# Fire-free alternatives to slash-and-burn for shifting cultivation of the Eastern Amazon: Selection of adapted cultivars

**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 productivity of rice, maize, cowpea and cassava cultivars was evaluated in mulched plots in order to select adapted cultivars for areas with fire-free land preparation in tropical fallow systems. In 1995 we tested 8 rice, 21 cowpea, 11 maize and 5 cassava cultivars, in 1997, 8 additional maize cultivars. The screening was carried out with and without the application of fertilizer (N, P, K). Cassava only made use of the residual fertilizer from the preceding maize screening. The best yielding new cultivar (CNA 7706; 1.3 t $ha^{-1}$) yielded 39% more than the local cultivar Ligeiro (0.9 t $ha^{-1}$). Rice yields with fertilization were, on average, 55% higher than without, whereas residual fertilizer effects on cassava yield amounted to 23%. For maize and cowpea cultivars the yields without fertilizer were, on average, only 14% of those from fertilized plots. No cultivar adapted to low external input cropping systems with fire-free preparation could be identified in the germplasm screened so far.

## RESUMO

O objetivo deste estudo foi selecionar cultivares de arroz, caupi, milho e mandioca adaptados ao sistema sem uso de fogo no preparo de área. Foram testadas em 1995, 8 cultivares de arroz, 21 de cowpea, 11 de milho e 5 de mandioca e, em 1997, mais 8 cultivares de milho. O screening foi avaliado com e sem o uso de fertilizante (N, P, K), porém mandioca somente fez uso do efeito residual do milho. O cultivar CNA 7706, nas parcelas sem NPK produziu 39% (1.3 t $ha^{-1}$) mais que o cultivar local Ligeiro (0.9 t $ha^{-1}$). Produção de arroz, com NPK, foi, em média, 55% maior do que sem NPK, onde efeito residual do fertilizante aumentou em 23% a produção de mandioca. A produção dos cultivares de milho e caupi sem NPK foi em média, somente 14% da produção com NPK. Até o momento, não foram identificados cultivares adaptados ao sistema sem o uso do fogo no preparo de área e sem fertilização.

## ZUSAMMENFASSUNG

Ziel der Studie war es, Reis-, Bohnen-, Mais- und Manioksorten zu selektionieren, die an den Anbau mit feuerloser Flächenvorbereitung angepaßt sind. 1995 wurden acht Reissorten, 21 Bohnensorten, elf Maissorten und fünf Manioksorten getestet, 1997 weitere acht Maissorten. Das Sorten-Screening wurde mit und ohne NPK-Düngung durchgeführt, wobei der Maniok lediglich vom residualen Effekt der Düngung profitierte. Die Sorte CNA 7706 erzielte ohne Düngung um 39 % höhere Erträge (1,3 t $ha^{-1}$) als die Lokalsorte Ligeiro (0,9 t $ha^{-1}$).

Die Erträge von Reis waren mit Düngung durchschnittlich um 55 % höher als ohne Düngung, die von Maniok aufgrund des residualen Düngereffektes um 23 % höher. Die Erträge bei Mais und Bohnen beliefen sich ohne Düngung auf nur 14 % der Erträge mit Düngung. Bis jetzt konnten keine Sorten identifiziert werden, die in besonderem Maße für das Anbausystem ohne Brennen und ohne Düngung geeignet wären.

## INTRODUCTION

The traditional cultivation system of small farming in the Eastern Amazon region is characterized by slash-and-burn agriculture. Although the production of these systems is satisfactory in the first year of cultivation due to improved availability of nutrients from the ash of burned biomass (Juo and Manu, 1996), losses of nutrients occur during the burning (Hölscher et al., 1995). Moreover, the increasing demand of plantation areas imposed by the demographic pressure consequently reduced the fallow periods affecting negatively the productive potential of the system.

The development of modified technologies such as slash-and-mulch represents an alternative for small farming (Kato et al., 1995). Emphasis was laid on increasing the production capacity of the system by reducing the loss of nutrients and organic matter by substituting slash-and-burn for cutting, chopping and mulching, but alternative fire-free land preparation methods may also require crop cultivars better adapted to low initial nutrient availability.

## OBJECTIVE

The objective of this study was to select rice, cowpea, maize and cassava cultivars adapted to areas with fire-free land preparation (slash-and-mulch) and to low pH and poor chemical conditions in tropical fallow.

## MATERIAL AND METHODS

The experiments were carried out in the municipality of Igarape-Açu, Pará state, Brazil, in a 4-year-old fallow vegetation. The municipality is located east of Belém (Bragantina Region) between 0° 55' and 1° 20' S; 47° 20' and 47° 50' W. In this region, the average annual rainfall is around 2.500 mm, the mean temperature varies between 25.5 °C and 26.8 °C, and relative humidity varies between 80 % and 89 %.

