2024 Pest Management Guide for Grapes in Washington

WASHINGTON STATE UNIVERSITY EXTENSION • EB0762

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EXTENSION

EB0762 Pest Management Guide for Grapes in Washington—2024

POISON EMERGENCY

Washington Poison Center: 1-800-222-1222
https://www.wapc.org/
For further information, see Pesticide Safety

PESTICIDE LABELS

YOU ARE REQUIRED BY LAW TO FOLLOW THE LABEL. It is a legal document. Always read the label before using any pesticide. You, the grower, are responsible for safe pesticide use.

Trade Names

Trade (brand) names are provided for your reference only. No discrimination is intended, and other pesticides with the same active ingredient, provided they are also registered for use on the intended crop and for the intended target, may be suitable. No endorsement is implied.

Pesticide Information

National Pesticide Information Center: 1-800-858-7378
http://npic.orst.edu/

Spray Guide Coordinators

Gwen Hoheisel, WSU Regional Extension Specialist
Michelle Moyer, WSU Viticulture Extension Specialist

Front Cover Photos

Delta trap: Stephen Onayemi
Nematode: Bernadette Gagnier

SECTION COORDINATORS:

Regulations & Safety

Rachel Bomberger, WSU Pesticide Coordinator

Pesticides

Rachel Bomberger, Wendy Sue Wheeler, WSU Pesticide Coordinators

Weeds

Rui Liu, WSU Weed Extension Specialist

Biological Control

David James, WSU Associate Professor of Entomology

Insects

Douglas Walsh, WSU Environmental and Agrichemical Education Extension Specialist

Nematodes

Inga Zasada, USDA-ARS Research Plant Pathologist
Michelle Moyer, WSU Viticulture Extension Specialist

Plant Diseases

Michelle Moyer, WSU Viticulture Extension Specialist
Naidu Rayapati, WSU Grape Virus Extension Specialist, Prashant Swamy, WSU Research Associate

Prepared by representatives of Washington State University, WSDA and USDA personnel, and industry representatives.

WSU Extension • Washington State University • Pullman, Washington

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GENERAL INFORMATION

The *Pest Management Guide for Grapes in Washington* presents various chemicals and their uses against pest problems in Washington vineyards. While the recommendations are based on eastern Washington conditions, the information may often be applied to similar pest problems found throughout the state. Specific and more detailed information on pests and diseases can be found in the *Field Guide for Integrated Pest Management in Pacific Northwest Vineyards* (PNW644).

Recommendations are suggested guidelines. They are not intended to represent pest control programs. The use of other materials and varying rates and treatments for control of particular pests depends on individual circumstances.

Caution: Before making any application of chemicals to any vineyard, **READ THE COMPLETE LABEL** and be certain that it is up to date.

Always consult with your processor, winery representative, or Extension agent if you have any questions on approved pesticides or pesticide uses. The registration status of various chemicals, formulations, and manufacturers' products changes rapidly. You may lose your crop or market if you misapply or use improper materials that leave illegal residues on your crop.

Pests Not on Product Label: Some suggested uses of pesticides in this publication are for pests not listed on product labels. These are indicated by the symbol '*'. Such uses comply with the federal law (FIFRA), which says a use is consistent with label directions provided the crop or site is on the label and directions concerning rates and interval before harvest are followed.

Precautions in Use and Storage

- Know the trade names and active ingredients for the pesticides you are using. Be familiar with the first aid treatments, especially anything unique, before you store or handle pesticides.
- To protect your workforce, comply with the US EPA Worker Protection Standard (WPS) that is administered by Washington Departments for Agriculture and Labor & Industries. WPS classifies employees as *workers* if they could be exposed while working in vineyards that were treated in the past 30 days. WPS classifies employees as *pesticide handlers* if they mix, load, apply, or conduct maintenance on application equipment because they have the possibility of direct exposure to pesticides while working. Agricultural pesticide labels state a Restricted Entry Interval (REI) for each crop. This REI is a time when no entry is allowed into the treated area, unless the person is provided extra protection as detailed in the regulations and on the label. The section of the label that addresses WPS is the *Agricultural Use Requirements* section. The regulation requires notifying employees about pesticides applied, training those employees, monitoring the handling of highly toxic pesticides, providing handlers clean PPE, and providing emergency transportation for any exposure of concern. The web site *http://pesticideresources.org* has WPS resources to assist grower's understand their responsibilities and has training information and tools.
- Pesticide labels state the personal protective equipment (PPE) to be worn when handling/applying pesticides. At a minimum, long sleeved shirt and long pants are required to protect your skin from exposure; usually waterproof gloves too. If there is an added risk due for the product, the label may require a coverall be worn over short sleeved shirt/short pants or long sleeved shirt/long pants. The coverall can be a standard cotton or cotton polyester coverall; some opt for a disposable coverall to reduce laundering hassles. To protect eyes, wear safety glasses with brow and side covers, a face shield, or goggles. Waterproof gloves and boots may be required; reusable nitrile gloves meet most label requirements. Lastly some products may require a respirator to filter out particulates or vapors/gasses from contaminated air. Obtain a NIOSH-certified respirator, and if needed, the appropriate chemical cartridge (most often an organic-vapor cartridge). Dispose of any PPE that cannot be cleaned. Wash all other PPE at the end of the task.
- Be aware of heat illness. By wearing PPE, your body does not cool as well. Washington Labor & Industries has Outdoor Heat Exposure regulations for agriculture (WAC 296-307). It sets thresholds at 89°F, 77°F, and 52°F depending on the number of layers of clothing a person is wearing and if the layer is non-breathable, like a rain suit. Acclimatization, drinking water, and illness awareness are the main requirements. Schedule pesticide applications during the cooler parts of the day.
- Some insecticides are *organophosphates* or *carbamates*. They have caused poisonings in Washington from unintended exposures during routine tasks. If either type of insecticide product has the signal word of Warning, Danger/Poison or Danger and they are handled (mix, load, apply) for more than 30 hours in a 30 day period, the Washington Dept. of Labor & Industries (WAC 296-307-148) requires a medical monitoring program. This is a blood testing protocol to monitor for exposures to reduce the chance on an accidental poisoning and to assist with treatment. A pre-season blood test determines your normal cholinesterase activity level. If symptoms occur, seek medical treatment immediately and they will retest your levels. There are antidotes to treat a poisoning; however, they are only administered by a medical professional.
- Keep soap and water available for emergency decontamination for an unexpected exposure, such as from a broken hose.
- Before recycling or disposal, triple-rinse containers and pour rinsate into the spray mixture you are making up. Puncture rinsed containers to ensure they cannot be reused. Offer rinsed plastic containers for pesticide container recycling (see next section). Washington State does not allow burning of used pesticide containers.
- Keep your pesticide storage area locked. Keep used, empty, triple rinsed pesticide containers in your storage area.
- Do not use your cell phone, smoke, chew tobacco, or eat while spraying or while your

hands are contaminated with concentrate products or a spray batch.

- Mix pesticides according to label directions and apply at the recommended rate.
- Collect spilled material and absorbent for later use or hazardous waste disposal. Wash the contaminated area with soap and water. The breakdown of insecticides can be accelerated by using a weak lye solution.
- Most pesticide labels prohibit applications during temperature air inversions. Inversions happen typically in the late afternoon as the air cools and settles, then lasts through the night and early morning. It does not dissipate until the sun warms the soil the next day and air starts to move around again. During an inversion, air cannot mix vertically, and spray particles may be carried horizontally for a great distance. New inversion meters are available to assess conditions. Unfortunately to combat the concerns for heat stress, the coolest time of the day is best to apply—just make sure there is no inversion.
- Cover or remove food and water troughs when spraying around livestock areas. Avoid contamination of fishponds, irrigation canals, streams, and lakes. Check wind direction with a hand-held weather station or anemometer often when applying in sensitive areas.
- Avoid drift of pesticides to other crops. Again, check wind direction often. Check equipment function, particularly look for leaks and malfunctioning nozzles.
- Given changing wind conditions, plan your application to keep the spray moving away from you and if the wind changes, change your strategy.
- Pesticides that persist for long periods of time in the soil may injure susceptible crops planted the following year and may result in illegal residues. Observe label restrictions concerning the intervals and crops which may be grown in treated soils.
- Some pesticides may cause plant injury under certain conditions or on certain varieties. Be sure the material is recommended for use on the plant to be treated and that conditions are favorable for application.
- Some processors may not accept a crop treated with certain pesticides. If crops are going to a processor, be sure to check with their field representative before applying pesticides.
- When a permanent vineyard crop cover has flowers, the cover must be mowed before spraying insecticides that are toxic to bees, and to protect all pollinators.

Pesticide Disposal and Plastic Container Recycling

Most pesticide products become classified hazardous waste upon disposal and fall under the Washington State Dangerous Waste Regulations, Chapter 173-303 WAC, which is administered by the Washington State Department of Ecology. The regulations are complex. A grower who needs to dispose of pesticide formulations or excess tank mix should contact the appropriate regional Ecology office for guidance.

Northwest Regional Office (Bellevue):
425-649-7000

Southwest Regional Office (Lacey):
360-407-6300

Central Regional Office (Yakima):
509-575-2490

Eastern Regional Office (Spokane):
509-329-3400

The Washington State Department of Agriculture's Waste Pesticide Program collects and disposes of unusable pesticides owned by agricultural producers. This program depends on state funding. Several collections are held throughout the state each year. Contact 1-877-301-4555 or visit their web site: *https://agr.wa.gov/departments/pesticides-and-fertilizers/pesticides/waste-pesticide*.

Triple-rinsed, plastic pesticide containers, large and small, are collected by the ACRC (Ag Container Recycling Program) contractor, which is currently Agri-Plas in Oregon; *https://agriplasinc.com/*. They provide collection and processing services for triple or pressure-rinsed plastic pesticide containers. They offer mobile grinding and whole container pickup, and have a pickup schedule on their web site.

Symptoms of Pesticide Poisoning

Herbicides and fungicides can result in skin, eye, or throat irritation. Redness or rashes are the most common poisoning symptoms. Some surfactants in herbicides are similar to soaps and can irritate or damage eyes. Read labels and wear noted PPE (gloves, protective eyewear, respirators, etc.) to protect skin and eyes, and prevent inhalation.

Many insecticides work on the human nervous system the same way they do on insects; it's the dose that makes the poison. They can enter through eyes or skin or by ingestion or inhalation. Read labels for PPE (gloves, protective eyewear, coveralls, respirators, etc.). Neurotoxic insecticides include *organophosphates* and *carbamates*, and the symptoms of acute poisoning develop within minutes to hours after exposure. Most commonly reported early symptoms include headache, nausea, dizziness, sweating, salivation, tearing, and nasal discharge. Muscle twitching, weakness, tremor, incoordination, vomiting, abdominal cramps and diarrhea signal more severe poisoning.

Protections, Emergency Treatment, and Pesticide Information

Good hygiene is important to reduce exposures. Wash your hands and face when done with a task, and shower at the end of the day. Wear clean clothes and PPE each day. Wash contaminated clothing separate from the family laundry.

Call the National Poison Center at 1-800-222-1222 for emergency information if an exposure occurs; they are staffed 24-hours a day. The person answering your call will refer you to the nearest hospital handling pesticide poisonings.

Emergency First Aid Basics—reference the pesticide label.

1. Reduce the exposure immediately when it occurs.
    a. Remove contaminated clothing, wash the affected area, then put on clean clothes.
    b. Move to fresh air when pesticides are in your air space.
    c. Rinse eye for 15 minutes if material enters the eye.
2. If breathing stops, the most important first aid is artificial respiration. Make sure first responders take care to avoid exposure while performing first aid.
3. Never try to give anything by mouth to an unconscious person.

Lastly, another resource for getting answers to questions about safety issues related to pesticides is the National Pesticide Information Center, *http://npic.orst.edu/*, or call **1-800-858-7378** between 8:00 AM to 12:00 PM Pacific Time, Monday through Friday. You can always email them as well at npic@ace.orst.edu.

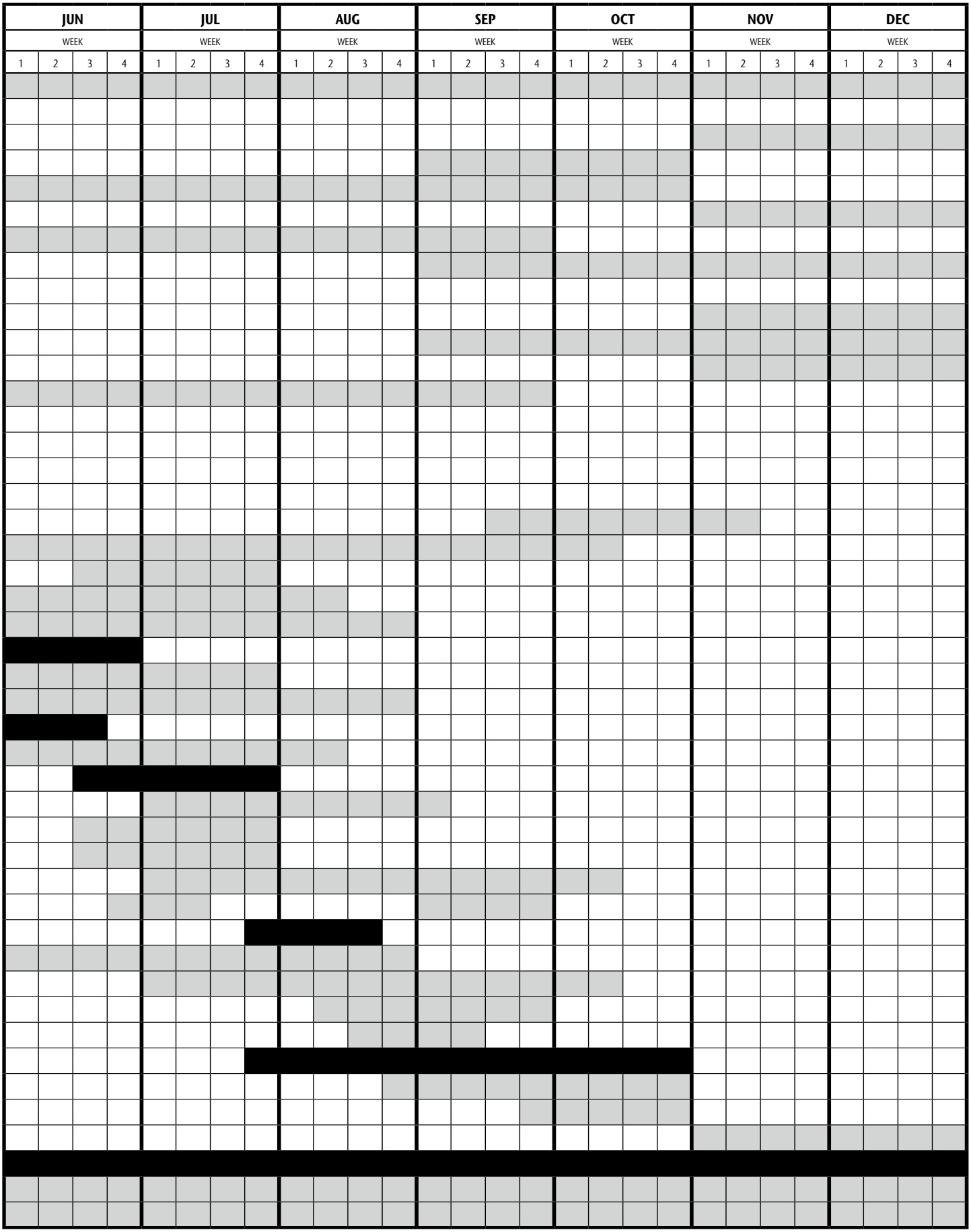
ANNUAL ACTIVITIES, SCOUTING, AND CONTROL IN WASHINGTON VINEYARDS

Integrated Pest Management is a combination of cultural, biological, and chemical control. This table highlights general timelines of when activities should be accomplished. It was created as part of the *Pest Management Strategic Plan for Washington State Wine Grape Production* (2014).

See Table on pages 6–7.

WORKER ACTIVITIES IN WASHINGTON WINE GRAPES

	JAN				FEB				MAR				APR				MAY			
	WEEK				WEEK				WEEK				WEEK				WEEK			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Site Selection																				
Dormant Pruning																				
Soil Testing																				
Fumigation																				
Fertilization/Amendment																				
Cover Crop Seedbed Prep																				
Mow Cover Crop																				
Vineyard Site Prep																				
BUD SWELL																				
App. Herbicide (Pre-Emrg)																				
Install New Irrigation																				
Plant New Plants																				
App. Herbicide (Emrgnt)																				
BUD BREAK																				
Cutworm Scouting/Control																				
Cutworm Barrier Treatment																				
Cutworm Foliar Treatment																				
Monitor for Nematodes																				
Nematode Control																				
Mealybug Scout/Control																				
Leafhopper Scout/Control																				
Thrips Scout/Control																				
SHOOT ELONGATION																				
Shoot Thinning																				
Trunk/Crown Suckering																				
BLOOM																				
Powdery Mildew Control																				
FRUIT DEVELOPMENT																				
Cluster Thinning																				
Position Canopy Wire																				
Leaf Removal																				
Regulated Irrigation																				
Scout for phylloxera																				
VÉRAISON																				
Botrytis Control																				
Spider Mite Scout/ Control																				
Hedging (Topping Vines)																				
Install & Remove Bird Nets																				
RIPENING																				
Harvest																				
Post-Harvest Irrigation Replenishment																				
Plant Annual Cover Crop																				
VINEYARD INFRASTRUCTURE																				
Irrigation Maint. & Repair																				
Trellis Maint. & Repair																				


JUN
JUL
AUG
SEP
OCT
NOV
DEC
WEEK
1 2 3 4

CONSERVATION BIOLOGICAL CONTROL: THE BACKBONE OF GRAPE PEST MANAGEMENT

Pest management in Washington vineyards has come a long way in a quarter of a century. Twenty-five years ago, pest management in Washington grapes depended on the routine application of broad-spectrum insecticides. Today, because we have moved away from broad-spectrum insecticides, the backbone of our pest management programs is conservation biological control (CBC). A community of beneficial insects and mites has moved into our vineyards. Conservation biological control is biological control that is available everywhere and to everyone. Without it, outbreaks of leafhoppers, mealybugs and spider mites would be very large, more frequent and need chemical control routinely. Other very minor pests like scale insects would also become major issues.

Washington vineyard CBC relies upon a community of natural enemies, not just one or two species of predators and parasitoids, but an entire assemblage, comprised of specialists (preying on specific pests) and generalists able to feed on a wide spectrum of pests. Research shows that the most effective biological control is provided by the most diverse and complex communities of natural enemies.

The best thing about CBC is that it is free! The biological control agents are tiny wildlife living in our environment. The only thing we need to do is to give them access to our vineyards, and to treat them well.

The most important thing we can do to treat them well is to make sure that when we use pesticides, we choose those with the least chance of harming our CBC agents. Fortunately, we have an array of chemical options, many of which are relatively safe to 'good' insects and mites. Always research the pesticide you use for its relative safety to beneficial insects.

What else can we do to help CBC? Research at WSU Prosser IAREC has focused on this in recent years and we have come up with two additional things you can do.

Create Better Habitat for CBC

Native natural enemies depend on native plants. These good insects were here long before we started growing grapes and have complex relationships with native plants. Providing the resources and refuge that these plants give enhances the ability of CBC agents to persist in or near vineyards and strengthens their performance as biocontrol agents. Many species of native plants enhance biological control services but our research has shown buckwheats (*Eriogonum* spp.), milkweeds (*Asclepias* spp.), nettles (*Urtica* spp.), yarrow (*Achillea millefolium*) and sagebrush (*Artemisia*), have particular value.

Attract More CBC Agents

Research at WSU Prosser IAREC has identified wintergreen or methyl salicylate as being an effective attractant for a community of natural enemies of pests. Vineyards baited with this minty compound routinely developed larger and more diverse communities of predators and parasitoids. Today, methyl salicylate is available commercially (*http://www.agbio-inc.com/*) as slow-release dispensers and is an easy and cost-effective way of enhancing CBC.

Utilizing and strengthening conservation biological control, the backbone of pest management in Washington vineyards, has multiple benefits. It reduces costs of management by reducing the number of sprays, which enables the production of wine grapes with reduced synthetic inputs. This benefits both the producer and consumer.

WEED CONTROL

Weeds can directly compete with grapevines for water, nutrients, and light. Weeds may also impact vines indirectly, by serving as alternate hosts for insect pests and pathogens; providing habitat for rodents; altering the distribution of irrigation water; interfering with the deposition of pesticides; and impeding the movement of workers and equipment. Successful weed management can be achieved by employing a combination of strategies, which includes the use of herbicides, to eliminate unwanted vegetation from vineyards. Herbicides, however, act upon different weed species and in different ways; care must be taken to ensure that the selected products will be effective at controlling the weed species that are present in the system. Herbicides are also capable of causing serious injury or death of vines and/or may have significant unintended consequences on neighboring ecosystems. Consequently, applicators must ensure that an acceptable level of crop safety can be achieved and that off-site/off-target damage is prevented.

The most appropriate choice of herbicide (or combination of herbicides) will be affected by numerous factors including:

- mode of action of the herbicide,
- the kind of weeds to be controlled,
- the size and/or age of the weeds to be controlled,
- soil type and herbicide incorporation strategy,
- the quantity and quality of the spray water,
- the age and health of the vines.

Application Rate and Equipment

The rate or amount of herbicide to be applied is shown as the amount per acre of the actual portion treated (i.e., the area directly under the vine row, or the area between vineyard rows), and not the total herbicide to be applied to an acre of vineyard. Thus, a 10-foot row spacing with a 2-foot band of herbicide sprayed under the vines would be two-tenths (one-fifth) of an acre to be treated or 20% of one acre of vineyard.

To reduce the hazard of injury to vines as well as to ensure the maximum effectiveness of the herbicides applied, select your equipment and its use carefully. Herbicides need to be applied with a fixed boomtype applicator equipped with flat, fan-type nozzles. The height of the boom depends on the height of weeds, the nozzles, and their spacing. Take care to ensure a uniform spray pattern and, thereby, a uniform herbicide deposit. Similarly, the speed of travel must be closely regulated. It is limited not only by safety, but also by the capacity of the pump. Regulating the pressure does not sufficiently alter the output. In general, use speeds of around 1.5 to 2 miles per hour.

When using standard flat fan nozzles with droplets in the 'fine' category, use low pressures (20 to 35 psi) to ensure coverage and penetration while minimizing spray drift. If using anti-drift nozzles, also called air induction nozzles, the pressure will have to be higher (40 to 50 psi) to achieve the correct gallons per minute from the nozzle. This higher rate is acceptable with an air induction nozzle because the droplet size is larger (coarse or very coarse) and will not drift as much. With either nozzle choice, be sure to check the nozzle catalog to verify pressure with the desired gallons per minute.

NOTE: With glyphosate or any broadleaf systemic herbicide, reducing drift is critical. Therefore, reduce pressure to 20psi or less when using standard flat fan nozzles or use air induction nozzles that produce a very large droplet.

Constant agitation of the spray mixture is essential with wettable powders and dry flowables, and agitation must be vigorous when using oils. A defoaming agent can be used. Follow quantity and directions on label.

General Precautions

1. Do not apply any herbicide to grapes unless there is a label registration for its use on grapes.
2. Check all herbicide and pesticide uses with the processor before using.
3. Do not use a combination of herbicides or other chemicals with herbicides unless the combination has been thoroughly tested and confirmed to not cause phytotoxic effects.
4. Avoid herbicide application to any part of the vine. Do not use weed sprayers to apply other pesticides to the canopy.
5. Do not repeatedly use the same mode of action (MOA) throughout the season (Table 1). The Herbicide Resistance Action Committee (HRAC) codes all chemicals based on the MOA. Using different HRAC codes or MOAs is part of a good herbicide resistant management program. For more information on controlling resistant weeds, see *Herbicide Resistant Weeds and Their Management* (PNW437).

Table 1. Mode of action of herbicides registered for use in grapes in the Pacific Northwest.

