Geophysical Research Abstracts
Vol. 19, EGU2017-12569, 2017
EGU General Assembly 2017

Mobilization of interactions between functional diversity of plant and soil organisms on nitrogen availability and use

Baptiste Drut (1), Nathalie Cassagne (1), Mario Cannavacciuolo (1), Alain Brauman (2), Gaëtan Le Floch (3), Jose Cobo (3), and Joëlle Fustec (1)

(1) USC LEVA, ESA, Angers, France (b.drut@groupe-esa.com), (2) IRD, UMR Eco&Sols, Montpellier, France, (3) EA 3882 LUBEM, Plouzané, France

Keywords: legumes, earthworms, microorganisms, nitrogen, interactions

Both aboveground and belowground biodiversity and their interactions can play an important role in crop productivity. Plant functional diversity, such as legume based intercrops have been shown to improve yields through plant complementarity for nitrogen use (Corre-Hellou et al., 2006). Moreover, plant species or plant genotype may influence the structure of soil microorganism communities through the composition of rhizodeposits in the rhizosphere (Dennis et al., 2010). Belowground diversity can also positively influence plant performance especially related to functional dissimilarity between soil organisms (Eisenhauer, 2012). Earthworms through their burrowing activity influence soil microbial decomposers and nutrient availability and have thus been reported to increase plant growth (Brown, 1995; Brown et al., 2004).

We hypothesize that i) plant functional (genetic and/or specific) diversity associated to functional earthworms diversity are key drivers of interactions balance to improve crop performances and ii) the improvement of plant performances can be related to change in the structure of soil microorganism communities due to the diversity of rhizodeposits and the burrowing activity of earthworms.

In a first mesocosm experiment, we investigated the effect of a gradient of plant diversity - one cultivar of wheat (Triticum aestivum L.), 3 different wheat cultivars, and 3 different cultivars intercropped with clover (Trifolium hybridum L.) – and the presence of one (endogeic) or two (endogeic and anecic) categories of earthworms on biomass and nitrogen accumulation of wheat. In a second mesocosm experiment, we investigated the influence of three species with different rhizodeposition - wheat, rapeseed (Brassica napus L.) and faba bean (Vicia faba L.) in pure stand or intercropped - and the presence of endogeic earthworms on microbial activity and nitrogen availability.

In the first experiment, biomass and nitrogen accumulation of wheat were improved in the presence of earthworms and clover. No effect of a plant genetic diversity was shown on crop performances. Furthermore, the influence of earthworms on bacterial diversity depended on plant diversity. In the second experiment, the specific composition of plant and earthworm presence modified the physiological profiles of rhizospheric microorganism communities (Microresp®) and nitrification potential. In the presence of faba-bean, microorganism activity was consistently increased and earthworms tended to decrease C:N ratio in the rhizospheric soil.

These results confirm the interest of legume based intercrops for the complementarity in nitrogen use thanks to biological fixation. This study showed the influence of earthworms on plant nitrogen acquisition by stimulating microorganism activity and nutrient availability around the roots. We also highlighted a synergistic effect between the presence of legume and endogeic earthworms for higher plant performances. We finally hypothesized that the combined effect of rhizodeposit diversity related to plant specific composition and soil chemical properties modified by earthworm activity drives the structure and activity of microorganism communities.

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