INTENSIFICATION OF SOIL ECOLOGICAL PROCESSES.HOW TO MANAGE SOIL BIODIVERSITY IN TROPICAL CROPPING SYSTEMS?

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1. Importance of ecological processes and complexity in agroecology

Agroecology is a new agricultural paradigm that gives a high importance to ecological processes and relies on biodiversity. A very critical challenge of agroecological practices is to stimulate soil ecological processes so as ecosystem goods and services will be provided in a way beneficial to the farmer and the society (Altieri, 1999). Agroecology has to face many difficulties and challenges; the objectives are to invest in ecosystem services, to promote biodiversity in cropping systems, to accept and deal with ecological system complexity, to take advantage of natural functions of ecosystems, to rely on ecosystem processes, to control biological processes and interactions in agroecosystems. Most of these items rely on biodiversity and especially on soil biodiversity whose activities are essential for the provision of ecosystem services.

2. Soil biodiversity and ecosystem services

Soils are known to harbour, under natural conditions, a wide range of soil organisms, varying in their taxonomy and functions. Soil biodiversity is mainly composed of 5 functional groups (Fig. 1): (i) Microorganismsalso sometimes called ‘chemical engineers’, and including bacteria and fungi). Microorganisms are responsible for the decomposition and mineralization of organic matter, the dynamics of nitrogen N and phosphorus P. Microorganisms cabe free in the soil or living as symbionts with roots (mycorrhiza and rhizobia). (ii)

Microregulatorscomprising small-sized predators of microorganisms, i.e. mainly protozoa and nematodes. By feeding on bacteria and fungi they release mineral N and P in the solution. (iii) Soil engineers including mainly soil macro-invertebrates such as earthworms, termites and ants. Roots are also classified in this category. The main role of these organisms is to modify the soil structure by the production of biogenic biostructures: aggregates, biopores and nests or mounds. They are able to ingest large amounts of soil and then to control the activity of soil organisms, the decomposition of soil organic matter, the nutrient cycling.(iv) Predators, i.e., large macroinvertebrates (insects, centipedes, etc.) feeding on other organisms. (v) Pests such as white grubs (Coleopteran larvae) whom some species feed on roots and cause crop damage.

