# Disease Susceptibility of Cold-Climate Grapes in Vermont, U.S.A.

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**Abstract**

**Fungal diseases and cold temperatures can be limiting factors when growing winegrapes in northeastern U.S.A. A research vineyard was planted at the University of Vermont Horticultural Research and Education Center in South Burlington, Vermont in 2007 with winegrape cultivars considered to be the most "promising" based on the experience and insights of Vermont grape growers. A randomized complete block design of six replicated blocks with four-vine plots of each cultivar per block was used and included six cultivars: 'Frontenac', 'La Crescent', 'St. Croix', 'Marquette', 'Prairie Star' and 'Corot Noir'. The vines were planted at a spacing of 1.8 m by 3.0 m and trained to a high-wire cordon system. All cultivars received the same fungicide treatments each year totaling five in 2014 and six in 2015. Foliar and fruit cluster disease assessments including incidence and severity measures were performed each year. Diseases assessed included powdery mildew (*Erysiphe necator*); downy mildew (*Plasmopara viticola*); black rot (*Guignardia bidwellii*); *Phomopsis* leaf spot and fruit rot (*Phompsis viticola*); angular leaf scorch (*Pseudopezicula tetraspora*); anthracnose (*Elsinoe ampelina*); and *Botrytis* bunch rot and blight (*Botrytis cinerea*). There was no single cultivar that was consistently more resistant to all the foliar or cluster diseases in this study and the ranking of cultivar susceptibility varied depending on the growing season and the disease. It is important to note that powdery mildew emerged as the most prevalent cluster disease with all cultivars showing at least 93% incidence in both growing seasons. Cultivars differed in foliar susceptibility to downy mildew, yet no symptoms on the fruit were observed in either year. Although disease susceptibility is an important component of selecting a cultivar, future research should incorporate yield and marketability, non-sprayed plots, comparison of multiple fungicide programs and the impact of training systems.**

**KEYWORDS:** *Vitis spp.,* cultivar evaluation, integrated pest management, powdery mildew

## INTRODUCTION

Although fungal diseases and cold temperatures can be limiting factors when growing winegrapes in the northeastern U.S.A., cold climate grape production continues to expand (USDA NASS., 2007; 2012). The reasons for this expansion include the economic opportunities that valued-added wine production offer plus the opportunity to capture agritourism markets though vineyard and winery tours. Additionally, the development of several new grape cultivars able to survive -34$^0$-37$^0$ C winter temperatures (Smiley et al., 2008) now offer growers more cultivar choices appropriate for the northern climates. Grapes can be difficult to grow in the humid northeastern U.S.A. and these new inter-specific hybrids were bred to offer disease resistance. Fungal diseases are particularly challenging and can include: black rot (*Guignardia bidwellii*); powdery mildew (*Erysiphe necator*); downy mildew (*Plasmopara viticola*); *Phomopsis* leaf spot

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and fruit rot (*Phompsis viticola*); angular leaf scorch (*Pseudopezicula tetraspora*); anthracnose (*Elsinoe ampelina*); and *Botrytis* bunch rot and blight (*Botrytis cinerea*). The purpose of this research was to compare disease incidence and severity of selected cold climate winegrape cultivars during the 2014-2015 growing seasons using an integrated pest management approach at the University of Vermont Horticultural Research Center vineyard.

## MATERIALS AND METHODS

A research vineyard to evaluate cultivar performance was planted at the University of Vermont Horticultural Research Center, South Burlington, Vermont, U.S.A. (lat. 44.43162, long. -73.20186, USDA hardiness zone 5a, Köppen-Geiger classification Dfb) in 2007. The vineyard is part of two multi-state USDA research projects (NE-1020 and NIFA-SCRI Northern Grapes Project) to evaluate cold-climate winegrape cultivars (Burr, 2004; Martinson, 2011). The vineyard represents the coldest winter temperatures and the coolest growing season conditions of all the NE-1020 sites in the eastern U.S.A. (Berkett et al., 2014). A randomized complete block experimental design of six blocks with four-vine plots of each cultivar was used to plant the following six winegrape cultivars: 'Frontenac', 'La Crescent', 'St. Croix', 'Marquette', 'Prairie Star' and 'Corot Noir'. Vines were planted 1.8 m apart within each row with 3.0 m between rows and trained to a high-wire cordon system.

