Intensifying the ecological functions of soils for a more sustainable agriculture: acting with actors

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Background

Soils are of central importance to some of the major issues concerning the future liveability of our planet, such as food security, adaptation to climate change and the preservation of biodiversity. Agricultural productivity, carbon storage and the stability of food webs are all dependent on the vast multitude of organisms which live in our soils. It is estimated that only a quarter of these subterranean species are known to humankind. And yet, this living fabric is all too rarely taken into consideration by agronomic innovators, and often neglected by farmers. IRD researchers and partner academics from the University of Antananarivo have been working to improve the integration of the soil's biological functions into agricultural practices in the rainy Hautes Terres region of Madagascar, boosting productivity, sustainability and resilience to climate change. This long-running collaboration has given rise to a new step-by-step protocol for engaging with local stakeholders, the "Soil Ecology Intensification Cure" (SE-Cure).

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Further reading
Blanchart E., Trap J., 2020 – Intensifier les fonctions écologiques du sol pour fournir durablement des services écosystémiques en agriculture. *Étude & Gestion des Sols*, 27: 121-134.

Soil biodiversity: a resource in need of protection

Soils are among our planets most diverse milieus. The physical and chemical complexity of our soils supports a vast array of habitats and a multitude of organisms, from bacteria and fungi to nematodes and worms. These organisms interact in complex networks and, ultimately, allow terrestrial ecosystems to function. Soils and the biodiversity they support form one of the central pillars of sustainable agriculture as defined by the Food and Agriculture Organization (FAO): efficient use of natural resources, management of nutrients, water and pests. The efficacy of agroecological practices is dependent on their capacity to manage soil biodiversity in such a way as to boost its ecological functions: freeing up nutrients for plants, capturing carbon, limiting pathogenic agents, regulating the flow of water etc. Farmers with a good understanding of their soils who use suitable agricultural practices can be a positive force for biodiversity.

Co-diagnosis

The first step in the SE-Cure process consists of a localised diagnosis at plot and farm level, analysing soil dysfunctions and associated pedological, sociological, ecological and agronomic constraints impeding the sustainability of agricultural operations. Identifying such problems requires interdisciplinary approaches in order to involve producers in the process of cataloguing and analysing, by means of

Examples of organisms found in soils
(*Atlas de la biodiversité des sols*, GSBI, 2015/Joint Research Centre [European Commission]).

Workshop for the co-construction of innovative practices integrating soil biodiversity in Madagascar.

surveys and workshops, traditional practices and obstacles to agricultural production. This phase should also include soil profiling analyses for farms. Surveys and soil quality diagnoses in the Hautes Terres region of Madagascar revealed that agricultural output was being held back by: 1) the poor fertility and lack of biological activity in the soils; 2) economic constraints endured by farmers, who were unable to buy the necessary inputs, as well as the lack of fertilisers on farms

Better understanding the workings of the soil

Our knowledge of the way soils work - and particularly the relationships between biodiversity, biotic processes, ecological functions and ecosystem services - remains too limited to predict the impact of agricultural practices on the workings of agrosystems. The second phase of the SE-Cure approach aims to fill this gap by conducting experiments in laboratory settings or in the field, inoculating organisms into the soils and restoring habitats to study the determinism of their biological functions. In Madagascar, for example, research focusing on upland rice has shown that certain organisms in the soil (earthworms, microorganisms and nematodes) perform important functions such as releasing bioavailable nutrients for plants, protecting crops from bioaggressors, capturing carbon in the soil and maintaining soil structure. For instance, we have demonstrated that the presence of earthworms increases the phosphorous content of plants by 87% compared with conditions in which worms are absent. This research demonstrates the advantages of restoring soil biodiversity and intensifying its functional contribution to agrosystems.

Testing innovative agricultural practices in response to soil dysfunctions

The aim of this phase is to identify agricultural practices which serve to intensify the ecological functions of soils and improve the agronomic performance of farming systems. The approach adopted is based on inter- and transdisciplinary participatory research involving sociologists, agronomists, ecologists and farmers. This phase incorporates co-learning workshops exploring both scientific and traditional knowledge of soil functions, as well as workshops co-designing measures to restore the biological functions of soils, while also taking socioeconomic constraints into account. The trials arising from these workshops focus on different agronomic approaches to restoring the ecological functions of soils, including organic and mineral fertilisation, plant diversity, genetic selection and biofertilisation. Fertilisation has emerged as a promising avenue for further exploration, combining organic and mineral fertilisers with beneficial organisms (bioinoculation) in order to resolve the fertility issues affecting some of Madagascar's upland agricultural soils.

Co-evaluating the effects of agricultural practices and disseminating the results

The final phase of the SE-Cure approach consists of co-evaluating the agronomic performance of innovative systems and aligning them with the ecological intensification of soil functions. Agronomic performance is assessed from the perspectives of both the farmers and the participating scientists. The tools used to measure the intensification of ecological functions in the soils must be perfectly calibrated to the local context, and the dysfunctions identified at the outset of the process. They are forged over the course of the three preceding phases in the SE-Cure process, and are in no way generic or pre-defined methods. The innovative practices selected at the culmination of this process are communicated to those directly concerned (farmers, politicians etc.) by means of pamphlets and booklets written in the local language, as well as workshops presenting the results to users and summary documents aimed at political decision-makers, and of course media coverage, social media posts and academic communications.

KEY POINTS

The co-construction of agricultural practices optimising the biological functions of impoverished soils represents a contribution to the food security of small farmers. Working with stakeholders upstream of the agroecological innovation process, and throughout the process of implementing new scientific approaches, makes it possible to build and apply innovative practices for improving the sustainability and resilience of agrosystems. With biodiversity in decline on a global scale, there is now an urgent need to improve our fundamental understanding of soil biodiversity and its effects, identifying and assessing agronomic factors on a local scale which can allow us to steer biological interactions in the soils for the purpose of reinforcing food security. The SE-Cure approach is an attempt to rise to this challenge. It has proved its worth in the context of upland agriculture in the Hautes Terres region of Madagascar, and could profitably be transferred to other contexts.

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