The Quest for Predicting Plant-Soil Feedback

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A new study from the Department of Soil Quality at Wageningen University and the Department of Terrestrial Ecology at Netherlands Institute of Ecology (NIOO-KNAW) gives evidence that plants grow better in soil from other species. Published today in *Journal of Ecology*, the paper is written by Cortois *et al.* and is titled '*Plant-soil feedbacks: role of plant functional group and plant traits*'.

Authors Roeland Cortois and Gerlinde De Deyn have described below their inspiration behind the study and the significance of their work in the understanding of plant-soil feedbacks and their role in plant communities.

It all started with a simple question which we asked ourselves several years ago: can plant-soil feedbacks explain overyielding in plant species rich communities?

First of all we aimed to figure out whether plant-soil feedback (PSF) is actually occurring at a measurable and relevant scale and whether feedback sign (positive, neutral or negative) and strength are predictable from plant traits. Considering the growth versus defense trade-off hypothesis, we expected plant species with more acquisitive traits to build-up more negative feedback, whereas species with conservative traits would build-up more positive feedback with their own soil biota.

We formed a strong team, with a fine combination of Dutch and Flemish researchers specializing in plant-soil feedback, and German collaborators with expertise on plant traits. With a species pool of 60, The Jena Biodiversity Experiment provided a very nice experimental setting to test our ideas, but imagine what this number of species meant for testing plant-soil feedbacks and quantifying above-ground and below-ground plant traits...

Roeland collecting Jena field soil which the plants used to culture their own microbes and test the feedback responses against a 'neutral' control.

For 48 focal plant species, we tested growth responses i) in their own soil, ii) in a neutral living soil (mixture of soil from all plant species), and iii) in a sterilized soil inoculum. Sounds easy, but the crux of the matter is how to choose experimental soils and how to interpret the results ecologically. We pondered about this for some time.

In the current study we decided to determine two important aspects of PSF-dynamics: the net effects of soil biota on plant growth and the potential of a plant species to escape (or lose) its own soil feedback by growing in other species' soil, which turned out to benefit most species. This has led to novel insights on both intra- and interspecific variability of plant-soil feedbacks. We found that graminoids and small herbs built up a net negative relationship with their own soil biota: they grew better in sterilized soil than in living soil. Legumes responded on average neutrally, while tall herbs seemed to harness more benefits than detrimental soil organisms: they mostly grew better in living soil than in sterilized soil.

Interestingly, most species grew better in neutral living soil compared to their own soil, irrespective of functional group. These findings may suggest that pathogens exhibit relatively strong host species-specificity while mutualists are more generalized. It is also possible that the herbs benefitted more from mutualists of other plants than of their own (Bever, 2002).

Left: One replicate block of the feedback experiment. *Right: Sanguisorba officinalis* planted at seedling stage but growing very differently in response to the soil treatments.

All together interesting findings, but we were not satisfied yet. The next step was to use plant traits to plant functional groups in order to predict the variation of plant-soil feedback. Our findings showed that plants with negative plant-soil feedback had on average thin roots and few arbuscular mycorrhizal fungi (AMF) in their roots, while positive plant-soil feedback plants had on average thick roots and were more colonized by AMF. This provides new evidence for the idea that 'fast' plants are vulnerable to detrimental soil factors, while 'slow' plants interact more positively with below-ground biota.

How do our findings add to our understanding of plant-soil feedbacks and their role in plant communities?

Firstly, we have provided increased predictability of plant-soil feedbacks by plant traits, which is useful for further integration of plant-soil feedback concepts in plant ecological strategy frameworks – in which plant trait analyses are an essential tool. Secondly, we found that plant functional group identity was also an important predictor of plant-soil feedback, and we showed that large forbs not only depend strongly on their own beneficial soil biota, but they benefit even more from biota in soils of other species. This latter observation makes it likely that plant species with a positive feedback from soil biota contribute more to plant productivity in mixtures than plants with negative feedback. In that sense, we also provide some understanding for the often supposed importance of plants with negative plant-soil feedback in causing higher productivity in increasingly diverse plant communities. Of course, these plants benefit from growing in soil of other species, but as the tall herbs with a positive feedback benefit as well, the net result may be that the positive plant-soil feedback plants dominate the diversity-productivity effect after all.

Turning back to the relationship between plant-soil feedbacks and the framework of fast-slow resource strategies of plants, we think that the coupling of functional traits and plant-soil feedback is a great way to integrate plant-soil feedback research in the study of plant ecological strategies. In a coexisting species pool of plants, species show trade-offs in dispersal, growth rate, defense against natural enemies, competitiveness *etc.*, which allows us to not only analyze and understand their coexistence, but also to understand the dynamics of plant communities, spatially and temporally. The relevance of plant-soil feedback for a plants' ecology only becomes clear when integrated with other aspects of its ecology. Our study lays important ground for this challenging quest.

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EDIT: you can read the press release from (NIOO-KNAW) here.

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