During each growing season (2014 and 2015), environmental conditions were monitored on-site with a Davis Vantage Pro Wireless Weather Station (Davis Instruments Corp., Hayward, CA). Environmental conditions and critical periods to manage grape diseases were used to determine fungicide application timing and frequency during the season. Fungicides selected were based on efficacy and resistance management considerations. All cultivars received the same fungicide treatments totaling five in 2014 and six in 2015. The following fungicides were applied at standard label rates either alone or in combination: captan (Captan 80 WDG, Drexel Chemical Co., Memphis, TN); mycobutinal (Rally, Dow AgroSciences, LLC); kresoxim-methyl (Sovran, BASF Corp., Research Triangle, Triangle, NC); mandipropamid (Revus, Syngenta Crop Protection, LLC, Greensboro, NC); cyprodinil (Vanguard 75WG, Syngenta Crop Protection, LLC, Greensboro, NC) and mono- and di-potassium salts of phosphorous acid (Rampart, Loveland Products, Loveland, CO). All applications were applied using a Rears Pul-Blast 300 Airblast Sprayer (Rears Manufacturing Inc., Eugene, OR). Standard insecticide sprays and fertilizer applications were uniformly applied in the vineyard during each growing season.

Foliage disease incidence and severity (area infected) were assessed by examining twenty leaves per four-vine plot between 3-10 Sept each year. Cluster disease incidence and severity were determined by visually assessing ten randomly selected clusters per four-vine plot at time of harvest for each cultivar. The Horsfall-Barratt scale (Horsfall and Barratt, 1945) was used to rate disease severity on foliage and clusters. Diseases assessed included: black rot, powdery mildew, downy mildew; *Phomopsis* leaf spot and fruit rot, angular leaf scorch, anthracnose, and *Botrytis* bunch rot and blight.

Cultivar data were compared using an analysis of variance (PROC GLM) with a significance level of 0.05 (SAS Version 9.4; SAS Institute, Cary, NC). If the overall F-test was significant, pairwise comparisons were performed using Tukey's Honest Significant Difference (HSD) test. Data in the form of proportions were transformed using the arcsine square root transformation and analyses were performed on the transformed data.

## RESULTS AND DISCUSSION

Powdery mildew was the most prevalent disease on foliage and clusters and was detected in all cultivars in both growing seasons (Table 1). In 2014, 'Corot Noir' had significantly lower

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foliar powdery mildew incidence than any other cultivar. For severity (area infected), powdery mildew was significantly higher in 'Prairie Star' foliage compared with all other cultivars except 'La Crescent'. In 2015, 'Corot Noir' ranked the lowest numerically in foliar powdery mildew incidence and exhibited less severe symptoms than all other cultivars except 'La Crescent'. In both growing seasons, powdery mildew incidence in clusters was above 93% and there were no significant differences among cultivars. The severity of powdery mildew on 'Prairie Star' clusters was significantly higher than any other cultivar in 2014. In 2015, mean separation was less distinct. 'La Crescent' had the highest percent severity, but it only differed significantly when compared with 'Frontenac' and 'Marquette'.

In 2014, there were no significant differences among cultivars for downy mildew incidence and severity on foliage (Table 1.). In 2015, 'Corot Noir' foliage had the highest amount numerically of downy mildew foliage disease incidence and severity. Downy mildew was not observed on any fruit clusters in the two years of the study.

The foliar diseases angular leaf scorch, black rot, anthracnose, *Phomopsis* leaf spot and *Botrytis* blight were not observed or were at low levels and there were no significant differences among cultivars in incidence or severity during the course of the study. Of the cluster diseases, higher percent incidences of black rot and *Phomopsis* fruit rot were observed than anthracnose and *Botrytis* bunch rot, especially in year two of the study (Table 2). This increase in disease in 2015 may be in part due to a wetter June when compared with June 2014. Incidence of black rot was zero in 'St. Croix' in both years and numerically highest in 'La Crescent' in 2014 and 'Frontenac' in 2015. 'Frontenac' had significantly higher incidence and severity of *Phomopsis* fruit rot than any other cultivar in 2014 and in 2015, 'Frontenac' ranked among the highest numerically. 'St. Croix' and 'Corot Noir' showed no or low incidence of *Phomopsis* fruit rots in 2014. In 2015, these same two cultivars had significantly lower incidence and severity than any other cultivar. There were no significant differences in anthracnose or *Botrytis* bunch rot incidence or severity among cultivars in 2014. In 2015, 'Corot Noir', 'St. Croix' and 'Marquette' had no incidence of anthracnose, which was significantly less than 'La Crescent' (8.3%). In 2015, 'Marquette' had significantly more *Botrytis* bunch rot incidence and severity than all other cultivars.

