Variation in Mycorrhizal Fungi Abundance Within Suburban Forests: Consequences for Fibrous and Taproot Plants

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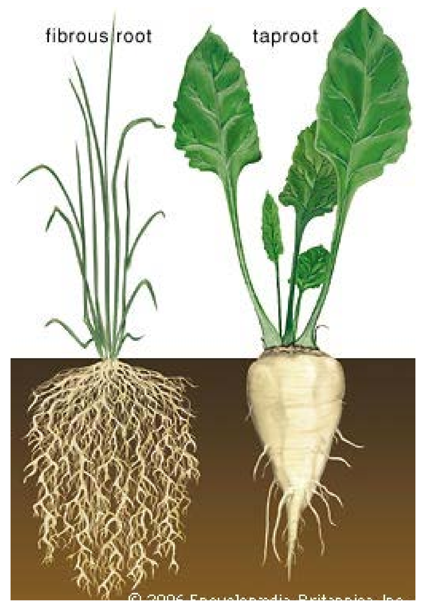
Abstract

One of the most important symbioses in nature is the fungal association in plant roots. Arbuscular mycorrhizal fungi (AMF) facilitate nutrient acquisition in root networks, and their degree of association varies by root types, with taproots benefitting more. AMF could thus be an important driver of plant community structure, specifically for taproot vs. fibrous - rooted plants. We investigated how AMF levels vary among and within suburban forests, which are reservoirs of biodiversity in the urbanizing mid - Atlantic region. We hypothesized that greater AMF biomass would predict greater taproot plant cover, but be less related to fibrous rooted plant cover. We collected five soil cores per plot in 16 16 m^2 plots in each of six forests, and pooled the five samples for professional microbial PLFA analysis. In order to document that the level of AMF biomass in forest soils translates into root colonization, we stained roots of one common species from the forests, *Lonicera japonica,* and quantified its AMF load (n=60), which indeed was greater in forests with higher AMF biomass. We estimated percent cover of all species in all 32 - 40 16 m^2 plots per forest, and categorized most as having taproots or fibrous roots. AMF biomass varied among forests (F=16.25, p<0.0001) and between plots (range: 348.15 - 76.28 ng/g soil). The six forests were categorized by three with greater and three with lesser vegetation density. There was a significant two - way interaction between forest and root type (F=31.89, p<0.0001), but its pattern did not mirror that of AMF biomass among forests, nor did regressions of plant cover on AMF biomass in the 60 measured plots indicate support for our hypothesis. Although AMF varies among plots and forests, it did not appear to be an important driver of taproot vs. fibrous rooted plant community structure in these suburban forests.

Introduction

Mycorrhizal fungi are an important group of soil microbes that contributes to cycling nutrients and maintaining soil quality. They colonize in and on roots of plants and enhance absorption (up to 700 times) and transportation of poorly mobile nutrients in the soil. Plant - mycorrhizal interactions are mutualistic; this mutualism is most optimal when plants have difficulty absorbing phosphorus and organic or insoluble nutrients that are typically unavailable to plants. The two different root structures that are the main focus of this study are taproots and fibrous roots. Taproot plants have thick roots, short root hairs and low root hair density. Fibrous root plants have thin roots, long root hairs, and high root hair density. Different root structures influence mycorrhizal colonization in plants. Taproot plants are more dependent on mycorrhizal fungi than fibrous plants because their low root surface area hinders their ability to absorb nutrients. Fibrous roots have longer and higher surface area that enables better acquisition of nutrients from the soil.



The difference between two root structures.

Is there a correlation between the abundance of mycorrhizae and the abundance of taproot and fibrous species in the community structure of six forests?

About 80% of angiosperms are mycorrhizal and depend on this plant - fungi symbiosis for growth. Of these angiosperms, taproot and fibrous root systems acquire nutrients differently, and these functions may affect the abundance of mycorrhizal fungi in the soil community and vice versa. As a result, it is important to acknowledge the variables that influence community structure. It is possible that a forest community has more taproot plants than fibrous plants because there is a high abundance of mycorrhizae in the soil. Analyzing this relationship may help us understand the distribution of taproot and fibrous species in the six study forests.

