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Editorial: Silicon cycling in agricultural soils under current anthropogenic influences

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Editorial on the Research Topic
Silicon cycling in agricultural soils under current anthropogenic influences

Silicon (Si) is a beneficial element for plants that can lower the effects of environmental stress such as metal toxicity, pests and diseases, drought, and saline stress (Cooke and Leishman, 2016; Debona et al., 2017). Several crops are known to accumulate Si in their tissues (Hodson et al., 2005), while environment stress and nutrient-limited situations are becoming more frequent due to climate change, anthropogenic exhaustion of natural resources, land degradation, and loss of soil biodiversity (Orgiazzi and Panagos, 2018; Alewell et al., 2020; Prăvălie et al., 2021). Under these circumstances, Si could become a critical elemental, enabling crops to yield more and with better quality with fewer resources (Barão, 2023). Si fertilization has already been adopted as an amendment in some cases where soil Si depletion is higher, especially in tropical agroecosystems, with benefits for crops (e.g., reduced accumulation of toxic metals which improves food security, or higher resistance to drought stress which limits irrigation needs, to name just a few). Also, understanding soil Si cycling and the processes that this element undergoes in close connection with carbon and nutrients such as nitrogen and phosphorus is crucial to pinpoint the agricultural and soil management practices that better potentiate the accumulation of this element by crops (de Tombeur et al., 2021). Several key points remain crucial in the study of Si cycling in the context of agricultural soils:

- What are the interactions between soil Si dynamics and other elements as affected by soil agricultural management;
- What is the role of macrofauna, mesofauna, and microorganisms on the availability of Si in agricultural soils;
- What is the effect of different agricultural management practices on soil Si cycling, and what new approaches could we adopt to maximize Si uptake by crops and their protection.

Within the broad topic of this issue addressing the Si cycle in agricultural soils, the articles accepted for publication mainly focused on effects that land use change and/or Si supplementation have on the Si cycle and plant performance respectively, while also covering some methodological issues related to the correct identification and quantification of the different Si pools in the context of agricultural soils and crops Si-accumulators. Below, there is a summary of the five articles:

Puppe et al. focused on the capacity for phytoliths (biogenic silica formed in plants) to show auto-fluorescence after heating. The objective of the study was to determine the mechanisms that induce auto-fluorescence in phytoliths from phytoliths extracted from plant samples and intact leaves of winter wheat. Results show that phytoliths treated at temperatures below approx. 400°C show auto-fluorescence if associated with organic compounds. For higher temperatures, auto-fluorescence was mainly due to molecular changes in phytolith silica. Results from SEM-EDX analyses also show that the majority of phytoliths were located in cell lumens compared to cell walls, with implications on their dissolution and potential to contribute to plant-available Si. Overall, this study shows that auto-fluorescence helps identifying the carbon sequestration potential of the soil (while also being a proxy for heat and fire heating. Such knowledge is important if dealing with soils where biochar is applied and/or fire management is a human activity performed.

Bal et al. quantified organic C, total N and biogenic Si stocks and their ratios in the soil of five different land use activities, common in South Africa within the Savannah biome. The hypothesis was that human-altered landscapes would contribute to the homogenization of soil nutrients, without clear concentration gradients along the soil profile. However, the results from field quantification of the different pools at 10 cm, show that some management activities such as fire management and game farming led to more variability in nutrient pools concentration in some locations, creating punctual C-N-Si hotspots

Rijnders et al. studied the effect of olivine application—often found in dunite rocks—for both enchancing weathering as well as improving wheat and barley growth. This innovative application not only contributes to CO_2 sequestration through chemical weathering, but also releases significant amounts of Si into the soil that could contribute to stronger and healthier plants. Contrasting with these benefits, dunite rock can also release toxic elements which may be taken up by the crops as well. The experiment conducted in the study concluded that using dunite as supplementation to barley and wheat contributed to the increase of leaf biomass, but it was strongly dependent on the rainfall regime.

Greenshields et al. addresses the potential effect in the Si cycle when lowland rainforest is transformed into oil-palm plantations. Such effects were detected using sequential extractions to quantify different soil Si pools. When using this technique, authors were able to quantify specific Si pools such as mobile Si, adsorbed Si, Si bound in soil organic matter (SOM), Si included in pedogenic oxides and hydroxides, and Si in amorphous silica of biogenic and pedogenic origin. The refinement in the quantification was useful to pinpoint the land use change effects on the different pools. Authors found that, although Si depletion had not occurred after palm-oil plantation, the depletion of the top rich Si pools (biogenic and OM enriched) are potentially a problem for the future.

Puppe et al. specifically addressed the methodology used to quantify Si concentrations in plants, using husk and winter wheat. This correct quantification is important to understand the Si cycle in agricultural soils, since crops may accumulate Si in different organs, while there is need to understand the relationship between Si content quantified and its availability in soil. The authors found that the extraction with Tiron was more reliable than sodium carbonate (Na_2CO_3) and they recommend it for future studies targeting the quantification of biogenic Si pools in soils and crops from agricultural lands. As seen above in the other articles, such detail quantification is crucial for a correct interpretation of the anthropogenic influence in the Si cycle.

Overall, the articles collected in this Research Topic covered a wide range of Research Topic, highlighting how complex the link is between Si cycle and soil biogeochemistry. Articles also show a complex link between land use change, introduction of farming activities and/or Si supplementation and the effects in crops and crop performance. It was shown that the diversity of Si pools in soil-plant systems, and not only their quantity, should be considered when studying anthropogenic effects on soils and plants. For this, the correct method should be adopted and interpreted accordingly.

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