# Improving Confidence and Understanding of Fungicide Program Design in USA Grape Growers Through Peer-Interactive Extension Programming

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## 1 Introduction

Fundamental to the practical success of grape disease research, whether on the biology of the pathogen, response of the host, or the application of epidemiological principles to the development of disease forecast systems, is the validation that an improvement in the system is achieved. This is typically done through metrics such as reduced instances of disease-induced crop loss, or a reduction in total pesticides used. These metrics are typically related to a change in behaviour, but they are not necessarily indicative that long-term knowledge gains have been made. Are these changes in behaviour a result of short-term reaction to a situation? Or are they a fundamental shift in baseline knowledge? If it is the former, then education and extension can suffer future setbacks, as information is forgotten and new industry members are unaware of resources available and susceptible to repeating past mistakes. What approaches should we take to ensure changes are a result of the latter situation – where the knowledge baseline has improved, and people have learned to help themselves?

Presented here is the framework of an extension curriculum designed to address the fundamental basics needed to design spray programs in viticulture. Designed to be adaptable to different regions or skill levels, this curriculum teaches participants what types of information they need to make informed product, and approach, choices.

## 2 Program background

The curriculum presented here was originally developed as a hands-on activity for those students completing an 18-month online-focused certificate in Viticulture through Washington State University (https://wine.wsu.edu/education/certificate/). Inclusive in this program are three in-person events where participants complete viticulture-relevant training activities to complement their online education.

While older training models in this program followed the traditional extension approach of simply listing different fungicides and the diseases they targeted, the new curriculum was designed to test's the participants abilities to recall the information they learned about disease epidemiology and apply it to the fundamentals of a chemical management program. Students were split into groups, all assigned the same potential vineyard scenario (with known weather events, given the beginning level of the participants), and asked to design a spray program with a limited number of fungicides (labels were provided). They then "defended" their program, and feedback on program design approach was provided by the instructor and fellow classmates. The feedback focused on concepts related to periods of peak host susceptibility to the target disease(s), influence of different weather patterns on the pathogen's ability to reproduce and spread, and whether selected fungicide intervals and rates were appropriate for the disease and the indicated weather conditions. It was also an opportunity to talk about what appropriate (and inappropriate) tank mixing was, and whether some products had expressed "warnings" on the label about product, weather, or host plant incompatibilities.

This curriculum has since undergone multiple iterations based on participant feedback, and training needs. Below is the current structure of the program, along with why that structure has been adopted, and ways the curriculum can be adapted to different audiences.

## 3 Core educational tools / modules

When solving a complex problem, such as the design of a pest management program, implicit knowledge if commonly used. Implicit knowledge is fundamental to many agricultural practices, but it does not mean that this knowledge base cannot be improved through supplemental explicit knowledge acquisition. This is where attendance at educational events (seminars, workshops) can be beneficial. However, to optimize the application of implicit and explicit knowledge to solve a problem, it is best to introduce the explicit knowledge (i.e., "the lecture") early in the activity, so that it can be integrated with the explicit knowledge base of the learner (Reber, 1989).

For this curriculum, the core educational tools can vary based on the participant needs.

*Beginners / new growers:* When focusing the curriculum on new growers (beginners), we tend to present information on sprayer calibration and optimization, understanding how fungicides work, and pathogen biology (usually limited to 1 pathogen).

*Experienced growers:* When participants are more experienced, we also introduce concepts related to fungicide resistance management, and introduce 1 to 2 more diseases for consideration.

*Crop consultants:* We typically provide the same core modules here as experienced growers, but will also place more emphasis on fungicide resistance management, and sprayer operation.

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The core educational modules can be presented prior to the group work (outlined below) via a digital platform, or at the beginning of the workshop for in-person events. Core modules are typically 30 to 45 minutes in length, so it is important to be selective with what is presented so as to not create an excessively long training program
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**4 Group work and peer evaluation**

What makes this program memorable, and valuable for participants is the group work and peer-evaluation of that work. This "peer-evaluation" is well documented as a primary driver for information sharing and knowledge acquisition among adult learners, particularly those learners in agriculture (Cofer, 2000; Franz *et al.,* 2010; Hoffman *et al.*, 2015; Omhart, 2008). Participants have to work together to identify key biological components to their assigned vineyard and pathogen system, read through fungicide labels to determine appropriate rates and intervals, and then negotiate with each other on how to best time those products. In doing such they learn how to apply scientific information and articulate their reasoning for that information application.

