OMAFRA Final Report to Ontario Grape and Wine Research Inc.

Project #: 002500

Project Title: Improving Potassium Recommendations in Ontario Vineyards

Pillar #

Kathryn Carter, and Dr. Tejendra Chapagain, OMAFRA. Final Report (Due March 31, 2022)

Reporting Period: September 30, 2021 to March 31, 2022 (Year 3)

Date of Submission: March 31, 2022

Program Coordinator: Darien Temprile

2. Executive Summary (in layman's terms – 1 page maximum)

This three-year project has focused on improving potassium recommendations in Ontario vineyards. Potassium (K) plays an important role in vineyards, with K deficiency resulting in negative impacts on vigour, yields and fruit ripening. Excessive K can result in deficiencies in other nutrients in the vineyard (e.g., Calcium and Magnesium) and has a negative impact on wine quality resulting in increased pH and a shorter shelf life of wines. Monitoring potassium levels in the vineyard is important for ensuring vine health, fruit quality and yields.

OMAFRA guidelines suggest soil sampling vineyards every 2 to 3 years (0 to 15 cm depth) for K, in conjunction with annual petiole analysis at veraison. However, previous research by Heck et al. (2014; Unpublished) found a poor relationship between soil sampling at 0-15 cm depth and petiole K at veraison, in some soil types (medium soils). Researchers found that soil sampling at a greater depth (15 to 30 cm or 0 to 15+ 15 to 30) provided a better relationship between K levels in medium textured soils and petiole K. As a result, Heck et al, proposed the need for further research to determine if Ontario guidelines for monitoring K levels in vineyards can be improved to optimize fertilizer applications resulting in economic and environmental benefits.

The objective of this project was to refine the use of soil testing and petiole analysis as tools for making K management decisions. Soil (0 to 15 cm, 15 to 30 cm, and 0 to 30 cm), tissue (petiole and leaf blade at bloom and veraison) and juice samples were collected from four vineyards over three years.

Unlike Heck et al. (2014; Unpublished), this study showed that there is a significant correlation between soil test K from 0 to 15 cm depth with petiole and leaf blade K concentrations at veraison. In fact, petiole K concentrations were more significantly correlated to soil K from 0 to 15 cm depth compared to leaf blade K concentrations. This supports OMAFRA's guideline to use 0 to 15 cm soil samples along with petiole analysis at veraison for determining nutrient needs in vineyards.

This study further demonstrated that petiole K and leaf blade K at veraison were also correlated with soil K from 15-30 cm depth. For the 0 to 30 cm soil samples, only the

leaf blades were correlated to soil K, indicating that leaf blade analysis may be a better tool for monitoring K levels in mature vineyards with deeper roots. No significant correlation between K levels in soil (0 to 15, 15 to 30 or 0 to 30 cm) and K concentration in petioles at bloom was found. Suggesting that bloom petiole sampling does not provide an accurate method of determining K fertilizer needs in vineyards.

Although bud hardiness was monitored at all blocks throughout the trial, there was insufficient data to determine if K levels in petioles at bloom or veraison impacted bud hardiness, as only one site had low potassium levels throughout the project.

This study found a positive association between petiole K at bloom and yields. There was no relationship between yields and soil K or tissue K (petioles and leaf blades) at veraison.

Juice potassium level was significantly and positively associated with petiole K at veraison indicating that petiole sampling at veraison may provide an opportunity to predict K levels in the fruit juice at harvest. Also, findings indicated juice K and pH were moderately (and positively) associated (i.e., as juice K levels increased, there was a corresponding increase in pH of the juice).

3. Detailed Description of the Project

a) Objectives and Project Input (anticipated and actual)

Identify project objectives (anticipated vs actual) • Identify project inputs i.e. funding level, staff resources, cash and in-kind contributions and other resources utilized towards the completion of the project

Project Objectives

- To refine the use of soil testing and petiole analysis as tools for making potassium management decisions
- To evaluate the relationship between sampling time (bloom vs veraison), tissue (petiole vs leaf blade) and soil depth (0 to 15 cm, 15 to 30 cm and 0 to 30 cm)
- To determine if petiole K determined at bloom or veraison can adequately predict the potential for bud sensitivity to winter injury
- To determine if soil K and petiole K at bloom or veraison can predict K levels in juice
- To determine the potential relationship between petiole K and leaf blade K and yields
- To measure soil health parameters in vineyards and evaluate its impact on soil and petiole K levels.

