World Congress on Conservation Agriculture Madrid, 1-5 October, 2001

Developing sustainable cropping systems with minimal inputs in Madagascar: direct seeding on plant cover with "soil smouldering" (écobuage) techniques

R. MICHELLON
Centre de Coopération Internationale de Recherche en Agronomie pour le Développement (CIRAD), BP 853, Antananarivo 101, Madagascar

RAZAKAMIARAMANANA, R. RANDRIAMANANTSOA
Centre national de la Recherche appliqué au développement rural (FOFIFA), BP 1690, Antananarivo 101, Madagascar

L. SEGUY
Centre de Coopération Internationale de Recherche en Agronomie pour le Développement (CIRAD), CP 504 Agencia Central, 74001-970 Goidna GO, Brazil

Abstract

In the Hautes-Terres region of Madagascar, population pressure is accelerating thé conversion of hilly areas with fragile and relatively infertile soils into cropland. As fertilizers are limited, crop yields remain low and erosion is destroying rice fields. Instead of clearing areas fallowed with Aristida sp. by burning, ibis biomass can be kept for use as mulch and for "soil smouldering" (écobuage). The effects of this strategy were found to be spectacular, i.e. boosting rainfed rice yields to levels that could bc achieved with high chemical fertilizer inputs-to which farmers have no access for financial reasons. All fuels used (Aristida sp. or barley straw, rice husks, and Acacia mearnsii branches) significantly inereased crop yields relative to thé control (without soil smouldering). A residual effect was noted in thé second year, especially on volcanic soils with high organic matter levels. Hence, sustainable cropping systems that fulfil farmers' needs while protecting their rice fields can be developed through thé use of soil smouldering-performed just once to boost soil fertility-associated with direct seeding techniques.

Keywords: Soil smouldering, écobuage, direct seeding, mulching, rice, soybean

Introduction

The soils in hilly areas in thé Hautes-Terres region of Madagascar are mainly ferrallitic and thus fragile and relatively infertile. In addition, under low température conditions, organic matter breaks down very slowly and traps nutrients that are essential for crops (Chabanne, Seguy & Razakamiaramanana, 1996). Saturation of lowland rice growing areas and high population pressure is leading to accelerated conversion of these hilly areas into cropland. Bush fires and successive ploughing bas led to severe soil erosion, silting of rice fields and destruction of agricultural development projects.

Direct seeding systems on plant cover offer a broad range of benefits, including erosion control and soil fertility enhancement (Rakotondralambo & Razanamparany, 1998). However, yield improvements are low because farmers-focusing chiefly on their immediate survivalapply very little fertilizer.

Materials and Methods

Fuels

"Soil smouldering" (écobuage) involves sluggishly burning plant matter (fuel) covered with a 10 cm layer of soi] in a 20-cm deep trench with air outlets spaced every mette. Several fuels for this purpose can bc obtained in fallowed fields (e.g. dried grasses, Aristida sp., and Acacia niearnsii branches), in addition to barley straw in volcanic areas, and rice husks. Fuels can be ignited in winter when they are driest (90% d.m.), combining them in one (for Acacia sp.) or two layers (for Aristida sp.) at 9 t.ha-1. Wider trenches are required (30 cm) to accommodate branches of Acacia sp. trees (at least 1 year old). A constant volume of fuel is required for each treatment to obtain a uniform dosage.
Soil smouldering was carried out in fallow fields alter mowing, on ferrallitic soils (Ibity), or ploughing subsequent to thé harvest of food crops on volcanic soils (Betafo). Fields where soils had been smouldered were subsequently cropped using direct seeding procedures on mulch (Aristida sp., 7 t.ha).

Pertilizers

The effects of thé différent fuels were assessed relative to four fertilizers adjusted according to thé type of soi] and crop (Table 1). The control treatment was carried out on bare soil alter ploughing prior to sowing thé crop. Another treatment, comparable to thé ploughed control, was conducted with an initial application of ash (4 t.ha-1) produced by open-air combustion of thé saine quantity of Arisfda sp. as that used for thé soil smouldering operation.
The expérimental conditions were identical in all cases: split-plot design (with 3 réplications), combining thé main treatments, i.e. thé fuels (and controls), with thé fertilizers on 13.5 in z plots.

Table 1. Manure or chemical fertilizer (kg.ha-1) in thé form of urea, ammonium phosphate, KCL and dolomite.

