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 the 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 be 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 increased crop yields relative to the control (without soil smouldering). A residual effect was noted in the 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 the 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 the Hautes-Terres region of Madagascar are mainly ferrallitic and thus fragile and relatively infertile. In addition, under low temperature 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 has 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 survival apply very little fertilizer.
Materials and Methods

Fuels

"Soil smouldering" (écobuage) involves sluggishly burning plant matter (fuel) covered with a 10 cm layer of soil in a 20-cm deep trench with air outlets spaced every metre. Several fuels for this purpose can be obtained in fallowed fields (e.g. dried grasses, Aristida sp., and Acacia niearansii 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 after mowing, on ferrallitic soils (Ibity), or ploughing subsequent to the 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 the different fuels were assessed relative to four fertilizers adjusted according to the type of soil and crop (Table 1). The control treatment was carried out on bare soil after ploughing prior to sowing the crop. Another treatment, comparable to the ploughed control, was conducted with an initial application of ash (4 t.ha-1) produced by open-air combustion of the same quantity of Aristida sp. as that used for the soil smouldering operation.

The experimental conditions were identical in all cases: split-plot design (with 3 replications), combining the main treatments, i.e. the fuels (and controls), with the fertilizers on 13.5 in z plots.

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

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Basal fertilization at sowing</th>
<th>Complement on rice (sowing, 25 and 60 days after sowing)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volcanic soil</td>
<td>Ferralitic soil</td>
</tr>
<tr>
<td>F₀ No fertilizer</td>
<td>Nothing</td>
<td></td>
</tr>
<tr>
<td>F₁ Manure alone</td>
<td>Cattle manure: 5000</td>
<td></td>
</tr>
<tr>
<td>F₂ Manure + chemical fertilizer</td>
<td>F₁ + 20N - 50 P₂O₅ - 30 K₂O 180 CaO</td>
<td>F₁ + 30N - 70 P₂O₅ - 50 K₂O 180 CaO</td>
</tr>
<tr>
<td>F₃ Manure + chemical fertilizer + amendment</td>
<td>F₁ + 40N - 90 P₂O₅ - 100 K₂O 720 CaO every 3 years</td>
<td>F₁ + 50N - 140 P₂O₅ - 100 K₂O 720 CaO every 3 years</td>
</tr>
</tbody>
</table>

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 soil 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.ha⁻¹ 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 of Aristida 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.

**VOLCANIC SOIL**

(*) 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, barley straw 19

**FERRALITIC SOIL**

(*) 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 the soil smouldering operation due to the low oxygen levels in the trench under the soil layer, and temperatures therefore remain moderate (Nzila, 1992). Most nutrients contained in the fuel are conserved in the soil. Heat generated by this operation also alters the 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 (Seguy, 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. Rakotoniaaina from the NGO Terre et Développement (TAFA) for technical assistance.

References

