AIP – Activity 6: Vineyard irrigation management in the larger context

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2016-17

Most of the objectives for this activity are on track with milestones reached. Objective A2 was adjusted and redirected due to winter damage and virus infection in two field experiments with Merlot and Chardonnay that were to study the interactive effects of irrigation and rootstock variety on vine performance. Both experiments suffered winter damage in 2013 and 2014 and have since been useful in evaluating the influence of rootstock variety on young vine (scion and roostock) hardiness. The experiment with Chardonnay became infected with leaf roll virus (about 25% infection in 2015, 30% infection in 2016) and has been repurposed to study the acquisition and spread of leaf roll disease and its vectors. This study continued through 2016. A new experiment to study the interactive effects of water stress and cluster exposure was added in 2015 in lieu of the loss of Objective A2. The study continued through 2016 and will be repeated and augmented in 2017. Wines were made in fall 2016 and will be evaluated for sensory characteristics in 2018. This experiment provides an excellent opportunity to study the use of remote thermal imaging to assess vine water stress as it includes irrigation treatments and precise measurements of water stress in replicated plots, necessary for ground-truthing stress predictions based on thermal imaging. We have acquired a drone, training/certification, and a thermal (IR) imaging system to embark on this work in 2017. Objective A3, to study the influence of mycorrhizal inoculation on young vine performance, is on track. It produced a new discovery that mycorrhizal infections improve the uptake of nutrients but also affect the root development and branching patterns (architecture) which varies among rootstock varieties. The influence of pre-inoculation of grapevines with commercial mycorrhizae on acquisition of native mycorrhizal infection in the field, and subsequent vine growth, will be studied in 2017. A MSc student, Antreas Pogiatis, has completed his graduate research on this project and will defend his thesis on April 19, 2017.

Objective: A5.1 Determine the long-term effects of irrigation regimes on vine vigor and fruit and wine quality.

Description: Determine whether irrigation regimes developed to conserve water while reducing water stress lead to enhanced fruit and wine quality in Pinot gris.
Outcome: Enhanced knowledge regarding the effects of irrigation and water stress management on vine performance and fruit and wine quality.
Performance Assessment/Variance: The performance is on target. Effects of irrigation regimes on Pinot gris wines have been evaluated and results reported to industry. New wines will be evaluated in 2017.
Objective: A5.2 Optimum irrigation regimes by rootstock.
Description: Determine the effects of irrigation regimes on Merlot and Chardonnay grapevines, own-rooted or grafted onto several commonly grown rootstock varieties, to find regimes that lead to water conservation and improved vineyard performance.
Outcome: Enhanced knowledge regarding the response of rootstocks to irrigation management, to provide insights to industry useful for selecting rootstocks and managing grafted vines to maximize vineyard performance.
Performance Assessment/Variance: Planned experiments with Merlot and Chardonnay scion varieties grafted onto 8 rootstock varieties were initiated in 2013. Both experiments suffered damage and mortality from winter injury, and despite replanting and consolidation of the plantings in 2014, damage in the Merlot experiment was so severe the experiment was halted in 2015. The effects of rootstock variety on the severity of cold injury of buds, stems and roots were assessed in both experiments in 2016-2017. In the Chardonnay experiment, vines became infected with leaf roll virus in 2015 and thorough testing in spring 2015 revealed that 25% of vines were infected, and 30% were found to be infected in 2016. The experiment has been repurposed into a valuable study of the acquisition and spread of leaf roll (LRV3) relative to vector populations.

A new experiment to study the interactive effects of water stress and cluster exposure was added to the activity in lieu of loss of Objective A2 in 2015, and was repeated in 2016. Wines were made from all treatments in fall 2016 and will be evaluated for sensory characteristics in 2018. This experiment provides an excellent opportunity to study the use of remote (drone based) thermal imaging to assess vine water stress. The inclusion of irrigation treatments and precise measurements of water stress in replicated plots of the experiment are necessary for ground-truthing stress predictions based on thermal imaging. We have acquired a drone, flight training/certification, and a thermal (IR) imaging system to embark on this work in 2017.

