WA 46°N WINE

Research Summary

Project Title: Effect of mycorrhizal inoculants on grapevine growth and nutrient uptake

Principle Investigator: Tanya Cheeke, Assistant Professor, Washington State University, Tri-Cities

To optimize the use of mycorrhizal inoculant products on wine grapes at the nursery stage, we tested the effect of a mycorrhizal inoculant product (MycoBloom) with and without the addition of phosphorus (P) fertilizer on the growth and tissue nutrients of two popular *Vitis vinifera* cultivars, 'Merlot' and 'Chardonnay'. We rooted dormant cuttings in autoclaved field soil with the following treatments added: no AM fungal inocula or P fertilizer; AM fungal inocula; P fertilizer; and co-amendment of AM fungal inocula and P fertilizer. We grew vines in their respective treatments in a greenhouse for five months. We found that vine growth response to the treatments differed by cultivar. 'Merlot' vines had a stronger growth response to the mycorrhizal inoculant product than 'Chardonnay', especially in pots to which no P fertilizer was added. The addition of P fertilizer reduced mycorrhizal colonization in the roots of both cultivars, from greater than 75% root colonization in pots with no P fertilizer added to less than 25% root colonization in pots with P fertilizer added. Merlot vines grown with the AM fungal inoculant product had higher tissue P than uninoculated vines, but there was no effect of inoculation on tissue nutrients of 'Chardonnay'. This study provides evidence of grapevine cultivar-specific responses to an AM fungal inoculant product in a greenhouse, which may be useful when planning nursery management strategies for the incorporation of biological amendments into grapevine production.

In a second greenhouse experiment, we tested the effect of three different mycorrhizal inoculant products (MycoApply® Endo, MycoBloom, and Mykos® Gold granular) and two locally-collected mycorrhizal inoculants (vineyard soil and remnant steppe soil) on Merlot vines grown in pots containing live field soil. Live field soil was used to represent the abiotic and biotic factors that young vines might encounter in a new vineyard planting. We predicted that locally- collected soil inocula would provide greater benefits to wine grape growth than the non-local inoculant products, as local soil microbes may be better adapted to local soil type and/or climate conditions than the microbes in non-local products. However, we found that adding mycorrhizal fungal inocula, from either a commercially-available product or from locally-collected field soil, at two different application rates, did not improve the growth of young, potted Merlot vines, nor did it increase mycorrhizal root colonization compared to vines grown in live field soil with no inocula added. This suggests that the soil into which new vineyards may be planted in the Inland Northwest may already contain enough viable mycorrhizal propagules to provide sufficient colonization of roots and benefits for wine grape growth. Thus, the decision to invest the time, resources, and effort into mycorrhizal inoculations during new vineyard establishment may involve the testing of different mycorrhizal products on the cultivar(s) of interest on a small scale, and under different growing conditions (e.g., with and without P fertilizer, higher or lower water availability) before investing in mycorrhizal inoculants at the vineyard scale.

Washington State Grape and Wine Research Program
FINAL REPORT
2022-23 Funding Cycle

1. **Summary**: See separate page

2. **Final Report**: This is a final report, summarizing all years of the project.

3. **Project Title**: Effect of mycorrhizal inoculants on grapevine growth and nutrient uptake

4. **Principal Investigator/Cooperator(s)**:

PRINCIPAL INVESTIGATOR

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COOPERATORS

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Organization	WSU-IAREC	Organization	Bleyhl Co-op
Description of participation:	ADVISORY ROLE FOR GRAPE PRODUCTION, OUTREACH AND EXTENSION	Description of participation:	ADVISORY ROLE FOR PLANT NUTRITION

5. **Objective(s) and Experiments Conducted to Meet Stated Objective(s)**:

To optimize the impact of mycorrhizal inoculations on wine grape production in Washington and to validate the efficacy of mycorrhizal inoculants that are available to growers in the area, this research pursued two objectives:

Objective 1. Determine whether inoculation with arbuscular mycorrhizal fungi (AMF) improves grapevine growth and foliar nutrient content under different P conditions. Two grape cultivars (Chardonnay and Merlot) were grown in the following treatments in a full factorial design: AMF+P, AMF-P, -P, and +P. Data were collected on plant growth, foliar nutrients, mycorrhizal colonization of roots, and root and shoot biomass. *Hypothesis: AMF will improve growth and foliar nutrient content in both grape cultivars and benefits of AMF will be highest in the low P treatment.*

