} auf 27,8 t ha^{-1}. Die Maniokerträge wurden nur in geringem Maße von dem Verzicht auf das Brennen der Brachevegetation beeinflußt (0 bzw. 18%).

INTRODUCTION

In Eastern Amazon, the production of small farmers is responsible for at least 80% of the basic food production. Shifting cultivation represents the predominant agricultural system and is characterized by slash-and-burn of the fallow vegetation (capoeira) followed by a cropping phase of mainly rice, maize, cowpea and cassava. As in other regions of the world shifting cultivation has been a sustainable system in the context of smallholders agriculture in Eastern Amazon under conditions of low demographic pressure (Bandy et al., 1993, Thurstons 1997), and is a system that is tightly associated with the vitality of the capoeira (Denich 1989).

Despite the well-known beneficial effect from burning the vegetation on land preparation (Beck and Sanchez, 1994), the negative effect on the environment, especially the loss of nutrients by volatilization, has recently been proved (Hölscher et al., 1997). Because of these losses and the shortening of the fallow period, the sustainability of the system is no longer guaranteed.

OBJECTIVE

The objective of this study was to evaluate alternatives to burning of the slashed fallow vegetation of different age on crop production in the Northeast of Pará State, Brazil.

MATERIAL AND METHODS

Field experiments were conducted in a 4 and a 10-year-old fallow area in the municipality of Igarapé-Açu, Pará, Brazil, located east of Belém (Bragantina Region). The average annual rainfall of this region is approximately 2,500 mm, the temperature ranges between 25.5°C and 26.8°C, and the relative humidity varies between 80% and 89%. The nutrient sources in the experiments are shown in Table 1.

Three treatments of land preparation were tested: Burn, mulch the above-ground fallow biomass on the soil surface and mulch incorporated into the soil, with and without NPK fertilization. The six treatments were arranged in a Square Latin design with 6 repetitions.

Each plot measured 10m x 12m. In the burned plots, a procedure similar to that used by the small farmers of the region was adopted: after cutting the vegetation manually, it was left to dry on the field for 3 to 5 weeks and was then burned. In mulched plots, the above-ground plant biomass of the 4-year-old-fallow vegetation was chopped with a tractor-propelled silage chopper immediately after clearing the vegetation, while in the 10-year-old-fallow vegetation, the herbaceous and fine woody material was chopped mechanically and the woody material was chopped manually. The material was mixed and distributed in the plots. The cropping sequence started with rice in January 1995, followed by cowpea and cassava. The second cropping cycle was conducted between January 1997 and June 1998.

Table 1: Nutrient sources in the experiments

Sources	4-year-old fallow vegetation	10-year-old fallow vegetation
Secondary vegetation		
Total biomass (t ha^{-1})	24	59
Nitrogen (kg ha^{-1})	143	332
Phosphorus (kg ha^{-1})	9	8
Potassium (kg ha^{-1})	72	186
Ashes		
Yield (t ha^{-1})	0.5	1.0
N_{total} (kg ha^{-1})	3.1	2.2
N_{min} (kg ha^{-1})	0.2	0.4
P_{total} (kg ha^{-1})	2.8	6.3
P_{H2O} (kg ha^{-1})	0.5	0.7
Soil (0 - 10 cm)		
N_{total} (kg ha^{-1})	882	847
N_{min} (kg ha^{-1})	67	100
Phosphorus-Mehlich (kg ha^{-1})	4	2
Potassium (kg ha^{-1})	19	25
	Rice	Cowpea
Fertilization		
Nitrogen (kg ha^{-1})	50	10
Phosphorus (kg ha^{-1})	25	22
Potassium (kg ha^{-1})	25	42

RESULTS AND DISCUSSION

In 1995, rice and cowpea on burned fields yielded 2 times higher than on not burned fields after 4 years of fallow and 4-5 times higher after 10 years of fallow. With the traditional slash-and-burn method and without fertilizer application, the rice production expressed in grain yield was higher after 10 years of following (2.2 t ha^{-1}) than after 4 years (1.5 t ha^{-1}).

The reverse was observed (0.5 vs. 0.8 t ha^{-1}) when the plant material was chopped and left in the field.

The crop traditionally following rice is cowpea, which is usually fertilized by the farmers. Yields without fertilizer were around 0.3 t ha^{-1}. When large quantities of chopped vegetation (10-year-old vegetation) were left in the field, cowpea did not produce at all, whereas with the younger vegetation, yields were depressed substantially (Table 2). The not burned areas, however, showed an increase in the yields of rice and cowpea in a second cropping period, separated from the first by a short (6 months) fallow period, and decrease in the yields of rice in burned area (Table 2).

Table 2: Yields (t ha^{-1}) of rice and cowpea grain (13% moisture) and cassava fresh roots in sequence in two continue cropping following different land preparation methods of a 4-(FV4y) and 10-(FV10y) fallow vegetation with and without the use of fertilizer.

