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Do Mycorrhizal Fungi Help Grapevines Acquire Nitrogen?

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Arbuscular mycorrhizal fungi (AMF) have traditionally been known to help plants obtain phosphorus (P) from soil and other nutrients with limited mobility in soil, such as copper and zinc. Recent reports of plant nitrogen (N) acquisition through AMF has led to the current belief that they help plants acquire N perhaps just as importantly as they do for P. However, studies showing significant N transfer from AMF to plants have used experimental systems where only the fungal hyphae, but not roots have access to labeled N by using fine mesh screens. These experiments separate roots and hyphae into different soil compartments, and N is only provided to the fungal compartment. In the real world, mycorrhizal hyphae do not grow in a separate compartment from roots.

Over the past 20 years, the Schreiner Lab has shown that AMF help grapevines acquire P, first and foremost. The uptake of other nutrients can then increase because P deficiency is overcome, and plants grow larger. In order to prove that uptake of another nutrient is enhanced by AMF, the relative increase of that nutrient in the plant needs to be greater than the relative increase in biomass due to AMF symbiosis. This was shown for potassium, zinc, and copper, but not for N. However, we recently found that root colonization by AMF in both Chardonnay and Pinot noir was reduced after applying N in the vineyard. This, in turn, reduced vine P status. How plants regulate their internal N and P status share some common elements (crosstalk), and plants respond in a similar way when either N or P is deficient. For example, N or P limitation both cause plants to shift more sugar to roots in an effort to increase root growth, causing the well-known increase in root-shoot ratio. Therefore, we wondered if AMF play a significant role in helping vines obtain N? Or, does crosstalk between the N and P regulatory pathways sometimes result in a N-induced rejection of AMF to the detriment of the plant?

This question became a central part of Tian's PhD research while working in my lab. Tian conducted several controlled greenhouse studies to understand how N influences AMF and if the fungi help grapevines obtain N from the soil. The first study examined how AMF and vines responded to varying N (supplied at four different rates) and P (supplied at three rates) in a factorial experiment. Nitrogen was supplied as ammonium nitrate (inorganic), and root colonization by AMF was reduced at both the lowest and highest levels of N supply. These findings suggest that AMF were themselves N-limited at the lowest N rate and competing with the vine for N, while AMF were down-regulated due to higher vine N status at the highest N supply. Importantly, AMF did not increase vine N uptake at any level of N in this experiment. A follow-up study focused on whether AMF might help vines acquire organic forms of N. Vines in this study were given two levels of N from ammonium nitrate (as a control), the amino acid glycine, or N-rich grass-clippings in another factorial experiment. Even here, AMF did not improve N uptake as compared to the non-colonized vines for any N source provided.

Thus far, the evidence obtained from all of the work in my lab, where AMF and roots have co-existed in the same soil compartment, indicates that AMF do not help grapevines obtain significant N from the soil. Nevertheless, N applications to soil can depress AMF colonization in grapevines and potentially reduce other benefits that these symbionts provide in vineyards. For viticulturists, the evidence thus far shows that AMF should not be considered a tool to improve N uptake, but rather that application of N to vineyard soils can negatively impact your 'friends in low places'. This is another argument why we should be judicious with N applications in vineyards.

Figure 1. *Pinot noir grapevines transplanted into pasteurized soil prior to applying nutrient treatments in the greenhouse at HCRU. (Photo by R. Paul Schreiner, USDA)*

Figure 2. *Pinot noir grapevines grown with different nutrient and mycorrhizal treatments for 14 weeks in the greenhouse at HCRU. (Photo by R. Paul Schreiner, USDA)*