



# Pressing Ahead

Advancing Pennsylvania's Wine and Grape Industry through Integrated Research



**PennState**  
College of Agricultural Sciences



## How does the **Penn State wine and grape team** advance grape production and winemaking in Pennsylvania?

Improving grape and wine quality in Pennsylvania is the goal that drives the Penn State Wine and Grape Team. We do this by researching and creating new solutions that address the significant problems facing Pennsylvania's grape and wine industry. Our close partnership with industry is embedded in our land-grant mission to provide educational resources based on our research findings to hundreds of attendees through in-person and online workshops and seminars offered year-round through Penn State Extension.

The work of growing grapes and making wine is naturally interdisciplinary. Our team spans across academic disciplines at multiple locations in the Commonwealth. We collaborate with one another and with the industry experts who rely on our contributions. By experimentation, viticulturalists provide guidance on how to manage vineyards to grow the best grapes for quality wines. Enologists and sensory scientists work together to identify wine quality defects and develop preventive or remedial strategies. Plant pathologists and entomologists discover effective measures to manage disease and insects in the vineyard. Marketing researchers assist industry with understanding and meeting consumer demand. It's all linked!

Providing access to ongoing assistance through webinars, telephone calls, emails, on-site visits, a blog, a newsletter, and social media posts, our team's efforts keep grape growers, tasting room managers, winemakers, and other industry members current with real-time vineyard, winery, marketing, and other research updates. Grape production and winemaking is an important and growing industry in Pennsylvania, and our team of scientists and educators aim to deliver the necessary research and science-based education that will ensure sustained growth for these partners.

**Molly Kelly, Ph.D.**  
*Enology Educator  
Penn State Extension*



At a Glance

# PENNSYLVANIA WINE INDUSTRY

5

DESIGNATED AMERICAN VITICULTURAL AREAS

14,000+

ACRES OF GRAPES

\$1.4 BILLION

ECONOMIC IMPACT OF WINE INDUSTRY IN PA

300+

INDEPENDENT WINERIES

2,000,000

GALLONS OF WINE PRODUCED ANNUALLY



## RESEARCH TEAM AT PENN STATE

19

FACULTY AND  
EXTENSION EDUCATORS

18

M.S. AND PH.D.  
STUDENTS SINCE 2011

Interdisciplinary Teams Across:

5

ACADEMIC DEPARTMENTS

2

CAMPUSES

Penn State University Park and Penn State Behrend

2

RESEARCH AND  
EXTENSION CENTERS

- Lake Erie Regional Grape Research and Extension Center (LERGREC)
- Fruit Research and Extension Center (FREC)

## REACH OF THE TEAM

26

ENGAGED INDUSTRY PARTNERS

400+

REGULAR CONTACTS THROUGH IN-PERSON  
VISITS, EMAIL, AND TELEPHONE

1,600+

WEEKLY NEWSLETTER SUBSCRIBERS

654

BLOG SUBSCRIBERS

1,090

FACEBOOK FOLLOWERS

## THE IMPACT

### Research on grape production sustains the market

Growing wine grapes in Pennsylvania can be a challenge. The state boasts a diversity of climate, soil, and topographical conditions across five designated American Viticultural Areas. The intensity and length of the winters, along with wetter conditions overall, means that grapes grown in other parts of the United States, such as the West Coast, are not always well suited for the Northeast. Because most research is conducted on grape varieties that do well in warmer, dryer climates, growers in Pennsylvania can be at a disadvantage without comparable scientific literature on how these varieties perform under cooler and wetter conditions typical of the eastern United States. Evaluation of new varieties that are cold tolerant and can resist disease and insect pressures that come with wetter climates is also important for the advancement of the Pennsylvania wine industry.

Research on grape production addresses concerns across the entire wine supply chain from grower to consumer, providing informed guidance on topics ranging from how best to grow grapes and ensure a profitable yield to what varieties are most suitable to the area. When combined with research on consumer tastes and preferences, this critical information can then be used to more purposefully:

- Tailor Pennsylvania's grape production to **best appeal to the market**
- Build a more **knowledgeable consumer base**
- Increase overall **wine sales**

### PLANT SCIENTISTS INVESTIGATE AND HELP TO PROVIDE:



Resistance and adaptability to **volatile and unseasonable weather**



Best practices for **plant health and productivity**



Biological interventions to enhance **wine quality and flavor**



Strength to the entire chain of **local agricultural business**



**Research Team:** Michela Centinari, Ryan Elias, Molly Kelly, Helene Hopfer, Donald Smith, and Meredith Persico

**Grants:** Does delaying budburst reduce the risk of frost damage while maintaining grape and wine quality? Comparing the effectiveness of pruning time and Amigo oil application

*Pennsylvania Wine Marketing and Research Board Research Program (2017–18, 2018–19)*

**Partner:** Fero Vineyards and Winery

## Delaying budburst to **reduce risk of frost damage** on fruit

**Problem:** Can frost avoidance practices that help maintain profitable yields also be affordable?

- Grape growers in Pennsylvania reported freeze damage to their crops as being one of the greatest economic challenges they face.
- The additional material and labor costs of frost avoidance practices and the uncertainty of their effects on crop yield or wine quality may discourage growers with smaller operations from implementing them.

