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Finger Lakes Vineyard Update

In This Issue:

GRAPE DISEASE CONTROL, 2019

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Keeping with tradition, the following is a brief pre-season summary of some of the newer grape disease management materials that I hope will be useful for grape growers in the 2019 season. The majority of these materials are not "brand new" and have been out there for a year or two or three, but as the list of options gets longer and longer (and longer…) we need reminders to make us aware of all the materials at our disposal. To get this rolled out ASAP, some of the information below has been borrowed from previous newsletters by Wayne Wilcox and myself.

First, a brief word about the **succinate dehydrogenase inhibitor fungicides (SDHIs).** As Wayne pointed out a few years ago, this class of fungicides has been experiencing a sort of renaissance. Under development since the 1960s, the early SDHIs controlled basidiomycete fungi that caused important rust and Rhizoctonia diseases on some major crops. But the disease control spectrum of SDHIs was greatly enhanced by some creative tweaks in chemical structural complexity a little over 20 years ago and many of the big ag chemical companies began working on their versions of this breakthrough. This resulted in the release of a number of important products in the 21st century that enhanced disease control for many additional crops the world over, including grapes. The first was boscalid (BASF; the active ingredient in Endura and one of the active ingredients in Pristine), a 'new generation' SDHI that could now provide control of ascomycete fungi that cause diseases like powdery mildew and Botrytis bunch rot, making the SDHIs, for the first time, a very important chemical class for grape growers. That was around 2002. Then came fluopyram (Bayer Crop Sciences), the foundation of the "Luna" series of fungicides, also for powdery mildew and Botrytis. From that, grape growers have Luna Experience (2012?) and more recently, Luna Sensation. Syngenta has since released their SDHIs for grapes in even newer products addressed below (benzovindiflupyr in Aprovia, pydiflumetofen in Miravis Prime), that even include efficacy against black rot.

At present, all the SDHI products are very effective against grape powdery mildew; that is their consistent strength. Their high activity against this disease generally makes them great options for fruit protection around bloom (first 2-3 weeks after capfall), when the fruit of all varieties are highly susceptible to that disease. With respect to price, I have found Endura (the oldest one) to be the least expensive, Luna Experience to be a little more expensive, and the newer materials like Aprovia and Miravis Prime, to be the most expensive. The only ones I have tested side by side for powdery mildew control are Endura, Luna Experience, and Miravis Prime (oldest to newest). It was a single trial on Concord grape, and I found Luna Experience and Miravis Prime to be significantly more effective than Endura in terms of limiting powdery mildew incidence on fruit. However, they were all statistically equal in terms of limiting disease *severity* on fruit (87, 99, and 100% control of fruit powdery mildew with Endura, Luna Experience, and Miravis Prime, respectively).

The SDHI products vary somewhat in their efficacy against *Botrytis*; Endura (boscalid) and the Luna products (fluopyram) appear to be good *Botrytis* materials, but Aprovia (benzovindiflupyr) and pydiflumetofen in Miravis Prime appear to have relatively little *Botrytis* activity. Therefore, pydiflumetofen is combined with fludioxonil (an older, but effective *Botrytis* material) to add control of that pathogen in the product, Miravis Prime. Lastly, they also vary widely in their efficacy against black rot; to my knowledge, boscalid (Endura) and fluopyram (in Luna products) have little or no efficacy against that disease, benzovindiflupyr in Aprovia has some, and pydiflumetofen in Miravis Prime has a high level of efficacy against black rot.

With this flush of new SDHI products though, it's also important to remember that these chemistries all hail from the same FRAC group 7 and therefore share the same narrow, single site mode of action (the inhibition of succinate dehydrogenase, an essential enzyme in fungal respiration) which makes them a risk for the development of resistance by the fungi that cause powdery mildew and Botrytis bunch rot. In other words, all of these SDHI fungicides target the same essential, biochemical process that can be overcome by a single mutation in the fungal pathogen, making the SDHIs a moderate to high risk for resistance. To complicate matters, a variety of mutations have been found in various target fungal plant pathogens that seem to confer resistance to one or some of the new SDHI active ingredients, but not to all. For example, several mutations have been identified in the *Botrytis* fungus that enable it to survive an application of boscalid but not fluopyram. In other words, these mutations may successfully exclude boscalid and allow fungal respiration to continue, but they do not exclude fluopyram from binding and jamming up the site and killing the fungus (fluopyram may still control the fungus to a high degree!). This was documented in a study with *Botrytis* on strawberries in Spain (Fernández-Ortuño et al. 2017), where four resistance patterns to boscalid were observed, but only one conferred resistance to both boscalid and fluopyram (cross-resistance only observed for one of the four mutation scenarios). In another example, isolates of the fungus that causes early blight of potatoes in Idaho (*Alternaria solani*), were found to be resistant to boscalid or fluopyram, but none were resistant to both; there was no cross resistance for boscalid *and* fluopyram (Miles et al. 2014). This has also been documented among fungi that cause Corynespora leaf spot and powdery mildew on cucumber in Japan; fungal isolates highly resistant to boscalid were still sensitive to, and well controlled by, fluopyram (Ishii et al. 2011). And in one particular case, a boscalid resistant fungal mutant was actually hypersensitive to fluopyram!

What about the fungus that causes powdery mildew of grape (Erysiphe necator)? A recent paper in Microbiological Research (Cherrad et al. 2018) documents grape powdery mildew resistance to boscalid in French vineyards, but again, no cross resistance to fluopyram. To the best of my knowledge, there is no confirmed grape powdery mildew resistance to this chemistry in the eastern U.S. *yet.* However, a tank mix with sulfur on sulfur tolerant varieties would not be a bad idea, and it still makes good sense to limit the use of ANY of these products to two applications per year. But interestingly, the idea that resistance to one chemistry in FRAC 7, is resistance to all in FRAC 7, "ain't necessarily so". It seems the structural diversity that exists among different SDHIs allows for a variety of fungal mutations to confer a variety of resistance scenarios. In the words of Kramer; 'Mother nature is a maaad scientist, Jerry'!

