Biofertilization and Biofortification of Allium porrum through Inoculation with Arbuscular Mycorrhizal Fungi across a Compost Gradient

By
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A Senior Comprehensive Project in Partial Fulfillment of the Requirements for a Bachelor of Science Degree from Allegheny College

I hereby recognize and pledge to fulfill my responsibilities as defined in the Honor Code
and to maintain the integrity of both myself and the College community as a whole.

Pledge
Approval by the Senior Thesis Committee:

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Dr. Bowden

Abstract

The relationship between crop plants and arbuscular mycorrhizal fungi (AMF) have been extensively studied due to their positive impact on plant growth and yield. There are fewer studies that investigate the effets of AMF on crop nutrient density. This experiment aimed to determine the effects of an arbuscular mycorriza *R. irregularis* and varying levels of compost addition on leek nutrient density and growth in greenhouse conditions. Height was taken prior to harvest while mass and nutrient analysis were done post harvest. There was no significant difference in height or mass between leeks grown with and without AMF. Compost addition did significantly increase both height and mass, however leeks did not reach market size. ICP-MS nutrient analysis revealed that AMF had no effect on the concentration of micronutrients significant to human health found in leeks, however compost addition significantly increased micronutrient concentrations. Nutrient analysis revealed that AMF had no effect on the concentration of most heavy metals found in leeks, however compost addition significantly decreased heavy metal concentrations. The concentration of silver significantly decreased with AMF addition, which may point to AMFs ability to sequester heavy metals. In contrast, aluminium concentration increased with AMF addition in high-compost media. Further research should consider expanding the compost gradient in order to better understand the nutrient limitations of *R. irregularis.* In addition, the nutrient composition of the media should be analyzed prior to planting the leeks to ensure there are not high concentrations of heavy metals. The effects of AMF on heavy metal sequestration could also be further investigated, particularly in the case of aluminium.

Introduction

A community garden can be defined as a collaborative project between community members, often in an urban setting and on shared land, where members collectively maintain and produce fruits, vegetables, and or flowers (USDA, 2020, Okvat and Zautra, 2011). Over the past 30 years community farms and gardens have increased by 30% (United States Senate, 2023). This rise parallels the rise of food justice and food sovereignty movements and can be considered a response to food system inequalities that particularly impact low income and minority groups (Clendening, 2015).

Community gardens can provide a number of socio-cultural, environmental, and health benefits (Ilieva et al., 2022, Pradhan et al., 2023, and Ruck, 2020). In a social sense, community

agriculture increases feelings of community cohesion through increased opportunities for social bonding (lieva et al., 2022). In an urban setting community agriculture can facilitate multi-cultural integration and lead to lower ethnocentrism (lieva et al., 2022). Community gardens are also considered a way to resist oppressive systems, such as racism, by increasing civic engagement and empowerment (lieva et al., 2022).

Environmental benefits of community gardens include regulation of stormwater runoff, micro-climate regulation, improved air quality, and even small levels of CO_2 reduction (Dubova and Machac, 2019). These benefits also provide economic benefits that extend to the city level by improving environmental resilience of cities (Dubova and Machac, 2019). Many of the health benefits of community agriculture are psychological. Spending time in nature while building social relationships leads to improved mental health outcomes (Soga et al., 2017, and Pradhan et al., 2023). These benefits can be also be found in other forms of small-scale agriculture (Rosset, 2000).

In terms of physical health community and small-scale gardeners have higher consumption of vegetables and participate in regular physical activity, which inherently has positive health outcomes compared to non-gardeners (Soga et al., 2017, and Pradhan et al., 2023). However, the nutritional outcomes of small-scale and community gardening are still unclear. Hidden hunger is a concept first recognized by the World Health Organization in 2004, that refers to a chronic lack of vitamins and minerals that can cause health issues that aren't immediately visible (Stein, 2010). Nutrient deficiencies vary globally due to variations in soils and soil health, as well as socioeconomic factors (Graham, 2008). As of 2008, 49% of global agricultural soils were deficient in zinc, 14% of soils were deficient in copper, and 10% in maganese (Graham, 2008). Globally, nearly 2 billion people suffer from micronutrient malnutrition (Shetty, 2011). Many see this problem as a call for micronutrient fertilizers, however the extraction of these minerals is often damaging to the environment (Azam et al., 2019).

Due to the differences in produce, location, and size of gardens it is difficult to quantify the nutritional benefits of small-scale agriculture. Community gardens are often small cohorts of gardeners, and may not reach many people, and common community garden crops are not the most nutrient dense (Nogeire-McRae et al., 2018). Though an increase in the consumption of fresh produce is never negative, particularly because many community gardens arise out of a need for fresh produce, the nutritional benefits could be improved by growing nutrient-dense crops (crops with low calories and high mineral contents), and using growing methods that increase the crop nutrient density.

