NYWGF RESEARCH - FINAL REPORT

Funding for fiscal year: April 1, 2024– March 31, 2025 (extended to June 30, 2025)

SECTION 1:

Project title: Survey of downy mildew fungicide resistance in the Lake Erie region of New York

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New Research ☒ **Continued Research** ☐

Amount Funded **$** 18,198

SECTION 2:

Project Summary Impact Statement: Downy mildew, caused by the pathogen, *Plasmopara viticola*, is a serious threat to commercial grape production in the Lake Erie grape growing region of New York, requiring regular applications of fungicides every year. The intensive reliance on fungicides for commercial control of this disease inevitably leads to the development of fungicide resistance in *P. viticola*, to single site inhibitors like the quinone outside inhibitors (QoIs/Abound), carboxylic acid amides (CAAs/Revus), phenylamides (PAs/Ridomil Gold), and phosphorous acid/phosphite fungicides. In this study, the authors have detected considerable downy mildew resistance to multiple fungicides in vineyards in western New York. These results aided research and extension staff in making important adjustments to management practices for grape growers, in order to minimize crop loss, avoid ineffective sprays, and maintain the competitiveness of New York growers, by sustaining maximum commercial production at minimum cost.

Fungicide applications for downy mildew are essential to the sustainable production of wine and juice grapes in the Lake Erie region of New York. Due to the loss of Ziram and possibly other "old standard" fungicides (like mancozeb and captan) that are currently relied upon for downy mildew control, fungicide resistance to the single site inhibitor fungicides will have serious additional consequences for the sustainability of the grape industry in the Lake Erie region. New single site

fungicides are rarely released, making preserving existing fungicides from resistance a top priority. This project's documented resistance to downy mildew fungicide active ingredients mandipropamid (CAAs), azoxystrobin (QoI; strobilurins), and the phosphorous acid fungicides, in vineyards in western New York is crucial information for growers to be able to effectively protect their grapes from downy mildew as well as preserve remaining fungicides from resistance development. This project's updated fungicide resistance profiles inform New York growers in how to adjust their spray programs to better manage this disease and sustain New York grape production in the Lake Erie region. In addition, the fungicide resistance information from this project is critical to inform regulation changes to fungicides under re-registration review particularly Mancozeb.

Objectives: This project will address the industry priority: Disease & Pest management: Develop effective, efficient and sustainable disease and pest management materials and techniques that minimize development of resistance and provide resilience to climate change.

Objective 1: Collect isolates of the downy mildew pathogen, *Plasmopara viticola* from commercial vineyards in New York: During the 2024 growing season, Penn State research and extension staff with the help from grower cooperators sampled leaves infected with downy mildew, from susceptible wine and juice vineyards along the Lake Erie grape belt in western New York.

Objective 2: Determine the frequency of resistance in samples of *P. viticola* to various chemical classes of fungicides for downy mildew, using a previously tested laboratory bioassay. Sporangia from downy mildew infected leaves collected from commercial vineyards, were inoculated on to healthy leaves (from potted greenhouse grown Chardonnay) that have been treated with various fungicides and observed for growth and sporulation. Resistance was assessed by the presence/absence of fresh sporulation on treated leaves.

Objective 3: Characterize resistance-conferring mutations in resistant phenotypes of the pathogen. Specific target genes of *P.viticola* resistant to CAA fungicides were amplified and sequenced from *P. viticola isolates* of interest to identify potential mutations conferring resistance in resistant isolates in comparison with sensitive isolates.

Objective 4: Utilize results of the bioassay and DNA isolation/amplification/identification to adjust and improve fungicide programs. These results were and continue to be used to advise growers of needed adjustments to fungicide programs for downy mildew, in order to prevent crop loss and manage resistance to fungicides in the future.

