EXECUTIVE SUMMARY – THIRD AND FINAL YEAR

Terroir Analysis for the Nova Scotia Wine Growing Region 2017 – 2018 – 2019

Introduction

The third and final year of the *terroir* study evaluated how appropriate management techniques developed in the vineyard can have a positive impact on plant development. To successfully provide the most accurate recommendations, it was essential to consider the proper information related to:

- Local climate and soil conditions
- The information of each vineyard separated by varieties, keeping them independent if they are hybrids or Vinifera
- Different practices, observations of pests and diseases, areas of the vineyard, spraying applications and doses throughout the growing season.

As in previous years, the experiment was set up the same as 2017 to preserve the continuity of the measurements. Keeping the experiments the same allowed for recommendations to be made, and their impact evaluated. In 2018, many suggestions were adopted in vineyard management, which resulted in positive outcomes for plant development. One example is the improvement of the canopy development and the proper balance of the yield per plant, which had a positive impact on the 'Fruit Kg / Foliar surface,' ultimately resulting in diminishing the time between bloom and veraison. Therefore, it's important to have consistency in tracking the changes in the vineyard management so that the inputs can be evaluated each year. In 2019, the measurements were done the same way as previous years so that the most accurate data could be obtained.

Similar to past years, the data in 2019 demonstrated how the climatic conditions of Nova Scotia are fluctuating, which once again proved challenging for the growing season. Due to the high fluctuations, the meteorological conditions data collected in 2017 and 2018 in each vineyard, or from the closest possible weather station, was crucial for evaluating the 2019 season. It's fundamental to build a complete climatic data report from the area, as it helps with decision strategies for vineyard management and overall improvements each year. Additional information related to the climatic measurements of 2019 are available in this executive summary.

In the second executive summary, the results from 2018 were compared with 2017's results. In this third and final summary, further comparisons were made between all the studied seasons, 2017, 2018 and 2019. The adoption or continuity of various suggestions has had a positive effect in the already established vineyards. Some technical recommendations from this study have already been adopted by some growers in the development of new vineyards.

In this executive summary, the main observations, measurements and results of the Terroir Analysis for the Nova Scotia Wine Growing Region were summarized with subsequent recommendations.

1. Climate

One of the most relevant characteristics of 2019 was the low temperatures throughout the growing season. According to the data analyzed, 2019 was one of the coldest in the last seven years.

Two of the studied zones, Wolfville and Avonport, were once again classified as Cold Climate areas, according to the Winkler Index. According to the Huglin Index, Wolfville classifies as a Cool Climate, while Avonport as a Very Cool Climate.

The reason for the low values of these indexes can be explained by the fact that the maximum and average temperatures in 2019 were very low. There were only a few days with temperatures above 30° C, with about half of the number of days with temperatures between 25 and 30° C, compared to 2018.

> *In 2019, the number of days with temperatures above 30 °C in Nova Scotia was a total of four days measured in Wolfville, compared to 13 days the previous season, and only two days in Avonport compared to ten days in 2018.*

Wolfville has the highest temperatures and the lowest rainfall. It's Free Frost Days (FFD) average is 177 days over the last seven years, the longest time in the studied areas. This area also has nights with the highest temperatures, 8.6°C, as the average for the same period.

The Avonport area is the coldest and rainiest of the analyzed areas, with an average of 160 mm more than Wolfville. Avonport has 168 FFD, which corresponds to nine days less than Wolfville and eight days less than Gaspereau, with 7.8 °C as an average Cool Night Index (CNI).

Taking into consideration the average of the last seven years, the vintage 2019 was in line with the average values. With 633 mm for Wolfville and 842 mm for Avonport, a consistent pattern can be observed; Avonport is the rainiest area of this analysis, with 33% more annual precipitation compared to Wolfville.

This data analysis confirms how difficult it was in 2019 to bring the harvest to optimal maturity, showing that this area of Nova Scotia is at the edge of the wine production zone and that low-quality vintages must be accepted from time to time. To obtain the maximum quality each year and ensure a minimum quality of grapes to produce sparkling and still wine, vineyard management must be very precise. This confirms that the potential for wine in this area is based on cold-climate varieties, such as Riesling, Chardonnay, Pinot Noir and some hybrids.

