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Effect of soil weathering degree on the increase of cotton biomass and silicon mineralomass after amendment with biochar highly concentrated in phytoliths

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Silicon (Si) is beneficial for plants, but not essential. It plays a crucial role in improving the yields of Si-accumulator crops through alleviating various biotic and abiotic stresses. The demand of Si fertilizers will likely increase due to soil desilication and removal of harvested biomass. Since plants accumulate Si in the form of readily soluble phytoliths, plant-derived biochar is considered as a Si source for Si accumulator crops. In addition to its beneficial effects on soil fertility and carbon sequestration, biochar is a promising cost-effective and environmentally friendly alternative to conventional Si amendments. Here, we study the impact of biochar materials with different phytolith concentrations on the bioavailability of Si in soils differing in weathering stage, and its effect on cotton biomass and Si mineralomass.

Two biochar materials were used: Miscanthus x giganteus (Si concentration: 34.6 g/kg) and soft woody material (Si concentration: 0.9 g/kg). A conventional wollastonite ($CaSiO_3$) treatment was carried for comparison purpose. The concentration of bioavailable Si was determined through 0.01 M CaCl2 extraction. Biochars were incorporated at the rate of 3% (w/w) in two soils: a slightly weathered Cambisol and a highly weathered Nitisol.

The Miscanthus biochar ability to release bioavailable Si in the Cambisol (CaCl2 extractable Si/total Si concentration) is significantly smaller (0.9%) than the one of wollastonite (5.2%). In the highly weathered Nitisol, the Miscanthus biochar ability to release bioavailable Si is much larger (1.4%) than that of wollastonite (0.7%). Miscanthus biochar significantly increases the cotton biomass and Si mineralomass relative to soft wood biochar. The increase is larger in the highly weathered Nitisol than in the slightly weathered Cambisol. Principal component analyses and linear regression show that both the larger release rate of bioavailable Si and CEC are the main factors responsible for the increase of cotton biomass after Miscanthus biochar amendment.

Thus, biochar made from Si high-accumulator Miscanthus can be considered as an alternative to wollastonite for supplying bioavailable Si in the highly weathered Nitisol. This beneficial effect is added to increased soil fertility and soil organic carbon content.

Key word: bioavailable silicon, high-accumulator biochar, highly weathered soil, Si fertilizer, biomass, silicon cycle