Methods

Herb Layer Census Data:

- Fall and Spring 2015
- 16 subplots were sampled within each plot (32 - 40 plots per forest) and percent cover was calculated for each species observed
- Percent cover was estimated at 10% intervals
- Used midpoints and average across all 16 0.25m² subplots
- Collected from 6 suburban forests

Soil Microbial Data:

- August 2015
- 5 soil cores were collected in each 16 plots per forest
- Sent to Ward's Soil Testing Laboratory, using a phospholipid fatty acid analysis (PFLA) technique to measure the abundance and diversity of the soil microbial community

Detection of in situ Mycorrhizal Colonization:

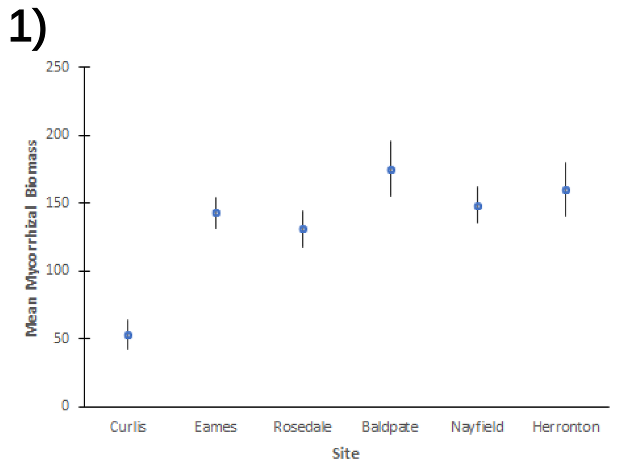
- Fall and Spring 2018
- Collected 30 samples of *Lonicera japonica* in both Curlis and Baldpate
- Each sample was cut into 10 root tips → each root tip cut into 10 sections → total of 100 root sections per sample vial
- Cleared roots: 5ml of KOH was added to the vial→Autoclave liquid cycle @ 121°C for 15 min →KOH dispensed →wash root sections with D.I. water 5 times →washed root sections in respective vial
- Stained roots: 5ml of Trypan blue dye was added to the vial→Autoclave liquid cycle @ 121°C for 15 min
- Quantified roots: vial sample poured in petri dish→sample looked under dissecting microscope with forceps→quantified whether each root section was "infected" by the presence of mycorrhizal fungi→proportion of infected out of 100 root sections (% infected)

Discussion

All of the forests chosen for this study expressed varying amounts of arbuscular mycorrhizal biomass. Due to varying levels across and among the forests, we were able to evaluate how plant communities varied along this variable. To illustrate how arbuscular mycorrhizal variation affected mycorrhizal colonization, we focused on one species (*Lonicera japonica)* that was abundant across all forests. We looked at their root colonizations in one forest with the lowest arbuscular mycorrhizal biomass (Curlis) and one forest with the highest (Baldpate). This analysis emphasized the biologically meaningful relationship between mycorrhizal biomass and mycorrhizal colonization. In addition, we hypothesized that greater arbuscular mycorrhizal biomass would predict great taproot plant cover, while there is less relation to fibrous root plant cover. Although there was a significant two- way interaction between forest and root type, their patterns among the forests did not mirror this hypothesis. There are many factors that influence plant communities and mycorrhizal fungi is only one facet in this network of interactions. This study confirmed that we cannot look at arbuscular mycorrhizal interactions independently. Instead, we must consider this relationship a small part of the network of interactions within ecosystem dynamics. To further this study, we can collect and look at the differences in mycorrhizal colonization between fibrous and taproot plants in these six suburban forests. This analysis will further illustrate direct mycorrhizal variation as a function of root type. In addition, we can expand this study to multiple years instead of 2015. Extending the study will allow us to see how mycorrhizal biomass varies along with taproot and fibrous root cover. Furthermore, we can study mycorrhizal colonizations between native and invasive species. This type of study may provide additional information on native or nonnative invasions. In conclusion, studying these relationships in depth will provide a better understanding of the role of arbuscular mycorrhizal fungi in plant communities.

