Report Type: Progress

Title: A field evaluation of mycorrhizal inoculants on grapevine growth and nutrient uptake

Principal Investigator(s) and Cooperator(s): PI: Dr. Tanya Cheeke, Assistant Professor, School of Biological Sciences, WSUTC. Cooperator: Dr. Michelle Moyer, Viticulture Extension Specialist, WSU-IAREC.

Abstract: As plant-mycorrhizal fungal interactions are known to be context dependent, a better understanding of the conditions in which mycorrhizal fungi are beneficial to grapevine growth will help to inform vineyard management strategies aimed at incorporating biological inputs and improving agricultural sustainability. In a field experiment at WSU Tri-Cities (WSUTC), my team and I are testing the growth response of Merlot (clone 4) with both self and grafted rootstock (phylloxera-resistant) to arbuscular mycorrhizal fungi (AMF) under different phosphorous (P) conditions. Field plots are arranged in a randomized complete block design with the following treatments: +AMF+P, +AMF-P, -AMF-P, and -AMF+P. Data will be collected on plant growth, leaf and soil nutrients, and mycorrhizal colonization of roots over the course of two years to determine the conditions in which mycorrhizal inoculations are most beneficial to wine grape production. We hypothesize that mycorrhizal fungi will improve growth and leaf nutrient content in both self and grafted Merlot vines and that benefits of AMF will be highest in the no P treatment. This proposal addresses BIOAg priorities aimed at developing biologically-intensive management strategies that are renewable, non-polluting, and mutually beneficial to farmers and society. This study provides research and training opportunities for a Master's student and undergraduate researchers at WSU Tri-Cities.

Project Description: This study addresses BIOAg priorities aimed at developing biologically-intensive management strategies that are renewable, non-polluting, and mutually beneficial to farmers and society by evaluating the conditions in which mycorrhizal fungi are most beneficial to grapevine growth in Washington State. Washington is the second largest producer of wine grapes in the United States, providing a total economic impact of $7 billion. Wine grapes are the 4th largest fruit crop grown in Washington and there are over 59,000 acres of vineyards across the state. One challenge for wine grape growers in Eastern Washington, where many vineyards are located, is that the soils are nutrient-poor, resulting in the need for fertilizer inputs. Increasingly, Washington grape growers are interested in reducing their chemical fertilizer inputs and instead incorporating biological amendments, such as compost, compost tea, and inoculations with beneficial soil organisms, such as mycorrhizal fungi, into their nutrient management regimes. However, data on the potential benefits of mycorrhizal inoculations to wine grape growth under field conditions are lacking.

Arbuscular mycorrhizal fungi (AMF) form symbiotic relationships with roots and benefit plant growth by improving nutrient and water uptake. In a bi-directional exchange, plants provide carbon (C) to mycorrhizal fungi and mycorrhizal fungal hyphae extend the surface area of the root system, increasing plant access to nitrogen, phosphorus (P), and water outside of the root zone. Grapevines can utilize AMF for normal growth and development and inoculations with AMF have been shown to increase shoot length and P uptake in Pinot noir (*Vitis vinifera*) and other grape varieties. Mycorrhizal fungi are most advantageous to plant growth under low-

nutrient conditions, and by acting as a natural fertilizer, may reduce the need for chemical inputs in vineyards. Arbuscular mycorrhizal fungi are also important to soil structure and function, and can increase soil aggregation, contribute to nutrient cycling, and enhance soil C storage. However, standard agricultural management practices such as tillage, pesticides, and chemical fertilizer applications can negatively impact resident mycorrhizal fungal communities in soil. Thus, mycorrhizal fungi may need to be added back into soil periodically through targeted inoculations in order to achieve maximal benefits of this symbiosis in agroecosystems.

While interest in using mycorrhizal inoculants in vineyards is increasing among growers, the benefits of AMF are known to vary among plant genotypes and are also influenced by environmental factors, including soil nutrients, soil type, and agricultural management practices. To optimize the impact of mycorrhizal inoculations on wine grape production in Washington, my team and I are testing growth response of self-rooted and self-grafted Merlot vines to mycorrhizal fungi under different phosphorus conditions in a field experiment at WSU Tri-Cities (Richland, WA). This research builds upon a greenhouse study we recently conducted at WSU Tri-Cities and is the next logical step in understanding the conditions in which mycorrhizal inoculations may positively impact grapevine growth in Washington State. A better understanding of the field conditions in which mycorrhizal fungi would be expected to be most beneficial to grapevine growth will help to optimize vineyard management plans in Washington aimed at incorporating biological inputs, reducing chemical fertilizer costs, and improving agricultural sustainability.