Herbicide Trade Name[1]	Chemical Name	WSSA Group[2]	HRAC Code[3]	Resistant Weed Species in PNW?[4]	Requires Respirator[6]
Fusilade DX	fluazifop	1	A	Yes	No[6]
Poast	sethoxydim	1	A	Yes	No
Select Max (and others)	clethodim	1	A	Yes	No
Matrix SG	rimsulfuron	2	B	Yes	No
Mission	flazasulfuron	2	B	Yes	No
Kerb SC (and others)	pronamide	3	K1	Yes	No
Prowl H20 or Prowl 3.3EC (and others)	pendimethalin	3	K1	Yes	No
Surflan AS[4] (and others)	oryzalin	3	K1	Yes	No
Treflan HFP 4EC (and others)	trifluralin	3	K1	Yes	No
Princep 4L or Princep Caliber 90 (and others)	simazine	5	C1	Yes	Maybe[5]
Karmex DF (and others)	diuron	7	C2	Yes	All handlers
Roundup Power Max (and others)	glyphosate	9	G	Yes	No
Rely 280 (and others)	glufosinate	10	H	Yes	No
Solicam DF	norflurazon	12	F1	No	No
Aim EC	carfentrazone-ethyl	14	E	No	No
Chateau SW	flumioxazin	14	E	No	No[6]
Venue	pyraflufen-ethyl	14	E	No	No
Zeus XC	sulfentrazone	14	E	No	No
Zeus Prime XC	sulfentrazone + carfentrazone-ethyl	14 (both)	E (both)	No	No
Gamma	tiafenacil	14	E	No	No
Devrinol 2-XT (and others)	napropamide	0	K3	Yes	No
Casoron CS (and others)	dichlobenil	29	L	No	No
Gallery 75 DF (and others)	isoxaben	29	L	No	No
Gramoxone SL 3.0 (and others)	paraquat	22	D	No	All handlers
Alion	indaziflam	29	L	No	No

[1] Herbicide Trade Names are for example purposes only and does not indicate an endorsement of a specific brand or company. Some active ingredients are available under multiple trade names.
[2] WSSA = Weed Science Society of America
[3] HRAC = Herbicide Resistance Action Committee
[4] At least one weed species resistant to this mode of action documented to occur in ID, OR, or WA; data from Heap, I. The International Survey of Herbicide Resistant Weeds. Available at www.weedscience.org
[5] Princep Caliber 90 requires a respirator for Mixers and Loaders. Princep 4L does NOT require a respirator for any reason.
[6] Other fruit and vegetable crops on the label do require a respirator

Factors Affecting Control

Classification of Herbicides

Herbicides differ with respect to how they are used. When describing herbicides, we can refer to them as being either 'pre-emergence' or 'post-emergence' applied. Pre-emergence herbicides are soil-applied products that act primarily on germinating weed seeds or young weed seedlings. They persist in the environment to provide extended weed control within or across seasons.

Products classified as post-emergence herbicides are applied directly to the foliage of emerged weeds to elicit control. Post-emergence herbicides can be further characterized as being either 'contact' or 'systemic' products. Contact generally refers to herbicides that only affect the tissues that are directly treated with the herbicide—these types of herbicides do not move (translocate) to untreated parts of the plant following application. Systemic or translocated herbicides can move from treated plant parts to untreated tissues via the xylem or phloem. Although some herbicides may exhibit both pre- and post-emergence activity, a combination of both foliar and soil-applied products are typically used to successfully manage weed communities in vineyards.

Often, herbicides are referred to as being either 'selective' or 'non-selective' (which is synonymous with 'broad-spectrum'). A selective herbicide is one that is effective at controlling some species but not others. Conversely, a non-selective herbicide is an herbicide that can control many different types of weedy pests. The most well-known examples of herbicide selectivity are: 1) the abilities of the '-fops' and the '-dims' (e.g. fluazifop and clethodim) to suppress grasses but not broadleaf species; and 2) the control of broadleaved weeds, but not grasses, by synthetic auxins (e.g. 2,4-D).

Kinds of Weeds to be Controlled

Weed species can be described by the length of their life cycle. Annual weeds (both winter-and summer-germinating) emerge, grow, flower, and set seed all within the course of a year. Biennial weeds complete their life cycles over the course of two years whereas perennials can persist across multiple seasons. Not all herbicides are equally effective against all three types of weed species. For example, although the seedlings of perennial weeds may be controlled by pre-emergence herbicides, much like annual species, mature plants are unlikely to be impacted.

It is possible for weed communities in vineyards to be comprised of species that are naturally sensitive to different herbicides or herbicide modes of action. They may also differ with respect to life history traits or emergence patterns. Herbicide labels list the weed species that can be suppressed or controlled by the active ingredient. The labels will also provide instructions on when to time applications to maximize herbicide efficacy and will also list appropriate tank-mix partners to help growers expand the spectrum of weed control. Always read labels to ensure that herbicide applications will be both effective and safe.

For help on weed identification, see *Invasive Weeds of Eastern WA* (EM005) and visit: *https://wine.wsu.edu/extension/pest-management/*. In addition, Washington State University Extension also provides a free Weed Identification Service. Information on this service can be found at: *https://css.wsu.edu/extension/weed-identification/*.

The Size and/or Age of the Weed to be Controlled

Weed control strategies may not always be 100% effective and escapes can occur for numerous reasons. One of those reasons is the size of plants at the time of application. The efficacy of post-emergence herbicides is often diminished when products are applied to large/mature plants. This can result from poor spray coverage and the ability of dense foliage to shield sensitive tissue from herbicide deposition. While plant size is mainly a concern with contact herbicides, the efficacy of systemic products can also be influenced. For example, may perennial species are tolerant of many herbicides, including translocated products like glyphosate, because their root systems and nutrient reserves support regeneration/regrowth. There are several strategies that growers can take to maximize weed control with post-emergence herbicides, including: timing applications to treat weeds while they are small/tender, applying herbicides at appropriate rates and volumes, and using label recommended adjuvants to improve herbicide contact and penetration.

The development of herbicide resistance is a significant concern for growers of perennial crops, including grapes. Weed species with resistance to glyphosate, glufosinate, and paraquat have been confirmed in California and Oregon as well as other Western states. Incomplete weed control can increase the chance of a herbicide resistant biotype reaching reproductive maturity, setting seed, and becoming established in a production system. Her-

bicide labels will provide instructions to applicators regarding strategies for resistance management. Additional information can be found at the Weed Science Society of America's (WSSA) web-page: *https://wssa.net/wssa/weed/resistance/* and *Herbicide Resistant Weeds and Their Management (PNW437)*.

Soil Type and Herbicide Incorporation Strategy

The length of time that pre-emergence herbicides may reside in a treated area will be influenced by multiple factors, such as soil texture and organic matter content. Soils that are high in clay or organic matter can bind herbicides tightly to the soil matrix. Conversely, coarse soils can enhance leaching potential. Herbicide persistence is also a function of herbicide chemistry. Some herbicides naturally bind very tightly to soil particles whereas others are significantly more mobile. The interactions between soil and herbicide chemistry can affect a product's use rate within a given system. This, in turn, may influence how well a herbicide performs, as well as how long it remains in the treated zone.

To be effective, pre-emergence herbicides must be incorporated (usually 1–2" deep) into the soil profile. Incorporation is required because these products are mostly active against newly germinated weed seedlings. Additionally, incorporation is needed to reduce or prevent volatilization and photodegradation, which can result in reduced herbicide performance. The length of time an herbicide can remain on the soil surface varies dramatically among products. Even if an herbicide does not require immediate activation to prevent product loss, an unincorporated herbicide is unable to control emerging weeds. While many growers will time herbicide applications to take advantage of naturally occurring rainfall, uncooperative weather may require the use of irrigation for activation. Some products, due to their mobility and potential for crop injury, may be incompatible with sprinkler systems; this is of particular concern when grapes are grown on shallow, coarse, sandy, or gravelly soils.

Check pre-emergence herbicide labels carefully to ensure that the product is being applied at the proper time of year to effectively target the weed species of concern in a vineyard. Apply and incorporate products as described to prevent crop injury; this includes following timing recommendations to avoid treating vineyards when and if significant crop damage could occur.

The Quantity and Quality of the Spray Water

Water is the main carrier for crop protection products, including herbicides. Consequently, the quantity and quality of spray water can impact herbicide distribution and performance. In general, higher carrier volumes have been shown to improve the efficacy of foliar-applied herbicides (glyphosate is a notable exception). Post-emergence herbicide labels provide instructions regarding the recommended application parameters (i.e. GPA, pressure, droplet size) to maximize weed control potential. Carrier volume can also affect the delivery of soil-applied products; always read the herbicide label to ensure that all herbicides are used both effectively and safely.

Water quality factors can also affect herbicide performance and safety. For example, herbicides that are weak acids (such as glyphosate) can have their efficacy reduced under alkaline conditions (pH >7). Salts and soil particles in spray water can bind to some herbicides, thereby affecting their dispersal, deposition, and uptake. Water quality recommendations exist for both pre- and post-emergence herbicides; read labels carefully.

The Age and Health of the Vines

Vine age can affect what herbicides are available for use in a production system. While competition from weeds is most severe in newly planted grapes, not all herbicides are labeled for use around young canes. Growers should be aware of re-plants in mature vineyards before making soil-applied treatments. Regardless of vine age, residual herbicides should be applied to soil that is settled and free of cracks to minimize the potential for crop injury. Avoid using herbicide-treated soil to backfill planting holes. Unless specifically noted on the label, avoid herbicide spray or mist contact with leaves, green bark, roots, or fruit to reduce the potential for crop injury.

Crop safety is paramount; however, the safety of species and habitats outside of the treated area are also a significant concern. Follow label instructions to reduce the potential of spray or volatility drift and subsequent damage to off-target organisms. Surface and groundwater advisories and buffer zone recommendations are included on several herbicide labels; read and follow all labeled guidelines to prevent contamination of aquatic systems.

General Precautions

1. Do not apply any herbicide to grapes unless there is a label registration for its use on grapes.
2. Check all herbicide or other pesticide uses with the processor or field representative before using.
3. Do not use a combination of herbicides or other chemicals with herbicides unless the combination has been thoroughly tested and confirmed to not cause phytotoxic effects.
4. Avoid herbicide applications to any part of the vine. Do not use weed sprayers to apply other pesticides to vines.
5. Do not use the same mode of action (MOA), repeatedly, throughout the season. Using different MOAs is part of a good herbicide resistant management program.

Soil-applied Herbicides:

Dichlobenil (Casoron CS, Casoron 4G) WSSA Group 29: inhibits cell wall synthesis

A soil-active herbicide for long-term or seasonal control of most weeds, dichlobenil can suppress the growth of some perennials (Canada thistle, quackgrass, field bindweed and bermudagrass), although higher use rates are recommended.

Dichlobenil is most effective when applied in the fall, at the beginning of the rainy season (about November 15 to February 15 in eastern Washington) and when the ground is cool. Application before a rain will reduce volatility and improve weed suppression. Do not apply when the ground is frozen. Applications can be made in the spring up to about May 1 (when the soil surface is still 60°F or below). If an application is not followed closely by rain, either incorporate into the soil surface mechanically or use a light sprinkler irrigation (0.5 to 1 inch of water); do not overwater to the point of runoff. This chemical can be used in sprinkler-irrigated vineyards but injury can occur; use the lower rate of chemical and reduce the amount of water applied in the first irrigation to 0.5 to 1 inch of water. Consult agricultural authorities before applying dichlobenil to sprinkler-irrigated vineyards. Avoid use on coarse, sandy, gravelly, or shallow soils because of potential injury. Do not apply to recently cultivated or loose soil or when the soil surface is wet and warm (above about 70°F); delay application until the soil is settled and dry. Do not apply to young vines until four weeks after transplanting, preferably in the winter after transplanting. Casoron CS can be applied after vines are 12 months old.

Diuron (Karmex DF, Diuron 4L) WSSA Group 7: photosystem II inhibitor

Diuron has pre-emergence and some post-emergence activity. Weeds should not be >2 inches in height or diameter or else post-emergence control may be compromised.

Diuron should be applied during the rainy period (from about November 1 to February 15 in eastern Washington), but not to frozen ground. Spring applications may not be as effective unless rains fall soon after application to incorporate the herbicides; however, heavy rains following a spring application may result in plant injury. Application to vineyards under sprinkler irrigation can be hazardous. Apply as a banded application to vineyards that have been established for at least 3 years and that have vines >1.5 inches in diameter. Do not apply to vineyards with shallow, coarse, sandy, or gravelly soils or to soils with less than 1% organic matter. Serious herbicide injury to grape roots has occurred when this herbicide is applied under improper conditions. Do not apply more than 5 lbs of Karmex DF per acre in a single use; do not apply more than 10 lbs per acre per year. Do not apply more than 4 qts of Diuron 4L per acre in a single use; do not apply more than 8 qts per acre per year.

Flazasulfuron (Mission) WSSA Group 2: acetolactate synthase (ALS) inhibitor

Mission is labeled for the control of certain broadleaf and grass weeds including annual ryegrass, common mallow, clover and willowherb. Mission has both pre- and early post-emergence activity; weeds should be <4 inches tall and grasses should not be tillering in order to maximize post-emergence control potential. If weed emergence is substantial at the time of application, consider mixing flazasulfuron with an approved post-emergence herbicide to improve control.

Apply pre-emergence as a directed spray to the soil under vines that have been established for at least 3 years; protective sleeves (nonporous wraps, grow tubes, waxed containers) are required for third year vines. Do not apply where grapevine roots are exposed or to gravelly soils. Must be activated with rainfall or irrigation of 0.25 to 0.5 inch for pre-emergence control; pre-emergence efficacy will be

maximized if the product is applied to bare soil. Do not apply more than two applications of 2.85 oz of formulated product per acre per year (maximum of 0.089 lbs of active ingredient or 5.7 oz of Mission per acre per year). The minimum allowed interval between treatments is 3 months. Do not apply within 75 days of harvest. A 25-foot buffer must be maintained between the point of direct application and the closest downwind edge of sensitive terrestrial habitats (forested areas, riparian areas), freshwater habitats (lakes, rivers, sloughs), and estuarine/marine habitats.

Flumioxazin (Chateau SW) WSSA Group 14: protoporphyrinogen oxidase (PPO) inhibitor

Chateau has both pre- and early post-emergence activity and can control broadleaf weeds up to about 2 inches tall. If weed emergence is significant or weeds are large, consider mixing flumioxazin with an approved post-emergence herbicide to improve control.

The preferred time for pre-emergence applications is fall, in order to maximize the potential for rain to activate the herbicide. Do not apply to vines established less than 2 years, unless they are trellised at least 3 ft from the ground, and protected by nonporous wraps, grow tubes, or waxed containers. Do not apply to non-trellised vines unless they are free-standing. New plantings of own-rooted varieties should have root systems a minimum of 8 inches below the soil surface. Chateau should not be applied to soils that are susceptible to dispersal by wind; wind-blown, herbicide-treated soil can cause serious injury to grapes and other plants. Do not apply after budbreak through final harvest in juice and wine grapes, unless using shielded application equipment and applicator can ensure spray drift will not come in contact with crop fruit or foliage. Dust created by mowing can also injure sensitive species; do not mow between budbreak and final harvest. The application and maximum use rates can vary with weed species and soil type, but will not exceed 12 oz of formulated product per acre per application and 24 oz of formulated product per acre per year. Do not apply within 60 days of harvest. Do not apply within 300 yards of non-dormant pears.

Indaziflam (Alion) WSSA Group 29: inhibits cellulose biosynthesis

Alion is labeled for the pre-emergence control of many annual grasses and broadleaf weeds. Controls perennial weeds from seed, only. The spectrum of weeds controlled will be affected by rate and the timing of activation.

Alion is most effective when applied in the fall or early spring to dry soil surface that does not have crack or depressions. Apply as a uniform broadcast or banded application. Alion applications should be followed by 48 hours without irrigation or rain; activating moisture (0.25 to 0.5 inches) must be received within 21 days or before weed seeds germinate. Do not use on sand or soils containing >20% gravel. Alion should not be applied to frozen or snow covered soils, or saturated soils. Use only on vines established at least three years that are exhibiting normal growth and good vigor. Ensure that there is 6 inches of soil between the soil surface and the major portion of the root. Do not apply more than 5 fluid ounces of formulated product (0.065 lbs of active ingredient) per acre per year; coarse soils with less than 1% organic matter require a lower use rate per application. If making more than one treatment per year, allow for 90 days between applications. Do not apply within 14 days of harvest. Clean spray tank thoroughly after use. Surface and groundwater advisories are included on the label because of potential to harm nontarget aquatic organisms, and potential for runoff and percolation to ground water.

Isoxaben (Trellis SC, Gallery SC) WSSA Group 29: cell wall synthesis inhibitor

A pre-emergence applied herbicide for the control of many annual broadleaf weeds.

Available for non-bearing (Gallery) and bearing (Trellis) vineyards, but do not apply to newly transplanted vines until the soil has settled and is free of cracks. Do not apply Trellis within 165 days of harvest. Must be incorporated within 21 days and before weeds emerge. Activate with 0.5 inch of water or shallow cultivation before weeds emerge. Most effective when applied to soil that is debris free. For bearing vineyards, do not make more than 2 applications per year up to a max use rate of 1 lb of active ingredient per acre per year. Select application rates based on weeds present.

Napropamide (Devrinol 2-XT, DF-XT) WSSA Group 0: inhibits very long chain fatty acid synthesis

A pre-emergence herbicide for the control of some annual grasses and broadleaf weeds. Will not give

complete control of nightshade, flixweed, tansy mustard, tumble mustard, or perennial weeds.

Apply fall through spring before weeds germinate. May be applied to both newly planted and established vineyards. Applications made from November 1 to February 15 should be incorporated with irrigation or shallow cultivation if rainfall does not occur within 2 weeks of treatment. Performance is reduced if excessive residue occurs on the soil surface. Applications made during the spring should be activated with sufficient water to wet the soil to a depth of 2 to 4 inches within 24 hours. Can be used safely in sprinkler-irrigated vineyards. The pre-harvest interval is 70 days. Do not apply more than 4 lbs of active ingredient per acre per crop cycle.

Norflurazon (Solicam DF) WSSA Group 12: inhibits carotenoid biosynthesis

A broad spectrum pre-emergence herbicide that will control many annual broadleaf and grass weeds found in vineyards. Solicam does not have any post-emergence weed control activity.

Solicam can be applied from fall to early spring before the weeds emerge to non-frozen soil. The soil should be settled and firm at the time of application and the surface must be free of soil clods, depressions, weeds and other plant residue. Requires rain to activate. If no rainfall occurs within 4 weeks after application, the product must be activated by sprinkler irrigation. Application to vineyards under sprinkler irrigation may be hazardous to vines growing on coarse soils; do not use on wine grapes grown in gravelly, sandy, loamy sand, or sandy loam soils in Washington. Norflurazon should not be applied to vines established less than 2 years. Whitening may occur if norflurazon is applied within 3 months after bud break. The maximum use rate per year for grapes should not exceed 5 lbs of formulated product per acre per year. Do not apply within 60 days of harvest.

Oryzalin (Surflan AS, other tradenames) WSSA Group 3: microtubule assembly inhibitor

Surflan is a pre-emergence herbicide that is particularly effective against annual grasses and some broadleaved weed species but will not give complete control of nightshade, tansy mustard, or tumble mustard.

Can be used in newly planted (if the soil has settled around vines) and established vineyards. Apply in late fall or early spring. Safe to use under sprinkler irrigation. Treated areas must be free of established weeds and well worked prior to spray application. A half-inch of rain or irrigation is necessary to activate this herbicide. If weeds begin to emerge before herbicide incorporation, a shallow cultivation (1 to 2 inches) will kill existing weeds and place the herbicide in the zone of weed seed germination. Surflan rates vary between 2 and 6 qt per acre per application depending on the desired length of weed control; the maximum use rate is 12 lbs of active ingredient per acre per year. The interval required between repeat applications is 2.5 months.

Oxyfluorfen (Galigan 2E, GoalTender) WSSA Group 14: proto-porphyrinogen oxidase (PPO) inhibitor

Provides both pre-emergent and early post-emergent control of broadleaf weeds in dormant grapes. It is most effective post-emergence when the seedling weeds have less than four leaves. Post-emergence weed control can be improved by tank-mixing with appropriate partners and adjuvants.

Direct the spray toward the base of vines in late winter or spring, avoiding direct plant contact; apply to bare soil. Apply after harvest, but before bud-swell in spring. The closer grapes are to bud swell at time of application, the greater the chance of crop injury. Do not apply to grapes established less than 3 years unless they have been staked or trellised 3 feet above the ground. Do not apply to grapes that are not staked or trellised unless they are free-standing. Apply only to healthy vines. Overhead moisture within 3 to 4 weeks will enhance herbicidal activity. The maximum use rate is 2.0 pounds active ingredient per acre per season except for GoalTender at 1.5 pounds per season. The lower rate is for control of susceptible broadleaf seedling weeds; the higher rate should be used for larger weeds or for preemergence control.

Pendimethalin (Prowl H2O, Prowl 3.3 EC) WSSA Group 3: microtubule assembly inhibitor

Prowl H2O and Prowl 3.3 EC are pre-emergence herbicides that are particularly effective against grasses.

Apply directly to the ground in dormant grapes before bud-break and before weeds emerge. Overhead moisture is required within 7 days for herbicide activation. Do not apply to newly

transplanted vines until the soil has settled and no cracks are present. If applying before transplanting, do not allow treated soil to come into contact with roots. Do not apply during or after bud swell in the spring. Do not apply over the tops of vines with leaves or open buds. Both labels include specific instructions regarding pre-plant or surface incorporated, surface-applied, and pre-emergence applications. The use rate is determined by the weeds requiring control and the length of control needed. The pre-harvest interval for Prowl H2O is 90 days. Prowl 3.3 EC is not labeled for use in bearing vineyards.

Pronamide (Kerb SC) WSSA Group 3: microtubule assembly inhibitor

Pronamide is a soil-applied product that is used for the control of grasses (annuals and some perennials) and some broadleaved species primarily for pre-emergence although Kerb can control some small weeds that have emerged.

Apply only once in the fall prior to soil freezing as a directed application when the soil temperature is below 55°F, but not when soil is frozen. Kerb is most effective when applied prior to weed emergence, to soil that is relatively free of residue, and when the application is followed by rainfall or irrigation. Use rate will be determined by the weed species to be controlled and soil type although the maximum use rate per acre per year is 4 lbs of active ingredient. Do not use on vines less than 1 year old, on fall-transplanted stock that has been transplanted less than 1 year, or to spring-transplanted stock that has been transplanted less than 6 months. Pronamide is a restricted-use chemical.

Rimsulfuron (Matrix SG) WSSA Group 2: acetolactate synthase (ALS) inhibitor

Matrix has both pre-emergence and very early post-emergence activity. When weeds are present at application, include a labeled burndown herbicide.

Can be applied broadcast to vineyard floor or banded at the base of the vines. Best pre-emergence results are obtained when the soil is debris-free and moist at time of application, and the site receives 0.5 inches of rain or irrigation moisture within 2 weeks of application. Crops must be established for 1 year before application (vines should be healthy and growing vigorously). Susceptible weeds are controlled from 60 to 90 days after application. Two applications separated by 30 days are allowed if applied in bands that cover half of the vineyard. Do not exceed 4 ounces of formulated product per acre on a broadcast basis per year. For best results, maintain spray tank solution at pH 5 to 7. The pre-harvest interval is 14 days.

Simazine (Princep 4L, Princep Caliber) WSSA Group 5: photosystem II inhibitor

Princep is a soil applied herbicide with efficacy against some grasses and broadleaf wed species.

Apply during the rainy period (from about November 1 to February 15 in eastern Washington) as a single application. Do not apply to frozen ground. Requires surface moisture for activation. Do not apply to vineyards established less than 3 years or to vineyards with shallow, coarse, sandy, or gravelly soils. Serious herbicide injury to grape roots has occurred when applied under improper conditions. Application to vineyards under sprinkler irrigation is hazardous. Do not apply more than 4 lbs of simazine (active ingredient) per acre per year.

Sulfentrazone (Zeus XC, Zeus Prime XC) WSSA Group 14: protoporphyrinogen oxidase (PPO) inhibitor

A pre-emergence or early post-emergence herbicide for controlling several species of annual broadleaf weeds. If weeds are emerged, mix sulfentrazone with an approved post-emergence herbicide.

Apply as a uniform broadcast soil application to vineyard floors or as a uniform band directed at the base of the vines then incorporate into the soil with rainfall or irrigation. Trunks can be wrapped in non-porous wraps, grow tubes, or wax container to protect against spray contact. Do not apply to vines younger than 3 years old. Activity of sulfentrazone increases dramatically under alkaline soil conditions or when irrigated with alkaline water. The pH of the spray solution should be between 5 and 9. If applied after bloom, use a shielded sprayer to avoid movement of spray mist to flowers. Sulfentrazone should not be applied to soils that are susceptible to dispersal by wind. Do not apply to frozen soils. Do not apply more than 12 oz of Zeus XC per broadcast acre per 12-month period. A prepackaged mix with carfentrazone-ethyl (Zeus Prime XC) is also available for grapes established at least 2 years. Do not apply more than 15.2 fluid ounces of Zeus Prime per acre per year. Do not apply within 3 days of harvest.

Tiafenacil (Gamma) WSSA Group 14: protoporphyrinogen oxidase (PPO) inhibitor

A non-selective contact herbicide used for broadleaf and grass weed control.

Gamma herbicide can be applied alone or in tankmix with other burndown herbicides, e.g., glufosinate, glyphosate. It works well on young (less than 5 inch) annual weeds, and can suppress some perennial weeds by desiccating green foliage. It needs an adjuvant (methylated seed oil, MSO, preferred) to have optimum burndown activity. It can be applied at 0.5 to 1.5 oz per acre at 2 week intervals during the season. Do not apply more than 4.5 oz per acre per year.

Trifluralin (Treflan HFP) WSSA Group 3: microtubule assembly inhibitor

A soil-applied product that is used for the control of grasses (annuals and some perennials) and many broadleaved species.

Can be used prior to transplanting as well as established vineyards. Apply before times of expected weed emergence or immediately after existing weeds are controlled. Trifluralin is best applied in the spring to provide almost season-long control of weeds. Must be mechanically incorporated 1 to 2 inches deep within 24 hrs following application to be effective and prevent loss of activity. Mixing activities should be done by equipment that will not injure vine roots. Since trifluralin (Treflan) is not leached into the soil, it is best applied in the spring and can be used in vineyards with sandy soils or sprinkler irrigation. Use lower rates on sandy soils or soil containing low organic matter levels. Lower rates should also be used in areas receiving less than 20 inches rainfall and irrigation. See label about mist propagated vines. The preharvest interval is 60 days.

