"How Low Can You Go?" – Low Temperature Reponses in Grapevines

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Adapted from VitisGen Voice newsletter, Spring 2015 by Chrislyn Particka.

Editor's note: The VitisGen Project was launched in September 2011 after being awarded a five-year grant by the USDA-NIFA Specialty Crops Research Initiative. The goal of the project is to develop new genetic markers that are closely associated with certain traits such as powdery mildew resistance, low tem-perature responses, and various fruit quality characteristics. These markers can then be used to identify or select plants as seedlings that have these high priority traits, which will speed up the breeding and evaluation process, so these traits can get incorporated into new grape varieties more quickly, benefiting both consumers and the grape industry.

The grapevine genus (*Vitis*) has evolved over a wide range of environmental conditions, from warm and humid conditions in the subtropics to dry, desert-like climates, to extreme cold in the northern US and Canada. Because of its superior fruit quality, commercial production has been historically dominated by a single grape species, *Vitis vinifera*, which evolved, and is traditionally grown in, milder Mediterranean climates. When *V. vinifera* is planted in regions with significantly different climatic conditions, such as very cold temperatures in the winter or highly variable temperatures in the early spring, these vines can be severely damaged or killed.

At A Glance…

- One of the biggest challenges faced by growers in colder climates is selecting varieties that will withstand severe winters, yet still produce a good quantity and quality of fruit and mature during short growing seasons.
- Some grape varieties can survive low tempera-ture events like extreme cold winter tempera-tures and early spring frosts due to multiple, complex, physiological adjustments (acclimation) in response to decreasing day length and the onset of low temperatures.
- *VitisGen* scientists are working to develop a better understanding of the genetic mechanisms involved in acclimation, dormancy, and freez-ing tolerance, with the goal of giving breeders better information to help them develop new varieties that can thrive under climatic condi-tions that previously made grape growing a major challenge.

Interest by potential growers and consumer demand for locally-produced grapes and wine has led to an expansion of grape cultivation into non-traditional growing areas in less favorable climates. One of the most important decisions for growers in these areas is selecting varieties that will withstand severe winters, mature during short growing seasons, and still produce a good crop. Winter injury can result in significant losses in the grape harvest, and consequently impact wine production and sales; for example, a single cold event in the Finger Lakes region of New York during the winter of 2004 caused over $63 million in lost revenue (Martinson and White, 2004).

Further, this expansion into non-traditional grape growing regions has resulted in the need for broader information regarding the genetic and physiological mechanisms that impact survival and productivity, including an understanding of how some grape species can survive extreme low temperatures or break bud later in the spring. Depending on cultivar, dormant *V. vinifera* buds and canes can be damaged at temperatures just below 0°F, while species that evolved in colder climates, like *V. labrusca* and *V. riparia*, can tolerate much colder temperatures with no significant damage. However, the fruit quality of these more hardy species is generally not valued as highly by consumers as that from *V. vinifera* cultivars. Thus, a greater understanding of the mechanisms underlying low temperature tolerance could allow for the development of new cultivars as well as improve cultural practices for existing varieties.

Dead primary (lower) and secondary (upper) grape buds due to winter cold injury.
Photo: James Monahan

Survival at low temperatures is dependent upon multiple, complex physiological adjustments (acclimation) to events such as decreasing day length and the onset of low temperatures. Exposure to short days and colder temperatures initiates protective biochemical measures within the vines to minimize cellular damage and initiate dormancy. Acclimation and dormancy, while closely interrelated, are distinct phenomena. Grape bud dormancy is an adaptive strategy for survival that has multiple stages, including paradormancy, endodormancy, and ecodormancy. Each of these stages is crucial for bud and vine survival, but in this article we will focus primarily on endodormancy and ecodormancy. In fall, the vine begins to prepare for winter conditions by ceasing vegetative growth and developing periderm (the outer layers of woody stems/roots) along the one year old shoots. The dormant buds that are left behind on the vines are in a state of endodormancy. Endodormancy is a biological state that prevents new growth from occurring in buds while early winter temperatures fluctuate. As the season progresses, extended periods of extreme temperatures promote increased freezing tolerance, protecting the vines from environmental extremes—in this case, mid-winter low temperatures.