In summary, there was no single cultivar that was consistently more resistant to all the foliar or cluster diseases in this study and the ranking of cultivar susceptibility varied depending on the growing season and the disease. It is important to note that powdery mildew emerged as the most prevalent cluster disease with over 93% incidence in both years. Although cultivars did differ in foliar susceptibility to downy mildew, there was no infection in the fruit in either growing season. This absence of downy mildew in clusters followed the trend noted in previous growing seasons in the same vineyard (Berkett et al., 2014). Overall foliar and cluster disease was higher in 2015 than 2014 perhaps a result of over 11 cm more rainfall during June 2015 (22.2 cm) compared with June 2014 (10.9 cm). On average, nine fungicide spray applications during each growing season are typical for winegrapes in the region (Weigle et al., 2016). In this study, only five or six fungicide applications were applied depending on the year. However, it is impossible to know whether disease incidence was higher due to ineffective fungicide protection during critical infection periods or whether disease was higher due to higher levels of inoculum since the design of the vineyard precluded the incorporation of non-sprayed plots for comparison. Although overall disease varied depending on the year, 'Corot Noir' and 'St. Croix' appeared to exhibit higher resistance to black rot and *Phomopsis* cluster diseases than the other cultivars in both years. Plot yield and marketability of the cultivars were not assessed in this study, yet this information would be critical to consider along with disease susceptibility when choosing cultivars. Innovative training systems may also impact fungicide spray penetration and coverage and therefore influence disease incidence (Pscheidt and Pearson, 1989). Future research

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incorporating non-sprayed plots, comparison of multiple fungicide programs and training systems in addition to assessment of yield and marketability are all necessary components to critically evaluate and select suitable cultivars for northeast conditions.

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Table 1. Comparison of percent incidence and severity of powdery mildew and downy mildew symptoms on grape foliage and clusters of six cultivars in 2014 and 2015.

| Cultivars | Powdery Mildew [1] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | | | 2015 | | | | | |
| | Foliage | | | | Cluster | | Foliage | | | Cluster | | |
| | % Inc.[2] | | % Sev.[2] | | % Inc. | % Sev. | % Inc. | | % Sev. | % Inc. | % Sev. | |
| Corot Noir | 60.00 | b | 5.28 | c | 100.00 | 7.57 b | 90.00 | | 9.77 b | 100.00 | 13.98 | ab |
| Frontenac | 89.17 | a | 22.15 | bc | 100.00 | 4.88 bc | 100.00 | | 39.96 a | 100.00 | 8.74 | b |
| La Crescent | 96.67 | a | 28.18 | ab | 100.00 | 3.04 c | 100.00 | | 32.43 ab | 100.00 | 16.87 | a |
| Marquette | 97.50 | a | 20.77 | bc | 100.00 | 4.57 bc | 99.17 | | 42.60 a | 100.00 | 8.90 | b |
| Prairie Star | 100.00 | a | 46.85 | a | 100.00 | 15.12 a | 98.33 | | 43.84 a | 100.00 | 14.68 | ab |
| St. Croix | 95.00 | a | 12.42 | bc | 93.33 | 4.06 bc | 98.33 | | 36.65 a | 98.33 | 11.44 | ab |

| Cultivars | Downy Mildew [1] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | | | 2015 | | | | | |
| | Foliage | | | | Cluster | | Foliage | | | Cluster | | |
| | % Inc. | | % Sev. | | % Inc. | % Sev. | % Inc. | | % Sev. | % Inc. | % Sev. | |
| Corot Noir | 10.83 | | 0.47 | | 0.00 | 0.00 | 63.33 | a | 11.68 a | 0.00 | 0.00 | |
| Frontenac | 0.00 | | 0.00 | | 0.00 | 0.00 | 4.17 | c | 0.10 c | 0.00 | 0.00 | |
| La Crescent | 16.67 | | 1.91 | | 0.00 | 0.00 | 49.17 | ab | 4.76 ab | 0.00 | 0.00 | |
| Marquette | 0.00 | | 0.00 | | 0.00 | 0.00 | 2.50 | c | 0.08 c | 0.00 | 0.00 | |
| Prairie Star | 16.67 | | 5.03 | | 0.00 | 0.00 | 32.50 | abc | 1.03 bc | 0.00 | 0.00 | |
| St. Croix | 8.33 | | 0.76 | | 0.00 | 0.00 | 16.67 | bc | 0.66 bc | 0.00 | 0.00 | |

