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Does crop rotational diversity increase soil microbial resistance and resilience to drought and flooding?

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Future climate scenarios indicate more frequent and stronger extreme weather events. This includes more severe droughts but also an increase in heavy rain events and flooding. Agricultural systems are of special interest in this context because of their role in food security but also because of their potentially changing role in global carbon and nutrient cycling under these extreme conditions. Plant diversification strategies like more complex crop rotations which support more diverse soil microbial communities with higher functional redundancy might be more resistant to drought and flooding and could help to reduce impacts on microbial carbon and nutrient cycling. To test how crop diversification affects the response of soil microbial processes to drought and flooding and reoccurring drought and flooding, we manipulated water regimes in lab incubation experiments using soils from four long term rotation experiments across the USA, including a low (one or two crops) vs. high (>3 crops) diversity rotations at each site. The sites range from low precipitation (Colorado), over intermediate precipitation (Michigan and South Dakota) to high precipitation in Maryland. Replicate sets of samples were either allowed to dry out, were gradually flooded or kept at a constant water content (control). We monitored CO_2 production during five stress cycles. Additionally, we determined microbial biomass, enzyme activities and N pools during the first and last stress cycle in soils from the precipitation extremes.
After a total incubation length of 165 days and five stress cycles only the soils from short rotations in Maryland and South Dakota that had been subjected to reoccurring drought showed significantly less cumulative CO_2 loss compared to their respective controls. All the other sites and rotation length did not significantly differ from control when subjected to reoccurring drought or flooding. A Principal component analysis using all measured parameters of Colorado and Maryland soils showed a clear clustering of samples by site and in case of Maryland also by rotation length before the first stress. During the stress, samples were significantly separated by the treatment (drought and flooding). Immediately after the stress, samples again clustered by site and rotation length. After four stress cycles, soils from the long rotation in Colorado were the only samples that did not show a significant response to the laboratory treatments anymore.
Our results indicate that agricultural soils, irrespective of the climatic region they are from and the rotation regime, are highly susceptible to changes in water content, especially drought. We did however also found that all tested soils were quickly recovering from the applied stress treatment and that plant diversification might help to increase the microbial resistance to water stress in certain soil systems.