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Heterogeneity of hydrolytic enzyme activities under drought: imaging and quantitative analysis

Muhammad Sanaullah (1,2), Bahar S. Razavi (1), and Yakov Kuzyakov (1)

(1) Department of Agricultural Soil Science, University of Göttingen, Germany, (2) Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan

The zymography-based "snap-shoot" of enzyme activities in the rhizosphere is challenging to detect the in situ microbial response to global climate change.
We developed in situ soil zymography and used it for identification and localization of hotspots of β-glucosidase activity in the rhizosphere of maize under drought stress (30% of field capacity). The zymographic signals were especially high at root tips and were much stronger for activity of β-glucosidase under drought as compared with optimal moisture (70% of field capacity). This distribution of enzyme activity was confirmed by fluorogenically labelled substrates applied directly to the root exudates. The activity of β-glucosidase in root exudates (produced by root and microorganism associated on the root surface), sampled within 1 hour after zymography was significantly higher by drought stressed plants as compared with optimal moisture. In contrast, the β-glucosidase activity in destructively sampled rhizosphere soil was lower under drought stress compared with optimal moisture. Furthermore, drought stress did not affected β-glucosidase activity in bulk soil, away from rhizosphere. Consequently, we conclude that higher release of mucilage by roots und drought stimulated β-glucosidase activity in the rhizosphere. Thus, the zymography revealed plant-mediated mechanisms accelerating β-glucosidase activity under drought at the root-soil interface. So, coupling of zymography and enzyme assays in the rhizosphere and non-rhizosphere soil enables precise mapping the changes in two-dimensional distribution of enzyme activities due to climate change within dynamic soil interfaces.