The Influence of ectomycorrhizal colonization on American chestnut trees (Castanea dentata) with regard to growth, fecundity, and susceptibility to chestnut blight (Cryphonectria parasitica).

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Introduction

Ectomycorrhizal fungi (ECM) contribute to the primary productivity and biogeochemical cycling of forest ecosystems. These fungi create symbiotic relationships with plants roots, which allow for the transfer of water and nutrients to the plant and photosynthates to the fungal symbiont. The provision of water and soil nutrients are important for the establishment of seedlings in forest restoration projects (Bauman et al. 2013). Surface mining reclamation introduces non-native herbaceous species in compacted soil conditions. Where soil is unsuitable for tree establishment, opportunistic invasive species take root and alter native vegetative plant community succession models. Deep-soil ripping aids in alleviating compaction, which aids in establishment and interactions with soil fungi. This study focused on the influence of ECM colonization on American Chestnut (C. dentata) planted on a reclaimed surface mine site in Ohio. These trees were once a major part of the ecosystem in the Eastern United States, but their vulnerability and mortality from chestnut blight (Cryphonectria parasitica) contributed to a widespread die-off. Breeding strategies initiated by the U.S. Forest Service produced blight-resistant hybrids and have incorporated them into Appalachian restoration projects (Jacobs et al. 2013). The objective of this study was to understand the relationship between ECM root colonization and tree health in disturbed soils on a reclaimed strip mine. Data were collected from 117, six-year-old trees to assess tree growth, fecundity and the tree's susceptibility to C. parasitica regressed by ECM root colonization.

Figure 1. Panel A) Pure American chestnut and blight-resistant chestnut hybrids were planted on a reclaimed coal mine site in Muskingum County, Ohio. One-year-old saplings were planted in soil that was prepared by deep-soil ripping. Panel B) Five years following planting, tree height and basal diameter were measured along with the presence of flowers and cankers. Root samples were also collected to measure percent ECM colonization on chestnut root tips. ECM species were morphotyped and identified by DNA sequencing.

Methods

American chestnuts were planted as one-year-old bare root seedlings on a Ohio reclaimed coal mine site in 2007 in Tri-Valley Wildlife Management Area, Muskingum County, Ohio. Plots were cross-rapped at a depth of 1.5 meters by a D-6 dozer with a 10 m ripper bar attachment. In April of 2012, data were collected from 117 six-year-old trees (Figure 1B). Growth was measured by tree height (cm) and basal diameter (cm). The fecundity was measured by presence or absence of flowers and burs (Figure 2B), and disease tolerance assessed by surveying chestnut blight (C. parasitica) cankers (Figure 2A).

ECM root colonization was measured by randomly selecting 100 root tips and quantifying percent colonization. ECM root tips were verified using a dissecting microscope for the presence of a fungal sheath (Figure 2C). All representative morphotypes were sampled for DNA extraction and sequencing of the internal spacer region.

Tree growth was calculated by taking the volume of the tree measurement data (V= πr²h). A simple regression was used to describe the relationship between ECM colonization and tree growth. Logistic regressions were utilized to see if ECM colonization is a predictor for presence of flowers and disease tolerance. In addition, an analysis of variance (ANOVA) was used to detect differences in ECM root colonization between trees that had flowers or cankers present.

Results

Figure 3. Panel A) A logistic regression and logistic regression curve was used to find the predictive value of percent ECM and the presence of flowers. Percent ECM was found to be a predictor of flowers (P = 0.04). Panel B) A simple linear regression was calculated to predict tree growth based on percent ECM. Chestnut volume can be predicted by percent ECM on chestnut root tips (R² = 0.18, P = 0.007).

Figure 4. Panel A) Mean percent ECM was higher in trees that were flowering when compared to those that did not produce flowers that season (P = 0.04). Panel B) However, no difference was in mean percent ECM on trees that had a C. parasitica canker when compared to those without canker infection (P=0.55).

Conclusion

- The results from the ECM morphotyping and DNA sequencing found that the most abundant fungal species was Cortinarius (Figure 2C).
- The ECM and tree growth data indicates the percentage of ECM colonization is a significant factor in chestnut growth and was found to be a predictor. The same predictive relationship was also found between percent ECM and the presence of flowers.
- This predictive value was not found between the percentage of ECM and the presence of cankers. This means that the percentage of ECM colonization stimulates greater growth and fecundity of the host plant however, did not effect the host plants tolerance or susceptibility to chestnut blight.
- ECM symbiotic relationships with host plants is required for forest reclamation in soils that are heavily disturbed, such as mine sites. The relationship that ECM have with the host plant provides a greater advantage and contributes to population sustainability due to potential increases in growth and reproduction.

Literature Cited