Foliar-applied Herbicides:

Carfentrazone-ethyl (Aim EC) WSSA Group 14: protoporphyrinogen oxidase (PPO) inhibitor

A contact herbicide that is active on annual broadleaf weeds.

Carfentrazone-ethyl may be applied alone or as a tank mixture with other labeled herbicides as a post-emergence directed treatment or as a hooded spray between rows to control emerged and actively growing weeds. Good spray coverage of the weeds is essential for control. May be applied anytime during the season. Control is enhanced with the addition of a nonionic surfactant or crop oil concentrate. Care must be taken not to allow spray mist to contact desirable fruit, foliage or green stem tissue. Lower rates may be used to control small susceptible broadleaf seedling weeds at the 2- to 3-leaf stage. The higher rate is needed to control larger weeds up to the 6-leaf stage. Do not use on newly-transplanted vineyards. Do not apply more than 2 oz of formulated product per acre per application. Do not apply more than 7.9 oz of formulated product per acre per season. Do not make sequential applications less than 14 days apart. The pre-harvest interval is 3 days.

Fluazifop (Fusilade DX), clethodim (Select Max and other tradenames) and sethoxydim (Poast) WSSA Group 1: acetyl CoA carboxylase (ACCase) inhibitors

Post-emergence control of annual and perennial grasses.

Fluazifop and sethoxydim are registered for use in nonbearing and bearing vineyards; clethodim is registered for use only in nonbearing vineyards that will not be harvested within 1 year after treatment. They are foliage applied, translocated herbicides which will control most actively growing grass weeds. The herbicide will not control annual bluegrass or the fine-leaf fescues. Results can be erratic on grasses stressed from lack of vigor, drought, high temperature, or low fertility. Apply fluazifop to actively growing grasses as a directed spray in water. Add 1 quart crop oil concentrate or 0.5 pint nonionic surfactant to 25 gallons of spray material. Apply when susceptible grasses are in the labeled growth stage. Apply clethodim to actively growing grasses as a directed spray in water. Add 1 pint of nonionic surfactant to 50 gallons of spray material. Apply sethoxydim to actively growing grasses listed on the label at the 4- to 5-leaf stage (6 to 12 inches tall). Add 2 pints of a non-phytotoxic oil concentrate per acre. Do not apply to grasses which are stressed.

Glufosinate (Rely 280) WSSA Group 10: glutamine synthase inhibitor

Foliage applied, contact herbicide used to control annual broadleaf and grass weeds and to suppress perennial weeds.

Apply when weeds are small and actively growing. Use as a directed spray. Avoid contact of spray or mist on new foliage or green shoots as severe vine injury may result. Use directed spray and shield young vines. Thorough coverage of target weeds is essential for control. No additional surfactant is needed. May be tank mixed with labeled residual herbicides to control later germinating weeds. Apply in a minimum of 20 gallons of water per acre. Do not exceed 4.5 lb ai/acre per 12-month season. Apply only to grapevines established at least 1 year. Do not apply within 14 days of harvest.

Glyphosate (Roundup Powermax and other tradenames) WSSA Group 9: inhibits EPSP synthase

A translocated herbicide which controls many annual and perennial weeds, both grasses and broadleaves.

For optimum control of perennial weeds such as Canada thistle, field bindweed, and quackgrass, consult labels for recommended rates and correct timing in relation to weed growth. Adding surfactant or mixing ammonium sulfate according to label may improve control of slightly stressed weeds. Apply in 20 to 60 gallons of water per acre on emerged and actively growing weeds. Glyphosate does not provide residual weed control. Do not treat when green foliage or shoots are in the spray zone. Follow all precautions on label. Repeated glyphosate applications have genetically selected for resistant biotypes of ryegrass, as well as other weed species, in the PNW. To avoid weed resistance, rotate and mix weed control practices.

Paraquat (Gramoxone SL 3) WSSA Group 22: photosystem I electron diverter

Foliage applied, contact herbicide used to control annual broadleaf and grass weeds and to suppress perennial weeds.

Apply as a directed, shielded spray to the base of vines when grasses and other weeds are growing actively and new growth is from 1 to 6 inches high. With mustard-type annual weeds, apply before leaves exceed 1 inch in diameter. Avoid contact of spray or mist on new foliage or green shoots as severe vine injury may result. Add a nonionic surfactant or crop oil concentrate according to label; avoid anionic formulations that react in the tank to form insoluble precipitates. Paraquat is corrosive to aluminum. Spray in 50 to 200 gallons of water for thorough coverage of the weeds. Five applications are allowed per year. This is a restricted-use herbicide. Do not ingest or inhale spray mist. Wear protective clothing, face shields and respirators when mixing and during application.

Pyraflufen-ethyl (Venue) WSSA Group 14: protoporphyrinogen oxidase (PPO) inhibitor

A contact herbicide that is active on annual broadleaf weeds.

Apply when the weeds are less than 4 inches tall or 3 inches across. Use as a directed spray and thoroughly cover weeds. Use lower rates for small weeds and higher rate for larger weeds. Avoid contact with desirable foliage, green bark, or fruit. Use an approved agricultural buffering agent if using in water of equal to or greater than pH 7.5. The addition of crop oil concentrate or nonionic surfactant is recommended for optimum control. Tank mixing can increase the weed spectrum that is controlled. Mix only the amount of solution that can be sprayed within 4 hours. Do not make more than 3 applications or exceed 6.8 fluid ounces per acre per season. Allow at least 30 days between applications. Shield 1 year old or younger vines with non-porous wraps, grow tubes, or wax containers. Apply in a minimum of 20 gallons of water per acre.

HERBICIDE INJURY

Herbicide Injury

Herbicide injury symptoms can sometimes be confused with injury resulting from viruses or deficiency of plant nutrients. 2,4-D, glyphosate, and some other classes of herbicides affect the new growth of grapevines, causing deformation of both shoots and leaves. The symptoms tend to disappear later in the season as the malformed foliage is covered up by new growth. Serious crop damage can result if contamination occurs during the early portion of the growing season. Leaf symptoms of herbicide injury and other disorders can be found online at WSU (*https://wine.wsu.edu/extension/*). See the *Field Guide for Integrated Pest Management in Pacific Northwest Vineyards* (PNW644) for pictorial guides to determining damage caused by various herbicides.

Report incidences of injury or severe symptoms in grapes from herbicide drift to the Washington State Department of Agriculture toll-free 1-877-301-4555.

2,4-D Drift Documentation

To report damage in vineyards due to 2,4-D drift, adequate documentation is necessary. Most documentation must occur early in the spring, and weekly notes on plant development and the development of damage symptoms are also needed.

WEED MANAGEMENT PROGRAM FOR GRAPEVINES

Broad categories of weeds and vineyard age are described for each herbicide. Detailed application notes are found in the previous sections on "Soil-applied" and "Foliar-applied" herbicides. It is important to reference those sections and the label before any application.

		MATERIAL PER ACRE TREATED*			
Weeds to be controlled	Active ingredient and formulation	Rate of formulated product per application per treated acre	Vineyard age	Vineyard Application Requires Respirator	WSSA HRAC Codes
PRE-EMERGENCE WEED CONTROL					
Annual & some perennial weeds	dichlobenil (a: Casoron 4G, b: Casoron CS)	a: 100–150 pounds b: 1.4–2.8 gallons	Casoron 4G for vineyards which have been transplanted more than 4 weeks; Casoron SC after vines have been transplanted for at least 12 months.	No	29 L
Annual grasses & broadleaf weeds	indaziflam (Alion)	3.5–5.0 fluid ounces	Use only on vines established at least three years that are exhibiting normal growth and good vigor.	No	29 L
Annual broadleaf weeds	isoxaben (Gallery SC, Trellis SC)	16–31 fluid ounces	Gallery is labeled for non-bearing crops, only. Trellis is available for non-bearing and bearing vineyards, but do not apply to newly transplanted vines until the soil has settled and is free of cracks.	No	29 L
Annual grasses & broadleaf weeds	napropamide (a: Devrinol 2-XT, b: Devrinol DF-XT)	a: 2 gallons b: 8.0 pounds	For newly planted and established vineyards.	No	0 Z
Annual grasses & broadleaf weeds	norflurazon (Solicam DF)	1.25–5.0 pounds	Norflurazon should not be applied to vines established less than 2 years.	No	12 F1
Annual grasses, some broadleaf weeds	oryzalin (Surflan AS)	2.0–4.0 quarts	Can be used in newly planted (if the soil has settled around vines) and established vineyards.	No	3 K1

WEED MANAGEMENT PROGRAM FOR GRAPEVINES

Weeds to be controlled	Active ingredient and formulation	MATERIAL PER ACRE TREATED* Rate of formulated product per application per treated acre	Vineyard age	Vineyard Application Requires Respirator	WSSA HRAC Codes
Annual grasses, some broadleaf weeds	pendimethalin (a: Prowl 3.3 EC, b: Prowl H2O)	a: 2.4–4.8 quarts b: 2.1–6.3 quarts	Prowl 3.3 is labeled only for nonbearing vineyards; Prowl H2O may be used in nonbearing or bearing vineyards. Do not apply to newly transplanted vines until the soil has settled and no cracks are present.	No	3 K1
Annual grasses, some broadleaf weeds, some perennials	pronamide (Kerb SC)	2.5–5 pints	Do not use on vines less than 1 year old, on fall-transplanted stock that has been transplanted less than 1 year, or to spring-transplanted stock that has been transplanted less than 6 months.	No	3 K1
Annual grasses & broadleaf weeds	simazine (a: Princep 4L, b: Princep Caliber 90)	a: 2.0–4.0 quarts b: 2.2–4.4 pounds	For vineyards established at least 3 years. Princep Caliber 90 (EPA Reg No 100-603) requires a respirator for Mixers and Loaders. Princep 4L (EPA Reg No 100-526) does NOT require a respirator for any reason.	See notes	5 C1
Annual grasses, some broadleaf weeds	trifluralin (Treflan HFP)	1.0–4.0 pints	For newly planted and established vineyards. For newly planted vineyards, follow rate on label based on soil type.	No	3 K1
PRE-EMERGENCE AND EARLY POST-EMERGENCE WEED CONTROL					
Annual grasses & broadleaf weeds	diuron (Diuron 4L)	E WA 0.8–2.4 quarts W WA 1.6–2.4 quarts	For vineyards established at least 3 years.	All handlers	5 C2
Annual grasses & broadleaf weeds	flazasulfuron (Mission)	2.14–2.85 ounces	For vineyards established at least 3 years; nonporous wraps, grow tubes, waxed containers, or other protective sleeves are required for vines in their 3rd season of growth.	No	2 B
Annual broadleaf weeds	flumioxazin (Chateau SW)	6.0–12.0 ounces	For vineyards established at least 2 years.	No	14 E
Annual grasses & broadleaf weeds	oxyfluorfen (GoalTender)	2.5–4.0 pints for pre–emergence; 1.0–4.0 pints for post–emergence	For vineyards established at least 3 years.	No	14 E
Annual grasses & broadleaf weeds, some perennials	rimsulfuron (Matrix SG)	4.0 ounces	Crops must be established for 1 year before application (vines should be healthy and growing vigorously).	No	2 B
Annual broadleaf weeds	sulfentrazone (a: Zeus XC, b: Zeus Prime XC)	a: 8.0–12.0 fluid ounces b: 7.7–15.2 ounces	For vineyards established at least 3 years. Zeus Prime XC (a pre-mix with carfentrazone-ethyl) is available for grapes established at least 2 years.	No	14 E

*Rates as given are per acre of ground sprayed. For band or spot treatment, calculate rates according to the actual portion of an acre treated.

WEED MANAGEMENT PROGRAM FOR GRAPEVINES

MATERIAL PER ACRE TREATED*					
Weeds to be controlled	**Active ingredient and formulation**	**Rate of formulated product per application per treated acre**	**Vineyard age**	**Vineyard Application Requires Respirator**	**WSSA HRAC Codes**
POST-EMERGENCE WEED CONTROL					
Annual broadleaf weeds	carfentrazone-ethyl (Aim EC)	1.0–2.0 fluid ounces	Do not use in newly-transplanted vineyards.	No	14 E
Annual & perennial grass weeds	fluazifop (Fusilade DX)	6–24 fluid ounces	Labeled for use in bearing and non-bearing vineyards.	Hand-held applications for berry crops	1 A
Annual grasses & broadleaf weeds, top kill of perennial grasses	glufosinate (Rely 280)	1.5–2.56 quarts	Do not apply to vines established less than 1 year unless protected by non-porous wraps, grow tubes, or waxed containers.	No	10 H
Annual grass & broadleaf weeds, suppression of perennial weeds	tiafenacil (Gamma)	0.5-1.5 ounces	Do not apply to vines established less than 2 years unless protected by nonporous wraps, grow tubes, or waxed containers	No	14 E
Annual & perennial weed control	glyphosate (many trade names)	see product label	Use as a directed spray in established vineyards or for site preparation before transplanting new vines	No	9 G
Annual grasses & broadleaf weeds, top kill of perennial grasses	paraquat (Gramoxone SL 3.0)	1.7–2.7 pints		All handlers	22 O
Annual broadleaf weeds	pyraflufen-ethyl (Venue)	1.0–4.0 fluid ounces	Do not apply to vines established less than 1 year unless protected by non-porous wraps, grow tubes, or waxed containers.	No	14 E
Annual & perennial grass weeds	sethoxydim (Poast)	0.5–2.5 pints	Labeled for use in bearing and non-bearing vineyards.	No	1 A
Annual & perennial grass weeds	clethodim (Select Max)	9–16 fluid ounces	Labeled for use in non-bearing vineyards only.	No	1 A

*Rates as given are per acre of ground sprayed. For band or spot treatment, calculate rates according to the actual portion of an acre treated.

Black Vine Weevil

This pest has decreased in importance as producers have switched to drip irrigation systems. Black vine weevil generally overwinters in the immature, larval or grub stage. The young larvae feed on small roots and root hairs. Larger larvae feed on larger roots, quite often within a few inches of the crown. The larvae change to inactive pupae and remain in earthen cells 3 to 4 inches below the ground in mid-April. The first adults emerge about May 20, and emergence peaks about June 20. All black vine weevils are females; males are not known. Each weevil is capable of laying 300 to 500 eggs. The first eggs are laid about 3 weeks after the adults emerge. Therefore, a grower has about three weeks from the time the first weevils emerge until controls must be applied.

The adult is a black-snouted beetle approximately 1/2 inch long (12.7 mm), having small gold patches on the fused wing covers. The beetle cannot fly. Adult beetles feed on grape clusters during June and July. Damage consists of girdled berry stems or cluster stems. Severely injured clusters have berries that do not size or ripen properly. Occasionally berries or parts of clusters are chewed off. Weevils are active and do most of their damage at night. They return to the ground at daylight to hide under clumps of soil, debris, or loose bark at the base of the plant. Therefore a weevil population may go undetected for a long time.

Registered synthetic pyrethroid insecticides can be applied as rescue treatments if infestations are severe. Direct insecticide sprays at the crown (base of the vine) and up several feet from the soil surface. Pyrethroid insecticides are biologically disruptive and can cause populations of secondary pests, including spider mites, to flare.

Brown Marmorated Stink Bug

In the eastern United States, Brown Marmorated Stink Bug (BMSB) is an invasive insect that has had severe economic impacts on numerous commodities. BMSB was discovered in the Pacific Northwest several years ago. It has not yet been a problem in commercial vineyards because the population sizes remain relatively low in eastern Washington. Western Washington has higher populations, yet no vineyards have reported infestations.

Because BMSB populations are known to gradually build over several years before becoming an economic pest, the current focus in Washington vineyards is detection. There are many native stink bugs that look similar to BMSB, yet the combination of these three key characteristics can distinguish BMSB: 1) light and dark bands on the antennae, 2) smooth "shoulders" with no spikes, and 3) dark and light bands around the abdominal margins. Pictures and additional descriptions of each life stage can be found in the *Field Guide for Integrated Pest Management in Pacific Northwest Vineyards* (PNW644) or *https://www.stopbmsb.org/*. If you detect BMSB in your vineyard, please contact your local extension office or research center.

Cutworms

Cutworms are the larvae, or wormlike stage, of night-flying gray to brown moths. Several species or kinds of cutworms cause injury in vineyards.

Cutworms and related species usually overwinter as partially grown (2nd or 3rd instar) cutworms in the soil, or under debris in the vineyard. Young cutworms begin feeding on winter annual weeds, particularly mustards, during warm periods in February and March. By the time of bud break they are nearly full grown. They remain under cover (within cracks in soil or plant debris, or under rough bark on trunks) during the day, but climb the vines to feed on buds or shoots at night—or on cloudy days when light levels are low.

Euxoa spp. cutworm types overwinter as eggs which hatch about April 10. Young larvae may climb vines and feed on buds or shoots. Some years cutworm injury can begin in late March or early April (spotted cutworm) and continue through May into early June (redback cutworm). Damage to newly planted vines may mean loss of shoot growth (nothing to train) or death of the plant; damage to older vines may cause fruit production losses. Cutworm damage is often intensified by discing the cover crop in early May.

Managing cutworms

Sampling for spotted cutworms before or at the time of bud break is very difficult. Therefore, growers may wish to make prophylactic applications of pyrethroid barrier sprays targeted towards the base of the trunk for cutworm control based on one of the following criteria:

1. Since early season cutworms are difficult to find and injuries caused by 2nd or 3rd instars are small, the decision to spray may be based on the recent history of the vineyard. Usually, cutworm problems in established vineyards occur in the same portions of a vineyard each year. In those cases, a prophylactic application of a synthetic pyrethroid as barrier may be warranted.
2. Inspect vineyards carefully for presence of cutworms. The best method is scouting trunks and cordons after dark by flashlight. Injured buds may be an indication of spotted cutworm injury (late March–early April). Injured buds and new shoots may be caused by large spotted cutworms (mid-to late April) or redback cutworms (late April to early June). Apply sprays when bud injury reaches 5% to 10% of the total bud crop. Base sprays for shoot or cluster bud injury on the amount of injury and economics.
3. Newly planted vines need special protection. Frequently the disturbance of weeds or other cover in the planting process leaves little food for resident cutworms. Since there may only be a few buds on a young plant, injury by cutworms may be severe.

   Registered synthetic pyrethroid insecticides can be applied as rescue treatments if infestations are severe. Pyrethroid insecticides are biologically disruptive and can cause populations of secondary pests, including spider mites, to flare.

How to use insecticides for cutworms

Follow label instructions. A synthetic pyrethroid barrier should be sprayed at sufficient concentrations and directed in sufficient volume of water to cover the trunk of the vine from just above the soil surface to a height of between 16 and 18 inches. Red-eye sensors that control spray volume and discharge a targeted spray at only the base of trunks and vineyard posts are the most efficient method of applying the barrier sprays. Research has demonstrated that barrier sprays are most effective if they are applied during the first two weeks of March.

Registration limitations of the more effective materials complicate control. Begin control in the delayed-dormant (wooly bud) period, just before buds start to swell. If the treatment is for cutworms alone, direct spray to the trunks, wire, and posts leading from the ground to the cordons.

Drosophila suzukii

D. suzukii, also known by the unofficial common name of spotted wing drosophila (SWD) is a problem for many berry growers, but does not appear to affect undamaged grapes and does not warrant specific control. *D. suzukii* invaded all Washington State grape producing counties in 2010. It is a vinegar fly, but unlike other common and ubiquitous vinegar flies, SWD has a serrated ovipositor used to puncture undamaged fruit and lay eggs. We have direct observation of it infesting ripening cherry, raspberry, blueberry, and apricot; it has also been observed attacking other soft-flesh fruit such as nectarines, peaches, and volunteer fruits including blackberry and hawthorn.

Populations or prevalence of *D. suzukii* or SWD is greatly influenced by temperature. In Eastern Washington, populations have generally remained lower in the early and mid-season when temperatures are exceeding 90°F, yet populations rise later in the season when daytime temperatures are cooler. In Western Washington, where temperatures can be more moderate, populations can build through the season. In other grape growing regions, specific thin-skinned grape varieties can be infested by *D. suzukii*. Caution should be taken if vineyards are established with thin-skinned varieties.

Grape Flea Beetle

The grape flea beetle, *Altica chalybea*, is occasionally a serious pest of grapes in the Midwestern U.S. It is rarely a pest in the PNW but populations can develop that defoliate newly-planted, non-bearing vineyards in mid to late spring, especially when grow tubes are used on young vines. Grape flea beetles are shiny metallic blue and about 3/16 inch (4.8 mm) long. They have long antennae and swollen “thighs” (i.e., femora) on their last pair of legs. When the adults are disturbed they jump; hence the name flea beetle. The larvae are extremely cryptic and typically not observed. The adults are highly clustered in their distribution within a vineyard and can be observed in substantial abundance.

Larvae and adults feed on the upper and lower leaf surfaces producing a skeletonized or lacey appearance, although this injury is usually not serious. The most serious damage occurs in the spring as the larva emerge from overwintering sites and feed on newly swollen grape buds. The adult beetles chew holes in the sides and ends of the buds often hollowing out the whole bud only

leaving the overwintering scleritized bud sheath. Their feeding damages primary and occasionally secondary and tertiary buds and can be confused with cutworm damage. However, cutworm damage tends to be more apparent and occurs on multiple swelling buds on an individual vine. Flea beetle damage to buds in mature vineyards is more sporadic than cutworm damage and less severe after buds have grown to 1/2 inch (12.7 cm) or more. Young plants can sustain more damage even through mid-summer.

Monitoring for flea beetle should be done in conjunction with cutworm monitoring. Because of the similarities in feeding, the cutworm protocol should detect populations of grape flea beetle adults and their damage.

Control is most important in newly-established vineyards and typically not recommended on mature vines. Insecticides will reduce adult populations. Vineyards infested with flea beetle populations the prior season should be monitored rigorously in spring to control the larvae. Current recommendations are to apply insecticides for larvae if more than 4% of buds are damaged in young vineyards. There are numerous insecticides registered for the control of flea beetles on grapes. Some of the active ingredients that are effective are spinosad, spinetoram, chlorantraniliprole, imidacloprid, thiamethoxam, and acetamiprid.

Grape Leaffolder

A species of grape leaffolder *Desmia maculasis* has emerged as a pest in several AVAs in Washington state. It is a close relative to another grape leaffolder species that is an occasional pest in California, *Desmia funeralis*. Research is ongoing in Washington state to determine economic injury and a potential economic threshold for *Desmia maculasis* in Washington State vineyards. Damage from *Desmia funeralis* activity after fruit set is rarely a concern; in California, 20% damage to leaves has been observed without damage to fruit quality or ripening. Damage to yields may occur if severe leaffolding occurs before and during bloom, which would restrict photosynthesis. Only treat for leaffolders if extreme damage resulting in crop loss has occurred in the past. Treatments would have to be applied as soon as the first leafrolling is noticed; small larvae are more susceptible to chemical intervention than instars. Treatment options include Spinosad (Entrust SC), Spinetoram (Delegate WG) and chlorantraniliprole (Altacor). Outbreaks of *Desmia funeralis* are sporadic and biological control is often established in subsequent years. Follow label instructions.

Grape Mealybug

Grape mealybug is the primary vector for the complex of several viruses that are the causal agents for grapevine leafroll disease (GLRD). Most notably grape mealybugs are a very efficient vector for *Grapevine leafroll associated virus 3* (GVLRaV-3). GVLRaV-3 is the overwhelmingly predominant causal virus of leafroll disease in Washington state vineyards. Mealybug populations should be managed following the guidelines in this document. A combination of several chemigations or foliar applications of insecticides are sufficient for managing mealybug infestations. Research has documented that managing mealybugs does slow the spread of grape leafroll disease, however, increased insecticide applications in an attempt to eradicate mealybugs has not substantially slowed the spread of grape leafroll disease in vineyards. Disease severity and expression of GLRD symptoms varies among virus strains, grape varieties and climatic conditions. However, there is no cure treatment for GLRD and infected vineyards will produce lower yields and juice quality. A secondary contamination can occur in late-season vineyards when the honeydew excreted by mealybugs drips on the foliage, twigs, and fruit. Sooty mold, a black fungus, may grow on this honeydew, producing a sooty appearance. Serious contamination can destroy the market value of the crop for processing.

Adult grape mealybugs are about 1/4 inch (6.35 mm) long, pink to dark purple, and covered with a white waxy powder. Strands of the wax extend from the body. Eggs are yellow to orange and are laid in cottony egg sacs. Crawlers are tiny, 1/16 to 1/8 inch (1.25–3.1 mm) long, pink to tan, and quite active.

Mealybugs overwinter as eggs or crawlers in the egg sacs, usually in the bark cracks or under the bark scales on the trunk and in the arms or cordons. In the spring, crawlers move quickly to new growth to feed. They mature in June, and adults move back to older wood to lay eggs. A second generation of crawlers will move to new growth, including the fruit, where they mature through July and August. The honeydew produced by this generation may contaminate fruit.