A potential solution to micronutrient malnutrition is to amend soils with Arbuscular Mycorrhizal Fungi. Arbuscular Mycorrhizal Fungi (AMF) are symbionts which form a mutualistic relationship with 80% of terrestrial plants (Wilkes, 2021). These microbes provide the host plant with nutrients in exchange for photosynthates (Werner and Kiers, 2014). Some positive effects of AMF include improved nutrient cycling (Pellegrino et al., 2013), increased crop biomass (Köhl, et al. 2015), and an increased tolerance to abiotic stresses (Pavithra, et al., 2018). High diversity of AMF is closely linked to soil carbon sequestration (Wilson et al., 2009). AMF can also improve the soil structure and increase moisture retention (Pavritha et al., 2018). Due to the benefits AMF can provide a host plant, AMF are largely regarded as a natural fertilizer.

The *Allium* genus and leeks make high quality model organisms for AMF studies due to their high colonization rates (Binh et al. 2019, Golubkina et al. 2020, Kucova et. al 2016, Rozpedek et al. 2016, and Jansa et al. 2007). For example, of 15 tested crops, leeks had the highest percentage of mycorrhizal colonization (Binh et al. in 2019). Leeks (*Allium porrum*) are a mineral-dense and widely cultivated vegetable in the same genus as onions, shallots, garlic, and scallions. Alliums are used in nearly every cuisine to enhance flavor and are widely recognized for their health benefits. They are high in antioxidants, dietary fibers, flavonoids, and sulfur compounds (Kothari et al., 2020). *A. porrum* is no exception and has been used in traditional medicine throughout the Mediterranean, Europe, and across Asia (Shahrajabian et al., 2021). Leeks have a low calorific value with high mineral density, most notably calcium, magnesium, zinc, copper, and maganese. They are also high in vitamin K, folates, and vitamin A (USDA, 2018).

Conventional agriculture and land management have had profound and negative impacts on AMF in agricultural soils. AMF spore density and species richness decreased in high-till topsoils (Sale et al., 2015). AMF diversity decreases in conventionally managed crops due to the high input of fertilizers. AMF is an obligate biotroph, which means it requires a host to survive. When nutrients such as nitrogen and phosphorus (elements regularly found in commercial fertilizers) are in excess, the mutualistic relationship between plants and AMF is unlikely to occur, leading to a depletion of AMF long-term (Fritz et al., 2004). This also is true for naturally high nutrient soils (Fritz et al., 2004). At the same time, many soils need supplemental nutrients, typically in the form of fertilizers, so that crops can grow well in nutrient deficient soil. This can make using AMF in practice vary between farms and gardens with different inputs and management practices. In conditions of low light or high phosphorus, the carbon cost to the host plant may exceed the benefits, which can result in AMF parasitism. Studying AMF responses to various nutrient conditions is important to making them viable biofertilizers. Chemical fertilizers

negatively impact ecosystems through eutrophication, environmental degradation from P and K mining, and high emissions from transportation (Azam et al., 2019). However, in intermediate-scale urban farming, there has been a rise in compost provided by municipalities. Compost is sometimes added in excess, and over time can lead to phosphorus runoff (Gaston et al., 2023). By adding both AMF and compost, the amount of compost added could potentially be reduced.

The relationship between nutrient-poor soils amended with compost and AMF remains unclear. Domestic compost increases leek growth, but high amounts of compost negatively impact AMF colonization (Akpinar et al., 2019).

A limited number of studies have investigated the effects of AMF on nutrient concentrations of edible foods. In chickpeas, the yield and uptake of N and P increased with AMF inoculation (Pellegrino and Bedini, 2014). Iron and zinc concentration in the grains were 5% and 16% higher than the control and shoot dry matter increased with the Mycorrhizal Index. AMF inoculation had a significant and positive impact on root colonization, nitrogen and phosphorus cycling, and Fe and Zn concentrations in the grain.

Despite the extensive study of leeks as mycorrhizal model systems, the relationship between AMF inoculation, compost application, and nutritional composition and yield has not been thoroughly investigated. This experiment aimed to determine how the yield and micronutrient content of leeks are impacted by inoculation with AMF under varying amounts of compost in greenhouse conditions.

Methods

The experiment was performed in the Allegheny College greenhouse beginning November 30, 2023 and ending January 24, 2024. 36 leeks were sown in an incubator then transplanted and moved to the greenhouse. The pots were arranged in a randomized block design. There were six treatment groups, each with six replicates.

The inoculum was purchased from Trifecta Natural Solutions. The Myco Supreme Mycorrhizal Innoulant claims to contain 50 spores of *Rhizophagus irregularis* per gram of inoculant. *R. irregularis* is known to improve nutrient uptake in a wide variety of plants, including *A. porrum* (Tran et al., 2019).

Sowing and Transplanting Leeks

Seeds of King Richard Leeks (*Allium porrum* cv. King Richard; Johnny's Selected Seeds) were used in this experiment due to their short time to maturity and cold hardiness. Seeds were initially germinated in 100% compost in an incubator at 23.8℃, 65% relative humidity, and 14 hours of light per day. For 2.5 weeks the seeds were bottom-watered, which resulted in the growth of a colonial algae due to the high nutrient content of the compost combined with the excess water. The algae was removed and seeds were top watered every four days for the remaining 3.5 weeks in the incubator.

