A Comparison of Invasive and Non-Invasive Soil Communities on Native Seedling Growth

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Abstract

It is well known that invasive plant species can alter abiotic conditions such as light and nutrient availability and effect the growth of native species. It is lesser known as to whether invasive species can alter biotic conditions, such as the soil microbial community. *Hedera helix* is an invasive yard plant that has rapidly spread to forested areas and is known for containing antifungal properties. These properties may give *H. helix* the ability to change the fungal soil community potentially suppressing the growth of native seedlings. *Liriodendron tulipifera* is a native tree that has symbiotic relationships with a specific type of root colonizing fungi, arbuscular mycorrhizae. If this relationship is altered, the growth of the seedling may be suppressed. We tested the growth of native seedlings in soil that previously contained *H. helix* against soil that was absent of *H. helix*. Our findings show seedlings that were grown in *H. helix* absent soils had significantly higher growth than the ones planted in soil grown with *H. helix* present. These results suggest that invasive plant species may alter the biotic conditions potentially suppressing the growth of native seedlings.

Introduction

Widespread dispersal of exotic organisms has caused growing concerns amongst ecologists. Non-native species can affect the growth of native species by altering the light and nutrient abiotic conditions and biotic conditions of soil. As exotic plants invade new areas they alter the components and functions of the host soil community (Wolfe and Klironomos, 2005). This change of microbial community could have detrimental effects on the native plant species' growth. This study aims to test the effects of the invasive English Ivy (*Hedera helix*) on the New Jersey native Tulip Poplar (*Liriodendron tulipifera)* tree.

The invasive species English Ivy, *H. helix*, which originated from Europe, Western Asia, and Northern Africa, has made its way to Eastern United States and some areas of the West. The English Ivy grows in shaded to extremely bright conditions in moderately fertile and moist soil. Forests openings, edges, cliffs, steep slopes, and fields are a few examples of the habitats it can invade. Each year, massive amounts of time, labor and resources are spent trying to remove infestations of English Ivy off of private and public properties. The invasion of *H. helix* threatens the growth of native vegetation by resource competition. Additionally, their vines bound around tree trunks and block sunlight from leaves, in turn prohibiting photosynthesis. *H. Helix* is known to have the ability to alter the biotic environment by harboring the bacterial plant pathogen *Xylella fastidious*, however, they may be able to alter the soil community in other ways as well. *H. helix* is known to contain antifungal compounds called saponins. These properties could affect the growth of common symbiotic relationships between the native plants and fungal mycorrhizae.

Mycorrhizae are root associations that aid plants in water and nutrient uptake, as well as protect the host plant from pathogens and heavy metals (Lux and Cumming, 2001). *L. tulipifera,* along with a majority of other plant species, depend on symbiotic relationships with mycorrhizae. Additionally, *L. tulipifera* is commonly associated with arbuscular and ectomycorrhizal fungi. This association is beneficial to the growth and survival of its seedlings. A study conducted in 2006 showed that soil from the invasive mustard seed, which also exhibits antifungal properties, suppressed the growth of native seedlings by altering the microbial community (Stinson et al., 2006). We propose that the invasive *H. helix*, which contains antifungal chemical compounds, can alter the relationship between *L. tulipifera* and its mycorrhizae growth, resulting in the suppression of *L. tulipifera* seedling growth.

In this study, twenty eight New Jersey native *L. tulipifera* seedlings were obtained from the New Jersey Pinelands and were planted in *H. helix* present and *H. helix* absent soil conditions. The plants were grown over the course of one month to observe whether the invasive species *H. helix* alters the biotic community in soil and hinders the growth of the native species *L. tulipifera.*

Materials & Methods

Twenty-eight (28) seedlings of *L. tulipifera* were obtained from the New Jersey pinelands' nursery. Seedlings were planted individually in 4" ceramic pots each containing varying soil condition. Four (4) pots/seedlings were dedicated to each of seven (7) soil conditions. Soil was sampled from two areas; one containing the invasive species, *H. helix*, (Native Regular) soil and one not containing *H. helix* (Invasive Regular) from a local New Jersey forest. To test the effect the biotic conditions of the soil have on *L. tulipifera* growth soil from each sample site was autoclaved (Native Autoclaved and Invasive Autoclaved). Three (3) positive controls were also set up to see if microbial communities were truly being altered by *H. helix* saponins. To see if microbial communities could be restored, autoclaved soil from each sample site was inoculated with un-autoclaved soil from the same site (Native Recovery and Invasive Recovery). To observe if the anti-fungal saponins could be manually released from *H. helix,* a third positive control consisted of *H. helix* absent soil treated with *H. helix* extract (Native Extract, extraction method described below).

Treatment and collection methods

The data collected before and after planting were measurements of plant mass. In addition, the root length (taken from the bottom of the shoot to the longest part of the root), and the root width, along with the shoot length and width were measured.

Before Planting

Before the seedlings were planted, all plants were removed from their soil, rinsed off with cool water, patted dry and measured. Likewise, photos of each plant were taken for documentation (data not shown). Soil was autoclaved for 1 hour and 45 minutes inside of labeled clay pots and allowed to cool to room temperature.

Extraction

Roots, leaves, and stems from *H. helix* were ground with a mortar and pestle with a few drops of water until a thin paste was formed. The paste was added to 400 ml of water and mixed thoroughly. A one-time addition of 100 ml of the extract solution was added to 4 pots.