Control procedures are most effective when the grape mealybug is in the crawler stage. Chemiga-

tion treatments with chloronicotinyl insecticides are registered for use on grapes. Chemigation treatments applied through drip irrigation can be effective at any time during the growing season. Irrigation water requirements for adequate distribution of systemic insecticides vary among products. Chemigation using imadacloprid has been an effective treatment available for grape mealybug control. Typically, it is applied in mid- to late-spring when the vineyard soil moisture is being held at or near field capacity. Chemigation with dinotefuran and thiamethoxam have proven effective when deficit irrigation is practiced through summer and fall. Depending on the product, thiamethoxam has a 30 to 60 day PHI for chemigation, so understand approximate harvest dates before applications are made. Foliar treatments can be applied to vineyards that are not irrigated by drip irrigation systems. Unfortunately, specific populations of grape mealybugs are showing signs of becoming tolerant to the neonicotinoid insecticides (ex. imidacloprid, thiamethoxam, dinotefuran). Other modes of insecticide classes should be rotated in with neonicotinoids. Research has demonstrated that foliar sprays of imidacloprid are not very effective at controlling grape mealybug infestations. Sprays of acetamiprid, dinotefuran, and thiamethoxam should be directed towards the trunk and cordon with sufficient water and pressure to get the pesticide into cracks and under loose bark. Movento should not be used in a delayed dormant application as it would be ineffective since it needs to be absorbed by actively growing tissue. Use sufficient water and pressure to loosen bark and drive the pesticide into cracks and under loose bark. Several insecticides have been registered recently that can control mealybugs. These include sulfoxaflor (Transform WG) and flupyridifuron (Sivanto Prime). Both can be applied through foliar applications and flupyridifuron can be applied through chemigation.

Grape mealybugs migrate from the clusters back to the cordons and main trunk between mid-August and mid-September. **Late summer spray applications for mealybug control are usually ineffective.** If large amounts of honeydew or honeydew and sooty mold are present on the fruit, a fungicide application may aid in disease suppression. Mealybugs will not exude honeydew after leaving the cluster.

A pheromone-based method has been developed for monitoring population abundance of mealybugs. Several companies have marketed pheromone lures (e.g., Trece) for grape mealybug. Our data indicates that traps should be placed in a density of at least 1 trap per 40 acres. Traps should be placed out in vineyards in late April. Specifically males are attracted to these traps. Males seeking mates begin to fly in late April and flights peak in late May to early June. These pheromone traps are specifically a useful tool for determining which vineyard blocks have the greatest abundance of mealybugs. These blocks should then be field-scouted directly to determine if the mealybug population abundance warrants further control actions. **Insecticides targeting the summer generation of mealybug crawlers should be applied 1 to 2 weeks following peak flights and trap capture of males.**

Phylloxera

Grape phylloxera is a tiny aphidlike insect that feeds on roots of *V. vinifera* grape and certain susceptible rootstocks, stunting growth of vines or killing them. It has been documented that phylloxera prefers heavy clay over sandy soils. Typically, phylloxera is not a consistent pest on soils >60% sand content. For more information on phylloxera, visit: *https://wine.wsu.edu/extension/pest-management/phylloxera/*.

While phylloxera is notorious for feeding on roots of *V. vinifera* wine grapes, there is another form that feeds on leaves. They are called Gallicoles. These gallicoles are wingless, cause leaf galls, and primarily found on some American grape species like *V. riparia*. To date this form of phylloxera has not been detected in grape growing regions of eastern Washington State. The predominant proportion of phylloxera in Washington state is the root feeding form called radicoles. These radicoles are the wingless root-feeding form of phylloxera. Radicoles can emerge occasionally as a winged form, called an alate. Research completed in California has concluded that the alates detected there are sterile. We have not detected any alates to date in Washington State.

The majority of grape phylloxera adults are wingless females. They are generally oval shaped, but those that lay eggs are pear shaped. Phylloxera adult females are small (0.04 inch long and 0.02 inch wide) and vary in color from yellow, yellowish green, olive green, light brown, brown, or orange. Newly deposited eggs are yellow, oval, and about twice as long as wide. The eggs transform to brown as they mature to hatch. Phylloxera are hemimetabolous insects, immature stages are called nymphs. Development proceeds in repeated stages of growth and ecdysis (moulting); these stages are

called instars. Juvenile phylloxera closely resemble adults, but are smaller and lack adult features such as wings (rare in adults) and genitalia.

Grape phylloxera overwinter as small nymphs on roots. In spring when soil temperatures exceed 60°F, they start feeding and growing. Optimum soil temperatures for phylloxera growth and development are between 70 to 86º F. First instar nymphs are active crawlers and may move from plant to plant in the ground, on the soil surface, or by blowing in the wind. We have observed the greatest abundance and movement of crawlers above ground in late June and mid-September indicating that 2 generations are developing in Washington state vineyards. They may also be moved between vineyards on cuttings, boots, or equipment. Established phylloxera feed externally in groups on roots. In fall when soil temperatures fall below 60°F, all life stages die except the small nymphs. There are three to five generations each year in California. Presently we think there are 2 generations per year in Washington State.

Damage

Grape phylloxera damage the root systems of grapevines by feeding on the root, either on growing rootlets, which then swell and turn yellowish, or on mature hardened roots, where swellings are often hard to see. Necrotic spots (areas of dead tissue) develop at the feeding sites on the roots. The necrotic spots are a result of secondary fungal infections that can girdle roots, killing large sections of the root system. Such root injury causes vines to become stunted, produce less fruit, and eventually kill the vine.

Root sampling

Initial infestations of grape phylloxera appear as a few weakened vines within the vineyard. These insects are difficult to detect in an apparently healthy vineyard. Therefore, monitor vines at harvest in an area of the vineyard that has consistently displayed weaker growth, especially vines at the edges of the weak areas. Grape phylloxera are more readily identified on vines growing in poor soils because their impact is greater on these vines than on vigorously growing vines.

In California it has been noted that phylloxera infested vines may exhibit symptoms similar to potassium deficiency. The infested area expands concentrically at a rate of two- to fourfold vines a year. Satellite infestations frequently establish downwind from larger infested areas. When searching for phylloxera, be aware that populations die out on declining vines. Therefore, concentrate monitoring efforts on the periphery of declining areas where damage symptoms are still minimal. Dig near the trunk of vines under the drip emitter and look for whitish yellow, hooked feeder roots that are galled. Examine the galls with a hand lens for the presence of phylloxera. If you cannot find any fine roots with branching, and only large roots remain, you will likely not find any phylloxera. In samples with fine roots, look for small galls on the fine root tips. The galls are similar in size and shape to mouse feces. The phylloxera insect ranges in color as it goes through different life stages, from bright yellow to pale yellow to a light brown as an adult. Adult female radicoles morphs of phylloxera are about 1 mm (0.4 inches) in size, and can be seen with the naked eye, but some form of magnification by hand lens or magnifying glass can be helpful.

Phylloxera Management

Rootstocks

Resistant rootstocks are the only completely effective means for phylloxera control in the most severely affected areas. Insecticide treatments will not eradicate phylloxera populations; the chemical cannot easily penetrate the heavy soils that this pest prefers. Also, effectiveness of a treatment is difficult to evaluate because although many phylloxera may be killed, populations may rebound rapidly and resume feeding on the vines. Because it may take years of insecticide treatments to reverse severe damage, treatments to prevent damage may be a better strategy than curative treatments. Unfortunately, there are only 2 classes of insecticides registered on grapes: neonicotinoids and lipid biosynthesis inhibitors. Most vineyards in Washington State have been treated routinely with neonicitinoids in the past. We have seen a decline on efficacy of imidacloprid on other heteropteran insects like grape mealybug. It is being investigated if extant mealybug and phylloxera populations in Washington State are becoming resistant to neonicotnyl insecticides like imidacloprid, thiamethoxam, clothianidin, or dinotefurone.

Biological Control

Little information on biological control of grape phylloxera is available. It is believed that environmental and root conditions are more important than natural enemies to phylloxera survivorship.

Insecticide treatment

Insecticide treatments can only suppress populations of phylloxera. The following insecticides are listed in order for efficacy and IPM fit by University of California Integrated Pest Management program: Spirotetramat, Imidacloprid, Clothianidin, Dinotefuran, Thiamethoxam. No insecticide efficacy has been developed by Washington State University. Insecticide efficacy trials will be completed over the next several years. Rates and specific notes for each active ingredient are listed in pesticide tables.

Leafhoppers

Two species of leafhoppers can be common in Washington State vineyards. These include the western grape leafhopper and the Virginia creeper leafhopper. In reports greater than 10 years old, the western grape leafhopper was the predominant species in Washington State. However, in recent surveys, the Virginia creeper leafhopper has become the predominant leafhopper in Washington vineyards. Recent research in Northern California has demonstrated that the endemic parasitoid guild that biologically regulates populations of western grape leafhopper are mostly ineffective against the invasive Virginia creeper leafhopper. We have no empirical evidence for this in Washington State, but this may account for the species replacement of the western grape leafhopper by the Virginia creeper leafhopper in Washington State vineyards in recent years. Leafhopper adults and nymphs generally feed on shaded leaves. In heavy infestations, they may move to sun leaves. In addition to causing leaf injury, some leafhoppers may secrete honeydew, which contaminates fruit.

There are two generations per year. Adults spend the winter in the vineyard on the fallen leaves and trash under the vines. They become active when the weather becomes warm in March or April, feeding on weeds and wild hosts until young grape leaves appear. Overwintering adults lay eggs in the leaf tissue on the underside of the leaf. Eggs hatch from mid-May to the end of June. New adults are active by the middle of June. Eggs of the second generation are laid in early July. These hatch by mid-July; adults are active on the vines until late fall.

Control is most effective if you treat vines when the leafhoppers are in the immature, nymphal stage. Most leafhopper infestations are clustered in a vineyard. Spot specific treatment of Concord vineyards may be recommended, since most infestations are rarely of economic proportions on Concord. Young wine grape vineyards or wine grape vineyards being managed for canopy development may suffer serious leafhopper injury when infestations exceed 60 leafhoppers per leaf. Foliar and drip chemigation with registered neonicotinyl insecticides are the most effective treatments available for control of leafhopper populations. Foliar sprays of registered chloronicotinyls, spirotetramat, flupyradifurone, and buprofezin, if timed correctly, can provide leafhopper control. In many vineyards leafhoppers are collateral kill in grape mealybug management programs.

The established treatment threshold for wine grape vineyards is 15 leafhoppers per leaf. A sequential sampling technique should be used in sampling for leafhoppers. First, a presence-absence technique—meaning not counting but assessing only if they are in the vineyard—can be used until close to 100% of the leaves are infested. Presence-absence sampling is not an efficient way of measuring leafhopper abundance at above 15-per-leaf densities. When 100% of the leaves are infested, a visible scan and count with a hand lens should be used to determine the actual density of leafhoppers present in the vineyard. Research has documented that when leafhopper counts exceed 15 per collected leaf, that it is an indication that 100% of the leaves have at least 1 leafhopper. However, economic damage is not suspected until threshold surpass 50 leafhoppers per leaf.

Mites

2-spotted Spider Mite and Willamette Mite

Problems with spider mites in eastern Washington are confined to *Vitis vinifera* wine grapes. Concord or similar American-type grapes are not affected. Willamette mite has largely replaced the two-spotted mite in Washington vineyards. Pacific mites that are commonly found in California do not affect Washington grapes.

Mites feed on young, tender leaves and shoot tips, causing scarred, stunted leaves which tend to cup or roll towards the undersurface. Injury stunts shoot tips and shortens the distance between leaf buds.

The development of high mite populations is favored by clean cultivation and dust, high temperatures, and low humidity. It is discouraged by the use of overhead sprinkler irrigation. Outbreaks of mites can follow the use of other pesticides in the pest control program.

Research has demonstrated that 100% of the leaves present in a vineyard are infested with mites when populations of mites exceed 15 mites per leaf.

Injury to fruit or reduction in juice quality is minimal at mite population densities of fewer than 30 mites per leaf after veraison. A binomial sampling technique for surveying mite abundance is recommended. The presence-absence sampling technique can be used until approximately 100% of the leaves are infested by mites. When mites are present on close to 100% of the leaves, a visual scan with a hand lens and a count of mites present on 20 leaves per sample site is recommended to quantify actual mite abundance in the vineyard. Research indicates that populations of mites below 30 mites per leaf are unlikely to damage an otherwise healthy vineyard. Other considerations include the presence or absence of beneficial arthropods that aid in the bioregulation of spider mites. These beneficial arthropods include several species of predatory mites, coccinelid ladybird beetles, lacewing larva, predatory bugs, and thrips. Care should be taken in choosing miticides that minimize harm to populations of these beneficial arthropods.

Bud Mites

Grape bud mites overwinter as small adults inside grape buds. They feed on bud tissue, either killing the bud overwinter, or resulting in very short, stunted, and zig-zag like shoots in the spring. An application of wettable sulfur in high water volume at the wooly-bud to budbreak stage is effective at bud mite control.

Grape Leaf Blister Mites (Erineum Mites)

Grape leaf blister mites are rarely of economic concern in commercial vineyards. While their characteristic galls on leaves (complete with a white downy underside of the galls) can be alarming, vines can survive a high level of infestation. Early season sulfur applications that are typically applied for powdery mildew or rust mite control are effective at controlling grape leaf blister mite. **Pesticide applications after blisters are visible are no longer effective.**

Rust Mite

Rust mite infestations have decreased in severity in vineyards over the past several years. Rust mites are primarily a nuisance pest and late season infestations are not likely to result in significant economic injury. Acaricide treatments are ineffective on late-season populations. An early season spray of 1.5 pounds per acre of wettable sulfur has proven to be an effective prophylactic control for rust mites. Vineyards infested the prior summer should be treated with sulfur early in the subsequent spring.

Plant-Parasitic Nematode Control

Plant-parasitic nematodes

Plant-parasitic nematodes are a major economic problem in every grape production region in the world. Plant-parasitic nematodes can cause direct and indirect damage to a vine. Nematode feeding can cause direct damage by stopping root elongation, killing plant tissue, changing root growth patterns, and by removing plant nutrients. These changes reduce the ability of the plant to translocate nutrients and water. Indirectly, plant-parasitic nematodes can damage plants by vectoring viruses or by increasing the severity of other plant diseases.

Plant-parasitic nematodes are present in nearly all natural and agricultural soils. The diversity of plant-parasitic nematodes in eastern Washington vineyards was determined in surveys conducted in 2003. The most commonly encountered plant-parasitic nematodes were northern root-knot (*Meloidogyne hapla*) and dagger (*Xiphinema* spp.) nematodes. *Meloidogyne hapla* is a sedentary endoparasite that invades roots and causes roots to gall. *Xiphinema* spp. are ectoparasites, and while feeding by these nematodes on grape roots may not result in direct damage to the plant, several species of *Xiphinema* can transmit tomato and tobacco ringspot viruses to grapevines. The ectoparasitic ring nematode (*Mesocriconema xenoplax*) was not commonly found in Washington vineyards. While ring nematode has been shown to reduce vine productivity in the Willamette Valley of Oregon, the impact of this nematode on vine productivity in semi-arid vineyards is unknown. Other plant-parasitic nematodes detected during the survey were lesion (*Pratylenchus* spp.), pin (*Paratylenchus* spp.), and lance (*Hoplolaiumus* spp.) nematodes. These nematodes are not considered significant pests of wine grapes.

Plant-parasitic nematode management

Once a vineyard is established there are few post-plant management practices that consistently and effectively reduce plant-parasitic nematode damage to established vines. Therefore, prevention is critical.

Sampling: The first step in managing plant-parasitic nematodes is to determine the species and densities of nematodes present in a field. Since nematodes are not uniformly distributed in a vineyard, the precision of estimating population levels increases with the number of subsamples collected. Prior to establishing a vineyard, a general rule is to

collect at least 20 cores along a "W" walk pattern in 2 to 5 acre area of a vineyard. Large vineyards should be partitioned by differences in soil type and crop history. Samples should be collected in areas where root growth occurred in the previous crop to a depth of 12 inches. **The best time to collect samples is from approximately mid-September to early November, when densities of many nematode species are at their highest.** Fall sampling also provides timely data on which to base management decisions before the next season. In established vineyards, samples should be collected within the root zone concentrated under emitters and roots should be included in the sample. Collect samples from affected and unaffected areas of a vineyard to enable comparisons in nematode population densities. Collected samples should be kept cool until delivery to a diagnostic laboratory.

Planting material: Only planting stock certified free of plant-parasitic nematodes should be used to establish a vineyard. The use of rootstocks may be a way to manage plant-parasitic nematodes. Rootstocks resistant to *M. hapla* nematode include '101-14 MGT', '110R', '3309C', '420A', 'Dog Ridge', 'Freedom', 'Harmony', 'Ramsey', 'Riparia Gloire', and 'St. George'. A field trial in a Washington vineyard demonstrated that '101-14 MGT', 'Teleki 5C', '1103P' and 'Harmony' are all excellent hosts for the dagger nematode. In western Washington where the ring nematode is common the rootstocks '420A' and '101-14 MGT' are highly resistant to this nematode, while '110R' is moderately resistant to the ring nematode. Variety selection may also be a means to reduce the impact of plant-parasitic nematodes. Field microplot and greenhouse experiments indicate that white grape varieties (Chardonnay and Riesling) are better hosts for root-knot nematode than red grape varieties (Cabernet Sauvignon, Syrah, Merlot). In particular, Riesling and Chardonnay clones supported ten times greater reproduction of northern root-knot nematode when compared to Merlot clones. In a preplant situation where root-knot nematode population densities are high and other preplant treatments cannot be used, the planting of a red grape variety may slow population increase, and the potential impact of northern root-knot nematode on the new planting.

Chemical: While preplant fumigation is a common recommendation for control of plant-parasitic nematodes, recent studies in Washington State show that it is effective for long-term management of *M. hapla*.

There are several post-plant nematicides registered for use on grapes in Washington, however, the efficacy of many of these products in reducing plant-parasitic nematode population densities in this region has not been demonstrated. If a post-plant nematicide is applied to a vineyard, application timing is critical. Research has demonstrated that the mobile, infective stage of the northern root-knot nematode is highest in abundance in the spring and in the fall. Therefore nematicide applications after approximately May 1st and before September 1st would potentially be less effective than earlier or later in the season.

Cultural: Waiting one year between vine removal and replanting will reduce nematode populations in soil. An important component of a fallow period is weed control since many weeds are also hosts for plant-parasitic nematodes. Proper irrigation and fertilizer application also reduce stress on vines and help to lessen the effect of plant-parasitic nematodes.

Cover crops: The role that cover crops may play in reducing plant-parasitic nematode populations in areas to be planted to vines is unclear. Cover crops that have received attention in Washington for the management of nematodes include mustards, arugula, and sudangrass. Some cover crops can be hosts for nematodes, therefore, it is important to know which nematodes are present for proper cover crop selection.

Scale Insects

Scale insects can damage fruit by leaving honeydew and transmitting viruses. Damage by some scale insects is caused by the young crawler sucking "sap" from the vines and shoots. A honeydew is then formed and drips on leaves and fruit. This can result in the development of Sooty Mold (see Diseases of Grapevines). However, another concern of scale insects is that some can vector Grapevine leafroll-associated viruses (GLRaVs) (see Viruses of Grapevines).

The most common scale insect in Washington is the European fruit lecanium scale, however, other scale insects like cottony maple scale and oyster scale have been noted as pests. Scales can vary in size and shape and are often difficult to detect as they live under bark and in crevices. They can be 1/16 to 1/4 inch long, depending on the scale. The lecanium scale changes the color of its rounded protective shell from pale colored to darker brown as the season progresses. The cottony maple scale is most recognized by the cottony white sticky masses that cover hundreds of eggs in early summer. Control for scale insects should always be done in the spring when crawlers and eggs are present.

Thrips

Thrips are small (1/16-inch, 1.5 mm) insects, usually found in association with flowers. In vineyards thrips overwinter in the leaf litter as mature females. Early in the spring, thrips develop on weeds and later move up to feed on grape foliage.

Thrips feeding in April can severely stunt leaf and shoot growth. Injured leaves may at first glance be confused with 2,4-D or mite injury. Careful inspection will reveal scarred midribs and veins on the underside of leaves. Injury to the shoot may result in shortened internodes (the distance between leaves), producing a stunted appearance. Thrips may scar very young berries. Later the scars restrict berry growth, producing odd-shaped or split berries.

Adult thrips are winged and may fly when the leaves are disturbed. However, the wingless, yellow to yellow-orange nymphs may be observed. Control of thrips will bring resumed normal growth of leaves and shoots. Earlier injury remains as a record of the infestation. High populations of thrips can be associated with high spider mite populations. Insecticidal control of thrips infestations has proven difficult. Spinosad can provide control in warm weather conditions. Pyrethroids are not recommended for thrips control on wine grapes.

PEST MANAGEMENT PROGRAM FOR GRAPEVINES

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			Material per Acre Treated					
Pests to be Controlled	**Materials & Formulation**	**IRAC MoA No.***	**Formulated Material**	**Min. Days Before Harvest**	**Remarks**	**Effect on Beneficials**	**RT25 Bee Mortality**	**Requires Respirator**
PRE-PLANT								
Nematodes	1. 1,3-dichloropropene (Telone II)		35 gallons		Check label for re-entry time for planting.	Excessive use harmful		Yes
	2. metam sodium (Vapam HL)		50–75 gallons		Check label for re-entry time for planting.	Excessive use harmful		Yes
	3. Many rootstocks are resistant to nematodes and an appropriate choice for long-term nematode management.							
POST-PLANT								
Nematodes	1. *Myrothecium verrucaria* (DiTera DF)		15 pounds		Labeled for organic production, microbial metabolic byproduct.	Safe		Mixers/ Loaders
	2. spirotetramat (Movento)	23	6.0–8.0 fluid ounces	7	Do not apply more than 12.5 fluid ounces per acre per season. Use a non-ionic, high quality adjuvant to obtain effective full canopy applications and uptake through tissues. Interval between applications is 30 days. Needs to be absorbed by green leaf or stem tissue, and translocated by the plant to the sucking insect. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.			No
	3. Rotational crops such as mustards, arugulas, and sudangrass can suppress populations of nematodes. However, you must know the nematode species present, as certain crops are more effective at suppressing specific nematodes than others. Thus, these crops are best if grown in a mix.							