Project Inputs

During the course of the three-year project, OMAFRA staff worked with summer students (OMAFRA funded and OGWRI funded) to collect field data. Data was analyzed over the winter, and the project was amended on a year-to-year basis, based on test results. OMAFRA collaborated with another researcher (Christoph Kessel) throughout

the project, to ensure the project remained on track. SGS laboratory provided a reduced rate for lab analysis for OMAFRA, and this was included as in-kind support for the project. Brewster Consulting Inc. provided bud hardiness analysis of samples.

b) Project Activities and Outputs

Identify key activities undertaken to achieve the project objectives • Link key activities with defined milestone schedule • Identify the activities in measurable and quantifiable terms

Baseline soil and tissue data were collected in 2019 from each of the four sites involved with this study. This information was then used to develop fertilizer recommendations for 2020.

In 2020 and 2021, each site was split into two blocks/treatments: 1) grower standard (yellow), and 2) OMAFRA recommended treatments (blue and white). Growers were asked to apply their regular fertilizer treatments on the yellow block but were asked to avoid applying nutrients to the blue blocks which were monitored and maintained by OMAFRA. Although many of the sites did not apply K to the OMAFRA treatments, there were some sites that applied manure (site 3) or accidentally applied fertilizer to the OMAFRA blocks (i.e., site 1). Although this was not optimal, and it did not affect our ability to collect and interpret data.

Soil and plant tissue samples taken from each block in each vineyard from 2019-2021 included:

- **Bloom**: petiole and soil sampling (0 to 15 cm, 15 to 30 cm and 0 to 30 cm depths) (June)
- **Veraison**: petiole and leaf blade analysis to determine petiole K and leaf blade K (August)
- **Harvest**: Yield assessments were conducted on 10 vines in each block (# of clusters per vine and weight of clusters per vine). A sample of 100 berries was collected from each treatment and send to CCOVI labs for analysis for Brix, pH, TA and K (September/October).
- **Bud hardiness**: Samples were collected by OMAFRA in February and submitted to Brewster Consulting Services Inc. for analysis.
- **Soil Health:** Soil samples were collected from each vineyard in 2020 and sent to A and L labs to analyze using the VitTellus soil health test.

Fertilizer treatments in OMAFRA blocks

OMAFRA monitored nutrient levels in vines and soil throughout the project. These sites were selected from the research initially conducted by Heck et al. (2014) due to their soil properties. However, it became apparent after the first year of testing that nutrient levels had changed since the original project (Table 1.0).

Table 1.0 Potassium (K) levels in soil (0 to 15 cm depth) and Petioles (%K) in 2013 and 2019.

Site	Soil K		Tissue K	
	2013	2019	2013	2019
Site 1 (Chardonnay)	Low	High	Low	High
Site 2 (Chardonnay)	Low	Low	High	High
Site 3 (Pinot Noir)	High	Low	Low	High
Site 4 (Chardonnay)	High	Low	High	High

Low soil K <150 ppm, Low %K petiole <1.2% K
High soil K >150 ppm, High %K petiole >1.2% K

Since K concentrations in petioles were adequate in 2019 at all 4 sites, there was no need to apply supplemental K in 2020. The decision was made to split each site into 2 blocks (OMAFRA and grower managed) and to continue to monitor potassium levels in soils and tissue in each block separately. The results of petiole analysis at veraison in 2020 indicated that site 2 had low levels of soil K and petiole K at veraison and as a result OMAFRA applied 9.3 kg of Muriate of Potash (MOP)/252 vines by hand (banding) in June 2021. Site 4 also received 9.5 kg of MOP/630 vines in June based on soil test results from 2020 which showed low soil K despite acceptable petiole K concentrations at veraison (see Appendix 1).

Soil health assessments were conducted at each vineyard site in 2020.

Table 02. Milestone and Activity update as of 2022.

Milestone Name	Milestone Description	Expected Outcome, Results of the Project and Proposed Deliverable	How will Success be Measured for each of the Milestones	Start Date	Completion Date	Status Update March 2021
One-Setting up Grower sites	Confirm four cooperating vineyards for participation for the three-year project.	Vineyard site selection based on previous project and will have one vineyard representing one of the following scenarios: 1) low soil test potassium (STK) and low % petiole K; 2) low soil K and high petiole K; 3) high soil K and high petiole K; and 4) high soil K and low petiole K	Vineyard co-operators will be set up for data collection to start in spring 2019. Sampling continues in 2020 and 2021.	May 1, 2019	June 1, 2019	Completed
Two- annual soil, petiole and leaf blade sampling	Soil, leaf blade (veraison) and petiole (bloom, veraison) samples will be collected from the 4 vineyard sites on an annual basis by OMAFRA staff.	Evaluating the relationship between: (1) soil sampling depth and tissue by completing soil (0-15 cm) texture and complete analysis, basic soil analysis completed on 15 to30 and 0 to 30 cm soil sample, and complete analysis on petioles and leaf blades; (2) K in petiole and blade sampled at veraison and winter bud hardiness; and (3) K in petiole and blade sampled at veraison and juice quality. Effect of K management practices assessed by dividing vineyard in half for two different K applications.	The data collected from all sites and submitted to laboratories for analysis. Analyses will be completed, and results received.	June 1, 2019	October 31, 2021	Completed
Three - Soil health	Soil samples (soil health) will be collected from the four vineyard sites in 2019 by OMAFRA staff.	Evaluating the relationship between soil health and the relationship between petiole K and soil K.	The soil samples will be collected from all sites and submitted to A and L laboratories for Solvita soil health analysis. Analyses will be completed, and results received.	June 1, 2019	October 31, 2021	Completed