One leek was transplanted per ¼ gallon pots after 5.5 weeks. Seedlings were removed from the compost, washed in tap water, then rinsed in deionized water. A pencil was used to make a hole 2.5 inches deep to accomodate the roots. For the inoculated treatments 3.07 grams of inoculum was added to each hole. The roots of the leeks were carefully brought into contact with the inoculum, but due to the looseness of the medium, it was hard to guarantee the roots actually contacted the inoculum before the media fell in on itself. To ensure the roots had contact with the spores, seedlings were watered with a suspension of 2 tbsp of inoculum to 4 gallons of water. Each AMF+ leek recieved 420mL of inoculated water one day after the initial transplant. AMF- leeks received 420mL of tap water. They were supplemented with 14 hours of light from sodium vapor lights.

Growing Media

Growing media consisted of 10% local soil, compost, and sand (v/v). Three gallons of local soil were collected from a wooded area at Robertson Athletic Complex (41.65469°N, 80.14793°W) on October 19, 2023. The humus layer was scraped off and only subsoil was collected. The local soil was double sieved, first with a 5.6 mm sieve to remove large debris, and then again with a 2.4 mm sieve to remove smaller debris. Compost was collected from the Allegheny College Physical Plant and was derived from Allegheny College food waste. Both the local soil and compost were autoclaved at 120 ℃ for two hours to remove any pests. Sand was a mixture of various play sands collected from the Allegheny College Greenhouse. All media for experimental treatments were mixed to homogeneity in bulk. Medium 1 was 10% local soil, 0% compost, and 90% sand (v/v). Medium 2 was 10% local soil, 33% compost, and 57% sand. Medium 3 was 10% local soil, 50% compost, and 40% sand.

Yield Assessment

Leeks were measured once a week from the soil surface to the tip of the tallest leaf for the first three weeks after transplanting, and then a final time before harvesting on January 24, 2024. At harvest leeks were washed in tap water then washed a second time in DI water. Roots of each plant were removed with a razorblade. Shoots were cut into smaller pieces, weighed using an analytical balance, dried in paper bags in an oven at 150℃ for 48 hours, and reweighed to determine the dry weights.

Nutrient Analysis

Dried shoots were ground using a mortar and pestle, and then reweighed. Due to the small size of many of the samples, two shoots were combined for nutrient analysis. Samples were ashed in a Thermolyne Furnatrol II muffle furnace at 550℃ for five hours. The ash was then moved to centrifuge tubes and shipped to Alexandrea Rice at Trace Metal Biogeochemistry Lab in Virginia. There, 5mL of 9:1 HNO3:HCL was added to each sample and was left to degas overnight. The samples were then heated to 80*C for one hour. The digest was diluted with deionized water to bring the total weight to 50g. From this, 3g of each digest was moved to a new centrifuge tube, diluted with 18.2MΩ of de-ionized water, and brought to a total weight of 15g. This final dilution was analyzed by an Agilent Technologies 7900 ICP-MS for Ca, Mg, Na, K, P, Si, Fe, Mn, Cu, Zn, Mo, Ni, Al, Ag, As, Cd, Cr, Pb, and V.

Statistical Analysis

A two-way ANOVA was run in Sigmastat version 12.5 for the height, mass, and the majority of the mineral concentrations. The software also ran comparison tests using the Holm-Sidak method. Distributions of quantities for some minerals did not pass the normal distribution test. Aluminium, nickel, silver and lead concentrations were ln-transformed prior to running the ANOVA. Arsenic was ln-ln transformed. For vanadium and chromium the data was ln-transformed, but could not be made to be normally distributed, so compost within AMF treatment and AMF within each compost were run seperately as two-tailed t-tests.

Results

Yield Assesment

The average height at harvest showed no significant effect of AMF on leek height (Figure 1). However there was a significant difference in height between the compost treatments (Table 1), with leeks growing the least in compost-free medium.

Growth	AMF	Compost
Height	0.462	**<0.001**
Mass	0.747	**<0.001**

Table. 1 P-values for leek height and dry mass due to AMF and compost addition.