Figure 1: This curriculum relies on peer-learning. By working with each other, participants experience first-hand how information can be applied in different ways; but it can also require some minor intervention from the instructor, in case inaccurate information is shared within a group.

*Assigning participants to a group.* When assigning participants to different groups, consider participant skill levels (if known), personality types, and places of employment. This information can be used to develop complementary groups that can provide both a challenging, and new environment, to test participant's knowledge.

*Clear instructions help guide group actions.* It is important to provide both written and verbal instructions with group work. Let them know what your expectations are – to see a spray program specific to their assigned vineyard that only uses the fungicides you have provided. Let them know if you expect them to include information such as application rates, intervals, or FRAC code indication when presenting their spray programs. Indicate if you would like them to include additional information such as the timing of cultural practices or other vineyard activities.

*Interact with groups during the activity.* As a program instructor, the group work is also a chance to interact with each group, to see how they are processing the available information, and what they are discussing amongst themselves. This information can be used to help formulate key topic areas for when you provide program review. The information is also informative in that it highlights knowledge gaps that could be covered through additional research, extension programming, or included in future delivery of this curriculum for a regionally-tailored experience.

**5 Fundamentals for program customization and adaptation to new regions**

For every individual vineyard in the world, there should be a site-specific spray program. As an educator, you will never be able to cover all potential scenarios that specifically fit the needs of every possible participant. However, there are approaches you can take to make the activity feel customized and approachable.

Outlined below are tips for using this curriculum approach effectively, and ways to best tailor it to the participants or targeted audience.

*Tip 1 - Start simple. Stay focused.* One of the earliest challenges with designing this curriculum was the need to balance realistic expectations (i.e., a season-long, full-spectrum management program), and what is practically achievable in a short workshop setting (i.e., a season-long, single focus / disease management program). You will have limited time, and limited knowledge of the skill level of your participants. Starting simple, such as designing a spray program for only 1 disease, is recommended. If participants can build a program for one disease, they can then apply those principles to build a program for other diseases. You can even do this in a three-part training program, where disease #1 is the focus of the first day, disease #2 is the focus on the second day, and the third day is dedicated to combing those two different programs into one program, while practicing the concepts learned in the curriculum. As scientists, we often emphasize learning of the pathogen or the system, but here, the focus is on learning the process of decision making.

*Tip 2 - Limit fungicide choices.* There are hundreds of potential fungicide options that can be considered when designing a spray program. While the challenge of choice occurs in the real world, that challenge can overly-complicate and detract from the intent of an educational activity. For these activities, we limit fungicide choice to approximately 20 product labels, that emphasize concepts that are the primary focus for that particular workshop focus. Fungicide choices should also be reflective of products relative to the region and diseases the activity is addressing. Example fungicide collections are highlighted in Table 1.

In addition to providing a limited list of fungicide choices, it is also important to not assume that all participants understand how to read a pesticide label and interpret the

information that is presented in them. In many modern viticulture production systems, vineyard owners or spray applicators are not the individuals writing the spray programs – they are often either accepting a program written for them by a private company, or they are following application information provided to them from another individual in the organization. This is a great opportunity to ensure this very basic educational need is met. For more advanced groups, additional discussions can be had on how to interpret information on labels, such as different product rates for different diseases, why spray intervals are listed as a range, and what the difference is between words such as "control" and "suppression". You can also focus on where to find information related to activity (contact, systemic), and resistance risk. There are numerous University and other government resources that offer training and information on how to read a pesticide label. It is helpful to provide this information to participants prior to the activity. We also recommend providing a worksheet for participants to copy key label information over for easier-access during the actual event. This reduces the need to constantly reference a fungicide label. They may also use it as a template for record organization on-farm.