Milestone Name	Milestone Description	Expected Outcome, Results of the Project and Proposed Deliverable	How will Success be Measured for each of the Milestones	Start Date	Completion Date	Status Update March 2021
Four-Bud hardiness evaluations	Evaluating the impact of potassium levels in the vine on bud hardiness.	To assess the relationship between winter bud hardiness and K in petiole and leaf blade, in January 2020 OMAFRA will collect six cane samples from each of the four vineyard sites and in January 2021 12 canes will be collected from each vineyard, six from each potassium treatment. Brewster Consulting Services (BCS) will provide training on vine and cane selection and number of canes required to sample's the bud hardiness of the samples and provide a report summarizing the results. Relationship between bud winter hardiness and plant tissue K will be assessed.	BCS will provide bud hardiness data to OMAFRA by May 2019 and March 2021.	January 1, 2020	May 1, 2021	Completed. Unfortunately we missed sampling in two vineyards, as they pruned the vineyards over the Christmas break.
Five- Juice and yield Analysis	Evaluating the impact of K levels on juice quality and yield.	To assess the relationship between juice quality, yield, K levels in petiole and leaf blades.	SGS will provide a report summarizing the results of the tissue analysis by November. CCOVI will provide juice analysis.	September, 2019	December 1, 2022	Completed
Six- Statistical analysis	Statistical analysis will be conducted on the data.	OMAFRA will provide laboratory analysis of the results to Dr. Richard Heck. Dr. Heck will arrange for analysis of the data and will work with OMAFRA staff to interpret the results of the data.	Dr. Heck was unavailable, and C. Kessel retired from OMAFRA in 2020. As a result, data were analyzed by new soil fertility specialist Dr. T. Chapagain (replacement of C. Kessel). Christoph Kessel assisted with interpreting the results of the data analysis.	September 1, 2019	March 31, 2022	Completed with the assistance of Christoph Kessel
Seven- Knowledge Translation and Transfer Activities	Dissemination of the preliminary results of the trial to grower co-operators. Dissemination of the results of the trial to Ontario Grape Growers.	OMAFRA will provide all grower co-operators with a summary of their soil and petiole analysis in January 2020, 2021 and 2022. Grower co-operators will be invited to a conference call to ask questions or discuss the preliminary results of the project. OMAFRA will present the results of the research project annually at grape grower meetings. OMAFRA will also prepare newsletter articles summarizing the results of the project.	A minimum of one oral presentation and one newsletter article (GGO newsletter) will be prepared in 2020 and 2021.A final report will be prepared and will be posted on the GGO website.	January 1, 2020	March 1, 2022	Each grower co-operator has received their soil and tissue analysis throughout the project. In March, a newsletter article was posted on the ON Fruit blog summarizing the results of the project to date. A presentation summarizing the results was made at OFVC in February 2022.

c) Reach and Communication

Identify the primary target audience/beneficiaries of the project i.e. agricultural producers, consumers, youth, farm families, rural Canadians, food processors, educators • Please indicate the total number of people reached (If project involves workshops/seminars, please indicate how many attended each event) • Indicate how the targeted audience/beneficiaries were reached i.e. research publications, seminars, press releases, promotional material. Please include samples of any communications material developed for the project and indicate the number printed/distributed • Indicate when OGWRI was identified as a supporter throughout the period of the project

The findings of this project will benefit grape growers and wineries across Ontario by providing a better understanding of the relationship between soil and/or plant tissue K and juice K concentrations. The information collected from this trial will be used to refine OMAFRA's guidelines for monitoring K concentrations in soil and tissue in vineyards. This information will help growers improve K monitoring in vineyards which will result in improved yields and fruit quality. Optimizing monitoring for K levels in vines may result in economic savings through reduced fertilizer use. The data collected on soil health in vineyards will benefit researchers and extension personnel in developing tools to monitor soil health in Ontario vineyards.