2. Vegetative Growth:

2.1 Phenological Stages

The 2019 year was very late for the budburst of Vinifera and hybrid varieties. Compared to 2017, Vinifera varieties showed a delay of 17 days and hybrid varieties a delay of 16 days in 2019. Regarding the veraison, vines were able to catch up with this delay, especially hybrid varieties that show a much shorter time between budburst and veraison.

In 2018, budburst started in Vinifera and hybrid plots earlier than the frost damage on June 4th. The first Vinifera plot to burst was CH 1 on May 18th, and the last plots were RI 2, SB and PN 1 on May 24th. Within hybrid plots, there was a more homogeneous budburst as all plots burst between May 18th and May 20th.

It's interesting to note that L'A 2 and L'A 3 (that underwent frost damage in June 2018) showed 50 % bloom only two days after the other L'A plot that was not affected by frost. This information reveals the high recovery potential of the L'Acadie hybrid to grow and bloom after frost damage.

When splitting the two groups, both Vinifera and hybrids, it shows the heterogeneity of buds, some plots with high and others with low bud numbers per plant. These numbers suggest that this loss in balance is primarily due to cultural practices and the wine style being produced (still or sparkling) rather than terroir conditions or factors related to Vinifera or hybrid varieties.

2.2 Vine Vigor

Regarding the average shoot length of hybrids compared to Vinifera varieties, there is a significantly higher shoot growth seen in the last ones within a range of 100 % to 145 % for the years of 2018 and 2019 (but only 58 % for 2017). Two main causes would explain this big difference. Firstly, six of seven study plots were damaged by frost in 2018, meaning that vines had to restart growth a few weeks later and therefore had less time to regain this shoot length gap. Secondly, the only non-frozen plot L'A 1 showed a shoot growth 42 % lower in 2018 compared to 2017. Causes for this could be non-observed frost damage to shoots, which produced a significant decrease in the shoot growth rate, plus important shoot damage may have been done mechanically during the season, impeding the tracking of the measurements.

L'A 2 and L'A 3 underwent an intensive weed and grass removal, by cutting and tilling them away, especially underneath the vine rows. This may have had an important impact on faster

shoot growth and longer shoot length in 2018 compared to 2017, ultimately improving the nutrient availability for these vines. However, this cultural practice was not repeated in 2019.

In most of the study plots that were frozen in June 2018, the shoot length heterogeneity was almost doubled. This could be interpreted as probable irregularity but non-visible frost damage in shoots, combining with shoot damages that occurred mechanically.

2.3 Lignification

Measurements of the shoot growing end dates reveal different growing patterns depending on the year. The year 2017 showed that almost all study plots could finish their shoot growing before harvest time. During the growing season of 2018, the conditions were similar to 2017. However, by the end of September 2018, there was a significant frost that damaged the vine leaves and therefore did not allow for the correct lignification process or good nutrient transfer from the leaves to the trunk and the roots.

In 2019, the effect of the 2018 autumn frost could be the reason why the budburst percentages were very low, confirming that nutrient reserves were not sufficient for enabling a normal budburst and correct vine vigour.

2.4 Water Status

Similar to the first two years, this year was not favourable for the water stress status in the grapevines, which was confirmed by the measurements of Stem Water Potential and Delta C13. In 2019, two measurements were made with the pressure chamber throughout the season and both times the results showed no water stress.

> *In the three years of this study, no level of water stress in the different study plots was observed. These results suggest that there is not enough water stress to permit vines to reduce vigour to achieve a shoot growing stop before harvest, improvement of the ripening process and wine grape quality, especially for red varieties.*

2.5 Nutritional Status

In 2019, at the moment of veraison, the Nitrogen was in the optimum range and higher in all plots compared to 2017, both for Vinifera and hybrids. The amount of this element is at a good level for this stage of development, remaining fairly stable over the last three years.

The Nova Scotia region has soils that are naturally poor in Potassium content, and rich in Magnesium. Potassium content must increase radically in the vines to ensure a good and quick ripening of the grapes, since this region doesn't have a long maturity period, and the weather conditions at the end of the season are unfavourable to ripen. For this reason, Potassium could help obtain a better-quality grape. At the same time, after three years of observation, there

has been a big difference between Viniferas and hybrids. One hypothesis to explain this could be that the hybrids are not good enough to take the Potassium from the soils, and the Viniferas with rootstocks have an advantage. The rootstock 101-14 is, at this moment, the best one to uptake potassium and should be considered the main rootstock for Nova Scotia.