With that background, we begin a review of some of the most pertinent fungicide product information for grape growers in 2019. Here are the main ones in alphabetical order…

Aprovia/Aprovia Top. The active ingredient in Aprovia is benzovindiflupyr. These fungicides first became available to PA growers in 2016 and then NY growers last year. The active ingredient in Aprovia is in the class of fungicides known as succinate dehydrogenase inhibitors (or SDHIs, introduced above) and belongs to FRAC Group 7, which also includes chemistries in products like Endura and Pristine (boscalid) and Luna Experience (fluopyram). Trials in NY have shown that the active ingredient in Aprovia is **very effective for the control of powdery mildew; that is its strength.** PA trials have shown some efficacy on black rot, but I would consider it more in line with "suppression" of this disease and I cannot recommend it for black rot control, especially on susceptible varieties and in wet seasons. Also, it should not be relied on for control of *Botrytis*. The label also lists control of Phomopsis and anthracnose, but like Wayne Wilcox, I have not seen any strong proof of that in field trials. Limited trial work at Penn State last year indicated little or no

control of Phomopsis shoot lesions but fair control of Phomopsis on cluster stems. Two years of crop injury testing on Concord has indicated no issues (no injury) with Aprovia to that variety. However, a quick check with our local ag products supplier has indicated that the cost of this product might be prohibitive for juice grapes (check with your local supplier for current prices).

Aprovia Top, on the other hand, is a mixture of two active ingredients: i) benzovindiflupyr, the active ingredient in Aprovia and ii) difenoconazole, a DMI fungicide with very good to excellent activity against powdery mildew, black rot, and anthracnose. Aprovia Top is also labeled for control of Phomopsis, but again, local experience and published results of field trials with Phomopsis is lacking. The label rate for Aprovia Top is 8.5 to 13.5 fl oz/A; 13.5 fl oz of Aprovia Top provides about the same amount of benzovindiflupyr as 10.5 fl oz of Aprovia; it also provides about the same amount of difenoconazole as 18 fl oz of Inspire Super, but falls a little short of that found in 7 fl oz of Revus Top. Aprovia and Aprovia Top have a 12 hr REI and a 21 day PHI. As with all the products containing difenoconazole, **Aprovia Top should not be applied to Concord grape and other varieties on which difenoconazole injury has been reported.** This also includes Brianna, Canadice, Concord Seedless, Frontenac (minor), Glenora, Noiret (minor), Skujinsh 675, St. Croix (minor), and Thomcord. Both products are legal to use in New York, including Long Island.

Dexter Max. Dexter Max is a product that contains two active ingredients that I think everyone is familiar with: (i) azoxystrobin (the active ingredient in Abound), and (ii) mancozeb, the active ingredient in Dithane, Manzate, Penncozeb, and many other products (e.g., Fortuna, Roper). This product should provide good control of powdery mildew, but only in the *absence* of resistance to strobilurins, which is becoming a rarer and rarer thing these days. It should also provide very good to excellent activity against black rot, downy mildew, and Phomopsis (by virtue of both active ingredients). But again, strobilurin resistance by the powdery mildew fungus is common in many grape growing areas of the east, and where present, will render this product ineffective against that disease. On varieties highly susceptible to powdery mildew and not sulfur sensitive, tank-mixing sulfur with this fungicide will give an extra measure of protection. Label rates for Dexter Max are 1.5 to 4.25 lbs/A. The 3.2 and 4.25 lb/A rates of this product contain the same amount of azoxystrobin as 10 and about 13.1 fl oz of Abound flowable (the low and mid-range of Abound rates for grapes, respectively), and the same amount of mancozeb as 3 and 4 lbs of the 75DF formulations of Dithane, Manzate, Penncozeb, and other 75DF mancozeb products. Dexter Max has a 24 hr REI and a 66 day PHI. Lastly, this product cannot be used in Erie county PA (contains azoxystrobin).

Flint Extra 500SC. Flint 50WG fungicide is a dry formulation of the strobilurin, trifloxystrobin, and has been available to grape growers for about 20 years. That dry formulation is being replaced by a liquid formulation trifloxystrobin called *Flint Extra*. You may recall that Flint was once known for outstanding activity against powdery mildew and was primarily used to control that disease as well as black rot. Unfortunately, with widespread powdery mildew resistance to the strobilurins, the use of this product is now considered risky for control of that disease. For rates of active ingredient applied, one fluid ounce of the new formulation is roughly equivalent to one dry ounce of the old formulation. However, the rates on the new label generally reflect a higher application of active ingredient for disease control, compared with those on the old label. For example, the old label listed a 1.5-2 ounce rate for powdery mildew control, whereas the new label lists a 3-3.5 fluid ounce rate for that disease; a substantial increase over the old rate of active ingredient. However, applying the higher rate of trifloxystrobin with Flint Extra will likely not overcome any resistance issues that may have developed. Like Flint 50WG, Flint Extra should be very good to excellent against black rot, fair against Phomopsis, and weak against downy mildew (suppression). The rates of active ingredient for black rot and Phomopsis have been bumped up as well, but the rates for downy mildew have remained about the same. Flint Extra also is labeled for control of *Botrytis*, although at a new rate of 3.8 fl oz/A, an increase in trifloxystrobin application of about 28% over the 3 oz rate on the old Flint 50WG label. However, be warned that *Botrytis* resistance to the strobilurins is also common in regions where strobilurins have been used for some time. Flint Extra has a 12-hr restricted entry interval and a 14-day preharvest interval. Like Flint, Flint Extra is phytotoxic on Concord grapes and it's important to thoroughly rinse spray equipment before application of other products to Concord grapes, especially if you're using the higher rates on the Flint Extra label. Though Flint Extra replaces Flint 50WG, grape growers will still be able to legally use up old stock of

Flint 50WG.