The results of this project were presented at the 2022 Ontario Fruit and Vegetable Convention (OFVC), and OGWRI funding was recognized in the acknowledgements. The presentation recording has been posted on the OFVC website. An article summarizing the results of the research and acknowledging the funding from OGWRI was posted on the ONFruit blog in March 2022 and will be provided to the Grape Growers of Ontario (GGO) to include in upcoming newsletters (which reaches their 500 members).

A copy of the newsletter article summarizing this research (Appendix 2) as well as a pdf of the presentation are provided along with this report.

4. Project Outcomes (actual vs. expected) at short and long-term

a) Short-term

Outline the actual short-term outcome compared to the expected

Identify the public good/benefit of the project

Relationship between tissue (petiole and leaf blade) and timing of sampling (bloom and veraison) and soil K

This study found that there was a significant relationship between soil K (0-15 cm) and petiole K and leaf blade K at veraison in medium soils. With petiole K at veraison more

significantly correlated with soil K from 0-15 cm depth as compared to leaf blade K. These results support OMAFRA's current guideline for soil sampling at the 0 to 15 cm along with petiole analysis at veraison to determine nutrient levels for vineyards.

This study demonstrated that leaf blade K at veraison was more correlated with soil K from 15 to 30 cm depth. For the 0 to 30 cm soil samples, only the leaf blade K was correlated to soil K demonstrating that leaf blade analysis is an effective tool for monitoring K levels at greater depths (i.e., 15-30 cm and 0-30 cm) in mature vineyards with deeper roots (Appendix 1).

We also observed that the relationship between soil K (at all depths) and petiole K at bloom were poor. Indicating that bloom petiole sampling is not a good indicator of K levels in the vine. In comparison, tissue sampling at veraison (petiole and leaf blade) was significantly correlated to soil K levels, indicating that this is the best timing for monitoring K levels in the vine. As a result, OMAFRA should not consider amending existing recommendations to include bloom petiole sampling, as it may underestimate K levels in the vine resulting in unneeded applications of K fertilizers.

Bud hardiness

Although bud hardiness was monitored at all of the blocks throughout the trial, the majority of the blocks had high K levels, so we had insufficient data to determine if low K levels in petioles at bloom or veraison impacted bud hardiness (Appendix 3).

Juice

Juice K levels were significantly and positively associated with petiole K at veraison indicating that petiole sampling at veraison may help to predict K levels in the fruit at harvest. There was a moderate association between juice K and leaf blade K at veraison ($r^2 = 0.28$) although it was not statistically significant. There was no association between juice K with petiole K at bloom (Appendix 4).

Also, juice K and pH was significantly (positively) associated (i.e., as juice K levels increased, there was a corresponding increase in pH of the juice). At all sites in all three years of the project, we saw high K levels in juice (1,056 – 2,776 mg/L K+) based on thresholds developed in other areas (Somers, 1975).

Yields

This study found a positive association between petiole K at bloom and yields (Appendix 5). There was no relationship between yields and soil K or tissue K (petioles and leaf blades) at veraison.

Soil Health

The A&L Labs Vitellus soil health test was conducted on a composite 0 to 15 cm soil sample from each of the vineyard sites in 2020 (Appendix 6). The science of soil health testing is relatively new and still developing as soil health indicators are evaluated. Researchers are also working on interpretation of the results of soil health tests. The ratings provided (low/medium/good/high) are based on A&L Lab interpretations and research conducted primarily in field crops such as grain corn. Due to lack of thresholds for horticultural crops, it is difficult to make any conclusions about the impact of soil K levels on soil health in vineyards. The soil health data collected thus far does provide an excellent baseline for soil health data in the cooperating vineyards. The general consensus is that due to variability in soil types between vineyards and the difference in sample timing, soil health should be evaluated on a site-by-site basis over time in relation to the production practices used. As a result, it is impossible to compare the soil health from one vineyard to another.

Soil health changes over time, generally not within a season or even a year or two. We hope to apply for funding in five years to return to these sites and re-evaluate soil health, to determine the potential impact of horticultural practices on soil health in vineyards. In the meantime, OMAFRA plans to conduct additional sampling and soil health evaluation with the Soil Health and Assessment Plan (SHAP) suite of indicators at these sites in the spring of 2022. The science of soil health indicators is still very much in the development stage, and the data collected will assist in evaluating the SHAP indicators in a perennial production system. This information will be used in the future to develop guidelines on soil health for Ontario vineyards.