There are no deficiencies in Magnesium. There is good availability and assimilation of this element, it follows this trend until flowering, and the vines have shown the same tendency over the last three years. The concentration of Magnesium is always similar between both Viniferas and hybrids, which shows the equal capacity of both to uptake this element from the soil.

There was also good availability and assimilation of Calcium and Phosphorus in all plots and studied soils of this region.

In 2019, all the plots had a low or very low level of Iron, compared to the minimum optimum level and the 2017 and 2018 growing seasons.

This low level of Iron is not a good sign for improving the grape ripening process, which is already at the limit in this area, due to the short ripening period, the cold temperatures and the rainy days. Therefore, to improve the quality of the grape as well as the wine, the Iron level needs to be raised. Foliar applications* are necessary during the early stages of the growth cycle to correct and improve the levels.

In all of the plots, there were good levels of Zinc and Boron in 2019, 2018 and 2017, and this was the same between varieties.

*It's been confirmed that after three years of study, there is a significant excess of Manganese in some plots, which might be risky for the potential toxicity in the plant. Work needs to be done on the soil compaction to improve its oxygenation, along with amending the pH by liming**.*

Not only is it important to control the quantities of each element in the vine, it's also very important to control the balance between these elements to ensure the best nutrition conditions. By combing all of the other factors and the optimal conditions, it's possible to achieve the best-quality wines of Nova Scotia's Terroir.

*Foliar application: Nitrogen, early in the season, Potassium, after bunch closure, Calcium after fruit set and Iron, early in the season.

**Soil application: Liming, after snowmelt, with CaO, Phosphorus, included in liming, with P2O5 and Potassium, also in liming, with K2O.

2.6 Grape Composition

When comparing the last three years, 2019 had a vintage with the lowest alcohol potential, due to the weather conditions. The vintage was cold and rainy, causing it to be very difficult to obtain good ripeness and concentration.

In the case of hybrids, they had less capacity for sugar production, with a lower alcohol percentage each year. However, even with unfavourable conditions, the hybrids achieved the minimum alcohol needed to produce sparkling wine, which is important to valorize the locations with less potential to make still wine.

It's clear that the Nova Scotia region produces wines with low alcohol potential. The weather conditions, including a cold winter and soils with snow, having bud break in the middle of May, and the shorter Free Frost Period, don't allow the necessary conditions to obtain higher levels of alcohol. Chaptalization or any way to concentrate the must are mandatory for this region if the objective is producing still wine. For sparkling wines, the achievable alcohol level is enough to obtain the base wine. The vegetal material choice and the canopy management are the keys to getting the best from this region and ultimately producing good wines.

The level of malic acid this year decreased in most of the plots compared to the level in 2018 but stayed higher than in 2017. In the Vinifera varieties, this decrease was by about 10%. These results show that the 2019 vintage is less ripe, despite the similar numbers for Viniferas, and lower for the hybrids. This year the region didn't have frost, giving a longer free frost time, but even with the lack of frost, the grapes hadn't reached similar levels as in 2017. The lack of high temperature and excessive rainfall meant that the acidity was maintained for a longer time, which didn't allow the grapes to obtain the correct maturity.

It's interesting to see the acidity evolution over the last three years, which confirms that hybrids are the best adapted to the local conditions. Even in the most difficult years, these varieties can reach the lowest levels of acidity. On the other hand, Viniferas are more dependent on weather conditions. For example, during this study period, New York Muscat had the lowest acidity level. Hybrids have a faster metabolism to ripen the grapes compared to Viniferas. Therefore, it's recommended to plant hybrids in colder soils or zones. It is also a

good idea to valorize these locations to obtain wines either for still or sparkling wine, maximizing the profitability of these areas.

It's remarkable to see the increase of YAN (Yeast Assimilable Nitrogen) in all plots in 2019, especially in CH 1, SB and the PN. On average, the Vinifera varieties increased by 95% to a level of 340 mg/l, which is very impressive after two years, with an average of around 180 mg/l. Hybrids had the same average growth as last year, but with some significant increases in specific plots. Overall, the evolution of the last three years has been positive.

