Programme Agri-science – Volet des grappes

Rapport final sur le rendement

Ce gabarit comprend le rapport annuel sur le rendement pour la dernière année de l'activité et comprend deux questions supplémentaires pour le rapport final sur le rendement.

Section A: Rapport annuel sur le rendement

Cette section est la même que celle qui figure dans les rapports annuels précédents achevés à ce jour et vise à ne saisir que les résultats qui ont été obtenus au cours de la dernière année de l'activité.

Nom du bénéficiaire : Canadian Grapevine Certification Network	
Titre du projet : Fostering sustainable Growth of the Canadian Grape and Wine Sector	
Numéro du projet : ASC-12	**Dernière période visée par le rapport :** 2022-04-01 à 2023-03-31
Numéro de l'activité : 5 **Nom de l'activité :** Assessing Grapevine Cold Hardiness under Climatic Conditions of Eastern Canada by Applying Various Techniques/ Évaluation de la rusticité des cépages dans les conditions de l'est du Canada en utilisant diverses méthodes	**Chercheur principal :** Dr. Caroline Provost, Dr. Gaétan Bourgeois
Date de début de l'activité : 2018-04-01	**Date de fin de l'activité :** 2023-03-31

1. Sommaire des activités

Veuillez fournir un résumé général de l'activité. Vous devez inclure une introduction, les objectifs, la méthode, les produits livrables, les résultats obtenus et une discussion. Vous pouvez utiliser un langage technique.

ACTIVITY 1. Implantation d'un système de suivi de la rusticité des bourgeons pour divers cépages dans les conditions de l'est du Canada/ Monitoring system for evaluation of cold hardiness of several grapevine cultivars under climatic condition of Eastern Canada

Introduction

Growing grapes in cold climates faces several challenges. Cold injury to grapevines is a significant problem, especially at the northern limits of the crop, where extensive damage to bud and spur tissues can result in severe economic losses. Grapevine health and productivity are influenced by site and climatic conditions during the growing season, but also during the dormant period.

Cold hardiness is a physiological process that starts at the end of the season (August) and continues until the end of the dormant period (March/April). Three periods are observed: acclimation, maximum resistance, and deacclimation (Willwerth et al. 2014). Acclimation is the process by which the plant increases tolerance to frost. Plant physiology is altered by different processes and is influenced by a shorter photoperiod and colder temperatures (Fennell 2004; Grant et al. 2013, 2015). Physiological changes include tissue dehydration, changes in hormone content (e.g. abscisic acid), and cryoprotectants, such as sugars, lipids, and proteins (Fennell 2004; Gusta et al. 2005; Grant et al. 2013, 2015). In late winter, warmer temperatures and longer days induce deacclimation of the vine. Deacclimation is the process by which the vine emerges from dormancy and begins to resume active growth (Willwerth 2014; Keller 2015). Plant water content gradually increases and hormone and cryoprotectant levels are reduced (Fennell 2004). This period is crucial for the plant, as water uptake increases bud sensitivity to freezing. Frost tolerance at this time is related to air temperature, timing of bud break (early or not), and rate of development (slow or rapid development after bud break) (Wolf and Cook 1992; Fennell 2004). After bud break, parts of the vine are very sensitive to frost until the end of the growing season. Spring or fall frosts can then cause severe damage and have a significant impact on vine yield and health. Site selection, cultural practices, and frost protection methods are essential to avoid frost injury during the growing season (Fennell, 2004).

Cold injury is the major threat to *Vitis vinifera* production in eastern North America. While genetics determine the ultimate degree of expression of cold hardiness, the environment, as well as cultural practices and pest management, affect this expression. Studies on cold hardiness and cold injury have led to breeding programs in eastern North America. From these studies, several hybrid grape varieties have been developed due to their increased cold hardiness (Reynolds 2015). Wild North American grapevine species carry adaptations that allow them to survive winter temperatures as low as -35 to -40 °C. Breeding using these grapevine varieties has led to the development of new cold-hardy grape varieties (Londo and Kovaleski 2017). These new grape varieties are primarily planted in the northeastern United States and Canada. Hybrid grape varieties have different degrees of cold hardiness and this can also vary by climatic region (Tab. I) (e.g., Rekika et al. 2002; Dami et al. 2016; Londo and Kovaleski 2017). In addition, the cold hardiness of individual grapevines may be seasonal, may vary with winter conditions, and varies across regions (Howell and Shaulis 1980; Plocher and Parke 2008). To help understand cold hardiness, methods and models for assessing bud freezing have been developed, often referred to as low temperature exotherm (LTE) analysis (Andrews et al. 1983; Wample et al. 1990; Wolf and Cook 1992; Mills et al. 2006; Ferguson et al. 2011). Monitoring several grapevines under field conditions over several years in different regions provides information on the suitability of grapevines for the site and the environmental conditions contributing to damage (Fennell 2004). Controlled freezing tests have been developed to assess freezing tolerance under specific controlled conditions (Fennell 2004; Mills et al. 2006). Supercooled freezing of tissues can be measured by differential thermal analysis (DTA) (Wample et al. 1990). DTA detects the thermal melting released when tissue supercooling water freezes. The temperature at which this occurs, called the low temperature exotherm (LTE), indicates the lethal temperature. Microcomputers and data acquisition systems have been developed specifically for grapevines (Wample et al. 1990, Mills et al. 2006).

Table I: Cold resistance of hybrid grape varieties.

Variety	Vigor	Cold hardiness	References
Red			
Baltica	moderate	-29°C to -34°C	1, 2
Concord	high	-26°C to -32°C	4, 5
De Chaunac	moderate/high	-26°C to -32°C	1, 4
Frontenac	high	-29°C to -34°C	1, 2, 3, 4
Léon Millot	high	-26°C to -32°C	1, 3, 4, 5
Marechal Foch	moderate	-26°C to -32°C	1, 3, 4, 5
Marquette	high	-29°C to -34°C	1, 3
Petite Perle	moderate	-29°C to -34°C	1, 3
Sabrevois	moderate	-29°C to -34°C	1, 3
Skandia	moderate	-29°C to -34°C	1, 2, 3
White			
St. Croix	moderate/high	-29°C to -34°C	1, 2, 3, 5
Frontenac blanc	high	-29°C to -34°C	1, 2, 3
Frontenac gris	high	-29°C to -34°C	1 , 2, 3
La Crescent	high	-29°C to -34°C	1, 2, 3
Louise Swenson	low	-29°C to -34°C	1, 2, 3
Seyval	moderate	-23°C to -29°C	1, 3, 4, 5
St.Pepin	moderate	-29°C to -34°C	1, 3, 5
Traminette	moderate/high	-23°C to -29°C	1, 4
Vandal Cliche	moderate/high	-26°C to -32°C	1
Vidal	moderate	-20°C to -26°C	1, 4, 5

The main objective of this project is to improve the knowledge of cold hardiness of hybrid (hardy and semi-hardy) and Vitis vinifera grape varieties, and to propose methods to reduce frost damage under eastern Canadian conditions to support the development of the wine industry.

Objectives

Specific objectives of this activity include:

1. Establishment of a monitoring system for periodic acquisition of bud strength data (LTE 10, 50, 90) to understand grapevine physiology related to cold hardiness and to help growers optimize the use of frost protection methods;
2. Development of models related to grapevine physiology of several grape varieties under eastern Canadian climatic conditions.

Grapevine production under eastern Canadian climatic conditions needs to be improved to reduce winter injury in order to obtain higher yields and better fruit quality. Some specificities are observed in Quebec, mainly with respect to the grape varieties used and in particular the hardy hybrids. Thus, the proposed project will help to better understand grapevine physiology in relation to frost tolerance in order to propose adaptations or new technologies that can be used to support growers and help increase yield and fruit quality.

Methodology

In collaboration with CCOVI, we acquired a bud cold hardiness monitoring system to follow several grape varieties under Quebec conditions. A Differential Thermal Analysis (DTA) system was developed to evaluate cold hardiness. This system includes a programmable freezer, a data acquisition system (DAS) and thermoelectric modules (TEM) (Mills et al. 2006). Bud resistance monitoring began in the fall of 2019, bud monitoring was the focus of two trials to assess bud resistance for two categories of grapevines: 1) cold-resistant hybrids throughout the dormant season; and 2) semi-hardy (material protected) hybrids and V. vinifera in late winter and spring 2020. Data was collected for the winters 2019-2020, 2020-2021, and 2021-2022.

For the cold-hardy hybrid varieties, five varieties were selected and monitored once every two weeks from November to May. The varieties studied were selected based on the area planted in Quebec and are as follows: Frontenac, Frontenac gris, Marquette, St-Pepin, Frontenac blanc, and Petite Perle (Gagné 2016). The samples were taken from 11 vineyards in different climatic regions of Quebec (Montérégie, Laurentides, Lanaudière, Estrie). For semi-hardy grape varieties and V. vinifera, 3 grape varieties were selected and monitored from March to May (after removal of winter protection). The grape varieties monitored were: Chardonnay, Vidal, Pinot noir. Data collection after removal of winter protection was scarce due to the fact that growers performed their final pruning immediately before installing geotextile, thereby limiting the available bud and wood for data collection.

Canes with 5 buds were collected on each sampling date. The protocol used for LTE analysis is the same as described by Mills et al. (2006) (and Willwerth). The freezer is programmed to remain at 4°C for 1 hour, drop to -40°C in 11 hours (4°C/hr cooling rate), hold at -40°C for 1 hour, and then return to 4°C in 10 hours (4.4°C/hr warming rate). The DAS records the signals at 15-second intervals. Lethal temperatures are reported as LTE10, LTE50 and LTE90 where 10%, 50% and 90% of the buds died. For all vineyards, cultural practices (e.g., fruit load, vine management, pruning, and pest management) are collected for association with bud resistance. In addition, in all vineyards, bud mortality after bud break, vine vigor, and yield were recorded for each growing season. Yield, vine vigor (leaf area and pruning wood weight), and bud survival were collected on 10 randomly selected individuals from the sample plot in each vineyard. The climatic conditions of each vineyard were obtained using HOBO temperature and humidity sensors and the AgroMétéo weather station network (across Quebec). Climatic conditions were taken into account in the data analysis.

With the three years of data collection completed, additional analysis were carried out on the dataset. The hardiness curves for all cultivars were plotted over time for all site to identify beginning and end dates of a midwinter hardiness interval (data not shown). The interval of 10 Dec to 1 Mar was selected from this evaluation. Within this date interval, only cultivar x site combinations with four or more sampling dates were kept for further analysis, to ensure that the data came from regularly sampled sites and was representative of midwinter hardiness status. Data was obtained for LT10, LT50 and LT90 to compare the three indices separately. Best annual hardiness was also calculated for the three indices by identifying the hardiest LT10, LT50 and LT90 within each combination of cultivar x site x year.

Statistical analysis using XLStat version 2022.5.1 (Addinsoft, France) was performed for DTA and bud survival. Three-way analysis of variance (ANOVA) was performed on cold hardiness data collected to determine differences between winters, regions and cultivars during the mid-winter hardiness phase. A two-way ANOVA was performed for comparing best annual hardiness, considering each vineyard as a replicate measurement, and using year and cultivar as factors. Data visualization was carried out with XLStat and using R (version 4.2.2; R Core Team 2021) and RStudio (version 2022.07.2+576; RStudio team 2020) with the ggplot2 (version 3.4.0; Wickham 2016) and gghalves (version 0.4.1; Tiedemann 2022) packages.

Technical bulletins presenting the results of the LTE were produced and sent every two weeks to producers and stakeholders through various means of communication (Agriréseau website, CVQ facebook, facbook vins du Québec). Since then, a user licence for the Vine Alert website (https://www.ccovi.ca//vine-alert) has been acquired, and all data has been placed on this website. All the data collected as part of this activity is therefore data is publicly available, free of charge. Data collected on subsequent winters will be shared on this platform as well.

Activity vote 1: (2021-2023) In addition, using this data, modeling was carried out by the bioclimatology team of Dr. Gaétan Bourgeois (AAFC). Two types of models will be developed: phenology according to grape varieties (or grapevine category: hardy, semi-hardy or V. vinifera) and cold hardiness for all varieties studied.

Results and discussion vote 10

The cold hardiness monitoring program was established and ran continuously for the 2018-2019, 2020-2021, 2021-2022 winters as planned, and data was shared in multiple ways to reach as many growers as possible. The integration of the data collected as part of this activity within the VineAlert website completes the establishment of this program. The data collected over the three winters was part of previous reports, but additional analysis has since been carried out on the complete dataset.