Identify the public good/benefit of the project

This project provides a better understanding of the optimal methods (petiole vs leaf blade) and timing (bloom vs veraison) for sampling K in vineyards, allowing growers to optimize their fertilizer programs and reduce unnecessary fertilizer use. Results suggest that sampling petioles at veraison provides a better understanding of the relationship between soil K (0 to 15 cm) and petiole K. These result support OMAFRA's current recommendations for monitoring K in vineyards.

However, sampling leaf blades at veraison correlated better with soil K at greater depths (15-30 and 0 to 30) Suggesting that leaf blade analysis might be an effective tool for monitoring K levels in mature vineyards with deeper roots. Sampling for K at bloom

would provide inaccurate results and may lead growers to apply higher rates of K then needed (Appendix 1).

The data suggests petiole K at veraison correlates with K levels in the grape juice. This suggests that in sites where wineries are concerned about K levels in grape juice, there may be some benefits to monitoring K in petioles at veraison as they may help predict high K levels in juice, which could require remediation in the winery.

Refining K monitoring in vineyards can potentially allow growers to reduce fertilizer use resulting in economic benefits to growers and the environment.

If applicable to the project, please include the following information:
• Policy dialogue: Project must indicate if, as a result of the project undertaken, the current or emerging issue has been redefined. Explain and provide a revised description of the policy issue.

b) Long Term

OMAFRA will incorporate the results of this trial into the soil and plant tissue sampling recommendations listed at the Soil Management, Fertilizer Use, Crop Nutrition and Cover Crops for Fruit Production (gov.on.ca). Site-specific impact on soil health over time will be observed (pending funding approval).

• Indicate the key indicators you will be using to measure the project success in the long-term. Please indicate where applicable:
o The number of jobs created
o Increased sales
o Increased use of Ontario products
o Increased yield or production of Ontario products
o Any other indicators outlined in milestone schedule

It is anticipated that the findings of this project will help increase efficiency of K fertilizer application in Ontario vineyards by following the recommended time and plant parts for plant tissue sampling. These indicators further improve yield and quality of wine, and reduce unneeded applications of K.

5. Final Comments and Conclusions

- **Identify any deviations from the project workplan, budget or schedule and discuss the effects of the deviations and the solutions**
- **Provide a discussion of "lesions learned", recommendations and overall perception of project success**

Potassium levels at the sites (soil and vines) had changed since Heck et al (2014, Unpublished), and as a result we had fewer sites with low potassium levels which delayed the need for K fertilizer applications accordingly.

Previous studies indicated that 0 to 15 cm soil samples did not provide a good indication of K levels in the vine, however, our results found a good relationship supporting the existing protocol (i.e., soil sampling at the 0 to 15 cm along with petiole analysis at veraison) for K monitoring in vineyards. The results of this study also found that soil sampling at 15 to 30 and 0 to 30 cm did not result in a better understanding of the relationship between soil and petiole K.

However, this study demonstrated that leaf blades K at veraison were correlated with soil K from 15 to 30 cm depth. For the 0 to 30 cm soil samples, only the leaf blade K were correlated to soil K. These results suggest that leaf blade analysis could also be an effective tool for monitoring K levels in mature vineyards with deeper roots. OMAFRA will incorporate this result into the soil and plant tissue sampling recommendations.

Above all, this trial found that monitoring K levels in the vine (petioles or leaf blades) at veraison provides a better relationship between K levels in the soil and vine than sampling at bloom. As a result, OMAFRA will not be recommending bloom sampling for monitoring K in vineyards. Having said that, it is important to note that there was a positive association between petiole K at bloom and yield indicating that petiole K at bloom may give an idea about yields, but petiole K was not associated with soil K.

At sites where there are concerns about high levels of K in juice, it may be beneficial for growers to conduct petiole sampling at veraison, to obtain a better understanding of the risk for high levels of K in juice. Future research may look at developing threshold for K levels in the vine to indicate the risk of high K in juice which may result in the need for remediation in the winery.