Intuity. This product is also relatively new, but the representative at Valent that I spoke to informs me there are no changes to make since last year. The active ingredient is mandestrobin, another strobilurin fungicide (FRAC group 11). Intuity offers protectant and antisporulant activity against Botrytis, for which it is exclusively recommended, though it will provide suppression of powdery mildew, at least where strobilurin resistance has not yet developed. In limited NY and PA trials, Intuity has provided good to fair control of Botrytis equivalent to current standards like Elevate, Vangard, Scala, and Switch. The label rate is 6 fl. oz/A with a maximum number of three applications (two is recommended) and 18 fl oz per season. Do not make sequential applications; rotate with non-FRAC 11 materials (Elevate, Endura, Fracture, Inspire super, Rovral, Scala, Switch, Vangard) and allow at least 20 days between Intuity applications. Intuity is at risk for resistance development by the Botrytis fungus and it is essential that its use be limited to rotations with other, unrelated Botrytis fungicides both within and between seasons to reduce the development of resistance. Intuity is rainfast within 2 hours of application, has an REI of 12 hours and PHI of 10 days. Do not use Intuity on *V. labrusca, V. labrusca* hybrids or other non-*vinifera* hybrids. In our trials on Vignoles we have not observed any injury issues from this product. Avoid mixing with organosilicone surfactants. To the best of my knowledge, Intuity has not yet been cleared for use in New York at press time.

Luna Sensation. The Luna series of fungicides have been around since about 2011/2012, and for grape growers, started with the release of Luna Experience (a combination of fluopyram and tebuconazole). Just recently, Luna Sensation has become available for use on grapes as well. Bayer Crop Science, the source of these fungicides, informs me that, like Luna Experience, Luna Sensation will be for general use in PA but *Restricted Use* in NY and cannot be used in Suffolk and Nassau counties in NY. Like all fungicides in the "Luna" series, Luna Sensation contains fluopyram, a relatively new "SDHI" (Group 7) fungicide similar to boscalid (the non-strobie component of Pristine) benzovindiflupyr (Aprovia), and pydiflumetofen (one of the active ingredients found in the new product, Miravis Prime, discussed next) which is active against powdery mildew and *Botrytis*. The second active ingredient in Luna Sensation is trifloxystrobin (just discussed above as Flint Extra), which provides good to excellent control of powdery mildew (in the absence of resistance to strobilurins) and black rot, and control of Botrytis at higher rates. As with Flint/Flint Extra, the label specifies that you do not apply or allow drift to Concord grapes or crop injury may occur.

Luna Sensation is labeled for control of powdery mildew at 4.0–7.6 fl oz/A, control of black rot, Phomopsis, and Botrytis at 5.0-7.6 fl oz/A, and suppression of downy mildew at the maximum rate of 7.6 fl oz/A. Activity against black rot, Phomopsis, and downy mildew comes from the trifloxystrobin component, whereas both active ingredients have activity against Botrytis and powdery mildew. For black rot and Botrytis control, the 5-7.6 fl oz rate of Luna Sensation should deliver enough trifloxystrobin for good to excellent control of these diseases (equivalent to about 2.5-3.8 fl oz of Flint Extra, that has about twice the concentration of trifloxystrobin as Luna Sensation). Of course, this level of *Botrytis* control would only apply in the absence of strobilurin resistance by this pathogen. The 7.6 fl oz rate for Phomopsis and downy mildew is about the same dose of trifloxystrobin as the 3.8 fl oz rate on the Flint Extra label for these diseases, still only providing for suppression of downy mildew. For powdery mildew control, the 4-7.6 fl oz label rate delivers a wider range of fluopyram than the 6-8.6 fl oz powdery mildew rate on the Luna Experience label, but they're *about* the same. For example, 6 and 8.6 fl ozs of Luna Experience actually delivers a dose of fluopyram equivalent to 4.8 and 6.8 fl ozs of Luna Sensation. That same 4-7.6 fl oz powdery mildew rate also delivers about the same amount of trifloxystrobin as 2-3.8 fl oz of Flint Extra. In the absence of strobilurin resistance, this should make for a very potent combination against powdery mildew. Like most modern fungicides however, the SDHI (Group 7) such as fluopyram and strobilurin (Group 11) materials such as trifloxystrobin are at high risk for resistance development. Indeed, with powdery mildew resistance to strobilurin fungicides becoming commonplace in many eastern grape growing areas, control of that disease with this product may come primarily or solely from the SDHI chemistry. Thus, it is recommended that use of this product and all other Group 7 and 11 products be limited to a maximum of two applications per season in total. Luna Sensation has a 12-hr REI and a 14-day PHI.

Miravis Prime. Miravis Prime is a combination of a new SDHI fungicide (pydiflumetofen, Group 7) and an older phenylpyrrole active ingredient (fludioxonil, Group 12), introduced about 25 years ago. In NY and PA trials, Miravis Prime has shown excellent activity against powdery mildew and good to excellent activity against black rot and Botrytis. Miravis Prime is also labeled for control of anthracnose and Phomopsis cane and leaf spot, but there is little local experience with control of these other diseases using this product. A couple of trials we ran last year on Concord grape seemed to indicate that Miravis Prime could provide modest, but significant reductions in shoot and cluster stem infections of Phomopsis. But again, the strengths of this product are in the strong activity against powdery mildew and black rot (primarily from the SDHI component, pydiflumetofen), and the *Botrytis* control from the fludioxonil component (also found in another combination product called Switch). Miravis Prime is said to accumulate in the waxy cuticle and "translocate through the leaves". It has a 12 hr REI and a 14 day PHI. Miravis Prime has been registered for use on grapes in PA, but not in NY, at press time. However, this product has received a "reduced risk" classification and might receive NY registration as early as May 2019!.

