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Can ectomycorrhizal symbiosis and belowground plant traits be used as ecological tools to mitigate erosion on degraded slopes in the ultramafic soils of New Caledonia?

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New Caledonia is an archipelago in the South West Pacific located just above the Tropic of Capricorn. The main island is bisected by a continuous mountain chain whose highest peaks reach more than 1 600 m. With mean annual rainfall above 2 000 mm in the South of the main island, frequent downpours and steep slopes, its soils are prone to water erosion. Deforestation, fires and mining activity are the main drivers of water erosion. Stakes are high to mitigate the phenomenon: extraction of nickel from ultramafic substrates (one third of the whole territory) is the main economic activity; New Caledonia is considered as a biodiversity hotspot. Restoration ecology is seen as a key approach for tackling such environmental challenges. Soil microorganisms could play significant roles in biological processes such as plant nutrition and plant resistance to abiotic and biotic stresses. Microorganisms could increase soil aggregate stability and thus mitigate soil erodibility. Plant roots increase soil cohesion through exudation and decomposition processes. To date, few studies have collected data on the soil aggregate stability of steep slopes affected by erosion and, to our knowledge, interactions between ectomycorrhizas (ECM), roots and erodibility of ultramafic soils have never been considered.

The objective of our study is to assess the influence of ECM symbiosis and plant root traits on the erodibility of ultramafic soils of New Caledonia and answer the following questions: 1/ What is the influence of plant root traits of vegetal communities and ECM fungal diversity on soil erodibility? 2/ What are the belowground plant traits of some mycorrhized endemic species used in ecological restoration? 3/ What is the influence of plant root traits and ECM fungal inoculation on soil erodibility?

At the scale of plant communities, five types of vegetation have been chosen in the South of the main island: degraded ligno-herbaceous shrubland, ligno-herbaceous shrubland, degraded humid forest with dominance of Arillastrum gummiferum, dense humid forest with dominance of Nothofagus aequilateralis, and finally mixed dense humid forest. These types of vegetation are widely represented on ultramafic soils of New Caledonia and are likely to correspond to different successional phases.

At the scale of species, dominant species in the above-mentioned types of vegetation are considered for herbaceous, shrubs and trees strata. Root traits of Costularia nervosa, Tristaniopsis glauca, Nothofagus aequilateralis and Arillastrum gummiferum are then characterized in situ. These species are of particular interest for post-mining ecological restoration in New Caledonia as they are light-tolerant, endemic, associated with ECM (except for Costularia nervosa) and of particular interest or already used by mining operators for post-mining ecological restoration.

For both scales (community and species), soil characteristics will be collected. Very fine and fine roots, mean root diameter, root diameter diversity, root mass density, root length density, and specific root length will be considered. Degree of ectomycorrhization and fungal biomass through qPCR will be determined. Soil aggregate stability will be measured according to the standardized method NF X 31-515. Besides, greenhouse trials with Costularia nervosa, Tristaniopsis glauca and Arillastrum gummiferum are carried out to assess the influence of plant root traits, fungal inoculation and soil aggregate stability. Controlled plant inoculations are performed using available pure fungal strains isolated from New Caledonian ultramafic soils. Plants have been bred on sterilized soil samples from the field sites.

Through this study, we target to identify associations between ECM fungi and plant species that could mitigate the erodibility of degraded ultramafic soils and then water erosion. A better knowledge of interactions between soil aggregate stability, ECM fungi and plant root traits is then expected to answer the following question: can soil aggregate stability be used as a bio-indicator of ecosystem functioning and services?