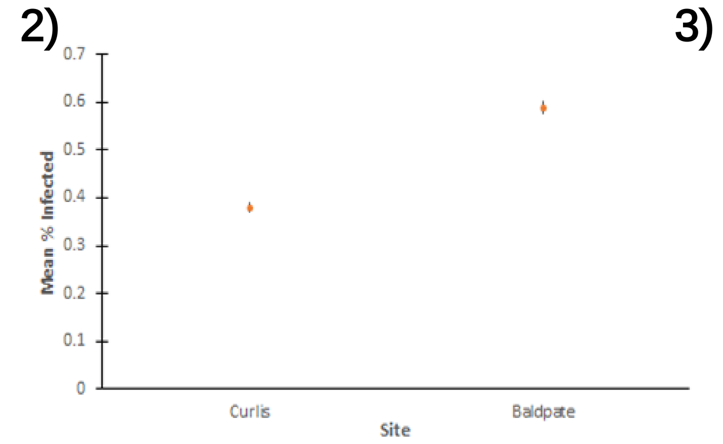
Results

1)



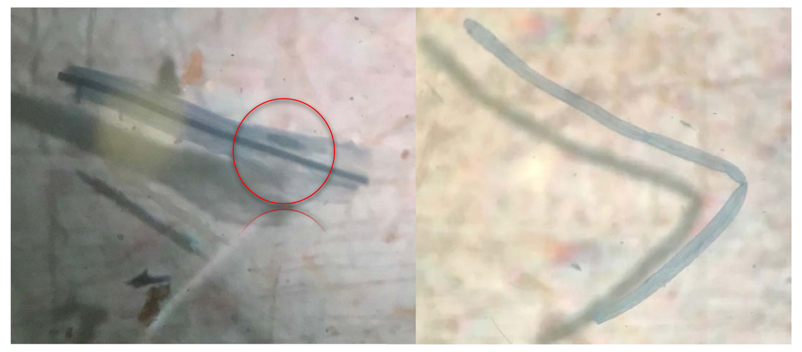
Mean mycorrhizal biomass (±SE) in six suburban forests. Forest, $F_{5,90}$ = 7.83, P<0.0001.

2)

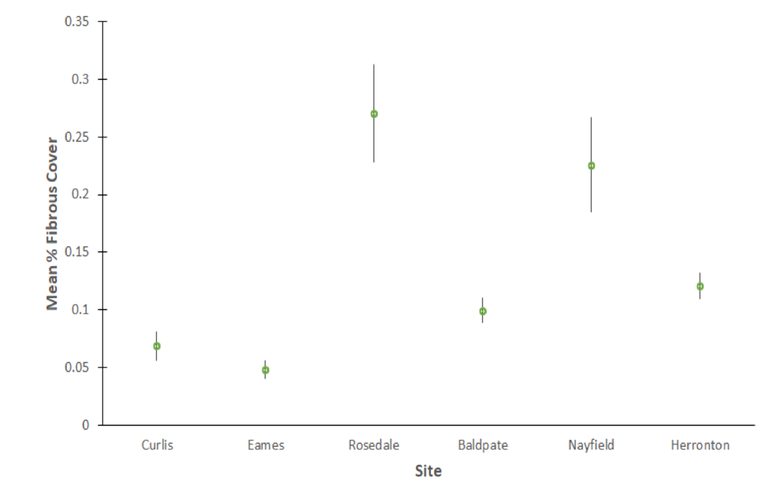


Mean % infected roots (±SE) in *Lonciera japonica.* t=-13.57, df=56, P<0.0001.