[1]Values represent the mean from 6 replicate four-vine plots per cultivar of 20 leaves or 10 clusters per plot. Disease severity (area infected) was rated using the Horsfall-Barratt scale and converted to percentages using the Elanco's conversion tables. Means followed by the same letters within columns are not significantly different according to Tukey's Honest Significant Difference (HSD) Test ($p \leq 0.05$).

[2] Inc.= Incidence; Sev.= Severity

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Table 2. Comparison of percent incidence and severity of black rot, *Phomopsis* fruit rot, anthracnose and *Botrytis* bunch rot symptoms on grape clusters of six cultivars in 2014 and 2015.

| Cultivars | Black Rot [1] | | | | | | | | *Phomopsis* fruit rot [1] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | 2014 | | | | 2015 | | | |
| | % Inc. [2] | | % Sev.[2] | | % Inc. | | % Sev. | | % Inc. | | % Sev. | | % Inc. | | % Sev. | |
| Corot Noir | 1.67 | ab | 0.04 | ab | 8.33 | cd | 0.20 | bc | 0.00 | b | 0.00 | b | 0.00 | b | 0.00 | c |
| Frontenac | 0.00 | b | 0.00 | b | 68.33 | a | 1.83 | a | 18.33 | a | 0.51 | a | 46.67 | a | 1.21 | ab |
| La Crescent | 10.00 | a | 0.23 | a | 20.00 | bc | 0.47 | abc | 3.33 | b | 0.08 | b | 48.33 | a | 1.21 | ab |
| Marquette | 3.33 | ab | 0.08 | ab | 43.33 | ab | 2.65 | a | 0.00 | b | 0.00 | b | 58.33 | a | 1.79 | a |
| Prairie Star | 8.33 | ab | 0.20 | ab | 45.00 | ab | 1.21 | ab | 0.00 | b | 0.00 | b | 28.33 | a | 0.66 | b |
| St. Croix | 0.00 | b | 0.00 | b | 0.00 | d | 0.00 | c | 0.00 | b | 0.00 | b | 5.00 | b | 0.12 | c |

| Cultivars | Anthracnose [1] | | | | | | | | *Botrytis* bunch rot[1] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | 2014 | | | | 2015 | | | |
| | % Inc. | | % Sev. | | % Inc. | | % Sev. | | % Inc. | | % Sev. | | % Inc. | | % Sev. | |
| Corot Noir | 1.67 | | 0.04 | | 0.00 | b | 0.00 | b | 0.00 | | 0.00 | | 5.00 | b | 0.12 | b |
| Frontenac | 0.00 | | 0.00 | | 1.67 | ab | 0.04 | ab | 0.00 | | 0.00 | | 5.00 | b | 0.12 | b |
| La Crescent | 0.00 | | 0.00 | | 8.33 | a | 0.20 | a | 0.00 | | 0.00 | | 1.67 | b | 0.04 | b |
| Marquette | 3.33 | | 0.08 | | 0.00 | b | 0.00 | b | 3.33 | | 0.08 | | 25.00 | a | 0.66 | a |
| Prairie Star | 0.00 | | 0.00 | | 3.33 | ab | 0.08 | ab | 1.67 | | 0.04 | | 0.00 | b | 0.00 | b |
| St. Croix | 0.00 | | 0.00 | | 0.00 | b | 0.00 | b | 5.00 | | 0.12 | | 8.33 | b | 0.20 | b |

[1] Values represent the mean from 6 replicate, four-vine plots per cultivar of 20 leaves or 10 clusters per plot. Disease severity (area infected) was rated using the Horsfall-Barratt scale and converted to percentages using the Elanco's conversion tables. Means followed by the same letters within columns are not significantly different according to Tukey's Honest Significant Difference (HSD) Test ($p \leq 0.05$).

[2] Inc.= Incidence; Sev.= Severity

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