Mid-winter hardiness was compared for the three cold hardiness indices LT10, LT50 and LT90, and to better understand the influence of cultivars, winters, and vineyards and to determine the range that can be expected from year to year. The three-way ANOVA to compare hardiness over the mid-winter hardiness portion of the winter indicated that the six main cultivars evaluated, Frontenac, Frontenac blanc, Frontenac gris, Marquette, Petite pearl and St-Pépin were not significantly different from each other (cultivar factor, Table 1), but sites and winters were. Since none of the interactions between the factors was significant (Table 1), it appears that the cultivars are behaving similarly in response to the various sites and winters, even when the vineyard and winter conditions are changing.

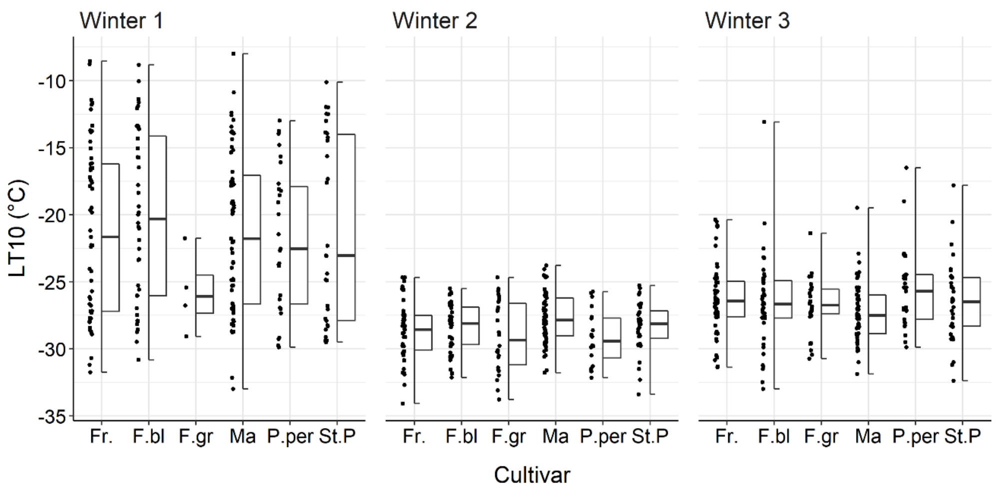
Table 1. Summary table of p-value for the three-way analysis of variance (ANOVA) of the mid-winter hardiness of the six hardy hybrid cultivars evaluated throughout the winters 2019-20, 2020-21, 2021-22, for the twelve sites regularly sampled.

Factors and interactions	LT10	LT50	LT90
Cultivar	0.789	0.653	0.104
Site	**0.001**	**<0.0001**	**<0.0001**
Winter	**<0.0001**	**<0.0001**	**<0.0001**
Cultivar*Site	0.9999	0.973	0.922
Cultivar*Winter	0.834	0.601	0.348
Site*Winter	0.393	0.071	0.078
Cultivar*Site*Winter	0.999996	0.9999	0.9999

The distribution of mid-winter hardiness LT10, LT50, and LT90 was similar across cultivars, and the three indices were impacted by vintages similarly (Figure 1). Winter 1, over the years 2019-2020, is associated to larger fluctuation in mid-winter hardiness for all cultivars compared to winter 2 (2020-21) and winter 3

(2021-22). Frontenac gris appeared hardier than the other cultivars in winter 1 (Figure 1), but it is likely since it was sampled regularly only one site, and no significant difference was measured (Table 1).

A)



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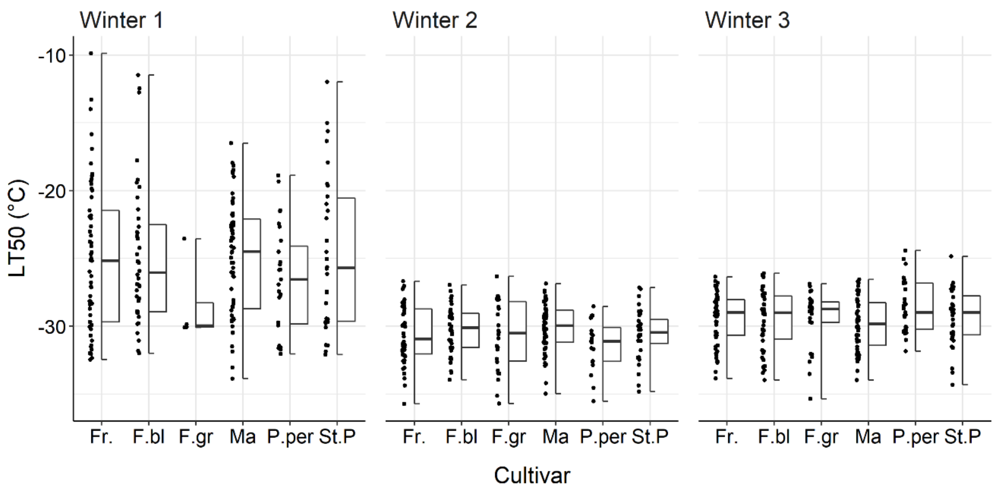

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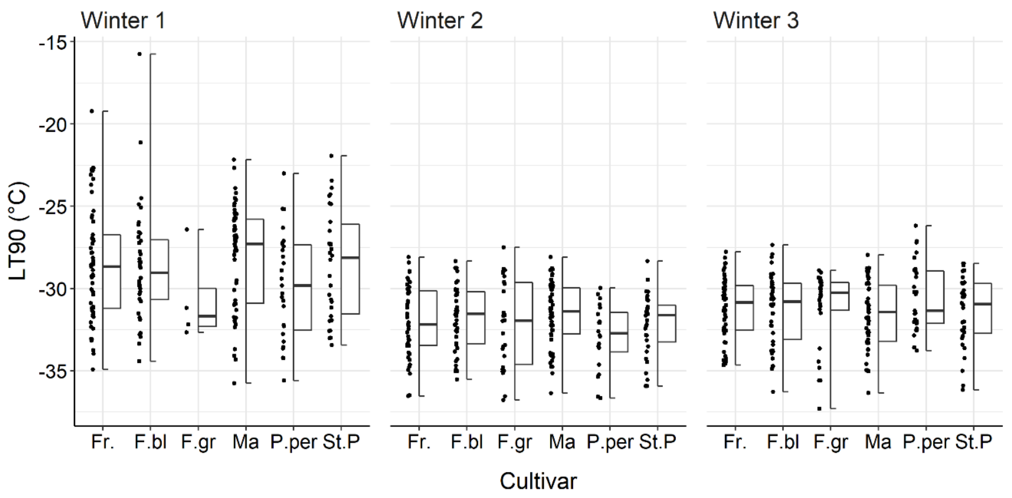
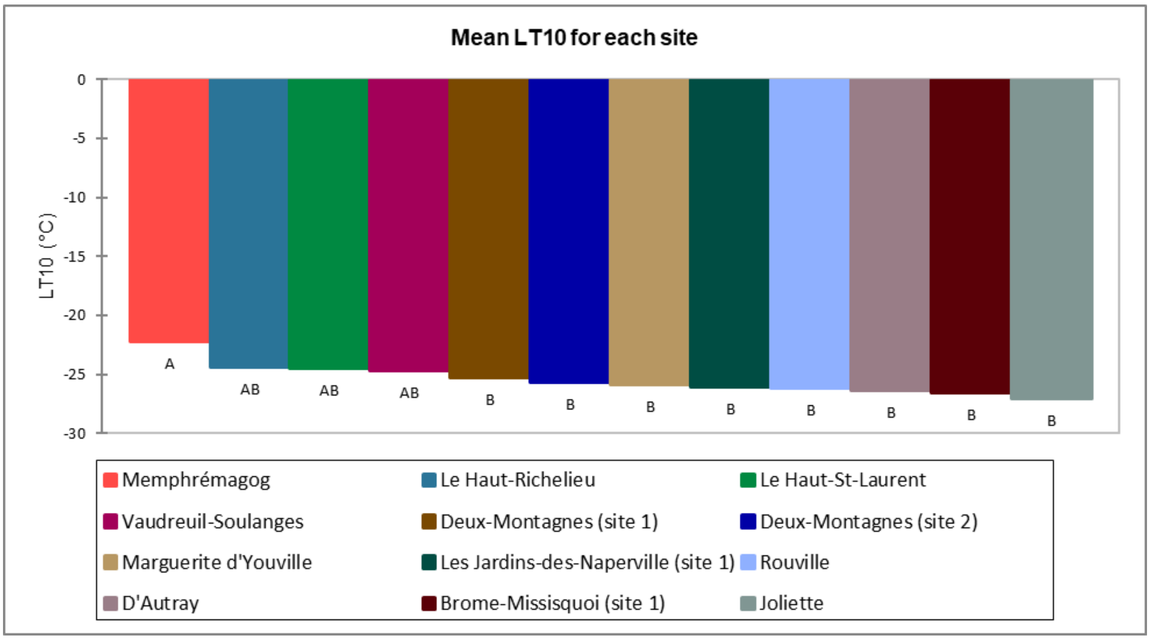


Figure 1 Annual distributions of midwinter A) LT10, B) LT50, and C) LT90 (lethal temperature of 10%, 50% and 90% of the buds, respectively) for the main cultivars (Fr: Frontenac, F.bl: Frontenac blanc, F.gr: Frontenac gris, Ma: Marquette, P.per: Petite pearl, St. P.: St-Pépin) over the three winters of data collection (winter 1: 2019-20, winter 2: 2020-21, winter 3: 2021-22). Each point on the right represents the LT10, LT50 or LT90 of one combination of site x years. The half boxplot on the left is the distribution of all vineyards sampled that year, with the median represented by the middle line, the top and bottom of the box representing the 25th

and 75th percentile, respectively, and the top and bottom whiskers representing the worst and best mid-winter hardiness, respectively, within that year.

Site differences were significant (Table 1) and similar amongst the three cold hardiness indices (Figure 2). Sites that were identified as colder in previous years, such as Joliette and D'Autray were generally hardier than other sites such as Memphrémagog (for all indices; Figure 2), and Haut St-Laurent (LT50 and LT90, Figure 2; panel B and C), and Haut-Richelieu (LT50, Figure 2; panel B). Cold hardiness is directly influenced by the temperature (Ferguson et al. 2011 and 2014, Kovaleski et al. 2023). We were therefore expecting that the less hardy vines would be on the warmer sites, but this is not what was recorded. The warmer sites of Marguerite d'Youville and Rouville, identified in previous years, were not significantly less hardy than the colder sites (Figure 2). Since all sites have overlap in the cultivars, and the cultivars are not significantly different from each other (Table 1), the difference between hardier and less hardy sites is likely associated to other factors, such as drainage and cultural practices which are known to impact hardiness (Fisher 1997, Brown et al. 2001, Dami et al. 2013) and were not quantified in the context of this activity. Further work will be required to better understand site differences in cold hardiness.

A)



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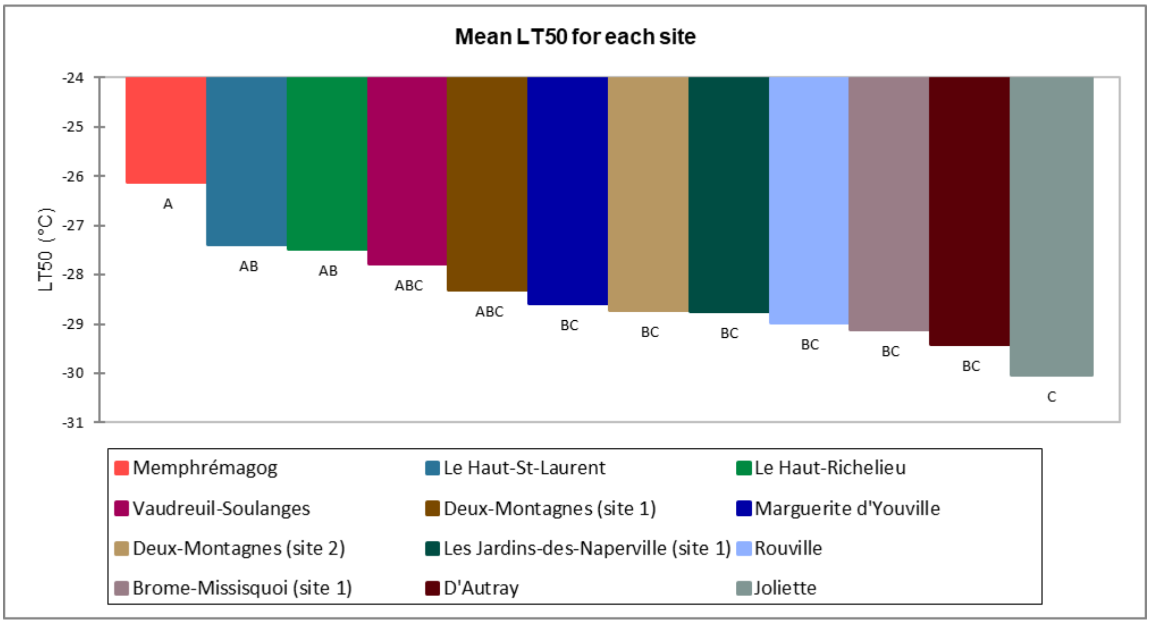