Objective: A5.3   The value of vineyard soil microbials.
Description: Determine the effects of inoculating grapevine transplants with commercial and locally isolated (native) mycorrhizae. Effects on early and long-term growth of grapevine rootstocks will be determined.
Outcome: Enhanced knowledge of the importance of early mycorrhizal associations in young rootstocks for establishing new vineyards, and whether native versus commercial (non-native spp.)

mycorrhizae are more beneficial.
Performance Assessment/Variance: Project objective is on target. A greenhouse experiment to evaluate commercial vs native mycorrhizae (sampled from local natural soil) was conducted in 2015 which revealed differences in response to commercial vs native mycorrhizae. The plants were transplanted to the field in spring 2016 and their growth response and acquisition of additional mycorrhizae infections from field soil is being evaluated (2016-2017). A UBC MSc student, Antreas Pogiatzis, conducted this research on this project and will defend his thesis in April 2017.
Objective: A5.4 Irrigation with dual systems.
Description: Determine the effects of drip vs drip + micro-irrigation on vineyard performance.
Outcome: Enhanced knowledge of grapevine response to limited/confined (drip) irrigation versus dual irrigation (drip + sprinkler) that leads to an expanded soil wetting pattern to provide water to floor vegetation.
Performance Assessment/Variance: Project objective is on target. The planned experiment to compare crop and floor vegetation responses to drip vs dual irrigation was conducted in 2016 and will continue in 2017. Microclimate mesh monitoring is revealing the effects of irrigation style and cover crop growth on microenvironment temperatures and humidity levels. Assessments of irrigation impacts to vineyard performance (vine growth, yield and fruit quality) will continue in 2017.

A drone and thermal imaging system were acquired to develop a water stress assessment technique for vineyard blocks (see description for Objective A2). The experiment underway for assessing water stress and fruit exposure effects on fruit quality provides an ideal setting for development of this technique.

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This research Activity addressed the larger context of irrigation management in vineyards including: the stability of irrigation regime effects on wine quality; impacts of dual (drip + sprinkler) irrigation systems on grapevine performance; and the potential role of soil microbials in influencing rootstock performance. The Activity also explored and developed new technologies including IR monitoring and drone-based imaging of vineyards to implement precision management techniques.

The benefits of frequent low-volume irrigations to the quality of red wine grapes grown on sandy soils were shown to continue over the longer term. This practice moderates vine water stress and enhances fruit compositional development and wine quality while reducing the total amount of water applied. A lower emitter density that results in deeper penetration of irrigation water was shown to enhance fruit quality for winemaking, but inconsistently. A similar finding of improved wine quality in response to more frequent and deeper irrigations was found for Pinot gris.

A new IR monitoring tool was developed to assess vine water stress and trigger irrigations when excess stress is detected. This tool reduced the irrigated volume applied by 50% to 75%, compared to standard deficit irrigation, without loss vineyard performance.

Floor vegetation management is key to achieving a balanced ecology in vineyards and for minimizing pest outbreaks and need for chemical controls. Most cover crops require irrigation in amounts and timings unsuitable for grapevines. Sprinkler irrigation is most suitable for cover crop maintenance but cools and humidifies the vineyard microclimate, promotes excess vine vigor resulting in poor quality fruit with delayed maturation, and increases disease outbreaks. Drip irrigation, on the other hand, is ideal for irrigating grapevines but does not support cover crops. Combining drip and micro-jet sprinkler irrigation, operated separately to service grapevines and cover crops, was shown to be effective for maintaining cover crops and improving wine grape quality and maturation compared with using sprinkler irrigation alone. Drone-captured IR emission and RBG reflectance imaging of vineyard floor vegetation revealed differences in species coverage and in floor temperature caused by transpirational cooling, in response to the irrigation regimes.

New research initiated on drone based IR imaging to assess spatial variation in vineyard water stress revealed the potential for developing this tool for precision irrigation management. Experiments that included controlled irrigation treatments and coordinated measurements of vine water stress provided an opportunity to calibrate and ground-truth data so that water stress variations could be assessed using thermal images.