Treatments/Crop	1995		1997	
	FV4y	FV10y	FV4y	FV10y[1]
Rice				
Burning	1.5 (±0.91*)	2.2 (±0.19)	1.4 (±0.13)	1.4 (±0.27)
Mulching	0.8 (±0.12)	0.5 (±0.09)	1.5 (±0.10)	1.7 (±0.34)
Incorporated	0.9 (±0.12)	0.4 (±0.08)	2.2 (±0.26)	1.3 (±0.08)
Burning + NPK	2.7 (±0.16)	3.0 (±0.20)	2.4 (±0.38)	3.9 (±0.17)
Mulching + NPK	2.5 (±0.17)	2.3 (±0.28)	3.2 (±0.27)	3.6 (±0.19)
Incorporated + NPK	2.1 (±0.15)	2.7 (±0.14)	3.1 (±0.11)	4.1 (±0.37)
$HSD_{P<0.05\%}$	0.48	0.69	0.77	1.17
Cowpea				
Burning	0.3 (±0.02)	0.29 (±0.39)	0.3 (±0.06)	0.3 (±0.03)
Mulching	0.2 (±0.04)	0.00**	0.6 (±0.11)	0.2 (±0.05)
Incorporated	0.2 (±0.04)	0.00**	0.5 (±0.10)	0.2 (±0.07)
Burning + NPK	1.6 (±0.05)	1.5 (±0.10)	1.6 (±0.19)	2.0 (±0.19)
Mulching + NPK	1.6 (±0.09)	1.6 (±0.10)	2.0 (±0.23)	2.3 (±0.14)
Incorporated + NPK	1.6 (±0.13)	1.6 (±0.12)	1.5 (±0.14)	2.1 (±0.17)
$HSD_{P<0.05\%}$	0.27	0.50	0.71	0.51
Cassava				
Burning	16.2 (±1.59)	15.5 (±1.55)	11.3 (±1.11)	10.2 (±1.12)
Mulching	17.7 (±1.24)	12.7 (±0.85)	17.4 (±0.84)	13.5 (±0.81)
Incorporated	18.8 (±3.07)	12.7 (±0.95)	14.8 (±0.74)	12.4(±0.86)
Burning + NPK	30.2 (±1.32)	29.9 (±1.91)	24.7 (±1.59)	29.0 (±2.71)
Mulching + NPK	28.8 (±2.10)	26.8 (±2.49)	26.0 (±2.24)	23.8 (±1.24)
Incorporated + NPK	36.1 (±1.07)	31.8 (±1.01)	27.5 (±3.9)	21.4 (±1.04)
$HSD_{P<0.05\%}$	7.57	5.85	8.84	6.66

Means (n=6), in FV10y 1997 for rice n=5; (*) SE- Standard error. ** Date not included in the statistic analysis

Fertilizers overcame the differences in yield due to fallow duration and land preparation. The yields of cowpea were 5-8 times, those of rice and cassava (tubers) 2-3 times higher than without fertilization in both burned and not burned areas. The final crop prior to abandoning the field in the traditional system is cassava, which normally is not fertilized but may benefit from residual fertilizer effects.

The age of the cleared fallow vegetation positively affected rice yields during the first cropping period in burned areas as well as rice and cowpea yields in the second cropping period in burned and not burned areas when fertilizers were applied. In the not burned areas the rice and cowpea yields were higher in the area of the 4-year-old fallow vegetation. The land preparation and the age of the fallow vegetation did not affect the cassava yields (Table 2).

CONCLUSION

The fire-free land preparation is a viable technology for the nutrient-poor soils of Eastern Amazon if fertilizers are applied to compensate for the fertilizing effect of the ashes from burning and the microbial immobilization of nutrients during the decomposition of the mulch layer.

A medium-term beneficial effect of the mulch was the improvement of the chemical soil properties, slowly deliberating nutrients from the organic matter, and reflecting in the increase of the production of the rice and cowpea in the second cycle.

REFERENCES

Bandy, D, Garrity, DP, and Sanchez, PA, 1993: The worldwide problem of slash-and-burn agriculture. Agroforestry Today, 5: 2-6.

Beck, M and Sanchez, PA, 1994: Soil phosphorus fraction dynamics during 18 years of cultivation on a typic Paleudult. Soil Sci., 34:1424-1431.

Denich, M, 1989: Estudo da importância de uma vegetacao secundaria nova para o incremento da produtividade do sistema de producao na Amazônia Oriental brasileira. Dissertation de Agricultura, Universität Georg-August de Göttingen. Göttingen-Germany. 283pp.

Hölscher, D, Ludwig, B, Möller, RF, and Fölster H, 1997: Dynamic of soil chemical parameters in shifting agriculture in the Eastern Amazon. Agriculture, Ecosystems and Environment 66: 153-163.

Thurstons, HD, 1997: Slash/mulch systems- Suitable methods for tropical agriculture. Westview Press, London, 196 pp.