Like many other fruit crops, grapes require a certain number of "chilling hours" during the dormant season in order to conclude endodormancy and properly break bud and grow the following spring. Chilling hours start accumulating in endordormant vines when temperatures occur between 0 and 7 ^{o}C. Chilling hours may accumulate quickly (mild winter with lots of days above freezing) or slowly (cold winter with lots of days below freezing). Different grape species and cultivars have varying chilling requirements (from 500–2000 hours) that must be met before bud break can successfully occur. This adaptation helps to ensure that new bud growth does not happen during short temperature fluctuations (midwinter warming) that can occur throughout the winter. If a particular winter is mild and the chilling requirement of a vine is met early, the vine will quickly emerge from dormancy in response to warm weather, leaving the new growth vulnerable to spring frosts. Although some cultivars can produce a crop on secondary buds if primary shoots are killed, the yield will be lower. Conversely, if chilling requirements are not met by spring, bud break will be erratic, desynchronized, and extended in the spring.

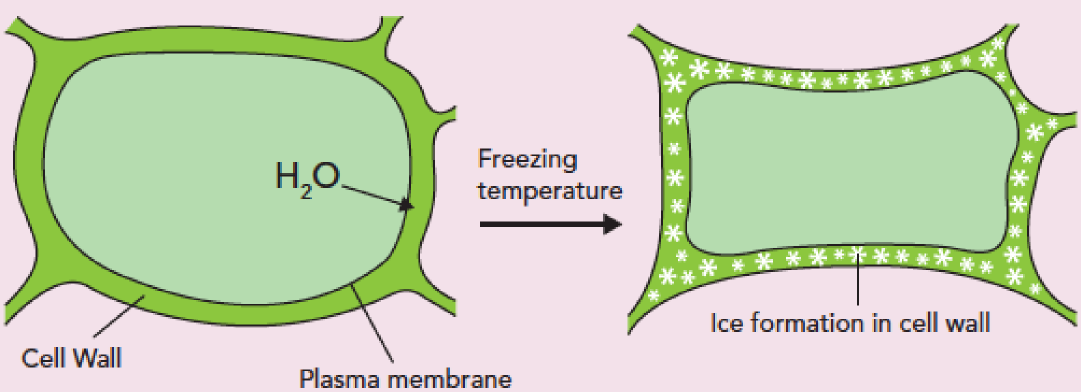
Once the chilling requirement is satisfied, the plant enters a different state of dormancy, ecodormancy. In this state, the buds are held dormant due to temperatures that are too low to allow growth. In late winter and spring, vines become responsive to increases in temperature, and will break dormancy and begin to grow.

There are some techniques growers can use to reduce the chance that their vineyards will suffer low temperature damage in winter and spring. They can choose cultivars adapted to local conditions, select sites well-adapted for grape production, use cultural practices such as canopy and crop load management, bury portions of vines during winter, or apply certain fertilizers or other products prior to or during dormancy that may increase tolerance to cold temperatures.

Because these techniques are not always successful and can be costly, the ability to identify markers linked to genes that improve low temperature survival and delayed bud break could have a significant impact on further expanding grape production in less-favorable climates. Grapevines' responses and acclimation to low temperature events is a complex process that is influenced both by the environment (where and how they are grown) and by their genetic makeup. *VitisGen* scientists are developing a better understanding of the genetic mechanisms involved in acclimation, dormancy, and freezing tolerance, with the goal of giving breeders information that will help them develop new varieties which will survive and thrive in an increasingly wider range of climatic conditions. This work will allow scientists to more objectively evaluate a vine's cold hardiness or resistance to early bud break independent of environment, and develop new varieties that can thrive under climatic circumstances that previous made grape growing a major challenge, or even impossible.

Reference:
Martinson, T. and G. White. 2004. Estimate of Crop and Wine Losses Due to Winter Injury in the Finger Lakes. http://www.fruit.cornell.edu/grape/pdfs/Cost of Winter Injury Finger Lakes 2004.pdf

How do grapevines protect their tissues from freezing in the winter?



Credit: Levitt, J. 1980. Responses of Plants to Environmental Stresses: Chilling, Freezing, and High-Temperature Stresses, Vol. 1 New York: Academic Press.

To avoid being damaged by temperatures below freezing, buds use the process of 'supercooling' that reduces the amount of water in the cell, increases concentration of solutes and reduces freezing temperatures.

