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Changes in Physicochemical Characteristics of a Serpentine Soil and in Root Architecture of a Hyperaccumulating Plant Cropped with a Legume

Authors : Ramez F. Saad, Ahmad Kobaissi, Bernard Amiaud, Julien Ruelle, Emile Benizri

Abstract : Agromining is a new technology that establishes agricultural systems on ultramafic soils in order to produce valuable metal compounds such as nickel (Ni), with the final aim of restoring a soil's agricultural functions. But ultramafic soils are characterized by low fertility levels and this can limit yields of hyperaccumulators and metal phytoextraction. The objectives of the present work were to test if the association of a hyperaccumulating plant (Alyssum murale) and a Fabaceae (Vicia sativa var. Prontivesa) could induce changes in physicochemical characteristics of a serpentine soil and in root architecture of a hyperaccumulating plant then lead to efficient agromining practices through soil quality improvement. Based on standard agricultural systems, consisting in the association of legumes and another crop such as wheat or rape, a three-month rhizobox experiment was carried out to study the effect of the co-cropping (Co) or rotation (Ro) of a hyperaccumulating plant (Alyssum murale) with a legume (Vicia sativa) and incorporating legume biomass to soil, in comparison with mineral fertilization (FMo), on the structure and physicochemical properties of an ultramafic soil and on root architecture. All parameters measured (biomass, C and N contents, and taken-up Ni) on Alyssum murale conducted in co-cropping system showed the highest values followed by the mineral fertilization and rotation (Co > FMo > Ro), except for root nickel yield for which rotation was better than the mineral fertilization (Ro > FMo). The rhizosphere soil of Alyssum murale in co-cropping had larger soil particles size and better aggregates stability than other treatments. Using geostatistics, co-cropped Alyssum murale showed a greater root surface area spatial distribution. Moreover, co-cropping and rotation-induced lower soil DTPA-extractable nickel concentrations than other treatments, but higher pH values. Alyssum murale co-cropped with a legume showed a higher biomass production, improved soil physical characteristics and enhanced nickel phytoextraction. This study showed that the introduction of a legume into Ni agromining systems could improve yields of dry biomass of the hyperaccumulating plant used and consequently, the yields of Ni. Our strategy can decrease the need to apply fertilizers and thus minimizes the risk of nitrogen leaching and underground water pollution. Co-cropping of Alyssum murale with the legume showed a clear tendency to increase nickel phytoextraction and plant biomass in comparison to rotation treatment and fertilized mono-culture. In addition, co-cropping improved soil physical characteristics and soil structure through larger and more stabilized aggregates. It is, therefore, reasonable to conclude that the use of legumes in Ni-agromining systems could be a good strategy to reduce chemical inputs and to restore soil agricultural functions. Improving the agromining system by the replacement of inorganic fertilizers could simultaneously be a safe way of rehabilitating degraded soils and a method to restore soil quality and functions leading to the recovery of ecosystem services.

Keywords : plant association, legumes, hyperaccumulating plants, ultramafic soil physicochemical properties
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