Prolivo 300SC. Prolivo contains an active ingredient (pyriofenone) that is in the same FRAC group (U8) as the active ingredient in Vivando (metrafenone). In limited NY trial work on Chardonnay, it provided control of powdery mildew - at the 4 and 5 fl oz label rates - similar to that of Vivando at the 10 fl oz rate. To limit the risk of developing resistance to Prolivo, the label specifies a maximum of three applications per year, and no more than two applications in a row before alternating to a different material. I would recommend that you *always* rotate to another FRAC group after a Prolivo or Vivando application. Prolivo has a 4 hr REI and a 0-day PHI (compare this to the 12 hr REI and 14-day PHI for Vivando).

Rhyme and Topguard EQ. These products were registered in most states in 2016 and in NY in 2017. The active ingredient in Rhyme is flutriafol (a sterol inhibitor, FRAC 3). I have not personally had the opportunity to test these products but thorough testing in New York has shown that Rhyme provides good to excellent control of powdery mildew. Rhyme has tended to work better than the older SIs like Rally (myclobutanil) and tebuconazole, but not as good as difenoconazole (the newer, more potent sterol inhibitor in Revus Top, Inspire Super, Quadris Top, and Aprovia Top). It is available for use in PA and NY (except for Long Island). Rhyme also has been shown to have excellent activity against black rot. Topguard EQ is a combination of flutriafol and azoxystrobin (the strobilurin in Abound). While not available to Erie county PA grape growers (due to azoxystrobin), it is available to New York grape growers (except Long Island). The azoxystrobin adds downy mildew (and Phomopsis?) control to the product, that the flutriafol won't control (except where there is downy mildew resistance to the strobies). For powdery mildew, the azoxystrobin adds a second mode of action against that disease, unless (once again) there is powdery mildew resistance to the strobies in your vineyard. One thing is for sure; Topguard EQ provides two very effective materials for black rot control and should provide excellent control of that disease.

Trionic 4SC. Trionic contains the same active ingredient (and the same amount of that ai) as Viticure and Procure. The active ingredient (triflumizole) is a sterol biosynthesis inhibitor (SI), in the same class (FRAC 3) as tebuconazole and difenoconazole. It is also labeled at the same use rates as Viticure; 4-8 fl oz/A. However, it's important to remember that unlike most other SIs, triflumizole only controls powdery mildew on grapes, not black rot.

On the lighter side, there are some biopesticides about which we have been able to develop a fair amount of information through local field trials at Cornell and Penn State Universities, and can report on here. In my experience, most of the low impact, biopesticides I have tested over the years have been most useful for controlling powdery mildew, a disease caused by a fungus that grows primarily on the surface of the plant and

is impacted by a whole host of oils, foliar fertilizers, plant based essential oils and fermentation products, etc. However, I am happy to report here on some materials that have tested quite well for additional diseases like bunch rots and downy mildew. Unfortunately, the one disease that still eludes control by this group of materials is black rot, a disease that has been one of the biggest challenges for organic grape growers in the east. For most biopesticides and other low impact materials, it's important to remember that they generally work best under relatively low disease pressure, as part of a production system that also relies heavily on good vineyard sanitation and integration of cultural controls. Not all these products are OMRI approved, but all are characterized by low mammalian toxicity. I would also stress that where these products are desired as part of a low impact/conventional 'hybrid' disease management system, they are best utilized outside the critical fruit protection period (beginning of capfall to 3 weeks later for powdery and downy mildew, 5-6 weeks later in the case of black rot), especially in wet seasons and when growing very susceptible (*V. vinifera*) varieties. In other words, where production goals strive to reduce reliance on synthetic pesticides, apply the heavier hitting, conventional materials during bloom and early fruit development, and utilize the biopesticides during early season (lower disease pressure) or late season (after fruit are resistant to most diseases).

Fracture. In NY and PA trials, Fracture provides what I would consider modest control of powdery mildew. However, I think it has more appeal as a material for bunch rot control (Botrytis and sour rot) in wine varieties prone to that disease. For example, in two years of trials at Penn State, it has provided bunch rot control as good as a standard Botrytis fungicide program. Earlier NY trials showed similar results. Fracture has a 4-hr REI and a 1-day PHI, and the residue of its active ingredient is exempt from tolerance by the US-EPA (i. e., it is considered safe enough to humans that there is no limit on the allowable residue level in/on food products)". However, to my knowledge it is not OMRI approved for use in organic production. Fracture is expensive, but may appeal to growers looking to reduce reliance on synthetic fungicides for bunch rot control, especially if used in combination with strict sanitation and cultural controls like leaf removal (more on this later).

LifeGard. LifeGard is an OMRI listed biopesticide approved for use on grapes. It has provided really good results for the control of downy mildew in New York trials. I wish I had more to report on this product from our end at Penn State, but three years of testing along the Erie lakeshore of PA have been relatively unproductive due to very dry conditions and virtually no downy mildew in 2016 and 2017. We did have a *fair* test of this product last year, but with rather disappointing results for downy mildew control. But again, the results from 3 years of New York trials are very encouraging for downy mildew control and testing should continue. One year of New York trials also showed it to be effective against powdery mildew as well. LifeGard works by triggering a plants' natural defense mechanisms against pathogens, so the product should perform best after the vine has been 'primed' by an initial spray a few days before it is challenged with the pathogen. The label states that "initial triggering of plant defense response occurs within minutes of application, but 3-5 days are required to attain maximum level of protection". LifeGard is labeled for use in both PA and NY.