Water inside a cell is like water in a ziplock bag, which is in turn inside a shoebox. Inside the cell (the ziplock bag) are all of the important structures like the nucleus and the chloroplasts. When temperatures go below freezing, the cells push water from inside the cell into the cell wall structure (shoebox) and extracellular space where it can freeze safely, away from those important organelles. With a lower concentration of water inside the cell, the remaining water will freeze at temperatures lower than 0°C, and thus allowing those cells within the bud tissues to survive below freezing temperatures.

Funding for VitisGen "Accelerating grape cultivar improvement via phenotyping centers and next generation markers" is provided by a Specialty Crop Research Initiative Competitive Grant, Award No. 2011-51181-30635, of the USDA National Institute of Food and Agriculture.

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Basic Spanish Vineyard Vocabulary

Gillian Trimber, Viticulture Extension Educator

Do you work with or hire individuals that don't speak the same language as you? Effective communication between Spanish-speaking and English-speaking workers and employers is a major challenge for many Finger Lakes vineyards. This winter, the Finger Lakes Grape Program will be working on developing resources and trainings that can help you and the people you work with communicate despite language and cultural barriers. Some of our initial ideas include a pocket-sized Spanish-English phrasebook, newsletter articles in both languages, and collaboration with groups that can speak on farm safety and other relevant topics in Spanish. However, these are just a few ideas; we really need to hear from you on what programming or information would be most useful. Please let us know your thoughts!

For now, we're starting by including Spanish and English vineyard vocabulary words relevant to the season in our newsletter. Please feel free to print these and use them in your work.

Winter Vocabulary/ Vocabulario de Invierno	
To prune	Podar*
To cut	Cortar
To remove	Quitar/ Remover*
To pull (off, out)	Sacar
Trunk	Tronco
Cane	Guía
Cordon	Cordón
Spur	Pico
Bud	Yema/ Brote
Renewal zone	Zona de repuesto
Graft union	Unión del injerto
Rachis	Raquis
Stem	Tallo
Vine	Parra/ Vid/ Mata
Row	Surco/ Linea
Pruners/Clippers/Shears	Tijeras
Electric pruners	Tijeras eléctricas*
Loppers	Tijeras grandes*
Wire	Alambre
Twine	Filo
Clip	Gancho
Winter hat	Gorra
Gloves	Guantes
Scarf	Bufanda
Coat	Chamarra/ Abrigo
Coveralls	Overoles

Numbers/ Numeros	
One	Uno
Two	Dos
Three	Tres
Four	Quatro
Five	Cinco
Six	Seis
Seven	Siete
Eight	Ocho
Nine	Nueve
Ten	Diez
Eleven	Once
Twelve	Doce
Thirteen	Trece
Fourteen	Catorce
Fifteen	Quince
Sixteen	Diez y sies
Seventeen	Diez y siete
Eighteen	Diez y ocho
Nineteen	Diez y nueve
Twenty	Veinte

