Bacteria stunt with established plant-soil feedback theory

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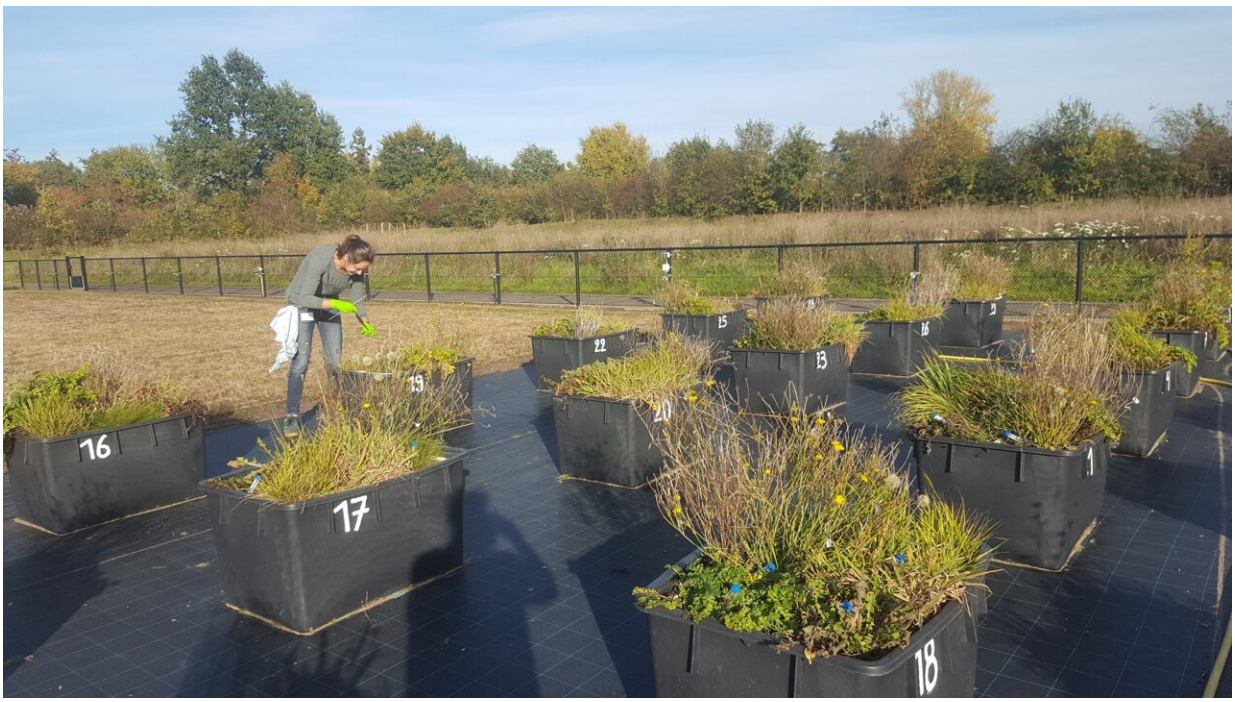

Credit: Leiden University

"What I find most alluring about soil life is that you can steer it," researcher Martijn Bezemer of the Institute Biology Leiden (IBL) reveals. "You can ask: What do you want? And then I can transform the soil into something you need. At least, that is what we thought."

For years, Bezemer studied the interaction between plants and the soil

microbiome: The bacteria and fungi living in the soil. "This microbiome and the plants affect each other, by the chemicals they release, for instance. We call that plant-soil feedback," the researcher explains.

It works as follows: when plant A is put in the soil, its surrounding soil changes. "In this way, you create a soil typical for plant A, thus soil A, with a matching microbiome," Bezemer says. But when plant A is replaced by plant B, the microbiome in the soil will slowly change into that belonging to plant B. "You can keep changing the soil, even with plant C, D or E. In this way, you could create desired microbiomes so that e.g. certain crops that you then plant in the soil can grow even better."

"However, it is remarkable that even though researchers are very fond of studying these plant-soil feedbacks and in steering soils, but that this has not yet been tested empirically so far. Therefore, in fact, it is just an assumption," Bezemer states. "In this latest study, we did test this theory." For a year, he and his team, a collaboration between the IBL and the Netherlands Institute of Ecology (NIOO-KNAW), grew six grassland species outdoors in large containers and regularly tested the microbiome's composition in the soil for each of those species.

Sensitive bacteria

After a period of three to four months of plant growth, the fungi in the soil reach an established composition. This was in line with the plant-soil feedback theory. Yet, even after a year, this was not the case for the bacteria in the soil.

Bezemer: "If you would measure today, you would see different bacteria in the soil than a few weeks earlier. That was quite the surprise." Still, there is an explanation for this result. "Bacteria are very sensitive to factors like moisture and temperature, after all."

From soil A to B?

In the second part of the study, the team went a step further. "This was the real feedback phase. Each of the large containers, where until then only plants of one species was grown, was divided into six parts. As an example, in a container with plant A and soil A, we now wanted to test the effect of regrowing plant A, ánd the effect of planting B to F on soil A," the researcher explains.

That was an enormous task. "Make no mistake, as we had five containers for each plant species to start. So with six plant species, we had thirty measuring points for a year already. Now, we multiplied that with six: 180 points, tested for six months by a team of seven people to look at which DNA we could find. And thereafter, Emilia Hannula, the first author of the article, got to analyze this enormous database."

Hannula adds: "You rarely get the chance to study soil microbes in this amount of detail to detect patterns and answer important questions," she says. "There are global studies out there with less data than we analyzed here for one soil, only changing the combination of plants growing now and earlier in it."

The setup should answer two questions. Will the soil change with the presence of the new plants? And will the effect of the previous plant, the so-called soil legacy, still be visible? After six months, legacies of the first plant were still visible, but only for fungi. However, the footprint of the new plant on the soil fungi had also already well established. None of this was the case for bacteria and it appeared that bacteria in the soil are largely irresponsive to the plants that grow in the soil.

Twist in the roots

However, there is a twist in this story. "We also looked at the microbiome in the roots of all plants grown in all the different soils. We call these microbes inside the plant endophytes," Bezemer says. "It turned out that even though bacteria belonging to the first plant were long gone in the soil, they still could be detected in the roots of the second plant! In the root of plant B, we found bacteria of soil A. Well, that ís interesting," he stated enthusiastically.

These endophytes can greatly influence plant growth, and this means that a plant can have a long-lasting effect on another later growing plant even when the legacy of the first plant in the soil has already faded away.

Bezemer suspects that the bacteria and fungi, right after planting the second plant species in the soil, have entered the roots through small cuts caused by planting. In the root, there is a safer and more constant environment, in which both fungi and bacteria can endure and these endophytes remained present inside the plants. To the surprise of the researcher. "The bacterial soil legacy of the first plant is preserved, albeit in the roots of the second plant and not in the soil. That is something we had never thought of before. They are still there!"

More information: S. Emilia Hannula et al, Persistence of plant-mediated microbial soil legacy effects in soil and inside roots, *Nature Communications* (2021). DOI: 10.1038/s41467-021-25971-z

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