European Commission

Science for Environment Policy

Increasing diversity through crop rotation boosts soil microbial biodiversity and productivity

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Planting a variety of crop species in rotation in agricultural fields increases the diversity of soil microbes below ground, recent research has found. This in turn positively affects soil organic matter, soil structure and aids the healthy functioning of the soil. The researchers say that rotational diversity can help farmers to grow crops in a more sustainable way that promotes soil stability.

Modern agricultural practices, including less crop rotation, have been accompanied by a loss of biodiversity. This negatively affects the functions of agricultural ecosystems and the services they provide, such as the regulation of soil and water quality. Having a greater diversity of plants is known to improve soil microbial biodiversity in natural systems. However, the impact of rotational crop diversity on soil biodiversity is not well understood.

This study investigated how soil microbial communities change when an increasing number of different crop species are grown in rotation. Soil microbes break down organic material in the soil helping to form soil organic matter (SOM). SOM provides nutrients for plants and binds the soil into clumps that improve soil structure and water storage capacity. This also helps to prevent soil erosion.

The research was carried out as part of a long-term agricultural biodiversity study in the midwest USA. On four fields, each divided into 21 separate 9 x 27 m plots, the researchers grew from one to five different crops on a three-year rotational plan. Each field was cultivated over 12 years.

The crops were corn monoculture; corn and soybean rotation; corn with one cover crop (crops which are not harvested but grown to improve the soil); and soybean-wheat-corn rotations, one with no cover crop, one with one cover crop and one with two cover crops (three crops grown a year).

No chemical or organic fertilisers or pesticides were applied, so any soil changes detected could be attributed only to the various crop rotations.

The researchers took soil samples from all the plots and separated them into two sizes: mega-aggregates (clumps greater than 2 mm) and micro-aggregates (clumps of 0.053–0.25 mm). The researchers measured carbon and nitrogen levels, extracellular enzyme activity (a measure of microbial activity and ecosystem processes, such as organic matter decomposition), and the composition of the phospholipid fatty acids (used by microbes to build cell walls) to assess the structure of the microbial communities.

The organic carbon and nitrogen concentrations of the soil increased with rotational crop diversity across both sizes of aggregate. For instance, soil carbon increased by 33% in mega-aggregates in soils planted with diverse crops compared with carbon in soils used to grow monoculture corn.

Continued on next page.

Source: Tiemann, L.K., Grandy, A.S., Atkinson E.E., Marin-Spiotta, E. & McDaniel, M.D. (2015) Crop rotational diversity enhances belowground communities and functions in an agroecosystem. *Ecology Letters*. DOI: 10.1111/ele.12453

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These changes under high-diversity rotations were associated with the increased stability of mega-aggregates, which is an indication of SOM formation and accumulation. This is because higher crop diversity increases the quality and quantity of crop residues that can be incorporated into the soil, which then become available to the microbial communities. As a result, microbial activity is increased, which enhances soil clumping into mega-aggregates where SOM becomes protected and can accrue. Microbial activity in micro-aggregates is also enhanced, further promoting micro-aggregate formation and increases in the amount of organic carbon and nitrogen that can be stored.

As the number of crops grown on a plot increased, the structure of the microbial community shifted, with the most diverse rotations having a greater abundance of fungi relative to bacteria. The researchers say this result highlights the importance of soil fungi in the development of stable soil structures, as fungal hyphae play an important role in the binding of soil particles together. Soil aggregates help to store and protect organic carbon and nitrogen in the soil.

A high level of SOM enhances soil fertility. These results confirm that rotational diversity enhances soil microbial diversity, with related increases in organic carbon, nitrogen and SOM. Particularly in agricultural systems practising conservation techniques, with minimal or no chemical inputs, growing a diverse range of plants in rotation can improve soil structure and boost soil fertility.

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