

2010 Pest Management Guide for Grapes in Washington

WASHINGTON STATE UNIVERSITY EXTENSION



POISON EMERGENCY**Washington Poison Center: 1-800-222-1222**

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 may be suitable. No endorsement is implied.

Pesticide Information

National Pesticide Telecommunication Network 1-800-858-7378

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GENERAL INFORMATION

The 2010 Pest Management Guide for Grapes in Washington presents all the various chemicals and their uses against pest problems common to 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.

Keep in mind that the 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.

PESTICIDE SAFETY

Precautions in Use and Storage

- If you plan to apply any of the more dangerous pesticides, make sure others know the types of compounds you are using. If you anticipate using the more toxic cholinesterase inhibiting materials, your physician may suggest that you have a preseasonal blood test to determine your normal cholinesterase activity level. Your physician will then be in a better position to deal with a sudden illness. If you are provided with a supply of atropine tablets for cholinesterase inhibiting poisoning, do *not* take them before definite symptoms occur. If you ever take atropine tablets, call your physician as soon afterward as possible.

Any person who is ill enough to receive a single dose of atropine should be kept under medical observation for 24 hours, because atropine may produce only temporary relief of symptoms in what may prove to be a serious case of poisoning. Keep atropine tablets away from children. Another antidote for treating cholinesterase inhibiting poisoning, pralidoxime chloride, available as protopam chloride (2-PAM), is

available at some hospitals and clinics in the Pacific Northwest.

- Wear water-repellent protective clothing while spraying hazardous materials, as toxic pesticides can be absorbed into the body through the skin. Applicators should remove contaminated clothing and bathe as soon after application as possible. Clothing, including special protective equipment such as rubber gloves and respirator masks, should be washed daily.
- Wear a respirator mask when loading or mixing wettable powders or when applying dust. *The respirator should be approved for the material in question by the U.S. Bureau of Mines or The National Institute for Occupational Safety and Health (NIOSH).* An approved respirator should be worn whenever the more volatile toxic compounds are being used. This is especially important when working with concentrate materials in hot weather since they volatilize more readily at higher temperatures. The filter and pads should be changed daily or more often if odor of the chemical is detected.
- Make empty containers of liquid pesticide as safe as possible before disposal. Triple-rinse containers and pour rinsate into the spray mixture you

are making up. Puncture or crush triple rinsed containers to ensure they can not be reused. Offer plastic or metal containers for pesticide container recycling. Washington State laws do not allow burning of used pesticide containers. Never measure or leave mixtures of insecticides in beverage bottles or in labeled cans or boxes which have contained food products. Each year tragic, preventable poisonings occur when children play with “empty” insecticide containers or obtain food containers filled with insecticide. Never leave concentrate materials unattended.

- Keep your pesticide storage shed or room locked. Also keep empty containers under lock and key.
- Do not smoke, chew tobacco, or eat while spraying or while your hands are contaminated, especially with concentrate materials.
- Mix pesticides according to label directions and apply at the recommended rate.
- Experience shows that poisoning occurs most often in hot weather. Spray with the more toxic materials during cooler periods insofar as possible. Take extra care when it is necessary to spray during periods of high temperature. Collect spilled material and absorbent for later use or hazardous waste disposal. Wash the contaminated area with soap and lots of water. The breakdown of these insecticides can be accelerated by using a weak lye solution.
- Keep soap and water available, especially where mixing and applying highly toxic pesticides.
- Do not apply pesticide sprays and dusts when there is a temperature inversion. This condition occurs when the air next to the ground is at a lower temperature than the air above it. The air cannot mix vertically, and spray or dust particles may be carried horizontally for a great distance. The presence of a temperature inversion is indicated when smoke is observed to move horizontally rather than vertically. Temperature measurements indicate an inversion when it is cooler 8 feet above the ground than it is at 32 feet.
- Cover or remove food and water containers when spraying around livestock areas. Avoid contamination of fish ponds, streams, and lakes.
- Avoid drift of pesticides to other crops—do not spray with leaking hose or connections—avoid working in the drift of spray or dust.

- 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 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 cover has flowers, the cover must be mowed before spraying to protect pollinators.

Pesticide Disposal

Most pesticide products become hazardous waste upon disposal and thus fall under the Washington State Dangerous Waste Regulations, Chapter 173-303 WAC. The Washington State Department of Ecology (Ecology) is the agency responsible for administering these regulations. 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 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 360-902-2056, or 1-877-301-4555, press 1,

then 5; or look for information on the Internet at <http://agr.wa.gov/PestFert/Pesticides/WastePesticide.htm>

Symptoms of Poisoning

Organophosphorus pesticide poisoning is indicated initially by one or more of the following symptoms: giddiness, headache, nausea, vomiting, excessive sweating, and tightness of the chest. These may be followed or accompanied by blurring of vision, diarrhea, excessive salivation, watering of the eyes, twitching of muscles especially in the eyelids, and mental confusion. One of the most characteristic signs is constriction of the pupils, but this may be preceded by dilation. Late signs are fluid in the chest, convulsions, coma, loss of urinary or bowel control, and respiratory failure. Onset of symptoms more than 12 hours after the termination of exposure excludes the possibility of organophosphate poisoning.

Carbamate pesticide poisoning is indicated by symptoms similar to those seen in organophosphate poisoning.

Chlorinated organic pesticide poisoning is indicated by hyperexcitability, tremors, and convulsions. General symptoms, which are also indicative of other illnesses, include malaise, headache, fatigue, lack of appetite, and weight loss. Symptoms have been reported as soon as 30 minutes after massive exposure, but generally develop more slowly. Maximum symptoms are usually reached within a few hours after acute exposure.

Emergency Treatment

Emergency information can be obtained from the National Capital Poison Center at 1-800-222-1222. Centers in Tacoma, Yakima, Seattle, and Spokane have been consolidated due to a decline in state funding. The person answering your call will refer you to the nearest hospital handling pesticide poisonings. This is a statewide, toll-free number, which is staffed 24-hours a day.

Organophosphorus pesticides cause the vast majority of occupational poisonings that lead to the

need for emergency treatment. However, the following suggestions apply to any type of pesticide poisoning.

1. If breathing stops, the most important first aid is artificial respiration.
2. Call a physician immediately for instructions on first-aid measures. Get the victim to the physician or a hospital as soon as possible. If you know which pesticide may be involved, take along a label for the doctor's information. If the label cannot be removed easily, take along the container. (However, be sure the container is relabeled as soon as possible.)
3. Decontamination is extremely important. If the pesticide has come in contact with skin and clothing, immediately remove all clothing and bathe the victim with generous amounts of soap and water, rinsing thoroughly. Avoid contaminating yourself by using protective clothing such as rubber gloves and apron.
4. If the eyes have been contaminated, wash immediately with flowing water for at least 15 minutes.
5. Never try to give anything by mouth to an unconscious person.

Reporting Poisonings and Pesticide Accidents

Prompt investigation of pesticide accidents, misuse, or poisonings by appropriate state or federal agencies is essential to minimize harmful effects, to determine causes and responsibilities, and to reduce the possibility of recurrences. These agencies have trained investigative personnel to handle such problems, but to do their job effectively it is important they be informed as soon as possible after an incident occurs. Otherwise valuable information may be lost, or it may be too late to adequately protect public health or property.

Human Poisonings or Suspected Excessive Exposure

As soon as the victim is under a physician's care, notify the following agency as soon as possible. Reports from growers, while not required, are helpful.

For human poisonings or excessive exposure, contact:

Washington State Department of Health
Division of Environmental Health
Office of Environmental Health Assessments
P.O. Box 47846, Olympia, WA 98504-7846; or call
1-877-485-7316 or 1-360-236-3184

For Spanish-speaking investigators, include:

Mario Magaña
Se habla español
Investigator (Eastern Washington)
509-575-2056

Accidents Involving Application

For drift problems, animal poisonings, plant damage, fish kill, etc., notify the Washington State Department of Agriculture, Pesticide Management Division (WSDA), P.O. Box 42589, 1111 Washington Street, S.E., Olympia, WA 98504-2589. Complete state laws and regulations are available on the Internet at <http://agr.wa.gov/PestFert/Pesticides/LawsRules.htm>, or from one of the four branch offices listed below; or **call toll-free, 1-877-301-4555**.

WSDA Pesticide Management Division—
Spokane Branch
222 N. Havana, Suite 203
Spokane, WA 99202-4776

WSDA Pesticide Management Division—
Moses Lake Branch
821 E. Broadway, Suite 4
Moses Lake, WA 98837

WSDA Pesticide Management Division—
Wenatchee Branch
1505 N. Miller Street, Suite 140
Wenatchee, WA 98801-1569

WSDA Pesticide Management Division—
Yakima Branch
21 N. 1st Avenue, Suite 236
Yakima, WA 98902

Accidents Involving Storage or Transportation

If significant pesticide contamination results from fires, floods, spillage, leakage, etc., notify the Department of Ecology at regional numbers listed on page 5 under Pesticide Disposal.

Other Sources of Information

For nonemergency information on pesticide toxicity, hazards, and treatment for poisonings, refer to the pesticide product Material Safety Data Sheets (MSDS). For additional toxicology information, contact the Washington State Department of Health, Office of Environmental Health Assessments, P.O. Box 47846, Olympia, WA 98504; or call 877-485-7316 or 360-236-3184.

The Department of Labor and Industries has recently selected Pathology Associates Medical Laboratories (PAML), 110 W. Cliff Avenue, Spokane, WA 99204, to run cholinesterase tests under WAC 296-307-148, Cholinesterase Monitoring. The selection has just been made, so PAML has yet to establish accounts with all involved medical providers. Final transition from the Public Health Laboratory to PAML and establishment of relationships with participating medical providers will be occurring through December of 2006.

For information on regulations concerning transportation of hazardous materials, contact the Washington State Patrol, P.O. Box 42614, Olympia, WA 98504-2614; or call 360-753-0281.