Treatment	Basal fertilization at sowing		Complement on rice (sowing, 25 and 60days after sowing)
	Volcanic soil	Ferralitic soil	
F_0 No fertilizer	Nothing		
F_1 Manure alone	Cattle manure: 5000		
F_2 Manure + chemical fertilizer	F_1 + 20N - 50 P_2O_5 - 30 K2O 180 CaO	F_1 + 30N - 70 P_2O_5 - 50 K2O 180 CaO	50N
F_3 Manure + chemical fertilizer + amendment	F_1 + 40N - 90 P_2O_5 - 100 K2O 720 CaO every 3 years	F_1 + 50N - 140 P_2O_5 - 100 K2O 720 CaO every 3 years	90N

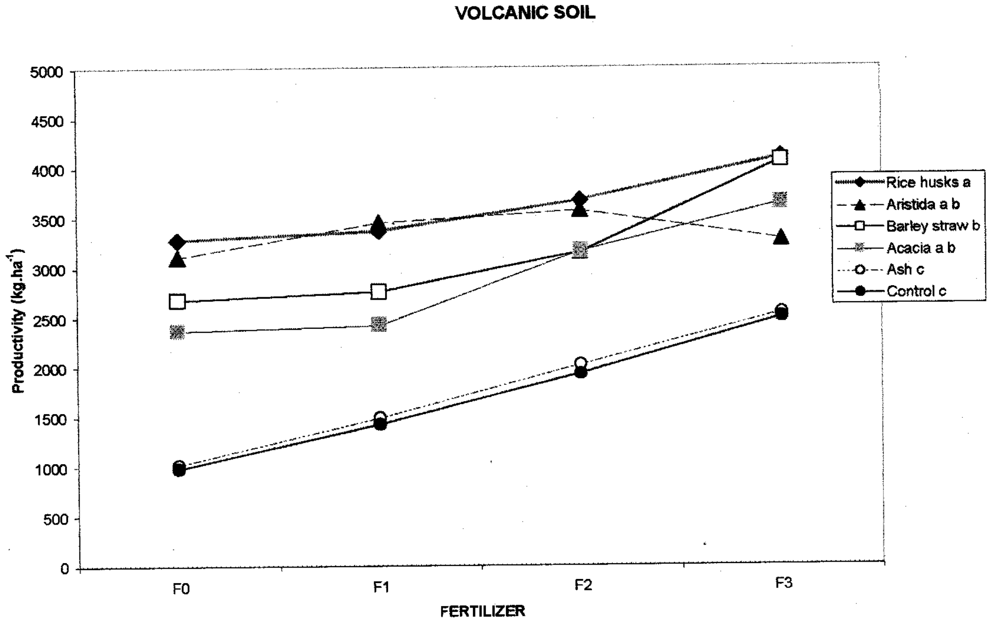
Cropping

Rice (cvs FOFIFA 133 or 152) and soybean (cv FT10) were sown in seed holes with 10 cm spacing on pairs of rows (30 cm between paired rows), with 50 cm spacing between pairs of rows. The test plots were ploughed or treated with herbicides (glyphosate) prior to rowing, and pesticides (seed treatments, carbofuran spot treatments, and deltamethrin against defoliating caterpillars on soybean).