The YAN concentration is high, which has improved the vegetative growth, and shown an optimization of the sunlight for photosynthesis. The huge increase this year is most likely due to the improvement of nitrogen mineralization as a result of soil work and due to the reduction of weed competition by keeping the plots very clean under the rows.

All plots ended this year with the lowest values of IBMP (green aroma molecules) during the study. This is mainly thanks to cultural practices. Considering the climatic conditions and the level of nitrogen, a much higher concentration of IBMP would likely have been obtained if proper cultural practices hadn't been put in practice.

It's interesting to note that despite the vintage and the weather events, the conditions of temperature, rainfall, nitrogen assimilation and production, 2019 didn't show any green aroma molecules, which is very positive for the future.

3. The cultural practices in the vineyard

A. New plantations

1. Plant density and row spacing

Given the context of cool climate conditions of the Nova Scotia wine-growing region, a minimum plantation density of 4,500 plants per hectare is recommended to decrease the "fruit yield per plant rate" and to optimize the "Fruit kg / Foliar Surface" rate.

A minimum plantation density of 4,500 plants per hectare can be achieved with a row spacing of 2 m and a plant spacing of 1.1 m on the row. The corresponding canopy height should be at an optimal height of 1.8 m.

During the three years of the study, the data has revealed that most of the plots have a low plantation density, which leads to a low photosynthetic "canopy surface per soil surface" as the "Canopy height / Row Spacing" (C/R) index is low or very low. Currently, rates between 0.32 and 0.58 are seen (only one study plot has an adequate C/R index of 0.68). These low C/R rates correspond to warm growing regions and are therefore not suitable for this cool climate region.

To achieve higher quality grapes and wines, the sunlight exploitation by the foliar surface of vines (canopy volume) should be very high for this region. This can be obtained by designing new vineyard plantations with a C/R rate of 0.7 (within a range of between 0.6 to 0.8).

2. Selection of rootstocks for Vinifera varieties

One of the generalized regional soil properties seems to be low potassium content, as the nutritional tissue analysis shows a repeated low potassium disposability for the vine. Currently, the most used rootstock for Vinifera plantations is the rootstock 3309 C.

Therefore, the selection of a 'potassium pumping' rootstock would be recommended when it comes to planning new vineyard plantations.

In the case where a soil analysis confirms a low potassium disposability for the vines, it would be reasonable to plant Vinifera varieties over a rootstock that shows a better potassium uptake to avoid low potassium levels in the long term. A potential rootstock option for this case is 101-14 Mgt.

3. Slope and row exposure

The generally observed NW – SE (North/West – South/East) row orientation is appropriate for this wine-growing region as it allows for good sun exposure in the morning hours, and even better exposure during the after-midday hours. Ultimately, this fact improves photosynthesis activity of the vine plants.

Regarding the slope expositions, it's recommended to plant Vinifera varieties, if possible, on South (especially South West) orientated slopes, as these varieties are the less adapted to cool climate conditions. Flatlands, instead, should be used to plant hybrid varieties. On the other hand, new vine plantings should consider a NW – SE row orientation, which should only be avoided in the case of a steep slope.

4. Soil study

Each soil has specific physical, chemical and biological characteristics that need to be studied before the planting decision in order to optimize vine behaviour, yield and wine quality in the long term. It's crucial to make the right decisions regarding liming necessity, soil aeration, mineral deficiencies or toxicities, soil water table and other factors for every studied soil unit before planting. Also, the drainage system properties will depend on the soil study, as mentioned below.

> *To guarantee good vine development and crop production of the vineyard in the long term and to optimize the soil's wine-making potential, consider a complete and profound soil study to have the appropriate tools and to make correct planting decisions.*

5. Drainage

Due to the local weather conditions such as a winter water supply of snow that melts in springtime, along with low water evaporation rates, an excess of water can be found in most of the vineyard plots. These conditions, especially in the case of a low subsoil permeability, cause the soil to remain water-saturated for quite a long time, significantly affecting the vine root development, the soil microflora and the soil mineralization.