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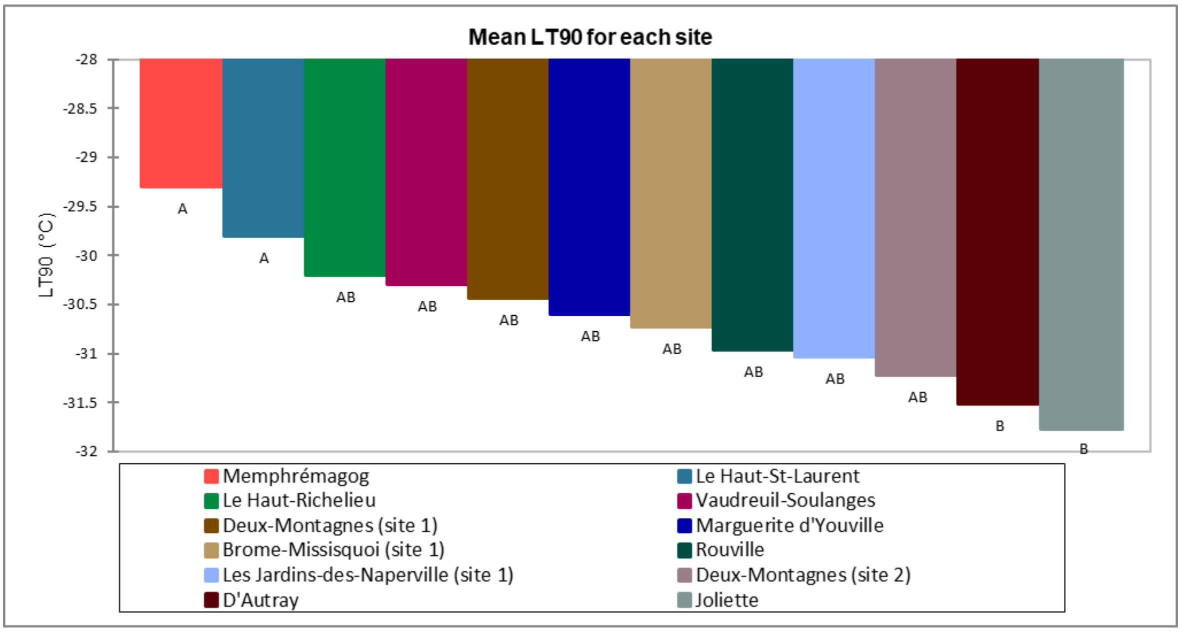


Figure 2. Mean midwinter A) LT10, B) LT50, and C) LT90 (lethal temperature of 10%, 50% and 90% of the buds, respectively) hardiness for the twelve sites. Means with different letters are significantly different according to Tukey H.S.D. post-hoc test ($p < .05$).

Within the mid-winter hardiness data, the best annual hardiness for the three indices was identified and compared by two-way ANOVA to evaluate the influence of the year and cultivar on the maximum hardiness potential. This revealed small cultivar differences, only for LT50, with Frontenac gris being hardier than all cultivars but St-Pépin (Table 2). The variation within each cultivar, brought on by the different sites, was generally larger than any differences brought on by the cultivar themselves. As it was the case with mid-winter hardiness, the winters influenced maximum hardiness (Table 2)

Table 2. Mean ± standard deviation for the best annual LT10, LT50, and LT90 values collected across different sites over the three years of the study. Means were separated by two-way analysis of variance (ANOVA) including the factors of cultivars and winters. Different letters after the mean indicate significant differences by Tukey H.S.D. post-hoc test ($p < .05$).

Factor	Cultivar	LT10	LT50	LT90
Cultivar	Frontenac	-29.9 ± 2.2	-32.2 ± 1.7 a	-34.0 ± 1.7

	Frontenac blanc	-30.6 ± 1.6	-32.2 ± 1.3 a	-33.9 ± 1.5
	Frontenac gris	-31.4 ± 1.6	-33.9 ± 1.4 b	-35.6 ± 1.2
	Marquette	-29.7 ± 1.4	-31.6 ± 1.3 a	-33.4 ± 1.4
	Petite perle	-29.7 ± 0.9	-31.8 ± 0.8 a	-34.1 ± 0.7
	St-Pépin	-30.8 ± 1.7	-32.7 ± 1.4 ab	-34.4 ± 1.2
	p-value	0.385	0.030	0.052
Winter	winter 1	-29.0 ± 1.6 a	-31.0 ± 1.4 a	-32.8 ± 1.5 a
	winter 2	-31.4 ± 1.3 c	-33.1 ± 1.3 b	-34.9 ± 1.0 b
	winter 3	-30.1 ± 1.4 b	-32.4 ± 1.1 b	-34.3 ± 1.2 b
	p-value	<0.0001	<0.0001	0.00014
Cultivar*Winter	*p-value*	0.107	0.237	0.710

Vote 1 Results

Ferguson's model

Grapevine cold hardiness varies throughout the dormant season, primarily in response to temperature changes. Ferguson et al. (2011) developed a dynamic model of bud cold hardiness for three grapevine varieties, Cabernet Sauvignon, Chardonnay and Concord. This model anticipates potential damage caused by winter temperature fluctuations and extreme cold events. It is implemented in the CIPRA software as published, based on the results obtained by the authors. For example, the cold hardiness model curve for Cabernet Sauvignon for the winter of 2021-22 as produced by CIPRA for the Frelighsburg weather station is presented in Figure 1. Data from Quebec wine regions will allow us to validate this model under the conditions observed here.

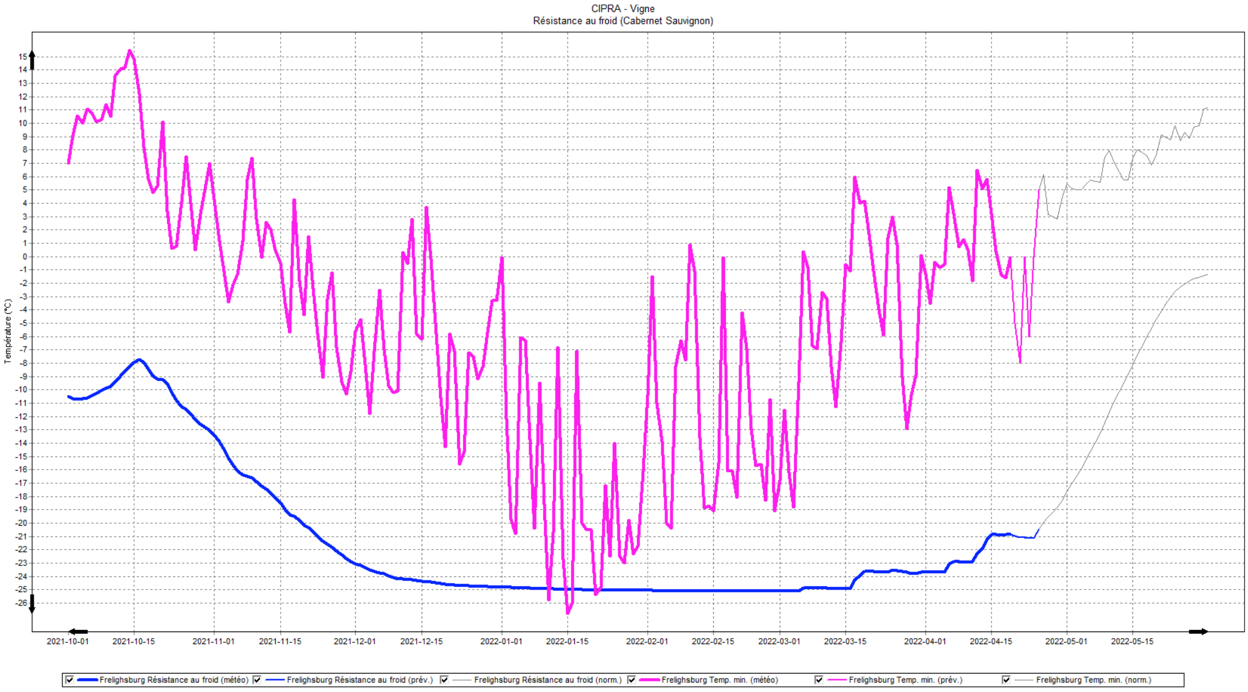


Figure 1. plot of the cold hardiness model (Ferguson,2011) as generated by CIPRA for Cabernet Sauvignon, using weather data from the station located in Frelighsburg, during the 2021-2022 dormant season.

Data analysis

Cold hardiness data of several grapevine varieties were collected between 2019 and 2022 at several sites in Quebec and weather data were recorded at each site. First, temperature data were compiled to produce minimum temperature curves (Tmin) during the dormant season, i.e. from early October to late May, for each site and year where cold hardiness data were taken. A total of 39 curves were made for the 16 sites and 3 years. In 8 cases, the data covered only part of the season, either because the project had only started in January 2020 at some sites (Deux-Montagnes site 2, Haut-St-Laurent, Memphrémagog and Vaudreuil-Soulange) or because the vines monitored were vinifera covered with canvas in November, and therefore not sampled for hardiness data after this operation (Joliette, Jardin de Napierville site 2, Maskoutains and Memphrémagog). Table 1 summarizes all the weather data compiled and Figure 2 represents an example of a graph for Brome-Missisquoi site 1, for the 2020-2021 season. The next step will be to analyze the cold hardiness data collected in the field between 2019 and 2022 in order to calculate the LTE curves generated by the Ferguson model and add them to the Tmin graphs.

Table 1. Summary of available weather data

MRC	Site	Données
Brome-Mississquoi site 1	Brome	2020-21
Brome-Mississquoi site 2	Dunham	2019-20, 2020-21, 2021-22
D'Autray	Lanoraie	2019-20, 2020-21, 2021-22
Deux-Montagnes site 1	Oka	2019-20, 2020-21, 2021-22
Deux-Montagnes site 2	St-Eustache	2019-20, 2020-21, 2021-22
Deux-Montagnes site 3	St-Joseph	2020-21
Haut Richelieu	St-Blaise	2019-20, 2020-21, 2021-22
Haut St-Laurent	Hinchinbrooke	2019-20, 2020-21, 2021-22
Jardins de Napierville site 1	Hemmingford	2019-20, 2020-21, 2021-22
Jardins de Napierville site 2	St-Jacques-le-Mineur	2019-20, 2020-21
Joliette	St-Thomas	2019-20, 2020-21, 2021-22
Marguerite d'Youville	Varennes	2020-21, 2021-22
Maskoutains	St-Louis	2019-20, 2020-21
Memphrémagog	North Hathley	2019-20, 2020-21
Rouville	Rougemont	2019-20, 2020-21, 2021-22
Vaudreuil-Soulange	Vaudreuil	2019-20, 2020-21, 2021-22