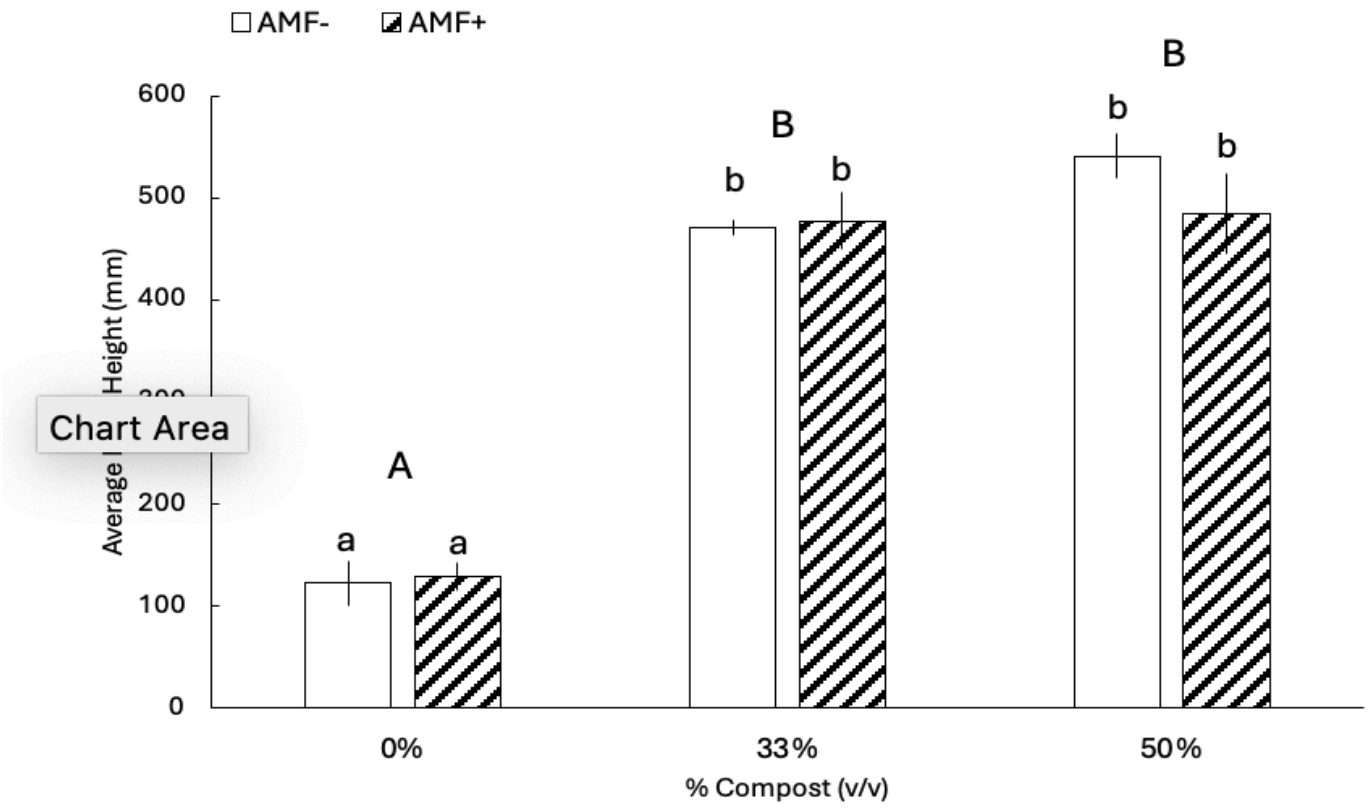

Figure 1. The average height at harvest for leeks grown with and without AMF in a compost gradient. Capital letters show the differences between compost treatments. Lower case letters show the difference in mycorrhizal treatments within the compost treatment.

The average dry weights after harvest did not show a significant difference between AMF treatments, but did show a significant difference between compost treatments (P-value <0.001) (Figure 2).

