Biological activities and interactions in soil: Key parameters for agroecological systems

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Soil: a living and functional component of agroecological systems

Microorganisms: Bacteria and fungi

Chemical engineers

Organic matter mineralization, N and P cycling, enzymatic activities, Detoxication, free or symbiotic

Microfauna : Protozoa and nematods

Microregulators

Control microbial populations

Macrofauna (and roots): Earthworms, termites…

Soil engineers

Bioturbation, Organic matter decomposition, Regulation of microbes, nutrient recycling

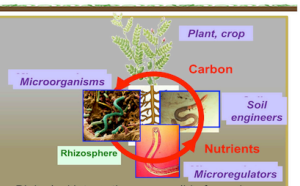
Predators

Control invertebrates populations

Pests

Root and plant feeders

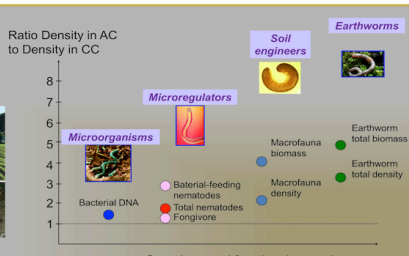
Soil functional biodiversity



Biological interactions reponsible for carbon transformations, nutrient cycling, structure maintenance and pest control in the rhizosphere

Soil functional groups in agroecological systems

Case studies: North of France



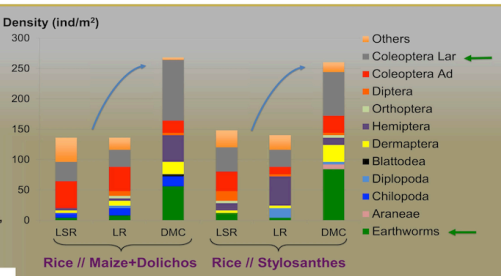
The density of soil organisms and functional groups are higher in agroecological systems than in conventional systems (represented by Ratios above 1). Earthworm populations are strongly modified (enhanced) by agroecological practices

Henneron L., Bernard L., Hedde M., Pélosi C., Villenave C., Chenu C., Bertrand M., Girardin C., Blanchart E. (2014) Fourteen years evidence for positive effects of conservation agriculture and organic farming on soil life. Agronomy for Sustainable Development, in press

Soil macrofauna in agroecological systems

Case studies: Madagascar (Lake Alaotra)

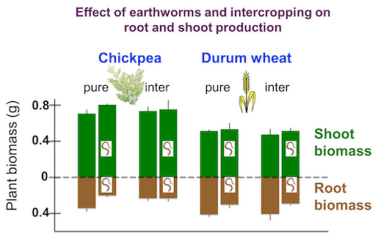
The density of soil macrofauna is higher in agroecological systems (DMC) than in conventional systems (LSR and LR), whatever the cropping systems. Earthworms and Coleopteran larvae are especially enhanced.



Rabary B., Randriamanantsoa R., Razafindrakoto M., Scopel E., Nacibide F., Jouquet P., unpublished data

Effects of earthworms on plant growth

Intercropping of legumes and cereals appears as an alternative agricultural practice to decrease the use of chemical fertilizers while maintaining high yields. What are the effects of earhworms on this interaction?

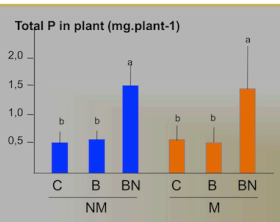


There was no overyielding of the intercrop in the absence of earthworms. Earthworms ♀ had a strong influence on biomass and resource allocation between roots and shoots whereas no modification was observed in terms of total biomass production and P acquisition. Earthworms could be seen as "troubleshooters" in plant-plant interaction as they reduced the competition between the intercropped species

Coulis M., Bernard L., Gérard F., Hinsinger Ph., Plassard C., Villeneuve M., Blanchart E. (2014) Earthworms modify soil phosphorus, plant growth and interactions in a legume-cereal intercrop. Plant and Soil, 379, 149-160

Complex trophic networks necessary for plant growth

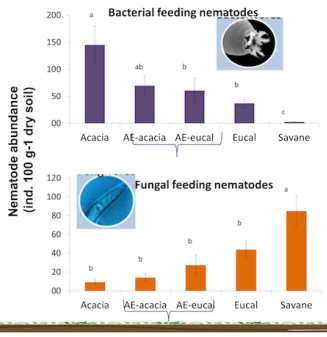
Plant (Pinus) growth without soil organisms (C), in the presence of bacteria alone (B), of bacteria+nematodes (BN), in the presence of mycorrhiza (M) or not (NM)

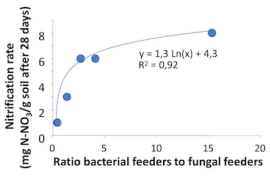


Without nematodes in the soil, the plant (Pinus) has no access to the phosphorus contained in the organic form phytate, even in the presence of phytate-mineralizing bacteria. The presence o fbacterial feeding nematodes (microregulators) is necessary to release inorganic P immobilized by microorganisms.

Irshad U., Villenave C., Brauman A., Plassard C., 2011. Grazing by nematodes on rhizosphere bacteria enhances nitrate and phosphorus availability to Pinus pinaster seedlings. Soil Biology and Biochemistry, 43: 2121-2126

Survey of nematode functional guilds and soil functions in mixed tree cropping systems in Congo





Very good relation between the nitrification rate in soil and the ratio bacterial feeding nematodes to fungal feeding nematodes

Robin A., Plassard C., Harmand J.M., Villenave C. (2013 Unpublished data

Conclusions: More biodiversity in agroecological systems, in terms of density, biomass, specific richness and functional diversity. Ecological functions are performed in a better way. There is a great challenge to manage soil biodiversity (interactions, functions) in order to reach and sustain ecosystem services.

Productivity, Adaptation
Maintenance of ecological functions
Intensification of plant production

Enhancement of soil functional biodiversity