CHEMICAL WEED CONTROL

Chemical control of undesirable vineyard vegetation is becoming increasingly important. Uses of chemicals not only reduces the need for seasonal labor, but can also improve vine growth, cropping, and pest control.

However, use caution in selecting and applying these herbicides. They are capable of causing serious injury or death of vines. Select the proper herbicide or combination of herbicides according to:

- the kind of weed to be controlled,
- the age of the vines,
- season and weather conditions,
- type of irrigation, and
- soil in different fields or portions of the vineyard.

The reasons for these differences are outlined in the discussion of each chemical.

Application Rate and Equipment

The rate or amount of herbicide to be applied is shown as the amount per acre of the actual portion of the acre treated. It is not the acreage of the vineyard. Calculate the acres of treated ground on the basis of the distance between rows or trellises, and the width of the area under the vines to be treated. Thus, a 10-foot row spacing with a 2-foot band of herbicide represents two-tenths (one-fifth) or 20% of an acre to be treated per 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.

Use low pressures (20 to 35 psi) to ensure coverage and penetration while minimizing spray drift.

NOTE: With 2,4-D or glyphosate, reduce the pressure to less than 20 pounds (psi).

Constant agitation of the spray mixture is essential with wettable powders and dry flowables, and agitation must be vigorous when using oils. Reduce excess foaming by adding 4 fluid ounces of kerosene per 100 gallons of water to the spray tank or by adding a defoaming agent. Adding kerosene or defoaming agent when the tank is being filled with water and before addition of the herbicide causes foam to form.

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 these have been thoroughly tested.
4. Avoid contact with any portion of the grapevine and do not use weed sprayers to apply other pesticides to vines.

HERBICIDE INFORMATION

The various chemicals used as herbicides differ in both their mode of action and use. Those grouped as “foliage applied herbicides” must be applied directly to the weed. Therefore, they control only existing weeds. The “soil-active herbicides” act primarily on germinating weed seeds or young seedlings. They give seasonal control but must be applied directly to the soil or incorporated into the soil surface.

A combination of both contact and soil-active herbicides may be required to kill existing weeds and provide seasonal control.

Soil-Active Herbicides (for seasonal control)

These residual chemicals can cause serious root injury and even the death of vines when improperly selected or applied. Their selection depends on the age of the vine, the type of soil, the method of irrigation, and the season of the year. Because these chemicals can leach down from the soil surface and into the root zone of the grapevine, particular caution is needed with shallow, coarse, sandy, or gravelly soils, and in vineyards irrigated by sprinklers.

Diuron (Karmex and other tradenames) and Simazine (Princep and other trade names). These two soil-active herbicides give seasonal control of weeds and have similar performance. To be effective they must be applied during the rainy period (from about November 1 to February 15 in eastern Washington), but not to frozen ground. Simazine may be applied anytime between harvest and early spring. Spring applications may not be as effective unless rains fall soon after application to carry the chemical into the soil surface.

NOTE: Serious herbicide injury to grape roots has occurred when either of these herbicides is applied under improper conditions. Do *not* apply to vines under three (3) years of age or to vineyards with shallow, coarse, sandy, or gravelly soils. Application to vineyards under sprinkler irrigation is extremely hazardous. Labels vary between formulation. Follow the respective label carefully.

Dichlobenil (Casoron). A highly effective, soil-active herbicide for long-term or seasonal control

of most weeds. It not only kills germinating seeds and young seedling weeds but also suppresses the growth of many perennials (Canada thistle, quackgrass, field bindweed and bermudagrass).

Removing old weed growth before application is unnecessary, nor does the manufacturer recommend it. Application is most effective in the fall, at the beginning of the rainy season (about November 1 to February 15 in eastern Washington) when the ground is cool.

NOTE: Do not apply when the ground is frozen.

Application can be made in the spring before the last rains and up to about May 1 when the soil surface is still 60°F or below. If 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).

NOTE: 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 one-half to 1 inch of water.

Caution: Avoid use on coarse, sandy, gravelly, or shallow soils because of potential injury. Do not apply either formulation to recently cultivated or loose soil or when the soil surface is wet and warm (above about 70°F). Delay application until the soil has settled with rain or irrigation and the soil surface is dry.

Napropamide (Devrinol). A soil-active herbicide which can be used safely in sprinkler-irrigated vineyards on grapes. It may be applied to newly planted and established vineyards and must be applied to bare ground. It is effective on germinating weed seed but will not give complete control of nightshade, flixweed, tansy mustard, tumble mustard, or perennial weeds.

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 application. Applications made later, during the

spring, should be irrigated into the soil on the day applied with sufficient water to wet the soil to a depth of at least 2 to 4 inches.

NOTE: Immediate mechanical incorporation enhances herbicide effectiveness regardless of time of application.

Oryzalin (Surflan and other tradenames). A soil-active herbicide which can be used safely on newly planted vineyards after the soil has settled around the vines and which is safe to use under sprinkler irrigation.

Surflan controls many annual grasses and broadleaf weeds but will not give complete control of nightshade, tansy mustard, or tumble mustard. Treated areas must be free of established weeds and well worked prior to spray application. A half-inch 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.

Trifluralin (Treflan and other tradenames). A soil-active herbicide which can be used at planting time as well as in established vineyards but must be mechanically incorporated into the soil immediately after application to be effective and prevent loss of activity. Treatment gives nearly seasonal control over most annual grasses and many broadleaf weeds.

NOTE: Since trifluralin (Treflan) cannot be leached into the soil, it is best applied in the spring and can be used in vineyards with sandy soils or sprinkler irrigation.

Norflurazon (Solicam). A broad spectrum soil-applied herbicide that will control many annual broadleaf and grass weeds found in grapes. Norflurazon can be applied from fall to early spring before the weeds emerge but not to frozen ground. The soil surface must be free of weeds and relatively free of plant residues at the time of application. The soil should be settled and firm at the time of application.

NOTE: Norflurazon should not be applied to vines established less than 2 years in the vineyard. Do

not use on wine grapes grown in gravelly, sandy, loamy sand, or sandy loam soils in Washington. 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.

Pronamide (Kerb). A soil-applied herbicide effective on annual grass weeds; will also control some perennial grasses. Apply in the fall or early winter when soil temperatures are below 55°F, but prior to soil freezeup. Kerb is most effective when applied to bare soil preemergence, and when the application is followed by rainfall or irrigation. Use rate will be determined by the grass species to be controlled and soil type.

NOTE: Do not use on seedling vines less than 1 year old, or on fall transplanted stock transplanted less than 1 year, or to spring transplanted stock transplanted less than 6 months. Apply only one time per year.

Pendimethalin (Prowl and other trade names). A soil-active herbicide registered for use in nonbearing and bearing grapes.

Must be applied before weeds germinate. Pendimethalin is most effective when adequate rainfall or irrigation is received within 7 days after application. The use rate determines the length of weed control obtained.

NOTE: Do not apply to newly transplanted vines until the soil has settled and no cracks are present. Apply only to dormant grapevines and before the buds have started to swell.

Oxyfluorfen (Goal, Galigan, GoalTender). Apply this material as a directed spray to dormant vineyards either preemergence or to control annual broadleaf weeds. Apply only to grapes which have been staked or trellised. It is most effective postemergence when the seedling weeds have less than four leaves. When applied preemergence to the weeds, apply oxyfluorfen to bare soil. At least a fourth-inch of overhead moisture within 3 to 4 weeks will enhance herbicidal activity.

NOTE: Cultural practices which disturb the soil surface after application will decrease weed

control. Multiple applications may be made, but do not apply more than 1.5 pounds active ingredient per acre per season. Add 1 quart of a nonionic surfactant per 100 gallons of spray.

Caution: Do not apply after buds have started to swell or when foliage or fruit are present. The closer grapes are to bud swell at time of application, the greater the chance of crop injury. Avoid direct grape plant contact with the herbicide.

Flumioxazin (Chateau). A preemergence or postemergence herbicide for controlling several annual broadleaf weeds. To be effective preemergence (prior to weed emergence), it must be applied to weed-free soil or with glyphosate, paraquat, or glufosinate, and be moved into the soil with overhead moisture to control germinating weeds. Flumioxazin also has postemergence (after weed emergence) activity on weeds 2 inches or less in height or across, and activity is enhanced when a non-ionic surfactant is added to the spray mix. For weeds larger than 3 inches tall, apply with glyphosate, paraquat, or glufosinate. Do not apply to grapes established less than two years in the vineyard unless they are trellised at least 3 feet from the soil surface or are protected from spray by non-porous wrap, grow tubes, or waxed containers. Do not apply after flowering. Do not make a sequential application within 30 days of the first application. Do not apply within 60 days of harvest. Do not apply more than 0.38 pound flumioxazin per acre during a single application, or 0.76 pound per acre per calendar year. A maximum rate of 0.19 lb ai/A (6 ounces product) should be used on any soil that has a sand content over 80% if vines are under three years of age.

Caution: Contact with new foliage or green bark can cause severe injury. Do not apply to grapes that are not trellised or staked unless they are free standing.

Foliage-Applied Herbicides

Glyphosate (Roundup and other tradenames). 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 the label for recommended rates and correct timing in relation to weed growth. Apply in 20 to 60 gallons of water per acre on emerged weeds. Glyphosate does not provide residual weed control. Avoid spray contact with green bark, suckers, and foliage, as vine injury may occur.

NOTE: If repeated treatments are necessary for weed control, do not exceed a total of 10.6 quarts per acre per year. Do not treat between 14 days before harvest to fall dormancy when green vegetation, canes, or shoots exist in the spray zone.

2,4-D (Recoil Broad Spectrum; a pre-packaged mix with glyphosate). A translocated herbicide which controls most broadleaf weeds, including Canada thistle and field bindweed, but not grasses. Apply only with low pressure (20 psi or less) and when the wind velocity is under 2 mph and temperatures are less than 85°F. Best results are obtained when applied within 2 days following an irrigation and when weeds are growing actively. Wet weed foliage thoroughly but avoid run-off.