Objective 2. Evaluate the impact of different mycorrhizal inoculant products compared to locally-collected soil inocula on wine grape growth and foliar nutrient content. Grapevines were grown with one of three different mycorrhizal inoculants available to growers, locally-collected inocula containing local mycorrhizal fungi, or no inocula to determine whether there would be an additional benefit to plant growth of inoculating live field soil with locally-collected soil inocula. *Hypothesis: Locally-collected soil inocula will increase growth and foliar nutrient content in grapevines relative to inoculant products and uninoculated field soil.*

This research benefits the Washington wine and grape industry by providing critical information about the conditions in which mycorrhizal inoculations are most likely to positively impact grapevine growth (by testing different grape cultivars, fungal inocula sources, and fertilizer treatments) and tests a cross-section of mycorrhizal inoculation products currently on the market so that growers can optimize their use of biological inputs in vineyard management plans. This research addresses Washington State Viticulture and Enology Research Priorities aimed at improving viticulture production efficiency and profitability by developing nutrient management strategies for optimal vine health. This study provided valuable research and training opportunities for undergraduate students in the Viticulture and Enology and Biology programs at WSU Tri-Cities, where the following greenhouse experiments took place (2019-2023).

Experiments Conducted to Meet Objectives

Experiment 1 (Obj.1)

Overview: In a greenhouse experiment, we tested the effect of inoculation with arbuscular mycorrhizal (AM) fungi with and without P fertilizer addition on grapevine growth and foliar nutrient content. We grew two grape cultivars (Merlot and Chardonnay) in the following treatments: 1) no AM fungal inoculant or P fertilizer amendment; (2) AM fungal inoculant; (3) P

fertilizer; or (4) a co-amendment with both the AM fungal inoculant and P fertilizer. Plant growth data were recorded monthly for the duration of the five-month experiment. Data on plant biomass, tissue nutrients, and mycorrhizal colonization of roots were collected. We predicted that the AM fungal inoculant product would increase vine growth and tissue nutrients in both cultivars, and that the benefits of inoculation would be highest in the vines that received no P fertilizer.

This study was featured on the cover of the June 2023 issue of HortScience: ***Citation:*** *Cifizzari, K.C., Moyer, M.M., and T.E. Cheeke. 2023. Growth responses of potted Vitis vinifera cultivars differ to a mycorrhizal inoculant and phosphorus fertilizer.* HortScience. *58(6): 643-650. https://doi.org/10.21273/HORTSCI17114-23*

Methodological details for Experiment 1

Plant material. We obtained callused, unrooted cuttings of Chardonnay (*Vitis vinifera;* FPS selection 79.1) and Merlot (*V. vinifera*; FPS selection 15) from Inland Desert Nursery (Benton City, WA). The callused, unrooted cuttings were rooted *in situ* to their experimental pots to ensure that roots were not pre-colonized with AM fungi prior to the start of the experiment. Vines were grown in 4L pots on greenhouse benches (WSU, Richland, WA) in a randomized complete block design for five months. The experiment was established on 2 Oct 2019 and the vines were destructively removed from pots on 2 Mar 2020. There were a total of 15 vine replicates of each treatment (2 cultivars x 4 treatments x 15 replicates = 120 experimental units). Each pot contained a single plant.

Soil. We collected field soil from a local agricultural field near research vineyards at the WSU Irrigated Agricultural Research and Extension Center (Prosser, WA). We mixed the field soil 1:1 (by volume) with medium-course landscaping sand (Beaver Bark, Richland, WA) to improve drainage and autoclaved it twice (121°C for 2 h, rest for 24 h) to eliminate resident soil organisms, including pests and pathogens. All pots in the experiment contained the same autoclaved sand:soil substrate to which the AM fungal inoculant and/or P fertilizer was added.

Mycorrhizal fungal inoculant. We used MycoBloom, LLC (Lawrence, KS) as the mycorrhizal inoculant product, which included the following AM fungal species: *Acaulospora spinosa, Cetraspora pellucida, Claroideoglomus claroideum, Claroideoglomus lamellosum, Entrophospora infrequens, Funneliformis mosseae,* and *Racocetra fulgida*. Each inoculated pot contained 400 cm^3 of the fungal inoculant (10% inoculation rate, by volume) added to the rooting zone of each vine. To account for potential effects of non-mycorrhizal microbes present in MycoBloom, each pot also received a microbial filtrate prepared from the fungal inocula, which was filtered through a sieve (38 µm), then through filter paper (5 to 10 µm), allowing bacteria to go through but not spores, roots, or larger organisms.