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| **Washington, Fungicide Resistance Management (beginner), Powdery Mildew only:** Actinovate AG, Aprovia, Double Nickel 55, Dusting Sulfur, Flint Extra, Inspire Super, JMS Stylet oil, Kaligreen, Luna Experience, M Pede, Mettle, Microthiol Disperss, Pristine, Procure, Quadris Top, Quintec, Regalia 5%, Serenade Opti, Torino SC, Vivando 2.5F |
| **Minnesota / Wisconsin / Michigan, Fungicide Resistance Management, Powdery Mildew and Downy Mildew:** Aliette WDG, Aprovia, Double Nickel 55, Flint Extra, Inspire Super, JMS Stylet Oil, Luna Experience, Pristine, Procure 480 SC, Quadris Top, Quintec, Ranman 400 SC, Reason 500 SC, Revus Top, Ridomil Gold MZ, Sovran, Sulfur - Microthiol Disperss, Tanos, Torino SC, Vivando 2.5F |
| **Washington, Organic emphasis, Powdery Mildew and Botrytis Bunch Rot:** Double Nickel 55, Flint Extra, Gatten, Inspire Super, JMS Stylet Oil, Kaligreen, Luna Sensation, Merivon Xemium, M Pede, Pristine, Procure 480SC, Quadris Top, Quintec, Regalia, Romeo, Serenade Opti, Sovran, Sulfur - Microthiol Disperss, Torino SC, Vivando 2.5F |

Table 1: Example fungicide collections, based on scenario region, focus (disease management of fungicide resistance mitigation), and target disease. Trade names are listed (United States). Products listed are for example purposes only, and do not indicate product endorsement. Labels are available at: http://www.cdms.net/Label-Database

*Tip 3 - Vineyard scenarios should be as realistic as possible.* While the workshop learning environment has a high level of control, it is very important that the given vineyard scenarios are reflective of reality. As such, real-world environmental trends should be used (typically sourced from local weather networks), along with regionally-relevant viticulture information, such as typical vineyard size, average dates for key phenological stages of vine development, specific varieties grown, and common regional cultural practices. Even more important, particularly for curricula designed for a more advanced group, is to include appropriate spraying information, which could include water volume delivered, sprayer manufacturer, and nozzle type (when necessary).

For more experienced participants, or for crop consultants, you might wish to have them evaluate existing spray programs that failed to provide disease control. For many individuals, this is what they spend time doing in their job. Identifying potential weak points in another person's program forces the participants to really think about which spray program components are important, and which are more flexible to a given location (or design style). We still include a basic vineyard scenario, but we also provide them with the example spray program, associated fungicide labels, and images of water-sensitive paper (spray coverage) from different points in the season. The participants are asked to use that information or ask the moderator additional "vineyard questions" to help them draw a conclusion as to what may have gone wrong over the growing season.

*Tip 4 - Give people enough time to complete the group work.* Group work will inherently require a "warm-up" period as participants learn and negotiate working with each other. It is important to allocate sufficient group work time. We have found that group work typically requires 1.5 to 2 hours. Some groups may never fully finish the activity in the allotted time, but interest tends to decline after 2 hours of working. When the group work time is too short, participants tend to feel rushed, and may never get into the purpose of the group work: to discuss strategies and approaches and challenge each other as to why those approaches are chosen.

One approach to help keep the group work on time and focused is to assign a "moderator" for the group. This moderator can take notes on the spray program for the participants and can help stimulation or guide discussion if needed. However, they should not actively participate in the final decision making. Engaging regional experts for this role is exceptionally helpful and rewarding for both the expert and the participants. Examples of a "regional expert" includes: university extension faculty, research faculty, advanced graduate students, or respected industry members. Pre-activity training may be needed to ensure the moderator understands the goals of the activity, and their role in facilitation, not participation.

*Tip 5 - Spray program reviews should focus on the process – there is no real "best" spray program!* While there will be some spray programs that will clearly result in disease control failure, as a program, it is still a valuable learning tool for this curriculum. If only good programs are presented, participants will never learn why a program might fail. Treat every program review as an opportunity to highlight good practices, and to discuss practices that could be improved. It is also important to remember that outside of the scientific community, the practice "peer-review" (public evaluation) is not common, and might be very uncomfortable for some participants, but it's also very helpful to the learning process. Program instructors should take the effort to focus evaluation language on successes and *opportunities for improvements* of

the design approach of a team, rather than successes and *failures*.