Outputs

Overview of Work Completed and in Progress: We set up a field experiment on the WSU Tri-Cities campus in summer 2020 to test for effects of mycorrhizal inoculation on grapevine growth and nutrient uptake under different P conditions. Because grafting on rootstock will become more common in Washington due to problems associated with phylloxera, we focus on the wine grape variety Merlot, evaluating self-rooted, and rootstock-grafted vines. Plants are currently being grown in field plots (1 x 4 m) with the following treatments: +AMF+P, +AMF- P, -AMF-P, and -AMF+P. Plots are arranged in a randomized complete block design to account for spatial heterogeneity in the field, with five replicates of each treatment, and 3 m aisles between plots and edges to maintain treatment effects (total of 40 plots). Each plot contains seven grape plants, with 0.5 m spacing between each plant and plot edges, for a total of 280 plants in the experiment. At planting, mycorrhizal fungal inocula was added to the root zone of each plant in the +AMF plots. Plants in control plots had the same amount of heat-killed inocula added to their root zones. Phosphorous fertilizer was added to the +P plots at a typical rate used by grape growers in the region (advised by Dr. Moyer, IAREC) and an equivalent amount of water was added to control treatments. Soil samples were collected from each plot before treatments were added and analyzed for baseline nutrient content. Soil samples will be collected again for nutrient analysis at the end of the experiment.

COVID-related impacts: The field experiment was established later than we originally planned due to COVID-related delays associated with accessing campus facilities and equipment, staggered work-schedules, and social distancing, which limited the number of people who could work in a given place at a given time. The delivering nursery also suffered similar delays in planting stock preparations. Because the field experiment was planted in late summer, rather than

in the spring as originally planned, we opted not to collect root and leaf samples at the end of the first growing season as we did not want to stress the young plants before the winter. We plan on collecting our first set of root and leaf samples in late Spring 2021, after the vines emerge from dormancy. We then plan on collecting data on plant growth (e.g., height, leaf chlorophyll content) each month for the duration of the growing season. In late summer/early fall 2021, leaf and root samples will be collected from each plot and analyzed for leaf nutrient content and mycorrhizal colonization of roots. Because of the challenges to our research associated with COVID-related delays, we may delay our final harvest until Fall 2022, rather than harvest plants in Fall 2021 as originally planned. At the end of the experiment, plants will be destructively sampled and roots and shoots will be separated and dried for biomass. Biomass and leaf nutrient data will be used to evaluate potential differences in plant growth response to AMF in different soil P treatments. Results from this research will be used to improve viticulture production efficiency and profitability by optimizing biologically-based nutrient management strategies for vine health and agricultural sustainability.

Methods, Results, and Discussion (discussion for final reports only):

Methods: The field plots at WSUTC were prepared in June 2020 (e.g., tillage, staking out the plots, setting up irrigation, initial soil sampling). Dormant non-rooted cuttings, both self and grafted rootstock (1103P), of the *Vitis vinifera* variety Merlot (clone 4) were obtained from Inland Desert Nursery (Benton City, WA) in July. Plants were rooted in their respective mycorrhizal treatments (MycoBloom or heat-killed inocula) for two weeks in July prior to being transplanted into the field. The mycorrhizal product, MycoBloom was used as the AMF inocula for this experiment because it been shown to improve the growth of perennial plants in >15 peer-reviewed scientific papers and is publicly available for purchase by growers. Data on initial vine height and leaf number were recorded at the time of transplanting into the field. Phosphorous treatments were applied to the +P plots (an equivalent amount of water was applied to the -P plots) after the plants had established. Because we did not want to stress the plants by sampling roots or leaves of the recently-planted vines before winter, qualitative viability data were collected (scale 0-4) on height, health, and appearance of each plant in October 2020.

Results: Because the experiment is still in progress, we do not have any results to report at this time.

Discussion: Not Applicable (for final reports only)

Publications, Handouts, Other Text & Web Products: Because the experiment is still underway, we do not have any publications, handouts, or web products to report at this time. However, this wine grape research project did recently get some coverage in the media:

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

Outreach & Education Activities: This project has provided a Research Assistant position for WSU Master's student, KC Cifizzari and valuable research and training opportunities for five WSU undergraduate students and technicians.

Impacts

- **Short-Term:** Within the first year of the project, this project has provided valuable research training for a graduate student and five undergraduate students/technicians at WSUTC. Because our experiment is located in a prominent position on the WSUTC campus, it has garnered substantial attention from faculty, students, and members of the greater Tri-Cities community and increased the public engagement of this work (see media coverage above). The Master's student on the project will be presenting a poster of their wine grape-mycorrhizal fungal research at the upcoming 2021 WineVit conference.
- **Intermediate-Term:** As this experiment is still underway, we have no intermediate-term impacts to report.
- **Long-Term:** As this experiment is still underway, we have no long-term impacts to report.

Additional funding applied for/secured: I have not applied for additional wine grape research funding at this time. However, with the data obtained upon completion of this field study, I plan to submit a proposal to the Washington State Grape and Wine Research Program to conduct an additional field study to test a cross-section of commercial mycorrhizal inoculants to determine the optimal mycorrhizal product(s) for Washington State wine grape growers.

Graduate students funded: One Master's student at WSUTC has been funded by this research

Recommendations for future research: In the future, I think it would be interesting to conduct a greenhouse rootstock screen to test a cross-section of commercial mycorrhizal inoculants on different wine grape rootstocks and under different nutrient regimes.

Photos of our field experiment can be viewed here:
https://www.flickr.com/photos/wsutricities/albums/72157716632542281
All photos were taken by Maegan Murray, Assistant Director of Marketing and Communication, Washington State University Tri-Cities