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Commercial Mycorrhizal Inoculation of Non-Sterile Field Soil Does Not Enhance Colonization or Reduce Nitrate Leaching

Madelyn Schoenberger
University of Minnesota - Morris, scho0872@morris.umn.edu

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Advisor: Professor Miriam Gieske
University of Minnesota, Morris | Undergraduate Research Opportunities Program

Arbuscular mycorrhizal fungi promote plant and ecosystem health

- Arbuscular mycorrhizal fungi (AMF) form a mutually beneficial symbiosis with most terrestrial plants wherein the fungus provides nutrients for the plant and receives organic compounds in return[1]
- Laboratory studies found AMF significantly decreases soil nitrate leaching loss compared to sterile soil[2,3]
  - May reduce agricultural nutrient runoff, which contaminates drinking water and causes fish kills
- I conducted a study to determine whether inoculation of non-sterile field soil similarly decreases nitrate leaching

Corn (*Zea mays*) inoculated with commercial AMF

- I grew corn plants for 7 weeks in pots of 2:1 non-sterile field soil:sand mixture with or without a commercial mycorrhizal inoculant
- After 7 weeks' growth, I fertilized each pot with urea, a nitrogen source
  - Two weeks later, I simulated a heavy (~5 cm) rainfall by pouring 2 L diH_2O over each pot and collected the water that seeped through the soil (leachate) for nitrate analysis at Agvise Laboratories in Benson, MN
- I harvested and dried aboveground plant matter and weighed the dry shoot biomass
- I dyed root samples with trypan blue and examined for AMF colonization under a microscope

Figure 1. Experimental setup for nitrate leaching and water sample collection. The black pots on the top shelf contain roots and soil leftover after shoot biomass was collected. The red buckets on the lower shelf were aligned below each pot to collect water that leached through the soil. These water samples were frozen and analyzed for nitrate content. Image credit: Madelyn Schoenberger

AMF inoculation had no significant effects in mycorrhizal-colonized field soil

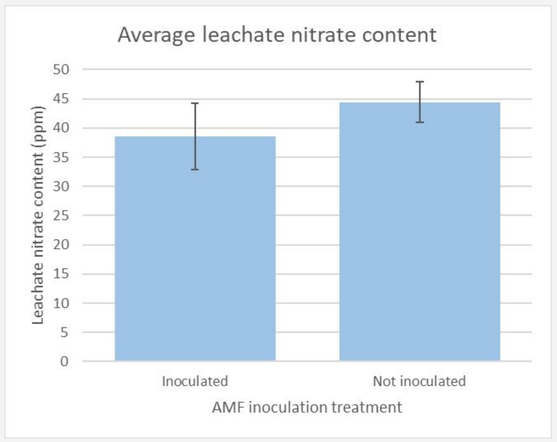

Figure 2. Average leachate nitrate content in parts per million (ppm) as a function of inoculation treatment. Water nitrate analysis was outsourced to Agvise Laboratories in Benson, MN. No significant difference was detected in average leachate nitrate content between inoculated and non-inoculated treatments (One-way ANOVA, $p = 0.40$). Error bars show standard error of the mean.

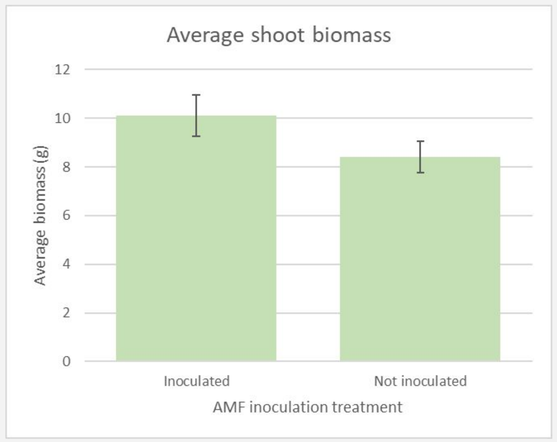

Figure 3. Average shoot biomass in grams (g) as a function of inoculation treatment. No significant difference was detected in average shoot biomass between inoculated and non-inoculated treatments (One-way ANOVA, $p = 0.16$). Error bars show standard error of the mean.

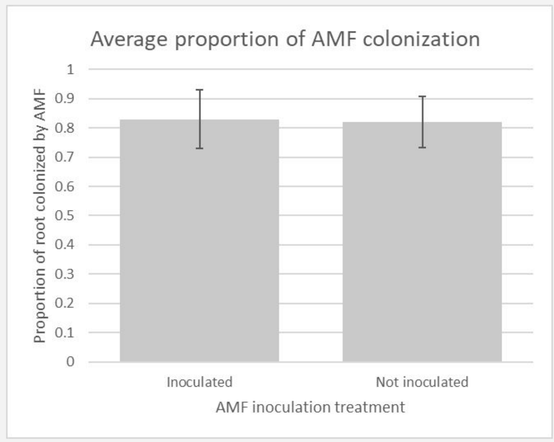

Figure 4. Proportion of root AMF colonization was determined by examining root segments at 100x magnification. Proportion of root AMF colonization was averaged for all samples within each treatment. No significant difference was detected between inoculated and non-inoculated treatments (One-way ANOVA, $p = 0.97$). Error bars show standard error of the mean.

Ecological role of AMF varies locally

- While AMF inoculation of sterilized soils significantly decreases nitrate leaching[2,3], inoculation of non-sterile field soil did not increase plant biomass or reduce nitrate leaching in this study
- Existing mycorrhizal networks in field soil colonize roots effectively, as seen in non-inoculated controls
  - Native mycorrhizae may compete with or inhibit commercial mycorrhizal inoculants by preemption
- Commercial inoculation is likely unnecessary in soil sampled in this study, but is applicable in other areas
  - Soils that have been historically mismanaged or left without plant cover could be remediated by commercial inoculation
  - Supporting native mycorrhizal networks should take precedent when possible[4]
- Avenues for further research:
  - AMF effects in other soils
  - AMF interception of agricultural phosphorus pollution
  - Interactions between AMF inoculants and the native soil microbial community

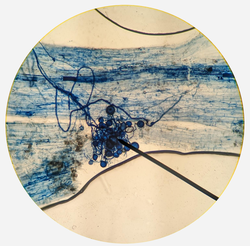

Figure 5. Mycorrhizal vesicles and hyphae at 100x magnification. Root AMF colonization was identified morphologically at each root intersect. Image credit: Madelyn Schoenberger

References & Acknowledgements

[1] Stamets, P. 2005. Mycelium Running: How Mushrooms Can Help Save the World. Penguin Random House LLC.
[2] Asghari, H. R., Cavagnaro, T. R. 2012. Arbuscular mycorrhizas reduce nutrient loss via leaching. PLoS One. 7(1): e29825. doi: 10.1371/journal.pone.0029825.
[3] Bender, S. F., van der Heijden, M. G. A. 2014. Soil biota enhance agricultural sustainability by improving crop yield, nutrient uptake and reducing nitrogen leaching losses. Journal of Applied Ecology. 52(1): 228-239. doi: 10.1111/1365-2664.12351.
[4] Basiru, S., Hijri, M. 2022. Does Commercial Inoculation Promote Arbuscular Mycorrhizal Fungi Invasion? Microorganisms. 10(2): 404. doi: 10.3390/microorganisms10020404.

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