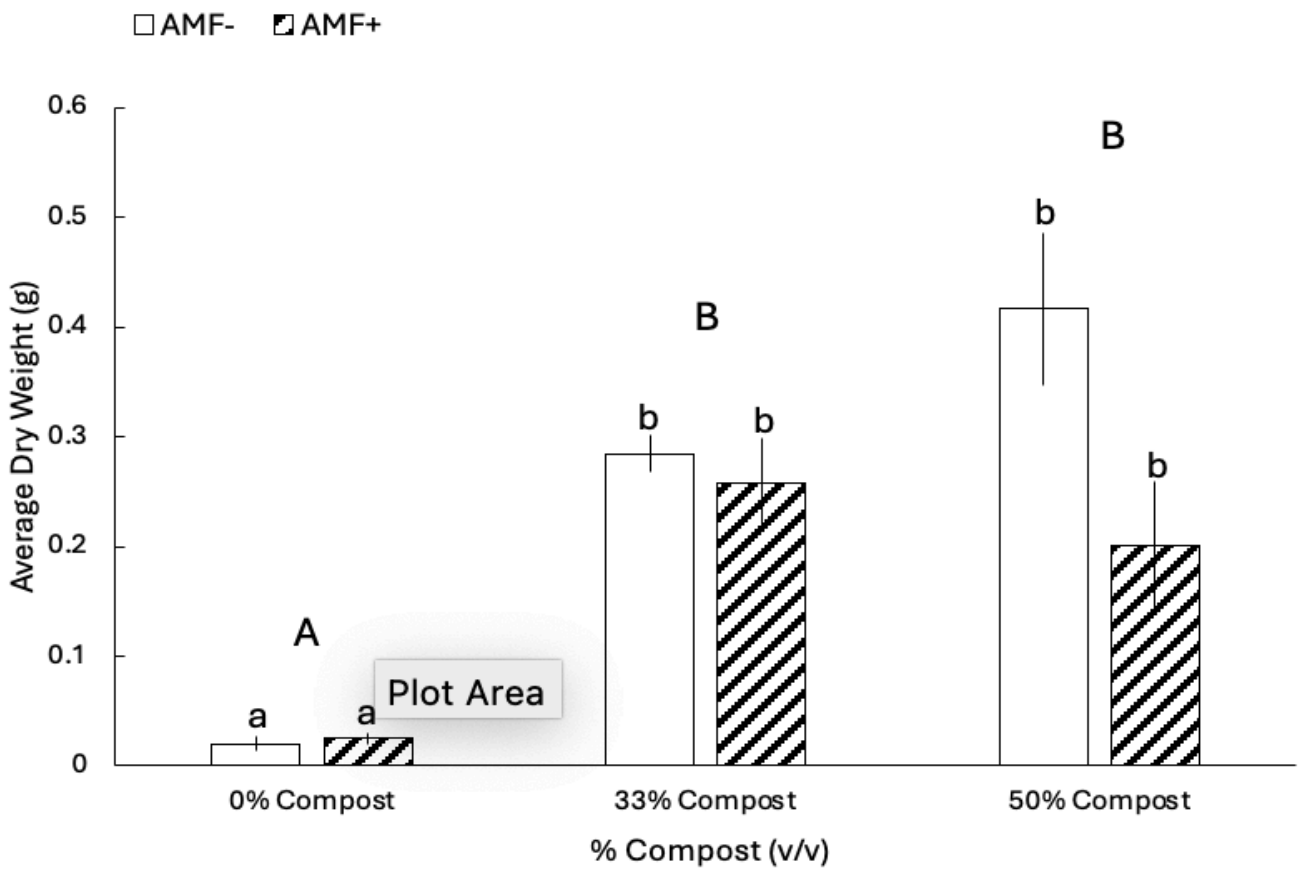

Figure 2. Average dry weight after harvest for leeks grown with and without AMF in a compost gradient. Capital letters show the differences between compost treatments. Lower case letters show the difference in mycorrhizal treatments within the compost treatment.

Nutrient Analysis

Generally, the addition of AMF had no impact on the micronutrient uptake of minerals significant to human health (Table 2). Most often, the addition of compost did impact micronutrient uptake, but there were no differences between media containing 33% or 50% compost. Compost increased the micronutrients in the leeks, except in copper, chromium, iron, and manganese. Copper and chromium decreased with compost addition while iron and manganese remained the same across the compost gradient (Figure 3). AMF addition did significantly decrease the concentration of magnesium, but only in the 33% compost treatment.

		AMF	Compost
Minerals Significant to Human Health		P-value	
	Ca	0.235	**<0.001**
	Cu	0.056	**0.003**
	Cr	N/A	N/A
	Fe	0.384	0.136
	K	0.328	**<0.001**
	Na	0.98	**0.009**
	Mn	0.134	0.151
	Mg	**0.045**	**<0.001**
	P	0.219	**<0.001**
	Mo	0.713	**<0.001**
	Zn	0.58	**0.015**
Heavy Metals			
	Ag	**0.001**	**<0.001**
	Al	**0.023**	**0.001**
	As	0.59	**<0.001**
	Cd	0.122	**<0.001**
	Pb	0.16	**<0.001**
	V	N/A	N/A
Other Minerals			
	Ni	0.697	**<0.001**
	Si	0.628	**<0.001**

Table 2. P-values for mineral concentrations. Significant values are bolded. P-values of chromium and vanadium were not included because they were unable to be run as a two-way ANOVA. For chromium in each compost concentration there was no difference for AMF (P=

0.58, 0.246, and 0.349 as compost increases). Differences in compost were compared within the mycorrhizal treatment. Within AMF+ treatments, the 50% and 33% compost were different from 0% compost (P=0.04), but not from eachother (P=0.767). Within AMF- treatments, the 50% and 33% compost were different from 0% compost (P=0.02 and 0.018 respectively), but not from eachother (P=0.791). For vanadium there was no difference for AMF as compost increased (P=0.797, 0.470, and 0.367). Within AMF+ treatments, the 50% and 33% compost were different from 0% compost (P=0.015 and 0.012 respectively), but not from eachother (P=0.837). Within AMF- treatments, the 50% and 33% compost were different from 0% compost (P=0.009), but not from eachother (P=0.767).