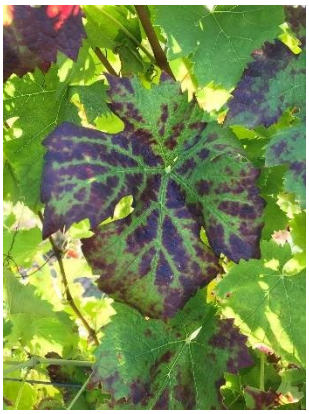
Polyoxin D zinc salt. Polyoxin D zinc salt (PZS) is a relatively new fungicide active ingredient with very low mammalian toxicity that has been classified by the U.S. Environmental Protection Agency (USEPA) as a "biochemical-like" pesticide. It also degrades rapidly in the environment with a soil half-life of 2-3 days. Production of PZS occurs through a fermentation process using the soil bacterium *Streptomyces cacaoi var. asoensis*. The active ingredient inhibits chitin synthase, an enzyme essential for the production of chitin, an important component of fungal cell walls. The product is being sold as Tovano and OSO5%SC and is marketed through Certis USA. Over the past two seasons, our results with OSO on Concord and Chambourcin grapes have shown good to modest efficacy against powdery mildew, but no practical level of activity against black rot. For powdery mildew efficacy on fruit, OSO, at the 13 fl oz rate, was equal to or better than BadgeX2 (fixed copper), and equal to a standard rotational program of Quintec/Vivando/Toledo. As with most of the biopesticide type fungicides, cost per application is generally going to be higher than that of the standard synthetic fungicides.

Regalia. *Some of this information is based on the fact finding of Amara Dunn, Cornell University.* Regalia is labeled for powdery mildew, Botrytis and downy mildew. In PA trials it provided modest control of powdery mildew. NY trials by Wayne Wilcox et al. were more extensive and testing examined activity on all three diseases, where it was only effective against powdery mildew and worked best where disease pressure was moderate. Regalia works by activating the vine's defenses against pathogens and upon the first seasonal application, requires 48 hours to fully activate those defenses. Subsequent applications only require 3-4 hours for activation. Pay close attention to the manufacturer's instructions for best results; apply with a spreader-sticker, allow 3-4 hours of drying time prior to rain, adjust the pH of the spray mixture between 6 and 8. Regalia has a 4 hr REI and a 0 day PHI. A new formulation (Regalia CG) was registered in NY in Fall 2018 with the same active ingredient, REI and PHI. It lists powdery mildew, Botrytis, downy mildew, ripe rot, and sour rot on the label, but the efficacy of this formulation has not yet been tested in NY or PA.

DISEASES

Rather than repeat what is in the grape guidelines here for the majority of the common grape diseases, I am reporting on our recent work with grapevine leafroll virus and bunch rot.

Grapevine leafroll viruses and leafroll disease. The presence of grapevine leafroll-associated viruses (GLRaVs) in the phloem of grapevines can have serious consequences on yield, vigor, cold hardiness, and most notably fruit/wine quality (Naidu et al. 2014). The main physiological effect of GLRaVs is the impairment of leaf photosynthesis, which occurs as a result of phloem disruption (Almeida et al. 2013). This in turn results in a delay in ripening, often manifested as lower soluble solids content and elevated titratable acidity of the must, particularly in cool climate regions (Almeida et al. 2013).



These viruses are widespread throughout many grape growing regions of the world. In Pennsylvania, we have been investigating the two most economically important and widely distributed GLRaVs, which are GLRaV-1 and 3. After a two-year survey of 63 Pennsylvania wine grape vineyard blocks, about a third of the blocks we have sampled from have vines that test positive for leafroll viruses 1 and/or 3. Initial observations in two Pennsylvania vineyards, where we have taken a closer look at the effects of GLRaVs on *Vitis vinifera* 'Cabernet franc', indicated significant negative effects on fruit soluble solids and titratable acidity at harvest that could translate to reduced wine quality. However, these effects seem to depend on climatic variables which we hope to examine in closer detail next.

Currently, there are several species of GLRaVs reported in cultivated grapevines and there appears to be no plant resistance mechanisms to these viruses; they can infect many cultivated grapevine species and varieties. However, *V. vinifera* is most dramatically affected, with *V. labrusca* and interspecific hybrids of *Vitis* being much less affected or unaffected (Naidu et al. 2014; Bahder et al. 2013). GLRaV-1 and 3 have been spread across long distances (worldwide) through the sale and distribution of infected nursery material. Short distance spread of GLRaV-1 and/or 3 (within the vineyard or between adjacent vineyards) occurs through the movement of phloem feeding insect vectors, specifically mealybugs and scales.

In addition to the negative effects on vigor, yield, and hardiness mentioned above, the more obvious symptoms of the disease on some grape varieties are cupping and loss of chlorophyll in the leaves in late summer and fall, during the ripening period. On red-fruited varieties, like *Vitis vinifera* 'Cabernet Franc', leaves

of infected vines can display red coloration of the interveinal tissue, while veins remain green. On white-fruited varieties like Chardonnay, symptoms are less noticeable and leaves tend to look yellowish and cupped. However, the presence of these symptoms does not automatically confirm the presence of GLRaVs, as symptoms associated with nutrient deficiencies, water stress, and crown gall are similar. Confirmation can *only be made in the laboratory* through serological or molecular analysis of phloem tissues in leaf petiole or dormant cane samples of suspect vines. For these reasons, V. vinifera vineyards should be scouted annually and tissue samples from suspect vines can be sent to a laboratory for confirmation.

Infection by GLRaVs is permanent, and management calls for removal or rogueing of infected vines and replanting with certified virus-free material. Insecticide applications to control crawler stages of the vectors can slow the spread of GLRaVs within and between vineyards. In our survey efforts we have seen the full range of incidence of infection in V. vinifera vineyards, from less than 1% to 50% or more. In vineyards with a very low incidence of the virus, the effects of immature fruit from a few vines will be minimal or insignificant to the overall quality of the crop. This is often what we encounter in relatively young vineyards, where little time has elapsed for local spread by vectors. In our experience, the really high incidence is most often encountered in older (20-30 years or more) infected vineyards where the original material may have been less “clean”, and more time has allowed for greater local spread by vectors.