Materials & Methods: Objectives 1 and 2: Collect isolates of the downy mildew pathogen, *Plasmopara viticola* from commercial vineyards in New York and determine the frequency of resistance in isolates of *P. viticola* to various chemical classes of fungicides for downy mildew. Penn State research and extension staff with the help from grower cooperators sampled leaves infected with downy mildew (at least 10 infected leaves per variety/block), from susceptible wine and juice

vineyards along the Lake Erie grape belt in New York. Samples were taken from 14 sites throughout New York (Chautauqua, Niagara, and Ontario Counties), and included 12 different cultivars for a total of 169 samples. Cultivars sampled were mostly vinifera from wine grape vineyards. There were a few samples from Niagara juice grapes, but none from Concord vineyards due to very low levels of infection in Concord vineyards.

Each infected leaf per plant was collected into a separate plastic Ziploc bag, labelled with collection site and cultivar and stored in an icebox for transport to the Penn State lab in North East, PA. Spray records for vines from which samples were collected were obtained from participating growers, if possible. Once in the lab, collected leaves were rinsed with water to remove old sporulation, transferred to individual Ziploc bags containing moist paper towels, and incubated overnight at about 70°F, to obtain fresh sporulation for the bioassay the following day. The following morning, fresh sporangia were removed from leaves by flooding leaves with water and sucking released spores from the leaf with a pipette. Spore solutions of each leaf sample were adjusted to a spore concentration of about 10^5 spores per ml and inoculated onto fresh, healthy leaves of Chardonnay vines (grown in the greenhouse) that have been coated with either Revus, Abound, Reliant, Ridomil, or water (check) and placed upside down in petri plates of water agar. Spores were distributed onto leaves in 10 microliter drops, five isolates per leaf, with 3 replications of each leaf. Plates are sealed with parafilm and incubated under lights providing a 12:12 light/dark cycle. Sporulation of the pathogen was rated after 7 and 14 days. Resistance was assessed by the presence/absence of fresh sporulation on fungicide treated leaves, in comparison to the water check (no fungicides). From the bioassay results, the frequency of resistance in samples of *P. viticola* to various chemical classes of fungicides for downy mildew was calculated.

Objective 3: Characterize resistance-conferring mutations in resistant phenotypes of the pathogen. In Dr. Campbell's lab at Penn State Behrend, a student amplified and sequenced specific target genes from *P. viticola* samples to identify potential mutations conferring resistance to fungicides. This was done for CAA fungicides for which the specific mutations are already known (Baudoin et al., 2008; Gisi et al. 2007). Sporangia of *P. viticola* samples in question were lyophilized, and the DNA was extracted for PCR amplification and sequencing of target genes (Campbell et al., 2020).

Objective 4: Use results to adjust and improve fungicide programs. Cooperating growers were advised of any specific resistance issues that existed in their vineyard blocks and how best to deal with them. On a broader scale, the results were and continue to be used to advise the industry in western New York of any needed adjustments to fungicide programs for downy mildew, in order to prevent crop loss and manage resistance to fungicides in the future. This included notices to growers and industry representatives of the resistance results and recommendations at coffee pot meetings, crop updates, processor representative meetings, the annual growers conference and discussed in the 2025 New York and Pennsylvania Pest Management Guidelines for Grapes. Resistance results were also shared with the EPA in regard to the re-registration of Mancozeb, providing an up-to-date profile of single site fungicide resistance in the Lake Erie region of New York.

Results/Outcomes/Next Steps:

Resistance to commonly used downy mildew fungicides had not previously been thoroughly investigated in New York vineyards of the Lake Erie region. This project was able to quantify downy mildew resistance to commonly used single site inhibitor type fungicides including QoIs, CAAs, PAs, and phosphorous acids. In New York, only 3% of samples showed no resistance to any fungicide tested. No sample showed resistance to mefenoxam (Ridomil, FRAC 4). 95% of samples showed resistance to phosphorus acid and salts (Reliant, FRAC P07). 82% of samples showed resistance to strobilurins (Abound, FRAC 11). 46% of samples showed resistance to mandipropamid (Revus, FRAC 40) (Chart 1). Since, no samples were collected from Concord vineyards, we cannot determine at this time, if there is or is not *P. viticola* fungicide resistance in Concord vineyards, which make up 80% of the grape acreage in the Lake Erie grape growing region of New York.