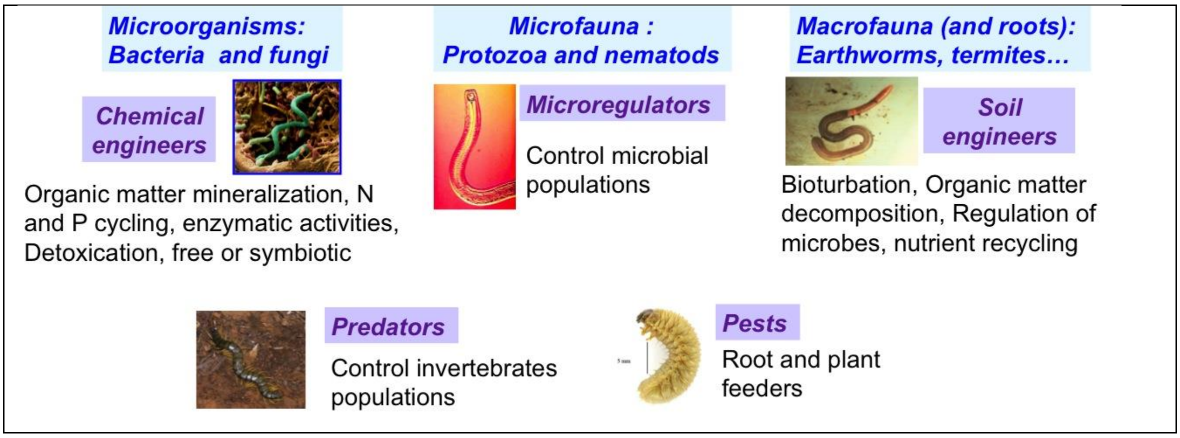

Fig. 1: diversity of soil functional groups

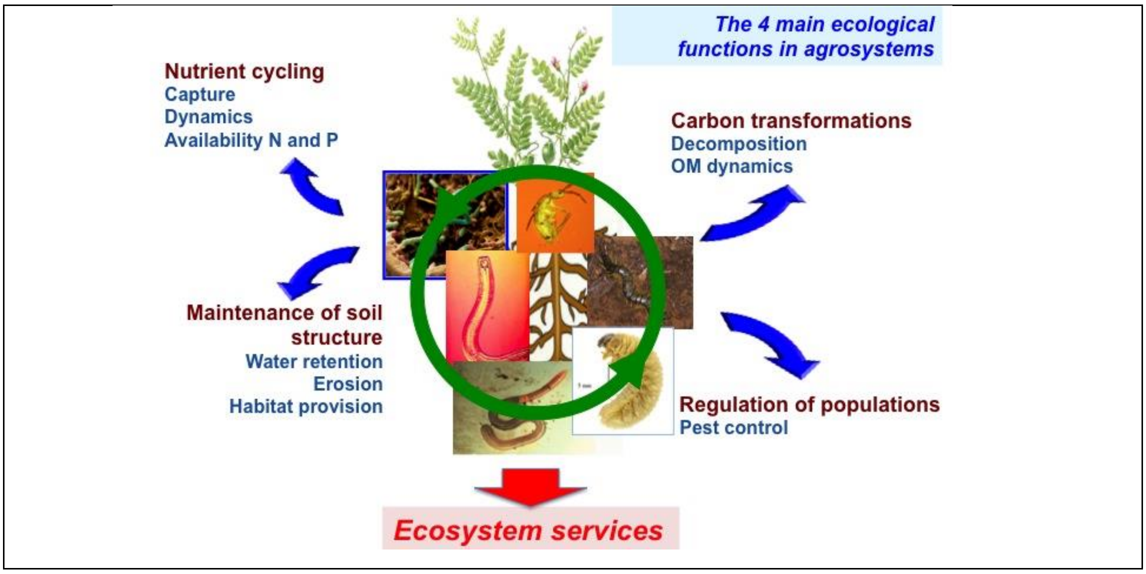

Fig. 2: Interactions between soil organisms at the base of the provision of ecosystem services

Soil organisms act and interact in very complex interactions that control the main ecological functions: maintenance of soil structure, recycling of soil nutrients, decomposition of organic materials, regulation of pests and pathogens (Kibblewhite et al., 2010). These functions are the base of ecosystem services in the sense of the Millennium Ecosystem Assessment (2005), i.e., food and biomass production, carbon sequestration, control of soil erosion, etc. (Fig. 2)

3. Modification of biodiversity by cropping practices

The aim of this presentation is to synthesize recent knowledge from research on soil ecological processes, and particularly from research in cropping systems from Madagascar. On the highlands of Madagascar, different agricultural practices result in different soil organism communities. All function groups of soil organisms, i.e., microorganisms, microregulators, engineers, predators, and pathogens are modified by agricultural practices and enhanced in conservation agricultural systems (Figure 3). These modifications have strong consequences on the functions performed by soil organisms and on the interactions among soil organisms (including plant roots). For instance, the behaviour of white grubs can move from a root-feeding habit to a saprophagous habit (Randriamanantsoa et al., 2010). The effect of soil engineers on soil organic matter decomposition, on soil nutrients and on carbon sequestration can also been strongly modified.