As the acreage of *V. vinifera* in the northeast continues to expand and become a larger part of the premium wine industry, our encounters and frustrations with GLRaVs will likely increase. It is therefore essential to create a growing body of information that will help vineyard managers reduce their spread and impact. Below are some references that I drew from for this bit on leafroll viruses and grapevine leafroll disease (GLD). The last reference is available free, online, and is a great review of GLD by some of the leading experts from New York, California, and Washington.

Almeida, R., K.M. Daane, V.A. Bell, G.K. Blaisdell, M.L. Cooper, E. Herrbach, and G. Pietersen. 2013. Ecology and Management of Grapevine Leafroll Disease. Frontiers in Microbiology, Vol 4, Article 94, pages 1 -13.

Bahder, B., Alabi, O., Poojari, S., Walsh, D., and Naidu, R. 2013. A Survey for Grapevine Viruses in Washington State ‘Concord’ (Vitis x labruscana L.) Vineyards. Plant Health Progress, August 5, 2013. American Phytopathological Society (online).

Compendium of Grape Diseases, Disorders, and Pests. 2nd edition, 2015. Editors Wayne F. Wilcox, Walter D. Gubler, and Jerry K. Uyemoto. The American Phytopathological Society. Pp. 118-119.

Naidu RA, Rowhani A, Fuchs M, Golino D, Martelli GP. 2014. Grapevine leafroll: a complex viral disease affecting a high-value fruit crop. Plant Dis. 98: 1172–85. https://www.researchgate.net/publication/270339365_Grapevine_Leafroll_A_Complex_Viral_Disease_Affecting_a_High-Value_Fruit_Crop

A continuation of new developments in Botrytis bunch rot/sour rot control

Last season was a horrendously wet season for many grape growers in the eastern U.S. As a result, many growers have complained that 2018 produced one of their worst crops ever, often due to the development of various late season bunch rots. Late season fruit rots are often a result of a combination of Botrytis (which can be controlled to some extent with fungicides) and non-*Botrytis* microorganisms (that are not as easily, or not at all controlled by fungicides). In my experience, *Botrytis* specific fungicide trials over a number of years have often resulted in mediocre bunch rot control to Vignoles grape, suggesting that consistent improvements to late season fruit rot management *requires* the integration of cultural and other non-chemical methods. One of the most commonly recommended practices for integration into bunch rot management programs is fruit-zone leaf removal, developed over many years, by lots of research, by many people. Simply put, removal of leaves from nodes in the fruit-zone increases sunlight exposure, air circulation, and pesticide penetration to

developing fruit, creating a hostile environment for Botrytis and other harvest-rot-inducing microorganisms that otherwise thrive in darkness, still air and high humidity.

The traditional timing for this practice has generally been between fruit set and veraison, with earlier being better than later. More recently, an *early fruit zone leaf removal* (ELR), which involves the removal of leaves just before or at the beginning of bloom, is gaining attention for effects on crop load management, fruit and wine quality, and control of bunch rots. The removal of the most mature, photosynthetically active leaves (those in the fruit zone) before or during bloom, starves the inflorescences for sugars, and reduces the number of flowers that set fruit. Fewer berries per cluster generally results in looser clusters that develop less bunch rot. Taken together, ELR combines the benefits of an improved fruit zone environment with less susceptible clusters and often greater, more consistent reductions in bunch rot development than what would be achieved with post fruit set leaf removal. This practice can also reduce reliance on Botrytis specific fungicide applications. However, the reduction in berry number per cluster from ELR generally results in lower cluster weights and potentially lower yields. And though this can be managed to some extent, yield reductions may not jive with every grower's business plan.

Manual leaf removal is expensive and time consuming, and timing can be critical, making mechanization of ELR an important next step in the stream of leaf removal research. Over the past four years, we've been experimenting with air pulse leaf removal technology for ELR on two trellis systems (four-arm kniffen and single high wire cordon) for Vignoles grape, and on Pinot gris and Pinot noir trained to vertical shoot position trellis systems. In our experiments, the air pulse system tended to remove about 35-50% of the leaf area which would be achieved by hand removal in the fruit zone, working most efficiently on more upright, two dimensional training systems like the vertical shoot position and four-arm kniffen systems, when compared to more three dimensional training systems like the single, high-wire cordon, no-tie system.

On Vignoles, cluster weight was significantly reduced by mechanical ELR (compared to no leaf removal) on both trellis systems. Bunch rot was also reduced by mechanical ELR compared to no leaf removal, but the reductions were greater and more frequently significant among vines on the four arm kniffen system (significant in 3 of 4 years) compared to the high wire cordon (no tie) system (significant in only 1 of 4 years). With respect to juice composition, mechanical ELR generally resulted in higher brix and lower titratable acidity (TA) when compared to no leaf removal, but again, the differences were more frequently significant among four-arm kniffen trained vines (3 of 4 years for TA), than single high wire cordon trained vines (2 of 4 years for TA).

If you have bunch rot susceptible varieties like Chardonnay, Vignoles, or Pinot gris, and would like to test this practice in your vineyard, I would recommend you test it out on a few vines first and compare the results to the rest of your vineyard (all other things being equal) to see if this is something that will work for you, or not. Also, test it over more than one year; the results may vary somewhat from one variety to the next and from one season to the next. We often find that efforts to reduce bunch rot through treatments that loosen clusters, tend to be more effective in years when natural fruit set is higher rather than lower.

Lastly, some excellent research was conducted by Megan Hall and Wayne Wilcox a few years back that is important news for wine grape growers with sour rot susceptible varieties: please review Wayne's newsletter from June 2017 (Grape Disease Control 2017) regarding the Cornell research on sour rot control. However, I will attempt to summarize it here.