One application of 2,4-D seldom eradicates Canada thistle or field bindweed. To increase the effectiveness of the springtime treatment, lightly cover the treated bindweed with soil 2 or 3 weeks after applying 2,4-D. Apply when annual weeds are young and actively growing, or when perennial weeds are in the early bud stage of growth or have 6 to 8 inches of regrowth.

NOTE: Grapes are extremely sensitive not only to fumes but even to traces of 2,4-D in the air. Use only registered, nonvolatile formulations and never allow 2,4-D to contact any portion of the grapevine, including trunk and suckers.

Do *not* apply to bare ground or within 5 to 7 days before an irrigation. 2,4-D is readily leached down in the soil to the roots of the grapevines with irrigation water.

Paraquat (Gramoxone Max, Gramoxone Inteon, Firestorm). A highly effective, contact herbicide for killing annual broadleaf weeds and grasses and suppression of perennial weeds. Apply when grasses

and other weeds are growing actively and new growth is from 1 to 6 inches high. Use a directed spray in 50 to 200 gallons of water for thorough coverage of the weeds.

With mustard-type annual weeds, apply before leaves exceed 1 inch in diameter. This may require application in December or January as well as during the growing season. For more woody weeds, perennials, and late-germinating weeds, make additional spot treatments as necessary for control.

NOTE: Apply with nonionic surfactant. Paraquat is corrosive to aluminum.

Caution: Contact with foliage, new growth, and suckers can cause severe injury. Use as a directed spray and shield young vines.

DANGER: Poison—paraquat is toxic to humans particularly when ingested or inhaled into the lungs. Always use an approved face shield during mixing. Avoid contact with clothes and skin and wash thoroughly after using paraquat.

Glufosinate (Rely). 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. Do not allow spray or mist to contact foliage or green bark of desirable species. 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. Glufosinate is rainfast 4 hours after application.

Do not apply within 1 year of transplanting. Do not harvest within 14 days of application.

For sucker control, use a split application, applied approximately 4 weeks apart. Coverage of all sucker foliage is necessary for optimum control. Suckers should not exceed 12 inches in length.

Carfentrazone-ethyl (Aim). Carfentrazone may be applied alone or as a tank mixture with other labeled herbicides as a postemergence directed treatment or as a hooded spray to control emerged and actively growing weeds. Good spray coverage of the weeds is essential for good control. May be applied anytime during the season. Carfentrazone-ethyl can be used for sucker control.

Control is enhanced with the addition of a nonionic surfactant containing at least 80% active at 0.25% v/v or crop oil concentrate at 1% v/v. The 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 make applications less than 14 days apart. Do not apply more than 7.9 fluid ounces (0.124 lb ai) of Aim EW per acre per season. Do not harvest within 3 days following last application.

Do not use on seedlings or newly transplanted vines, or allow spray to contact foliage, fruit, or the green bark on trunks.

Pyraflufen ethyl (Venue). A contact herbicide that is active on annual broadleaf weeds. Apply in a minimum of 10 gallons of water per acre when the weeds are less than 4 inches tall or 3 inches across. Use as a directed spray and thoroughly cover weeds with spray. 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. Mix only the amount of solution that can be sprayed within 4 hours. Do not make more than 3 applications or exceed 6.8 fl oz/A of product during the growing season. Allow at least 30 days between applications. May be tank-mixed with 2,4-D or glyphosate for enhanced control of larger weeds or with a labeled grass herbicide for improved grass control.

Caution: Do not allow spray to contact green bark or foliage.

Fluazifop (Fusilade), clethodim (Select and other tradenames) and sethoxydim (Poast). Fluazifop and clethodim are registered for use only in non-bearing vineyards that will not be harvested within 1 year of treatment. Sethoxydim is registered for use in bearing vineyards. They are foliage applied, translocated herbicides which will control most actively growing grass weeds. The herbicide will not control annual bluegrass or the fine-leaved fescues. Apply fluazifop to actively growing grasses as a directed spray in water. Add 1 quart crop oil concentrate or a half-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 four- to five-leaf stage (6 to 12 inches tall). Add 2 pints of a nonphytotoxic oil concentrate per acre.

NOTE: Do not apply to grasses which are stressed.

Rimsulfuron (Matrix FNV). A preemergence or very early postemergence herbicide to weeds that can be applied to healthy vines. Best results are obtained when the soil is debris free and moist at time of application, and 1/2 inch of overhead moisture occurs within 2 weeks after application. When weeds are present at application, include a labeled burndown herbicide. For best results, maintain spray tank solution at pH 5 to 7. Susceptible weeds are controlled from 60 to 90 days after application. Will not provide season-long control of summer annual grass.

Note: Vines should be established in the field at least one full growing season. If the application is banded over the 50% or less of vine row, a second application may be needed to provide extended weed control. Allow a minimum of 30 days between applications. Do not exceed 4 ounces of product per acre on a broadcast basis per year.

WEED CONTROL PROGRAM FOR GRAPES

Material per Acre Treated*				
Weeds to be controlled (For specific weeds, see label.)	Materials & Formulation	Active Ingredient	Formulated Materials	Remarks and Restrictions
FALL OR EARLY WINTER APPLICATION—For seasonal control apply during the rainy period (November 1 to February 15 in eastern Washington) and when the ground is not frozen. See labels for application timing restrictions.				
Annual grasses & broadleaf weeds	1. dichlobenil (Casoron 4G) or (Casoron CS)	4.0–6.0 pounds 1.96–3.92 pounds	100–150 pounds 1.4–2.8 gallons	Casoron 4G for vineyards which have been transplanted more than 4 weeks; Casoron CS after vines have been transplanted for at least 12 months. May be applied where weeds are present. Consult agricultural authorities before applying dichlobenil to sprinkler-irrigated vineyards. Do not apply to coarse sandy, gravelly, or shallow soil. See text for details.
	2. diuron (Karmex DF) or simazine (Princep 4L) or (Princep Caliber 90)	2.4 pounds 2.0 pounds 1.98 pounds	3.0 pounds 2.0 quarts 2.2 pounds	

*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 CONTROL PROGRAM FOR GRAPES, continued

Weeds to be controlled (For specific weeds, see label.)	Material per Acre Treated*			Remarks and Restrictions	
	Materials & Formulation	Active Ingredient	Formulated Materials		
Annual grasses & broadleaf weeds (continued)	3. flumioxazin (Chateau WDG)	0.19–0.38 pound	6.0–12.0 oz.	For vineyards established at least 2 years. Controls several annual broadleaf weeds. Rate depends on soil type, weeds to be controlled, and age of the vines. Apply to a weed free soil surface or mix with glyphosate, paraquat, or glufosinate. Must be incorporated with overhead moisture. Do not apply within 60 days of harvest. See text and label for details.	
	4. napropamide (Devrinol 50DF)	4.0 pounds	8.0 pounds	For newly planted and established vineyards. Apply to the bare ground and incorporate if rain does not occur within 2 weeks after application. See text.	
	5. norflurazon (Solicam DF)	0.98–3.93 pounds	1.25–5.0 pounds	For vineyards established at least 2 years. Do not apply to gravelly, sand, or loamy sand soils. See text.	
	6. oryzalin (Surflan A.S.)	2.0–6.0 pounds	2.0–6.0 quarts	While not required, weed control may be enhanced by mechanical incorporation. Use higher rates for longer in-season control. See text for details.	
	7. oxyfluorfen (Goal 2XL, Galigan 2E) or (GoalTender, Galigan H2O)	0.5–1.5 pounds 0.5–1.5 pounds	2.0–6.0 pints 1.0–3.0 pints	For vineyards established at least 3 years. The lower rate is for control of susceptible broadleaf seedling weeds up to the four-leaf stage. The higher rate should be used for weeds up to the six-leaf stage or for preemergence control. See text.	
	8. pendimethalin (Prowl 3.3 EC) or (Prowl H2O)	1.98–3.96 pounds 3.04–5.99 pounds	2.4–4.8 quarts 3.2–6.3 quarts	Prowl 3.3 is labeled only for nonbearing vineyards; Prowl H2O may be used in nonbearing or bearing vineyards. Use the lower rate for coarse soils and the higher rate for fine-textured soils. Pre-harvest interval for Prowl H2O is 90 days.	
	9. pronamide (Kerb 50W)	1.0–4.0 pounds	2.0–8.0 pounds	For grass control in vineyards established at least 1 year if transplanted in the fall or at least 6 months if transplanted in the spring. Apply to bare soil. Apply in fall prior to soil freeze-up. See text.	
	10. rimsulfuron (Matrix FNV)	1.0 oz.	4.0 oz.	Apply preemergence or early postemergence to weeds. Controls several annual grass and broadleaf weeds. A repeat application may be made if banded over the row. Do not harvest for 14 days.	
	SPRING APPLICATION—For application to bare ground.				
	New Plantings—Annual grasses & certain annual broadleaf weeds	1. napropamide (Devrinol 50DF)	4.0 pounds	8.0 pounds	Apply to bare ground and irrigate into soil the same day. Mechanical incorporation enhances weed control.
2. oryzalin (Surflan A.S.)		2.0–6.0 pounds	2.0–6.0 quarts	Does not require mechanical incorporation into the soil. Use higher rates for longer season control. See text for details.	
3. pendimethalin (Prowl 3.3EC) or (Prowl H2O)		1.98–3.96 pounds 3.04–5.99 pounds	2.4–4.8 quarts 3.2–6.3 quarts	Use the lower rate for coarse soils and the higher rate for fine-textured soils.	
4. trifluralin (Treflan 4L)		0.5–0.75 pound	1.0–1.5 pints	Must be incorporated into the soil mechanically after application to be effective. May be applied before or after planting. See text for details.	