**Findings:** An effective and affordable strategy for protecting grapevines against spring frost is delaying the onset of budburst either through the application of a vegetable-oil-based adjuvant or by delaying winter pruning.

- Over two growing seasons, the team compared the effectiveness of the two methods and studied the biological mechanism behind the delay in budburst, which had not been previously understood.
- They also collected information on fruit ripening, wine chemistry and sensory perception, and vine susceptibility to cold temperature damage in response to the delay in budburst and a shorter annual growing cycle.

**Impact:** In conducting this comprehensive analysis, the researchers provided field-tested results and recommendations for grape growers and winemakers in cooler regions to help them improve the profitability of growing grapes in Pennsylvania by demonstrating the effectiveness and affordability of frost avoidance practices.

## Targeting signature aromas to **market and differentiate** Pennsylvania-grown wines

**Problem:** Could the peppery aromas of varieties that grow well in the northeastern region be leveraged as a point of distinction for Pennsylvania wines?

- Rotundone is the chemical that gives Australian Shiraz, a popular but cold-tender vinifera, its distinctive aroma of black pepper. In some markets, wines high in rotundone are able to command premium prices.

**Findings:** Complementary research projects studied growing practices that affect rotundone concentrations in varieties that grow well in Pennsylvania, such as Noiret, a red hybrid, and Grüner Veltliner, a white European variety.

- Plant scientists investigated how mesoclimatic conditions, viticulture parameters, and management methods stimulate the production of rotundone and identified means to influence the final concentration of rotundone in wine grape berries.
- Sensory scientists studied the variable sensitivity and acceptability of rotundone among Pennsylvania wine consumers; both qualitative and quantitative data indicated that typical wine consumers in Pennsylvania do not find these aromas appealing.

**Impact:** This integrated field-to-consumer research provides a holistic perspective for grape growers and winemakers to consider when developing targeted growing and marketing strategies for Pennsylvania wines high in rotundone.



**Research Teams:** John Hayes, Helene Hopfer, Alyssa Bakke, and Tiffany Murray  
Michela Centinari, Ryan Elias, Richard Marini, and Andrew Harner

**Grants:** Rotundone as a potential impact compound for Pennsylvania wines

Defining the effects of meso- and microclimatic factors on rotundone accumulation in Noiret wine grapes

*Pennsylvania Wine Marketing and Research Board Research Program (2017–18, 2018–19)*

**Partners:** Cornell University, Lake Erie Regional Grape Research and Extension Center, The Australian Wine Research Institute, Happy Valley Vineyard & Winery, Endless Mountains Vineyard, Arrowhead Wine Cellars, and Brix Winery





**Research Team:** Michela Centinari, Kathleen Kelley, Don Smith, and Suzanne Fleishman

**Grant:** Evaluating the impact of under-trellis groundcover practices on wine grape production profitability and sustainability

*Pennsylvania Wine Marketing and Research Board Research Program (2018–19)*

**Partners:** Waltz Vineyards Estate Winery, Fero Vineyards and Winery, and Russell E. Larson Agricultural Research Center at Rock Springs

## Using under-trellis groundcover practices to **improve profitability and sustainability**

**Problem:** Can the use of herbicides in vineyards be reduced or even eliminated with alternative methods of weed suppression?

- Herbicide resistance and continued efficacy for vineyard weed management is increasingly becoming a concern.

**Findings:** Plant scientists studied the use of cover crop species by introducing competition with the grapevines at different times of the growth cycle. In three well-replicated field trials, the team used three different vine varieties to test cover crop performance, vine vegetative growth, production, and fruit chemistry.

- The team identified cover crop and vine combinations that showed no indication of competition, did not reduce yield and cluster weight, and did not have negative effects on fruit chemistry.

**Impact:** The results of this research will assist vineyard owners and managers in fine-tuning weed control strategies to match their production and sustainability goals.