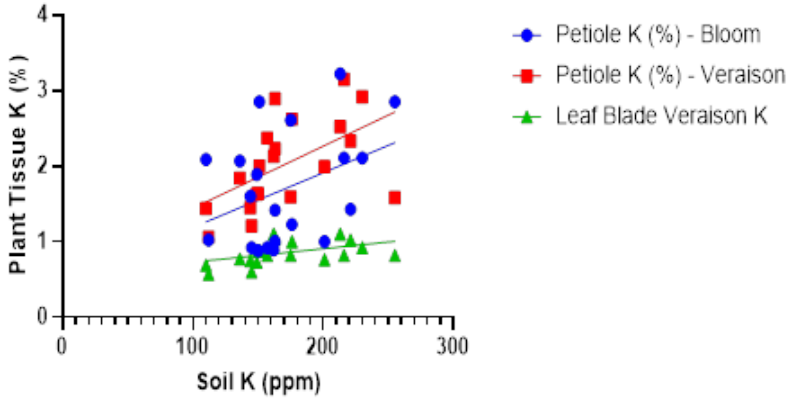
Reference:

Heck, R., C. Kessel, K. Carter. (2014) Potassium fixation and availability in the dominant vineyard soils of the Niagara Region to improve soil potassium fertilizer application guidelines. Unpublished.

Somers, T.C. (1975) In search of quality for red wines. Food Technology in Australia. 27:49-56.

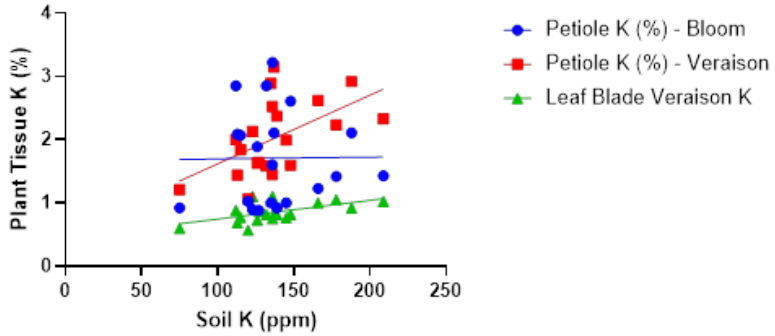
Appendix 1: Association between soil K at different depths with K in petioles and leaf blades (2019-2021).

Association between soil K (0-15) and plant tissue K from 2019-21



Petiole K Bloom: r = 0.38; r^2 = 0.14; y = 0.007239x + 0.4644
Petiole K Veraison: r = 0.54; r^2 = 0.30; y = 0.008218x + 0.6206
Leaf Blade K Veraison: r = 0.45; r^2 = 0.20; y = 0.001779x + 0.5510
Note: Soil K <150 ppm is considered to be low

Association between soil K (15-30cm) and plant tissue K from 2019-21



Petiole K Bloom: r = 0.01; r^2 = 0.00; y = 0.0002658x + 1.669

Petiole K Veraison: r = 0.54; r^2 = 0.30; y = 0.01086x + 0.5312

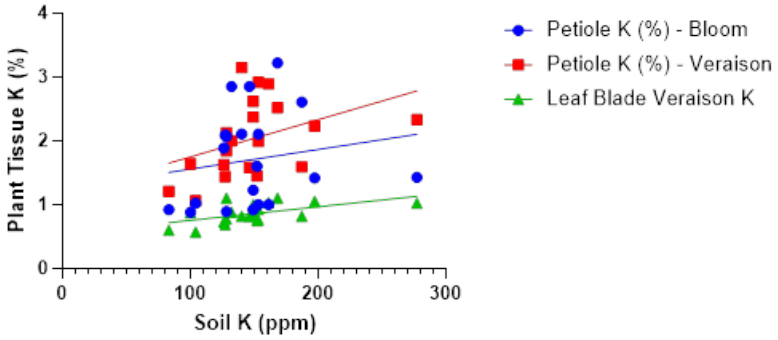
Leaf Blade K Veraison: r = 0.56; r^2 = 0.32; y = 0.002957x + 0.4480

Bloom: Low petiole K<1% K

Veraison: low petiole K <1.2% K

Veraison: low leaf blade K<.6% K

Association between soil K (0-30cm) and plant tissue K from 2019-21



Petiole K Bloom: r = 0.17; r^2 = 0.03; y = 0.003077x + 1.250

Petiole K Veraison: r = 0.40; r^2 = 0.16; y = 0.005843x + 1.165

Leaf Blade K Veraison: r = 0.56; r^2 = 0.31; y = 0.002130x + 0.5408

Appendix 2: Newsletter article for ON Fruit blog.

Improving Grape Potassium monitoring in vineyards
By Kathryn Carter and Dr.Tejendra Chapagain, OMAFRA

Background

Potassium (K) plays an important role in vineyards, with K deficiency resulting in negative impacts on vigour, yields and fruit ripening. High levels of K in fruit at harvest has a negative impact in wine quality resulting in increased pH and a shorter shelf life of wines (Gardner, 2016). Hence, monitoring K levels in the vines is very important to ensuring healthy vines that produce good quality fruit.