Greenhouse conditions and management. The average greenhouse daily low temperature was 16 °C and average daily high was 28 °C. Humidity ranged from 20 to 40% during the growing period. Vines received additional lighting beginning at 76 days after planting to achieve a total

photoperiod of 16 h from 1000 W high pressure sodium bulbs. Vines were watered daily, for 3 to 4 minutes, using an automated drip irrigation system (drip rate: 25 ml/min). When most vines had three to four true leaves (approximately 20 days after planting), we added a P fertilizer used by local growers (NUE 0-30-0; BioGro, Mabton, WA) to the P fertilizer treatments. Each vine was also fertilized with a P-free (15-0-15) fertilizer (Simple Lawn Solutions, Lake Panasoffkee, FL) 111 days after planting, which added N and K to the soil to reduce the potential for macronutrient deficiencies during the experiment. To reduce potential for micronutrient deficiencies, we applied a foliar micronutrient treatment (BioGro, Mabton, WA) twice thereafter.

Plant growth measurements. We recorded initial bud number for each cutting at the time of planting to account for variation in size pre-treatment. We began collecting shoot length data 60 days after planting, measuring from the base of the shoot to the tip of the apical meristem. We continued to record shoot length every 30 days for the remainder of the experiment. Five months after planting, we destructively harvested the vines and separated the roots from the shoots for biomass. Subsamples of fine roots were collected from each vine to assess percentage mycorrhizal colonization of roots. The fresh weights of the whole root system and the root subsample were recorded separately, and a dry weight conversion was used to add back in the weight of the subsampled roots to get total root biomass before analysis. Shoots and roots were dried for 48 h at 70°C for above and belowground biomass data (g, dry weight). Aerial plant tissue was collected from all vines to assess foliar nutrients, including N, P, K, and Ca (KUO Testing Labs, Pasco, WA).

Mycorrhizal colonization. Roots were cleared in 10% potassium hydroxide and stained with Trypan blue, and assessed for the presence of AM fungal structures including hyphae, arbuscules, and vesicles using a compound microscope at 200x total magnification. Percentage colonization of AM fungi was determined as the number of intersections containing one or more AM fungal structures out of 100 total root intersections analyzed.

Statistical analysis. We used linear mixed effects models to test the effect of cultivar, mycorrhizal inocula, P fertilizer, and their interactions on vine shoot length, shoot biomass, root biomass, root-to-shoot ratio, percentage mycorrhizal colonization of roots, and nutrients of vine tissue. Initial bud number was included as a covariate to account for potential variation in initial size of the vine cuttings pre-treatment, and greenhouse block was included as a random effect to account for potential environmental variation. We tested the significance of terms using ANOVA. Pair-wise contrasts to test the effects of AM fungal inocula on vine growth and/or tissue nutrients for each cultivar in each P fertilizer treatment were performed using the 'emmeans' package of R. Tukey adjustments were made to limit type-1 error rate due to α-inflation in the contrast comparisons. We calculated the mycorrhizal growth response of each cultivar, which represents the relative change in aboveground biomass due to the addition of AM fungal inocula in the different P fertilizer treatments. This resulted in a total of four mycorrhizal growth response values: (1) Merlot to AM fungi with no P fertilizer added; (2) Merlot to AM fungi with P fertilizer added; (3) Chardonnay to AM fungi with no P fertilizer added; (4) Chardonnay to AM fungi with P fertilizer added.

Experiment 2 (Obj. 2)

Overview: For Experiment 2, we tested the efficacy of different commercially-available mycorrhizal inoculant products (MycoApply® Endo, MycoBloom, and Mykos® Gold granular) on grapevine growth and foliar nutrient uptake compared to mycorrhizal fungi in local vineyard soil (Kiona Vineyards, Benton City, WA) and local soil collected from an undisturbed remnant shrub-steppe natural area (Rattlesnake Mountain, Benton County, WA) in a greenhouse experiment. Local field soil collected from near the WSU Tri-Cities Research Vineyard (Richland, WA) was used as the live background soil in all pots to which the different treatments were added. The background field soil in this experiment was not sterilized (as it was in Exp. 1), so that we could assess the potential impact of different mycorrhizal inoculants on wine grape growth when added to live field soil, that had a resident mycorrhizal community already in place. We used Merlot as the cultivar in this experiment, as it showed a stronger growth response to mycorrhizal fungi than Chardonnay in Exp. 1. Additionally, Chardonnay vines were not available in enough quantity for our experiment in Spring 2022 due to supply-issues stemming from the COVID pandemic. We predicted that locally-collected soil inocula would provide greater benefits to wine grape growth than the non-local inoculant products, as local soil microbes may be better adapted to local soil type and/or climate conditions than the microbes in non-local products. In this experiment, we included a number of controls, including pots containing a microbial wash from the respective treatments (bacteria but not mycorrhizal fungi), as well as a control treatment containing only autoclaved background soil to determine whether the local field soil (representative of a new vineyard) had a resident mycorrhizal community that improved Merlot vine growth compared to sterilized soil.

