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Plant-induced weathering of minerals in subsoil – release of ‚non-exchangeable' potassium from illite

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Availability of soil potassium (K) is crucial for plant nutrition in cultivated as well as natural ecosystems. Minerals holding K are feldspars, micas, and clay minerals. The 2:1 phyllosilicates have portion of the K+ ions at interlayer positions, where they cannot be exchanged, thus, hardly contribute to plant nutrition. However, plant roots can aquire non-exchangeable K by several processes. This typically involves exchange of interlayer K for hydrated cations, resulting in expansion of the interlayer space.

Objective of the work was to investigate the potential contribution of 'non-exchangeable' K in interlayer of illite to crop nutrition and to identify the driving factors. Small gauze bags were filled with illitic material and implemented into the top- and subsoil of a Haplic Luvisol for 4 months, in order to investigate in-situ transformation of illite as induced by different crops. Additionally, soil material from the Bt horizon was used in compartment system experiments to enable spatially resolved sampling of soil solution at increasing distance from the root surface over time.

Horizons of the study soil, isolated clay fractions, and material at the illite–root interface of the compartment experiment were analyzed for mineral and chemical properties using XRD, SEM-EDX, XRF and wet chemical methods.

Soil clay fractions comprised quartz, mica/illite, kaolinite, and feldspars. Vermiculite increased with depth, which could be result of the application of K fertilizers or subsoil K uptake by the plants and release in the topsoil upon decomposition of plant residues.

XRD patterns of the clay fraction at the illite–root interface showed small alterations of the 001 basal reflection of illite accompanied by a slight peak shifting after 98 days of contact with the root mat. High initial Ca concentrations in soil solution caused to Ca accumulation close to the root mat, resulting in a general depletion of Ca in the compartment system. No changes in K concentration in soil solution have been detected during the same period. The most likely source is K from interlayers of the illite. The corresponding change in the d spacing of the 001 reflection is in agreement with that assumption.