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Changes in Arbuscular Mycorrhizal Fungal Abundance and Community Structure in Response to the Long-Term Manipulation of Inorganic Nutrients in a Lowland Tropical Forest

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The arbuscular mycorrhizal (AM) symbiosis is considered primarily mutualistic. In exchange for up to 30% of plants' total photosynthate, AM provide improved access to mineral nutrients. While there is evidence that AM fungi provide nitrogen, potassium and other nutrients to their host plants, most research has focused on their effect on plant phosphorus uptake. Pot experiments have shown, and field experiments have provided further support, that nutrient availability (primarily P, but also N) is inversely correlated with mycorrhizal colonization, indicating plant control over carbon losses to AM fungi. Yet pot experiments have also shown that some fungal species are more mutualistic than others and that AM colonization may cause decreased plant growth, suggesting that plant control is not absolute. AMF communities are diverse, and it is poorly understood how factors such as adaptation to local soil environment, fungal-plant compatibility, and plant nutrient status combine to shape AMF community structure. We conducted a study to examine the relative effects of N, P, and K addition on the AMF community in a plant species rich tropical forest, given the long-held belief that AMF are primarily involved in plant P uptake, particularly on weathered tropical soils. Our study site is the Barro Colorado Nature Monument in Panama. It is a 13 year-old factorial N, P, and K addition experiment (40 m x 40m plots; n=4) in an AMF dominated, old (>200 yr), secondary, tropical forest. Previous research has shown co-limitation by N, P, and K, but the strongest plant growth responses were obtained with K additions. We analyzed the AMF community using 454 pyrosequencing of the ribosomal small subunit (SSU) on both soils and the roots of the 6 dominant AMF tree species. Additionally, we used the AMF-specific neutral lipid fatty acid (NLFA) biomarker as a measure of AMF biomass.

Both AMF biomass and community structure were altered by nutrient additions. AMF biomass in soil was reduced by N or P additions (∼30% reduction) and heavily reduced by combined N and P addition (∼50%), but not affected by K addition, despite K addition bringing about a strong reduction (∼ 30%) in plant root biomass at this site. AMF biomass in roots was similarly affected, though the plant roots generally did not have a greater reduction in the +N,+P treatments than in either the +N or +P treatments. Phosphorus had the strongest effect on AMF community composition, although nitrogen also had a strong effect in roots; N and P interacted in their effect on both soil and root AMF communities. K addition did not have an effect on the AMF communities in soil or roots. These finding implicates AMF in plant acquisition of both N and P, particularly given that K addition had a marked effect on root growth but not on AMF community composition or biomass. Responses of AMF to fertilization differed between root and soil communities with some treatments; the reasons for these asymmetric changes in soil versus root AMF communities are discussed as are fungal and plant species-specific responses to fertilization.