Restoring Biodiversity through Agricultural Intensification in the Rainforest Region of Madagascar

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1. Introduction

The rainforests of Madagascar, harboring one of the world's richest flora and fauna, are threatened by slash and burn agriculture. Through repeated burning and cropping, primary vegetation is rapidly converted to an exotic, herbaceous, and species-poor fallow vegetation, where rainforest species stop regenerating and where soils and their microbial life rapidly degenerate, unable to sustain any future agricultural production.

2. Goal

The **goal** of our study is to develop fire-less upland management practices that:
1) Intensify, improve, and sustain agricultural production; and
2) Conserve and restore biodiversity within the agro-ecological system.

3. Objectives

3.1. Test agricultural techniques where burning is replaced by mulching and the application of locally available guano-phosphate.

3.2. Identify native endo-mycorrhizal fungi, along a gradient of increasing frequency of burning and soil degradation.

3.3. Identify useful native rainforest tree species to be integrated into improved agroforestry systems.

4. Methods

Study location: Rainforest region along the Mantadia – Zahamena forest corridor, altitude: 500-700 m.a.s.l., annual rainfall > 2600mm, Oxisols and Ultisols, with pH of 4.5-5.5, available P <1 mg/kg, exchangeable Al 30-250 mg/kg.

Fallows and soils studied: 4 fallow types were selected along a soil degradation gradient: *Trema orientalis* (tree fallow), *Psiadia altissima, Rubus mollucanus* (shrubby fallows) *and Imperata cylindrica* (herbaceous fallow).

1 Land productivity experimentation:
Experiment on the 4 fallow types, CRB design, Treatments: 1) Slash and mulch (=SM) 2) SM and guano-phosphate (GP)(50 kg/ha P), 3) SM +GP (100kg/ha P), 4) Slash and burn (SB) (control). Rotation: upland rice – beans – ginger within 18 months. Traditional planting techniques and crop management

2. Endo-mycorrhizal fungi inventory:
From each vegetation category, fungal spores were extracted from soils and species identified according INVAM protocols http://invam.caf.wvu.edu/methods.htm

3 Indigenous useful tree species inventory:
Ethnobotanical inventory with species description and prioritization by the local population.

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5. Results

5.1. Land productivity improvement : Results from *Rubus sp.* fallow

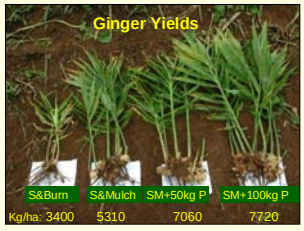
Initial soil analysis
Available nutrients in mg/kg, Morton Extraction

pH: 5.0 P: 0.05 mg/kg K: 48.8 mg/kg
Mg: 27.0 mg/kg Al: 244.3 mg/kg

Rice Yields (kg/ha)

- Slash & Burn 835
- Slash & Mulch 712
- SM +50kg P 770
- SM +100kg P 802

Bean Yields (winter crop)



With a rotation of upland rice, beans, and ginger the slash and burn (SB) treatment was slightly better with the first crop, but with the second and third crop, yields declined drastically due to rapid loss of nutrients with this management system. For the rice crop, yields were similar under slash and mulch (SM) with guano- phosphate (GP) and SB. For the beans, yields were three to four times higher under SM+GP than for SB. Yields were more then doubled for ginger, the important cash crop in the region. SM by itself was not sufficient to restore soil productivity in the short term, but some yield improvements could be observed with the ginger crop.

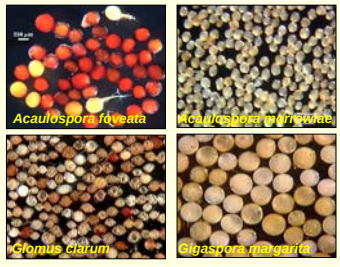
5.2. Mycorrhiza fungal diversity as impacted by land degradation

Primary forest
Acaulospora spinosa Walker and Trappe
Acaulospora foveata Trappe & Janos
Acaulospora koskei Blaszkowski
Acaulospora morrowiae Spain & Schenck
Entrophospora infrequens (Hall) Ames & Schneider
Gigaspora margarita Becker & Hall
Glomus clarum Nicolson & Schenck
Scutellospora pellucida Walker & Sanders

***Trema orientalis* Tree fallow**
Acaulospora koskei Blaszkowski
Entrophospora infrequens (Hall) Ames & Schneider
Scutellospora pellucida Walker & Sanders

***Psiadia altissima* Shrub fallow**
Acaulospora spinosa Walker and Trappe
Acaulospora morrowiae Spain & Schenck

***Imperata cylindrica* Grass fallow**
Paraglomus occultum (Walker) Morton & Redecker
Glomus clarum Nicolson & Schenck



Our results show a clear trend in a decline of genera and species encountered on the more degraded sites. This may indicate that for successful rainforest tree establishment in agroforestry systems, fungal inoculation would be of great importance. Additional studies are underway to examine the influence of agricultural treatments (as under 4.1) on the fungal community, as well as the infection potential of the present fungi.

5.3 Useful indigenous tree species identification

A total of 264 useful rainforest tree species were inventoried and their uses described. Identification was done with local plant experts. Botanical samples were taken and scientific determination done at the National Herbarium of Antananarivo. Market surveys in 3 large towns near the forest indicated which forest products arrive at these markets and the prices that these products obtain. For each use group, the local population identified the 10 most preferred species, which we propose for further cultivation studies.

6. Discussion and Conclusions

In the fast degrading landscapes of Madagascar, more stable, resilient and diversified farming systems can be developed through agricultural intensification based on biological and agro-ecological dynamics. Fire-less land management in combination with the supplementation of essential nutrients to the poor and acid soils, allows farmers to increase and stabilize their agricultural production. With improved organic matter management, soil health is also improved. We hypothesis that native mycorrhizal fungi will be able to proliferate and fulfill their essential functions in crop production and in tree establishment and growth (study underway). Being protected from fires, useful indigenous rainforest species can be integrated into agroforestry systems. These trees will play important roles in stabilizing hillsides and protecting watersheds, while simultaneously providing farmers with essential products for their livelihoods.The planting of native trees outside the dwindling rainforests will contribute to the restoration and conservation of one of the world's most unique areas in terms of biological diversity.

7. Acknowledgments

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