- Under-trellis cover crops can limit excessive grapevine vegetative growth—a problem faced by growers in cool and humid regions—reducing labor intensive canopy management practices.
- Cover crops help minimize chemical input for weed suppression and provide growers with options to better align with growing consumer interest in more environmentally friendly grown grapes.

# THE IMPACT

## Sensory research improves wine quality

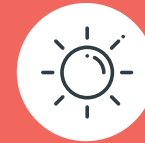
For the more than 300 wineries in Pennsylvania, producing quality wines that appeal to consumers is an enduring challenge. Pennsylvania growers and winemakers have the best results when they cultivate climate-appropriate varieties. However, the existing research on grapes grown in other regions of the world and the established methods to induce desirable qualities do not readily apply. Vineyards and wineries in the Commonwealth are also considerably smaller than most of the commercial producers in other regions, requiring an adjustment in methods for processing and the equipment needed.

Sensory scientists and food chemists address these challenges facing flavor and scale by working directly with industry partners to identify desirable traits in wine and test consumer preferences for those traits. They then connect this information into collaborations with plant scientists, entomologists, plant pathologists, and market specialists to provide recommendations for industry to:

- **Extract the best qualities** from regionally appropriate grapes
- Adopt **novel ways for correcting issues** caused by climate or pests
- Translate region-specific analyses of compounds and consumer tastes into **a more marketable product**

## FOOD AND SENSORY SCIENTISTS

### INVESTIGATE AND HELP TO SOLVE:



**Climate impacts** on ripeness and flavor profiles



**Negative flavor and aroma compounds** caused by pests and diseases



**The gap** between industrial- and farm-scale production



**Research Team:** Ryan Elias, Helene Hopfer, Greg Ziegler, and Conor McCaney

**Grant:** Effect of maceration parameters on white wine quality made from interspecific hybrid grapes (*Vitis* spp.)

*Pennsylvania Wine Marketing and Research Board Research Program (2017–18)*

**Partner:** Happy Valley Vineyard & Winery

## Novel techniques help to **improve quality** of Pennsylvania wines

**Problem:** Could Pennsylvania winemakers coax more interesting flavors out of hybrid grape varieties in order to produce higher-quality hybrid wines?

- French-American hybrid grape varieties are of particular interest to the Pennsylvania wine industry, as they are extremely productive and disease resistant yet in many cases lack complex and interesting flavors.
- Pennsylvania winemakers rely heavily on hybrid wine grapes and are constantly searching for ways to increase the quality and economic value of hybrid wines.

**Findings:** Food scientists studied and compared three different methods of maceration in the winemaking process—rapid-rate cryogenic maceration, slow-rate cryogenic maceration, and short-duration cold soaking—to test which process best extracted the beneficial chemical constituents in the grape and skin of hybrid varieties and to produce the desirable traits associated with the more common European varieties.

**Impact:** The results of the various tests conducted by the researchers provides Pennsylvania winemakers with detailed flavor and aroma profiles that can be achieved by different maceration processes from the hybrid grapes.

- Growers and winemakers alike will be able to make more informed decisions on which varieties produce the desired profile they seek in order to create a more competitive wine.

## Building consumer appeal for new wine varieties in Pennsylvania

**Problem:** How can Pennsylvania grape growers and winemakers build in market growth as consumer preferences are likely to change with new generations of wine drinkers?

- Although the Baby Boomer generation (born 1946–1964) accounts for the largest proportion of wine sales in the past 20 years, that number is expected to decline over the next few years.
- The Millennial generation (born 1981–1997) is expected to surpass both Baby Boomer and Generation X in wine consumption by 2026.

**Findings:** An interdisciplinary team investigated the potential for Grüner Veltliner to become a high-quality signature wine variety that can be successfully grown in Pennsylvania's climate and appeal to younger generations with more adventurous flavor palates.

**Impact:** These investigations are at the forefront of research on this variety in the United States and provide industry with informed guidance on producing new wines.

- Growers and winemakers can improve their promotional strategies to appeal to wine consumers and implement best practices for introducing Grüner Veltliner to tasting room visitors not familiar with the variety.
- The project is a model for future research that may focus on European and hybrid varieties that are relatively unknown to wine consumers but have the potential to produce other high-quality wines.



**Research Team:** Michela Centinari, Ryan Elias, Bryan Hed, Helene Hopfer, Kathleen Kelley, Stephanie Keller, and Andrew Harner

**Grant:** Defining regional typicity of Grüner Veltliner wines

*Pennsylvania Wine Marketing and Research Board Research Program (2018–19)*

**Partners:** Galen Glen Winery, Stony Run Winery, Stargazers Vineyard LLC, Dickerson Vineyards, Fero Vineyards and Winery, Moorhead Farms, Nimble Hill Vineyards and Winery, Rassie Farms, and Lake Erie Regional Grape Research and Extension Center



**Research Team:** Helene Hopfer, Marielle Donohue, Denise Gardner, Tiffany Murray, and Gloria Wang

**Grants:** Sensory characterization of Riesling wines from different Pennsylvania regions with a trained panel and winemakers

Do Pennsylvanian Riesling and Vidal Blanc wines differ in their sensory properties across different regions?

