Geophysical Research Abstracts
Vol. 19, EGU2017-1141-3, 2017
EGU General Assembly 2017
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Interactions between soil texture, water, and nutrients control patterns of biocrusts abundance and structure

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Heterogeneity in the abiotic environment structures biotic communities by controlling niche space and parameters. This has been widely observed and demonstrated in vascular plant and other aboveground communities. While soil organisms are presumably also strongly influenced by the physical and chemical dimensions of the edaphic environment, there are fewer studies linking the development, structure, productivity or function of surface soil communities to specific edaphic gradients. Here, we use biological soil crusts (biocrusts) as a model system to determine mechanisms regulating community structure of soil organisms. We chose soil texture to serve as an edaphic gradient because of soil texture's influence over biocrust distribution on a landscape level. We experimentally manipulated texture in constructed soil, and simultaneously manipulated two main outcomes of texture, water and nutrient availability, to determine the mechanism underlying texture's influence on biocrust abundance and structure. We grew biocrust communities from a field-sourced inoculum on four different soil textures, sieved from the same parent soil material, manipulating watering levels and nutrient additions across soil textures in a full-factorial design over a 5-month period of time. We measured abundance and structure of biocrusts over time, and measured two metrics of function, N2 fixation rates and soil stabilization, at the conclusion of the experiment. Our results showed finer soil textures resulted in faster biocrust community development and dominance by mosses, whereas coarser textures grew more slowly and had biocrust communities dominated by cyanobacteria and lichen. Additionally, coarser textured soils contained cyanobacterial filaments significantly deeper into the soil profile than fine textured soils. N2-fixation values increased with increasing moss cover and decreased with increasing cyanobacterial cover, however, the rate of change depended on soil texture and water amount. Soil shear resistance was highest on finer textured soil with the highest watering treatment, whereas compression resistance was highest on the coarsest textured soils with the highest watering amounts. Nutrient addition did not influence total cover or biocrust function, but did decrease lichen cover. Taken together, these results suggest that interactions between soil texture, water, and to a lesser degree nutrients, create predictable patterns in biocrust assemblage and offers a mechanistic understanding of edaphic controls over biocrust abundance and structure. These insights add to our increasing understanding of how edaphic gradients structure soil communities.