Planting Methods

Pots were filled ¾ of the way full of soil. Recovery pots were filled to the ½ way mark with autoclaved soil and the then filled with un-autoclaved soil until the ¾ mark and mixed. The seedlings were then planted in the soil. Each pot was then given 100 ml of water, except for the pots that received the extract solution. Once planted, the seedlings were moved into the greenhouse and allowed to grow.

Results

The results of the difference in shoot length over the one month growth period are shown in Figure 1. Seedlings grown in the native, *H. helix* absent soils, had overall greater average shoot growth. Unfortunately, many of the positive controls did not have the reduction in growth that would be expected at the loss of the microbial communities. All groups that received an autoclave treatment (Native Autoclaved, Native Recovery, Invasive Autoclaved, Invasive Recovery) had comparable or higher growth than their un-autoclaved counterparts (Native Regular and Invasive Regular). The most likely cause of this is due to an improper autoclave time exposure period. Additionally, the Native Extract group saw no obvious different in growth when compared to the untreated soil. Interestingly, the seedlings grown in the Invasive Regular soil saw a statistically significant decrease in overall shoot length growth compared to the seedlings grown in Native Regular ($p < 0.05$).

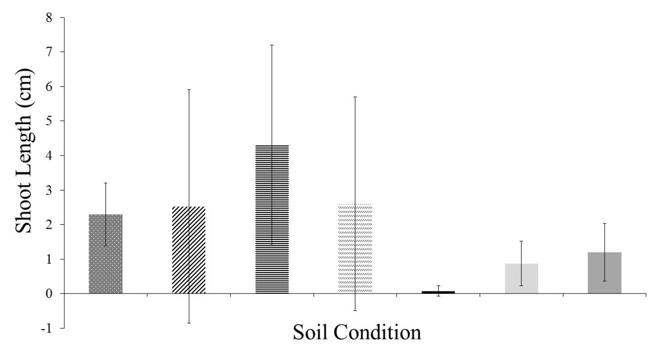

Figure 1. Average shoot growth for each soil condition. Native Regular – grey with crosses; Native Autoclaved – upward diagonal bars; Native Recovery – dark, horizontal bars; Native Extract – dashed, upward diagonal; Invasive Regular – solid black; Invasive Autoclaved – solid light grey; Invasive Recovery – solid dark grey.

Discussion

Previous studies have demonstrated that certain plant species have the ability to alter soil conditions and suppress the growth of native seedlings; however the effects of the invasive species *H. helix* are not yet known. In an effort to study the soil altering effects of *H. helix* and effect on the growth of the native tree *L. tulipifera*, we experimentally grew native seedlings in seven different soil treatments and compared growth rates between conditions. Most interestingly, the seedlings that were grown in the native regular soil had significantly higher shoot growth compared to the seedlings that were planted in the invasive regular soil. This indicates that there may have been some soil-altering properties present in *H. Helix* that affects the growth of the native *L. tulipifera.* These results are parallel to those in the garlic mustard study (Stinson et al., 2006). Interestingly, unlike the Stinson study, the native soil that contained *H. helix* extract had approximately the same amount of growth as the native regular seedlings. We propose that it that it may take time for *H. helix* to alter the soil conditions, or *H. helix* may need to be living in the soil in order to alter the community.

In order to delineate the alteration of the microbial communities as the potential factor for altered *L. tulipifera* growth, a series of controls were conducted. Pots containing both *H. helix* present soil and *H. helix* absent soil were autoclaved to compare the effects the microbial communities have on the growth of *L. tulipeifera* (Native Autoclaved and Invasive Autoclaved in Figure 1, respectively). Additionally, to see if the microbial communities could be reintroduced to the soil to restore growth, the autoclaved soil was 'inoculated' with unautoclaved soil for both *H. helix* absent and present soils (Native Recovery and Invasive Recovery in Figure 1) Unexpectedly the two autoclaved control groups had significant growth, which may be due to insufficient time in the autoclave, resulting in incomplete eradication of the microbial communities. Additionally, due to time constraints the colonization of arbuscular mycorrhizae was not measured, which posed limitations on interpretation of the results. Overall, even with the limitations of the study, *H. helix* was shown to suppress the growth of *L. tulipifera* to statistical significance. These findings suggest that there are complex interactions when invasive plants colonize new habitats, which can alter the soil and plant community structure. The mechanisms by which the invasive plants alter the community are not fully known, but are possible future areas of study.

Understanding the effects that invasive plant species have on the microbial community within the soil is important to forestry and agriculture. Non-native plants are introduced to areas frequently as ornamental yard vegetation, and can easily be spread by wind, water, and animals. Once they move into forested habitats they can suppress growth by obtaining nutrients and habitat, as well as block sunlight. It is lesser known what effects these plants may have on the below ground soil conditions. These results indicate that the invasive species *H. helix* may not only suppress the growth of the native *L. tulipifera* seedlings by growing rapidly, removing nutrients and blocking out UV rays, but also by altering the soil conditions. By altering the soil conditions, the growth suppressing effects are effective even when *H. helix* has been removed from the soil, making it more difficult for the native *L. tulipifera* seedlings to recolonize the areas. This could be detrimental to the progression of reforesting native tree species.

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