Methodological details for Experiment 2

Plant material. We obtained 1.5-year-old own-rooted vines of *Vitis vinifera* (‘Merlot,’ clone 15) (Skagit Horticulture, Mabton, WA). Roots were collected from a subset of vines prior to experimental set up to verify that there was no mycorrhizal colonization originating from the nursery prior to planting into treatments. Vines were grown in their respective treatments in 4L pots on greenhouse benches (WSU, Richland, WA) in a randomized complete block design for four months. The experiment was established on 1 July 2022 and the vines were destructively harvested on 2 Nov 2022. Each pot contained a single vine, and vines were pruned to one primary shoot prior to planting.

Soil. We collected field soil (soil series: Finley; SoilWeb) from 0.6 m depth near the Washington State University Research and Teaching Vineyard (WSU; Richland, WA, USA). We mixed the field soil 1:1 (by volume) with pasteurized medium-course landscaping sand (Beaver Bark, Richland, WA) to improve drainage.

Mycorrhizal inocula: We used three mycorrhizal inoculant products that are available to local growers, MycoApply® Endo, MycoBloom, and Mykos® Gold granular, as well as two locally-collected mycorrhizal inoculants: One from an undisturbed, remnant shrub-steppe natural area dominated by mature sagebrush (Rattlesnake Mountain, Benton County, WA) and the other from

an established 50-year-old vineyard (Kiona Vineyards, Benton City, WA). We inoculated the vines at two different rates – one at the recommended commercial rate as described on the packaging of the product and the other at a standardized rate, based on propagule viability, as described for the MIP assay below.

Mycorrhizal Inoculation Potential (MIP) assay: Because not all mycorrhizal spores are viable at the time of application, we performed a mycorrhizal inoculation potential (MIP) assay prior to inoculating the main experiment to test for variation in mycorrhizal inoculation potential among the different mycorrhizal treatments. To do this, *Zea mays* (corn) was grown in conetainers (150 ml; Stuewe and Sons, Tangent, OR) containing an autoclaved soil mixture and 15 mL of a mycorrhizal treatment (or autoclaved inocula as controls), with ten replicates of each. Plants were harvested after four weeks and percentage mycorrhizal colonization of roots was determined using the slide-intersect method. Negative controls were used to verify soil sterilization. Because variation in inoculation potential was detected among the different inocula, we adjusted the volume of inocula added to each pot so that each received approximately the same inoculation potential. We thus inoculated the vines at two application rates: one rate based on viable propagules in the inoculant (called 'standardized' rate) and the other rate based on manufacturer recommendations (called 'commercial' rate).

Microbial extract: To control for effects of non-mycorrhizal soil microbes in each inoculant, we added a microbial extract to each uninoculated pot. For the microbial extract, a volume of inocula equivalent to either the commercial or standardized rate of application was mixed with the same volume of sterile water to make a slurry. The slurry was filtered through a 38 µm sieve at least two times to remove larger particles, followed by being twice filtered through filter paper with 20-25 µm openings, and then finally filtered through filter paper with 5-10 µm openings.

Growing conditions and management: Plants were grown in a randomized complete block design on greenhouse benches at WSU Tri-Cities (Richland, WA). Average temperatures in the greenhouse ranged from a low of 22.8˚C to a high of 32.0˚C and humidity ranged from 16-66%. Supplemental lighting was used to provide a 16-hour day length. An automatic drip irrigation system was used as described in Exp. 1 to reduce the possibility of microbes splashing between treatments and so that vines received equal amounts of water each day. Vines were inspected daily to ensure adequate watering and optimal growing conditions.

Plant growth measurements. Data were collected on vine growth, foliar nutrients, percentage mycorrhizal colonization of roots, and root and shoot biomass. Vine growth measurements were collected every 30 days, including day of planting, for the duration of the experiment. Measurements included shoot length, leaf number, node number, and leaf chlorophyll content. Roots and shoots were separated at the time of harvest and dried for 48 hours at 70˚C prior to recording dry weights.