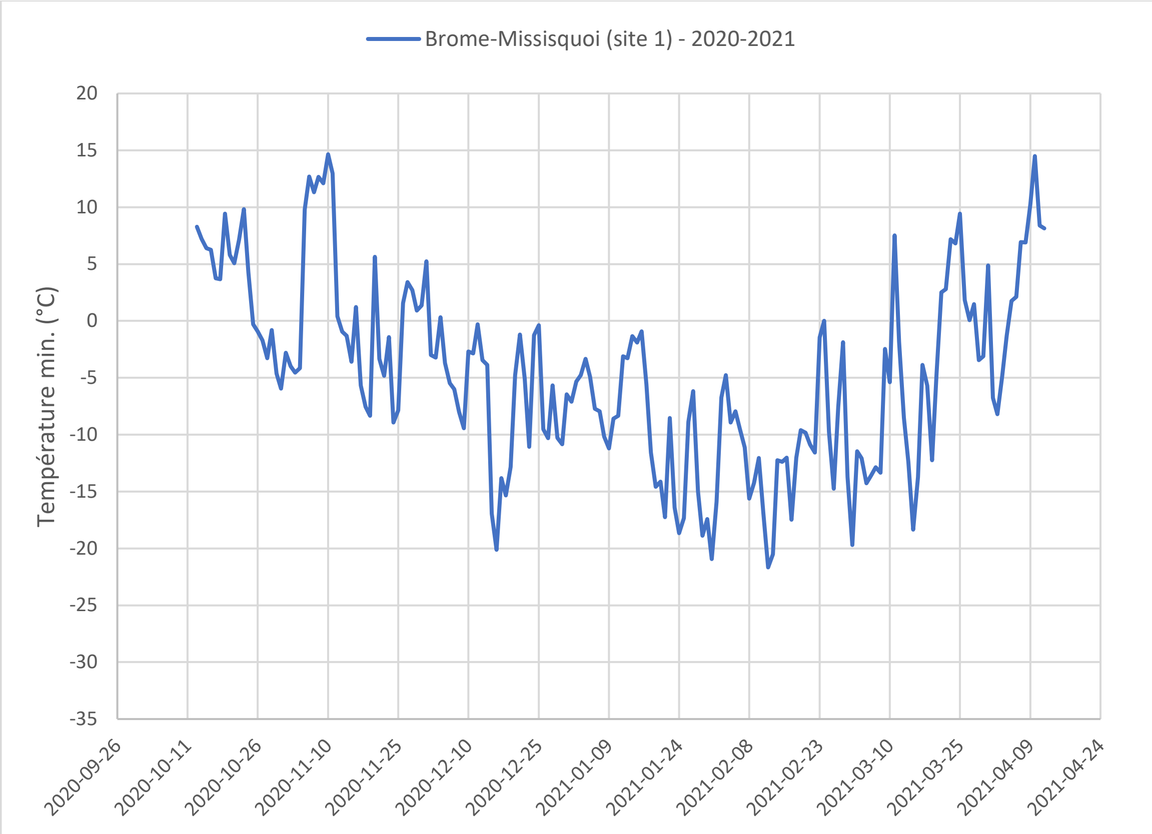


Figure 2: Graph of minimum temperatures recorded at site 1 in Brome-Missisquoi for the 2020-2021 dormant season

Literature review on cold hardiness in grapevine¸
- A literature review was conducted to verify the availability of bioclimatic models to predict cold hardiness in grapevine during winter
- Key articles: Ferguson et al. (2011, 2014), Hoegh and Leman (2015), Rubio and Pérez (2020). All of these articles use or refer to the model developed by Ferguson et al. (2011) that has been implemented in CIPRA software.
- Other interesting articles: Antivilo et al. (2017), Londo and Kovaleski (2017), Meier et al. (2018), Rubio et al. (2016)

Implementation of the model in CIPRA software
- The model comes from the publications of Ferguson et al. (2011, 2014). The selected grape varieties are Cabernet Sauvignon, Chardonnay, Concord, Pinot gris, and Riesling.
- From October 1 to budbreak, the model predicts the lethal temperature at which 50% of the buds will die (LT50). A second curve represents the observed hourly minimum temperatures and the forecast for the next 5 to 6 days.
- The following text has been incorporated into the "CIPRA Crop Guide":

"Canadian winters can be difficult for grapevines. One extreme cold snap can damage vines and reduce crop yields by 50%. Before the season begins, growers need to assess winter damage so they can adjust pruning accordingly and adjust their viticultural practices to ensure the quality of the next crop, the sustainability of the vines and the economic stability of their business. Predicting the cold hardiness of vines allows the use of direct protection methods during extreme cold (candles, heaters, water spraying, air mixing) that can reduce the risk of bud damage. Cold hardiness varies during hardening off, dormancy and bud break. The colder the temperatures during hardening off, the more resistant the vine buds will be to cold. De-hardening occurs more quickly than acclimation and is dependent on increasing warm temperatures. Temperature fluctuations (freeze-thaw) can also lead to desiccation. Climatic factors that influence damage are duration of exposure to cold temperatures, drastic decreases in temperature, and thawing prior to freezing events."

Bioclimate modeling activities
- All air temperature measurements collected during three winter periods (2019-2020, 2020-2021 and 2021-2022) in about 15 vineyards were collated and the minimum temperature curves were prepared to juxtapose them with the cold hardiness data of the vine buds (see information provided by Dominique Plouffe).
- The Ferguson et al. (2011) model was implemented in CIPRA software for Cabernet Sauvignon, Chardonnay, Concord, Pinot gris and Riesling grape varieties, according to the parameter values indicated in the documentation available for this model.
- To evaluate the behavior of the grapevine cold hardiness model, simulations were run with L'Acadie weather data for the winters of 2019-2020 (Fig. 1), 2020-2021 (Fig. 1), and 2021-2022 (Fig. 3).

Bibliographic references consulted

Antivilo, F.G., R.C. Paz, M. Keller, R. Borgo, J. Tognetti, and F.R. Juñent. 2017. Macro- and microclimate conditions may alter grapevine deacclimation: variation in thermal amplitude in two contrasting wine regions from North and South America. International Journal of Biometeorology 61:2033-2045.

Brown M, Ferree DC, Scurlock DM and Sigel G. 2001. Impact of soil drainage on growth, productivity, cane dieback, and fruit composition of ‘Chambourcin’ and ‘Pinot Gris’ grapevines. HortTechnology 11:272-274.

Dami, I. E., Ennahli, S., & Scurlock, D. (2013). A five-year study on the effect of cluster thinning and harvest date on yield, fruit composition, and cold hardiness of ‘Vidal Blanc’ (Vitis spp.) for Ice Wine Production. HortScience, 48(11), 1358–1362. https://doi.org/10.21273/HORTSCI.48.11.1358Ferguson J.C., J.M. Tarara, L.J. Mills, G.G. Grove, and M. Keller. 2011. Dynamic thermal time model of cold hardiness for dormant grapevine buds. Annals of Botany 107:389-396.erguson J.C., M.M. Moyer, L.J. Mills, G. Hoogenboom, and M. Keller. 2014. Modelling dormant bud cold hardiness and budbreak in twenty-three Vitis genotypes reveals variation by region of origin. Am. J. of Vitic. 65(1):59-71.

Fisher HK. 1997. Drainage for optimal vineyard root growth. Wine East (April) 10-20. 41.

Hoegh, A. and S. Leman, 2015. A spatio-temporal model for assessing winter damage risk to east coast vineyards. Journal of Applied Statistics 42(4):834-845.

Londo, J.P. and A.P. Kovaleski. 2017. Characterization of wild North American grapevine cold hardiness using differential thermal analysis. American Journal of Enology and Viticulture 68:203-212.

Meier, M., J. Fohner, and A. Holzkämper. 2018. Changing risk of spring frost damage in grapevines due to climate change? A case study in the Swiss Rhone Valley. International Journal of Biometeorology 62:991-1002.

R Core Team. 2021. R: a Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

RStudio Team. 2020. RStudio: Integrated Development Environment for R. RStudio, PBC, Boston, MA

Rubio, S., D. Dantas, R. Bressan-Smith, and F.J. Pérez. 2016. Relationship between endodormancy and cold hardiness in grapevine buds. Journal of Plant Growth Regulation 35:266-275.

Rubio, S. and F.J. Pérez. 2020. Testing the Ferguson model for the cold-hardiness of dormant grapevine buds in a temperate and subtropical valley of Chile. International Journal of Biometeorology 64:1401-1408.

Wickham H. 2016. ggplot2: Elegant graphics for data analysis. Springer-Verlag, New York

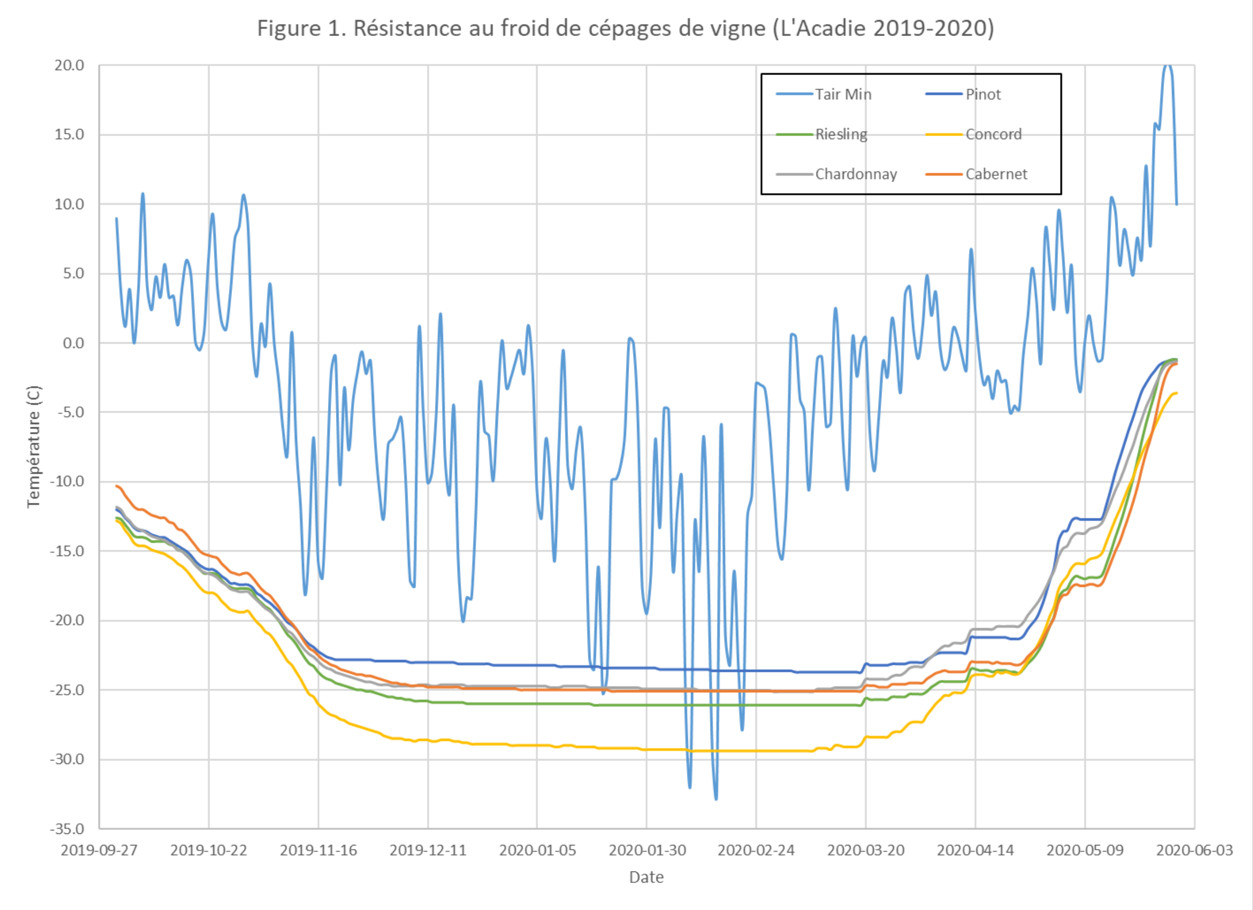


Figure 2. Résistance au froid de cépages de vigne (L'Acadie 2020-2021)