*Updated as of 12/21/2015

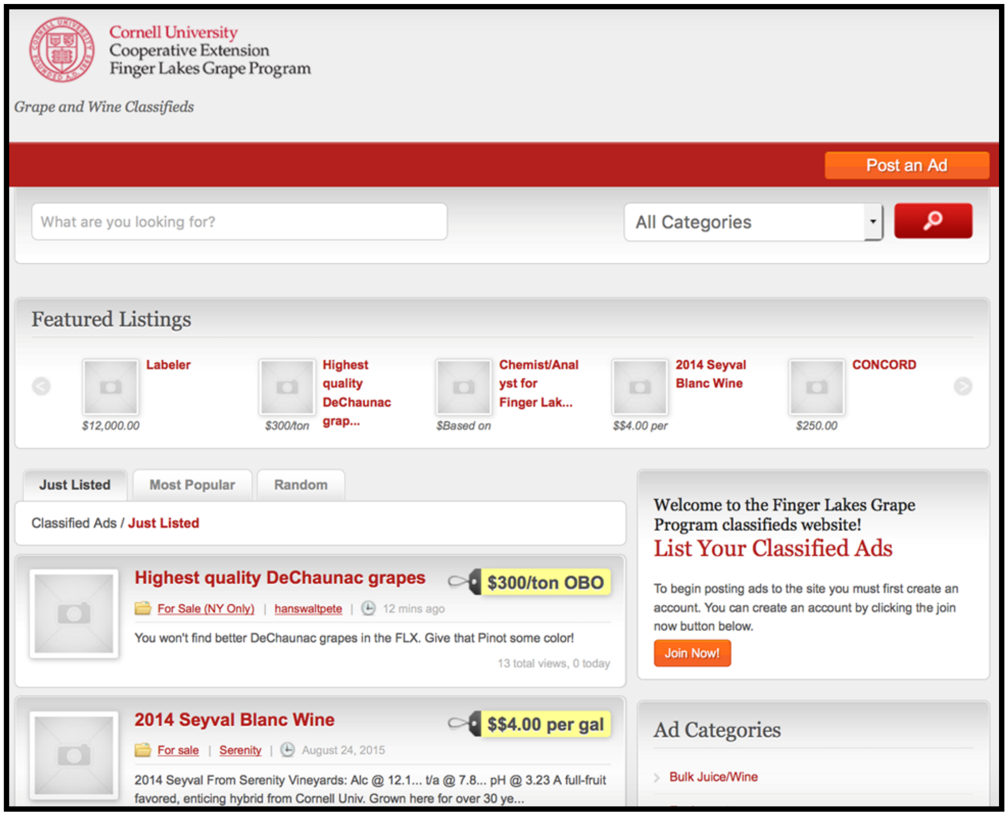
Winter Phrases/ Frases de Invierno	
Please prune (here/these rows).	Por favor, pode (aqui/ estas lineas).
Leave (four/fewer/more) (canes/buds) per (vine/spur).	Dejen (cuatro/menos/más) (guías/yemas) por cada (viña/ pico).
This cane is (too thick/too small/already dead/ healthy).	Este guía es (demaseado gorda/ demaseado pequeña /ya muerte/ de buen salud).
If the vine is very small, leave only two canes.	Si la viña está muy pequeña, deje solamente dos guías.
Please pull cuttings out of the trellis and place in the middle of the rows.	Saca los cortes de los soportes y ponga en medio del surco.
It's cold.	Hace frío.
It's snowing.	Está nevando.
It's cloudy.	Está nublado.
Maybe there will be sun today!	¡Quisas hace sol hoy!
Would you like some coffee?	¿Quiere café?

NY Grape & Wine Classifieds Upgrade Coming

We are just about ready to unveil the new and improved New York Grape & Wine Classifieds site. We have spent the past several months working on a new site using a different software platform, which should make the site more user-friendly and easier for us to manage from the back end.

Here are a few of the changes on the new site:

- Easier to post ads and search for what you are looking for.
- Easier to include pictures in your ads to make them stand out more.
- Easier to manage your ads. No more digging through your email box to find a confirmation email to delete or edit your ad!
- Ads will be listed for 30 days, and then expire. If you want to list your ad for another 30 days, it takes just a few clicks to do it.
- NO SPAM!! (or at least a lot less)



One of the biggest changes users of the system will notice is that you will now need to create a username and password to use the site. While this can be a bit of a pain, it has a couple of advantages. First, it will help to reduce the amount of spam messages that make it onto the system. This is one of the biggest reasons we would get bombarded by ads from all over the world sometimes on the current site. Secondly, this will allow you to see and manage all of the ads that you have posted. If you need to edit one of your ads, you can easily do that from your profile page.

We are planning on launching the new site in early January, right after the holidays. Just before we do so, we will host a webinar to introduce the new site and show how to use its basic functions. For those who do not have access to a computer or the Internet, we will still be happy to post an ad for them.

B.E.V. NY

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Program and Registration Information Available Soon!

Economic impact of grapevine leafroll disease on *Vitis vinifera* cv. Cabernet franc in Finger Lakes Vineyards of New York.

Shady Atallah, Miguel Gomez, Marc Fuchs, and Timothy Martinson
Adapted for Appellation Cornell by Amanda Garris

Editor's Note: This article originally appeared in the May 2012 issue of Appellation Cornell. We wanted to reprint it during the winter as a reminder about the potential value of rogueing out infected vines, or even removing an entire vineyard block, and replanting with virus-free material. While there is no official virus-free certification program in New York yet, our local nurseries have taken great strides in improving the cleanliness of their stocks over the past several years. Growers should be continually evaluating the need to replace infected vines if they are having a negative impact on their profitability.