*Tip 6 - You evaluate their programs, they should evaluate your curriculum.* Most academic efforts will require some form of institutional documentation that those efforts were of value. This can be done through documenting the participant's change in knowledge or confidence in the area of grape pest management program design. This documentation can come through a series of pre and post-activity survey questions designed to gauge their perceived gains in understanding concepts, or their general confidence in performing certain tasks or jobs. The idea of "impact" is also favoured by many administrative units. While true impact likely takes decades to achieve, for impact to start, a participant must change a behaviour. Thus, asking participants if they plan on changing a practice on their farm, or applying what they learned from the activity to their professional work, can be used to form baseline impact statements. Combined, these two forms of survey questions can be used to create statements such as "100% of participants indicated improved confidence in reading fungicide labels, and 80% indicated they will review FRAC codes when designing a fungicide program."

While every one of our delivered spray program curriculums had different target audience focus and approach, we have always found over 90% of participants indicating they feel their knowledge of the principles behind developing spray programs that focus on pathogen biology has improved. When workshops are in-person, we get 100% survey response rate (without incentive to turn in surveys), which is typically indicative of participants efforts to document their enjoyment of such activity. Additional select qualitative feedback on what participants have learned, and they plan on changing on their farm, is presented in Table 2. These are direct quotes from surveys completed at the end of several recent activities.

## 6 Conclusions

In 2021, Oliver *et al*. surveyed United States grape growers to determine their knowledge base on principles and practices related to fungicide stewardship (i.e., resistance management). Through this self-assessment of their knowledge, as determined by several question sets that asked participants to rank the importance of a practice in fungicide resistance management, they found that many growers were able to identify important practices related to resistance management. But *identifying* practices, and actually *doing* those practices, are two different things. Developing, and delivering this activity across the US in 2019-2022 (in person, and virtually), is a part of a national educational effort to teach the *how* of implementing fungicide stewardship practices in spray program design. A follow-up survey to Oliver *et al.* (2021), is intended to see if these types of educational efforts have resulted in a change in how growers think about fungicide stewardship and implement fungicide stewardship practices.

| **What they learned** | **What they will change** |
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| "I learned how hard it is to create a fungicide spray program"<br>"To never use fungicides with same group number back to back"<br>"What fungicide rates (max, min) mean"<br>"People from different regions have different practices"<br>"What other's thought processes are"<br>"Restricting, as opposed to limiting 3 & 11 will put pressure on novel synthetics"<br>"Use more than 50 gal/acre and the ease of using spray coverage tests"<br>"Better understanding of FRAC resistance"<br>"Today I learned more about where to start on a spray program, how to organize and apply it"<br>"It's okay to take sprays out!" [*In response to changing a preplanned program in response to unfavorable weather conditions for disease in the growing season*]<br>"Learned about the various factors to take into consideration when designing a spray program"<br>"Learned that I am probably over-spraying!" | "Making sure timing of fungicide application and correct product use is more of a focus"<br>"Using sulfur and oils early in the season"<br>"Develop a spray program by starting at the most critical times [for disease control] first."<br>"Consider pulling 3 & 11 for one-year break."<br>[Winemaker]: "I will become more involved with the vineyard spray program and follow up with vineyard staff with this material"<br>"Will pay closer attention to 'critical periods'"<br>"I will now make a spray plan before the season starts" [*this response typically shows up in over 50% of our responses from new growers*]<br>"I will pay attention to what's happening with weather and in my vineyard to determine how to control diseases"<br>"Spray from a plan for the first 4 sprays, then scout for pressure!"<br>"We will spray our Minnesota hybrids less" [*MN hybrids are often more DM and PM resistant that* V. vinifera, *but are commonly sprayed the same*] |

Table 2: Qualitative feedback from select workshop participants, from 2015-2021. Most post-workshop surveys ask participants what they learned from the workshop (short term knowledge change), and what they may change as a result of workshop attendance (medium term behavioral changes). Some examples of these responses from these workshops are highlighted below, and additional context, when needed, is provided in brackets

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