Traditionally in North America grape petiole tissue is most commonly used to evaluate nutrient levels in the vine due to ease of sampling and large amounts of historical data. In Europe, vineyards rely on the use of leaf blades which are considered to provide a more accurate understanding of nutrient (N, P, K) concentrations in the vine. Other grape growing regions (e.g. Pennsylvania and Washington) also have developed nutrient recommendations for sampling grapevines at bloom. The benefit of sampling grapevines at bloom allows growers to amend their nutrient applications in the current season, resulting in more timely information for making fertilizer decisions.

Currently Ontario guidelines recommend soil sampling in vineyards (0 to 15 cm depth) every three years to monitor soil K. In addition, petiole analysis at veraison (onset of ripening) is used to evaluate K levels in the vine. However, Heck et al. (2014; Unpublished) suggested that there may be opportunities to improve the accuracy of nutrient sampling in vineyards as there wasn't a strong relationship between soil K levels (0 to 15 cm) and petiole analysis at veraison. They found that petiole K had a greater correlation with soil K at greater soil depths (15 to 30 cm). Indicating the opportunity to improve sampling guidelines for K in vineyards.

To test and validate these relationships, OMAFRA conducted a three year project (2019-2021) looking at refining the use of soil testing and petiole analysis as tools for making K management decisions. The objectives of this project were to answer the following questions:

- Can soil sampling at a greater depth (15 to 30 cm or 0 to 30 cm) provide a better understanding of K levels in the vine than the current soil testing guidelines (0 to 15 cm)?
- Can sampling leaf blades provide a better understanding of K levels in the vine as opposed to sampling petioles?
- What is the impact of K levels in the vine (Petiole and Leaf Blade) on bud hardiness?
- Can petiole sampling at bloom be a viable alternative to monitoring K levels in vineyards?
- Does K level in the vine (petioles and leaf blades) impact yields?
- Do K levels in the soil or vine impact grape juice quality?

Results

Unlike Heck et al. (2014; Unpublished), this study found that there was a significant relationship between soil test (0 to 15 cm) with petiole K and leaf blade K at veraison in medium soils. With petiole K at veraison more significantly correlated with soil K from 0 to15 cm depth compared to leaf blade K. These results support OMAFRA's current guideline for soil sampling at 0 to15 cm along with petiole analysis at veraison to determine nutrient levels for vineyards.

This study further demonstrated that leaf blade K at veraison were more correlated with soil K in deeper soils (15 to 30 cm depth). For the 0 to 30 cm soil samples, only the leaf blade K were correlated to soil K indicating that leaf blade analysis may be an effective tool for monitoring K levels in mature vineyards with deeper roots.

The data we collected suggests that the relationship between soil K (at all depths) and petiole K at bloom were poor indicating that bloom petiole sampling is not a good indicator in predicting K levels in the vine. In comparison, tissue sampling at veraison (petiole and leaf blade) was significantly correlated to soil K levels, indicating that this is the best timing for monitoring K levels in the vine.

This study found a positive association between petiole K at bloom and yields, indicating that petiole K at bloom may give an idea about yields, however petiole K was not associated with soil K. There was no relationship between yields and soil K or tissue K (petioles and leaf blades) at veraison.

Juice K level was significantly and positively associated with petiole K at veraison indicating that petiole samples at veraison may be used to get a better understanding of the K levels in the fruit at harvest. We did not observe any association between juice K with petiole K at bloom.

Also, we found that juice K and pH was significantly (and positively) associated (i.e., as juice K levels increased, there was a corresponding increase in pH of the juice).

Although bud hardiness was monitored at all blocks throughout the trial, we had insufficient data to determine if K levels in petioles at bloom or veraison impacted bud hardiness, as only one site had low K levels throughout the entire project.

Take home message

The data we collected provides a better understanding of optimal timing for tissue sampling in vineyards, suggesting that growers should continue to sample petioles for K at veraison instead of bloom.

The results of this trial do not support Heck et al. (2014, Unpublished) that increasing soil sampling depth to 15 to 30 cm results in a better relationship with K levels in petioles. Instead, soil sampling at 0 to 15 cm should provide adequate results in medium soils. However, the results suggest that leaf blade sampling at veraison provides a better understanding of how K levels in the vine relate to soil K in deeper soils (15 to 30 and 0 to 30 cm).

In sites or years where wineries are concerned about K levels in grape juice, there may be some benefits to monitoring K in petioles at veraison as they may indicate a relationship with juice K.

