May 8th, 12:00 AM

Impact of Earthworms on Plant Development, Soil Properties, and Root Response

Lucia Bolles
University of Southern Maine

Alexandria Miller
University of Southern Maine

Elisabeth Seliga
University of Southern Maine, elisabeth.seliga@maine.edu

Impact of Earthworms on Plant Development, Soil Properties, & Root Response

Authors: Lucia Bolles, Alexandria Miller, Elisabeth Seliga
Faculty Mentor: Dr. Joseph K. Staples
University of Southern Maine, Department of Environmental Science & Policy

INTRODUCTION

- Earthworms throughout most of North America were wiped out approximately 10,000 years ago by glaciers. Only a few species survived. Today, virtually all earthworms in the northern half of the continent are non-native. Earthworms occurring in the northeast today likely arrived with the first european settlers in root balls of plants or in the ballast of ships. The result is that earthworms in the northern tier of N. Am. likely changed the physical composition of soils in vast areas of forests and grasslands.
- European earthworms continue to expand into new territory in the north central and northeastern United States. Once established on the formerly worm-free areas, the invaders consume and combine the organic horizons of the forest floor, often removing leaf litter within several years of invasion (Erik Lilleskov, USDA Forest Service - Northern Research Station). Lighter organic materials on the upper horizons become prone to erosion. Structural changes in soil carbon, nutrients, microclimate, hydrology, and soil organisms and can further lead to changes in plant community assemblages.

METHODS

- This research was conducted at the University of Southern Maine (USM) Gorham.
- Two soil samples were collected on March 2, 2020 from a flower garden outside Bailey Hall (Soil #1), and from a Hemlock stand behind the John Mitchell Center (Soil #2). Both soil samples were sieved upon collection, once through a No. 5 (4 mm) mesh and then through a No. 10 (2 mm) mesh. The sieved soil was heated to 60° C for 45 hours to kill microorganisms or microbes. Soil #1 and Soil #2 were combined to create a total weight of 67 oz. Next, 600 mL of water was mixed into the soil until the soil held shape when squeezed.
- Our experimental design consisted of six treatment replicates and six controls in a 760 mL container measuring 12 cm in diameter at the top. Each container received approx. 6.14 oz of the combined soil and an additional 20 mL of water. Each of the twelve containers received fifteen *Triticum aestivum* seeds. The *T. aestivum* seeds were placed within 1 cm of the surface, with minimal pressure applied. Next, to mimic the layer of litterfall on the forest floor, 0.4 oz of ground spinach was added to the top of each of the twelve containers. The final step was adding two Canadian Nightcrawlers, *Lumbricus terrestris*, to the six experimental containers.
- The containers were checked weekly for four weeks. Measurements and observations were made on the 9th, 16th, 23rd, and 30th of March. Measurements included: shoot length of *T. aestivum,* worm survivorship, and qualitative observations about the soil and plants based on appearance. On April 1st, the plants were cut at the base where the plant exited the seed husk. The plants were immediately weighed using an OHAUS Analytical Plus Semi microbalance and data was recorded on total germination.
- Descriptive statistics and a t-test were calculated using the Data Analysis Toolpak in Excel. Observations were made throughout the experiment on the changes to physical properties of the soil.

NOTE: Due to the circumstances of the global COVID-19 pandemic, data was unable to be recorded regarding the chemical or biological properties of the soil.

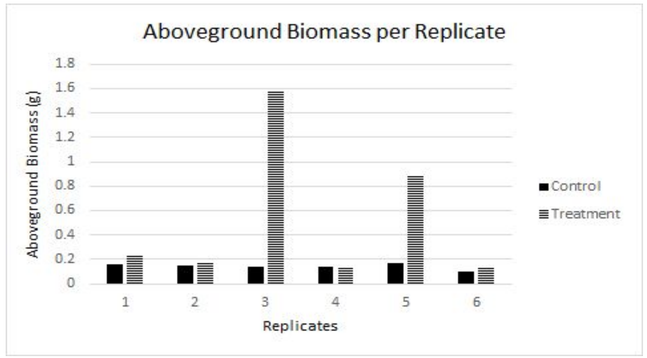

Figure 1. Aboveground Biomass. This figure displays the aboveground biomass (g) per replicate at the end of the experiment in both the control and treatment replicates.

