Arbuscular Mycorrhizal Fungi and Effects on Basil Plants

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Background

Arbuscular mycorrhizal fungi (AMF) develops mutualistic relationships with plant roots. AMF obtains carbon rich compounds from the host plant, and in exchange, improves the plant's water and nutrient uptake (Mohammadi et al. 2011). This expanded root zone, the hyphosphere, leads to enhanced soil structure, nutrient mineralization, water holding capacity, and resistance to stress. The presence of a hyphosphere may also increase organic matter decomposition and nutrient availability which can improve crop growth and quality (Begum et al. 2019). The objective of this project was to examine the effects of AMF on plant growth in the presence or absence of field pea/rye cover crop residue.

Hypothesis

1. The presence of AMF will result in improved plant growth, compared to the treatment without AMF inoculants that will show signs of struggle.
2. Treatments with organic matter additions will increase nutrient availability and result in increased plant growth.

Methods

Basil was planted into a soil-sand mix. The topsoil was first sterilized to remove fungal spores. After mixing with sand, but prior to planting, the soil was inoculated with free-living soil microbes (< 11 µm).

Table 1: Components of each treatment

	AMF	Organic Matter	Plant
Treatment A	X	X	X
Treatment B	X		X
Treatment C		X	X
Treatment D	X	X	

The 64 basil plants were divided into two harvests. Half of the plants were harvested on June 13. The remaining plants were harvested on July 28.

Results

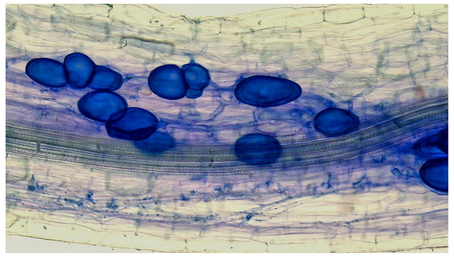

Figure 1: Treatment A, mycorrhizal vesicles (nutrient storage structures) visible in stained root.

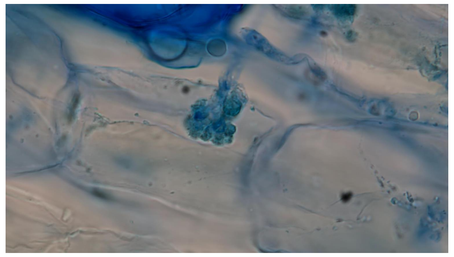

Figure 2: Treatment B, part of arbuscule inside stained root cell (nutrient exchange area)

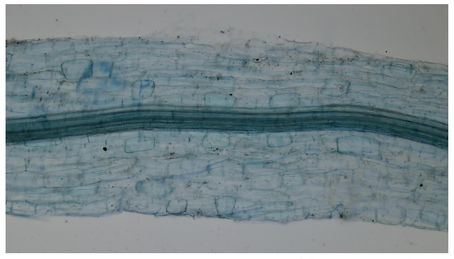

Figure 3: Treatment C, no AMF visible in stained root.

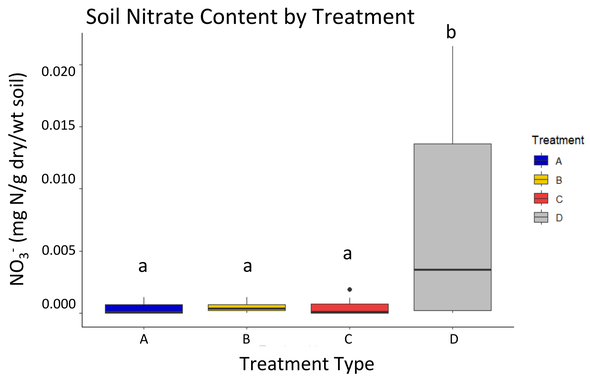

Figure 4: Soil nitrate content by treatment. Letters designate statistical differences ($p < 0.05$).