Plant nutrients: Dried foliar material from six replicates per treatment were sent to a commercial lab to determine foliar nutrient concentrations of N, P, K, S, Ca, Mg, Fe, Mn, B, Zn, Cu, and Na (KUO Testing Labs, Pasco, WA).

Mycorrhizal colonization. Roots were cleared, stained, and assessed for percentage AM fungal colonization, as described for Experiment 1.

Statistical analysis. We used linear mixed effects models to test the effect of mycorrhizal inoculants and rate of application on vine shoot length, shoot biomass, root biomass, root-to-shoot ratio, percentage mycorrhizal colonization of roots, and foliar nutrients. Initial vine weight or height was included as a covariate in each model to account for potential variation in initial size of the vines pre-treatment. Greenhouse block was included as a random effect to account for potential environmental variation. We tested the significance of terms in our linear mixed effects models using ANOVA. Pair-wise contrasts to test the effects of AM fungal inoculants on vine growth and/or tissue nutrients were performed using the 'emmeans' package of R. Tukey adjustments were made to limit type-1 error rate due to α-inflation in the contrast comparisons.

6. **Summary of Major Research Accomplishments and Results by Objective**

In **Experiment 1 (Objective 1)**, we found that young, potted Merlot vines had a stronger growth response to mycorrhizal fungi than young, potted Chardonnay vines, and that the addition of P-fertilizer reduced mycorrhizal colonization in roots from greater than 75% to less than 25% in both cultivars (Cifizzari et al, 2023). The co-amendment of AM fungi and P-fertilizer resulted in greater root biomass for Merlot, but not Chardonnay. Merlot vines grown with the AM fungal inoculant product also had higher tissue P than uninoculated vines, but there was no effect of inoculation on tissue nutrients of Chardonnay. This study provides evidence of grapevine cultivar-specific responses to an AM fungal inoculant product in a greenhouse, which may be useful when planning nursery management strategies for the incorporation of biological amendments into grapevine production.

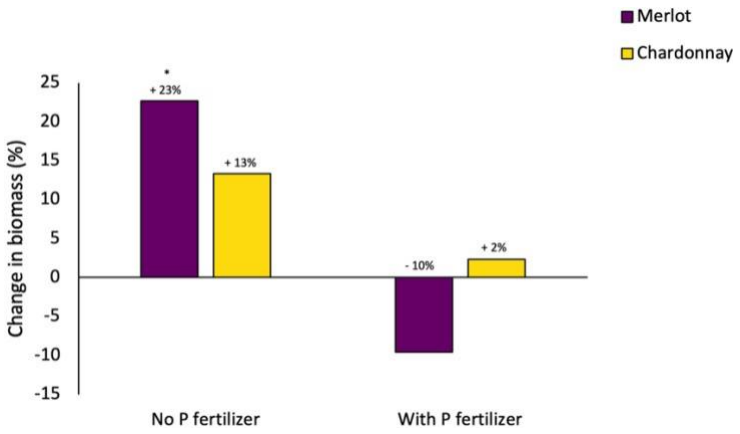

Figure 1. Variation in mycorrhizal growth response (% change in biomass) of young, potted *Vitis vinifera* Merlot (purple) and Chardonnay vines (gold), to an arbuscular mycorrhizal (AM) fungal inoculant product, MycoBloom LLC, without (left) or with (right) the addition of phosphorous (P) fertilizer. The mycorrhizal growth response represents the relative change in aboveground biomass due to the addition of AM fungal inocula in each P fertilizer treatment.

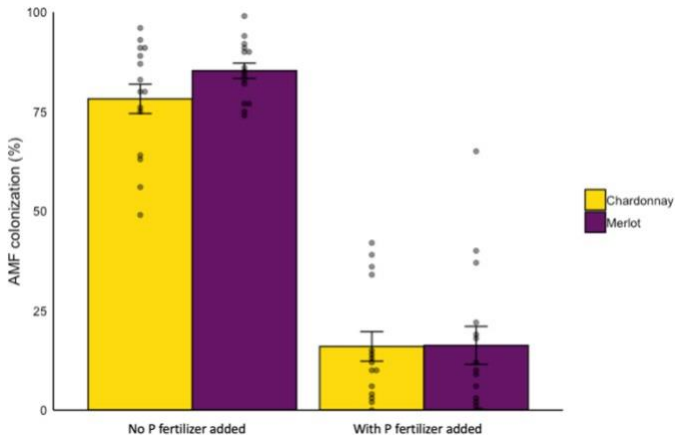

Figure 2. Mean percentage arbuscular mycorrhizal fungal (AMF) colonization for Chardonnay (gold) and Merlot (purple) grapevines grown without the addition of P fertilizer (left) and with the addition of P fertilizer (right). Columns show the mean and standard error and dots within each column show the percentage AMF colonization for individual plants. Uninoculated plants were confirmed to have no AMF colonization in roots via microscopy.