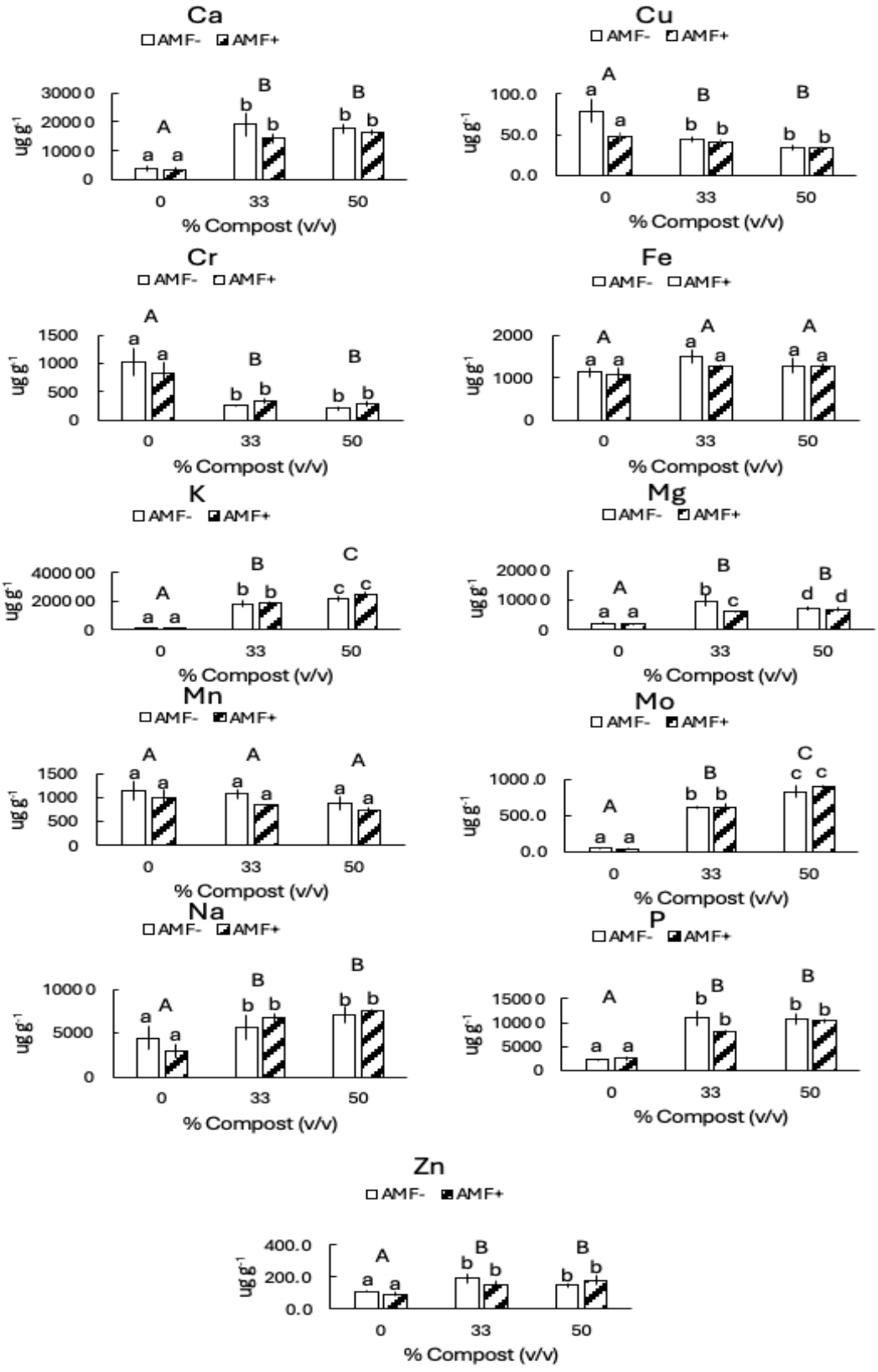

Figure 3. Concentration of minerals significant to human health found in leeks grown with and without AMF in a compost gradient. Capital letters show the differences between compost treatments. Lower case letters show the difference in mycorrhizal treatments within the compost treatment.

AMF addition significantly decreased the silver content of the leeks in the 0% compost treatment, but it had no effect in the higher compost treatments. AMF addition significantly increased the aluminium content of the leeks in the 50% compost treatment, but it had no effect in the lower compost treatments. The remaining heavy metals were only affected by the compost additions, but there was no difference between 33% and 50% compost treatments.