Results

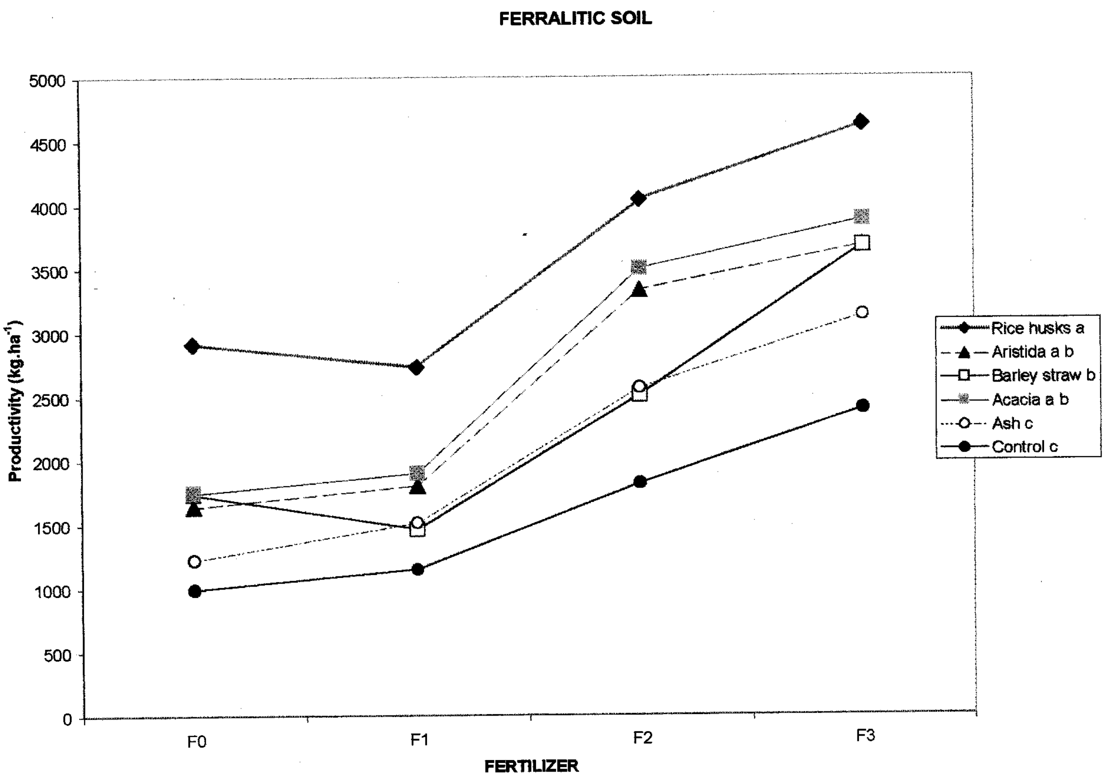
In the first year, the soi] smouldering technique had spectacular effects, i.e. boosting rainfed rice yields to levels that could be achieved with high chemical fertilizer inputs-to which farmers have no access for financial reasons (Fig. 1). On the two types of soil, mean yield gains of 1-2 t.hâ l were obtained, depending on the fuel, as compared to the ploughed control treatment, without any effect of the fertilization level.
The type of material used for fuel affected crop yields, with rice husk fuel giving the best results on ferrallitic soils.
Lower yield gains were achieved when applying ash produced by open-air combustion of the same quantity ofAristida sp. as that used for the soil smouldering operation, i.e. 0.5 t.ha 1 of rice on ferrallitic soils, but this input had no effect on volcanic soils.
A residual effect was observed on soybean yields in the year following the soil smouldering operation-this effect was more substantial on volcanic soils (Fig. 2).

Figure 1. Effects of the type of fuel used for soil smouldering (écobuage) on rainfed rice yield.



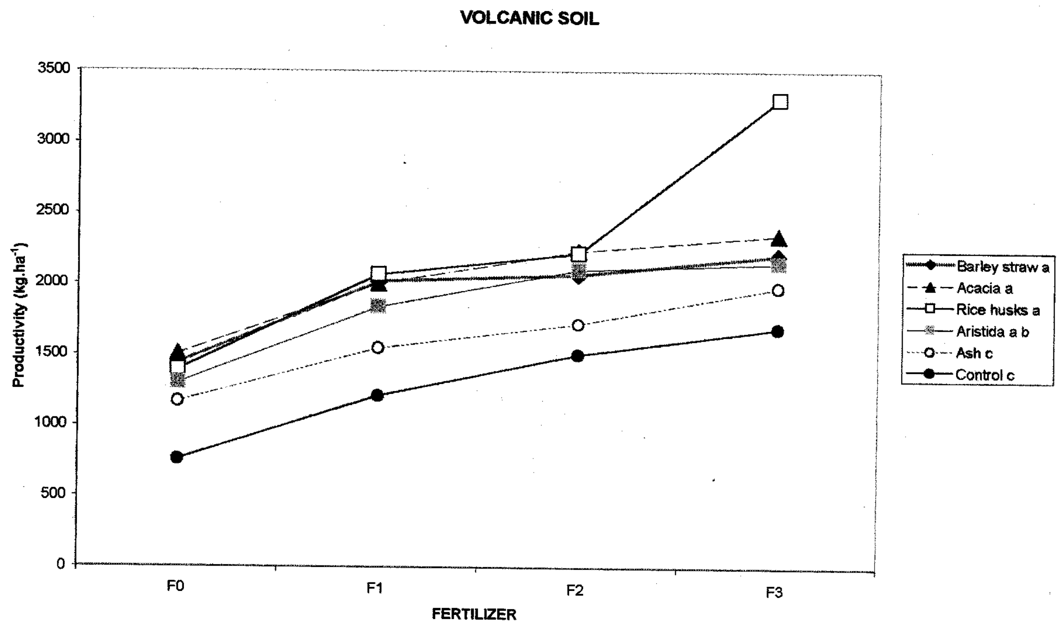
(*)Treatments ranked by the Newman and keuls test (5% threshold)
CV fuels= 21%; CV Fertilizers=15%, respective SDs=580 and 428 $kg.ha^{-1}$

Fuel dose in $l.ha^{-1}$ d.m.:acacia 39, aristida 54, rice husks 50, bbarley straw 19