These high levels of resistance to 3 of the 4 fungicides tested revealed that multi-chemistry resistance is also high. 48% of samples displayed resistance to 2 fungicides and 24% to 3 fungicides. These high levels of resistance to 3 of the 4 fungicides surveyed demonstrate the need for growers to adjust their spray programs to avoid potential devasting crop loss and to preserve remaining single site fungicides for as long as possible by implementing resistance mitigation practices.

The results of this survey and recommendation to growers regarding how to effectively manage downy mildew as well as downy mildew fungicide resistance have been presented to, and discussed with, extension and research colleagues at Penn State and Cornell Universities, growers and industry representatives at extension based/grower meetings (coffee pot meetings, processor rep meetings, field days, extension meetings, annual grape growers conference), newsletters, and the 2025 New York and Pennsylvania Pest Management Guidelines for Grapes. These results have also been shared with the EPA regarding the re-registration of Mancozeb. These results will continue to be shared with growers and industry partners at future opportunities.

Technology Transfer Plan:

These results and the recommendations to growers on how to effectively manage downy mildew as well as fungicide resistance have led to revisions in the 2025 New York and Pennsylvania Pest Management Guidelines for Grapes. They will continue to be shared at extension based/grower and industry meetings (coffee pot meetings, processor rep meetings, field days, extension meetings, annual grape growers conference) and newsletters.

Attachments:

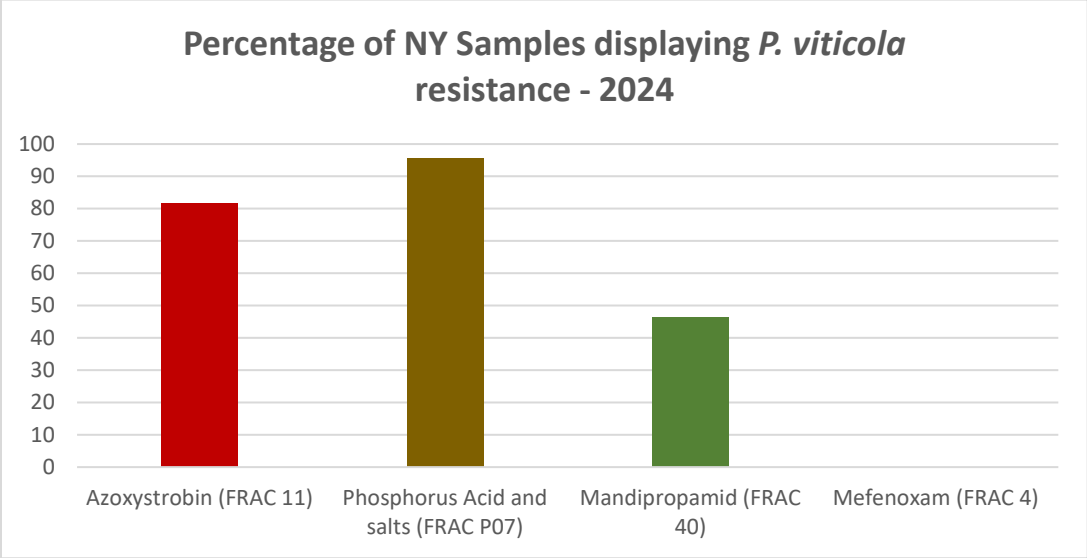


Chart 1.
This chart shows the percentage of samples collected that display *P. viticola* resistance to each fungicide.

SECTION 3: (The goal of this research is to benefit growers and producers across New York State. Result summaries will be shared on the NYWGF website and via email newsletters. To that end, this section should be brief and written in terms understandable for the average grower and producer, as well as consumers and trade interested in our industry.)

