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Soil water holding capacity and its relation to biogeochemical cycling

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Soil water holding capacity (WHC) is a key soil property determining water availability to plants. Plants increase the organic carbon content of soils, depending on the amount and quality of litter, and with this affect the WHC. Plants accumulate also high amounts of amorphous silica (ASi) of calcium oxalate (Ca-ox) in their tissues. After plant tissues are deposited in the soil, this results in elevated concentrations of these compounds in soils. ASi content in soils range between 0 and 6%. It was suggested that agricultural practice (yearly export of biomass) leads to a strong decrease of ASi content in soils. We tested the effect of biogenic (plant derived) ASi on soil water holding capacity. We found that biogenic ASi forms silica gels with WHC > 700% and it increases soil WHC to values similar to those of clay minerals. An increase of biogenic ASi pools by 5% enhances soil WHC by >15%. Biogenic ASi (mostly phytoliths) can be preserved in soils for many years (as biogenic ASi) until Si is mobilized to dissolved silica DSi by phytolith dissolution. Increasing DSi content in soils slightly decreases the soil WHC. However, high DSi contents favor neoformation of clay minerals, which have high WHC. WHC of soils with 5% biogenic ASi content is higher than soils with 5% montmorillonite, a mineral of the fine clay fraction, known to be responsible for large parts of WHC. Consequently, the speciation of Si is highly important because it determines the WHC of soils. Additionally, we analyzed the effect of Ca-ox on WHC. Increasing soil Ca-ox content increases WHC, especially under negative water potentials. However, for common values of Ca-ox in soils (<1%) Ca-ox effects on soil WHC are negligible. In summary, we propose that preserving the biogenic ASi content in soils should be a target of agricultural practices that aim at increasing WHC and reducing the negative effects of drought on crops.