The woody fallow vegetation was mechanically chopped and spread as mulch over the plots. In 1995, eight rice (*Oriza sativa*), 21 cowpea (*Vigna unguiculata*), 11 maize (*Zea mays*) and 5 cassava (*Manihot esculenta*) cultivars and in 1997, eight additional maize cultivars were tested (Table 1). The screening was carried out with and without the application of fertilizer (N, P, K) to rice, maize and cowpea, whereas cassava was not fertilized but benefited from residual fertilizer from the preceding maize screening. The N, P and K rates applied were: for rice 50-25-25 kg $ha^{-1}$, for cowpea 10-22-42 kg $ha^{-1}$ and for maize 60-25-25 kg $ha^{-1}$ in the form of urea, triple super-phosphate and potassium chloride, respectively.

Single plot size, spacing and replication differed among the crops: Rice was planted in plots with the size of 3.5m x 3m at a spacing of 0.3m x 0.3m with 5 replications set. Cowpea plants were arranged in plots of 1.75m x 3m at a spacing of 0.3m x 0.5m with 4 replications.

The plot size for maize was 4m x 2m and the plants were arranged at a spacing of 1m x 0.5m with 5 replications. Cassava plots had a size of 4m x 4m (spacing 1m x 1m). Grain yield (13% moisture) was determined for rice, cowpea and maize and tuber yield was measured from cassava as fresh weight.

**Table 1:** Rice, maize, cassava and cowpea cultivars tested in the screening for fire-free land preparation. Igarapé-Açu-Pa-Brazil

| **Rice**[1] | **Maize** | | **Cassava**[1] | **Cowpea**[1] | |
|---|---|---|---|---|---|
| Araguaia | BR 106[1] | CMS 473[1] | Aipim Rosa | TE86-80-3G | BR 3 |
| CNA 7706 | BR 5102[2] | Cincalli 93SA3[3] | Mameluca | TE86-80-86F | Vita 7 |
| CNA 6843-1 | CMS 04C[2] | Cincalli 93SA4[3] | Milagrosa | TE89-149-3G | TE86-73-3G |
| Caiapó | CMS 28[1] | Cincalli 93SA5[3] | Pretinha | TE89-149-11G | TE89-149-7G |
| Ligeiro | CMS 39[1] | Cincalli 93SA6[3] | Tapioqueira | TE89-149-10G | TE86-80-120F |
| Progresso | CMS 50[1] | Sikuani TCA-V110[3] | | TE86-80-111F | TE89-149-5G |
| Rio Parnaiba | CMS 59[1] | Pontinha[2] | | TE86-80-75F | Canindé |
| Xingú | CMS 453[1] | Saracura[1] | | TE89-149-4G | TE89-158-2G |
| | CMS 14[3] | | | TE89-149-1G | TE89-149-8G |
| | CMS 36[3] | | | TE86-80-73F | TE89-149-6G |
| | | | | TE89-149-2G | |

cultivars tested = [1] in1995; [2] in 1995 and 97; [3] in 1997

## RESULTS AND DISCUSSION

Within the eight rice cultivars tested under slash-and-mulch conditions, grain yields varied between 0.95 (Ligeiro) to 1.3 t $ha^{-1}$ (CNA 7706) in the unfertilized plots (Fig. 1). With the use of fertilizers, production varied from 1.8 t $ha^{-1}$ for Ligeiro to 3 t $ha^{-1}$ for Progresso. Under unfertilized conditions, the new cultivar CNA 7706 yielded 39% more than the local cultivar Ligeiro. The rice cultivars yielded, on average, 45% more if fertilizer was applied, and the high-yielding cultivar Progresso produced 67% more grain than the local cultivar Ligeiro.

**Table 2:** Average grain yield (13 % moisture) of 8 rice cultivars tested under mulch conditions with and without fertilizer.

| Cultivar | Rice grain yield (t $ha^{-1}$) | |
|---|---|---|
| | Fertilizer | No fertiliser |
| Progresso | **3.0** a | 1.0 a |
| CNA 68 | 2.7 ab | 1.1 a |
| Xingú | 2.5 ab | 1.0 a |
| Caiapó | 2.4 ab | 1.2 a |
| Rio Parnaíba | 2.4 ab | 1.2 a |
| CNA 7709 | 2.3 bc | **1.3 a** |
| Araguaia | 2.2 bc | 1.0 a |
| Ligeiro (Local) | *1.8 c* | *0.9 a* |

The results show that cowpea yields did not exceed 0.3 t $ha^{-1}$ without NPK fertilizer. If fertilizer was applied, the grain yield was, on average, 7 times higher, and varied from 1.0 to 1.5 t $ha^{-1}$ (Table 3).