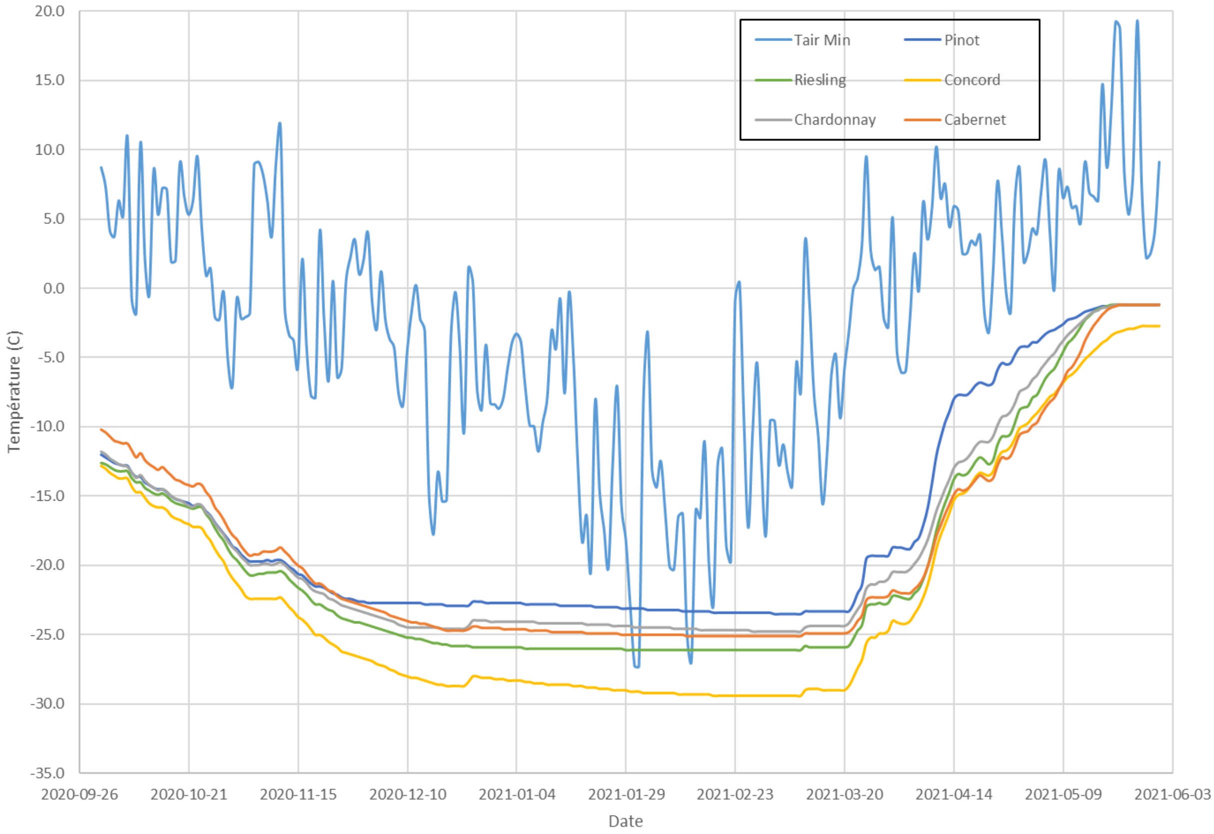
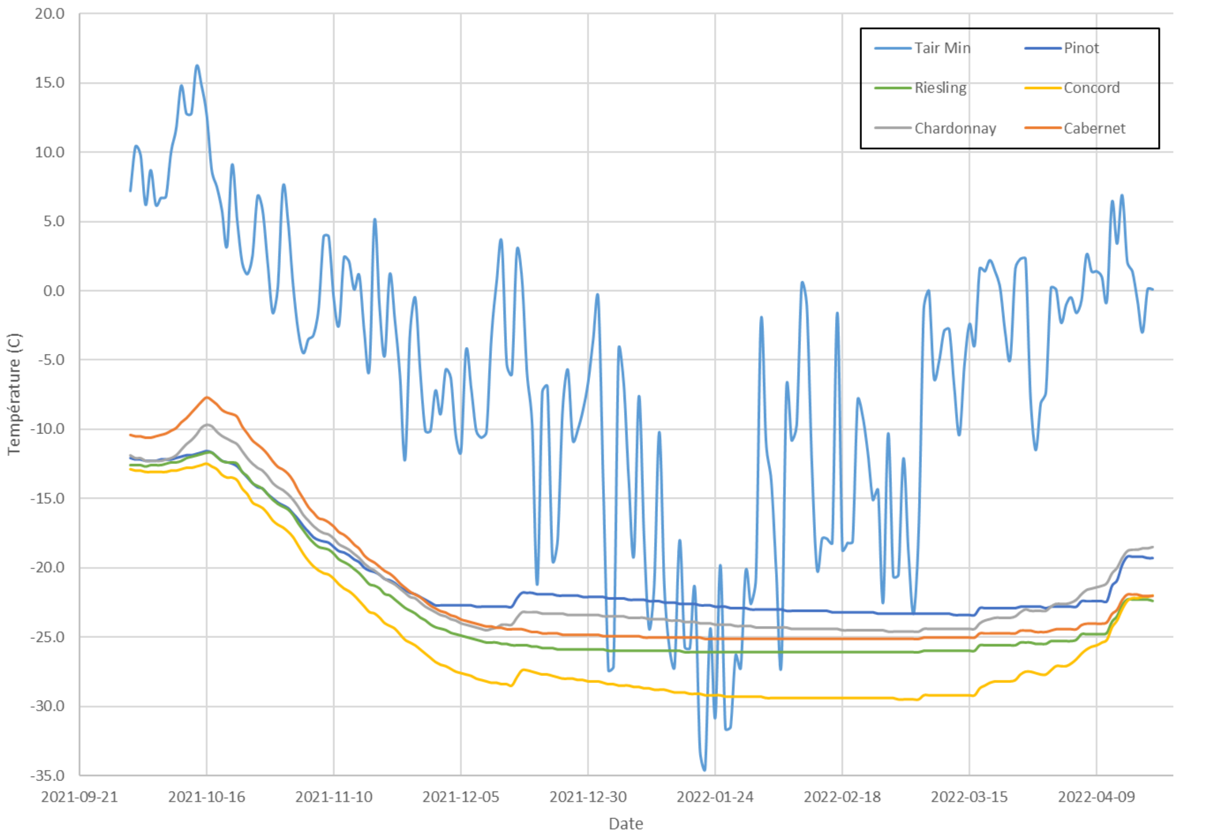


Figure 3. Résistance au froid de cépages de vigne (L'Acadie 2021-2022)



Activity 2: Utilisation de toiles géotextiles comme protection hivernale pour les cépages non rustiques/ Use of winter protection systems to reduce winter injuries of cold sensitive cépages.

Introduction :
Cultural practices (e.g., vine loading, weed control, management system...) during the growing season and vineyard health (crop stress, diseases, insects...) can affect cold hardiness (Wolpert and Howell 1985; Howell 2001; Willwerth et al. 2014). Bud protection from winter frost damage is essential for grapevine production in northern regions and is directly related to the dormant bud (Zabadal et al. 2007). Bud protection from winter damage begins at the end of the growing season and is strongly influenced by temperature and photoperiod (Schnabel and Wample 1987; Grant et al. 2013). Winter protection methods have been developed to use less cold-hardy grape varieties (soft, semi-hardy) in cold regions. Several methods are available such as wind machines, insulation with snow, mulch, soil (ridging), and geotextiles to reduce winter damage (Zabadal et al. 2007). However, the use of these methods needs to be adapted to specific regions or improved for specific grape varieties. Few studies have evaluated the use of geotextile in eastern Canadian conditions, however Khanizadeh's team conducted a study under Quebec conditions. They evaluated winter protection methods for twenty grape varieties in three regions in Quebec (different soil and microclimatic conditions) (Khanizadeh et al. 2004, 2005). They observed that grape varieties responded differently to winter protection and were also influenced by the test sites. The use of geotextile seems to be more effective for soft and semi-hardy grape varieties. Results showed that the hardy varieties Sabrevois, Prairie Star, Delisle, Mitchurinetz, St. Croix and St. Pepin were less affected by winter protection, with similar yields in the presence and absence of protection. However, semi-hardy varieties such as ES-6-12-28, GR-7 and Lucie Kuhlmann, produced higher yields when covered with snow or geotextile compared to no winter protection. Ridging (with soil) of Seyval blanc appeared to be ineffective in addition to increasing disease risk and production costs. Khanizadeh et al (2008) also observed that winter protection affected fruit distribution. For hardy and semi-hardy varieties, they observed that the use of geotextile as winter protection resulted in fruit distribution with the highest percentage of clusters between 81 and 125 cm above the ground. In contrast, the soft grape varieties had scattered fruit, with an overall distribution concentrated between 0 and 125 cm. This difference between hardy, semi-hardy and soft grape varieties using geotextile protection may be attributed to the management method used. Recently, other studies have been conducted under Ontario climatic conditions (Willwerth 2013; Willwerth et al. 2014). They noted that the use of geotextile to protect vines produced a "greenhouse effect" and increased temperatures (daily average, minimum and maximum). The geotextile had effects on grapevine cold hardiness with some reductions in hardiness levels, primarily LTE 10, during acclimation and deacclimation periods. To reduce winter and spring frost, it is important to remove the geotextile at the appropriate time, as it may reduce resistance during the deacclimation period. In general, the use of geotextile has been shown to be very effective in protecting buds from frost and results in better vine health and higher yields.

The main objective of this project is to improve the knowledge of cold hardiness of hybrid (hardy and semi-hardy) and *Vitis vinifera* grapevines and to propose methods to reduce frost damage in eastern Canadian conditions to support the development of the wine industry.

Specific objectives of this activity include:
1. Acquire knowledge on winter protection systems with geotextile (or other materials) to optimize vine winter protection and increase yield and fruit quality;

2. Development of optimal use (timing of installation and removal) of geotextile as winter protection.

Methodology

Several winter protection systems using geotextile have been developed by grape growers and new materials are available. However, the timing of installation and removal can vary, and little is known about the impact on the vines.

Three types of geotextiles were evaluated: Hibertex 2.2 mm, Hibertex 3mm and Texel Arbo Pro. Four treatments were evaluated: 1) early installation (November, physiological leaf fall) / early removal (March-April, depending on snow); 2) late installation (December, 2 weeks after leaf fall) / early removal (March-April, 2 weeks after the first removal); 3) early installation (November) / late removal (late April-May); and 4) late installation (December) / late removal (late April-May) Three varieties were evaluated, one semi-hardy: Vidal; and two *V. vinifera*: Chardonnay and Pinot noir. For each treatment, four replicates were set up in randomized blocks and each plot included ten grapevines. The trials were installed in one vineyard in the fall of 2018, followed by three more in 2019 (Tab.I). The trials will be installed in four additional vineyards in 2020 (Tab.I). The trials will be conducted on a specific grape variety for three consecutive years in a minimum of two different vineyards and in various regions of Quebec.

Table I: Distribution of sites for conducting tests with geotextile fabrics.

Vignoble	Code du site	Types de toile et les moments d'installation *(nombre de plants par cépage)*				
		Total	**Vidal**	**Pinot**	**Chardonnay**	**Année essais**
Domaine du Fleuve	Vidal-DF, Pinot-DF, Chardo-DF	**560**	**240**	80	**240**	2018, 2019, 2020
La Bullerie	Vidal-Bul	**240**	**240**	--	--	2020, 2021, 2022
Domaine St-Jacques	Chardo-DSJ	**240**	--	--	**240**	2020, 2021, 2022
Nival	Vidal-DN, Pinot-DN	**240**	160	80	--	2019, 2020, 2021
Grand-St-Charles	Vidal-GSC	**80**	80	--	--	2019, 2020, 2021

En vert: "Moment" seulement
En bleu: "Type" seulement
En noir: "Type" de toile et "moment"

Data Collection:

Daily climatic conditions (temperature and relative humidity) were collected using Hobo throughout the dormant season, both under and outside the geotextile. Several parameters were collected starting in the spring to compare all treatments and the evolution of vine acclimation and deacclimation:

- Snow cover: the height of the snow cover as well as the percentage of fabric covered with snow was noted once a month during the winter.
- Bud survival (field assessment): 6 canes (2/vine) with 8 buds were collected after removal of the canvases and observed in the laboratory. Primary and secondary bud mortality was determined by dissection.
- LTE10, LTE50 and LTE90: during the month following the removal of winter protection, LTE was determined using the DTA system once a week.
- Phenology: phenological stages were determined using the BBCH scale (Lorenz et al., 1995). Observations were made twice a week from early April to early June and once a week from June to September.
- Leaf area: leaf area was determined using Li-COR equipment at two times (July and August) during the growing season.
- Yield (number of clusters, kg/plant, cluster weight and berry weight): total cluster weight per plant and number of clusters per plant were collected. The average cluster weight was calculated. Berry weight was determined at harvest by random sampling (3 times the weight of 100 berries).

- Berry chemistry at harvest (pH, TA, TSS): complete chemical analyses were performed on the juice at harvest.
- Lignification: lignification was assessed by measuring the length of lignified wood on vine branches (2 per vine) at two time periods in the fall (August and September).

All data were collected on the three central vines of the plot.
All statistical analysis was performed using XLStat version 2022.5.1 (Addinsoft, France). Different tests were used based on the data. Generalized linear mixed models (GLMM), analysis of variance, and regression analyses were used to compare the impact of winter protection materials and treatments (installation and removal schedule) on phenological stages, periderm formation, and harvest parameters. The impact of timing and type on bud survival was achieved by building contingency tables and analyzing them with χ^2 or Fisher's exact test when the bud survival was below 5 for any cell. Treatments were then individually compared using the Monte Carlo method with 5000 simulations to identify the significantly different treatments within the table. Subsequently, the impact of timing and type of geotextile were evaluated separately by χ^2. When only timing or type of geotextile was tested within a vineyard, the χ^2 test was used to identify significant differences between the treatment, and followed by the Monte Carlo method when differences were identified.

Results and discussion

Data for the 2020-2021 winter and 2021 harvest was presented in the last report. As such, this report includes the results of the growing season 2022 following the 2021-2022 winter. Following the 2021-2022 winter, the two times of removal were separated by 14 to 16 days, depending on the vineyard (Table 2). The Pinot noir at Domaine du Nival only has one removal date since only the type of geotextile was tested there, and not timing of installation and removal.