3)

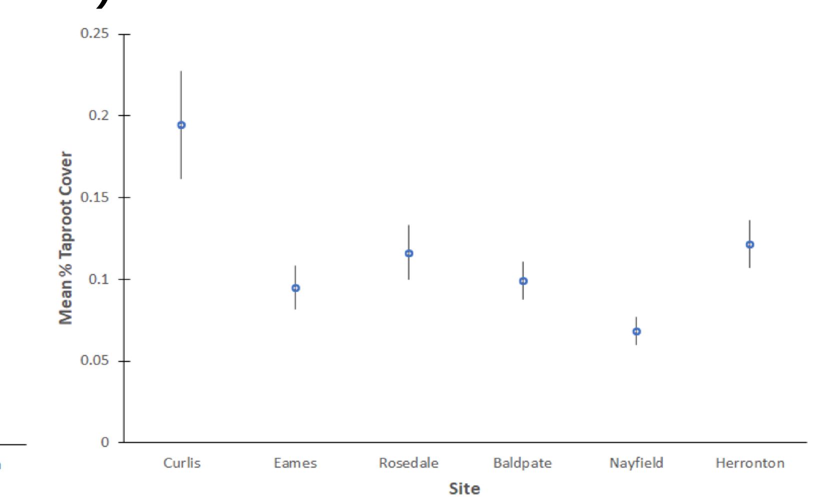

Illustrations of what an arbuscular mycorrhizal fungi infection (left) and uninfected (right) root looks like. The difference is in the small tubular structures that represent fungi (circled).

4a)



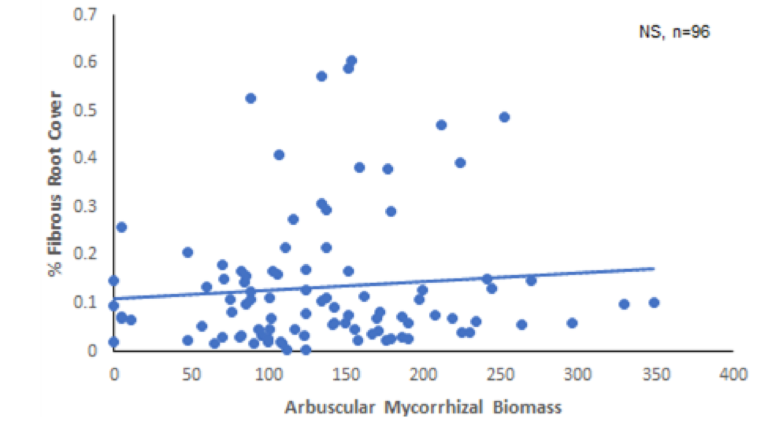
Mean % fibrous root cover (±SE) in six suburban forests. Forest x Root type, $F_{2,90}$ = 31.88, P<0.0001.

4b)



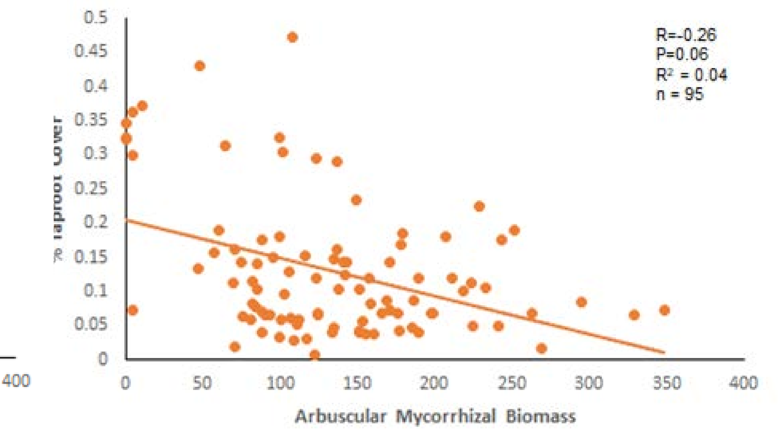
Mean % taproot herbaceous cover (±SE) in six suburban forests. Forest x Root type, $F_{2,90}$ = 31.88, P<0.0001.

5a)



Percent fibrous root cover as a function of arbuscular mycorrhizal biomass in six suburban forests.

5b)



Percent taproot cover as a function of arbuscular mycorrhizal biomass in six suburban forests.

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