First, by sour rot, we're talking about the rot that smells of vinegar from acetic acid - with or without any observable mold - that attracts fruit flies and repels humans. Because the microorganisms that cause sour rot

do not typically have the 'tools' to penetrate the skin of fruit, sour rots are initiated by wounding of the fruit, which can occur through feeding injury by birds or insects, powdery mildew and/or Botrytis infections, cluster compactness, rain cracking, etc. So, injuries enable various bacteria and yeasts to breach the skin and access the flesh of the fruit as a substrate for growth and reproduction. Warm, wet conditions favor these colonization processes and sour rot generally becomes manifest at the time fruit attain soluble solids levels of 15 brix, followed by a precipitation event. The yeast turn the sugar into ethanol and the bacteria turn the ethanol into acetic acid. But, for the last step to take place requires fruit flies.

Bottom line: There is no silver bullet for bunch/sour rot control. But by combining i) leaf removal in the fruit-zone with ii) the use of more upright, two dimensional training systems (like four-arm kniffen or VSP), followed by iii) control of sour rot inducing microorganisms (with sterilants or antimicrobials like Oxidate) and fruit flies (with insecticides) at around 15 brix, growers of susceptible varieties may more consistently improve control of sour/bunch rots, in spite of the weather.

Seeking Additional Grower Collaborators

Justine Vanden Heuvel

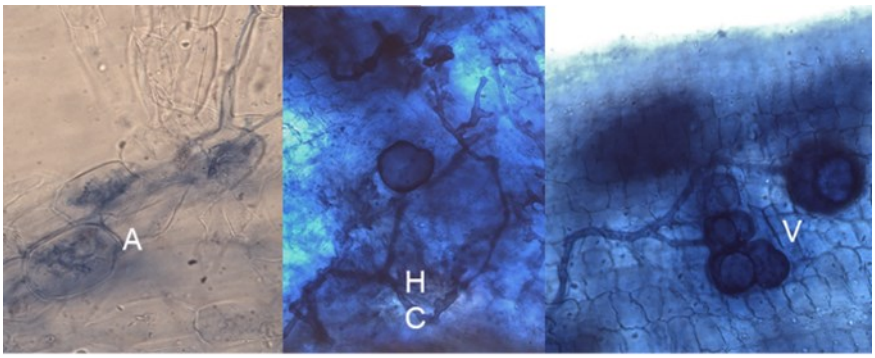


Fig 1. Arbuscular mycorrhizal fungal (AMF) structures in the fine roots of Vitis vinifera cv. Pinot noir. Samples were collected in November, 5 months after inoculation. A: Arbuscules, HC: Hyphal coils, V: Vesicles, 40x magnified. AMF can improve vine health, nutrition, and water relations.

Grapevines benefit from a symbiotic relationship with arbuscular mycorrhizal fungi (AMF). Together the vine and the AMF form mycorrhizae, which play an important role in vine health, grapevine nutrition, and water relations. A range of products - generally referred to as soil microbial stimulators - are sold with the goal of encouraging the formation of mycorrhizae.

The Vanden Heuvel research program began working with growers in 2018 to trial some of the more promising products on the market, with positive results (Table 1).

Table 1: Vine petiole nutrient analysis of cv. Pinot noir inoculated with different biofertilizers in June 2018. Petioles were collected at veraison.

	Petiole Nutrient Concentration		
Treatment	% Total Nitrogen	% Phosphorous	% Potassium
Control (no application)	0.68	0.21	1.75
Big Foot Concentrate	0.72	0.25	2.32
MycoGrow Soluble	0.76	0.28	2.60
BioOrganic	0.79	0.30	2.72
MycoApply All Purpose	0.84	0.37	3.09

We are seeking more growers to purchase and trial at least one product containing Glomus. If you are interested in purchasing and trialing a product on a small area of your vineyard please email Justine@cornell.edu. We will help you evaluate potential impacts on your vineyard.
This project is funded by the New York Farm Viability Institute.

Interested in trialing under-vine cover crops in your vineyard?

Justine Vanden Heuvel

Under-vine cover crops help reduce soil erosion and nutrient leaching while providing an opportunity to reduce excessive grapevine vigor. We've worked with a range of cover crops that have varying impacts on vine size (Table 1).

Table 1. Summary of impact of under-vine cover crops on vine yield and pruning weight

Little to no impact	Moderate impact	Significant impact
Buckwheat	Tillage Radish	Chicory
Rosette-forming turnip	Alfalfa	Annual Ryegrass
	Fescue	
	Natural vegetation	

Northeast SARE (Sustainable Agriculture Research and Extension) has funded a project to help grape growers trial under-vine cover crops. If you are located in the Finger Lakes region we can provide the seed, help you seed the covers and evaluate their impacts. Please contact Justine Vanden Heuvel (justine@cornell.edu) or Steve Lerch (sdl5@cornell.edu) if you'd like to participate in the project.

eNEWA for Grapes – Back by Popular Demand

Tim Weigle, NYS IPM Program

What is eNEWA you ask? eNEWA is a daily reminder of the current weather and grape disease and insect model information found on NEWA (Network for Environment and Weather Applications) http://newa.cornell.edu. This daily email contains current weather and grape pest model information from a station, or stations, near you. The email will contain; 1) high, low and average temperature, rainfall, wind speed and relative humidity 2) the 5-day forecast for these weather parameters, 3) GDD totals (Base 50F), 4) 5-day GDD (Base 50F) forecast and 5) model results for powdery mildew, black rot, Phomopsis and grape berry moth.

eNEWA is a great way to get an idea of pest potentials for your vineyard operation without having to click around the NEWA website every day. eNEWA is not meant to be a replacement for the website, rather it is a quick and easy way to determine if a visit to the website is warranted. For example, if one of the pest models is reporting the potential for an infection event, you can visit the NEWA website to provide information specific to your site. This will increase the accuracy of the output of the disease and grape berry moth models. You will also need to access the NEWA website to use the DMCast model for downy mildew as user input is required.