Table 2. Installation and removal date for the geotextile for each cultivar on all sites evaluated. Dates for all years are included in this table.

Site	Cépage	Date early installation	Date late installation	Date early removal	Date late removal
Domaine du Fleuve	Vidal	2018-11-14	2018-11-28	2019-04-16	2019-05-04
Domaine du Fleuve	Chardonnay	2018-11-14	2018-11-28	2019-04-16	2019-05-04
Domaine du Fleuve	Pinot Noir	2018-11-14	2018-11-28	2019-04-16	2019-05-04
Domaine du Fleuve	Pinot Noir	2018-11-17	2018-11-28	2019-04-16	2019-05-04
Grand St-Charles	Vidal	2019-11-20	-	2020-04-16	-
Nival	Vidal	2019-11-20	-	2020-04-01	-
Domaine du Fleuve	Chardonnay	2019-11-22	-	2020-04-02	-
Domaine du Fleuve	Pinot Noir	2019-11-22	-	2020-04-02	-
Domaine du Fleuve	Vidal	2019-11-21	-	2020-04-02	-
La Bullerie	Vidal	2020-11-02	2020-11-16	-	-
Domine du Nival	Pinot Noir	2020-11-04	-	2021-04-08	-
Domine du Nival	Vidal	2020-11-04	2020-11-18	2021-04-08	2021-04-26
Grand St-Charles	Vidal	2020-11-04	2020-11-18	2021-04-08	2021-04-26
Domaine St-Jacques	Chardonnay	2020-11-05	2020-11-19	2021-04-06	2021-04-23

Domaine du Fleuve	Chardonnay	2020-11-06	2020-11-20	2021-04-05	2021-04-27
Domaine du Fleuve	Pinot Noir	2020-11-06	-	2021-04-05	-
Domaine du Fleuve	Vidal	2020-11-06	2020-11-20	2021-04-05	2021-04-27
La Bullerie	Vidal	2021-11-05	2021-11-17	2022-04-06	2022-04-21
Domine du Nival	Pinot Noir	2021-11-08	-	2022-04-05	-
Domine du Nival	Vidal	2021-11-08	2021-11-19	2022-04-05	2022-04-21
Grand St-Charles	Vidal	2021-11-02	2021-11-19	2022-04-06	2022-04-21
Domaine St-Jacques	Chardonnay	2021-11-04	2021-11-16	2022-04-04	2022-04-20

Note: A late installation was not possible in 2019 because of early snow while the COVID-19 pandemic interfered with the removal in the spring 2020.

Temperatures under the geotextiles were similar between the treatments, whether it is the different types of geotextiles or the timing of installation and removal. In general, no difference were observed between the treatments (for example for the Chardonnay at Domaine St-Jacques, Figure 1). Some individual treatments sometimes appeared colder than others, such as the late installation/early removal treatment under the Hibertex 2mm geotextile at the Bullerie site (Figure 2).

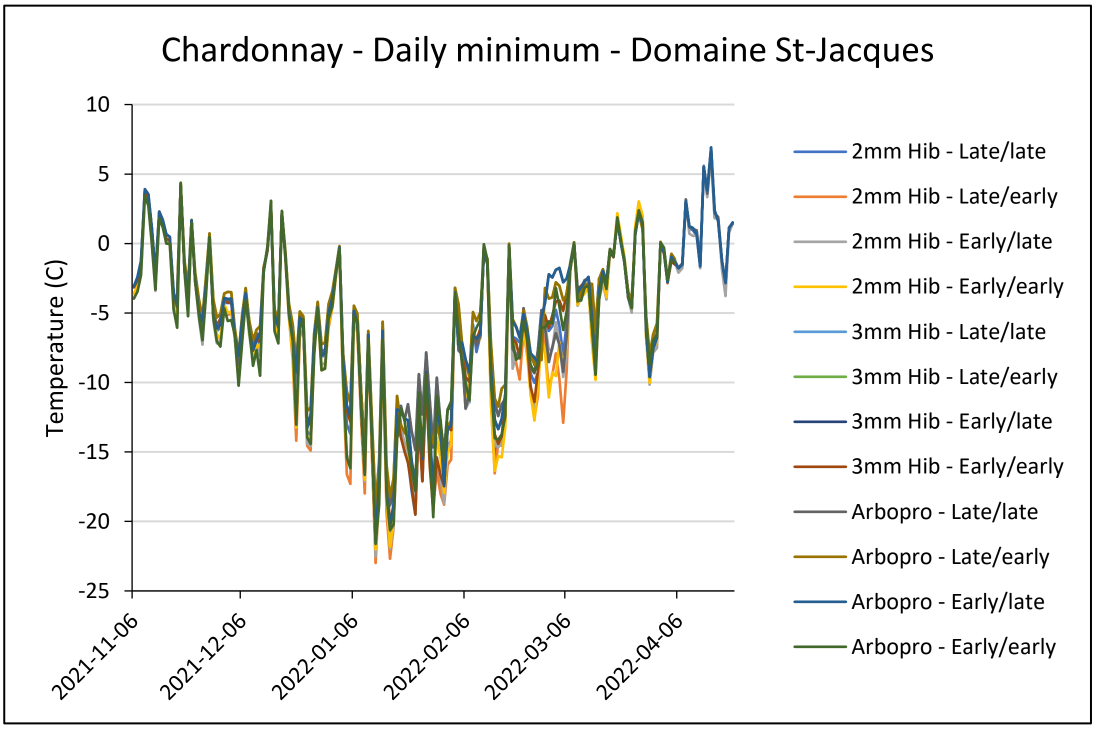


Figure 1. Daily minimum temperature under the geotextiles for all treatments (type of geotextile – timing of installation/timing of removal) for the Chardonnay cultivar at Domaine St-Jacques.

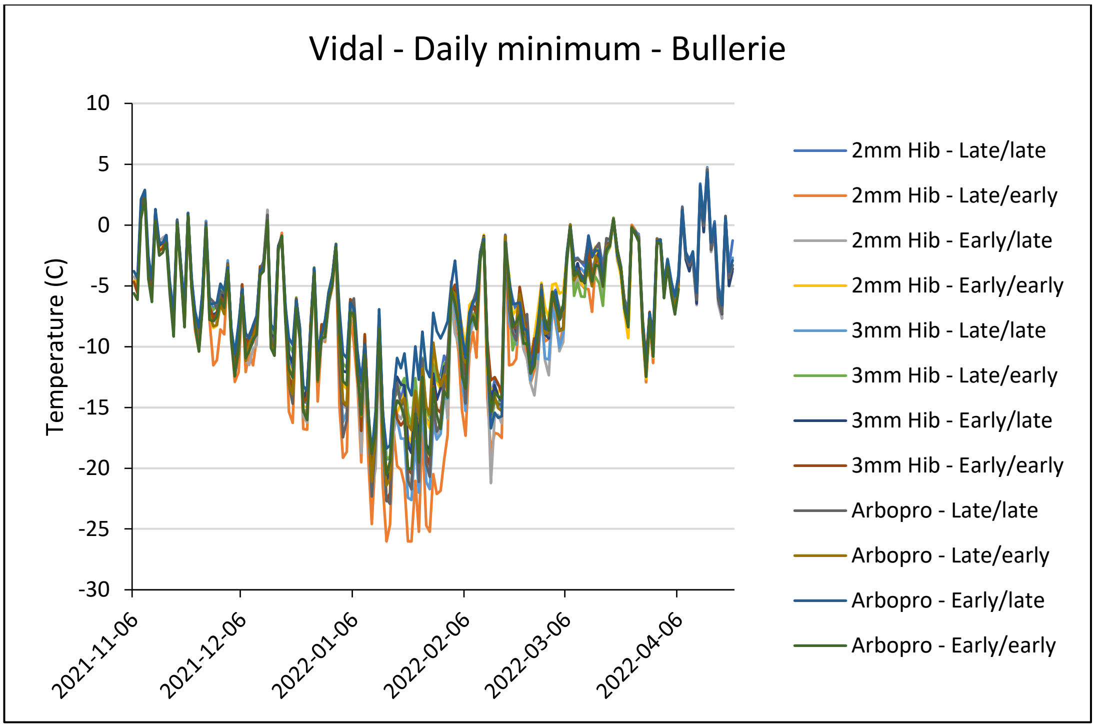


Figure 2. Daily minimum temperature under the geotextiles for all treatments (type of geotextile – timing of installation/timing of removal) for the Vidal cultivar at Bullerie site.

Bud survival was generally not impacted by the type of geotextile or the timing of installation and removal (Table 3). The only significant difference identified was for the Vidal cultivar at la Bullerie, but further statistical comparison by the Monte Carlo method (simulation numbers = 5000) failed to identify a significantly different treatment (Figure 3). Separate evaluation of type of geotextile and timing did not reveal significant differences either. Lack of differences in bud survival between the treatments supports the fact that the temperatures under the geotextiles were not impacted by the treatments.

Table 3. Significance level of the χ^2 test (or Fisher's exact test for the Bullerie site) to compare bud survival for all sites and cultivars following the 2021-2022 winter. Bolded value indicates a significant difference (p<.05) within the cultivar x site combination.

Cultivar	Site	Type and timing	Type	Timing
Vidal	Bullerie	**0.0004**	0.778	0.553
	Grand St-Charles	-	-	0.965
	Domaine du Nival	-	-	0.998
Chardonnay	Domaine St-Jacques	0.996	0.890	0.965
Pinot noir	Domaine du Nival	-	0.981	-

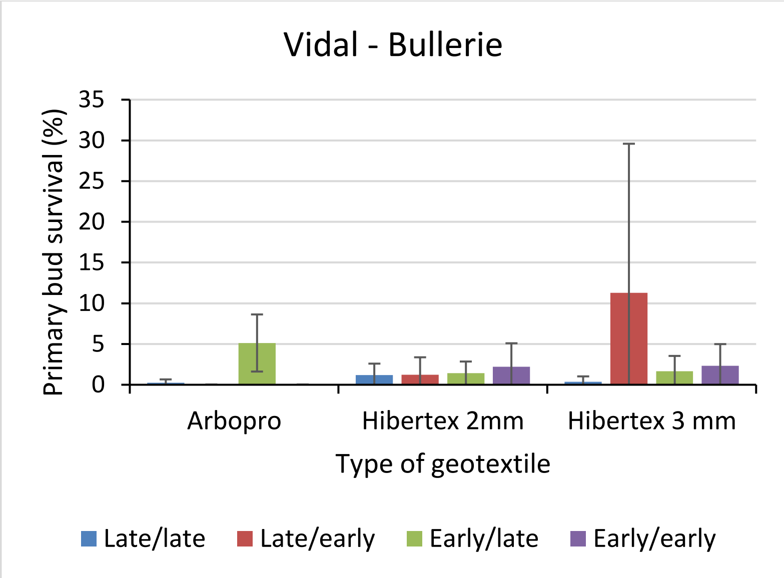


Figure 3. Mean primary bud survival level (n=4) for the Vidal at the Bullerie site. No significant difference was identified between the treatment using the Monte Carlo method with 5000 simulations. Error bars represent standard error.

Timing of phenological stages were not impacted by the treatments, whether it is by the type of geotextile or the moment of installation and removal. Variation between treatments were not consistent from one date to the next, as it was the case at on the Bullerie site (Figure 4). The types of geotextile had not impact on phenological stages (Figure 5). The timing of installation and removal also had no impact, regardless on the cultivar and the site (Figure 6 and Figure 7).