*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 CONTROL PROGRAM FOR GRAPES, continued

Weeds to be controlled (For specific weeds, see label.)	Material per Acre Treated*			Remarks and Restrictions
	Materials & Formulation	Active Ingredient	Formulated Materials	
Established Plantings— Annual grasses & certain annual broadleaf weeds	1. dichlobenil (Casoron 4G)	4.0–6.0 pounds	100–150 pounds	For vineyards which have been transplanted more than 4 weeks. May be applied where weeds are present. Consult agricultural authorities before applying dichlobenil to sprinkler irrigated vineyards. Do not apply to coarse sandy, gravelly or shallow soils. See text for details.
	2. flumioxazin (Chateau WDG)	0.19–0.38 pound	6.0–12.0 oz.	Controls several annual broadleaf weeds. Rate depends on soil type, weeds to be controlled, and age of the vines. Apply to a weed free soil surface or mix with glyphosate, paraquat, or glufosinate. Must be incorporated with overhead moisture. Do not apply within 60 days of harvest. See text and label for details.
	3. napropamide (Devrinol 50DF)	4.0 pounds	8.0 pounds	Apply to bare ground and irrigate into the soil the same day. Mechanical incorporation enhances weed control. See text.
	4. norflurazon (Solicam DF)	1.97–3.93 pounds	2.5–5.0 pounds	For vineyards established at least 2 years. Do not apply to gravelly, sand, or loamy sand soils. See text.
	5. oryzalin (Surflan A.S.)	2.0–6.0 pounds	2.0–6.0 quarts	Does not require mechanical incorporation into the soil. Use higher rates for longer season control. See text for details.
	6. trifluralin (Treflan 4L)	0.5–2.0 pounds	1.0–4.0 pints	Must be incorporated into the soil mechanically after application to be effective. See text for details. Do not apply within 60 days of harvest.
	7. pendimethalin (Prowl H2O)	3.04–5.99 pounds	3.2–6.3 quarts	Prowl H2O may be used in nonbearing or bearing vineyards. Use the lower rate for coarse soils and the higher rate for fine-textured soils. Pre-harvest interval is 90 days.
TEMPORARY CONTROL—Apply as needed to control.				
Annual broadleaf weeds	1. carfentrazone-ethyl (Aim EW)	0.016–0.031 pound	1.0–2.0 fl. oz.	Use as a directed spray. Repeat if needed. Keep off green foliage and stems. Do not apply more than 7.9 fl. oz. per acre per year. Do not harvest within 3 days of treatment.
TEMPORARY CONTROL—Apply as needed to control (continued).				
Annual broadleaf weeds (continued)	1. pyraflufen ethyl (Venue)	0.44–2.51 grams	0.7–4.0 fl oz.	Use as a directed spray during the dormant period prior to bloom. Repeat if needed. Keep off green stems and foliage. Do not apply more than 6.8 fl oz per acre per growing season.
Annual grassy & broadleaf weeds & top kill of perennial weeds	1. glufosinate (Rely) or (Rely 200)	0.75–1.5 pounds	3.0–6.0 quarts	Use as a directed spray. Repeat if needed. Keep off of green foliage and stems. Do not apply to vines established less than 1 year unless protected by non-porous wraps, grow tubes, or waxed containers. Do not harvest within 14 days of treatment.
		0.75–1.5 pounds	1.8–3.6 quarts	

*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 CONTROL PROGRAM FOR GRAPES, continued

Weeds to be controlled (For specific weeds, see label.)	Material per Acre Treated*			Remarks and Restrictions
	Materials & Formulation	Active Ingredient	Formulated Materials	
Annual grassy & broadleaf weeds & top kill of perennial weeds (continued)	2. paraquat (Gramoxone Max) or (Gramoxone Inteon) or (Firestorm)	0.64–1.0 pound	1.7–2.7 pints	Use as a directed spray. Repeat if needed. Keep off stems. Can cause injury on 1- and 2-year-old vines by absorption through thin bark. Most effective when weeds are less than 4 to 6 inches high and are actively growing. See text.
	+ nonionic surfactant	0.625–1.0 pound	2.5–4.0 pints	
		0.64–1.0 pound	1.7–2.7 pints	
Annual & perennial weed control	1. glyphosate (Roundup and others) (3 lb ae/gal)	0.9–1.36 pounds	One 2 lb 13 oz packet per 1.67 to 2.5 acres	Use as a directed spray in established vineyards or for site preparation before transplanting new vines. Refer to label for rate and timing, especially on perennial weeds. Do not allow spray drift or mist to contact green foliage, green bark, suckers, or vines and renewals less than 3 years old. Do not treat within 14 days of harvest.
	2. 2,4-D + glyphosate (Recoil Broad Spectrum) (1.07 lb ae 2,4-D + 1.58 lb ae glyphosate/gal)	0.27–1.07 pounds 0.4–1.58 pounds	1.0–4.0 quarts 1.0–4.0 quarts	Apply to annual weeds when young and actively growing or when perennial weeds are in the early bud stage or have 6 to 8 inches of regrowth. <i>Grapes are extremely sensitive to 2,4-D. Do not use on sandy soils (70% or more sand). Do not use on vines established less than 3 years. Use a hooded boom and low-pressure, flooding nozzle to avoid contact or drift on grapevines. See text.</i>
Annual & perennial grasses	1. clethodim (Select 2EC)	0.09–0.125 pound	6.0–8.0 fl. oz.	Apply clethodim to actively growing grasses in the labeled stage of growth. Add 1 pint of non-ionic surfactant to 50 gallons of spray material. Apply as a directed spray in vineyards that will not be harvested for at least one year following treatment. Use on nonbearing vineyards only.
	2. fluazifop (Fusilade DX)	0.25–0.38 pound	1.0–1.5 pints	Apply to actively growing grasses in the labeled stage of growth. Add 1 quart crop oil concentrate or 1/2 pint nonionic surfactant to 25 gallons of spray material. Apply as a directed spray in vineyards which will not be harvested within 1 year of treatment. Use on nonbearing vineyards only.
	3. sethoxydim (Poast)	0.28–0.47 pound	1.5–2.5 pints	Apply to actively growing grasses in the four- to five-leaf stage of growth (6 to 12 inches tall). Add 2 pints of a nonphytotoxic crop oil concentrate per acre. Do not harvest within 50 days after application.

*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.

INSECTS OF GRAPES

Grape Mealybug

Grape mealybug is a documented vector for the complex of several viruses that are the causal agents for grapevine leafroll disease (GRLV). When virus has been detected within a vineyard or in nearby vineyards the treatment threshold for mealybug is of little concern. Disease severity and expression of GRLV symptoms varies among virus strains, grape varieties and climatic conditions. However, there is no cure of treatment for GRLV and infested vineyards will produce lower berry yields and juice quality. A secondary contamination can occur in late-season vineyards when the honeydew mealybugs excrete 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 $\frac{1}{4}$ inch 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, $\frac{1}{16}$ to $\frac{1}{8}$ inch 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 laterals. 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. Chemigation 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 imidacloprid is an effective treatment available for grape mealybug control

when 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. Foliar treatments can be applied to vineyards that are not irrigated by drip irrigation systems. Foliar sprays of chlorpyrifos are labeled exclusively for dormant or delayed dormant applications. Research has demonstrated that foliar sprays of imidacloprid (Provado) are not very effective at controlling grape mealybug infestations. Foliar sprays of acetamiprid, dinotefuran, and thiamethoxam should be directed towards the trunk and main laterals. Use sufficient water and pressure to loosen bark and drive the pesticide into cracks and under loose bark.

Grape mealybugs leave the clusters and migrate back to the rough bark on the main trunk or lateral arms of the vine. The migration begins in mid-August and is usually complete by 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 deposit honeydew after leaving the cluster.

Leafhoppers

Leafhopper adults and nymphs generally feed on “shade” 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 spotty in a vineyard. Partial 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. Foliar and drip chemigation with registered neonicotinyl insecticides are the most effective treatments available for control of leafhopper populations. Foliar sprays of registered chloronicotinyls and buprofezin, if timed correctly, can provide leafhopper control.

The established treatment threshold for wine grape vineyards is 15 hoppers per leaf. Presence-absence sampling is not an efficient way of measuring leafhopper abundance at higher population densities. Research has documented that 100% of leaves in a vineyard are infested by leafhoppers when the population abundance of leafhoppers exceeds about 15 leafhoppers per leaf. A sequential sampling technique should be used in sampling for leafhoppers. A presence-absence technique can be used until close to 100% of leaves are infested. When 100% of 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.

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 or 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 3 weeks from the time the first weevils emerge until controls must be applied.

The adult is a black-snouted beetle approximately $\frac{1}{2}$ inch long, 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. Such fruit loss may amount to several tons per acre. Weevils are active at night and do most of their damage at this time. They return to the ground at daylight to hide under clumps of soil, debris, or loose bark at the base of the plant. Therefore, unless a grower is aware of the injury, 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, at the 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.

Cottony Maple Scale

This scale spends the winter on grape canes. It is an immature, brownish to black scale, about $\frac{1}{16}$ to $\frac{1}{4}$ inch long. It begins to grow in the spring when the vines start to leaf out. It reaches maturity in June and lays eggs beneath the scale cover. Each scale is capable of producing hundreds of young from eggs laid in a white, cottony, sticky mass in the early summer. The crawlers appear in July and August and crawl over the vines.

Damage by scale is caused by the young crawlers sucking "sap" from the vines and shoots. A honeydew is formed that drips on the leaves and fruit. Black fungus often develops on this honeydew and can make the grapes unusable for processing.

Since much of the vine is removed at pruning, it may not be necessary to apply control measures unless the scale is infesting the main framework of the vine (main canes, laterals, and trunk). For control, spray a dormant oil during the winter, or treat the crawlers in July.

Black Rust Mite

Black Rust mite infestations have increased in severity in vineyards over the past several years. We speculate that traditional sulfur programs for powdery mildew control suppressed black rust mite populations in past years. As growers have shifted away from sulfur to alternative programs, rust mite populations have increased. 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 lbs/acre of wettable sulfur has proven to be an effective prophylactic control for rust mites.

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 trunk) 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). 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.