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Pests to be Controlled	Materials & Formulation	IRAC MoA No.*	Formulated Material	Min. Days Before Harvest	Remarks	Effect on Beneficials	RT25 Bee Mortality	Requires Respirator
DORMANT TO DELAYED-DORMANT (WOOLY BUD)								
Scale insects	1. horticultural mineral oil (Damoil)		4.0–6.0 gallons per 200–300 gallons water/ acre; 1.0–2.0 gallons per 200–300 gallons water/ acre when tank-mixed with other pesticides		Apply late March to early April. Direct spray to trunk and main cordons. Do not apply horticultural mineral oil at these concentrations after bud break with green tissue.	Moderately harmful		No
DELAYED-DORMANT (WOOLY BUD) TO BUD BREAK								
Scale insects	1. horticultural mineral oil (Damoil)		0.75 gallons per 100 gallons water/ acre		May give only marginal control.	Moderately harmful		No
Cutworms	1. fenpropathrin (Danitol 2.4 EC)	3A	Follow label instructions		Barrier spray to trunk and posts in early- to mid-March.	Extremely hazardous	192-336	No
	2. bifenthrin (Brigade 2EC)	3A	Follow label instructions		Barrier spray to trunk and posts in early- to mid-March.	Extremely hazardous		No
	3. beta-cyfluthrin (Baythroid XL)	3A	2.4–3.2 fluid ounces	3	Barrier spray to trunk and posts in early- to mid-March.	Extremely hazardous	240	Aerial and chemigation
	4. zeta-cypermethrin (Mustang Maxx)	3A	2.0–4.0 fluid ounces	1	Barrier spray to trunk and posts in early- to mid-March.	Extremely hazardous	96	No
	5. chlorantraniliprole (Altacor)	28	3–4.5 ounces per acre	14	Do not apply more than 9 ounces Altacor or 0.2 pounds of active ingredient of chlorantraniliprole containing products per acre per crop per season. The minimum interval between treatments is 7 days. Thorough coverage is essential to achieve best results. Select a spray volume appropriate for the size of vines and density of foliage. For best results apply 100–150 gallon water per acre. Do not apply dilute applications of more than 200 gallon water per acre. Do not apply less than 30 gallon water per acre.	Safe	3	No
BUD BREAK TO PREBLOOM (15 inch Shoot Growth)								
Scale insects	1. horticultural mineral oil (Damoil)		0.75 gallons per 100 gallons water/acre		May give only marginal control.	Moderately harmful		No
Cutworms	1. spinosad (Success)	5	4.0–8.0 fluid ounces	7	More effective when temperatures exceed 70°F. Do not use more than 0.45 pound of active ingredient per acre per season.	Safe	3	No
	2. spinetoram (Delegate WG)	5	3.0–5.0 ounces	3				No
	3. chlorantraniliprole (Altacor)	28	3–4.5 ounces per acre	14	Do not apply more than 9 ounces Altacor or 0.2 pounds of active ingredient of chlorantraniliprole containing products per acre per crop per season. The minimum interval between treatments is 7 days. Thorough coverage is essential to achieve best results. Select a spray volume appropriate for the size of vines and density of foliage. For best results apply 100–150 gallon water per acre. Do not apply dilute applications of more than 200 gallon water per acre. Do not apply less than 30 gallon water per acre.	Safe	3	No

* To help prevent the development of resistance, rotate chemicals with a different mode-of-action (IRAC number), and do not use products with the same mode-of-action twice per season. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at *http://www.irac-online.org/*

PEST MANAGEMENT PROGRAM FOR GRAPEVINES

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Pests to be Controlled	Materials & Formulation	IRAC MoA No.*	Formulated Material	Min. Days Before Harvest	Remarks	Effect on Beneficials	RT25 Bee Mortality	Requires Respirator
Grape leafhopper, Grape mealybug	1. buprofezin (Applaud 70DF)	16	9.0–12.0 ounces	7	Target young nymphs on vines and leaves. Make no more than 2 applications per season.	Safe		No
	2. potassium salts of fatty acids (M-Pede)	NC	2 gallons/100 gallon spray	0 (REI = 12 hrs)	Apply M-Pede in 100 to 200 gallons of water per acre from mid-June to late July.	Moderately harmful		No
	3. imidacloprid (Admire Pro)	4A	Foliar: 1.0–1.4 fluid ounces Soil: 7.0–14.0 fluid ounces	0 (REI = 12 hrs) 30	Maximum foliar rate allowed is 2.8 fluid ounces per acre per year. Maximum soil rate allowed is 14 fluid ounces per acre per year. Drip-applied imidacloprid should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Potential insecticide resistance in mealybug populations exposed to previous imidicloprid applications. Use a different IRAC group if control efficacy is reduced.	Moderately harmful	2-8	No
	4. dinotefuran (Venom)	4A	Foliar: 1.0–3.0 ounces Soil: 5.0–7.5 ounces	1 28	Regardless of application method do not apply more than a total of 12 oz Venom per acre per season. Foliar application is limited to 6 ounces and soil application is limited to 7.5 ounces per acre per season.	Moderately harmful	39	No
	5. thiamethoxam (Platinum)	4A	8.0–17.0 fluid ounces	60	Only two applications per season are allowed and can not total more than 17 ounces per acre. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.			No
	6. spirotetramat (Movento)	23	6.0–8.0 fluid ounces	7	Do not apply more than 12.5 fluid ounces per acre per season. Use a non-ionic, high quality adjuvant to obtain effective full canopy applications and uptake through tissues. Interval between applications is 30 days. It needs to be absorbed by actively growing green leaf or stem tissue, and translocated by the plant to the sucking insect to protect honey bees, apply only during late evening, night, or early morning when bees are not present.	Moderately safe		No
	7. flupyradifurone (Sivanto Prime)	4D	Foliar: 7–10.5/ 12.0–14.0 ounces Soil: 21.0–28.0 fluid ounces/ acre	0 30	Foliar applications have a minimum of 10 days between treatments in 50 gallons/acre for ground applications. For either foliar or soil chemigation, do not apply more than 28 fluid ounces of Sivanto Prime (or 0.365 pounds of all flupyradifurone products) in a single season.	Safe	3	No
	8. sulfoxaflor (Transform WG)	4C	1.5–2.75 ounces/acre	7	Minimum interval between applications is 7 days. Do not apply more than 8.5 oz of Transform (0.266 pounds of any sulfoxaflor) product in a single season. Do not apply more than 4 treatments per year and no more than 2 consecutive applications of products with sulfoxaflor.	Moderately safe	3	No
Thrips	1. spinosad (Success)	5	4.0–8.0 fluid ounces	7	More effective when temperatures exceed 70°F. Do not use more than 0.45 pound of active ingredient per acre per season. Needs to be absorbed by green leaf or stem tissue, and translocated by the plant to the sucking insect.	Moderately harmful	3	No

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Pests to be Controlled	Materials & Formulation	IRAC MoA No.*	Formulated Material	Min. Days Before Harvest	Remarks	Effect on Beneficials	RT25 Bee Mortality	Requires Respirator
Phylloxera	1. spirotetramat (Movento)	23	8.0 fluid ounces	7 (REI = 24 hrs)	Multiple applications over several years reduces, not eliminate, phylloxera populations. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Do not apply more than 12.5 fluid ounces per acre per season. Use a non-ionic, high quality adjuvant to obtain effective full canopy applications and uptake through tissues. Apply with enough water to provide complete coverage. Interval between applications is 30 days. Needs to be absorbed by green leaf or stem tissue, and translocated by the plant to the sucking insect.			No
	2. imidacloprid (Admire Pro)	4A	Soil: 14.0 fluid ounces	30 (REI = 12 hrs)	Multiple applications over several years reduces, not eliminate, phylloxera populations. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Do not exceed 0.5 lb or 14 fluid ounces per acre per year.	Moderately harmful	2-8	No
	3. clothianidin (Belay-Soil)	4A	6.0–12.0 fluid ounces	30 (REI = 12 hrs)	Apply to soil. Multiple applications over several years reduces, not eliminate, phylloxera populations. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.			No
	4. dinotefuran (Venom)	4A	Soil: 5.0–7.5 ounces	28 (REI = 12 hrs)	Apply to soil and limit application to 7.5 ounces per acre per season. If using foliar applications for other pests, do not apply more than a total of 12 oz dinotefuran per acre per season. Multiple applications over several years reduces, not eliminate, phylloxera populations. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.	Moderately harmful	39	No
	5. thiamethoxam (Platinum)	4A	17.0 fluid ounces	60 (REI = 12 hrs)	Only two applications per season are allowed and can not total more than 17 ounces per acre. Multiple applications over several years reduces, not eliminate, phylloxera populations. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.	Moderately harmful		No

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Pests to be Controlled	Materials & Formulation	IRAC MoA No.*	Formulated Material	Min. Days Before Harvest	Remarks	Effect on Beneficials	RT25 Bee Mortality	Requires Respirator
BLOOM TO PEASIZE FRUIT								
Grape leafhopper, Grape mealybug	1. imidacloprid (Admire Pro)	4A	Soil: 7.0–14.0 fluid ounces Foliar: 1.0–1.4 fluid ounces	30 0 (REI = 12 hrs)	Maximum foliar rate allowed is 2.8 fluid ounces per acre per year. Maximum soil rate allowed is 14 fluid ounces per acre per year. Drip-applied imidacloprid should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Potential insecticide resistance in mealybug populations exposed to previous imidicloprid applications. Use a different IRAC group if control efficacy is reduced.	Moderately harmful	2-8	No
	2. spirotetramat (Movento)	23	6.0–8.0 fluid ounces	7	Do not apply more than 12.5 fluid ounces per acre per season. Use a non-ionic, high quality adjuvant to obtain effective full canopy applications and uptake through tissues. Interval between applications is 30 days. Needs to be absorbed by green leaf or stem tissue, and translocated by the plant to the sucking insect. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.			No
	3. buprofezin (Applaud 70DF)	16	9.0–12.0 ounces	7	Target young nymphs on vines and leaves. Make no more than two applications per season.	Safe		No
	4. dinotefuran (Venom)	4A	Foliar: 1.0–3.0 ounces Soil: 5.0–7.5 ounces	1 28	Regardless of application method do not apply more than a total of 12 oz Venom per acre per season. Foliar application is limited to 6 ounces and soil application is limited to 7.5 ounces per acre per season. Sprays should be directed towards the trunk and cordons. Use sufficient water and pressure to loosen bark and drive the pesticide into cracks and under loose bark.	Moderately harmful	39	No
	5. acetamiprid (Assail 70WP)	4A	1.1–2.3 ounces	3	Sprays should be directed towards the trunk and cordons. Use sufficient water and pressure to loosen bark and drive the pesticide into cracks and under loose bark. Only two applications per season are allowed. Respirator required for mixer/loader for aerial application.	Moderately harmful		See Notes
	6. thiamethoxam (Platinum)	4A	8.0–17.0 fluid ounces	60	Only two applications per season are allowed and can not total more than 17 ounces per acre. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.	Moderately harmful		No
	7. thiamethoxam (Actara)	4A	1.5–3.5 ounces	5		Moderately harmful		No
	8. flupyradifurone (Sivanto Prime)	4D	Foliar: 7–10.5/ 12.0–14.0 ounces Soil: 21.0–28.0 fluid ounces/ acre	0 30	Foliar applications have a minimum of 10 days between treatments in 50 gallons/acre for ground applications. For either foliar or soil chemigation, do not apply more than 28 fluid ounces of Sivanto Prime (or 0.365 pounds of all flupyradifurone products) in a single season.		3	No
	9. sulfoxaflor (Transform WG)	4C	1.5–2.75 ounces/acre	7	Minimum interval between applications is 7 days. Do not apply more than 8.5 oz of Transform (0.266 pounds of any sulfoxaflor) product in a single season. Do not apply more than 4 treatments per year and no more than 2 consecutive applications of products with sulfoxaflor.		3	No

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Pests to be Controlled	Materials & Formulation	IRAC MoA No.*	Formulated Material	Min. Days Before Harvest	Remarks	Effect on Beneficials	RT25 Bee Mortality	Requires Respirator
BLOOM TO PEA SIZE FRUIT (continued)								
Phylloxera	1. spirotetramat (Movento)	23	8.0 fluid ounces	7 (REI = 24 hrs)	Multiple applications over several years reduces, not eliminate, phylloxera populations. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Do not apply more than 12.5 fluid ounces per acre per season. Use a non-ionic, high quality adjuvant to obtain effective full canopy applications and uptake through tissues. Apply with enough water to provide complete coverage. Interval between applications is 30 days. Needs to be absorbed by green leaf or stem tissue, and translocated by the plant to the sucking insect.			No
	2. imidacloprid (Admire Pro)	4A	Soil: 14.0 fluid ounces	30 (REI = 12 hrs)	Multiple applications over several years reduces, not eliminate, phylloxera populations. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Do not exceed 0.5 lb or 14 fluid ounces per acre per year.	Moderately harmful	2-8	No
	3. clothianidin (Belay-Soil)	4A	6.0–12.0 fluid ounces	30 (REI = 12 hrs)	Apply to soil. Multiple applications over several years reduces, not eliminate, phylloxera populations. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.		112-512	No
	4. dinotefuran (Venom)	4A	Soil: 5.0–7.5 ounces	28 (REI = 12 hrs)	Apply to soil and limit application to 7.5 ounces per acre per season. If using foliar applications for other pests, do not apply more than a total of 12 oz dinotefuran per acre per season. Multiple applications over several years reduces, not eliminate, phylloxera populations. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.	Moderately harmful	39	No
	5. thiamethoxam (Platinum)	4A	17.0 fluid ounces	60 (REI = 12 hrs)	Only two applications per season are allowed but no more than 17oz/acre are allowed annually. Multiple applications over several years reduces, not eliminate, phylloxera populations. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.	Moderately harmful		No

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PEA SIZE FRUIT TO VÉRAISON								
Grape mealybug, Grape leafhopper	1. imidacloprid (Admire Pro)	4A	Foliar: 1.0–1.4 fluid ounces Soil: 7.0–14.0 fluid ounces	0 (REI = 12 hrs) 30	Maximum foliar rate allowed is 2.8 fluid ounces per acre per year. Drip-applied imidacloprid should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Potential insecticide resistance in mealybug populations exposed to previous imidicloprid applications. Use a different IRAC group if control efficacy is reduced.	Safe	2-8	No
	2. buprofezin (Applaud 70DF)	16	9.0–12.0 ounces	7	Target young nymphs on vines and trees. Make no more than two applications per season.	Safe		No
	3. dinotefuran (Venom)	4A	Foliar: 1.0–3.0 ounces Soil: 5.0–7.5 ounces	1 28	Regardless of application method do not apply more than a total of 12 oz Venom per acre per season. Foliar application is limited to 6 ounces and soil application is limited to 7.5 ounces per acre per season. Sprays should be directed towards the trunk and cordons. Use sufficient water and pressure to loosen bark and drive the pesticide into cracks and under loose bark.	Moderately harmful	39	No
	4. acetamiprid (Assail 70WP)	4A	1.1–2.3 ounces	3	Sprays should be directed towards the trunk and cordons. Use sufficient water and pressure to loosen bark and drive the pesticide into cracks and under loose bark. Only two applications per season are allowed. Respirator required for mixer/loader for aerial application.	Moderately harmful		See Note
	5. spirotetramat (Movento)	23	6.0–8.0 fluid ounces	7	Do not apply more than 12.5 fluid ounces per acre per season. Use a non-ionic, high quality adjuvant to obtain effective full canopy applications and uptake through tissues. Interval between applications is 30 days. Needs to be absorbed by *actively growing* green leaf or stem tissue, and translocated by the plant to the sucking insect. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.			No
	6. thiamethoxam (Platinum)	4A	8.0–17.0 fluid ounces	60	Only two applications per season are allowed and can not total more than 17 ounces per acre. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.	Moderately harmful		No
	7. thiamethoxam (Actara)	4A	1.5–3.5 ounces	5		Moderately harmful		No
	8. flupyradifurone (Sivanto Prime)	4D	Foliar: 7–10.5/ 12.0–14.0 ounces Soil: 21.0–28.0 fluid ounces/ acre	0 30	Foliar applications have a minimum of 10 days between treatments in 50 gallons/acre for ground applications. For either foliar or soil chemigation, do not apply more than 28 fluid ounces of Sivanto Prime (or 0.365 pounds of all flupyradifurone products) in a single season.		3	No
	9. sulfoxaflor (Transform WG)	4C	1.5–2.75 ounces/acre	7	Minimum interval between applications is 7 days. Do not apply more than 8.5 oz of Transform (0.266 pounds of any sulfoxaflor) product in a single season. Do not apply more than 4 treatments per year and no more than 2 consecutive applications of products with sulfoxaflor.		3	No
Mites	1. bifenazate (Bizate 50WDG)	20D	0.75–1.0 pound	14		Safe	3	No
	2. fenpyroximate (FujiMite SC)	21A	2.0 pints	14	Apply before the mite population reaches an outbreak population density. Some formulations of this active ingredient will require a respirator. For example, Fujimite XLO requires a respirator, but Fujimite SC does not.	Safe		See Note

* To help prevent the development of resistance, rotate chemicals with a different mode-of-action (IRAC number), and do not use products with the same mode-of-action twice per season. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at *http://www.irac-online.org/*

PEST MANAGEMENT PROGRAM FOR GRAPEVINES

The brand names shown are for demonstration purposes only. The formulation and rates are specific to that example.
In most chemicals, there are other labeled products with the same active ingredient.

Pests to be Controlled	Materials & Formulation	IRAC MoA No.*	Formulated Material	Min. Days Before Harvest	Remarks	Effect on Beneficials	RT25 Bee Mortality	Requires Respirator
	3. abamectin (Agri-Mek SC)	6	1.75–3.5 fluid ounces	28	Always use with a nonionic surfactant and sufficient gallonage for coverage.	Moderately harmful	7.96	No
	4. spirodiclofen (Envidor 2SC)	23	16.0–34.0 fluid ounces	14	Apply in a minimum of 50 gallons/acre and fully cover the wood and foliage. One application per year is allowed.			No
	5. propargite (Omite 30WS)	12C	5.0–9.0 pounds	21	Respirator required to be on hand for Mixer/Loaders with water soluble packets.	Safe		See Note
Thrips	1. spinosad (Success)	5	4.0–8.0 fluid ounces	7	More effective when temperatures exceed 70˚F. Do not use more than 0.45 pounds of active ingredient per acre per season.	Safe	3	No
Phylloxera	1. spirotetramat (Movento)	23	8.0 fluid ounces	7 (REI = 24 hrs)	Multiple applications over several years reduces, not eliminate, phylloxera populations. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Do not apply more than 12.5 fluid ounces per acre per season. Use a non-ionic, high quality adjuvant to obtain effective full canopy applications and uptake through tissues. Apply with enough water to provide complete coverage. Interval between applications is 30 days. Needs to be absorbed by green leaf or stem tissue, and translocated by the plant to the sucking insect.			No
	2. imidacloprid (Admire Pro)	4A	Soil: 14.0 fluid ounces	30 (REI = 12 hrs)	Multiple applications over several years reduces, not eliminate, phylloxera populations. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Do not exceed 0.5 lb or 14 fluid ounces per acre per year.	Moderately harmful	2-8	No
	3. clothianidin (Belay-Soil)	4A	6.0–12.0 fluid ounces	30 (REI = 12 hrs)	Apply to soil. Multiple applications over several years reduces, not eliminate, phylloxera populations. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.		112-512	No
	4. dinotefuran (Venom)	4A	Soil: 5.0–7.5 ounces	28 (REI = 12 hrs)	Apply to soil and limit application to 7.5 ounces per acre per season. If using foliar applications for other pests, do not apply more than a total of 12 oz dinotefuran per acre per season. Multiple applications over several years reduces, not eliminate, phylloxera populations. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.	Moderately harmful	39	No
	5. thiamethoxam (Platinum)	4A	17.0 fluid ounces	60 (REI = 12 hrs)	Only two applications per season are allowed but no more than 17oz/acre are allowed annually. Multiple applications over several years reduces, not eliminate, phylloxera populations. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.	Moderately harmful		No

* To help prevent the development of resistance, rotate chemicals with a different mode-of-action (IRAC number), and do not use products with the same mode-of-action twice per season. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at *http://www.irac-online.org/*

PEST MANAGEMENT PROGRAM FOR GRAPEVINES

The brand names shown are for demonstration purposes only. The formulation and rates are specific to that example.
In most chemicals, there are other labeled products with the same active ingredient.

Pests to be Controlled	Materials & Formulation	IRAC MoA No.*	Formulated Material	Min. Days Before Harvest	Remarks	Effect on Beneficials	RT25 Bee Mortality	Requires Respirator
VÉRAISON TO PREHARVEST								
Grape mealybug, Grape leafhopper	1. imidacloprid (Admire Pro)	4A	Foliar: 1.3–1.4 fluid ounces	0 (REI = 12 hrs)	Maximum foliar rate allowed is 2.8 fluid ounces per acre per year. Drip-applied imidacloprid should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant, therefore soil applied application not recommended for most WA vineyards at this stage. Potential insecticide resistance in mealybug populations exposed to previous imidicloprid applications. Use a different IRAC group if control efficacy is reduced.	Safe	2-8	No
	2. buprofezin (Applaud 70DF)	16	9.0–12.0 ounces	7	Target young nymphs on vines and leaves. Make no more than two applications per season.	Safe		No
	3. dinotefuran (Venom)	4A	Foliar: 1.0–3.0 ounces Soil: 5.0–7.5 ounces	1 28	Regardless of application method do not apply more than a total of 12 oz Venom per acre per season. Foliar application is limited to 6 ounces and soil application is limited to 7.5 ounces per acre per season. Soil application has a 28 day pre-harvest interval and may be inappropriate at this plant stage or limit harvest dates. Sprays should be directed towards the trunk and cordons. Use sufficient water and pressure to loosen bark and drive the pesticide into cracks and under loose bark.	Moderately harmful	39	No
	4. acetamiprid (Assail 70WP)	4A	1.1–2.3 ounces	3	Sprays should be directed towards the trunk and cordons. Use sufficient water and pressure to loosen bark and drive the pesticide into cracks and under loose bark. Only two applications per season are allowed. Respirator required for mixer/loader for aerial application.	Moderately harmful		See Note
	5. spirotetramat (Movento)	23	6.0–8.0 fluid ounces	7	Do not apply more than 12.5 fluid ounces per acre per season. Use a non-ionic, high quality adjuvant to obtain effective full canopy applications and uptake through tissues. Interval between applications is 30 days. Needs to be absorbed by *actively growing* green leaf or stem tissue, and translocated by the plant to the sucking insect. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.			No
	6. thiamethoxam (Platinum)	4A	8.0–17.0 fluid ounces	60	Note the 60 day pre-harvest interval may limit harvest dates if applied at this time of year. Only two applications per season are allowed and can not total more than 17 ounces per acre. Soil moisture is important for effectiveness. Drip-applied applications should not be used when vines are also under water stress (regulated deficit irrigation) as the product will not be taken up by the plant. Chemigate when vineyard is at or near field capacity. Follow label instructions carefully.	Moderately harmful		No
	7. thiamethoxam (Actara)	4A	1.5–3.5 ounces	5		Moderately harmful		No
	8. flupyradifurone (Sivanto Prime)	4D	Foliar: 7–10.5/ 12.0–14.0 ounces Soil: 21.0–28.0 fluid ounces/ acre	0 30	Foliar applications have a minimum of 10 days between treatments in 50 gallons/acre for ground applications. Soil application has a 30-day pre-harvest interval and may be inappropriate at this plant stage or limit harvest dates. For either foliar or soil chemigation, do not apply more than 28 fluid ounces of Sivanto Prime (or 0.365 pounds of all flupyradifurone products) in a single season.		3	No
	9. sulfoxaflor (Transform WG)	4C	1.5–2.75 ounces/acre	7	Minimum interval between applications is 7 days. Do not apply more than 8.5 oz of Transform (0.266 pounds of any sulfoxaflor) product in a single season. Do not apply more than 4 treatments per year and no more than 2 consecutive applications of products with sulfoxaflor.		3	No

* To help prevent the development of resistance, rotate chemicals with a different mode-of-action (IRAC number), and do not use products with the same mode-of-action twice per season. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at *http://www.irac-online.org/*

Several types of disease organisms, in addition to nematodes, can affect grapes. While a number of potential problems exist, only a few are of economic importance in Washington State.

WSU has an online system called AgWeatherNet that uses weather data to detect and alert users when conditions are favorable for disease outbreak (*http://weather.wsu.edu*). Check AgWeatherNet frequently during the growing season to see if conditions are favorable for disease outbreaks. In addition, see *Field Guide for Integrated Pest Management in Pacific Northwest Vineyards* (PNW644) for a visual key to several grape diseases.

Trunk and Root Diseases

Crown Gall

This bacterial disease is widespread. Crown gall has especially plagued young vines and is associated with freezing injury. Low temperatures, particularly occurring early in winter, lead to high incidence of crown gall.

The bacterium infects plants through wounds (such as those that occur during propagation of cuttings) or through root lesions. The bacterium survives systemically in symptomless grapevines and can be carried in dormant grape cuttings used in the propagation of plants.

The first symptoms are swellings on wood that is more than 2 years old. Young galls are soft, creamy to greenish, with no bark or covering. As the tissue ages, it darkens to brown. The surface can become hard and very rough and black as it dies.

Planting certified stock reduces the potential risk of crown gall as these plants are visually free of gall symptoms. Use certified stock that came from a Foundation Program that uses microtip propagation. Protect vines from freezing injury. Avoid wounding plants during cultivation and discard plants with galls. Soil fumigation has not been effective in eradicating the crown gall bacterium. (See *https://wine.wsu.edu/extension/pest-management/* for more information on Crown Gall.)

Eutypa Dieback

Eutypa dieback of grapevine is an important grape disease in Washington and throughout the world. Disease incidence is especially high in older vineyards where large pruning wounds were made to alter the training system. Most commercial grape cultivars are affected by this disease. Both young and old vines are susceptible. However, Eutypa dieback is generally not found in vines younger than 5 years old.

Symptoms of Eutypa dieback include stunting of spring shoot growth, yellowing and cupping of newly emerged leaves, shedding of blossom clusters, vascular discoloration, and cankers in stems associated with old pruning wounds. In advanced stages, part or all of a vine will die. Symptoms are best seen in the spring when shoots of healthy grapevines are 10–15 inches long. Later in the growing season affected shoots are stunted, and leaves of infected vines become tattered and scorched. Clusters on infected shoots are poorly developed and often wither and drop. Foliage of infected vines may be covered and masked by the foliage of healthy grapevines. An important diagnostic symptom of Eutypa dieback on the trunk or arms is a canker associated with a pruning wound. However, the bark must be peeled away to see the canker. It is also common to find one side of a vine dead or with disease symptoms and the other side appearing healthy.

Infection occurs when airborne spores of the fungus come in contact with fresh pruning wounds during or immediately following rainstorms. Spores germinate on the wound, and the fungus grows into the wood and produces a canker. Symptoms may not appear on diseased vines for more than 3 years after infection. Cankers expand lengthwise in both directions from the wound and will eventually girdle and kill arms or trunk of infected vines in 5 to 10 years.

Losses due to Eutypa dieback can be reduced by identifying and removing portions of diseased vines before the fungus spreads extensively in the infected vine. In the spring, when disease symptoms are most noticeable (shoots of healthy vines will be 10–15 inches long), is a good time to locate and mark the diseased vines. Diseased wood should be removed 4 to 6 inches below the canker and a new, healthy shoot trained into position. Remove the diseased wood after peeling the bark and tracing the canker or by making a series of successive cuts until a final cut is made in healthy tissue with all brown, discolored wood removed. If the canker has grown below ground level, remove and replace the vine. Replacement may be quicker in this situation if a shoot of an adjacent vine is layered and trained into position than if a cutting or rooting

were planted. The fungus does not persist in soil, and it is not spread by pruning tools.

In addition, double pruning, or mechanically pre-pruning early in the dormant period, followed by a hand-pruning later in the dormant period, can also reduce infection risk of the main trunk, by removing segments of cane tissue that may have been recently infected.

Pruning wounds become resistant to infection about 2 to 4 weeks after pruning. The time required for a wound to become resistant depends on when the pruning is done. Pruning cuts made in December remain susceptible for a longer time than cuts made in late winter and early spring. Therefore, waiting to prune until late winter and early spring may be better than pruning earlier, if the weather is not rainy.

Applications of latex paint and other wound dressings on pruning wounds have not been effective in reducing infections.

Phomopsis Cane and Leaf Spot

This fungus disease attacks leaves, shoots, rachis, and berries of grapes in many parts of the country. It produces small brown to black spots, usually with yellow margins on leaves. Portions on leaves may die if large numbers of spots develop; infections on leaf petioles will cause the leaves to turn yellow and abscise. Spots on shoots are oblong and generally at the basal portion; spots on flower cluster stems are similar to those on leaves and shoots. Wet weather during early shoot growth favors disease development. To date, it has not been an economic problem in Washington State.