References

Gardner, 2016. Making [red] wine from fruit high in potassium | Penn State Extension Wine & Grapes U. (wordpress.com)

Heck, R., C. Kessel, K. Carter. (2014) Potassium fixation and availability in the dominant vineyard soils of the Niagara Region to improve soil potassium fertilizer application guidelines. Unpublished.

Appendix 3: Bud Hardiness data and K levels.

	2019				2020 yellow				2020 blue				2021 yellow				2021 blue			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
% K petiole veraison	2	1.44	2.52	1.45	1.63	1.21	2.92	2.37	1.84	1.06	3.15	1.99	1.58	2.13	2.33	2.89	1.59	1.64	2.23	2.62
blade veraison	0.88	0.69	1.1	0.75	0.73	0.6	0.92	0.82	0.77	0.57	0.82	0.76	0.82	1.1	1.02	1.03	0.82	0.87	1.05	1
the fruit (mg/L)	1067	1088	1354	1473	1367	1310	2204	1606	1589	1338	2222	1763	1905	1419	1736	1660	1255	1222	2055	1634
hardiness LT 90 (°C)	n/a	23.37	22.99	24.44	n/a	-25	n/a	-24.4	n/a	n/a	n/a	n/a	n/a	-24.9	n/a	-27	n/a	-25	TBD	-26.4

Not enough data to be able to comment on K levels in vine and winter hardiness.

Appendix 4: Association of juice K with other parameters (2019-2021).

Indicators	Fruit Potassium vs. Petiole K (%) - Bloom	Fruit Potassium vs. Petiole K (%) - Veraison	Fruit Potassium vs. Leaf Blade Veraison K	Fruit Potassium vs. Brix	Fruit Potassium vs. Juice pH	Fruit Potassium vs. Titrable Acidity (g/L)
Pearson r	-0.03253	0.6356	0.2808	0.04584	0.5351	-0.06050
95% confidence interval	-0.4683 to 0.4160	0.2686 to 0.8414	-0.1847 to 0.6433	-0.4049 to 0.4787	0.1213 to 0.7905	-0.4899 to 0.3925
R squared	0.001058	0.4039	0.07883	0.002102	0.2864	0.003660
P (two-tailed)	0.8917	0.0026	0.2305	0.8478	0.0150	0.8000
P value summary	ns	**	ns	ns	*	ns
Significant? (alpha = 0.05)	No	Yes	No	No	Yes	No

- Fruit potassium level is significantly and positively associated with Petiole K at Veraison and pH.

Appendix 5: Association of grape yield with other parameters (2019-2021).

Indicators	Grape Yield vs. Soil K (0-15cm)	Grape Yield vs. Soil K (15-30cm)	Grape Yield vs. Soil K (0-30cm)	Grape Yield vs. Petiole K (%) - Bloom	Grape Yield vs. Petiole K (%) - Veraison	Grape Yield vs. Leaf Blade Veraison K	Grape Yield vs. Brix	Grape Yield vs. pH	Grape Yield vs. Titrable Acidity (g/L)	Grape Yield vs. Fruit Potassium (mg/l)
Pearson r	0.1758	0.04554	0.2791	0.6205	-0.2035	0.02034	-0.2748	-0.04067	-0.4076	-0.1252
95% confidence interval	-0.2892 to 0.5737	-0.4051 to 0.4784	-0.1864 to 0.6423	0.2454 to 0.8340	-0.5926 to 0.2627	-0.4260 to 0.4587	-0.6396 to 0.1909	-0.4746 to 0.4092	-0.7202 to 0.04265	-0.5379 to 0.3359
R squared	0.03091	0.002074	0.07792	0.3850	0.04139	0.0004139	0.07553	0.001654	0.1661	0.01567
P (two-tailed)	0.4584	0.8488	0.2333	0.0035	0.3896	0.9322	0.2409	0.8648	0.0745	0.5990
P value summary	ns	ns	ns	**	ns	ns	ns	ns	ns	ns
Significant? (alpha = 0.05)	No	No	No	Yes	No	No	No	No	No	No

- There exists significant association between Grape Yield and Petiole K at bloom stage. Petiole K at bloom could be a strong determinant of Grape Yield.

Appendix 6: Soil health indicators (0-15cm) as reported by A&L Lab for four different sites in Spring-2020.

Indicators	Sites			
	Site 1	Site 3	Site 4	Site 2
Texture	Loam	Sandy Clay Loam	Loam	Silt Loam
Organic Matter	2.4	3.3	2	2.9
CO_2 respiration	50	75	22	38
Mineralizable N (lb/acre/yr)	64	82	38	54
Active Carbon	543	781	521	689
Biological quality rating	4	4	3	3
Overall Rating	Ideal	Ideal to High	Moderate to Low	Moderate