The capture of hypospectral images of vineyard blocks at low elevation allowed for ultra-high resolution assessment of leaf spectral signatures, and verified the potential to assess the stress and health of individual grapevine leaves. These are important accomplishments for initiating new research on developing drone-based imaging tools for precision management of irrigation and nutrition in vineyards.

Arbuscular mycorrhizal fungi (AMF) infections of young grapevines were shown not only to improve nutrient uptake but also to affect root development and branching patterns. These effects on root architecture varied among rootstock cultivars. In another study, inoculation of young rootstock plants with commercial AMF products was not superior to inoculation with a mixed microbial inoculum derived from a local soil. This finding indicated there is little value of using commercial biofertilizers in grapevine nurseries.

The composition of natural soil microbial communities was shown to vary with environmental conditions in the Okanagan Valley, and to shift in response to vineyard management practices. These findings indicate that the services provided by soil microbials can be altered by cultural management choices.

The demonstration of ultra-high resolution hyperspectral images capture using a drone-based system revealed the potential for developing leaf hyperspectral signatures for diagnosing a range of vineyard stressors including water and nutrient stress and disease infections.

This research Activity addressed the larger context of vineyard irrigation management that encompasses a major industry goal to improve vineyard sustainability by maintaining a balanced vineyard ecology while conserving resources. The research focused on understanding and preserving the ecological services provided by floor vegetation and soil microbials, and ensuring that newly developed irrigation practices continue to improve fruit quality for the long term. The Activity also explored and developed new technologies including IR monitoring and drone-based imaging (remote sensing) in vineyards to implement precision irrigation management for improving fruit quality while conserving water.

6.1 Long-term effects of irrigation regimes on vine vigor and fruit and wine quality.
This objective was focused on refining irrigation regimes to improve fruit and wine quality. A 3-year experiment had been conducted with Merlot that included irrigation at two rates and two frequencies, and with emitter densities of 1-3 emitters/vine. Wines were evaluated for sensory characteristics including flavour and aroma intensities and mouthfeel characteristics. The lower irrigation rate (more intense deficit) produced wines with more fruit aroma, less floral and spice aromas, and less herbaceous flavour. The high-frequency irrigation regime produced wines with more intense black fruit flavour, and more body and aftertaste. Using only one rather than three emitters per vine to increase the irrigation penetration depth, increased the black fruit aroma and reduced the floral aroma of wines, but these effects were not consistent. Overall these results support using high-frequency low-volume irrigations, applied using one emitter/vine. These findings are consistent with our previous work and recommendations for producing red wine grapes on sandy soils. A similar experiment was conducted with Pinot gris and found improved wine flavour and body in response to higher-frequency and deeper (fewer emitters) irrigations. Sensory evaluation of the second year Pinot gris wines is pending as new wines needed to be made in 2017.

Irrigation experiments were initiated with Chardonnay and Merlot on several rootstocks to study the long term effects of irrigation regimes on vineyard performance and wine quality. These experiments were suspended due to cold damage in the year after planting (Merlot and Chardonnay) and infection by leaf roll virus (Chardonnay), but were reutilized for Activities devoted to research on leafroll virus (Activity 3) and hardiness (Activity 5) as described below. In lieu of the planned work we initiated new research on the development and application of IR monitoring and drone-based imaging tools for precision management of irrigation.

6.2 Optimum irrigation regimes by rootstock.

This objective was focused on the interactive effects of rootstocks and irrigation on grapevine physiology and fruiting performance. The experiments were initiated with Merlot and Chardonnay, self-rooted and grafted onto eight commonly grown rootstock varieties, to find regimes that lead to water conservation and improved vineyard performance over the long term. These large experiments were initiated in 2013 in commercial vineyards. Both experiments suffered damage and mortality from winter injury in winter 2013-2014, and despite replanting and consolidation of the plantings in 2014, cold damage in the Merlot experiment re-occurred and was so severe the experiment was halted in 2015. Effects of rootstock variety on cold injury severity was assessed in both experiments in 2016-2017. In the Chardonnay experiment, vines became infected with leafroll virus 3 (LRV3) in 2015 and thorough testing revealed infection increasing from 15% in 2015 to 30% in 2016 and 40% in 2017. The experiment was unsuitable for the planned irrigation research and repurposed to study of the acquisition and spread of LRV3 relative to vector populations. In 2017 the LRV3 infected block was used for drone based hyperspectral imaging to develop a spectral signature for LRV3 infection for diagnostics. This new work is described in the report for Activity 3.