In **Experiment 2 (Objective 2; data analysis currently in progress)**, we tested the effect of three different commercially-available mycorrhizal inoculant products and two locally-collected mycorrhizal inoculants on the growth of young, potted Merlot vines planted into live field soil in a greenhouse experiment. Live field soil was used in Exp. 2 to represent the abiotic and biotic factors that young vines might encounter in a new vineyard planting. We found that adding mycorrhizal fungal inocula, from either a commercially-available product or from locally-collected field soil, at two different application rates, did not improve the growth of young, potted Merlot vines (Fig. 3), nor did it increase mycorrhizal root colonization compared to vines grown in live field soil with no inocula added (Fig. 4). Although the local remnant shrub-steppe soil improved vine growth compared to one of the mycorrhizal products (MycoBloom), neither improved vine growth compared to the uninoculated live field soil (Fig. 3). This suggests that the soil in which new vineyards may be planted in the Inland Northwest may already contain enough viable mycorrhizal propagules to provide sufficient colonization of roots and benefits for wine grape growth (Fig. 4). Thus, the decision to invest the time, resources, and effort into mycorrhizal inoculations during new vineyard establishment may involve the testing of different mycorrhizal products on the cultivar(s) of interest on a small scale, and under different growing conditions (e.g., with and without P-fertilizer, higher or lower water availability) before investing in mycorrhizal inoculants at the vineyard scale. However, it is important to note that our studies were conducted under controlled greenhouse conditions, so results in the field may differ from what we observed under greenhouse conditions, and may also differ among vine cultivars and under different environmental conditions.

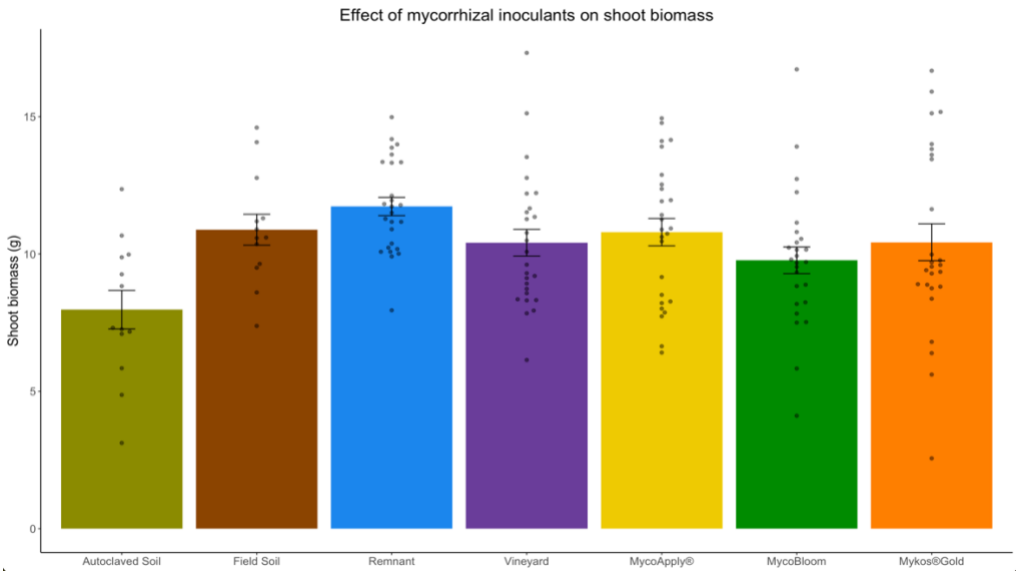

Figure 3. Shoot biomass (g, dry weight) of Merlot inoculated with remnant shrub-steppe soil (blue), vineyard soil (purple), MycoApply® (yellow), MycoBloom (green), and Mykos® Gold (orange) compared to shoot biomass of Merlot grown in autoclaved field soil (olive green) or live field soil (brown). Data show that although all treatments improve shoot growth compared to autoclaved field soil (olive green), none of the inoculants improved vine growth compared to the uninoculated live field soil (brown). Inocula from remnant shrub-steppe soil (blue) increased shoot biomass compared to MycoBloom (green), but neither increased shoot biomass relative to the live field soil (brown). Vine growth was lower in autoclaved field soil (olive green) compared to live field soil (brown) and compared to live field soil with any of the inoculants added (blue, purple, yellow, green, orange).