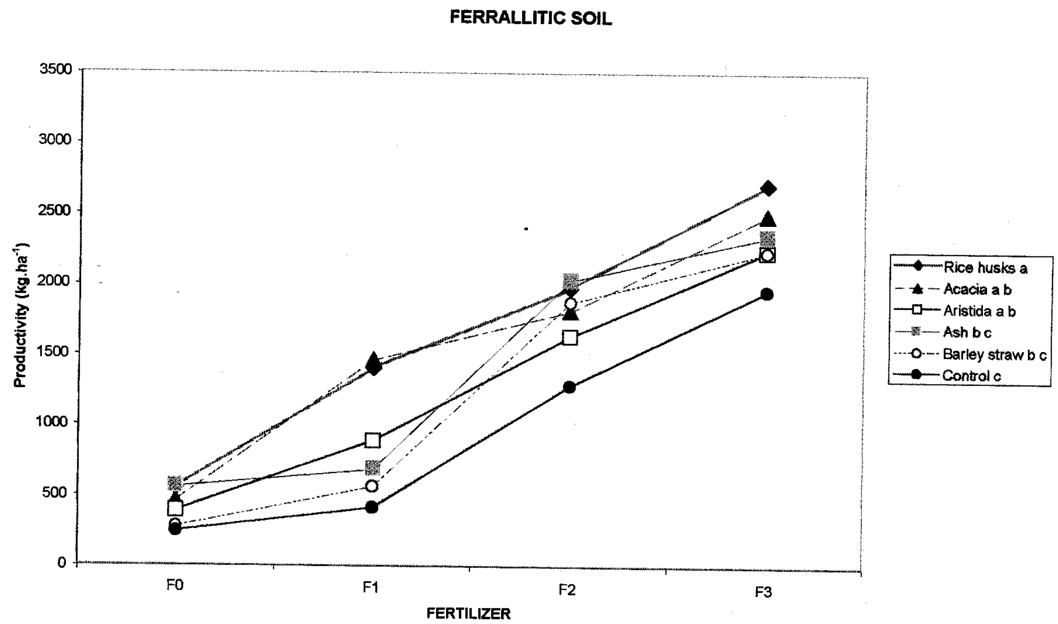


(*)Treatments ranked by the Newman and keuls test (5% threshold)
CV fuels= 18%; CV Fertilizers=11%, respective SDs=489 and 283 kg.ha-1

Figure 2. Residual effects of the type of fuel used for soil smouldering (écobuage) on soybean yield.



(*)Treatments ranked by the Newman and keuls test (5% threshold)
CV fuels= 20%; CV Fertilizers=19%, respective SDs=372 and 342 $kg.ha^{-1}$



(*)Treatments ranked by the Newman and keuls test (5% threshold)
CV fuels= 23%; CV Fertilizers=34%, respective SDs=319 and 468 $kg.ha^{-1}$

Discussion

Burning is sluggish during thé soil smouldering opération due to thé low oxygen levels in thé trench under thé soil layer, and températures therefore remain moderate (Nzila, 1992). Most nutrients contained in thé fuel are conserved in thé soil. Heat generated by this opération also alters thé soil colour (brick red) and characteristics, with an increase in pH and release of minerals (P, Ca, Mg, K) in forms that are readily assimilable by crops (Séguy, 1974). Combining soil smouldering with direct seeding improves a broad spectrum of subsoil properties, especially macrofauna activity, thus enhancing cropping system sustainability.

Acknowledgements

We thank N. Moussa and F. Rakotoniaina from thé NGO Terre et Développement (TAFA) for technical assistance.

References

Chabanne A, Seguy L, Razakamiaramanana. 1996. Gestion de la fertilité des rizières d'altitude â Madagascar, exemple de la plaine de Vinaninony (1875 m). In: Actes du séminaire riziculture d'altitude, pp. 187-196. 29 mars - 05 avril 1996. Antananarivo, Madagascar. Eds Poisson C, Rakotoarisoa J. 1997. CIRAD Montpellier. 272 pp.

Nzila JP. 1992. La pratique de l'écobuage dans la vallée du Niari (Congo). Ses conséquences sur l'évolution d'un sol ferrallitique acide. Document ORSTOM N°7. Montpelier. 190 pp. Rakondralambo P, Razanamparany C. 1998. Adaptation du semis direct dans les régions de Madagascar. In: Actes de l'atelier international sur la Gestion agrobiologique des sols et des systèmes de culture. pp 257 - 263. 23-28 mars 1998. Antsirabe Madagascar. Eds Rasolo F, Raunet M. 1999. ANAE, CIRAD, FAFIALA, FIFAMANOR, FOFIFA, TAFA. Montpellier. 658 pp.

Seguy L. 1974. Influence de la technique de l'écobuage sur les rendements de maïs et sur les propriétés physicochimiques des sols. O.N.A.R.E.S.T. IRAT/CVT. Rapport de synthèse sur les cultures vivrières. Cameroun. pp 44-47.