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Advancing our understanding of plant adaptation to metal polluted environments – new insights from Biscutella laevigata

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The legacy of industrial pollution alters ecosystems, particularly at post-mining sites where metal trace elements have created toxic conditions that trigger rapid plant adaptation. Apart from the purely scientific merits, in-depth knowledge of the mechanisms underlying plant adaptation to metal contamination is beneficial for the economic and societal sectors because of its application in bioengineering (e.g. phytoremediation or biofortification). An important process is the evolution and/or enhancement of metal tolerance, a trait that has predominantly been studied by applying acute metal stress on species that allocate large quantities of certain metals to their foliage (so-called hyperaccumulators). As the vast majority of vascular plants does not hyperaccumulate metals, more efforts are needed to investigate non-hyperaccumulating species and thereby broaden understanding of biological mechanisms underlying metal tolerance. The pseudometallophyte Biscutella laevigata has shown potential in this respect, but its characteristics are insufficiently understood.

We determined the zinc tolerance level and various plant responses to environmentally relevant zinc concentrations in ten metallicolous and non-metallicolous B. laevigata populations. In a two-phase hydroponic experiment, we scored multiple morphological and physiological traits (e.g. biomass, visible stress symptoms, element content in foliage) and assessed phenotypic variability within plant families. The structure of these quantitative traits was compared to that of neutral molecular markers to test, whether natural selection caused population differentiation in zinc tolerance. While all genotypes were tolerant compared to a zinc sensitive reference species, we found congruent trends toward higher tolerance in metallicolous compared to non-metallicolous plants. We identified the most indicative parameters for these differences and find that enhanced zinc tolerance in metallicolous populations is driven by divergent selection in response to metal contamination.

These findings promote B. laevigata as constitutively zinc tolerant but non-hyperaccumulating organism to study plant adaptation to contaminated environments. Remarkably, tolerance differences between edaphic types emerged already at an environmentally relevant zinc concentration. This opens an unusual perspective on plant adaptation that should be tested in other non-hyperaccumulating species.