*Pennsylvania Wine Marketing and Research Board Research Program (2017–18, 2018–20)*

**Partners:** Galer Estate Vineyard & Winery, Armstrong Valley Vineyard & Winery, and Happy Valley Vineyard & Winery

## Identifying **distinct regional fingerprints** to market Pennsylvania white wines

**Problem:** How can Pennsylvania winemakers enhance the reputation of their product and establish the state as a premium East Coast wine region?

- Distinguishable regional differences in wines are an important concept for “Old World” wines grown in “premier” regions and are also a factor that consumers strongly consider when deciding to buy a wine.
- Riesling and Vidal Blanc varieties are widely grown in Pennsylvania with only anecdotal evidence of the unique flavor profiles that are specific to the different growing regions within the state.

**Findings:** In a two-year study, a team of sensory scientists established that Riesling and Vidal Blanc wines differ significantly across Pennsylvania regions in their sensory properties, creating distinct regional fingerprints.

- They conducted a wine sensory analysis with a trained sensory panel and then performed basic wine chemical measurements to define the differences.

**Impact:** In identifying the unique qualities of the wines from different growing regions of Pennsylvania, this research provides science-based information that can be used to promote the diversity of flavors afforded by the state’s varying landscapes and climates.

- This information is invaluable for the establishment of regional- and cultivar-specific marketing strategies that support and bolster the state’s wine economy and a broader appreciation of wine by enhancing consumers’ and tourists’ knowledge of regional specificity.

# THE IMPACT

## Disease and pest research protects profits and makes a safer product

Pennsylvania's hot summers, humid climate, and cold winters do not easily accommodate popular wine grape varieties grown in warmer, dryer parts of the world such as California and Australia. Fungal and bacterial diseases proliferate in the wetter climates of the northeastern United States, and the proximity to international ports of entry make regional vineyards susceptible to the introduction of invasive species. The European varieties used to produce some of the more popular wines are especially vulnerable to these pressures, making an integrated disease management plan essential but also a challenge for Pennsylvania growers.

Plant pathologists and entomologists test new techniques of insect and disease management and the efficacy of existing pesticides. Their coordinated efforts and collaborations with plant, sensory, and food scientists produce recommendations that help growers:

- Be more knowledgeable, proactive, and effective in **controlling the spread** of diseases and insects
- Produce higher yields and better-quality grapes that will **generate more income**
- Adopt alternative, sustainable solutions that **require fewer chemical inputs**
- **Ensure minimal impact** of pest and disease management strategies on wine quality

## PLANT PATHOLOGISTS AND ENTOMOLOGISTS INVESTIGATE AND HELP TO MANAGE:



**Grape diseases** such as powdery and downy mildew, black rot, Phomopsis cane and leaf spot, bunch/sour rot, and grapevine leafroll virus



**Grape insect pests** like grape berry moth, Japanese beetle, plant bugs, and rose chafer



**Invasive species** such as spotted lanternfly and spotted wing drosophila



**Research Team:** Bryan Hed and Michela Centinari

**Grant:** The mechanization of early leaf removal for enhanced adoption into bunch rot control programs in Pennsylvania

*Pennsylvania Wine Marketing and Research Board Research Program (2016–17, 2017–18)*

**Partner:** Lake Erie Regional Grape Research and Extension Center

## Mechanizing early leaf removal for **sustainable prevention** of bunch rot

**Problem:** Can practices that reduce pesticide applications also be cost-effective and practical for growers?

- Pesticides to treat bunch rot, a common disease affecting vineyards around the world, especially in wetter climates, are prone to developing resistance.
- Early leaf removal improves air circulation, sunlight exposure, and pesticide penetration, which helps to reduce fruit susceptibility to bunch rot but requires expensive and scarce hand labor.

**Findings:** Plant pathologists and plant scientists tested air-pulse leaf removal technology to mechanize the removal of the vines' leaves around the fruit, comparing the method against manual removal of the leaves along with the timing of their removal. The team analyzed the impact on bunch rot development, cluster morphology, yield parameters, and fruit composition across different wine grape varieties, finding that the mechanized removal was a viable alternative to manual removal.