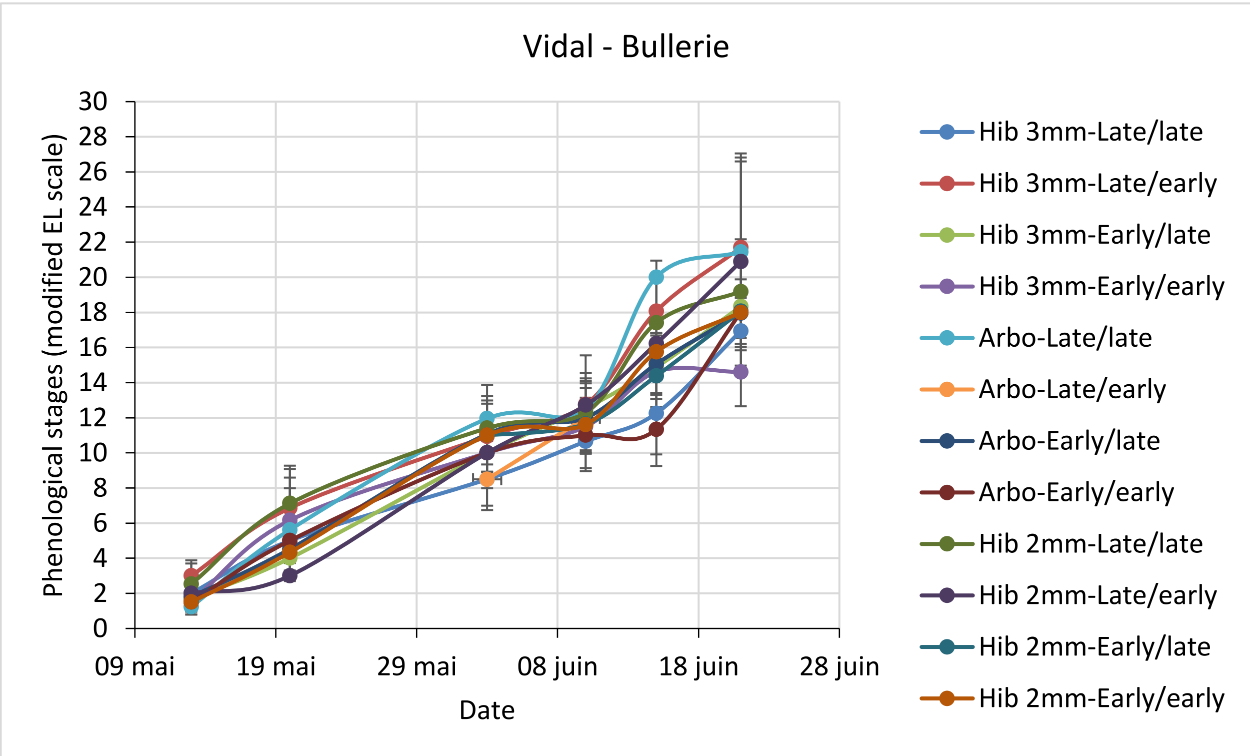


Figure 4. Progression of phenological stages over time for the Vidal at the Bullerie site. Each data point represents the mean of 4 replicates, and the error bars represent the standard deviation. The treatments are presented as Geotextile – timing of installation/timing of removal (Hib: Hibertex, Arbo: Arbopro).

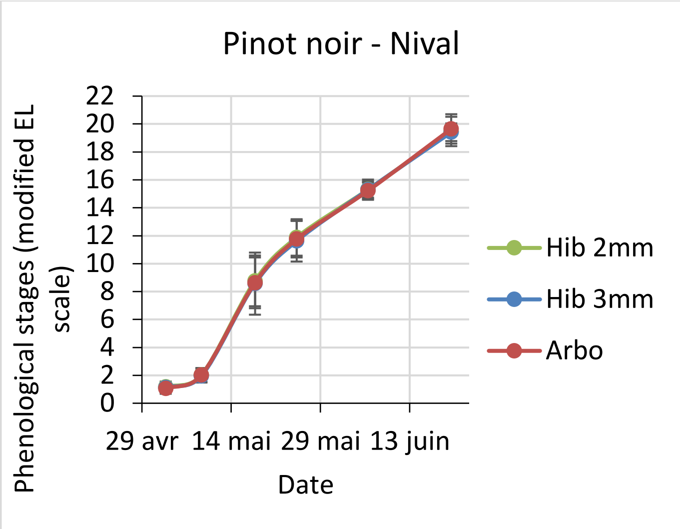


Figure 5. Progression of phenological stages over time for the Pinot noir at the Domaine du Nival site for the vines covered by the three types of geotextiles (Hib: Hibertex, Arbo: Arbopro). Each data point represents the mean of 4 replicates, and the error bars represent the standard deviation.

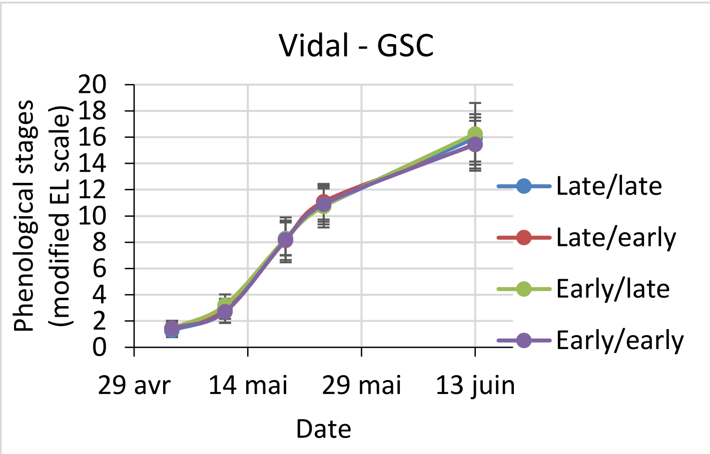


Figure 6. Progression of phenological stages over time for the Vidal at the Grand St-Charles site for the four timing of installation and removal treatment (presented as timing of installation/timing of removal). Each data point represents the mean of 4 replicates, and the error bars represent the standard deviation.

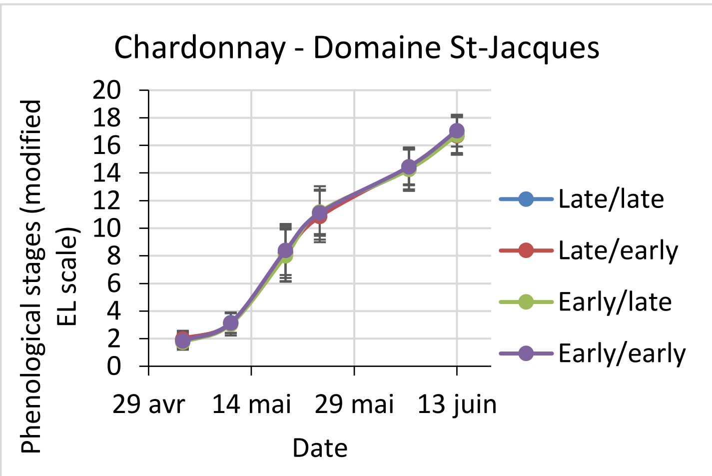


Figure 7. Progression of phenological stages over time for the Chardonnay at Domaine St-Jacques for the four moments of installation and removal treatment (presented as timing of installation/timing of removal). Each data point represents the mean of 4 replicates, and the error bars represent the standard deviation.

Periderm formation on all sites was measured, but was already completed by the time data was recorded at Domaine St-Jacques and Bullerie site. Therefore, no differences were noted between the treatments. For the other sites, no significant differences were observed between the treatments. The periderm formation was similar for Pinot noir regardless of the types of geotextiles that had covered the vines the previous year (p=0.832; Figure 8). Similarly, the timing of installation and removal did not impact periderm formation either, whether it was on Vidal (p=0.465; Figure 9), or Chardonnay (p=0.187; Figure 10).

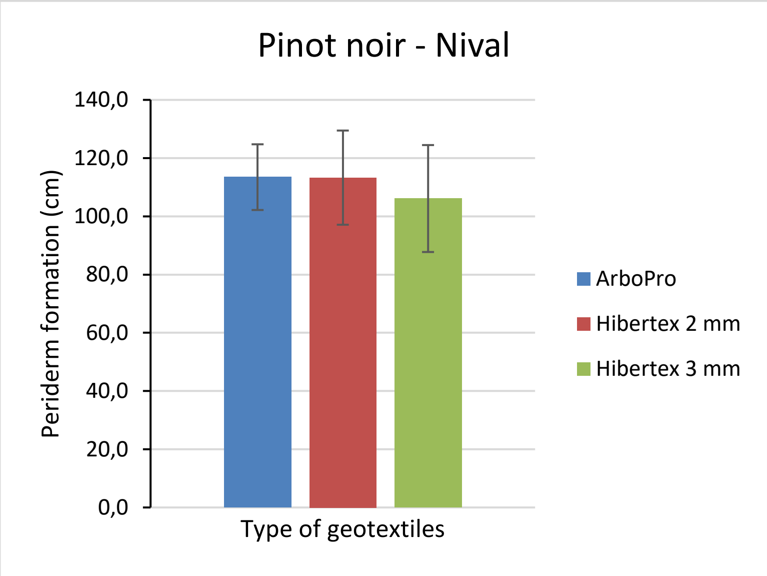


Figure 8. Mean periderm formation between the different treatment of types of geotextile as measured on September 30th, 2022 on the Domaine du Nival site. Error bars represent standard error (n=4). The means were not significantly different at a 5% significance level according to a one-way analysis of variance.

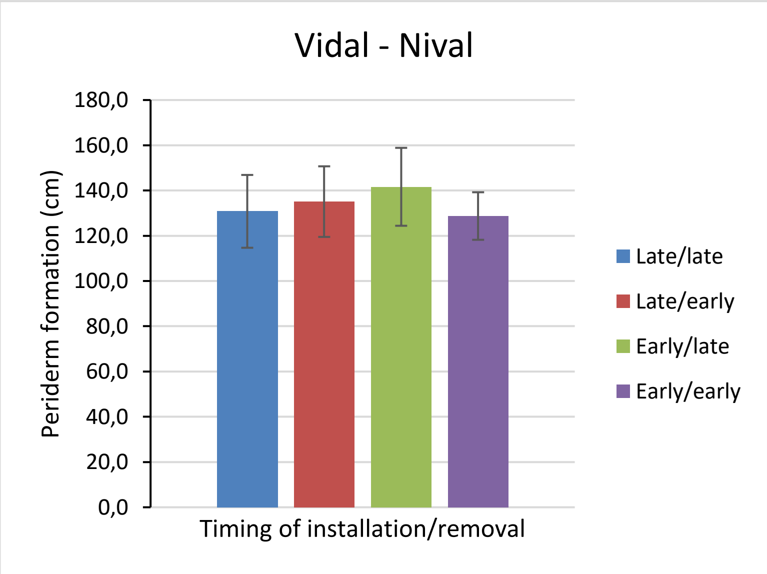


Figure 9. Mean periderm formation between the different timing of installation and removal as measured on October 21, 2022 on the Domaine du Nival site. Error bars represent standard error (n=4).. The means were not significantly different at a 5% significance level according to a one-way analysis of variance.

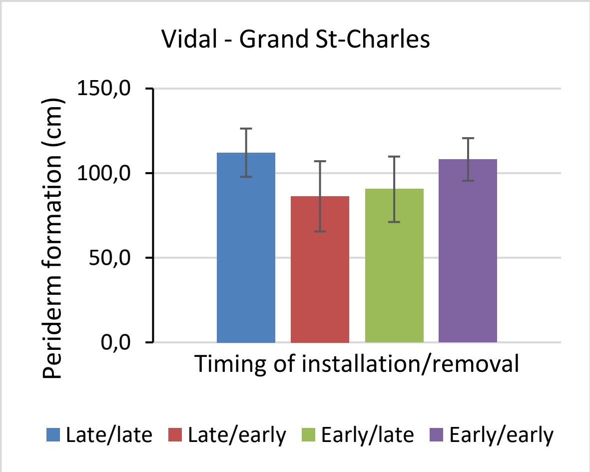


Figure 10. Mean periderm formation between the different timing of installation and removal as measured on October 21, 2022 on the Grand St-Charles site. Error bars represent standard error (n=4). The means were not significantly different at a 5% significance level according to a one-way analysis of variance.

Yield components and berry chemistry were not impacted by the type of geotextile or the timing of installation and removal (Table 4). Unfortunately, the sites of Bullerie did not have a crop to harvest due to important winter damage, and the Domaine St-Jacques site was harvested by the producer before data could be collected. The type of geotextile was compared only for the Pinot noir at Domaine du Nival (Figure 11), and no differences were recorded (Table 4). Timing of installation and removal was compared using two-way ANOVA to evaluate the impact of installation and removal separately (Table 3). No significant differences were calculated for the Nival site (Figure 12) or the Grand St-Charles (Figure 13) sites. Similarly to yield parameters, no differences was identified in berry chemistry for all treatments, regardless of the sites and cultivars (Table 5).

Table 4. Significance level of the ANOVA test (α=0.05) to compare the impact of type of geotextile or timing of installation and removal on the yield components for the harvest 2022. The sites of Bullerie and Domaine St-Jacques were not harvested.