Foliar and Fruit Diseases

Botrytis Bunch Rot

Botrytis bunch rot can produce significant yield and quality losses in tight-clustered wine varieties such as Riesling and Chenin Blanc. In addition to desiccation and rotting, the disease may provide an entrance for secondary microorganisms that cause additional fungal rots or bacterial sour rots.

Symptoms consist of brownish rotted fruit, usually with tufts of gray fungal growth (hyphae and spores) on the berry surface. The fungal growth usually begins at skin cracks and then spreads over the entire berry, giving a gray moldy appearance. Fungal growth and spread are enhanced by rain and prolonged overhead sprinkler irrigation.

Remove cluster mummies (infected dry clusters) from the vines at pruning and disc into the soil. Vines of susceptible varieties should not be sprinkler irrigated once the fruit is mature. Summer pruning or leaf removal of vigorous vines to increase air circulation around clusters and improved spray penetration may reduce disease incidence and severity.

Protect susceptible varieties in vineyards that have a history of bunch rot with fungicides. Vangard WG and Scala SC (FRAC 9) and Elevate SC (FRAC 17) are three relatively new and effective fungicides. Rovral (FRAC 2) is still a widely used and effective fungicide. Fungicide applications are most important during bloom and immediately before bunch closure. Additional applications may be necessary during prolonged periods of wet weather. Because fungicides can inhibit yeast fermentation, use them with caution within 1 month of harvest on wine grapes.

Some fungicides and fungicide premixes provide control of both powdery mildew and bunch rot when applied according to label instructions. These should be considered at critical times. For additional control information see *Botrytis Bunch Rot in Commercial Washington Grape Production: Biology and Disease Management* (FS046E).

Powdery Mildew

This is one of the most economically important diseases on wine grapes in the state of Washington. It attacks all green tissues of the vine, but is most damaging to leaves and green fruit, covering them with a gray, powdery layer of fungal threads and spores. Affected fruit often cracks, allowing secondary rots to become established.

This disease rarely damages the American *Vitis labruscana* varieties, such as Concord, and only slightly damages hybrid grapes. Conversely, European *Vitis vinifera* varieties are highly susceptible. The first mildew colonies often appear on the undersides of leaves close to the bark. Infection occurs in response to early season rains and symptoms are usually evident by June.

The fungus survives winter as cleistothecia (minute fungal fruiting bodies) in bark crevices and leaf litter. Each viable cleistothecium contains numerous spores known as ascospores. The ascospores persist (and the risk of primary infection exists) through bloom. Ascospore release and primary infection require at least 0.1 inch (2.5 mm) of moisture at temperatures of 50°F or greater. Ascospores are dispersed in wind currents and land on leaves, where they germinate, giving

rise to microscopic mildew colonies. Conidia, the asexual and far more numerous spore type, are produced in the primary mildew colonies. Dispersed by wind to foliage and fruit, conidia infect and produce subsequent secondary mildew colonies. This process repeats through the growing season. Powdery mildew is promoted by overcast weather and high humidity.

The grape powdery mildew fungus can develop resistance to many popular and highly effective fungicides, most notably the DMI and QoI (strobilurin) compounds. To prevent resistance, incorporate several different fungicidal modes of action into the spray program. Do not exceed three applications per year of any systemic fungicide and do not apply any specific class more than twice in sequence.

Management should include:

- use of a training system that allows good air movement through the canopy and prevents excess shading;
- use of a recommended spray program. **CAUTION: Sulfur can cause burning of the foliage.** See *Powdery Mildew in Eastern Washington Commercial Grape Production: Biology and Disease Management* (EM058E), and *Powdery Mildew in Western Washington Commercial Grape Production: Biology and Disease Management* (EM059E);
- where wettable sulfur is recommended, any formulation of finely ground sulfur paste having at least 60% sulfur may be substituted at the rate of 1 pint of sulfur paste in place of 1 pint of wettable sulfur;
- employ techniques such as shoot thinning and leaf stripping that improve light and spray penetration in the fruiting zone;
- particular vigilance during the prebloom period through pea-size berries;
- consult grape powdery mildew models on AgWeatherNet (*http://weather.wsu.edu*) for favorable environmental conditions; and
- proper irrigation management.

Managing resistance to powdery mildew fungicides

Washington wine grape growers have several new fungicides at their disposal for managing powdery mildew. New products included in the powdery mildew toolbox include: Inspire Super (difenoconazole + cyprodinil), Vivando (metrafenone), and Mettle (tetraconazole). Inspire Super, along with the existing products Flint (trifloxystrobin) and Pristine (pyraclostrobin + boscalid), provide the added benefit of also controlling Botrytis bunch rot, when applied at the appropriate rates. A non-exhaustive list of powdery mildew compounds is included in this section under Table 2. The table includes fungicide class information and Fungicide Resistance Action Committee (FRAC) group number or code. The FRAC code represents the mode of action of the fungicide. This information is helpful when designing a fungicide program that conforms to FRAC resistance management guidelines. It is important to remember that if a pathogen population develops resistance to fungicides within a FRAC group, it is likely to be resistant to all members of that group. Resistance is more likely to develop if the pathogen is frequently treated with one or multiple fungicides within a given FRAC group. Included in the table are members of the fungicide classes (or FRAC Groups) known as benzophenones (metrafenone, Group U8), DMI (demethylation inhibitors, Group 3), QoI (quinone outside inhibitors; previously called strobilurins, Group 11), quinolines (quinoxyfen, Group 13), sulfur (Group M2), various "biological" fungicides (Group 44), SDHI (succinate dehydrogenase inhibitors, Group 7), petroleum derived spray oils, and potassium bicarbonate. Petroleum spray oils and potassium bicarbonate are listed as "Not Classified" (NC) by FRAC. Several products are formulations or "premixes" of two different fungicide classes, modes of action, of FRAC groups. Consult product labels for appropriate rates and spray intervals. The resistance risk is product-dependent (Table 2). All of the aforementioned "new" products have performed well in efficacy trials at WSU-IAREC.

The availability of "premix" or combination fungicide formulations is a relatively recent trend in agriculture. The grape toolbox contains several of these product types: Inspire Super (difenoconazole + cyprodinil), Luna Experience (fluopyram + tebuconazole), Pristine (pyraclostrobin + boscalid), and Quadris Top (difenoconazole + azoxystrobin). Both active ingredients in these compounds, **with the exception of Inspire Super,** have activity against powdery mildew (only the difenoconazole component of Inspire Super is active against the fungus). When both modes of action have activity against the target organism, some level of resistance management is built into the products provided that they are used rationally. The use of "premix" types of products can provide better disease control, provide disease control security if there is field resistance to one of the two active ingredients, and help prevent resistance if there is not.

Table 2. Common fungicides used in PNW vineyards, with associated FRAC codes and fungicide resistance risk. For an expanded list, please see "Field Guide for Integrated Pest Management in Pacific Northwest Vineyards - 2nd Edition". PNW Extension Publishing #644, page 11.
PM = powdery mildew; BBR = Botrytis bunch rot; Mod. = moderate; gray shading = Not registered for that pest.

Fungicide Trade Name Example[1]	Chemical Name[7]	Class	FRAC Group	Resistance Risk	Registered for PM[3]	Registered for Botrytis	Requires Respirator
Rovral, Nevado 4F	iprodione	Dicarboximide	2	High		*	Hand-held applications
Rally 40WSP	myclobutanil	DMI	3	Mod.	**		No
Toledo 45WP, Orius 20AQ	tebuconazole	DMI	3	Mod.	**		No
Mettle 125ME	tetraconazole	DMI	3	Mod.	**		No
Procure 480SC, Trionic 4SC	triflumizole	DMI	3	Mod.	**		No
Inspire Super[4]	difenoconazole[2] / cyprodinil	DMI / AP	3 / 9	Mod. / High	***	*	No
Quadris Top[4]	difenoconazole[2] / **azoxystrobin**	DMI / QoI	3 / 11	Mod. / High	***		No
Kenja 400SC	isofetamid	SDHI	7	High	**	***	No
Aprovia	benzovindiflupyr	SDHI	7	Mod.-High	***		No
Endura	boscalid	SDHI	7	High / Mod.	**	*	No
Luna Experience	fluopyram[4] / tebuconazole	SDHI / DMI	7 / 3	High / Mod.	***	*	No
Miravis Prime	pydiflumetofen / fludioxonil	SDHI/PP	7 / 12	High / Mod.	Yes	Yes	No
Vangard WG	cyprodinil	AP	9	High		*	Mixer/Loader
Scala SC	pyrimethanil	AP	9	High		*	No
Switch 62.5 WG	cyprodinil / fludioxonil	AP/PP	9 / 12	High / Mod.		*	Mixer/Loader
Abound	**azoxystrobin**	QoI	11	High	**	*	No
Sovran	**kresoxim-methyl**	QoI	11	High	**	*	No
Flint[4]	**trifloxystrobin[2]**	QoI	11	High	***	*	No
Pristine[4]	**pyraclostrobin[2]** / boscalid	QoI / SDHI	11 / 7	High / High	***	*	No
Luna Sensation	fluopyram / trifloxystrobin[2]	SDHI / QoI	7 / 11	High / High	**	**	No
Merivon Xemium	fluxapyroxad / pyraclostrobin[2]	SDHI / QoI	7 / 11	High / High	**	**	No
Quintec	quinoxyfen	azanaphthalene (quinoline)	13	Mod.	***		No
Elevate	fenhexamid	SBI Class 3	17	Mod.		*	No
Ph-D, Oso 5% SC	polyoxin-D zinc salt	Polyoxin	19	Mod.	*	*	No
Actinovate-AG	*Streptomyces lydicus*	Biological	None	Low	*	*	Applicators/ Handlers
Serenade Max	*Bacillus subtilis*	Biological	44	Low	*	*	Applicators/ Handlers
Sonata	*Bacillus pumilus*	Biological	44	Low	*		Applicators/ Handlers
Several formulations	sulfur[2]	Inorganic	M2	Low	**		No
Ziram 76DF	ziram	Dithiocarbamates	M3	Low		*	All handlers
Dithane F-45, Penncozeb 75DF	mancozeb	Dithiocarbamates	M3	Low		*	No
Theia	*Bacillus subtilis st.* AFS032321	Biological	BM02	Low	*	*	All handlers
Howler	*Pseudomonas chlororaphis* AFS009	Biological	BM02	Low	*	*	All handlers
Regalia	extract of *Reynoutria sachalinensis*	Plant Extract	P5	Low	*	*	No
Torino	cyflufenamid	phenyl-acetamide	U6	Mod.	**		No
Vivando	metrafenone	aryl-phenylketone	50 (formerly U8)	Mod.	***		No
Prolivo 300 SC	pyriofenone	aryl-phenylketone	50 (formerly U8)	Mod.	***		No
Gatten	flutianil	thiazolidine	U13	Mod.	**	NR	No
Kaligreen	potassium bicarbonate	none listed	NC	Low	*[5]		No
M-Pede	Soap, potassium laurate	soap	None	Low	**		No
JMS Stylet Oil, Neem Oil	Mineral oils, organic oils, plant oils	oil	NC	Low	**[6]		No

[1]Fungicide Trade Names are for example purposes only and does not indicate an endorsement of a specific brand or company. Some active ingredients are available under multiple trade names.
[2]These products have varying degrees of phytotoxicity (leaf burning) on *Vitis labruscana* 'Concord'.
[3]PM=Powdery Mildew
[4]Do not use on grapes that may be used for purposes other than wine (i.e., table or juice grapes).
[5]Eradicant activity good, protective activity poor
[6]Eradicant activity good, protective activity good
[7]Boldfaced chemical names are those that fall into the FRAC 11 category. FRAC 11 fungicide resistance has been documented in some vineyards in Washington.

Fungicide Resistance Management

From 2016-2019, surveys in Oregon and Washington vineyards that lost powdery mildew disease control early in the season showed that the powdery mildew present in almost all of those vineyards tested was resistant to FRAC 11 fungicides. Since then, we have also documented resistance in FRAC 3, FRAC 7, and FRAC 13 fungicides, with suspected potential resistance developing in FRAC 50 and FRAC U6 fungicides.

FRAC 11 resistance is all-or-nothing; but regional efforts towards the smart use of this fungicide group can help reduce or eliminate the spread of resistant fungi. These products are important in both the powdery mildew and Botrytis bunch rot management arsenal, so proper management of this developing resistance is critical for our industry. Resistance in FRAC 3 and FRAC 7 fungicides is a gradient; for a time, maximum label rates may perform better than minimum label rates, and/or specific active ingredients within that FRAC group may perform better than others within that same group. Resistance in the remaining FRAC groups is not well understood at this time. In some cases, we have encountered powdery mildew populations that are resistant to multiple classes of fungicides.

The increasing occurrence of fungicide resistance in grape fungal diseases, indicates that we must carefully reconsider our approaches for disease management, with a **greater emphasis** on **product stewardship**. General disease management, that adheres to good product stewardship, includes:

1. Incorporation of **cultural practices** that lower disease pressure. Cultural practices such as vigor management, shoot removal and positioning, and leaf removal will lower disease pressure and improve spray penetration.
2. Always **follow label instructions** pertaining to application rates and intervals and always use a **properly calibrated sprayer** and **sufficient spray volume** to provide thorough coverage.
3. Always use fungicides in a protective, rather than reactive, manner. It is far **easier to prevent disease than to cure it.**
4. **Limit the number of applications** of individual modes of action (FRAC group) per season and limit sequential applications. Medium risk compounds such as DMI (Group 3), SDHI (Group 7), and quinoline compounds (Group 13) should be applied no more than 2 times per season and never in sequence. High risk QoI (FRAC Group 11) compounds or premixed formulations containing them (Flint, Sovran, Pristine, and Abound) should only be used 1 time a season.
5. **Tank-mix using multi-site products**, such as oil, sulfur, bicarbonates, and many biologicals, when also using medium- or high-risk compounds. However, please check product labels for tank-mixing compatibility.
6. Consider **starting the season off with a multisite or biological product.** That will reduce the initial selection pressure on fungicide-resistant pathogen populations. Use short intervals early-season to ensure proper coverage in a rapidly-developing canopy.

Powdery mildew is an early-season disease. The first management application should be completed by no-later than 10-inch shoot growth. **The most critical period for powdery mildew control on clusters is from immediate prebloom to three weeks postbloom.** Our most effective compounds should be utilized during this period. Bloom is also a critical period for the establishment of Botrytis bunch rot in the vineyard. As noted above, several of our highly effective powdery mildew fungicides/fungicide premixes provide (when used at appropriate rates) activity against both powdery mildew and Botrytis bunch rot. These compounds are logical for deployment during bloom but remember to keep applications of QoI (Group 11) compounds, or mixtures containing them, to a minimum. If you have known resistance in your vineyard to any of the FRAC fungicide groups, avoid using those products during this critical window.

For more information on when certain fungicides should be avoided when faced with fungicide resistance, please visit: *https://framenetworks.wsu.edu/grower-information/*. Current research is underway on when and how these fungicides can be re-introduced into a spray regime.

Sooty Mold

When honeydew (an insect excretion; see also Mealybugs and Scales) covers the vines, leaves, and fruit, a black fungus may develop on the honeydew. While this fungus rarely causes any direct damage, it can destroy the economic value of juice grapes for processing.

The primary control of this problem requires controlling the insects that produce honeydew.

DISEASE MANAGEMENT PROGRAM FOR GRAPEVINES

Material per Acre Treated						
Materials and Formulation	**FRAC Code**	**Forumated material per acre**	**PHI (days)**	**Remarks**	**Effect on Beneficials**	**Requires Respirator**
BUDBREAK TO PREBLOOM (15 Inch Shoot Growth)						
Powdery mildew						
1. micronized flowable sulfur (Microthiol Disperss)	M2	See product-specific labels	min 28	Sulfur has both contact and volatile activity when applied at temperatures between 68°F and 85°F. When temperatures are colder, it works as a contact product only. When temperatures are warmer, there is risk of phytoxicity. Some phytoxic effects on juice grapes. PHI listed is to avoid fermentation issues with field-applied sulfur.	Excessive use harmful	No
2. sulfur dust (Dusting Sulfur)	M2	5.0–10.0 pounds	min 28	Begin sulfur applications when shoots are 6 to 8 inches long. Make a second application when shoots are 12 to 15 inches long, and a third about 14 days later. Repeat at 10- to 14-day intervals to protect new growth. PHI listed is to avoid fermentation issues with field-applied sulfur.	Excessive use harmful	No
3. petroleum / mineral / paraffinic oil	NC	1–2%	0	Do not mix oil with sulfur or apply either compound within 2 weeks of the other. Apply at 10- to 14-day intervals. Not all oils are the same purity or have the same PHI for table grapes. The 1–2% recommended rate is for pure (98%+) active ingredient. Do not use on juice grapes.	Excessive use harmful	No
4. Potassium salts of fatty acids (M-Pede)	NC	1–2%	0	Can effect waxy bloom on fruit; do not use after pea-sized berry development. Spray interval of 7 to 10 days. Do not use within 3 days of sulfur application. For stand-alone mildew control rates should be above 1.5%.		Yes
5. Potassium bicarbonate (Kaligreen, Milstop SP)	NC	See specific labels	1	Sufficient water is needed for thorough coverage. High concentrations (max rate in low water volume) may cause phytotocixity. Most labels indicate a concentration spray based on 100 gallons/ acre delivery. Spray intervals 7-14 days.	Excessive use harmful	No
6. BLAD (Fracture, ProBlad Verde)	BM1	See product specific labels	1	Minimum spray water volume of 40 gal/acre. Requires 2-4 hrs dry time. Intervals up to 14 days. Do not make more than 5 applications per season; do not make more than 2 sequential applications.		Depends
7. extract of *Reynoutria sachalinensis* (Regalia 12)	P05	13.33–53.33 fluid ounces	0	Also provides control of Botrytis bunch rot. Always tank mix with other fungicides if disease pressure is high. Spray in 50-100 gallons per acre. Spray intervals of 7-14 days.	Safe	No
8. *Bacillus amyloliquefaciens* (Double Nickel 55)	44	0.25–3 lbs	0	Spray intervals 7-10 days.		Yes
9. *Bacillus mycoides* (LifeGard LC)	44	1%	0	Apply to actively growing plants. Do not apply to drought-stressed plants. Spray intervals of 7-14 days.		Yes
10. *Bacillus subtilis* (a: Serenade ASO, b: Serenade Max)	44	a: 2-6qts b: 1-3lbs	0	Spray intervals 7-10 days. Coverage is essential		Yes
11. *Bacillus pumilus* (Sonata)	NC	2.0–4.0 quarts	0	Spray intervals 7-14 days. Spreader / sticker recommended.		Yes
12. Cerevisane (Romeo)	NC	0.23 lbs	0	Avoid applications during high temperatures. Spray interval 7-10 days.		No
13. myclobutanil (Rally 40WSP)	3	3.0–5.0 ounces	14	Do not exceed a 14 day interval. Use higher rates on susceptible varieties or under heavy disease pressure. Do not apply more than 1.5 pounds (0.6 pound of active ingredient) per acre per year. We recommend tank mixing myclobutanil with either oil or sulfur. When mixing with oil, add myclobutanil to the tank prior to adding oil.	Safe	No
14. tebuconazole (Orius 20AQ, Toldeo 45WP, Tebucon 45DF)	3	See product labels	14	Spray intervals typically 14 days. Do not apply FRAC 3 fungicides sequentially, and try to limit FRAC 3 fungicide applications to 2 per year.	Safe	No
15. tetraconazole (Mettle 125 ME)	3	3.0–5.0 fluid ounces	14	Do not apply more than 10 ounces of Mettle per acre per year. Do not apply FRAC 3 fungicide sequentially. Try to limit applications of FRAC 3 fungicides to 2 per year. Recommended spray interval not longer than 14 days.	Safe	No
16. *Bacillus subtilis st.* AFS032321 (Theia)	BM02	1.5 - 5 pounds	0	Protectant fungicide. Typical application intervals for powdery mildew not specified, but likely around 7-10 days.		Yes
17. *Pseudomonas chlororaphis st.* AFS009 (Howler)	BM02	2.5 - 7.5 lbs	0	Preventative fungicide. Active ingredient colonizes living plant tissue. Retreatment required after heavy rains. Apply higher rates, 5.0-7.5 lbs for sour rot suppression when used alone.		Yes

DISEASE MANAGEMENT PROGRAM FOR GRAPEVINES

Material per Acre Treated						
Materials and Formulation	**FRAC Code**	**Forumated material per acre**	**PHI (days)**	**Remarks**	**Effect on Beneficials**	**Requires Respirator**
PREBLOOM (15 Inch Shoot Growth) TO BLOOM						
Powdery mildew						
1. myclobutanil (Rally 40WSP)	3	3.0–5.0 ounces	14	Do not exceed a 14 day interval. Use higher rates on susceptible varieties or under heavy disease pressure. Do not apply more than 1.5 pounds (0.6 pound of active ingredient) per acre per year. We recommend tank mixing myclobutanil with either oil or sulfur. When mixing with oil, add myclobutanil to the tank prior to adding oil.	Safe	No
2. tebuconazole (Orius 20AQ, Toldeo 45WP, Tebucon 45DF)	3	See product labels	14	Spray intervals typically 14 days. Do not apply FRAC 3 fungicides sequentially, and try to limit FRAC 3 fungicide applications to 2 per year.	Safe	No
3. tetraconazole (Mettle 125 ME)	3	3.0–5.0 fluid ounces	14	Do not apply more than 10 ounces of Mettle per acre per year. Do not apply FRAC 3 fungicide sequentially. Try to limit applications of FRAC 3 fungicides to 2 per year. Recommended spray interval not longer than 14 days.	Safe	No
4. difenoconazole + mandipropamid (Revus Top)	3 + 40	7.0 fluid ounces	14	Spray interval 10-21 days, however, resistance recommendations are to not exceed 14 days. Do not do sequential applications. Do not apply more than 0.46 lb/ ai of difenoconazole products per season.		No
5. difenoconazole + cyprodinil (Inspire Super)	3 + 9	16–20 fluid ounces	14	Also provides control of Botrytis bunch rot. Do not do sequential applications. Spray intervals 10-21 days (although 21 days is not recommended for resistance management). Do not apply more than 80 ounces per acre of Inspire Super per season. Do not apply more than 1.4 pounds of active ingredient/acre of a cyprodinil containing product. Do not treat grapes such as Thompson Seedless and Concord which may be used for purposes other than wine.	Safe	No
6. metrafenone (Vivando)	50 (formerly U8)	10.3–15.4 fluid ounces	14	While the label allows 3 applications per year, WA has known resistance to this active ingredient. For good resistance management, we recommend no more than two applications per year and not consecutively. Do not apply more than 46.2 ounces of product per acre per crop.	Safe	No
7. pyriofenone (Prolivo 300SC)	50 (formerly U8)	4.0–5.0 fluid ounces	0	Spray intervals are 14 days. Season total maximum is 16 fluid ounces. Minimum water volume at 50 gallons. Do not make more than two sequential applications of FRAC 50 fungicide.	Unknown	No
8. isofetamid (Kenja 400SC)	7	20–22 fluid ounces	14	Spray intervals of 7-14 days. Do not make more than 2 sequential applications.		No
9. benzovindiflupyr (Aprovia)	7	8.6–10.5 fluid ounces	21	Spray intervals are 14–21 days. Season total maximum application is 31.5 fluid ounces/acre.	Unknown	No
10. pydiflumetofen + fludioxonil (Miravis Prime)	7 + 12	9.2–13.4 fluid ounces	14	Do not make more than 2 consecutive applications. Maximum spray interval is 21 days. Season total maximum of 36.5 fluid ounces a year.		No
11. fluopyram + tebuconazole (Luna Experience)	7 + 3	6.0–8.6 fluid ounces	14	Spray interval of 12-21 days. Also provides control of Botrytis bunch rot at highest labeled rate. Do not apply more than 34 fluid ounces/acre per season.	Safe	No
12. azoxystrobin + difenoconazole (Quadris Top)	11 + 3	12–14 fluid ounces	14	RESISTANCE MANAGEMENT: Do not make sequential applications with another FRAC 11 containing product. Do not exceed 14 day spray interals. Do not apply to Concord grapes and Thompson Seedless. Azoxystrobin is extremely toxic to certain apple varieties. Do not apply more than 56 fluid ounces/acre per season. Leaf burn can occur if applied with certain surfactants - see label for more details. Try to limit FRAC 11 fungicides to 1 per year.	Safe	No
13. flutianil (Gatten)	U13	6.4 fluid ounces	14	Spray interval of 7-14 days. Thorough coverage is essential. Do not use less than 20 gallons of water. Do not make more than 4 applications a year.		No
14. cyflufenamid (a:Torino, b: Miltrex 10 SC)	U6	a: 3.4–6.8 fluid ounces b: 1.7–3.4 fluid ounces	a: 7 b: 3	Use higher rates during high disease pressure. Intervals are 14 days. Do not apply sequentially.	Safe	No
15. micronized flowable sulfur (Microthiol Disperss)	M2	See product-specific labels.	min 28	Sulfur has both contact and volatile activity when applied at temperatures between 68°F and 85°F. When temperatures are colder, it works as a contact product only. When temperatures are warmer, there is risk of phytoxicity. Some phytoxic effects on juice grapes. PHI listed is to avoid fermentation issues with field-applied sulfur.	Excessive use harmful	No