When to Use Insecticides

Sampling for spotted cutworms before or at the time of bud break is very difficult. Therefore, grow-

ers 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. 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. Usually the amount of injury does not justify a spray.
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. In this case, chlorpyrifos may be used.

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

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 12 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. Treat at the first sign of infestation and repeat at 7- to 14-day intervals if necessary.

Registration limitations of the more effective materials complicate control. Begin control in the delayed-dormant 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 laterals.

Thrips

Thrips are small ($1/16$ -inch) 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 may scar very young berries at the time of bloom. Later the scars restrict berry growth, producing odd-shaped or split berries. 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.

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.

Grape Phylloxera

The grape phylloxera is related to aphids and attacks the roots of European-type grapes as well as

some American grapes. Phylloxera infestations have completely destroyed grape plantings in Europe and California. The most effective control is the grafting of susceptible varieties onto specified root stocks which tolerate phylloxera. However, growing conditions and established cultural practices in Washington State currently make growing grapes on rootstocks impracticable.

Grape phylloxera was found in a 1988 survey conducted by the Washington State Department of Agriculture. Both Concord and wine grape vineyards were infested.

In most areas of the world where grape phylloxera has been a problem, the primary dispersal form has been the winged stage that comes out of the ground and establishes colonies in galls on grape leaves. Although the "leafgall" form of the phylloxera has not been found in south central Washington, a "crawler" or "wanderer" nymphal stage in the soil does a limited amount of moving and results in a slow spread of the infestation within the vineyard.

No chemical control recommendations are available at this time. However, the use of certified, phylloxera-free plants in new plantings is emphasized.

NOTE: To avoid problems, import and plant only certified insect-free grapevines. Report all suspicious cases to the Washington State Department of Agriculture immediately.

Mites

Problems with spider mites in eastern Washington are confined to vinifera grapes. Concord or similar American-type grapes are not affected. The McDaniel mite (mainly a pest of tree fruits) and the two-spotted mite infest grapes in Washington State. Willamette and 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 20 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 25 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, coccinellid ladybird beetles, lacewing larva, predatory bugs, and thrips. Care should be taken in choosing miticides that minimize harm to populations of these beneficial arthropods.

Nematode Control Program for Grapes

Plant Parasitic Nematode Species: Plant-parasitic nematodes are major pests of grapes worldwide. In California, root-knot nematodes alone have been estimated to cause a 20% economic loss. Symptoms associated with nematode infested soils are gradual and lead to a general reduction in vine vigor and fruit production. Nematodes can feed on the roots and modify root growth (galling and stunting), compete with the plants for carbohydrates, and predispose the plants to infection by other pathogens. In addition, some species of

nematodes also vector important viruses of grapes. In perennial crops, population densities of nematodes can build up from low levels to damaging levels during the lifetime of the crop. When grapes are replanted in an old vineyard site, nematodes and other soilborne pathogens may adversely affect the establishment and productivity of young vines.

In Washington State, the following nematodes were found to be the predominant species in most fields surveyed in 2003 by E. Riga and J. Pinkerton. Unthrifty vines were associated with populations of the northern root-knot nematode (*Meloidogyne hapla*) and dagger nematodes (*Xiphinema* spp.) in several vineyards. However, additional plant parasitic nematodes were found, i.e. *Pratylenchus* spp. (lesion), *Criconemella* spp. (ring), *Paratylenchus* spp. (pin), and *Hoplolaimus* spp. (lance), whose effect on vine vigor and establishment is not known yet.

Chemical and Biological Controls: In an open field, soil fumigation before planting vines is the most effective method for controlling nematodes.

Good control can be achieved using Telone II at 35 gallons per acre and Vapam HL drenched at 50 to 75 gallons per acre. Waiting one year between vine removal and replanting will reduce the nematode populations even further (http://www.uccac.edu/nematode/PDF/replanting_grapes.pdf). When replanting vineyards, growers may leave the trellis in place. In this situation, a soil fumigant (e.g. Vapam) delivered through the drip irrigation system may be the most cost effective method. A synthetic nematicide that has shown potential against nematodes is Enzone. It can be used in post-plant applications or for pre-plant fumigation. The following organically derived nematicides also have shown potential in controlling nematodes at post-plant: Ditera, a fungus byproduct at 15 pounds per acre, and Promax, a microbial byproduct at 2 quarts per acre. Another approach would be to use rotational crops such as mustards, arugula, or sudangrass, which were shown to suppress nematode populations in Washington.

DISEASES OF GRAPES

Several types of disease organisms affect grapes: bacteria, fungi, viruses, and nematodes. While a number of potential problems exist, only a few are of economic importance in the state of Washington.

WSU has an online system called AgWeather Net that uses weather data to detect and alert users when conditions are favorable for disease outbreak (www.agweathernet.wsu.edu). There are currently models for grape powdery mildew and bunch rot.

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.

Infection occurs as a result of wounds or injury. 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 near the base of the vine or trunk. 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.

The most effective control is to avoid planting anything but disease-free stock. 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 EB0742, *Crown Gall of Grapes*.)

Powdery Mildew

This is the most economically important disease 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 *Labrusca* varieties, such as Concord, and only slightly damages the hybrid grapes. Conversely, some of the European *vinifera* varieties are highly susceptible. The symptoms resemble mildew on other crops; minute spots appear on the upper and lower leaf surfaces and are soon covered with a white powdery mass which may spread to cover the major part of the leaf. 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 requires at least 0.1 inch 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 Qol (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 severe burning

of the foliage. (See EB1202, *Powdery Mildew of Grapes in Washington*);

- particular vigilance during the prebloom period through pea-size berries;
- consult grape powdery mildew models on AgWeather Net (www.agweathernet.wsu.edu) for favorable environmental conditions; and
- proper irrigation management.

Phomopsis Cane and Leaf Spot

This fungus disease attacks leaves, shoots, cluster stems, 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.

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 5-10 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 to 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.

Infections can be reduced by making clean, close pruning cuts to encourage callusing, avoiding large pruning cuts when possible, and avoiding pruning during and before wet weather.

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 Decem-

ber 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.

Black Sooty Mold

When honeydew 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.

Botrytis Bunch Rot

Botrytis bunch rot can produce significant yield and quality losses in tight-clustered wine varieties such as White 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 berry 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 may reduce disease incidence.

Protect susceptible varieties in vineyards that have

a history of bunch rot with fungicides. Vanguard, Scala, and Elevate are three relatively new and effective fungicides. Rovral 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. Consult the grape bunch rot models on AgWeather Net (www.agweathernet.wsu.edu) for favorable environmental conditions that can lead to an outbreak. Because fungicides can inhibit yeast fermentation, use them with caution within 1 month of harvest on wine grapes.

Virus Diseases

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 “healthy” wines. Among the virus diseases infecting grapevines, “traditional” virus diseases such as leafroll complex, rugose wood complex, and fanleaf are of great economic significance globally and

are well known disorders in several grapevine-growing 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.*

Grapevine Leafroll Disease: Grapevine leafroll disease (GLD) is a complex viral disease of major concern in Washington State. It is estimated that GLD currently affects about 10% of the acreage of wine and juice grapes combined. In recent years, however, the spread of GLD has been increasing throughout the state. In fact, GLD 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 GLD, with fewer and smaller bunches. In addition, fruit maturity is delayed by 3 weeks to 1 month. GLD 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. GLD is, therefore, a particularly serious problem for red wines.

GLD do not produce symptoms for most of the season—these begin to appear in the early part of the autumn. GLD symptoms are more dramatic in red- and black-fruited varieties than white-fruited varieties. In the former varieties, the foliar symptoms are characterized initially by red and reddish-purple tints in the inter-veinal areas. These discolorations may coalesce with time, leading to reddish-purple color of inter-veinal 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 autumn is red leaves with green veins and downward-rolled leaf margins. In the white-fruited varieties, infected leaves turn yellow between the veins and show rolling. GLD symptoms develop during the late summer to autumn period in these varieties 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 GLD is a complex disease. At least ten serologically distinct viruses, termed *Grapevine leafroll-associated viruses* (GLRaVs), and numbered sequentially GLRaV-1 to -10 in order of discovery, have been associated with the disease. Recent studies have shown that GLRaV-1, -2, -3, -4, -5, and -9 are present in Washington State vineyards. Among them, GLRaV-3 was most common. GLRaV particles are highly flexuous and localized in the vascular tissue, i.e. phloem. Consequently, these viruses interfere with the movement of nutrients in the vine, thereby causing secondary physiological effects that lead to the foliar symptoms. Since 1989, plant-to-plant spread of GLD 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 has been shown to be capable of transmitting GLRaV-3 under laboratory conditions. 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 GLD. For more details on GLD, refer to **EB2027E Grapevine Leafroll Disease** at <http://wine.wsu.edu/virology/images/virus-ext-bull.pdf>.

Rugose Wood Complex: 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. *Vitis*

vinifera cultivars carry symptomless infections of RW complex until they are grafted onto American rootstocks. 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 the Columbia River valley of eastern Washington, there is an increased tendency to top-work existing grapevines to other cultivars in order to save time and costs in establishing new vineyards. In all these cases, a transition from grapevines on their own roots to vineyards propagated on rootstock can result in increased problems due to 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, -B, -D and -E, and *Grapevine rupestris stem pitting-associated virus* (GRSPaV)—have been consistently found in different disorders of RW complex. However, none of these viruses has been identified or confirmed as the causal agent of RW complex. All these viruses are filamentous, phloem-limited, and are graft-transmissible, and thus are spread by infected propagation material. It has been reported that corky bark disease has been transmitted from vine to vine by mealybugs. The natural spread of rupestris stem pitting and stem grooving diseases 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. Currently, GRSPaV is not listed as a restricted

virus in certification schemes in other states like California, whereas it is a controlled virus in the Washington State certification program. Therefore, it is important to import planting material tested for GRSPaV. Grapevine Virus-A and -B have recently been documented in Washington State vineyards.