**Impact:** As a part of an integrated program for maximum rot control, the mechanization of prebloom leaf removal can help Pennsylvania growers reduce their reliance on pesticide inputs, delay eventual resistance, and improve harvest bunch rot control.

- Using fewer inputs will improve the industry's profile on environmental sustainability and help delay the onset of resistance to essential pesticides without sacrificing bunch rot control.

## Safely and effectively combating the invasive **spotted wing drosophila**

**Problem:** How can the cost, health hazards, and workload be reduced for growers battling against the invasive spotted wing drosophila?

- Since 2011, the spotted wing drosophila has posed significant damage to Pennsylvania vineyards by laying their eggs in the fruit and introducing diseases, such as sour rot and fungal disease.
- Insecticide labels recommend application frequency without indication of how long the sprays are effective or when it is best to apply them.

**Findings:** Over two years, the team tested five commonly used insecticides to determine the efficacy of the residual compounds from the spray against spotted wing drosophila. They then measured the toxicity of the residual concentrations in the grapes that were sprayed. These results were then compared with stated results of the insecticide labels and existing pest management guidelines.

**Impact:** Growers can use this research to determine best practices for the most efficient and safest rate of application of insecticides to protect their vineyards from the damage caused by this insect.

- By knowing the efficacy rate of the various insecticides, they can prevent overexposure of the chemicals to workers and the environment.



**Research Team:** Samuel Nutile, Adam Simpson, Jody Timer, and Andrew Muza

**Grant:** Residual decline and efficacy of commonly used insecticides against spotted wing drosophila in Pennsylvania wine grapes

*Pennsylvania Wine Marketing and Research Board Research Program (2017–18, 2018–20)*

**Partner:** Lake Erie Regional Grape Research and Extension Center





**Research Team:** Molly Kelly, Michela Centinari, Julie Urban, Jared Ali, and Erica Smyers

**Grant:** Impact of spotted lanternfly on quality of Pennsylvania wines

*Pennsylvania Wine Marketing and Research Board Research Program (2018–20)*

## Protecting Pennsylvania's wine grapes against **spotted lanternfly**

**Problem:** How can growers and winemakers prepare for potential harmful effects of the invasive spotted lanternfly?

- The spotted lanternfly indiscriminately feeds on the plant sap of more than 70 species of plants, including grapevines, and has already caused significant losses in grape yield and fruit quality since it first appeared in Pennsylvania in 2014.
- Spotted lanternfly may produce an alkaloid chemical compound and secretes a sugary excrement or honeydew that can weaken the plant, both of which may have a negative sensory impact in the wine produced from infested vineyards.

**Findings:** Extension enologists, plant scientists, and entomologists studied the chemical parameters impacting the toxicity and wine quality in grape products contaminated with spotted lanternflies.

- Increasing amounts of the insects were added to red and white wines produced at a small scale, similar to what may be found under routine winemaking conditions with fruit from infested vineyards.
- The scientists compared this contaminated product with wine produced from healthy fruit that showed no spotted lanternfly presence.

**Impact:** The results of the research provide Pennsylvania winemakers with research-based recommendations on appropriate measures for handling infested vineyards and with information about the safety of their wine and acceptable spotted lanternfly levels at harvest.

## Providing **long-term contributions** to industry through research and education

The research conducted by the Penn State Wine and Grape Team contributes a significant resource to the industry by training the next generation of qualified personnel to extend their experiences and the knowledge they gain through their education to become the future of the wine and grape industry in Pennsylvania and the nation. These interdisciplinary projects provide for the students:

- Hands-on experiences that uncover the impact of their research along every step of the supply chain
- Close research collaborations with industry growers and winemakers that offer networking opportunities to learn about the wine industry
- Presentation opportunities at public programming events
- Active participation as undergraduates in research projects that introduce potential careers in wine and provide a unique experience to work in vineyards

A number of students have leveraged their educational experiences with the Wine and Grape Team to become leaders in the wine industry, occupying positions as owners, executives, winemakers, research scientists, and extension educators.



### **Penn State Wine and Grape Team Alumni Career Placements**

- Biltmore Co.
- Constellation Brands
- Denise Gardner Winemaking
- Doumi Wine Co.
- E&J Gallo Winery
- Galer Estate
- Happy Valley Vineyard & Winery
- Johnson Estate Winery, LLC
- Mazza Vineyards
- Naked Mountain Vineyard and Winery
- Ohio State University
- Robertet Group
- Steven Bahn Winery
- University of Minnesota





**PennState**  
College of Agricultural Sciences

Office for Research and Graduate Education  
College of Agricultural Sciences  
The Pennsylvania State University

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