Project summary and objectives: (5 Sentence Max)
Downy mildew, caused by the pathogen, *Plasmopara viticola*, is a serious threat to commercial grape production in the Lake Erie grape growing region of New York, requiring regular applications of fungicides every year. The intensive reliance on fungicides for commercial control of this disease inevitably leads to the development of fungicide resistance in *P. viticola*, to single site inhibitors like the quinone outside inhibitors (QoIs/Abound), carboxylic acid amides (CAAs/Revus), phenylamides (PAs/Ridomil Gold), and phosphorous acid/phosphite fungicides. In this study, the authors have detected considerable downy mildew resistance to multiple fungicides in vineyards in western New York. These results have aided research and extension staff in making important adjustments for grape growers, in order to minimize crop loss, avoid ineffective sprays, and maintain the competitiveness of New York growers, by sustaining maximum commercial production at minimum cost.

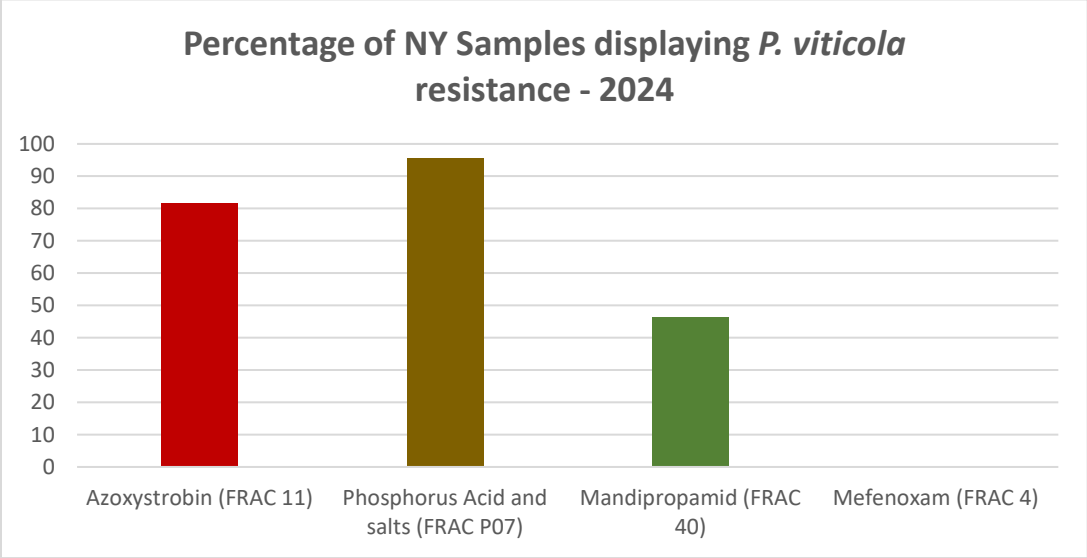
Importance of research to the NY wine industry: (5 Sentence Max)
This project's documented resistance to downy mildew fungicide active ingredients mandipropamid (CAAs), azoxystrobin (QoI; strobilurins), and the phosphorous acid fungicides, in vineyards in western New York is crucial information for growers to be able to effectively protect their grapes from downy mildew as well as preserve remaining fungicides from resistance development. This project's updated fungicide resistance profiles inform New York growers in how to adjust their spray programs to better manage this disease and sustain New York grape production in the Lake Erie

region. In addition, the fungicide resistance information from this project is critical to inform regulation changes to fungicides under re-registration review particularly Mancozeb.

Project Results/next steps:

This project was able to quantify downy mildew resistance to commonly used single site inhibitor fungicides including QoIs, CAAs, PAs, and phosphorous acids. In New York, only 3% of samples showed no resistance to any fungicide tested. No sample showed resistance to mefenoxam (Ridomil, FRAC 4). 95% of samples showed resistance to phosphorus acid and salts (Reliant, FRAC P07). 82% of samples showed resistance to strobilurins (Abound, FRAC 11). 46% of samples showed resistance to mandipropamid (Revus, FRAC 40) (Chart 1). These high levels of resistance to 3 of the 4 fungicides surveyed demonstrate the need for growers to adjust their spray programs to avoid potential devasting crop loss and to preserve remaining single site fungicides for as long as possible by implementing resistance mitigation practices. These recommendations can be found in the 2025 New York and Pennsylvania Pest Management Guidelines for Grapes.

Supporting attachments: (Choose a maximum of 1 supporting figure or table to demonstrate results if desired)



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