> *Considering these issues, it's highly recommended to plan and install a long-term efficient drainage system. Installing a drainage system will aim to help remove the surplus soil water content and to deepen the height of the water table within the soil profile. This is crucial for all varieties, and especially for the elaboration of fine red wines.*

> *An efficient soil drainage system is a system that works properly after many years and has, therefore, adapted to the specific soil characteristics of the plot. To achieve this goal, it's highly recommended to build the drainage design based on a previous soil study considering the complete soil profile.*

B. Existing plantations

1. Pruning strategy

Several study plots show an important difference in bud numbers left after 2019 pruning, further confirming this tendency during the three years of study. This difference indicates that the wine style target for a given plot is not consistent, resulting in different bud pruning

strategies each year. One year has high bud load for sparkling wines and the following year, a low bud load for still wines. To maintain similar vigour conditions and a nutritional balance in the long term, the vines need to follow a similar growing pattern year after year.

To allow the vine plant to adapt to a specific vigour and yield year after year, the pruning strategy of a plot should be consistent throughout the time and follow the specific wine style destination. If the decision is to elaborate sparkling wine, a higher bud number is desired; when the plot's target is to obtain still wine, a lower bud number would be recommended.

2. Yield strategy

In 2019 the yield per plant was lower for both hybrids (1.8 kg/vine) and Vinifera (1.5 kg/vine) varieties when compared with the 2017 season where the production per plant was greater, especially for Vinifera at 60% higher. The yield strategy is linked to the pruning strategy, but other strategies should also be considered throughout the growing season to obtain the desired product.

The decrease in yield per plant has an important impact on the duration of the time between bloom and veraison. In addition, if the exposed leaf surface (related to the shoot growth) is significantly higher, there will be a double effect on the precocity between the phenological stages of bloom and veraison.

Moreover, an inverse correlation between yield and potential alcohol and concentration in resulting wine exists. Therefore, it would be highly recommended to adapt yield ranges to the wine style sought-after in order to improve wine quality.

3. Missing and death plants

Plant counting done in 2019 has confirmed high percentages of missing plants in several plots: one study plot showed a very high missing plant percentage (up to 48 %), several plots have a plant loss in the ranges of 20 to 30 %.

In cases of high to very high missing plant percentages, a new plantation is recommended. However, this should only happen after having made a complete analysis of the vine loss reasons and after having proceeded to rectify the encountered loss reasons.

4. Canopy management

Again in the year 2019, and confirming the tendency of the previous two years, practices such as de-budding are done, but often not on time, or are not consistent with the pruning strategy put in place for that year.

> *The practice of de-budding can be used to lower the vine's vigour, but shoot thinning should be realized on time. This means shoot thinning should happen before the start of bloom to avoid competition between canopy and fruit. In cases of normal to low vigour, it would be best to adjust the bud/plant number during pruning (leaving a maximum of 20 % more buds), ultimately avoiding de-budding practices and debilitation of the vine.*

5. Diseases

2019 was a year with climate conditions that led to the development of downy mildew. Downy mildew was present during the early stages of bloom formation, until late in the growing season even after harvest. Its presence has caused big yield losses and canopy damage that did not allow the vine plant to continue to make an efficient photosynthesis.

> *Tracking of weather conditions and vineyard surveillance is extremely important, and it's recommended to take action against diseases in the very early phenological stages to avoid yield and canopy loss.*

6. Vine training system

The vertical shoot positioning (VSP) is the most commonly used vine training system in the region. The VSP is one of the recommended training systems to provide the vines with a good amount of sunlight and allows for foliar exposure to light. This pruning system is mainly used on one or double cane with or without spur (*guyot simple* or *guyot double*); some double trunks were also observed.

7. Cover crop

The choice of a cover crop strategy should be made carefully to avoid a high nutrient uptake by the crop. Planting the wrong cover crop could provoke a low nutrient availability, or a nutrient unbalance for the grapevines and could cause competition in the vine development.

> *It's recommended to review the cover crop strategy concerning nutrient absorption capacity. The consequence might be an important nutrient uptake that would diminish nutrient disposability for the vines. In many analyzed plots, a dense cover crop root was observed that invades first soil horizons. Regular cutting of the cover crop should be considered to lower disease development like downy mildew.*