DISEASE MANAGEMENT PROGRAM FOR GRAPEVINES

Material per Acre Treated						
Materials and Formulation	**FRAC Code**	**Forumated material per acre**	**PHI (days)**	**Remarks**	**Effect on Beneficials**	**Requires Respirator**
16. sulfur dust (Dusting Sulfur)	M2	5.0–10.0 pounds	min 28	Begin sulfur applications when shoots are 6 to 8 inches long. Make a second application when shoots are 12 to 15 inches long, and a third about 14 days later. Repeat at 10- to 14-day intervals to protect new growth. PHI listed is to avoid fermentation issues with field-applied sulfur.	Excessive use harmful	No
17. petroleum / mineral / paraffinic oil	NC	1–2%	0	Do not mix oil with sulfur or apply either compound within 2 weeks of the other. Apply at 10- to 14-day intervals. Not all oils are the same purity or have the same PHI for table grapes. The 1–2% recommended rate is for pure (98%+) active ingredient. Do not use on juice grapes.	Excessive use harmful	No
18. Potassium salts of fatty acids (M-Pede)	NC	1–2%	0	Can effect waxy bloom on fruit; do not use after pea-sized berry development. Spray interval of 7 to 10 days. Do not use within 3 days of sulfur application. For stand-alone mildew control rates should be above 1.5%.		No
19. Potassium bicarbonate (Kaligreen, Milstop)	NC	See specific labels.	1	Sufficient water is needed for thorough coverage. High concentrations (max rate in low water volume) may cause phytotocixity. Most labels indicate a concentration spray based on 100 gallons/ acre delivery. Spray intervals 7-14 days.	Excessive use harmful	No
20. BLAD (Fracture, ProBlad Verde)	BM1	See product specific labels.	1	Minimum spray water volume of 40 gal/acre. Requires 2-4 hrs dry time. Intervals up to 14 days. Do not make more than 5 applications per season; do not make more than 2 sequential applications.		Depends
21. extract of *Reynoutria sachalinensis* (Regalia 12)	P05	13.33–53.33 fluid ounces.	0	Also provides control of Botrytis bunch rot. Always tank mix with other fungicides if disease pressure is high. Spray in 50-100 gallons per acre. Spray intervals of 7-14 days.	Safe	No
22. *Bacillus amyloliquefaciens* (Double Nickel 55)	44	0.25–3 lbs	0	Spray intervals 7-10 days.		Yes
23. *Bacillus mycoides* (LifeGard LC)	44	1%	0	Apply to actively growing plants. Do not apply to drought-stressed plants. Spray intervals of 7 - 14 days.		Yes
24. *Bacillus subtilis* (a: Serenade ASO, b: Serenade Max)	44	a: 2-6qts b: 1-3lbs	0	Spray intervals 7-10 days. Coverage is essential		Yes
25. Bacillus pumilus (Sonata)	NC	2.0–4.0 quarts	0	Spray intervals 7 to 14 days. Spreader / sticker recommended.		Yes
26. Cerevisane (Romeo)	NC	0.23 lbs	0	Avoid applications during high temperatures. Spray interval 7-10 days.		No
27. *Bacillus subtilis st.* AFS032321 (Theia)	BM02	1.5 - 5 pounds	0	Protectant fungicide. Typical application intervals for powdery mildew not specified, but likely around 7-10 days.		Yes
28. *Pseudomonas chlororaphis st.* AFS009 (Howler)	BM02	2.5 - 7.5 lbs	0	Preventative fungicide. Active ingredient colonizes living plant tissue. Retreatment required after heavy rains. Apply higher rates, 5.0-7.5 lbs for sour rot suppression when used alone.		Yes
BLOOM TO PEA SIZE FRUIT						
Powdery mildew						
1. myclobutanil (Rally 40WSP)	3	3.0–5.0 ounces	14	Do not exceed a 14 day interval. Use higher rates on susceptible varieties or under heavy disease pressure. Do not apply more than 1.5 pounds (0.6 pound of active ingredient) per acre per year. We recommend tank mixing myclobutanil with either oil or sulfur. When mixing with oil, add myclobutanil to the tank prior to adding oil.	Safe	No
2. tebuconazole (Orius 20AQ, Toldeo 45WP, Tebucon 45DF)	3	See product labels	14	Spray intervals typically 14 days. Do not apply FRAC 3 fungicides sequentially, and try to limit FRAC 3 fungicide applications to 2 per year.	Safe	No
3. tetraconazole (Mettle 125 ME)	3	3.0–5.0 fluid ounces	14	Do not apply more than 10 ounces of Mettle per acre per year. Do not apply FRAC 3 fungicide sequentially. Try to limit applications of FRAC 3 fungicides to 2 per year. Recommended spray interval not longer than 14 days.	Safe	No
4. difenoconazole + mandipropamid (Revus Top)	3 + 40	7.0 fluid ounces	14	Spray interval 10-21 days, however, resistance recommendations are to not exceed 14 days. Do not do sequential applications. Do not apply more than 0.46 lb/ai of difenoconazole products per season.		No

DISEASE MANAGEMENT PROGRAM FOR GRAPEVINES

Material per Acre Treated						
Materials and Formulation	**FRAC Code**	**Forumated material per acre**	**PHI (days)**	**Remarks**	**Effect on Beneficials**	**Requires Respirator**
5. difenoconazole + cyprodinil (Inspire Super)	3 + 9	16–20 fluid ounces	14	Also provides control of Botrytis bunch rot. Do not do sequential applications. Spray intervals 10-21 days (although 21 days is not recommended for resistance management). Do not apply more than 80 ounces per acre of Inspire Super per season. Do not apply more than 1.4 pounds of active ingredient/acre of a cyprodinil containing product. Do not treat grapes such as Thompson Seedless and Concord which may be used for purposes other than wine.	Safe	No
6. metrafenone (Vivando)	50 (formerly U8)	10.3–15.4 fluid ounces	14	While the label allows 3 applications per year, WA has known resistance to this active ingredient. For good resistance management, we recommend no more than two applications per year and not consecutively. Do not apply more than 46.2 ounces of product per acre per crop.	Safe	No
7. pyriofenone (Prolivo 300SC)	50 (formerly U8)	4.0–5.0 fluid ounces	0	Spray intervals are 14 days. Season total maximum is 16 fluid ounces. Minimum water volume at 50 gallons. Do not make more than two sequential applications of FRAC 50 fungicide.	Unknown	No
8. isofetamid (Kenja 400SC)	7	20–22 fluid ounces	14	Spray intervals of 7-14 days. Do not make more than 2 sequential applications.		No
9. benzovindiflupyr (Aprovia)	7	8.6–10.5 fluid ounces	21	Spray intervals are 14–21 days. Season total maximum application is 31.5 fluid ounces/acre.	Unknown	No
10. pydiflumetofen + fludioxonil (Miravis Prime)	7 + 12	9.2–13.4 fluid ounces	14	Do not make more than 2 consecutive applications. Minimum interval is 21 days. Season total maximum of 36.5 fluid ounces a year.		No
11. fluopyram + tebuconazole (Luna Experience)	7 + 3	6.0–8.6 fluid ounces	14	Spray interval of 12-21 days. Also provides control of Botrytis bunch rot at highest labeled rate. Do not treat grapes such as Thompson Seedless and Concord which may be used for purposes other than wine. Do not apply more than 34 fluid ounces/acre per season.	Safe	No
12. azoxystrobin (Abound)	11	10.0–15.5 fluid ounces	14	Azoxystrobin is phytotoxic to certain apple varieties. RESISTANCE RECOMMENDATION: Tank mix with a contact fungicide. Do not make sequential applications of a FRAC 11 fungicide. Spray intervals 10-14 days. Try to limit FRAC 11 fungicides to 1 per year.	Safe	No
13. kresoxim-methyl (Sovran)	11	3.2–4.8 ounces	14	RESISTANCE RECOMMENDATION: Tank mix with a contact fungicide. Do not make sequential applications of a FRAC 11 fungicide. Try to limit FRAC 11 fungicides to 1 per year.	Safe	No
14. trifloxystrobin (Flint)	11	1.5–2.0 ounces	14	Do not use Flint on juice grapes. RESISTANCE RECOMMENDATION: Tank mix with a contact fungicide. Do not make sequential applications of a FRAC 11 fungicide. Try to limit FRAC 11 fungicides to 1 per year.	Safe	No
15. azoxystrobin + difenoconazole (Quadris Top)	11 + 3	12–14 fluid ounces	14	RESISTANCE MANAGEMENT: Do not make sequential applications with another FRAC 11 containing product. Do not exceed 14 day spray interals. Do not apply to Concord grapes and Thompson Seedless. Azoxystrobin is extremely toxic to certain apple varieties. Do not apply more than 56 fluid ounces/acre per season. Leaf burn can occur if applied with certain surfactants - see label for more details. Try to limit FRAC 11 fungicides to 1 per year.	Safe	No
16. pyraclostrobin + boscalid (Pristine)	11 + 7	8.0–12.5 ounces	14	Start applications before disease symptoms are visible. Do not make sequential applications of a fungicide containing a FRAC 11 product. Alternate to a fungicide with a different mode of action (FRAC group). Do not use on Concord. Resistance management recommendations: Do not use more than twice a year, and never sequentially for the target disease.	Safe	No
17. flutianil (Gatten)	U13	6.4 fluid ounces	14	Spray interval of 7-14 days. Thorough coverage is essential. Do not use less than 20 gallons of water. Do not make more than 4 applications a year.		No
18. cyflufenamid (a:Torino, b: Miltrex 10 SC)	U6	a: 3.4–6.8 fluid ounces b: 1.7–3.4 fluid ounces	a: 7 b: 3	Use higher rates during high disease pressure. Intervals are 14 days. Do not apply sequentially.	Safe	No
19. micronized flowable sulfur (Microthiol Disperss)	M2	See product-specific labels.	min 28	Sulfur has both contact and volatile activity when applied at temperatures between 68°F and 85°F. When temperatures are colder, it works as a contact product only. When temperatures are warmer, there is risk of phytoxicity. Some phytoxic effects on juice grapes. PHI listed is to avoid fermentation issues with field-applied sulfur.	Excessive use harmful	No
20. sulfur dust (Dusting Sulfur)	M2	5.0–10.0 pounds	min 28	Begin sulfur applications when shoots are 6 to 8 inches long. Make a second application when shoots are 12 to 15 inches long, and a third about 14 days later. Repeat at 10- to 14-day intervals to protect new growth. PHI listed is to avoid fermentation issues with field-applied sulfur.	Excessive use harmful	No
21. petroleum/ mineral / paraffinic oil	NC	1–2%	0	Do not mix oil with sulfur or apply either compound within 2 weeks of the other. Apply at 10- to 14-day intervals. Not all oils are the same purity or have the same PHI for table grapes. The 1–2% recommended rate is for pure (98%+) active ingredient. Do not use on juice grapes.	Excessive use harmful	No

DISEASE MANAGEMENT PROGRAM FOR GRAPEVINES

Material per Acre Treated						
Materials and Formulation	**FRAC Code**	**Forumated material per acre**	**PHI (days)**	**Remarks**	**Effect on Beneficials**	**Requires Respirator**
22. Potassium bicarbonate (Kaligreen, Milstop)	NC	See specific labels.	1	Sufficient water is needed for thorough coverage. High concentrations (max rate in low water volume) may cause phytotocixity. Most labels indicate a concentration spray based on 100 gallons/ acre delivery. Spray intervals 7-14 days.	Excessive use harmful	No
23. BLAD (Fracture, ProBlad Verde)	BM1	See product specific labels.	1	Minimum spray water volume of 40 gal/acre. Requires 2-4 hrs dry time. Intervals up to 14 days. Do not make more than 5 applications per season; do not make more than 2 sequential applications.		Yes
24. extract of *Reynoutria sachalinensis* (Regalia 12)	P05	13.33–53.33 fluid ounces.	0	Also provides control of Botrytis bunch rot. Always tank mix with other fungicides if disease pressure is high. Spray in 50-100 gallons per acre. Spray intervals of 7-14 days.	Safe	No
25. *Bacillus amyloliquefaciens* (Double Nickel 55)	44	0.25–3 lbs	0	Spray intervals 7-10 days.		Yes
26. *Bacillus mycoides* (LifeGard LC)	44	1%	0	Apply to actively growing plants. Do not apply to drought-stressed plants. Spray intervals of 7-14 days.		Yes
27. *Bacillus subtilis* (a: Serenade ASO, b: Serenade Max)	44	a: 2-6qts b: 1-3lbs	0	Spray intervals 7-10 days. Coverage is essential		Yes
28. *Bacillus pumilus* (Sonata)	NC	2.0–4.0 quarts	0	Spray intervals 7-14 days. Spreader / sticker recommended.		Yes
29. Cerevisane (Romeo)	NC	0.23 lbs	0	Avoid applications during high temperatures. Spray interval 7-10 days.		No
30. *Bacillus subtilis st.* AFS032321 (Theia)	BM02	1.5 - 5 pounds	0	Protectant fungicide. Typical application intervals for powdery mildew not specified, but likely around 7-10 days.		Yes
31. *Pseudomonas chlororaphis st.* AFS009 (Howler)	BM02	2.5 - 7.5 lbs	0	Preventative fungicide. Active ingredient colonizes living plant tissue. Retreatment required after heavy rains. Apply higher rates, 5.0-7.5 lbs for sour rot suppression when used alone.		Yes
Botrytis bunch rot						
1. iprodione (Rovral)	2	1.5–2.0 pints	7	Apply early to mid-bloom. Do not apply after bunch closure. Do not make more than four applications per season for wine and sherry grapes; do not make more than one application per season for table and raisin grapes.	Safe	Hand-held applications
2. boscalid (Endura)	7	8 ounces	14	Also provides control of Powdery Mildew. Do not apply more than 24 ounces/acre per season. The rate and max number of applications differ if the target pest is Botrytis.	Safe	No
3. isofetamid (Kenja 400SC)	7	20–22 fluid ounces	14	Minimum interval of 14 days. Apply in 50-100 gallons of water per acre. Do not make more than 2 sequential applications.		No
4. pyraclostrobin + boscalid (Pristine)	11 + 7	18.5–23 ounces	14	Do not make sequential applications of a fungicide containing a FRAC 11 product. Alternate to a fungicide with a different mode of action (FRAC group). Resistance management recommendations: Do not use more than twice a year, and never sequentially for the target disease.	Safe	No
5. pydiflumetofen + fludioxonil (Miravis Prime)	7 + 12	10.3–13.4 fluid ounces	14	A maximum of 2 sprays (total) can be made at bunch closure and veraison or 3-4 weeks before harvest. Season total maximum of 36.5 fluid ounces a year.		No
6. fluopyram + tebuconazole (Luna Experience)	7 + 3	8.0–8.6 fluid ounces	14	Also provides control of powdery mildew. Do not treat grapes such as Thompson Seedless and Concord which may be used for purposes other than wine. Do not apply more than 34 fluid ounces per acre per season.	Safe	No
7. cyprodinil (Vangard WG)	9	10.0 ounces	7	Do not apply more than 30 ounces per acre per crop per year. Rate can be reduced to 5.0 ounces when tank mixed with other Botryticide products. Do not do sequential applications.	Safe	Mixer / Loader
8. pyrimethanil (Scala SC)	9	18.0 fluid ounces	7	Max rate for stand-alone applications. For tank mixes with other Botryticide products, rates can be 9-18 fluid ounces.	Safe	No
9. cyprodinil + fludioxonil (Switch 62.5WG)	9 + 12	11–14 ounces	7	Minimum spray interval 21 days. Use sufficient water for coverage. Do not apply more than 56 oz/acre of Switch per year, and do not exceed 1.4 lbs/ai cyprodinil or 0.9 lb/ai fludioxonil per year.		Mixer / Loader
10. difenoconazole + cyprodinil (Inspire Super)	3 + 9	16–20 fluid ounces	14	Also provides control of powdery mildew. Do not apply more than 80 ounces per acre of Inspire Super per season. Do not apply more than 1.4 pounds of active ingredient per acre of a cyprodinil containing product. Do not treat grapes such as Thompson Seedless and Concord which may be used for purposes other than wine.	Safe	No
11. fenhexamid (Elevate 50 WSG)	17	1.0 pound	0	Apply in a minimum 50 gallons per acre. Do not make more than 2 consecutive applications.	Safe	No

DISEASE MANAGEMENT PROGRAM FOR GRAPEVINES

Material per Acre Treated						
Materials and Formulation	**FRAC Code**	**Forumated material per acre**	**PHI (days)**	**Remarks**	**Effect on Beneficials**	**Requires Respirator**
12. *Bacillus amyloliquefaciens* (Double Nickel 55)	44	0.25–3 lbs	0	Spray intervals 7-10 days.		Yes
13. BLAD (Fracture, ProBlad Verde)	BM1	See product specific labels	1	Minimum spray water volume of 40 gal/acre. Requires 2-4 hrs dry time. Intervals up to 14 days. Do not make more than 5 applications per season; do not make more than 2 sequential applications.		Yes
14. Cerevisane (Romeo)	NC	0.23 lbs	0	Avoid applications during high temperatures. Spray interval 7-10 days.		No
15. extract of *Reynoutria sachalinensis* (Regalia 12)	P05	13.33–53.33 fluid ounces	0	Also provides control of powdery mildew. Always tank mix with other fungicides if disease pressure is high. Spray in 50-100 gallons per acre.	Safe	No
16. *Bacillus subtilis st.* AFS032321 (Theia)	BM02	1.5 - 5 pounds	0	Protectant fungicide. Typical application intervals for powdery mildew not specified, but likely around 7-10 days.		Yes
17. *Pseudomonas chlororaphis st.* AFS009 (Howler)	BM02	2.5 - 7.5 lbs	0	Preventative fungicide. Active ingredient colonizes living plant tissue. Retreatment required after heavy rains. Apply higher rates, 5.0-7.5 lbs for sour rot suppression when used alone.		Yes
VERAISON TO PREHARVEST						
Botrytis bunch rot						
1. iprodione (Rovral)	2	1.5–2.0 pints	7	Apply early to mid-bloom. Do not apply after bunch closure. Do not make more than four applications per season for wine and sherry grapes; do not make more than one application per season for table and raisin grapes.	Safe	Hand-held applications
2. boscalid (Endura)	7	8 ounces	14	Also provides control of Powdery Mildew. Do not apply more than 24 ounces/ acre per season. The rate and max number of applications differ if the target pest is Botrytis.	Safe	No
3. isofetamid (Kenja 400SC)	7	20–22 fluid ounces	14	Minimum interval of 14 days. Apply in 50-100 gallons of water per acre. Do not make more than 2 sequential applications.		No
4. pydiflumetofen + fludioxonil (Miravis Prime)	7 + 12	10.3–13.4 fluid ounces	14	A maximum of 2 sprays (total) can be made at bunch closure and veraison or 3-4 weeks before harvest. Season total maximum of 36.5 fluid ounces a year.		No
5. cyprodinil (Vangard WG)	9	10.0 ounces	7	Do not apply more than 30 ounces per acre per crop per year. Rate can be reduced to 5.0 ounces when tank mixed with other Botryticide products. Do not do sequential applications.	Safe	Mixer / Loader
6. pyrimethanil (Scala SC)	9	18.0 fluid ounces	7	Max rate for stand-alone applications. For tank mixes with other Botryticide products, rates can be 9-18 fluid ounces.	Safe	No
7. cyprodinil + fludioxonil (Switch 62.5WG)	9 +12	11–14 ounces	7	Minimum spray interval 21 days. Use sufficient water for coverage. Do not apply more than 56 oz/acre of Switch per year, and do not exceed 1.4 lbs/ai cyprodinil or 0.9 lb/ai fludioxonil per year.		Mixer / Loader
8. fenhexamid (Elevate 50 WSG)	17	1.0 pound	0	Apply in a minimum 50 gallons per acre. Do not make more than 2 consecutive applications.	Safe	No
9. *Bacillus amyloliquefaciens* (Double Nickel 55)	44	0.25–3 lbs	0	Spray intervals 7-10 days.		Yes
10. BLAD (Fracture, ProBlad Verde)	BM1	See product specific labels	1	Minimum spray water volume of 40 gal/acre. Requires 2-4 hrs dry time. Intervals up to 14 days. Do not make more than 5 applications per season; do not make more than 2 sequential applications.		Yes
11. Cerevisane (Romeo)	NC	0.23 lbs	0	Avoid applications during high temperatures. Spray interval 7-10 days.		No
12. extract of *Reynoutria sachalinensis* (Regalia 12)	P05	13.33–53.33 fluid ounces.	0	Also provides control of powdery mildew. Always tank mix with other fungicides if disease pressure is high. Spray in 50-100 gallons per acre.	Safe	No
13. *Bacillus subtilis st.* AFS032321 (Theia)	BM02	1.5 - 5 pounds	0	Protectant fungicide. Typical application intervals for powdery mildew not specified, but likely around 7-10 days.		Yes
14. *Pseudomonas chlororaphis st.* AFS009 (Howler)	BM02	2.5 - 7.5 lbs	0	Preventative fungicide. Active ingredient colonizes living plant tissue. Retreatment required after heavy rains. Apply higher rates, 5.0-7.5 lbs for sour rot suppression when used alone.		Yes

VIRUSES OF GRAPEVINES

Like any other crop, grapevines are susceptible to a broad range of plant viruses. In fact, grapevines appear to be infected with more viruses than any other perennial woody species. Viruses infecting grapevines are diverse, with distinct biological properties and genome characteristics. Some of these viruses are widely distributed wherever grapevines are grown, and others are present locally or in limited geographic range. Many of these viruses are spread by aerial transmission through insect vectors and some are spread through soil by nematodes.

With no exception, all viruses infecting grapevines are transmissible through grafting. Since grapevines are propagated through vegetative cuttings to maintain clonal identity or trueness-to-type, the risk of spreading viruses to new areas is far greater through the distribution of cuttings from infected vines than by other modes of virus dissemination. In general, virus diseases affect growth and longevity of grapevines, as well as yield and quality attributes of grapes, leading to economic losses to growers. Poor quality grapes, in turn, lead to a marked decline in producing premium wines. As the demand for premium wines is increasing globally, it is critical to maintain healthy vines for producing high quality wines.

Among the virus diseases infecting grapevines, "traditional" virus diseases such as Grapevine leafroll disease, ruguose wood complex, and Grapevine fanleaf disease are of great economic significance globally and countries around the world. However, many of these diseases are complex syndromes and are still largely unsolved virus disease problems. Fortunately, vineyards in Washington State are free from many, though not all, of the debilitating virus diseases.

NOTE: State regulations prohibit the importation of grapevines that are not certified as virus-free.

Management of Grapevine Virus Diseases

Once a virus disease is established in a given vineyard, it is not amenable to any curative or therapeutic control measures. Given the difficulties in achieving high levels of preventive measures and the cost of replacing infected vines, it is vital to focus efforts on eliminating or reducing initial sources of infection.

Since all debilitating virus diseases are spread through grafting, the first and foremost approach in this direction should be planting virus-tested materials obtained from reliable and certified sources. Due to the distinct nature of viruses and their diverse modes of spread, there is no "one-size fits-all" approach for the management of viral diseases. Thus, accurate diagnosis of viruses is the cornerstone of virus disease management strategies. Constant vigilance and careful monitoring for any unusual symptoms will facilitate quick action before the problem gets out of control. A comprehensive virus indexing of plant materials should be done to reduce spread of infection in existing vineyards, because field diagnosis of grapevine diseases may be difficult and symptoms displayed in the field may often be confused with other problems, such as abiotic stress (viz. nutrient deficiency, herbicide damage), physical damage, and genetic abnormalities. In addition, expression of many viral symptoms depends on several variables including cultivar, age of vine at which infection occurred, particular stage of disease development, and time of year when the symptoms were observed. Many different types of diagnostic tests are available to confirm the presence of a particular virus. They include biological indexing (field indexing and mechanical inoculation on to herbaceous hosts), serological tests (enzyme-linked immunosorbent assay or ELISA), and molecular tests (polymerase chain reaction or PCR). These are complementary and so a combination of tests can be used to confirm the presence of a virus in suspected plant material.

Grapevine Leafroll Disease

Grapevine leafroll disease (GLRD) is a complex viral disease of major concern in Washington State. It is estimated that GLRD currently affects about 10-15% of the acreage of wine and juice grapes combined. In recent years, however, the spread of GLRD has been increasing throughout the state. In fact, GLRD is currently considered the biggest constraint to the production of premium grapes for high quality wines in Washington State. Significant reduction in yield is commonly reported due to GLRD, with fewer and smaller bunches. In addition, fruit maturity is delayed substantially depending on severity of symptoms, cultivar and environmental conditions. GLRD affects the quality of grapes by delaying the accumulation of sugars, lowering the accumulation of anthocyanins,

and causing up to 50% loss of pigment concentration in red wine varieties. GLRD is, therefore, a particularly serious problem for red wines.

