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Arbuscular Mycorrhizal Fungi and Glomalin Play an Important Role in Pb-Contaminated Soil Aggregate Stability

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Introduction

Arbuscular mycorrhiza fungi are a diverse collection of soil fungus that play critical ecological roles. They may form mutualistic symbioses with nearly 80% of terrestrial plants and play an important role in nutrient intake, stress tolerance, soil structure modification and the restoration of damaged ecosystems. The extraradical hyphae generated by AMF can extend beyond the nutrient-deficient zone of the rhizosphere and improve phosphorus, nitrogen and water absorption. In response, the host plant provides 4–20 percent of the carbon hydrate created by photosynthesis to AMF in order for it to grow and flourish. Furthermore, AMF can promote plant adaptation to environmental challenges by increasing the expression of antioxidant enzymes, aquaporin, metallothionein and other associated genes [1].

Description

AMF establish a common mycorrhizal network among plant species, controlling critical ecological processes such as nutrient delivery, plant competition and community structure and succession. However, it is unclear what function AMF has in the stability of soil aggregates in degraded ecosystems. Soil is not only a vital component of the terrestrial environment, but it also provides nutrients to our food supply. Soil structure is an essential soil property because it impacts the retention, transformation and transfer efficiency of water, air, heat and nutrients in soil.

The composition and stability of soil aggregates, which are the foundations of soil structure, are critical elements influencing soil fertility and ecosystem processes. Furthermore, AMF hyphae and the generated glycoprotein can bind soil particles together via the "bonding–joining–packing" mechanism, acting as a bio-glue to stimulate the production of large aggregates and boost the structural stability of the soil. Glomalin is a form of glycoprotein generated especially by AMF hyphae and spores and released into the soil following decomposition; it is broadly dispersed, hydrophobic, insoluble and stubborn in nature. Previous research found that AMF inoculation enhanced the GRSP content, mean weight diameter (MWD) and geometric mean diameter (GMD) of soil aggregates [2].

The poisoning of soil by HMs is a severe environmental issue. Pb is one of the most prevalent and most toxic HMs in soil. China is the world's greatest mineral Pb producer, accounting for 63.9 percent of global mineral Pb output in 2020. (China Lead Industry Development Report 2020). Pb contamination from mine, smelting, processing and other operations has been growing in recent years and HM pollution situations, such as blood Pb overload, have occurred on occasion. China has conducted extensive research and practise to effectively address soil Pb contamination and restore degraded ecosystems. Most earlier research concentrated on Pb-contaminated soil distribution patterns, health risk evaluations and remediation techniques.

Lead is an exceedingly harmful and poisonous contaminant for organism growth and development and it is abundantly dispersed in nature. Pb stress causes a considerable number of reactive oxygen species (ROS) to be produced in biological cells, primarily superoxide anion (O_2), hydrogen peroxide (H_2O_2) and hydroxyl radical (OH^-). Small levels of ROS produced by external stimulation during signal transmission can stimulate signalling pathways, engage in cellular signal transduction processes and activate antioxidant signalling pathways in the body. Furthermore, Pb^{2+} can cause decreased enzyme activity or even inactivation by competing for the enzyme's ion-binding site and inhibiting the active core of the enzyme, exacerbating the buildup and toxicity of ROS in the cells [3].

At the moment, most aggregate research focus on particle size, composition and stability, nutrient content features and organic carbon content, but the content and enrichment properties of heavy metals in aggregates, as well as their influence on aggregate stability, are seldom documented. Pb treatment substantially raised the fraction of soil grains 0.053 mm while decreasing the proportion of soil grains >2 mm and 2-1 mm, preventing the development of soil macroaggregates and resulting in a strong negative connection between Pb concentration and soil-aggregate stability. This was mostly owing to the Pb stress's inhibitory effect on AMF growth and development, which drastically decreased the glomalin-related soil protein content released into the soil [4,5].

Conclusion

Pb stress at medium and high doses (>1000 mg kg^{-1}) strongly hindered AMF growth and development, with a significant decrease in MC, HLD, SPD and AMF-secreted glomalin. Meanwhile, the AMF shown some resistance to Pb stress, with no significant variations in MC, HLD, SPD and glomalin levels under low Pb stress concentrations compared to the control. This was also probably related to the reduced availability of Pb under slightly alkaline circumstances. The Pb stress raised the mass percentages of fine sand, silt and clay particles (0.25 mm), while decreasing the mass percentages of gravel (>1 mm), resulting in a strong negative connection between soil-aggregate stability and Pb concentration.

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Conflict of Interest

No potential conflict of interest was reported by the authors.

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