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# Colocalization Analysis to Understand Yttrium Uptake in Saxifraga paniculata Using Complementary Imaging Technics

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**Abstract :** Over the last decades, yttrium (Y) has gained importance in high-tech applications. It is an essential part of alloys and compounds used for lasers, displays, or cell phones, for example. Due to its chemical similarities with the lanthanides, Y is often considered a rare earth element (REE). Despite their increased usage, the environmental behavior of REEs remains poorly understood. Especially regarding their interactions with plants, many uncertainties exist. On the one hand, Y is known to have a negative effect on root development and germination, but on the other hand, it appears to promote plant growth at low concentrations. In order to understand these phenomena, a precise knowledge is necessary about how Y is absorbed by the plant and how it is handled once inside the organism. Contradictory studies exist, stating that due to a similar ionic radius, Y and the other REEs might be absorbed through $Ca^{2+}$-channels, while others suspect that Y has a shared pathway with $Al^{3+}$. In this study, laser ablation coupled ICP-MS, and synchrotron-based micro-X-ray fluorescence (µXRF, beamline Nanoscopium, SOLEIL, France) have been used in order to localize Y within the plant tissue and identify associated elements. The plant used in this study is Saxifraga paniculata, a rugged alpine plant that has shown an affinity for Y in previous studies (in prep.). Furthermore, Saxifraga paniculata performs guttation, which means that it possesses phloem sap secreting openings on the leaf surface that serve to regulate root pressure. These so-called hydathodes could provide special insights in elemental transport in plants. The plants have been grown on Y doped soil (500mg/kg DW) for four months. The results showed that Y was mainly concentrated in the roots of Saxifraga paniculata (260 ± 85mg/kg), and only a small amount was translocated to the leaves (10 ± 7.8mg/kg). µXRF analysis indicated that within the root transects, the majority of Y remained in the epidermis and hardly penetrated the stele. Laser ablation coupled ICP-MS confirmed this finding and showed a positive correlation in the roots between Y, Fe, Al, and to a lesser extent Ca. In the stem transect, Y was mainly detected in a hotspot of approximately 40µm in diameter situated in the endodermis area. Within the stem and especially in the hotspot, Y was highly colocalized with Al and Fe. Similar-sized Y hotspots have been detected in/on the leaves. All of them were strongly colocalized with Al and Fe, except for those situated within the hydathodes, which showed no colocalization with any of the measured elements. Accordingly, a relation between Y and Ca during root uptake remains possible, whereas a correlation to Fe and Al appears to be dominant in the aerial parts, suggesting common storage compartments, the formation of complexes, or a shared pathway during translocation.

**Keywords :** laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), Phytoaccumulation, Rare earth elements, Saxifraga paniculata, Synchrotron-based micro-X-ray fluorescence, Yttrium
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