EGU22-10552
https://doi.org/10.5194/egusphere-egu22-10552
EGU General Assembly 2022

Microbial and Abiotic Effects of Experimental Nitrogen Deposition on Dryland Soil Organic Carbon Storage

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Nitrogen enrichment due to atmospheric nitrogen deposition has affected plant growth and microbial activity globally, leading to an increase in soil organic carbon in many ecosystems. Drylands cover ~45% of the global land area and constitute ~32% of the global carbon stocks, but the response of dryland carbon storage to atmospheric nitrogen deposition remains unclear and understudied relative to mesic systems. Observations from mesic systems suggest that nitrogen enrichment can increase the efficiency by which microbes incorporate carbon into mineral-associated forms if pH stays constant. Under acidification, a common response to nitrogen deposition, microbial biomass and enzymatic organic matter decay often decrease, leading to a build-up in plant-derived particulate organic carbon. However, in drylands, where organic carbon often associates with mineral surfaces via Ca-bridging, acidification may also abiotically decrease mineral-associated organic carbon if Ca is leached. In this study we tested how experimental nitrogen deposition affects different soil organic carbon fractions in drylands through microbial and abiotic effects.

We used four long-running nitrogen deposition experiments in Mediterranean shrub- and grassland ecosystems in Southern California, where two of the sites showed strong nitrogen-induced acidification (pH drop by ~1.5 units). We studied changes in soil organic carbon fractions, soil extracellular enzyme activity, microbial carbon stabilization efficiency and exchangeable Ca. Experimental nitrogen deposition had relatively small effects on soil organic carbon storage, which appeared to be mostly driven by soil physicochemical changes. Particulate organic carbon did not increase despite previously reported increases in plant biomass and decreases in microbial biomass and extracellular enzyme activity in acidified sites. Furthermore, microbial carbon stabilization efficiency was unaffected by N fertilization in non-acidified sites and decreased in short-term but not long-term incubations in acidified sites. Importantly, mineral-associated organic carbon decreased significantly by 20% in response to N fertilization at one of the acidified

sites, likely as result of pH-induced loss of Ca, which dropped by 48%. Our measurements suggest that long-term effects of nitrogen fertilization on dryland carbon storage might be primarily abiotic in nature, such that drylands, which may undergo acidification and where Ca-stabilization of soil organic carbon is prevalent, may be most at risk for loss of mineral-associated organic carbon.