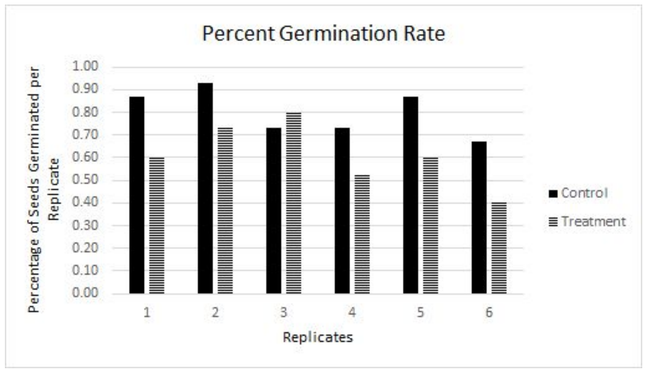

Figure 2. Percent Germination Rate. This figure displays the percentage of seeds germinated out of the 15 seeds per replicate in both the control and treatment trials.

Figure 3. *Lumbricus terrestris* Treatment. Treatment container immediately after adding *L. terrestris.*

Figure 4. Treatment container on day 14 of the experiment.

RESULTS

Plant Development

- The average aboveground biomass in the control trial was 0.14 g, whereas the average in the experimental trial was 0.52 g (Figure 1).
- A statistically significant difference in aboveground biomass was seen ($p<0.05$, $t = 2.23$), despite four of the six treatment replicates being very similar in values to the control replicates.
- The average plant in the experimental trial weighed 0.056 g, while the average plant in the control trial weighed 0.012 g.
- On average, more *Triticum aestivum* seeds germinated in the control trial (Figure 2).
- The average germination rate in the experimental trial was 9.17 seeds, or 61%, whereas the average germination rate in the control trial was 12 seeds, or 80% (Figure 2).
- The t-test explains that the control and treatment replicates have a statistically significant difference in germination rates ($p<0.05$, $t = 2.23$).

Soil Properties

- Without *L. terrestris*, the seeds in the control replicates were enveloped in a fuzzy white mold by the first week of observations (Figure 4).
- By the second week, the soil in the control replicates had become dry while the soil in the treatment replicates was retaining moisture.
- In the control replicates soil appeared compacted, while the soil in the treatment containers appeared loosely structured.
- Burrowing activity was visible on the sides of the containers.
- Organic matter remained on the surface of the control replicates throughout the experiment, whereas organic matter in the treatment replicates was diminished by the first week of observations.

Root Response

- Roots of the *T. aestivum* plants appeared long in control plants.
- Root systems in the control replicates remained moldy and saturated.

DISCUSSION

- *Lumbricus terrestris* earthworms have a measurable impact on both germination and aboveground biomass, displaying statistically significant differences in each.
- There was a clear impact on soil water content given the presence of *L. terrestris*. Treatment replicates retained far more moisture than the control replicates, which reveals the known ability of earthworms to increase water infiltration.
- It was expected that the presence of earthworms in the treatment replicates would result in a decrease in fine root density. Considering that the soil horizons are an area of frequent travel by earthworms, the roots may adapt to take up less space.

References

Cassin, C. M., & Kotanen, P. M. (2016). Invasive earthworms as seed predators of temperate forest plants. *Biological Invasions, 18*(6), 1567-1580. doi: 10.1007/s10530-016-1101-x

Barbosa, J. Z., Demetrio, W. C., Silva, C. M., & Dionisio, J. A. (2017). Earthworms (*Amynthas spp.*) increase common bean growth, microbial biomass, and soil respiration. *SEMINA-CIENCIAS AGRARIAS, 38*(5), 2887-2898. doi: 10.5433/1679-0359.2017v38n5p2887

Cameron, E. K., Cahill Jr, J. F., & Bayne, E. M. (2014). Root foraging influences plant growth responses to earthworm foraging. *PLOS ONE, 9*(9). doi: 10.1371/journal.pone.0108873

Smithsonian Environmental Research Center. (n.d.). Earthworm Invaders. Retrieved April 12, 2020, from https://ecosystemsontheedge.org/earthworm-invaders/