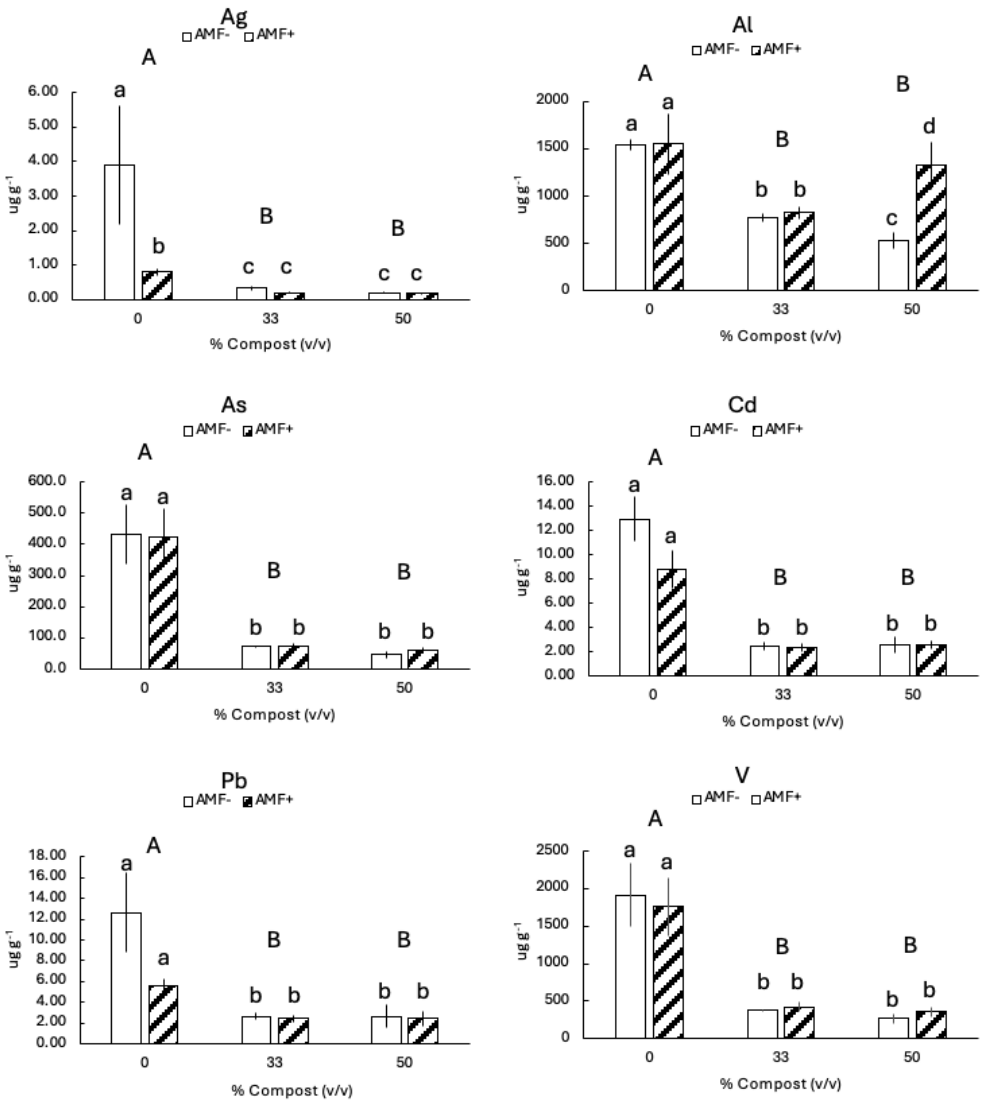

Figure 4. Concentrations of heavy metals in leeks with and without AMF across a compost gradient. Capital letters show the differences between compost treatments. Lower case letters show the difference in mycorrhizal treatments within the compost treatment.

Discussion

The leeks did not grow to “market size,” despite their claimed short growing season. All dry weights were less than a gram. The sand-grown leeks had low concentrations of soil nutrients, so it was expected that they would not get very large. When growing leeks it is common practice to mound the soil. This blanches the stem and encourages the plant to grow taller (University of California, 2024). Mounding was not possible in pot cultures which may have contributed to reduced growth. Windstorms in northwest Pennsylvania in late December and early January drove cold air through the greenhouse vents. The low temperatures may have stunted the leek growth. Though most cultivars of leek are cold-hardy, cold temperatures can still slow their growth rate (Pokorny, 2023). If this experiment were to be repeated, a longer growing period in warmer months would be recommended.

It is unclear if the AMF actually colonized the roots of the experimental leeks. Roots were not stained for colonization, but in the future this would be highly recommended. Inoculated leeks only had contact with the AMF for 38 days. In a study by Arle et al., 2024, *A. porrum* inoculated with *R. irregularis* were harvested after 71 days. The leeks spent nearly double the amount of time with AMF, but no effects on growth were observed and colonization was relatively low at 27±8%. This indicates that this species of AMF takes longer than 71 days to fully colonize the roots of *A. porrum.* Additionally, commercial AMF can take longer to colonize host plants than locally gathered innocula (Shao et al., 2022). In a field study on pear trees, commercial *Funneliformis mosseae* and *R. irregularis* had the lowest colonization percentage of all tested species after 125 days (Shao et al., 2022). Local AMF can provide more benefits to nutrient uptake over commercial isolates because they are diverse mixtures of species adapted to local soils and plants can select for the most efficient partner AMF (Shao et al., 2022, Wagg et al., 2011, Whiteside et al., 2019). Without staining it cannot be confirmed that AMF colonized the roots of the experimental leeks, but based on these studies, it is likely that *R. irregularis* did not have enough time to significantly colonize the roots, which may explain the lack of differences between AMF treatments.

Mineral	Experimental Range (µg/g)	USDA-Reported Concentration (µg/g)
Ca	3497-19050	589.9
Cu	33.7-78.7	1.2
Fe	1078-1500	21.01
K	4120-245422	1797.8
Mg	1930-9667	279.8
Mn	732-1136	4.81
Na	2911-7512	20
P	2296-10913	350.6
Zn	90.3-191.7	1.2

Table 3. Comparison of experimental range of mineral concentrations to USDA calculated mineral concentrations of raw leeks. (USDA, 2017).

Generally, AMF did not affect plant growth or nutrient contents. When compared with USDA nutritional facts on leeks, the experimental leeks had much higher concentrations of each mineral (Table 3). The methods used to grow and determine nutrient concentrations by the USDA are unclear, however they analyzed just the lower leaf and bulb portion of the leeks. In this study the entirety of the leek was analyzed, which could account for the discrepancies in mineral concentrations. The USDA did not report a concentration for chromium or molybdenum. Both chromium and copper are heavy metals needed by humans in trace amounts. The concentration of copper in the experimental leeks (Table 4) fell below the Recommended Dietary Allowance (RDA) (Institute of Medicine (US) Panel on Micronutrients, 2001). The concentration of chromium in just one gram of experimental leeks fell far above the Adequate Intake (AI) (Institute of Medicine (US) Panel on Micronutrients, 2001). There is no Tolerable Upper Intake Level (UL) for chromium because few serious effects have been associated with excess chromium intake from food (Institute of Medicine (US) Panel on Micronutrients, 2001).