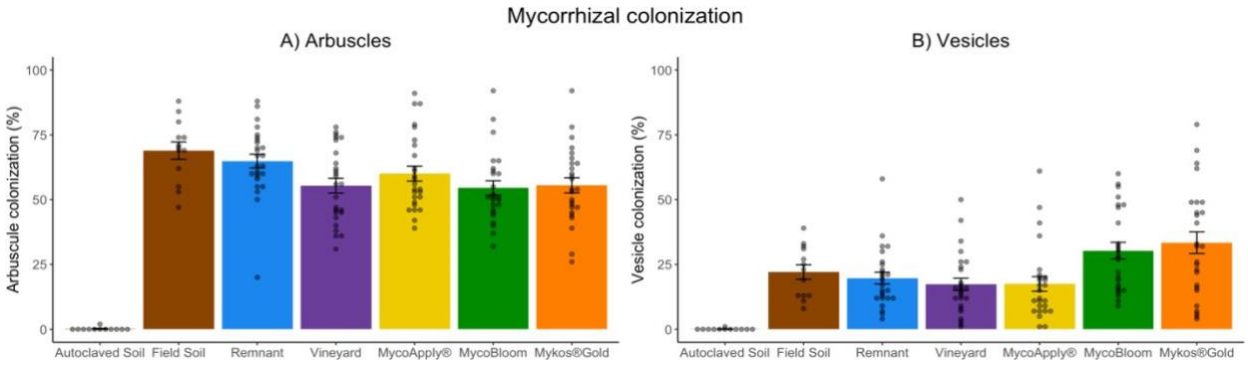

Figure 4. None of the inoculants increased (A) mycorrhizal colonization by arbuscules in Merlot roots compared to the uninoculated field soil (brown). However, (B) vesicle colonization in roots differed between some treatments, e.g., Mykos® Gold had greater colonization by vesicles than MycoApply®, vineyard, or remnant soil inocula. Autoclaved field soil had almost no mycorrhizal colonization, demonstrating successful elimination of resident soil organisms by autoclaving.

7. **Outreach and Education Efforts - Presentations of Research**: Information resulting from this work has been shared with the scientific community and local growers through publication in a Horticulture-specific journal (HortScience), where it was featured as the cover story for the June 2023 issue (Cifizzari et al, 2023). We also shared our results with end-users and stakeholders through articles published in a trade publication, Good Fruit Grower, through a radio interview for the Pacific Northwest Ag Network, WAVE Minute, in a research poster and oral presentation at the WA WineVit conference, and in an invited presentation for WAVE/WAVEx. Results were also shared through a number of other public presentations, including invited talks, conference presentations, symposia, and guest lectures, as well as through media coverage of our research, outlined below. The outreach and education associated with this project also included the training of Viticulture & Enology and Biology students on the WSU Tri-Cities campus.

Publications

2023 Cifizzari, K.C., Moyer, M.M., and T.E. Cheeke. Growth responses of potted *Vitis vinifera* cultivars differ to a mycorrhizal inoculant and phosphorus fertilizer. HortScience. 58(6): 643-650. https://doi.org/10.21273/HORTSCI17114-23 *This article was featured on the cover of the June 2023 issue of HortScience.*

Presentations (*Presenter; Cheeke lab graduate student)

2023 Lueck, M.R.*, Moyer, M.M, and T.E. Cheeke. An evaluation of mycorrhizal inoculants on the growth and foliar nutrient content of European wine grapes (Vitis vinifera) grown in live field soil, Ecological Society of America, Portland, OR, August 6 – 11 (*upcoming*)

2023 Lueck, M.R.*, Moyer, M.M., and T.E. Cheeke. An evaluation of mycorrhizal inoculants on the growth and foliar nutrient content of young grapevines grown in live field soil, Mycological Society of America, Flagstaff, AZ, July 30 – August 2 (*upcoming*)

2022 Lueck, M.R.*, Moyer, M.M., and T.E. Cheeke. An evaluation of mycorrhizal inoculants to inform a greenhouse study using wine grapes. Mycological Society of America, Gainesville, FL, July 10 – 14