Treatment	Cultivar	Site	Cluster (#/vine)	Yield (kg/vine)	100-berry weight (g)
Type	Pinot noir	Nival	0.5146	0.6356	0.9568
Timing	Vidal	Nival	0.4704	0.2016	0.2964
		Grand St-Charles	0.6732	0.6446	0.2849

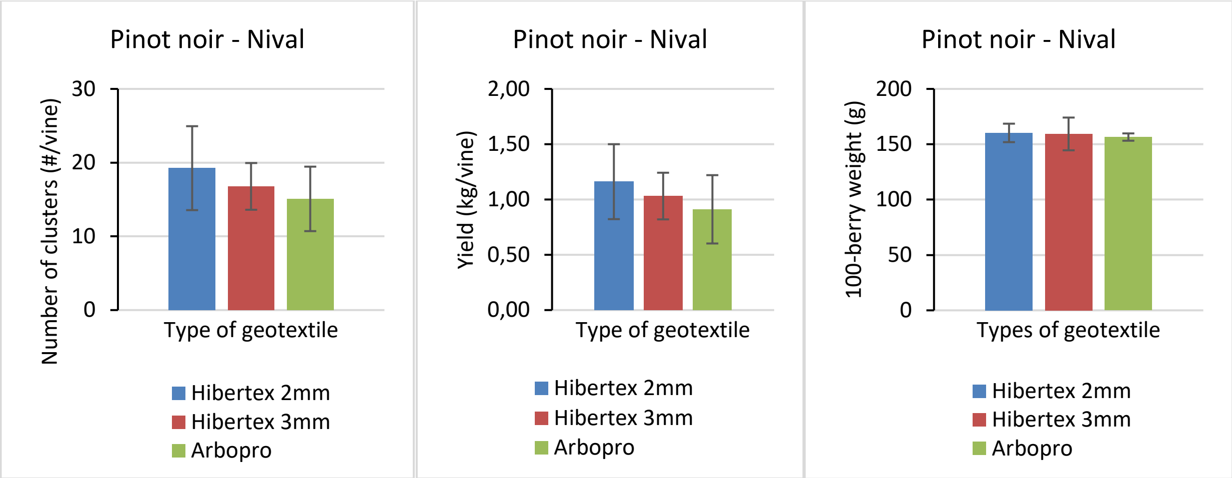


Figure 11. Mean yield components for Pinot noir at Domaine du Nival. Error bars represent standard error (n=4). No significant differences were calculated between the treatments.

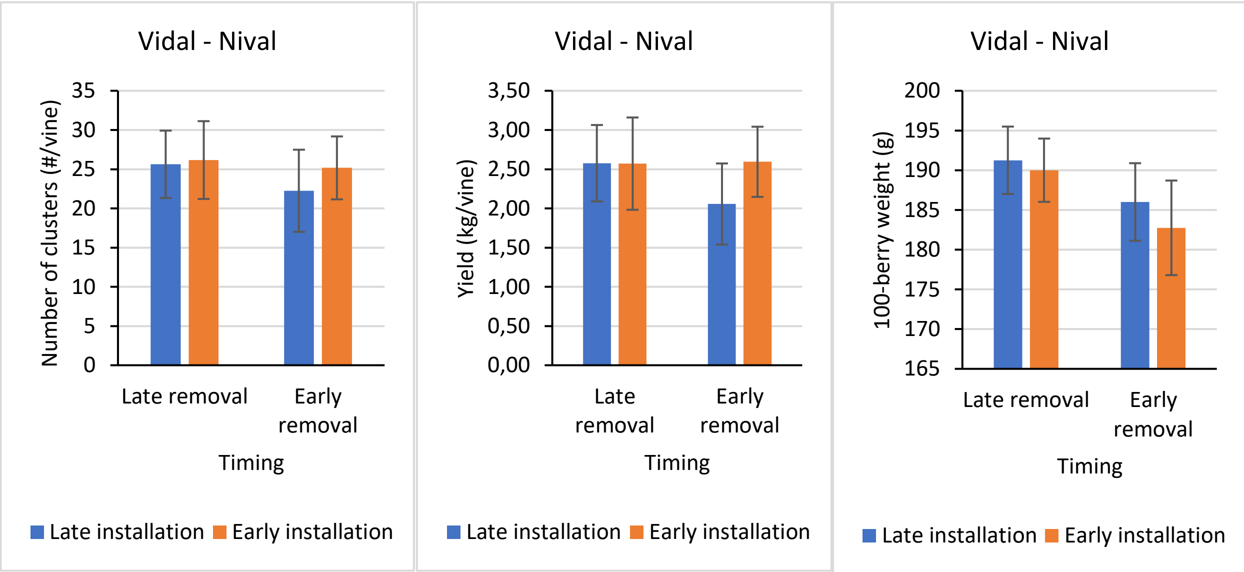


Figure 12. Mean yield components for Vidal at Domaine du Nival. Error bars represent standard error (n=4). No significant differences were calculated between the treatments using a two-way analysis of variance (α = 0.05) to compare the impact of timing of installation and timing of removal.

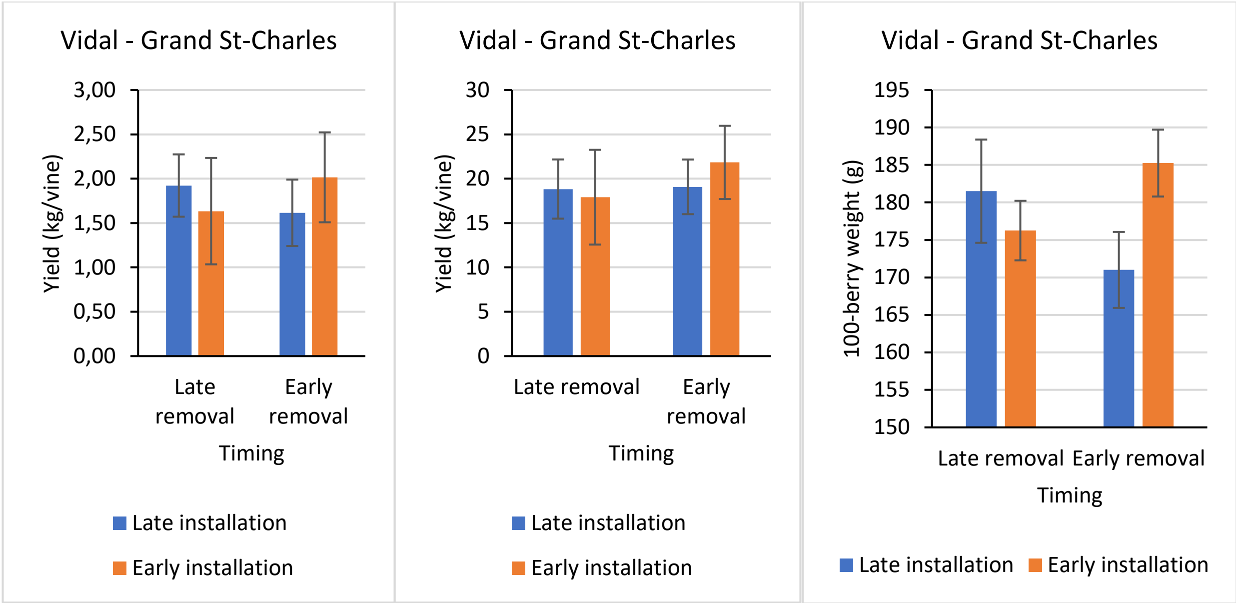


Figure 13. Mean yield components for Vidal at Grand St-Charles. Error bars represent standard error (n=4). No significant differences were calculated between the treatments using a two-way analysis of variance (α = 0.05) to compare the impact of timing of installation and timing of removal.

Table 5. Comparison of berry chemistry parameters (TA: titratable acidity) for the cultivars and sites that were harvested in 2022. Within each site and cultivar, the treatments were compared by ANOVA at a 5% significance level. Parameters are presented as mean ± standard error (n=4). The treatments of timing are presented as timing of installation/timing of removal.

Cultivar	Site	Treatment	Soluble solids (Brix)	pH	TA (g tartaric acid/L)
Pinot noir	Nival	Arbopro	16.37 ± 0.32	3.32 ± 0.02	8.13 ± 0.46
		Hibertex 2mm	16.63 ± 0.45	3.39 ± 0.04	7.73 ± 0.50
		Hibertex 3mm	17.03 ± 0.34	3.42 ± 0.05	7.23 ± 0.47
		p-value	0.5366	0.3263	0.4907
Vidal	Grand St-Charles	Early/early	14.43 ± 0.46	3.20 ± 0.03	11.01 ± 0.24
		Early/late	14.10 ± 0.88	3.17 ± 0.01	11.04 ± 0.50
		Late/early	14.73 ± 0.69	3.18 ± 0.03	10.83 ± 0.18
		Late/late	13.30 ± 0.33	3.18 ± 0.02	10.53 ± 0.23
		p-value	0.4300	0.5863	0.5311
	Nival	Early/early	17.68 ± 0.49	3.13 ± 0.02	11.84 ± 0.31
		Early/late	18.00 ± 0.49	3.14 ± 0.02	11.81 ± 0.33
		Late/early	17.99 ± 0.20	3.14 ± 0.02	11.85 ± 0.28
		Late/late	17.46 ± 0.22	3.11 ± 0.02	12.21 ± 0.32
		p-value	0.4455	0.8283	0.6441

2. Réalisations clé

Une réalisation clé est une importante réalisation ou un résultat concret que les agriculteurs, le secteur ou le milieu scientifique pourraient utiliser. Veuillez décrire des réalisations clé (un à trois paragraphes) qui répondent à l'un des critères suivants :

1) Le produit à un certain potentiel commercial (tous les essais sont terminés).
2) Le produit a été commercialisé.
3) Le produit a été adopté par le secteur.

Vous pourriez donner comme exemples de résultats concrets une durabilité accrue (pratique de gestion bénéfique), la réduction des coûts, l'augmentation de la productivité ou une rentabilité accrue. Veuillez prendre note que les renseignements fournis seront utilisés à des fins de communication seulement.

Si aucune réalisation clé n'a été achevée à ce stade, veuillez ne rien inscrire ici.

Activity 1

This activity provided the means to set up a bud hardiness monitoring program in Québec, Canada. The results were particularly important for the industry. The data collected over the course of the last three winters was communicated over dozens of bulletins. The bulletins were forwarded by the Quebec Reference Center for Agriculture and Agri-food (CRAAQ) reaching everyone subscribed to received updates on grape and wine news. Each bulletin was also seen by more than 100 members in a private Facebook group reserved for members of the Conseil des Vins du Québec (CVQ). The data was also recently shared on the VineAlert website, and 29 commercial vineyards have since signed up to receive data update as it is collected. Additionally, the cold hardiness of the main cultivars grown in Quebec had never been quantified, and the data collected will be used in the future to determine risk susceptibility upon establishment of new vineyards. Thus, the bud hardiness monitoring program was successfully adopted by the industry, and the data collected by the program will have a lasting economic impact on the industry.

Activity 2

Our study is commercially relevant for the sector as it provides key information on the types of geotextile and on the timing of their installation and removal. We have demonstrated that the types of geotextile, whether it is the Texel Arbopro or the Hibertex 2 mm or 3mm all provide similar protection against the winter temperatures for cold tender cultivars. This can now influence decision-making for grape-growers by providing alternatives for winter protection. Our study also provides key information for grape growers regarding timing of installation and removal. We demonstrated that the timing of installation does not influence the outcome, so grapegrowers can perform all tasks relevant to installation, such as pruning and/or tying down, over a longer period of time than previously thought. The timing of removal could potentially be more important as it tended to raise maximum daily maximum temperatures, but without directly impacting bud survival, phenology or yield parameters. Since the impact of this higher temperatures close to budbreak are not well understood yet, growers have therefore been encouraged to remove the geotextile whenever possible. With these results presented on several occasions to grape growers, we were able to assess the impact of the findings on the grape growing community. Several growers have reported to remove their geotextiles as early as possible in the spring, and installing them when time is available during the busy fall season. This project clarified several important questions on geotextile practices, and the results will set the stage to additional research in the years to come.

Activity 3

This study has demonstrated that rootstocks may affect cold-hardy hybrids in different ways and some of them showed higher potential than others for use under eastern North American conditions. Our results obtained for Frontenac, Frontenac blanc and Marquette did not show a significant effect of rootstock on bud survival, vine physiology during the spring nor for the remainder of the season but the grapevine vigor was affected by rootstock, where lower vigor was observed with Riparia Gloire. For vine varieties known to have magnesium deficiencies, such as Frontenac, the use of rootstock 3309 reduces this deficiency. Rootstocks may also affect some yield components and fruit composition parameters, but the effect of growing season (vintage) is predominant. The significant impacts of grafting on fruits are on wine appreciation where higher aromas were noted on wines produced with grapes on grafted vines compared to own-rooted vines. The wines made from own-rooted vines were the least popular. Thus, the results of this project allow us to propose the use of certain rootstocks, such as 3309 and 101-14, which are well adapted to soil and climatic conditions. Some growers have already asked nurserymen to prepare hybrid plants with these rootstocks. In the coming years, the use of rootstocks with hybrids could increase. Growers will be able to use the results of this project to select the desired rootstock.