In 2015 a new experiment to study the interactive effects of water stress and cluster exposure was added to the Activity in lieu of loss of the Merlot and Chardonnay on rootstocks plantings, and was repeated in 2016 and 2017. Wines were made from all treatments in fall 2016 and will be ready for evaluation for sensory characteristics in 2018. This experiment provided an opportunity to study the use of remote (drone based) thermal imaging to assess grapevine water stress in 2017. The inclusion of irrigation treatments and precise measurements of water stress in replicated plots enabled development of ground-truthing for stress predictions based on thermal imaging. Using our drone and thermal (IR) imaging systems we conducted initial ground-truthing and calibration in 2017. This work will continue in a new project planned for initiation in 2018.

6.3 The value of vineyard soil microbes.

This objective was focused on the role of soil microbial communities in vineyard ecosystems and their influences on grapevine performance. The first study characterized the soil microbial communities found in vineyards and natural sites throughout the Okanagan Valley, and demonstrated that the communities have evolved in response to site conditions including climate, soil texture and chemistry, and native plant communities. Comparing microbial communities in vineyards with those in nearby natural sites showed that vineyard management practices shift the structure of soil microbial communities which likely affects resource availability to plants including grapevines and cover crops.

The second study compared the effects of locally sourced soil microbial inocula with two commercial arbuscular mycorrhizal fungi (AMF) inocula on root colonization and early growth and physiology of grapevine rootstocks Riparia Gloire, 101-14 Mgt and SO4. Mycorrhizal colonization ranged widely among inocula with the highest rate from one of the commercial inocula followed by a locally collected inoculum composed of native-plant root fragments, and poor or no colonization by another commercial inoculum and locally collected mycorrhizal spores. Colonization affected SO4 vine characteristics, especially leaf greenness, which increased in response to a commercial and a locally sourced inocula. Greater growth (root biomass, shoot biomass and shoot length) was observed in Riparia Gloire and 101-14 Mgt vines inoculated with the locally sourced compared to the commercial inoculum. The inconsistency of effects among rootstocks and inocula tested illustrates the unpredictability of this symbiosis, and does not support the use of commercial AMF biofertizers in grapevine nurseries.

The third study characterized the effects of AMF infection on the growth and development of six grapevine rootstock varieties: Salt Creek, 3309, Riparia Gloire, 101-14, Schwartzmann and 5C. Root architecture (branching angles and patterns) was altered by AMF infection and the effects differed among rootstock varieties. This finding implies that management practices, such as irrigation and fertilization, that affect AMF communities and infection can influence grapevine rooting depth and branching intensity (proliferation). This study formed the thesis research of UBC MSc student, Antreas Pogiatzis, who defended his thesis in June 2017.

6.4 Irrigation with dual systems.

This objective was focused on the refining irrigation management to optimize water supplied to grapevines and cover crops in vineyards. Although sprinkler irrigation is effective for cover crop maintenance it cools and humidifies the vineyard microclimate and promotes excess vine vigor resulting in delayed fruit maturation, poor quality fruit, and increased disease outbreaks. Drip irrigation, while ideal for irrigating grapevines but does not support cover crops. A study was conducted to compare vineyard performance in response drip irrigation, sprinkler micro-jet irrigation, and a combination of both techniques operated separately to service the water requirements grapevines and cover crops. Drip combined with micro-jet irrigation was verified to be effective for maintaining cover crops and improving wine grape quality and maturation when compared with using sprinkler irrigation alone.

Drone-captured IR emission and RBG reflectance images of vineyard floor vegetation revealed differences in species coverage and transpirational cooling in response to the irrigation regimes.