GLRD does not produce symptoms for most of the season—these begin to appear in late summer and/or the early part of the Fall. GLRD symptoms are more dramatic in red- and black-fruited cultivars than white-fruited cultivars. In the former cultivars, the foliar symptoms are characterized initially by red and reddish-purple tints in the interveinal areas. These discolorations may coalesce with time, leading to reddish-purple color of interveinal areas and green tissue near the main veins. In the advanced stages, the margins of infected leaves roll downward, expressing the symptom that gives the disease its common name. Thus, the major symptom in late Fall is red leaves with green veins and downward-rolled leaf margins. In the white-fruited cultivars, infected leaves show mild yellowing between the veins and show downward rolling. GLRD symptoms develop during the late summer to fall period in these cultivars and vary depending on the cultivar and time of the year. Usually, the symptoms begin to appear on the mature leaves near the base of the shoots and develop progressively up the canes.

The GLRD is a complex disease. Several serologically distinct viruses, termed *Grapevine leafroll-associated viruses* (GLRaVs), and numbered sequentially GLRaV-1, -2, -3, etc., have been associated with the disease.

Recent studies have shown that GLRaV-1, -2, -3, and -4 and its strains GLRaV-5 and GLRaV-9 are present in Washington State vineyards. Other GLRaVs have not been documented so far in Washington vineyards. GLRaV particles are highly flexuous and localized in the vascular tissue, i.e. phloem. Consequently, these viruses possibly interfere with the movement of nutrients in the vine, thereby causing secondary biochemical and physiological effects that could lead to the development of foliar symptoms. Since 1989, plant-to-plant spread of GLRD has been observed in vineyards in various countries and insect vectors such as mealybugs (*Pseudococcidae*) and scale insects (*Coccidae*) are thought to be responsible. At least six different mealybug species have been documented on grapevines in California. However, only grape mealybug (*Pseudococcus maritimus*) is known to occur in Washington vineyards. Grape mealybug is a known vector for GLRaV-3. Studies conducted outside the U.S. have shown that GLRaV-3, in the presence of mealybugs as vectors, can spread from a low incidence to almost complete infection of a new vineyard in less than a decade. Thus, grape mealybugs are an increasing concern for Washington grape growers, primarily due to the fact that they are vectors of GLRD. For more details on GLRD, please see *Grapevine Leafroll Disease* (EB2027E). A disease management strategy for controlling GLRD should involve planting tested virus-free vines and mealybug/scale insect-free planting materials, close monitoring of the vineyards for mealybugs and scale insects and their control by judicious use of pesticides.

Rugose Wood Complex (Grafted Vines)

All the graft-transmitted disorders of the woody trunk are grouped under Rugose Wood (RW) disease complex. RW is characterized by modifications of the woody cylinder, typified by marking with pits and/or grooves. It consists of four different disorders, namely rupestris stem pitting (RSP), Kober stem grooving, LN33 stem grooving, and corky bark. They may occur on the scion, rootstock, or both, depending on the rootstock and scion cultivar. European *Vitis vinifera* cultivars carry symptomless infections of RW complex until they are grafted onto American rootstocks. Thus, in eastern Washington where grapevines are grown as own-rooted vines, symptoms induced by the four disorders of RW complex may not be apparent.

Infections due to RW complex can significantly reduce the survival rate of grafted vines when compared to grafted virus-tested vines. Moreover, the severity of disease may vary according to the genotype of the rootstock that is grafted with infected scion wood. RW affected vines may be dwarfed and less vigorous than normal and may have delayed bud opening in the spring. Some vines decline and may die within a few years after planting, due to graft incompatibility. In western Washington, grapevine cultivars are propagated by grafting onto suitable rootstocks to gain security from phylloxera and nematode-borne virus infection, and to promote early ripening in areas of reduced heat units. In eastern Washington, vines are predominately own rooted. There is an increased tendency to top-work existing grapevines to other cultivars in order to save time and costs in establishing new vineyards. Because RW is symptomless in *V. vinifera*, grafting onto untested vines can unwittingly result in infection of the new scion. Due to increased emphasis of using rootstocks to

mitigate nematode- and Phylloxera-induced problems, disorders of the RW complex might become a concern in future. Therefore, growers should ensure that grafted vines for new plantings are tested free from viruses associated with RW complex.

The etiology of RW syndrome is complex and has not yet been completely worked out. At least four different viruses—namely, *Grapevine Virus* A (GVA), B, D to J, L and M, and *Grapevine rupestris stem pitting-associated virus* (GRSPaV)—have been consistently found in different disorders of RW complex. GVA, GVB and GVD were implicated in disorders of RW complex and the pathogenic role of other viruses remains to be determined. All these viruses are filamentous, phloem-limited, and are graft-transmissible, and thus all four disorders are spread by infected propagation material. GVA and GVB were reported to be transmitted by mealybugs. The natural spread of GRSPaV and other viruses listed above is not yet established. Currently, GRSPaV is known to be present in Washington State and according to some estimations, it affects approximately 5% of the grapevines in the state. When GRSPaV is present alone, grapevines do not produce foliar symptoms and there are no effects on the growth and yield of plants. However, when present as mixed infections with other viruses, RW-type symptoms may occur. GVA, GVB and GVE have so far been documented in Washington State vineyards. However, GVA and GVB appear to be more widespread than GVE.

Grapevine Fanleaf and Grapevine Decline Diseases

Grapevine fanleaf is a soil-borne disease spread by nematodes with a world-wide distribution. The disease often occurs in patches in the vineyard. In fact, it is the oldest known virus disease of *Vitis vinifera*. All grape species and cultivars are susceptible to fanleaf disease. Infection due to fanleaf leads to vine decline but not death of the vine. Like other diseases, fanleaf disease drastically affects vine growth and yield and quality of grapes. The diseased vines show three distinct types of leaf symptoms: fanleaf deformation, yellow mosaic, and vein banding. All of these symptom patterns are caused by the same virus and reflect varied responses by different cultivars. Fanleaf is caused by *Grapevine fanleaf virus* (GFLV). The two known nematode vectors are *Xiphinema index* and *X. italiae*. *Xiphinema index*, or dagger nematode, is by far the more efficient vector and currently not found in Washington State. Grapevine decline is another nematode-transmitted virus disease. At least three distinct viruses—*Tomato ring spot virus* (TomRSV), *Tobacco ring spot virus* (TRSV), and *Peach rosette mosaic virus*—have been implicated in the genesis of the disease. Two distinct strains of TomRSV are present and they induce different symptoms. GFLV and TRSV have recently been documented in Washington State vineyards.

Management of soil-borne diseases like Grapevine fanleaf disease involves testing the soil for nematode vectors before planting a vineyard, soil fumigation if any nematode vectors are present and planting virus-tested planting materials. Soil treatment to control nematode vectors may not provide lasting control in the existing vineyards. In the case of of TomRSV and TRSV, the nematode will shed the virus while molting. A possible control is to remove any plant species (weeds, grapes, grape roots) that are hosts for the nematode and allow the ground to be fallow for several years to minimize the presence of the virus and vector. Initial investments in testing the soil for nematode vectors and planting virus-tested cuttings are preferable to such measures, and will help maintain a healthy vineyard.

Grapevine Red Blotch Disease

Recently, Grapevine red blotch virus (GRBV) with single-stranded circular DNA was discovered in grapevines. This virus is implicated in symptoms of the Grapevine red blotch disease (GRBD). The disease has been documented recently in certain *Vitis vinifera* cultivars planted in Washington. In red-fruited cultivars, mature leaves at the bottom portions of canes show red veins, red blotches and total reddening. No such symptoms are apparent in white-fruited cultivars. In red-fruited cultivars, GRBD-affected vines show poor growth with significant reduction in fruit yield and berry quality.

The role of GRBV in producing symptoms of GRBD is not fully understood. It should be noted, however, that symptoms produced by GRBD show several similarities with symptoms of GLRD. Further studies are in progress to better understand epidemiological differences between these two distinct diseases in Washington vineyards. In the meantime, growers are advised to test suspected samples for accurate identification of viruses associated with GRBD and GLRD.

Potential Virus Diseases

There are many other diseases reported from different countries and they are of local or minor significance. With rapid expansion of plantings and changing viticultural practices, new and emerging problems with elusive virological etiology have become increasingly apparent in several grape-growing countries, such as virus-induced graft incompatibility disorders, destructive phytoplasma epidemics, and viroid-induced diseases. *Grapevine rupestris vein feathering virus*, *Grapevine red globe virus, Grapevine fleck virus* and *Grapevine syrah virus-1* have recently been documented in Washington vineyards. Three viroids (*Hop stunt viroid, Grapevine yellow speckle viroid-1 and Grapevine yellow speckle viroid-2*) have also been documented in the state's vineyards. Although other virus and virus-like problems are not yet reported in Washington State vineyards, constant vigil and careful monitoring of vineyards is important to make sure that no new virus disease becomes established in the state. It is very important that vines showing any unusual symptoms be brought to the attention of the Grape Virologist (Naidu Rayapati, naidu.rayapati@wsu.edu) at WSU-IAREC, in Prosser.

SPRAY RECOMMENDATIONS

General

- The rates given per acre and amount of formulated material in the tables are based on dilute sprays applied by ground equipment. You generally need approximately the same amount of active ingredients of insecticides, fungicides, or growth regulators per acre whether you apply them in dilute form, as concentrates, or as semiconcentrates.
- Proper pruning and spacing of vines is an aid in the control of many insects and diseases.
- Proper timing of sprays and adequate coverage is essential for good pest and disease control. Each vineyard operation differs with regard to equipment, spacing, and size of vines, local weather conditions, and particular pest problems. The timing, concentration, and gallonage of spray per acre should vary accordingly.

Formulations

Wettable powders (WP) are dry forms of pesticides. The toxicant is mixed with special powders, and wetting agents are added to make the mixture blend readily with water. Wettable powders form a suspension-type spray, which must be kept agitated in the spray tank. This type of formulation is often recommended for use in grapes because it is less likely to cause foliage injury. See Table 11 at the end of this section for dilutions for wettable powder and emulsifiable concentrates. Alternatively, there are smart phone apps like "Tank Mix" that will help calculate the amount of product and water to the appropriate spray tank size.

Liquid concentrates (L or LC) are formulations containing toxicants which are water soluble. No emulsifying agents or organic solvents are required. The designations L and LC are sometimes used to indicate emulsifiable concentrates.

Emulsifiable concentrates (EC) contain a pesticide and an emulsifying agent in a suitable solvent. These materials are diluted with water and applied as sprays. They leave much less visible residue than WP formulations, but are much more likely to injure fruit and foliage. See Table 11 at the end of this section for dilutions for wettable powder and emulsifiable concentrates. Alternatively, there are smart phone apps like "Tank Mix" that will help calculate the amount of product and water to the appropriate spray tank size.

Dry Flowable (DF) formulations are similar to wettable powders except that the powders (clay particles) are formed into tiny spheres. They do not tend to pack together, so they "flow" easily from the product container. Another name used for this type of formulation is Water Dispersible Granule.

Flowable (F) formulations are a liquid and viscous concentrate of suspendible pesticide in water. They usually cause less injury to fruit and foliage than EC formulations and generally, but not always, are as safe as WP formulations.

Soluble powders (SP) are powder formulations that dissolve in water. A few pesticides and many fertilizers are prepared as soluble powders.

Dusts (D) are usually made by mixing the chemical toxicant with finely ground talc, clay, or dried plant materials. Because of extreme drift hazards, dusts are now seldom used in vineyards.

Granules (G) are formed by saturating an inert carrier with pesticide. The particles are 30 to 60 mesh size. Granules are usually used for soil- or water-dwelling pests.

Baits consist of a poison plus a substance which will attract the pest. In vineyards, they are used only in cover crops and around vines. They are less hazardous to the general environment than many sprays and dusts. Birds, however, do occasionally feed on baits and may die if they eat large amounts.

Calibration of Vineyard Sprayers

A complete step-wise guide of calibrating airblast sprayers and selecting nozzles is available in *Six Steps to Calibrate and Optimize Airblast Sprayers for Orchards and Vineyards* (PNW749). Basic maintenance should be conducted to ensure a proper functioning pressure gauge and pump, no leaks from hoses, and no worn/clogged nozzles.

Speedometers on tractors are not always accurate. Ensure their accuracy by using either the vine spacing-miles per hour chart (Table 1), with two flags set 88 feet apart and calculate speed, or a hiking gps while driving on a tractor. For more details on the last two methods, see *Six Steps to Calibrate and Optimize Airblast Sprayers for Orchards and Vineyards* (PNW749). An example of the vine spacing method is assume your vine spacing is 8 feet and you pass

11 vine spaces (88 feet) in 1 minute, you are traveling at 1 mile per hour. A watch with a sweep second hand will be very helpful in determining your speed. Further calculations are shown in Table 1.

Dilutions

Low-Volume Spraying. There are various definitions for low-volume sprays. The generally accepted gallonages for spray work in vineyards include:

Dilute (High Gallonage)—301 or more gallons per acre

Semi-Concentrate—101 to 300 gallons per acre

Concentrate—10 to 100 gallons per acre

Very Low Volume—1 to 9 gallons per acre

Ultra Low Volume—Less than 1 gallon per acre undiluted material.

Many ground sprayers using concentrate sprays apply 50 to 100 gallons of spray per acre. Others, however, may apply as little as 10 gallons per acre. Information on use of much of this equipment on grapes in eastern Washington is not known at present. The tables showing acreage rates in this publication may be used as general guide in applying low-volume sprays. Check with your field representative or processor, however, before applying low-volume sprays. They may not be permitted by label directions.

Where oil-susceptible varieties or young vines are to be sprayed, lower rates than those shown in the table for horticultural mineral oil and oil-phosphate mixes may be desirable. Information in Washington on oil rates for total gallonages below 60 gallons per acre have not been studied. **Be sure that agitation is adequate to keep the spray mixed uniformly while applying oils and oil-phosphate mixes at all gallonages, but be particularly careful at low-volume or concentrate rates.**

Table 10. Vine spaces per minute.

		Vine spacing in a row				
		6 ft	7 ft	8 ft	9 ft	10 ft
Miles/hour	Feet/minute	Number of Vines				
1.0	88	14.7	12.8	11.0	9.8	8.8
1.5	132	22.0	18.9	16.5	14.7	13.2
2.0	176	29.3	25.1	22.0	19.6	17.6
2.5	220	36.7	31.4	27.5	24.4	22.0
3.0	264	44.0	37.7	33.0	29.3	26.4
4.0	352	58.8	50.2	44.0	39.2	35.2

Table 11. Dilutions for wettable powder and emulsifiable concentrates.

Type of material	Quantities of material for indicated quantities of water						
	100 gallons	75 gallons	50 gallons	10 gallons	5 gallons	3 gallons	1 gallon
Dry: Wettable Powder[1]	5 lb	3.75 lb	2.5 lb	8 oz (227 g)	4 oz (113 g)	2.4 oz (68 g)	0.8 oz (23 g)
	4 lb	3 lb	2 lb	6.4 oz (181 g)	3.2 oz (91 g)	1.9 oz (54 g)	0.64 oz (18 g)
	3 lb	2.25 lb	1.5 lb	4.8 oz (136 g)	2.4 oz (68 g)	1.4 oz (41 g)	0.48 oz (14 g)
	2 lb	1.5 lb	1 lb	3.2 oz (91 g)	1.6 oz (45 g)	1.0 oz (27 g)	0.32 oz (9 g)
	1 lb	12 oz (340 g)	0.5 lb	1.6 oz (45 g)	0.8 oz (23 g)	0.5 oz (14 g)	0.16 oz (5 g)
	0.5 lb	6 oz (170 g)	4 oz (113 g)	0.8 oz (23 g)	0.4 oz (11 g)	0.25 oz (7 g)	0.08 oz (2 g)
Liquid: Emulsifiable concentrate	5 gal	3.75 gal	2.5 gal	0.5 gal	32 oz (946 ml)	19 oz (568 ml)	6 oz (189 ml)
	4 gal	3 gal	2 gal	51 oz (1514 ml)	26 oz (757 ml)	15 oz (454 ml)	5 oz (151 ml)
	3 gal	2.25 gal	1.5 gal	38 oz (1136 ml)	19 oz (568 ml)	12 oz (341 ml)	4 oz (113 ml)
	2 gal	1.5 gal	1 gal	26 oz (757 ml)	13 oz (379 ml)	8 oz (227 ml)	2.5 oz (76 ml, 5 tbl)
	1 gal	0.75 gal	0.5 gal	13 oz (379 ml)	6 oz (189 ml)	4 oz (114 ml)	1 oz (38 ml, 2 tbl)
	1 qt (32 oz)	24 oz (710 ml)	16 oz (473 ml)	3 oz (95 ml)	2 oz (47 ml)	1 oz (28 ml, 2 tbl)	0.3 oz (9.5 ml, 2 tsp)
	1 pt (16 oz)	12 oz (355 ml)	8 oz (237 ml)	1.6 oz (47 ml)	1 oz (24 ml)	0.5 oz (14 ml, 1 tbl)	0.2 oz (5 ml, 1 tsp)

gal = gallons, lb = pounds, oz = ounces, g = grams, qt = quart, pt = pints, tbl = tablespoons, tsp = teaspoons

[1] For wettable powders, the number of dry tablespoons per ounce of dry pesticide varies greatly with different products because some materials are light and fluffy; others compact and heavy. In general, there are 2 to 6 level tablespoons per ounce of these dry materials. It is always better to weigh your materials than use tablespoons. However, if you want to convert ounces to tablespoons for small amounts of materials used repeatedly, weigh out the appropriate amount and then empirically measure the tablespoons or teaspoons.

REGULATORY INFORMATION

Federal and state pesticide regulations change frequently. Growers are advised to check with county agents or pest control consultants for the latest information before applying any chemical. Growers are also advised to check with their buyers, processors, or packers before applying chemicals. In some cases, buyers and processors may not accept grapes treated with certain materials, even though these materials are approved for use by federal and state agencies.

Pesticide Residues on Grapes

Residues of pesticides are permitted on harvested crops only under two conditions: an exemption is granted to the requirement for a tolerance, or the residue level does not exceed tolerances established by the Environmental Protection Agency.

To avoid illegal residues, it is imperative that you follow directions carefully with respect to rates of application, number of applications, and intervals between application and harvest. You must avoid drift, especially where other crops are adjacent to the crop being treated. Pesticide residues that are permitted on one crop may be illegal when present on another. For lists of pesticide tolerances, see the Global MRL database at *https://www.globalmrl.com/db#login*.

Pesticide Restricted Entry Standards

Unprotected workers must not be permitted in fields treated with pesticides during a specified interval after application. This interval, known as a restricted entry interval, appears on the label. All production agricultural pesticides state the restricted entry interval (REI), and it's usually in the "Agricultural Use Requirements" section of the label.

Workers may enter treated fields before the end of the restricted entry period if they wear protective clothing and if they are trained as "early entry workers." Protective clothing items required for early entry are stated on the label.

Warnings must be given to workers who are expected to work in treated fields within 30 days of the application. Warnings may be given orally, or by signs at the usual entrances to the field, and must be written in a language the workers understand. It is the responsibility of the owner or lessee of the treated field to see that workers comply with the standards.

With any pesticide, unprotected persons must not be allowed in areas being treated, and employees, other than those involved in the application, must not be exposed to drift.

Licensing

Most licenses must be renewed annually. Any person licensed as an applicator or operator is qualified as a certified applicator for the use of restricted-use pesticides. Those who sell, distribute, apply or advise on the use of pesticides may need to be licensed by the Washington State Department of Agriculture (WSDA), Pesticide Management Division, in one or more of the following categories.

Commercial Applicator. Any individual applying pesticides for hire to the lands of another must obtain an annual license.

Pesticide Dealer and Dealer Manager. Any individual acting as a pesticide dealer must obtain an annual license from the WSDA. All pesticide dealer outlets must employ a pesticide Dealer Manager.

Pest Control Consultant. Any individual who offers recommendations, technical advice, or aid on the use of pesticides except those packaged only for home and garden use must obtain an annual license. They cannot apply pesticides or supervise applications.

Private Pesticide Applicator. Any person who applies or supervises the application of restricted-use pesticides on land owned, leased, or rented by him/her or by an employer for the purpose of producing (growing) an agricultural commodity. Unlicensed employees of the Private Applicator may apply restricted-use pesticides only if supervised by the Private Applicator. Supervision of such employees includes adequate instruction regarding the safe and proper application of these pesticides as well as being readily accessible to the employee if problems occur. The Private Applicator bears legal responsibility for any pesticide application conducted by employees. The supervised employee must be a trained pesticide handler under the Worker Protection Standard (page 1). A grower may apply pesticides on the lands of another on trade-work basis without obtaining a commercial applicator's license.

Chemigation

State and federal regulations prohibit application of any pesticide through an irrigation system unless the label specifically allows this means of application. Backflow prevention devices, automatic check valves, and interlocking controls are required on all systems used for chemigation. Any person calibrating, loading, starting up, monitoring during application, or shutting down the system must be, or be supervised by, a certified applicator. For more information, contact Carl Henrikson, WSDA, (509) 771-5684.

The state of Washington has declared certain pesticides to be restricted for the protection of groundwater. These may only be used by certified applicators. There are two chemicals registered for use on grapes that are restricted for protection of groundwater: diuron and simazine.

State Laws and Regulations

Complete state laws and regulations can be obtained from the Pesticide Branch, Washington State Department of Agriculture, 2015 South 1st Street, Yakima, WA 98902, (509) 575-2746, or from the Washington State Department of Agriculture, 1111 Washington Street S.E./2nd floor NRB Building, P.O. Box 42560, Olympia, WA 98504-2560, toll free 1-877-301-4555.

Worker Right-To-Know Act

The Worker Right-To-Know Act was passed by the Washington State legislature in 1984. It is fairly similar to the federal/state Worker Protection Standard, but has additional requirements. It requires employers to train and inform their employees about hazardous chemicals in the workplace. The act does not apply to family operated vineyards or businesses that do not rely on hired workers. The following statement about the law was provided by the Department of Labor and Industries:

Grape growers now join all employers statewide in warning the workers about hazardous chemicals. This warning takes the form of information and training. Operators must develop and maintain a written program that explains how they inform and train their employees about the hazardous chemicals they are likely to be exposed to.

"Information" means telling workers about your chemical labels and safety data sheets (SDS). SDS are obtained from chemical manufacturers and dealers and kept on file where workers can see them. All workers must be told where hazardous chemicals, such as pesticides, are being used.

"Training" must be given to workers who are using the chemicals or who might be exposed to them.

For example, a person who enters a field that has been treated during the current growing season is considered to be exposed and therefore must be given the training.

This training includes:

- How to tell if the chemical is present (what it looks like, what it smells like).
- What the physical and health hazards are (symptoms or effects of overexposure).
- How workers can protect themselves (the SDS or label should explain the appropriate protection, such as gloves or a face mask).
- Good work practices (no eating or smoking around chemicals; wash thoroughly after leaving the area).
- Emergency procedures (whom to call and what to do if someone is overexposed).
- Where to find the SDS (make available to workers).
- How to obtain more information on the chemical and how to use that information.

Pesticide dealers must give farmers SDS with the initial purchase of all restricted-use pesticides. Pesticide applicators who sell pesticides must also provide SDS.

The Department of Labor and Industries will answer your questions about this program. For a copy of the new guidelines, call 360-902-5478. Both English and Spanish speakers may also contact Pedro Serrano at 360-902-6652 or email serp235@lni.wa.gov, or call toll-free within Washington: 1-800-547-8367. For more information, visit the Worker Right-to-Know Act website at *https://lni.wa.gov/workers-rights/*.

Horticultural Pest and Disease Boards

Washington counties may establish Horticultural Pest and Disease Boards to more effectively control and prevent the spread of horticultural pests and diseases. Boards are located in the following counties: Adams, Benton, Franklin, Chelan-Douglas,

Grant, Kittitas, Klickitat, Okanogan, Skagit, Spokane, Walla Walla, Whatcom, and Yakima. The boards may determine which pests and diseases must be controlled, receive complaints concerning infestation of horticultural pests, inspect any parcel of land to determine the presence of pests, order any landowner to control pests and prevent their spread from the property, or control the pests and charge the landowner for the expense of the control work.

Boards can be created by presenting a petition signed by 25 landowners to the county commissioners, or the commissioners can formulate a board on their own initiative, following a public hearing. Members of the board are appointed by the commissioners, with the horticultural inspector-at-large for the county involved being a mandatory voting member. Operational funds for the board must be provided by the commissioners.

Complaints are to be submitted to the board in writing. For more information on submitting a complaint, contact your District Horticultural Inspector or your county Extension agent.

Tank Mixes

Tank mixes of two or more pesticides and applications of one pesticide immediately or shortly following the application of another have been put into three categories by the Environmental Protection Agency:

Category 1. The use is indicated on the label of one or more EPA-registered products.

Category 2. The use is covered by state registration.

Category 3. The use has been tested and recommended by Agricultural Experiment Stations or State Departments of Agriculture, or is a common agricultural practice. Applications recommended on EPA or State approved labels (Categories 1 and 2) are legal.

Other uses (Category 3) will be permitted if dosages do not exceed label instructions for any product in the mix used singly for the same pests on the same crop and if labels do not explicitly instruct against such a mixture.

The EPA has not reviewed the effectiveness or the human or environmental hazards of combinations of products in Categories 2 and 3. The user is at risk in applying these mixtures with respect to effects on crops and equipment, applicator safety, environmental effects, and preharvest tolerance intervals. If a particular mixture causes adverse effects, the EPA will, on a case-by-case basis, rule that it is not permitted.

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Use pesticides with care. Apply them only to plants, animals, or sites listed on the label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

You may order copies of this and other publications from WSU Extension, at 1-800-723-1763 or *http://pubs.extension.wsu.edu*.

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