Background. Grapevine leafroll disease is one of the most widespread viral diseases in vineyards, affecting nearly all grape and wine regions in the world. Infection causes yield losses, ripening delays, and alters fruit chemistry, including lowering soluble solids and increasing titratable acidity. The viruses associated with leafroll disease are transmitted through propagation of infected material, grafting, and several insect vectors. Little is known about the economic impact of grapevine leafroll disease over the lifespan of a vineyard and the cost-effectiveness of interventions of such as replacement of individual vines or vineyard replanting. Current methods to control the spread of grapevine leafroll disease in New York State are limited to planting material derived from certified, virus-tested stock and identification and removal of infected vines. We compared the economics of several leafroll management strategies and recommend loss-minimizing strategies for vineyards in the Finger Lakes of New York.

Experimental design. Ten winery-vineyard operations in the Finger Lakes of New York with a history of grapevine leafroll disease were surveyed in 2009 and 2010 to determine the prevalence of the disease, resulting yield reductions, control measures used, and any financial penalties for poor fruit quality. To model disease management scenarios, initial disease levels of 0-60% together with existing models were used to predict levels of infection over time in the presence of vectors. Control options included roguing (removal and replacement of individual infected vines), replacement of entire vineyards, or no action. The model also included virus-induced yield reductions of 30% or 50%, and possibility of a 10% price penalty for lower quality fruit. We computed the per-acre net present value[1] per acre for a Cabernet franc vineyard over a typical 25-year life span for the following six scenarios:

1) Baseline: A vineyard free of grapevine leafroll disease
2) Early infection without intervention: Disease introduction in year 1 with no roguing or replacement
3) Clean planting: A vineyard initially planted to material derived from certified, virus-tested stock at a 25% higher planting material cost
4) Vigilant management: Disease introduced during planting, but symptomatic vines are replaced
5) Early vineyard replacement: Replacement of the entire infected vineyard in year 4 with certified virus-tested stock
6) Later introduction with and without removal: A vineyard with disease introduced between years 12 and 20, with and without roguing

[1]*Net Value* is the difference between revenues and costs. The term *Present* indicates that the *Net Value* over 25 years is expressed in today's dollars to take into account the time value of money.

Results. The net present value (NPV, see footnote above) was used to compare the economic impact of grapevine leafroll disease on the six scenarios. Without any disease control, the economic impact ranged from $10,000 to 17,000/acre over the lifetime of a Cabernet franc vineyard, depending on the degree of yield reduction and the size of the penalty for poor fruit quality.

Planting with clean plant material, which added a 25% price premium to the overall cost, reduced grapevine leafroll disease-related losses to $750/acre, whereas roguing and replacement with clean plant material resulted in losses ranging from $1,300 for a vineyard with initial low infection rate (1%) to $9,500 for a vineyard with a moderate initial infection rate (25%). For vineyards with an initial infection level of at least 25%, the economically optimal solution was to replace the vineyard. A decision matrix is presented in Table 1 (below).

Degrees of disease-induced yield reduction	Recommended action n if there is a 10% penalty for lower fruit quality	Recommended action if there is no penalty for lower fruit quality
< 30% yield reduction		
≤ 25% infection	**Rogue**	**Rogue**
>25% infection	**Replace Vineyard**	**Do not control [2]**
30% yield reduction		
≤ 25% infection	**Rogue**	**Rogue**
> 25% infection	**Replace Vineyard**	**Indifferent**
50% yield reduction		
≤ 25% infection	**Rogue**	**Rogue**
> 25% infection	**Replace Vineyard**	**Replace Vineyard**

Conclusions

- The economic impact of uncontrolled grapevine leafroll disease on Cabernet franc vineyard in the Finger Lakes ranges from $10,000 to $17,000 per acre over 25 years.
- Replanting with certified, virus-tested vines significantly reduce losses.
- Disease control decisions should be based on the level of infection, yield penalty, price penalty for lower quality fruit, and the age of the vineyard.

The bottom line: Paying a premium of 25% for certified virus-tested planting material is financially rewarding, although it may not initially appear to be an attractive alternative.

[2]This decision applied only if there is no evidence of inter-vineyard disease transmission. Otherwise, decision would need to account for potential risk of spreading the disease to neighboring vineyards if disease were to be left uncontrolled.

Upcoming Events

B.E.V. NY 2016

Thursday, March 3 – Saturday, March 5, 2016

Trade Show: Friday, March 4 – Saturday, March 5

RIT Inn & Conference Center

Henrietta, NY

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2016 Pesticide Training and Recertification Series

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Exam Date: Monday, February 29, 20166:30 pm – 11:00 pm

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