Heavy Metal	Experimental Range (µg/g)	Limit Humans	Toxicity to Plants	Source
Ag	0.17-3.90	0.9 µg/kg body weight (ADI)	N/A	European Food Safety Authority
Al	528-1547	1 µg/g body weight/week	2-3 ug/g	Joint FAO/WHO Expert Committee on Food Additives, Rout et al., 2001.
As	46.8-432.1	0.5-2 ug/g	2.1 ug/g	FDA, National Acadamies Press (US), 1997.
Cd	2.32-12.93	62 ug/ day/ 70 kg person	3-30 ug/g	Satarug et al., 2017, Haider et al., 2021
Cr	207-1020	25-35 µg/day (AI)	N/A	Institute of Medicine (US) Panel on Micronutrients, 2001
Ni	5.1-31.6	NH	1.5 µg/g	Harvard TH Chan School of Public Health, Mustafa et al., 2023
Pb	2.44-12.60	8.8ug/day (IRL)	N/A	FDA, National Acadamies Press (US), 1997.
V	265-1915	NH	N/A	Agency for Toxic Substances and Disease Registry, 2008

Table 4. Range of heavy metals in experimental leeks compared to plant toxicity and safe limits for humans. NH means the amount found in foods is considered not harmful. ADI is the adequate dietary intake which is similar to AI, the adequate intake. IRL is the interval reference level determined by the FDA. For many of the metals there was not a numerical limit for plant toxicity, so those were considered N/A.

The concentration of heavy metals may have impacted leek growth and toxicity. The sand-grown leeks had higher levels of aluminium, silver, arsenic, cadmium, chromium, lead, and vanadium than leeks grown with compost (Figure 4). This may indicate that the sand mixture was high in these metals. To confirm, the media would have to undergo ICP analysis. The concentration of aluminium in all treatments was high enough to cause aluminium toxicity in the

leeks. Aluminium toxicity is known to be a growth-limiting factor for plants grown in acidic soils and can present itself as yellowing and death of leaf tips (Bhalerao and Prabhu, 2013), which occured in leeks of all treatments. Despite this, leeks of all treatments did not have aluminium contents high enough to be toxic if consumed. The concentration of arsenic was high enough in leeks of all treatments to have negative effects on plant growth. Arsenic inhibits root proliferation and slows shoot biomass accumulation (Finnegan and Chen, 2012). Additionally, the leeks also fell above FDA limits for arsenic in food products. Long term exposure to arsenic through drinking water and food can cause cancer, skin lesions, increased risks of cardiovascular disease and diabetes, and have negative impacts on cognitive development in children (WHO, 2022). The concentration of cadmium in leeks of all treatments (Table 4), was high enough to negatively impact root and shoot growth. High concentrations of cadmium correlate to high levels of organic matter in acidic soils, and can cause stunted growth and lead to necrosis (Haider et al., 2021). The soil was acidic because acidic soils are preferred by leeks, which in combination with the compost may have contributed to the high amounts of cadmium. The cadmium concentration in all treatments fell considerably below the limits for human consumption, so consumption would not lead to any adverse health affects. The sand-grown leeks exceeded the FDA adult limits for lead consumption, but the remaining treatments fell below this limit. All treatments exceeded the interval reference level (IRL) for children of 2.2 ug/day. For children, high exposure to lead can permanently impact the development of the brain and nervous system (WHO, 2023). For adults, lead exposure can increase blood pressure, cadiovascular issues, and cause significant kidney damage (WHO, 2023). The levels of lead found in these leeks would be unlikely to significantly impact adults, but could greatly harm children and their development.

The addition of compost decreased the concentration of all heavy metals. This decrease supports the hypothesis that the heavy metals came from the sand, because they decrease as the amount of sand decreases. AMF are known to be able to sequester heavy metals in glomalin-related soil proteins (GRSP) (Wang et al., 2019). AMF release glomalin and GRSPs to coat and protect the hyphae, but also form aggregate structures in the soil (Li et al., 2022). These glycoproteins are released even before the host is colonized. Glomalin and GRSPs can sequester iron, manganese, copper, zinc, arsenic, cadmium, and lead (Wang et al., 2019). Some metal ions bind to the glomalin which prevent it from entering the plant (Wu et. al, 2008). GRSPs also mitigate aluminium toxicity using the same mechanism, but reache a limit in soils with 70% Al saturation (Aguilara et al., 2011). This limit could explain the increase in aluminium in the 50% compost treatment with AMF.

Further Considerations

In order to better determine the affects of AMF and compost on the nutrient concentration of leeks, this experiment would need to be repeated with some modifications. First, the components of the growing media should be analyzed before transplanting to ensure excess levels of heavy metals do not inhibit plant growth. Additionally, because the 33% and 50% compost treatments were not different from eachother for both yield and most nutrients, the compost gradient could be adjusted to include a wider range of compost amounts between 0% and 33%. Further research may also want to compare a commercial inoculant, like the one used here, to a local inoculant or inoculants with more than one AMF species.

Conclusion

Based on this research, it cannot be concluded that AMF impacted either yield or nutrient acquisition in leeks. However, due to the number of complications with growth, this does not mean AMF is not a solution to micronutrient deficiencies in small-scale and community farming. Additionally, AMFs ability to sequester heavy metals could be especially beneficial to small scale farming in urban or heavily polluted soils.

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