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 the *V. vinifera*. The disease appears in patches in the field. All *Vitis* 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*. *X. index*, or dagger nematode, is by far the more efficient vector. Grapevine decline is another nematode-transmitted virus disease. At least three distinct viruses—*Tomato ring spot virus* (TomRSV), *Tobacco ring spot virus*, 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 has recently been documented in Washington State vineyards.

Fear of the Unknown: There are many other diseases reported from different countries and they are of local or minor significance. With rapid expansion of viticulture 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. Although these problems are not yet reported in the vineyards of Washington State, scientifically documented evidence of the overall status of virus and virus-like disorders in the state are rudimentary at best. Therefore, 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 at WSU Prosser IAREC.***

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. Unfortunately, viral diseases cannot be controlled by using economically-feasible chemical agents analogous to fungicides and bactericides. Consequently, disease management efforts should be directed at reducing or eliminating sources of initial infection by planting virus-tested materials and preventing the secondary spread within a vineyard by targeting insect vectors. 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.

A disease management strategy for controlling GLD should involve planting virus-tested and mealybug-free planting materials, close monitoring of the vineyards for mealybugs and their control by judicious use of pesticides, and sanitation in terms of replacing infected vines with virus-tested vines during formative years of vineyard establishment. In contrast, management of soil-borne diseases like fanleaf 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. The only certain control will be to remove the vineyard and fallow the ground for six to ten years, so that both the residual roots from the old vineyard and the vector nematode population die out. 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.

Herbicide Injury

This is not a parasitic disease, but symptoms can be confused with those caused by viruses. 2,4-D and some other classes of herbicides tend to affect all the young shoots of a plant, 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.

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.

INSECT AND DISEASE CONTROL PROGRAMS

Pests to be controlled	Materials & Formulation	Material per Acre Treated			Remarks	Effect on Beneficials
		Active Ingredients	Formulated Material	Min. Days Before Harvest		
DORMANT—Apply before April.						
Cottony maple scale*	1. superior oil		4.0–6.0 gallons		Apply late March to early April. Direct spray to trunk and main laterals. Do not apply dormant oil after bud break. Do not apply to green tissue.	Moderately harmful
DELAYED-DORMANT—Apply from before bud break up to time shoots are 4 inches long.						
Cottony maple scale*	1. superior oil (Prescription Treatment Ultra-Fine Oil)		4.0–6.0 gallons		May give only marginal control.	Moderately harmful
Cutworms	1. fenpropathrin (Danitol 2.4 EC)	0.1 pound	Follow label instructions		Barrier spray to trunk and posts in early- to mid-March.	Extremely hazardous
	2. bifenthrin (Brigade 2EC or Capture 2EC)	0.05 pound	Follow label instructions		Barrier spray to trunk and posts in early- to mid-March.	Extremely hazardous
PRE-PLANT						
Nematodes	1. 1,3-dichloropropene (Telone II)		35 gallons		Check label for re-entry time for planting.	Excessive use causes reduction
	2. metham sodium (Vapam HL)		50–75 gallons		Check label for re-entry time for planting.	Excessive use causes reduction
	3. sodium tetrathiocarbonate (Enzone)		20–60 gallons		Check label for re-entry time for planting.	Excessive use causes reduction
POST-PLANT						
Nematodes	1. sodium tetrathiocarbonate (Enzone)		5–30 gallons		Microbial metabolic byproduct.	Excessive use causes reduction
	2. DiTera		15 pounds		Labeled for organic production, microbial metabolic byproduct.	Safe
	3. Promax		2 quarts			Safe
	4. 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.					Excessive use causes reduction

*Pest not on label, but use is consistent with label directions. See General Information.

INSECT AND DISEASE CONTROL PROGRAMS, continued

Pests to be controlled	Materials & Formulation	Material per Acre Treated			Remarks	Effect on Beneficials
		Active Ingredients	Formulated Material	Min. Days Before Harvest		
PREBLOOM						
Cutworms	1. spinosad (Success)	0.06–0.125 pound	4.0–8.0 fl. oz.	7	More effective when temperatures exceed 70°F. Do not use more than 0.45 pound per acre ai per season.	Safe
	2. spinetoram (Delegate)	0.047–0.078 pound	3.0–5.0 oz.	7		
Powdery mildew	1. azoxystrobin (Abound)	0.16–0.25 pound	10.0–15.5 fl. oz.	14	Note: azoxystrobin is phytotoxic to certain apple varieties. Read and follow resistance management recommendations on label.	Safe
	2. trifloxystrobin (Flint)	0.75–1.0 oz.	1.5–2.0 oz.	14	Do not use Flint on juice grapes.	Safe
	3. kresoxim-methyl (Sovran)	1.6–2.4 oz.	3.2–4.8 oz.	14		Safe
	4. triflumizole (Procure 50WS)	2.0–4.0 oz.	4.0–8.0 oz.	7		Safe
	5. myclobutanil (Rally 40W)	1.2–2.0 oz.	3.0–5.0 oz.	14	Begin application at prebloom (12- to 18-inch canes), and continue on a 14- to 21-day interval. Use higher rates on susceptible varieties or under heavy disease pressure. Do not apply more than 1.5 pounds (0.6 lb. ai) per acre per year. Place myclobutanil into solution before adding oil.	Safe
	6. tebuconazole (Elite 45DF)	1.8 oz.	4.0 oz.	14	Maximum 2 pounds per acre per season for Elite.	Safe
	7. quinoxyfen (Quintec)	0.05–0.065 pound	3.0–4.0 fl. oz.	14	Apply Quintec before visible symptoms of powdery mildew appear. Do not make more than 5 applications per year. Minimum interval is 14 days. Do not apply more than 6.6 fl. oz. per acre per application or more than 33 fl. oz. per acre per year.	Safe
	8. pyraclostrobin + boscalid (Pristine)	—	8.0–12.5 oz.	14	Begin applications at bud break or prior to onset of disease. Do not make more than 6 applications per season and no more than 2 sequential applications before alternating to a labeled fungicide with a different mode of action. Do not use on juice grapes.	Safe
	9. fenarimol (Rubigan E.C.)	0.02–0.05 pound	2.0–6.0 fl. oz.	21	Lower rates (2.0 to 3.0 fl. oz. per acre) are recommended for early season applications when disease pressure is less intense. Continue applications at full bloom (4.0 fl. oz. per acre), post-bloom (6.0 fl. oz. per acre), and at 14- to 18-day intervals if needed. Do not apply more than 6 fl. oz. per acre per application or more than 19 fl. oz. per acre per season.	Safe

INSECT AND DISEASE CONTROL PROGRAMS, continued

Pests to be controlled	Materials & Formulation	Material per Acre Treated			Min. Days Before Harvest	Remarks	Effect on Beneficials
		Active Ingredients	Formulated Material				
PREBLOOM (continued)							
Powdery mildew (continued)	10. paraffinic oil (JMS Stylet Oil)	—	1–2%		no PHI given (REI = 4 hrs)	Do not mix Stylet Oil with sulfur or apply either compound within 3 weeks of the other. As protection, alternate prebloom with DMI fungicides. Apply at 14- to 18-day intervals.	Excessive use harmful
	11. micronized flowable sulfur	—	See label.		no PHI given (REI = 24 hrs)		Excessive use harmful
	12. sulfur dust	—	5.0–10.0 pounds		no PHI given (REI = 24 hrs)	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.	Excessive use harmful
	13. potassium bicarbonate (Armcarb) or (Kaligreen)	—	2.5 pounds/100 gal. water		0 (REI—4 hrs)		Excessive use harmful
		—	2.5 pounds/100 gal. water		1		
BLOOM—Apply as close to but not later than full bloom.							
Botrytis bunch rot	1. captan (Captan 50WP)	1.5–2.0 pounds	3.0–4.0 pounds		0 (REI=72 hrs)		Safe
	2. fenhexamid (Elevate 50WDG)	0.5 pound	1.0 pound		0 (REI=12 hrs)		Safe
	3. cyprodinil (Vanguard WG)	7.5 oz.	10.0 oz.		7		Safe
	4. iprodione (Rovral)	0.75–1.0 pound	1.5-2.0 pounds		7	Apply at early to midbloom.	Safe
	5. pyrimethanil (Scala SC)	0.7 pound	18 fl. oz.		7		Safe
LATE SPRING							
Grape leafhopper, Grape mealybug	1. buprofezin (Applaud 70WP)	0.38 pound	0.54 pound		30	Target young nymphs on vines and leaves. Make no more than 2 applications per season.	Safe

INSECT AND DISEASE CONTROL PROGRAMS, continued

Pests to be controlled	Materials & Formulation	Material per Acre Treated			Remarks	Effect on Beneficials
		Active Ingredients	Formulated Material	Min. Days Before Harvest		
LATE SPRING (continued)						
Grape leaf-hopper, Grape mealybug (continued)	2. potassium salts of fatty acids (M-Pede)	2% solution	2 gal./100 gal. 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
	3. imidacloprid (Admire 2F)	0.25 pound	16 fl. oz.	30	Can use 32 fl. oz. rate for severe mealybug infestations.	Moderately harmful
	4. dinotefuran (Venom)	Foliar application: 0.045–0.132 pound	1.0–3.0 oz.	1	Both foliar and soil applications are limited to 6 oz. per acre per season.	Moderately harmful
		or Soil application: 0.226–0.264 pound	5.0–6.0 oz.	28		
5. thiamethoxam (Platinum)	0.125–0.266 pound	8.0–17.0 fl. oz.	60	Chemigate via drip irrigation. Follow label instructions.		
Thrips	1. spinosad (Success)	0.06–0.125 pound	4.0–8.0 fl. oz.	7	More effective when temperatures exceed 70°F. Do not use more than 0.45 pound ai per acre per season.	Safe
EARLY SUMMER—Late June and July						
Botrytis bunch rot	1. iprodione (Rovral)	0.75–1.0 pound	1.5–2.0 pounds	7	Apply prior to bunch closing.	Safe
	2. cyprodinil (Vanguard WG) (alone)	7.5 oz.	10.0 oz.	7	Do not apply more than 30 oz. per acre per crop per year.	Safe
	3. fenhexamid (Elevate 50WDG)	0.5 pound	1.0 pound	0 (REI=12 hrs)		Safe
	4. pyrimethanil (Scala SC)	0.7 pound	18 fl. oz.	7		Safe
	5. cyprodinil (Vanguard WG) (tank mixes)	3.75–7.5 oz.	5.0–10.0 oz.	7	Do not apply more than 30 oz. per acre per crop per year.	Safe
Grape leafhopper, Grape mealybug	1. imidacloprid (Provado Solupak)	0.56–0.75 oz.	0.75–1.0 oz.	0 (REI=12 hrs)	Use only for leafhoppers. Comes as 8 water soluble 1-oz bags. Do not use more than 2 oz. formulated product per acre per year. Allow 14 days between applications.	Moderately harmful

