Geophysical Research Abstracts
Vol. 20, EGU2018-11459-1, 2018
EGU General Assembly 2018

N transfer from biocrusts to dryland plants driven by water and N availability

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Microbial interactions in the soil may couple the resource dynamics of primary producers that are functionally disconnected and thus affect fluxes and pools of resources. Drylands have low-density plant communities and biological crusts as primary producers. Many biocrusts fix nitrogen, but this bioavailable N may be inaccessible to plants if soil moisture is insufficient to activate plant metabolism or if roots do not extend to the surface in interspaces. The fungal loop hypothesis proposes that fungi can uptake resources during times that other organisms are inactive and transport resources between plants and biocrusts, enhancing production. We investigated: 1. Does N transfer occur more rapidly when fungi are able to grow between the interspace and roots? 2. Does N transfer occur more rapidly when provided as an organic or inorganic form? We addressed these questions across different sites, species, and seasons to determine if the patterns hold and we collected abiotic and biotic soil conditions to help explain patterns.

We conducted a field experiment where we isolated a target plant and adjacent biocrust using metal flashing (25 x 50cm “raceways”). We added isotopically enriched substrate to the biocrust end and collected leaves after 3d and roots after 10d. To address Q1, we added a vertical strip of hydrophilic mesh with pore sizes that either allowed fungi to pass through but inhibited roots or inhibited both roots and fungi between the plant and the biocrust. The controls had no mesh. To answer Q2, we added 15N as either glutamate or nitrate. We repeated these treatments at the northern and central reaches of the Chihuahuan desert (Sevilleta LTER and Jornada LTER) in spring and monsoon seasons of 2017, and selected a widespread C4 grass, Bouteloua eriopoda and C3 forb, Gutierrezia sarothrae as target plants. We recorded moisture, available N, and microbial and fungal biomass in a subset of the raceways.

We found some support for the fungal loop hypothesis because more translocation occurred under harsh and nutrient-depleted conditions. More 15N moved into the B. eriopoda leaf tissue after 3 d under drier conditions ($P = 0.05$) and when nitrate content in the interspace soil was low ($P = 0.003$), but the relationships did not differ by connection treatment ($P > 0.05$). Microbial biomass and ergosterol content did not affect changes in 15N content of B. eriopoda leaves.

We found that patterns of retention in roots were not consistent across the different communities, but the form of nitrogen provided was in some cases important for retention. In Spring, at the Sevilleta, B. eriopoda root 15N content of raceways labeled with glutamate and nitrate did not differ, but at the Jornada, B. eriopoda root 15N content of raceways labelled with nitrate was 21% higher than of glutamate (interaction $P = 0.03$).

Overall, we found that abiotic drivers were stronger predictors of N movement than microbial abundance, and thus these processes will be strongly directly affect by anthropogenic changes such as nitrogen deposition and variability in precipitation regime.