Geophysical Research Abstracts
Vol. 16, EGU2014-16293, 2014
EGU General Assembly 2014

Effects of earthworms and plants on the soil structure, the physical stabilization of soil organic matter and the microbial abundance and diversity in soil aggregates in a long term study

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Earthworms and plant roots, as ecosystem engineers, have large effects on biotic and abiotic properties of the soil system. They create biogenic soil macroaggregates (i.e. earthworm casts and root macroaggregates) with specific physical, chemical and microbiological properties. Research to date has mainly considered their impacts in isolation thereby ignoring potential interactions between these organisms. On the other hand, most of the existing studies focused on short to midterm time scale. We propose in this study to consider effect of earthworms and plants on aggregate dynamics at long time scale.

A 24 months macrocosm experiment, under semi-controlled conditions, was conducted to assess the impacts of corn and endogeic plus anecic earthworms (Apporectodea caliginosa and Lumbricus terrestris) on soil structure, C stabilization and microbial abundance and biodiversity. Aggregate stability was assessed by wet-sieving. Macroaggregates (>2 mm) were also visually separated according to their biological origin (e.g., earthworms, roots). Total C and N contents were measured in aggregates of all size classes and origins. Natural abundances of 13C of corn, a C4 plant, were used as a supplemental marker of OM incorporation in aggregates. The genetic structure and the abundance of the bacterial and fungal communities were characterized by using respectively the B- and F-ARISA fingerprinting approach and quantitative PCR bacteria (341F/515R) and fungi (FF330/FR1).

They significantly impacted the soil physical properties in comparison to the other treatments: lower bulk density in the first 10cm of the soil with 0.95 g/cm3 in absence of corn plants and 0.88 g/cm3 in presence of corn plants compared to control soil (1.21g/cm3). The presence of earthworms increased aggregate stability (mean weight diameter) by 7.6 %, while plants alone had no simple impacts on aggregation. A significant interaction revealed that earthworms increased aggregate stability in the presence of roots by 2.4% when compared to macrocosms without plants. Additionally, the presence of roots increased the total C and N concentration in earthworm casts, while earthworms increased C storage in microaggregates within root-derived aggregates. Analyses of 13C abundances revealed that OM had been incorporated in earthworm casts from the fifth month of the experiment. Earthworms showed an impact on bacterial abundance of 26.7% of increase in single species macroaggregates and 35.5% in mixt species macroaggregates after the first harvest of corn plants. Trends however changed on the long term since bacterial abundances decreased dramatically (67.1% in single species treatments and 59.3% in mixed species treatments) during the second year and fungal abundances, stable during the first 5 months of the experiment, later increased 80% and 73.2% in earthworm and mixed species macroaggregates.

This experiment showed how interactions between plants and earthworms can influence the soil structure and the soil aggregates dynamics by cooperating in macroaggregate formation. Both organisms need to be considered simultaneously for proper management of soils.