We worked with Dan Olmstead, NEWA Coordinator, to streamline the sign up process for eNEWA in 2019. By visiting http://blogs.cornell.edu/yourenewa/e-newa/ you will have the ability to choose from any station that is currently part of the NEWA network in New York and Pennsylvania. You can choose to receive information from one to five station locations and have the information delivered up to three times a day. Please keep in mind that you will receive a separate email (approximately 3 pages in length) for each station you choose. Once during the growing season and again after harvest, you will be asked to complete a short survey to assist us in improving the eNEWA for grapes email system. If you would like to be a part of this project visit http://blogs.cornell.edu/yourenewa/e-newa/. eNEWA alerts should start shortly after the growing season begins

Upcoming Events

Don't forget to check out the calendar on our website (http://flgp.cce.cornell.edu/events.php) for more information about these and other events relevant to the Finger Lakes grape industry.

Spring Grape IPM Meeting
Wednesday, May 15, 2019 4:30 – 6:00 PM (with dinner following)
Doyle Vineyard Management
10223 Middle Road, Hammondsport NY

Come one, come all for this year's Spring Grape IPM meeting! Come for the credits and the information, stay for the food! Speakers will cover topics including disease and weed management, the latest on the Spotted Lantern Fly, insecticide use for managing fruit flies and sour rot, and more. And don't forget to stick around afterwards for dinner and some social time with your fellow growers.

The meeting is free to those who are enrolled in the FLGP for 2019, and $15 per person for those who are not ($25 at the door regardless of enrollment status, which will be limited). In order to have an accurate count for dinner, we need everyone to register for the meeting by Friday, May 10. Please register at https://flgp.cce.cornell.edu/event.php?id=391 or call Brittany at 315-536-5134.

Tailgate Meeting #2
Tuesday, May 28, 2019 4:30 – 6:00 PM
James Hicks Farm
5305 Seneca Point Road
Canandaigua, NY

Our second Tailgate Meeting of the season will be held at Jim Hicks' vineyard on the west side of Canandaigua Lake. Pesticide credits will be available for each Tailgate Meeting this season. No registration required – just bring a chair and your questions and observations about what's going on in the vineyard.

ASEV-Eastern Section Annual Meeting and Shaulis Symposium on Digital Viticulture
July 16-18, 2019
Hobart & William Smith Colleges, Geneva NY
A special vineyard tour and symposium entitled "Digital Viticulture: New Tools for Precision Management" will be featured as part of the annual American Society for Viticulture and Enology- Eastern Section (ASEV-ES) conference at Hobart and William Smith Colleges in Geneva, NY on July 16 through July 18.

The two-day program and vineyard tour will bring together suppliers, researchers, and growers to explore the tools and concepts of precision viticulture. New technologies, such as inexpensive sensors, digital imaging, geographical information systems, and precision machinery are converging to make precision viticulture possible. This field tour and symposium will focus on tools, concepts, and platforms for putting it all together to manage vineyards.

More information about the conference, field tour and symposium can be found at http://www.asev-es.org.

2019 GDD & Precipitation

FLX Teaching & Demonstration Vineyard – Dresden, NY					
Date	**Hi Temp (F)**	**Lo Temp (F)**	**Rain (inches)**	**Daily GDDs**	**Total GDDs**
4/24/2019	53.7	40.2	0.00	0.0	55.6
4/25/2019	63.3	36.7	0.00	0.0	55.6
4/26/2019	64.9	47.4	0.28	6.2	61.8
4/27/2019	46.1	36.1	0.01	0.0	61.8
4/28/2019	47.6	37.3	0.03	0.0	61.8
4/29/2019	49.7	29.8	0.10	0.0	61.8
4/30/2019	49.2	41.3	0.00	0.0	61.8
Weekly Total			**0.42”**	**6.2**	
Season Total			**2.38”**	**61.8**	

GDDs as of April 30, 2018: 15.3

Rainfall as of April 30, 2018: 1.92”

Seasonal Comparisons (at Geneva) as of April 30

Growing Degree Day

[1] Accumulated GDDs for each month.

	2019 GDD [1]	Long-term Avg GDD [2]	Cumulative days ahead (+)/behind (-) [3]
April	48.1	64.1	-5
May		255.5	
June		480.9	
July		642.1	
August		592.7	
September		357.6	
October		110.1	
TOTAL	48.1	2503.0	

[2] The long-term average (1973-2017) GDD accumulation as of that date in the month.

[3] Numbers at the end of each month represent where this year’s GDD accumulation stands relative to the long-term average. The most recent number represents the current status.

2019 GDD & Precipitation (continued from page 7)

Precipitation

	2019 Rain [4]	Long-term Avg Rain [5]	Monthly deviation from avg [6]
April	2.22”	2.85”	-0.63
May		3.13”	
June		3.60”	
July		3.44”	
August		3.21”	
September		3.57”	
October		3.39”	
TOTAL	2.22”	23.16”	

[4] Monthly rainfall totals up to current date

[5] Long-term average rainfall for the month (total)

[6] Monthly deviation from average (calculated at the end of the month)

Additional Information

Become a fan of the Finger Lakes Grape Program on Facebook, or follow us on Twitter (@cceflgp) as well as YouTube. Also check out our website at http://flgp.cce.cornell.edu.

Got some grapes to sell? Looking to buy some equipment or bulk wine? List your ad on the NY Grape & Wine Classifieds website today!

Cornell Cooperative Extension
Finger Lakes Grape Program
Hans Walter-Peterson—Team Leader
Donald Caldwell—Viticulture Technician

The Finger Lakes Grape Program is a Cornell Cooperative Extension partnership between Cornell University and the Cornell Cooperative Extension Associations in Ontario, Seneca, Schuyler, Steuben, Wayne and Yates Counties.

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