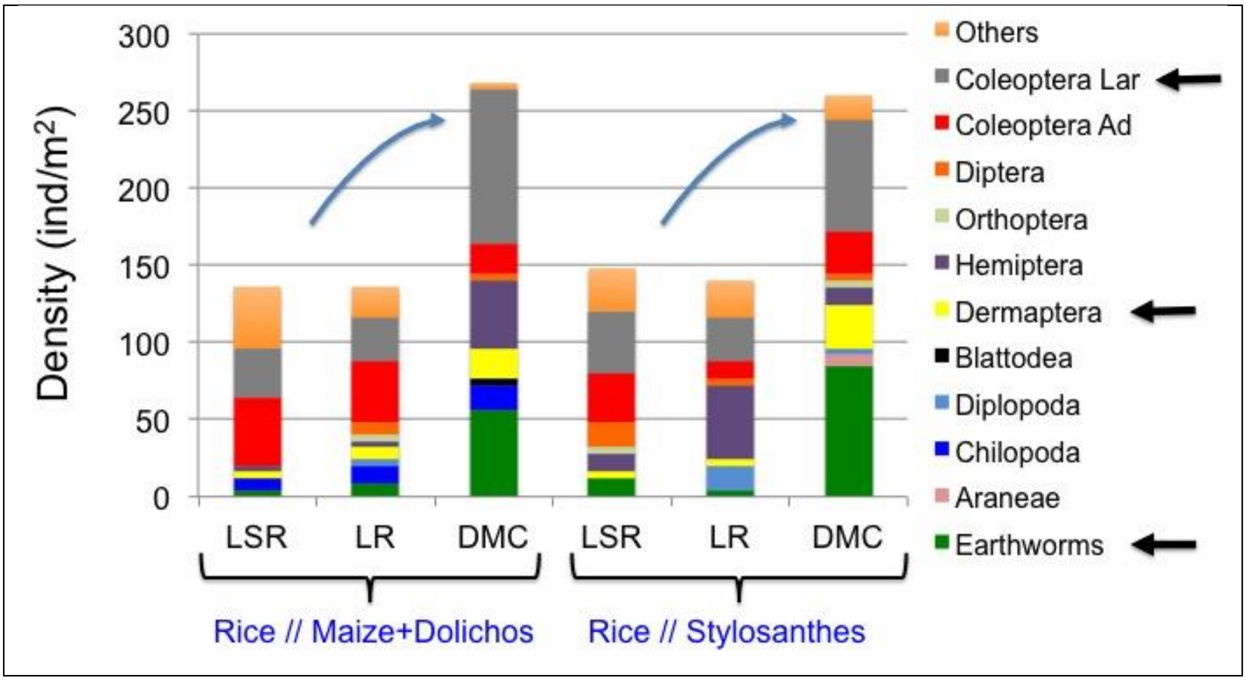

Figure 3: Density of soil macro-invertebrates in different cropping systems (rice in rotation with maize+Dolichos, and Rice in rotation with Stylosanthes) in Madagascar. Legend: LSR (tillage without residue restitution), LR (tillage with restitution), DMC (direct seeding mulch-based cropping system).

4. Potential for intensifying soil ecological processes

In this talk, we will describe the recent known effects of soil ecological functioning regarding plant growth and other ecosystem services and we willanalyse the potential ways to manage soil biota in a way beneficial to crop production and agroecosystem resilience to climate.

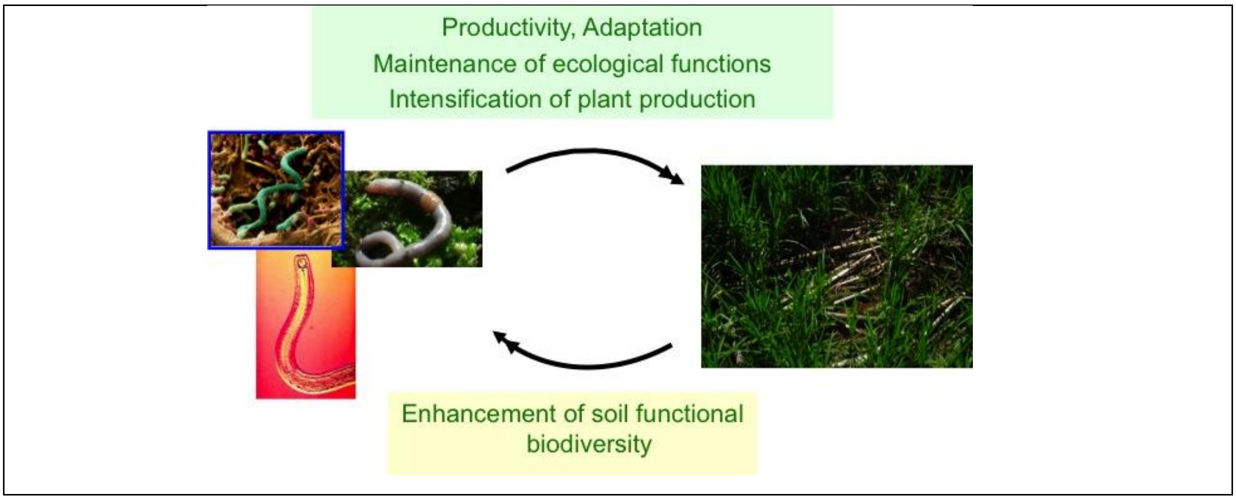

Figure 4: Link between biodiversity and sustainability and productivity of cropping systems

A particular interest will be given to the potential of the manipulationof soil engineers in rainfed rice systems in the Highlands of Madagascar in order to increase rice productivity and to restore ecosystem services at a field scale, through a modification of organic matter decomposition and dynamics, nutrient recycling, and soil physical properties (Senapati et al., 1999; Jouquet et al., 2014).

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