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Linkage of root physiology and morphology as an adaptation to soil phosphorus impoverishment in tropical montane forests

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Tropical forests in Borneo maintain a high level of productivity/biomass even under phosphorus (P)-limited conditions. The P-acquisition properties of roots may be an important factor that contributes to forest productivity, but they have not been well evaluated compared with aboveground properties of plants. In the present study, we analyzed root acid phosphatase activity and morphological properties (surface area, diameter and tissue density of roots) of dominant tree species in three tropical montane forests on Mt. Kinabalu, Borneo, to investigate changes in root properties along a soil P availability gradient.

We found at the community level that root phosphatase activity and specific root surface area (root surface area per gram root biomass) increased, and root diameter decreased, with decreasing soil P availability at the community level, and the relationship was not changed in general even if we focused on a single tree species distributed across multiple study sites that differ in soil P availability. Root acid phosphatase was significantly positively correlated with specific root surface area, and negatively correlated with root diameter, suggesting that finer roots have higher phosphatase activities. Furthermore, we compared root acid phosphatase activity with leaf P concentration of a given tree species, and found a significant negative correlation between them. The significant correlation suggested that root P-acquisition properties could influence leaf P concentration, and/or vice versa. Belowground properties (i.e., root P-acquisition properties) might be directly/indirectly linked to aboveground properties (i.e., leaf P concentration) of a tree individual.

In conclusion, the root physiological and morphological properties change along a gradient of soil P availability in the tropical montane forests. In addition, the changes in the root properties are coordinated with the changes in leaf P concentrations. The adaptive changes in the aboveground and belowground properties along the soil P gradient could contribute to the maintenance of forest productivity in the tropical montane forest in Borneo.

Keywords: Phosphatase activity, Plant-soil interactions, Tree roots, Root surface area, Soil phosphorus availability, Tropical montane forests