INSECT AND DISEASE CONTROL PROGRAMS, continued

Pests to be controlled	Materials & Formulation	Material per Acre Treated			Remarks	Effect on Beneficials
		Active Ingredients	Formulated Material	Min. Days Before Harvest		
EARLY SUMMER—Late June and July (continued)						
Grape leafhopper, Grape mealybug (continued)	2. imidacloprid (Admire 2F)	0.25–0.5 pound	16.0–32.0 fl. oz.	30	Do not exceed 0.5 pound active ingredient imidacloprid (Admire + Provado) per acre per year.	Moderately harmful
	3. buprofezin (Applaud 70WP)	0.38 pound	0.54 pound	30	Target young nymphs on vines and leaves.	Safe
	4. dinotefuran (Venom)	Foliar application: 0.045–0.132 pound or Soil application: 0.226–0.264 pound	1.0–3.0 oz.	1	Both foliar and soil applications are limited to 6 oz. per acre per season.	Moderately harmful
				28		
	5. acetamiprid (Assail 70WP)	0.05 pound	1.1 oz.	7		Moderately harmful
	6. thiamethoxam (Platinum)	Soil application 0.125–0.172 pound	8.0–11.0 fl. oz.	60		Moderately harmful
	7. thiamethoxam (Actara)	Foliar application 0.023–0.055 pound	1.5–3.5 oz.	5		Moderately harmful
Powdery mildew	1. azoxystrobin (Abound)	0.16–0.25 pound	10.0–15.5 fl. oz.	14	Note: azoxystrobin is phytotoxic to certain apple varieties. Read and follow resistance management recommendations on label.	Safe
	2. trifloxystrobin (Flint)	0.75–1.0 oz.	1.5–2.0 oz.	14	Do not use Flint on juice grapes.	Safe
	3. kresoxim-methyl (Sovran)	1.6–2.4 oz.	3.2–4.8 oz.	14		Safe
	4. triflumizole (Procure 50WS)	2.0–4.0 oz.	4.0–8.0 oz.	7		Safe
	5. paraffinic oil (JMS Stylet Oil)	—	1–2%	no PHI given (REI=4 hrs)	Do not mix Stylet Oil with sulfur or apply either compound within 3 weeks of the other. As protection, alternate prebloom with DMI fungicides. Apply at 14- to 18-day intervals.	Excessive use harmful
	6. myclobutanil (Rally 40W)	1.2–2.0 oz.	3.0–5.0 oz.	14		Safe
	7. tebuconazole (Elite 45DF)	1.8 oz.	4.0 oz.	14		Safe

INSECT AND DISEASE CONTROL PROGRAMS, continued

Pests to be controlled	Materials & Formulation	Material per Acre Treated			Remarks	Effect on Beneficials
		Active Ingredients	Formulated Material	Min. Days Before Harvest		
EARLY SUMMER—Late June and July (continued)						
Powdery mildew (continued)	8. sulfur dust	—	5.0-10.0 pounds	no PHI given (REI = 24 hrs)	Begin sulfur applications at bud break. Repeat when shoots are 6, 12, and 15 inches long and then at 2-week intervals.	Excessive use harmful
	9. quinoxyfen (Quintec)	0.05–0.065 pound	3.0–4.0 fl. oz.	14	Apply Quintec before visible symptoms of powdery mildew appear. Do not make more than 5 applications per year. Minimum interval is 14 days. Do not apply more than 6.6 fl. oz. per acre per application or more than 33 fl. oz. per acre per year.	Safe
	10. pyraclostrobin + boscalid (Pristine)	—	8.0–12.5 oz.	14	Begin applications at bud break or prior to onset of disease. Do not make more than 6 applications per season and no more than 2 sequential applications before alternating to a labeled fungicide with a different mode of action. Do not use on juice grapes.	Safe
	11. potassium bicarbonate (Armicarb) or (Kaligreen)	—	2.5 pounds/100 gal water	0 (REI=4 hrs)		Excessive use harmful
		—	2.5 pounds/100 gal water	1		
SUMMER—July-August						
Botrytis bunch rot	1. iprodione (Rovral)	0.75–1.0 pound	1.5–2.0 pounds	7	Apply at beginning of fruit ripening.	Safe
	2. cyprodinil (Vanguard WG) (alone)	7.5 oz.	10.0 oz.	7	Do not apply more than 30 oz. per acre per crop per year.	Safe
	3. tebuconazole (Elite 45DF)	1.8 oz.	4.0 oz.	14		Safe
	4. fenhexamid (Elevate 50WDG)	0.5 pound	1.0 pound	0 (REI=12 hrs)		Safe
	5. pyrimethanil (Scala SC)	0.7 pound	18.0 fl. oz.	7		Safe
	6. cyprodinil (Vanguard WG) (tank mixes)	3.75–7.5 oz.	5.0–10.0 oz.	7	Do not apply more than 30 oz. per acre per crop per year.	Safe

INSECT AND DISEASE CONTROL PROGRAMS, continued

Pests to be controlled	Materials & Formulation	Material per Acre Treated			Remarks	Effect on Beneficials
		Active Ingredients	Formulated Material	Min. Days Before Harvest		
SUMMER—July-August (continued)						
Grape mealybug, Grape leafhopper	1. imidacloprid (Provado Solupak)	0.56–0.75 oz.	0.75–1.0 oz.	0 (REI = 12 hrs)	Use only for leafhoppers. Comes as 8 water soluble 1-oz bags. Do not use more than 2 oz. formulated product per acre per year. Allow 14 days between applications.	Moderately harmful
	2. imidacloprid (Admire 2F)	0.25–0.5 pound	16.0–32.0 fl. oz.	30	Do not exceed 0.5 pound active ingredient imidacloprid (Admire + Provado) per acre per year.	Safe
	3. buprofezin (Applaud 70WP)	0.38 pound	0.54 pound	30	Target young nymphs on vines and trees. Make no more than 2 applications per season.	Safe
	4. dinotefuran (Venom)	Foliar application: 0.045–0.132 pound or Soil application: 0.226–0.264 pound	1.0–3.0 oz. 5.0–6.0 oz.	1 28	Both foliar and soil applications are limited to 6 oz. per acre per season.	Moderately harmful
	5. acetamiprid (Assail 70WP)	0.05 pound	1.1 oz.	7		Moderately harmful
	6. thiamethoxam (Platinum)	Soil application 0.125–0.172 pound	8.0–11.0 fl. oz.	60		Moderately harmful
	7. thiamethoxam (Actara)	Foliar application 0.023–0.055 pound	1.5–3.5 oz.	5		Moderately harmful
McDaniel mites*	1. propargite (Omite 30WS)	1.6–2.9 pounds	5.0–9.0 pounds	21	A problem only on vinifera or California-type grapes. Use 350 to 600 gallons of water per acre.	Safe
Mites	1. bifenazate (Acramite 50WS)	0.375–0.5 pound	0.75–1.0 pound	14		Safe
	2. fenpyroximate (FujiMite 5EC)	0.1 pound	2.0 pints	14	Apply before the mite population reaches an outbreak population density.	Safe
	3. abamectin (Agri-Mek 0.15EC)	0.01–0.02 pound	8.0–16.0 fl. oz.	28	Always use with a nonionic surfactant and sufficient gallonage for coverage.	Moderately harmful
Thrips	1. spinosad (Success)	0.06–0.125 pound	4.0–8.0 fl. oz.	7	More effective when temperatures exceed 70°F. Do not use more than 0.45 pound ai per acre per season.	Safe

*Pest not on label, but use is consistent with label directions. See General Information.

INSECT AND DISEASE CONTROL PROGRAMS, continued

Pests to be controlled	Materials & Formulation	Material per Acre Treated			Remarks	Effect on Beneficials
		Active Ingredients	Formulated Material	Min. Days Before Harvest		
PREHARVEST						
Botrytis bunch rot	1. iprodione (Rovral)	0.75–1.0 pound	1.5–2.0 pounds	7	Apply prior to harvest as needed.	Safe
	2. cyprodinil (Vangard WG) (alone)	7.5 oz.	10.0 oz.	7	Do not apply more than 30 oz. per acre per crop per year.	Safe
	3. fenhexamid (Elevate 50WDG)	0.5 pound	1.0 pound	0 (REI = 12 hrs)		Safe
	4. cyprodinil (Vangard WG) (tank mixes)	3.75–7.5 oz.	5.0–10.0 oz.	7	Do not apply more than 30 oz. per acre per crop per year.	Safe
	5. pyrimethanil (Scala SC)	0.7 pound	18.0 fl. oz.	7		Safe
Grape mealybug, Grape leafhopper	1. imidacloprid (Provado Solupak)	0.56–0.75 oz.	0.75–1.0 oz.	0 (REI = 12 hrs)	Use only for leafhoppers. Comes as 8 water soluble 1-oz bags. Do not use more than 2 oz. formulated product per acre per year. Allow 14 days between applications.	Moderately harmful
	2. imidacloprid (Admire 2F)	0.25–0.5 pound	16.0–32.0 fl. oz.	30	Do not exceed 0.5 pound active ingredient imidacloprid (Admire + Provado) per acre per year.	Safe
	3. buprofezin (Applaud 70WP)	0.38 pound	0.54 pound	30	Target young nymphs on vines and leaves. Make no more than 2 applications per season.	Safe
	4. dinotefuran (Venom)	Foliar application: 0.045–0.132 pound or Soil application: 0.226–0.264 pound	1.0–3.0 oz. 5.0–6.0 oz.	1 28	Both foliar and soil applications are limited to 6 oz. per acre per season.	Moderately harmful
	5. acetamiprid (Assail 70WP)	0.05 pound	1.1 oz.	7		Moderately harmful
	6. thiamethoxam (Platinum)	Soil application 0.125–0.172 pound	8.0–11.0 fl. oz.	60		Moderately harmful
	7. thiamethoxam (Actara)	Foliar application 0.023–0.055 pound	1.5–3.5 oz.	5		Moderately harmful