2022 Cheeke, T.E.* WAVEx: Soil Inoculants webinar (Invited Speaker, virtual due to COVID)

2022 Lueck, M.R. Invited speaker, Xavier High School, NY, NY, via Zoom

2022 Cifizzari, K.P., Moyer, M.M., Lueck, M.R., and Cheeke, T.E.* Evaluation of mycorrhizal inoculant products and effects on young grapevine development. Soil Ecology Society, Richland, WA, May 17 – 19

2022 Lueck, M.R.* Commercial mycorrhizae: Potential to take root in viticulture. Three Minute Thesis Contest, WSU Tri-Cities, March 9 ******Contest Winner******

2022 Cifizzari, K.P.*, A mycorrhizal inoculant has varied effects on early *Vitis vinifera* 'Merlot' and 'Chardonnay' growth and nutrient uptake, Invited guest lecture, Soil-Plant-Microbial Interactions course, Soil Sci 541, WSU Pullman

2021 Cifizzari, K.P.* Does a mycorrhizal inoculant affect early grapevine growth and nutrient uptake? WineVit conference, Oral presentation, *virtual due to COVID*

2021 Cifizzari, K.P.* Does a mycorrhizal inoculant affect early grapevine growth and nutrient uptake? WineVit conference, Poster submission, *virtual due to COVID*

2021 Cifizzari, K.P.* Arbuscular mycorrhizal fungi may act as a bio fertilizer in grapes. Three Minute Thesis Contest, WSU Tri-Cities

2021 Cifizzari, K.P.* Does a mycorrhizal inoculant affect early grapevine growth and nutrient uptake? Symposium Presentation, WSU School of Biological Sciences

Media coverage

2022 **WSU Magazine**: *It's fungi to the rescue* https://magazine.wsu.edu/2022/10/31/its-fungi-to-the-rescue/

2021 **The Good Fruit Grower:** *Good to Know: Harnessing fungi power, How soil fungi could reduce fertilizer needs and improve grapevine growth* https://www.goodfruit.com/good-to-know-harnessing-fungi-power/

2020 **The Daily Evergreen:** *WSU Tri-Cities researchers use fungi to replace chemical fertilizers* https://dailyevergreen.com/95641/news/wsu-tri-cities-researchers-use-fungi-to-replace-chemical-fertilizers/

2020 **WSU Insider:** *Wine and fungi: The perfect pairing, news article on my wine grape research* https://news.wsu.edu/2020/11/30/wine-fungi-perfect-pairing/

2020 **Pacific Northwest Ag Network, WAVE Minute:** *Relationship Between Wine Health And Soil Health, Radio story highlighting our wine grape research at WSU Tri-Cities* https://www.washingtonagnetwork.com/2020/08/07/wave-minute-relationship-between-wine-health-and-soil-health/

8. **Research Success Statements**: This research benefits the Washington Wine industry by providing critical information about the conditions in which mycorrhizal inoculations may (or may not) benefit grapevine growth in the inland Northwest. In greenhouse experiments, we found that young vine growth response to mycorrhizal fungal inoculation differed among cultivars, fungal inocula sources, and fertilizer treatments. Inoculating young Merlot grapevines improved shoot growth and foliar P, but only when compared to vines grown in autoclaved soil (containing no AM fungi). In contrast, when different mycorrhizal inoculants were added to Merlot vines grown in live field soil, there was no benefit of any of the inoculants tested compared to the use of uninoculated live field soil. Taken together, our results suggest two potential management scenarios: 1) The customized-to-cultivar use of an inoculant in the nursery production stage, and 2) Once in the field, AM fungal inoculations may not be necessary / warranted given resident AM fungi and their ability to colonize grape roots.

Our experiments provided valuable training opportunities for undergraduate students in the Viticulture and Enology and Biology programs at WSU Tri-Cities, and resulted in two Masters Thesis projects for Biology graduate students at WSUTC. Some of the students who worked on this project have gone on to jobs in local wineries, vineyards, and/or have completed their degree in Viticulture and Enology at WSUTC, representing some of the future of the WA Winegrape Industry.

9. **Funds Status**: Include a general summary of how funds were spent.

Mycorrhizal Inoculants On Grapevine Growth Nutrient Uptake	**Expenses**
Salaries and Wages	$ 27,031.94
Purchased Services	$ 3,278.20
Goods and Services	$ 5,348.58
Travel	$ 48.80
Benefits	$ 2,140.48
Grand Total	**$ 37,848.00**