Figure 5: Treatment A vs. Treatment C height at Harvest 2

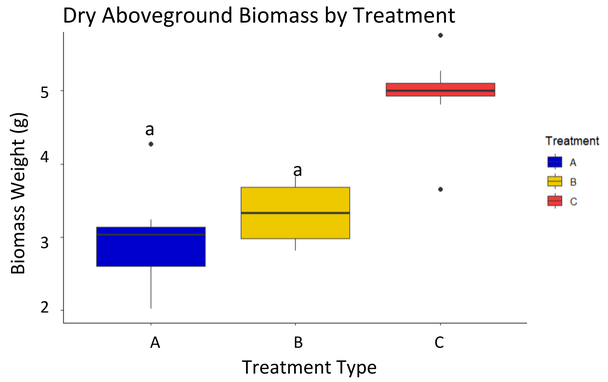

Figure 6: Dry aboveground biomass by treatment. Letters designate statistical differences ($p < 0.05$).

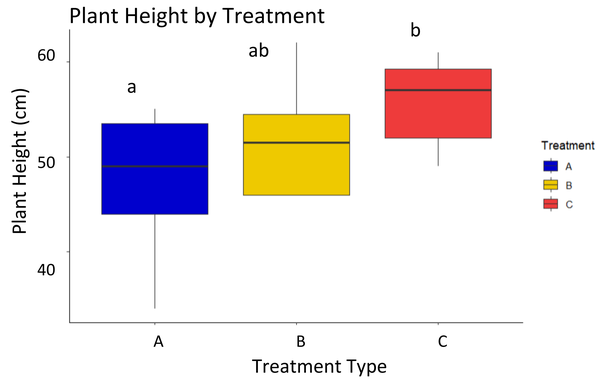

Figure 7: Plant height by treatment. Letters designate statistical differences ($p < 0.05$)

Discussion

Soil nitrate content is significantly higher ($p < 0.05$) in treatment D because there is no plant *(Table 1)* to take up the nitrate, leaving it in the soil. Whereas treatments A, B, and C are nutrient deficient and craving the nutrients, resulting in essentially no nitrate in the soil.

Treatment C plants, which have no AMF *(Table 1)*, are significantly greater ($p < 0.05$) in aboveground plant biomass (*Figure 6*) and height (*Figure 7*). These results contradict Hypothesis 1. With successful inoculation, the plants in treatments A and B allocated carbon and other resources to AMF symbionts, which reduced their aboveground growth in the N limited soil environment. In contrast, treatment C with no AMF thrived because soil bacteria and other saprotrophs could also release nutrients through organic matter decomposition without the plants allocating resources to the AMF, reducing apparent competition (Garrido et al. 2010).

Next steps:

- Analyze the basil shoot and root biomass for C and N content to examine if treatment impacted basil quality, and to further test Hypothesis 2.
- Measure soil organic matter (SOM) pools to investigate if AMF inoculation alters the size of SOM pools derived from cover crop decomposition (See et al. 2021).

Acknowledgments & References

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Begum N, Qin C, Ahanger MA, Raza S, Khan MI, Ashraf M, Ahmed N, Zhang L (2019) Role of Arbuscular Mycorrhizal Fungi in Plant Growth Regulation: Implications in Abiotic Stress Tolerance. *Front. Plant Sci.* 10:1068; Garrido E, Bennett AE, Fornoni J, Strauss SY (2010) The dark side of the mycorrhiza. *Plant Signaling & Behavior, 5*:8, 1019-1021; Mohammadi K, Khalesro S, Sohrabi Y, Heidari G (2011) A Review: Beneficial Effects of the Mycorrhizal Fungi for Plant Growth *Journal of Applied Environmental and Biological Sciences,* 1(9)310-319; See CR, Keller AB, Hobby SE, Kennedy PG, Weber PK, Pett-Ridge J (2022). Hyphae move matter and microbes to mineral microsites: Integrating the hyphosphere into conceptual models of soil organic matter stabilization. *Global Change Biology,* 28, 2527-2540.