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Contrasting effects of phytolith-rich biochar on the biomass and its mineralomass of silica-phytoliths in a pot experiment over two successive rice growing periods

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Summary:

Silicon (Si) in plants increases their photosynthetic activity and tolerance against various biotic and abiotic stresses. It is thus important to increase the pool of dissolved silicon (DSi) in soils to promote plant Si uptake and form biogenic Si (BSi) deposited as phytolith in plant tissues. The BSi pool may vary according to the soil weathering stage and removal of plant residues since both affect the DSi pool. This can impact the Si biocycling, particularly in agricultural systems due to large phytolith deposition within monocots. Applying biochar (Bi) pyrolyzed from phytolith-rich plants on soils may increase the DSi pool in croplands. Here we explore this possibility through a pot experiment during two successive rice growing periods. We compare the impact of Bi on rice above-ground biomass and Si mineralomass that of Wollastonite-Wo- ($CaSiO_3$), a common Si fertilizer.

We produced rice straws through a hydroponic device using Yoshida nutrient solutions, respectively enriched in $H_4SiO_4^0$ (40 ppm Si:Si+) and devoid of $H_4SiO_4^0$ (0 ppm Si: Si-). The straws were pyrolyzed to obtain biochar materials exhibiting identical physico-chemical characteristics except for their Si content (51.3 g Si kg^{-1} in Si+Bi *vs* 0.3 g Si kg^{-1} in Si-Bi). We further applied them at the rate of 8.5 t ha^{-1} Bi once in a Cambisol and compared it to Wo (1.8 t ha^{-1}) during two successive growing periods.

Si+Bi application led to the most positive impact on biomass and Si mineralomass as well as K, Ca, Mg and P mineralomass in both rice growing periods. Si-Bi application did not significantly increase the phytolith content in any of the rice organs during any growing period. As expected, Si+Bi and Wo significantly increased the phytolith content of rice plants in the two growing seasons.

Thus converting phytolith-rich rice straw to biochar and using it as a soil amendment can increase soil BSi content and bioavailable Si, the uptake of which improves plant productivity and Si mineralomass during two successive rice growing periods. Consequently biochar consists of an alternative to Si fertilizer. Its interest is not limited to Si biocycling since biochar application further increases pH, Cation Exchange Capacity, organic matter content as well as the plant Ca, Mg, K and P mineralomass.