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Microbial responses to drying and rewetting: The interaction between soil structure and precipitation history

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Intensified land-use management and climate change constitute two major challenges for maintaining the soil functions regulated by microbial communities. It is well known that tillage disturbs the soil structure by changing physical properties such as aggregation and water retention capacity, which both have an impact on microbial carbon cycling. In addition, extreme drought and rainfall events result in a significant release of carbon dioxide, where the amount of carbon respired depends on the legacy of precipitation. Thus, understanding the combined effect of land use and precipitation on microbial processes is important in order to predict the future terrestrial carbon cycle.

In this project, we investigated how both the precipitation history and the disruption of soil structure affect microbial growth and respiration during drying-rewetting. We expected that microorganisms in sites with lower historical precipitation might be used to drier conditions, and then exhibit a faster recovery after rewetting and lower respiration rates than those in wetter sites. We also expected that the disruption of soil aggregates would increase the respiration rates after rewetting. In addition, fungal growth would be more affected than bacterial growth due to a damaged hyphal network.

We selected 11 grasslands sites across an east-west precipitation gradient in Sweden ranging from 380 to 1220 mm mean annual precipitation. Three different experiments were carried out to determine the differences in microbial responses along this gradient, by measuring bacterial growth, fungal growth and respiration at high time resolution during seven days after drying-rewetting. First, we investigated the short-term effect of disturbing aggregates by grinding soils in the laboratory. We compared the results from undisturbed soils with those found after dry or wet crushing. Second, we studied the effect of soil structure disturbance in the field and if results from laboratory experiments could be extended to agricultural practices. For this, we established plots across the precipitation gradient, applied a tillage treatment with a rotary cultivator at the start of the growing season and measured microbial responses at the end of the summer. Third, we explored how the microbial responses to soil structure disturbances developed over time in the field. To do so, we used soil sampled from one site in the gradient after one week, one month and three months after disturbance.

Preliminary results showed that crushing soils in the laboratory accelerated the bacterial recovery after rewetting, but fungal growth and respiration were unaffected compared to undisturbed soil.

In the field, the microbial responses over time strengthened up to one month after the tilled treatment. The microbial responses along the precipitation gradient showed the importance of land-use management for carbon cycling under future scenarios of intensified weather events.