**Table 3:** Average grain yields (13 % moisture) of cowpea cultivars tested under mulch conditions with and without fertilizer.

| Cultivars | Yields t $ha^{-1}$ | | Cultivars | Yields t $ha^{-1}$ | |
|---|---|---|---|---|---|
| | Fertilizer | No Fertilizer | | Fertilizer | No Fertilizer |
| TE 86-80-86F | **1.49** | 0.13 | TE 89-149-5G | 1.23 | 0.16 |
| TE 86-80-3G | 1.48 | 0.15 | TE 86-80-73F | 1.23 | *0.11* |
| TE 89-149-3G | 1.42 | 0.15 | TE 86-73-3G | 1.21 | **0.28** |
| TE 89-149-10G | 1.37 | 0.15 | TE 89-149-1G | 1.20 | 0.15 |
| TE 86-80-111F | 1.36 | 0.15 | BR 12 Canindé | 1.19 | 0.19 |
| TE 89-149-11G | 1.34 | 0.21 | TE 89-149-4G | 1.18 | 0.24 |
| BR 3 | 1.32 | 0.24 | TE 89-149-2G | 1.14 | 0.13 |
| VITA 7 | 1.29 | 0.19 | TE 89-149-6G | 1.10 | *0.11* |
| TE 86-80-75F | 1.29 | 0.16 | TE 89-158-2G | 1.02 | 0.21 |
| TE 86-80-102F | 1.27 | 0.16 | TE 89-149-8G | *0.98* | 0.17 |
| TE 89-149-7G | 1.26 | 0.16 | | | |

**Table 4:** Average grain yield (13% moisture) of 11 maize cultivars tested in 1995 and 10 maize cultivars tested in 1997 under mulch conditions with and without fertilizer

| Cultivars tested in 1995 | Yield (t $ha^{-1}$) | | Cultivars tested in 1997 | Yield (t $ha^{-1}$) | |
|---|---|---|---|---|---|
| | Fertilizer | No Fertilizer | | Fertilizer | No Fertilizer |
| CMS 50 | **3.10 a** | **0.52 a** | CMS 04C | **2.45 a** | 0.27 a |
| BR 5102 | **3.00 a** | **0.54 a** | Cincalli 93 SA6 | **2.43 a** | 0.36 a |
| CMS 39 | 2.80 a | 0.42 ab | Cincalli 93 SA3 | **2.40 a** | 0.30 a |
| CMS 04C | 2.80 a | 0.32 ab | CMS 36 | 2.04 ab | 0.43 a |
| Saracura | 2.80 a | **0.54 a** | Cincalli 93 SA4 | 2.03 ab | 0.28 a |
| CMS 453 | 2.60 a | 0.39 ab | CMS 14C | 2.03 ab | **0.53 a** |
| BR 106 | 2.50 a | 0.20 b | Cincalli 93 SA5 | 2.01 ab | 0.35 a |
| CMS 473 | 2.40 a | 0.39 ab | Sikuani TCA-V110 | 2.01 ab | 0.40 a |
| CMS 28 | *2.30 a* | 0.30 ab | Pontinha | *1.36 b* | *0.19 a* |
| CMS 59 | *2.30 a* | 0.26 ab | | | |
| Pontinha | *2.30 a* | *0.17 b* | | | |

HSD ($P< 0.05$)

The productions of maize cultivars tested in 1995 and 1997 are presented in Table 4. There was a similar fertilization effect as observed in the cowpea plots. With NPK fertilization, grain production increased, on average, by 85% compared to unfertilized plots. Without fertilizer the largest grain productions were observed in the BR 5102 (0.54 t $ha^{-1}$), Saracura (0.53 t $ha^{-1}$) and CMS 50 (0.52 t $ha^{-1}$) cultivars in 1995. In the cultivars tested in 1997 without fertilization, the production did not exceed 0.53 t $ha^{-1}$ (CMS 14C).

When fertilization was applied, grain production varied from 2.29 t $ha^{-1}$ (Pontinha) to 3.01 t $ha^{-1}$ (CMS 50) in 1995 and from 1.4 t $ha^{-1}$ (Pontinha) to 2.5 t $ha^{-1}$ (CMS 04C) in 1997.

There were significant differences in the tuber yield among the cassava cultivars tested (Fig. 4). The production of fresh roots varied from 16.7 to 25.7 t $ha^{-1}$ in the fertilized plots (residual fertilizer) and from 12.4 to 20.1 t $ha^{-1}$ in the unfertilized plots. The residual fertilizer effect on cassava yield amounted to 23% (Table 5).

**Table 5:** Average fresh root yield of 5 cassava cultivars tested under mulch conditions with and without residual fertilizer.

| Cultivars | Yield (t $ha^{-1}$) | |
|---|---|---|
| | Fertilizer | No Fertilizer |
| Mameluca | **25.7 a** | **20.1 a** |
| Pretinha | 23.3 ab | 17.5 ab |
| A.Rosa | 23.2 ab | 16.8 ab |
| Milagrosa | *21.5 ab* | 18.6 ab |
| Tapioqueira | *16.7 b* | *12.4 b* |

HSD ($P < 0.05$)

No cultivar adapted to low external input cropping combined with fire-free land preparation could be identified in the germplasm screened so far. Additional efforts should be made to search for cultivars adapted to acid soils of low fertility using mulched plots as test locations.

## CONCLUSION

The tuber yields of all cassava cultivars were satisfactory under mulch conditions with and without fertilization.

An improved rice cultivar (CNA 7706) was found which achieved economic yields without fertilization and yielded noticeably more than the locally most widespread variety.

The maize and cowpea cultivars currently available in Amazonia seem poorly suited to soils of low fertility and thus require fertilization under mulch conditions.

## REFERENCES

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