NUTRIENT SPRAY PROGRAMS

Spray-applied nutrients can be absorbed by grape leaves. However, with the exception of some micronutrients, sprays do not supply vines with sufficient quantities of nutrients to support growth throughout the season. In the major grape growing area (southcentral Washington), research has not shown a benefit from spray applications of nutrients except for zinc (Zn) and iron (Fe). Nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) should be soil applied according to guidelines as suggested in WSU FG-13, *Fertilizer Guide for Irrigated Vineyards*. Boron (B) may be soil applied if soil test B is routinely low. If a vineyard shows routine symptoms of B stress, typically poor fruit set and/or monkey faced berries, a single yearly pre-bloom application of B may be helpful. However, tissue B should be monitored to prevent toxicity due to over application. Magnesium (Mg) and Manganese (Mn) deficiency symptoms are occasionally seen but are not considered to be of economic importance.

Caution: Minor elements can be extremely toxic even in small amounts. They can kill vines if applied in excess. Also some nutrient-deficiency symptoms can be confused with factors other than nutrient supply. Therefore, before making any applications, be sure to verify visible symptoms by tissue analyses.

Zinc (Zn)

Zinc deficiencies are sometimes observed in Washington vineyards. These deficiencies generally are associated with soils that have low zinc levels (<0.8 ppm), are very shallow, and/ or are calcareous (free lime). Heavy applications of animal manures have been suggested as increasing zinc deficiencies. However, this is not seen as a major management problem.

Where deficiencies are observed, spray zinc as soon as possible. Soil applications have proven most effective when made before planting or when incorporated into the root zone. Zinc sprays can be applied any time during the growing season but are most effective when applied from 2 weeks before bloom to 2 weeks after bloom. Thoroughly wet the upper and lower sides of the foliage to aid absorption.

Where zinc levels are known to be low, use an annual maintenance spray. Deficiencies often occur in combination with iron deficiency, and therefore both zinc and iron may be required (see also Iron).

Iron (Fe)

A condition commonly known as iron chlorosis may result from a combination of calcareous soil and high water table, overirrigation, or poor water movement in the soil. High bicarbonate content in the irrigation water may also contribute to the problem. The most effective control of iron chlorosis is through improved drainage and irrigation practices. Iron chlorosis tends to be more of a problem during a cool, wet spring. Avoid irrigating or use only light irrigations as necessary in the early spring.

Vines can be made green by early spray applications of iron chelates or ferrous sulfate. This is a temporary measure, which does not correct the basic cause of iron chlorosis. Usually two sprays are required. Apply the first about 2 weeks before bloom and the second about 2 weeks after bloom. Wet the foliage thoroughly. Thorough foliar applications by ground sprayers are more effective. Aerial sprays are not recommended.

NUTRIENT SPRAY PROGRAM FOR GRAPES

Nutrient	Materials & Formulation	Formulated Material		Remarks
		Per 100 Gallons	Per Acre	
ZINC—Apply 2 weeks before and 2 weeks after bloom.				
Deficiency	1. Zinc sulfate 36% crystals	1.0 pound	1.0 pound	100 gals/acre 2 weeks prebloom, 300 gals/acre 2 weeks post-bloom. Apply with ferrous sulfate if chlorosis is evident.
	2. Zinc sulfate 1.2 lbs./gal LC	0.3 gal	0.3 gal	Spray underside of leaves thoroughly for maximum absorption.
IRON— Foliage application 2 weeks before and 2 weeks after bloom.				
Iron chlorosis	1. Iron sulfate	3.0 pounds	3.0-9.0 pounds	Treatment can make vines green but may not correct the problem.
	2. Iron chelates or organic complexes	Do not exceed label rates		
	3. Combine ferrous sulfate with above zinc sulfate treatment if zinc deficiency symptoms are present	Dissolve zinc and iron compounds in water separately before dumping into spray tank. Add ferrous sulfate last. Dissolve in cold water, mix in spray tank, and spray immediately.		
	4. Several commercial products for application of foliar nutrients are also available	Sprays during hot periods may cause burning on leaves.		
BORON— Apply 2 weeks pre-bloom only.		See label for rate information		
SOLUBOR— Apply 2 weeks pre-bloom.		See label for rate information		

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.
- Because of the differences between districts, vineyards, and even parts of the same vineyard, detailed spray programs should be worked out for your vineyard(s). Consult your county Extension agent or field representative.
- 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.

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.

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.

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

The following steps are suggested in properly calibrating an air-blast sprayer:

- Determine by trial the rate of travel that will allow the air-blast to distribute the spray throughout the vines. This should be in the neighborhood of 1 to 2

miles per hour, and never under 1/2 mile per hour or over 3 miles per hour. If possible, direct most of the air toward the thickest and most distant parts of the vines and less toward the edges. Some machines have vanes or movable air outlets that can be adjusted to help direct the air where it is needed.

If you do not have a speedometer on your tractor, use the vine spacing-miles per hour chart. For example, if 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.

- Decide on the specific gallonage to be applied per acre. Use 100 gallons for our example.
- Now set up the sprayer to apply the needed gallonage at the desired speed. Use the following formula to determine the discharge rate from the manifold:

$$\frac{\text{gallons per acre} \times \text{mph} \times \text{feet between rows}}{1,000} = \text{gallons per min. (1 side)}$$

Using the predetermined gallonage and speed in the example:

$$\frac{100 \times 1 \times 8}{1,000} = 0.8 \text{ gallons per minute}$$

Set the nozzles on each side of the manifold to apply 0.8 gallons of spray per minute.

The size and arrangement of the nozzles is very important and will determine whether or not the

sprayer will give satisfactory pest control. Be sure the greatest amount of spray is applied through the center and upper portion of the vines.

Your equipment dealer has charts showing the output of various nozzle sizes. Both dealer and field representative will be able to give you advice on nozzle arrangement and size.

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 dormant oil and oil-phosphate mixes may be desirable. Information in Washington on oil rates for

Vine Spaces per Minute

Miles per hour	Feet per minute	Vine spacing in row				
		6 ft	7 ft	8 ft	9 ft	10 ft
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

total gallonages below 60 gallons per acre have not been studied. **Be sure that agitation is adequate to keep the spray mixed uniformly while apply-**

ing oils and oil-phosphate mixes at all gallonages, but be particularly careful at low-volume or concentrate rates.

Dilutions for Wettable Powder and Emulsifiable Concentrates

Type of material	Quantities of material for indicated quantities of water			
	100 Gallons	5 Gallons	3 Gallons	1 Gallon
Wettable Powder	5 pounds	15 tablespoons	10 tablespoons	3 tablespoons
	4 pounds	13 tablespoons	8 tablespoons	8 teaspoons
	3 pounds	10 tablespoons	6 tablespoons	2 tablespoons
	2 pounds	8 tablespoons	4 tablespoons	4 teaspoons
	1 pound	3 tablespoons	6 teaspoons	2 teaspoons
	0.5 pound	5 teaspoons	1 tablespoon	1 teaspoon
Emulsifiable concentrate	5 gallons	1 quart	1.25 pints	13 tablespoons
	4 gallons	1.5 pints	1 pint	10 tablespoons
	3 gallons	1.25 pints	0.75 pint	0.25 pint
	2 gallons	0.75 pint	0.5 pint	5 tablespoons
	1 gallon	0.5 pint	8 tablespoons	3 tablespoons
	1 quart	3 tablespoons	2 tablespoons	2 teaspoons
	1 pint	5 teaspoons	1 tablespoon	1 teaspoon

Quantities of Materials to Use per 100 Gallons for Various Rates of Application

Units of material desired per acre (pounds, gallons, and the like)*	Gallons of spray to be applied per acre						
	60	75	100	200	300	400	500
2	3.33	2.66	2	1	0.66	0.5	0.4
3	5	4	3	1.5	1	0.75	0.6
4	6.66	5.33	4	2	1.33	1	0.8
5	8.33	6.66	5	2.5	1.66	1.25	1
6	10	8	6	3	2	1.50	1.2
8	13	11	8	4	2.66	2	1.6
10	17	13	10	5	3.33	2.50	2
12	20	16	12	6	4	3	2.4
15	25	20	15	7.5	5	3.75	3
16	27	21	16	8	5.33	4	3.2
18	30	24	18	9	6	4.50	3.6
20	33	27	20	10	6.66	5	4
24	40	32	24	12	8	6	4.8
25	46	33	25	13	8.33	6.25	5
28	48	37	28	14	9.33	7	5.6
32	53	40	32	16	10	8	6.4
40	67	53	40	20	13	10	8
48	80	64	48	24	16	12	10
55	92	73	55	28	18	14	11

*When using material at units of 1 or less per acre, it will be more accurate to first convert the quantity to smaller equivalent units. For example, convert 1 pint to 16 fluid ounces, or 1 gallon to 8 pints, and then use the table to find the number of units needed per 100 gallons of spray.

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 when they do 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 information on pesticide tolerances, contact WSU Pesticide Coordinator, at 509-372-7495.

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 will state the usual restricted entry interval (REI) 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 will be stated on the label. For more information see NE/HEG8115, *Laundering Pesticide Contaminated Clothing*.

Warnings must be given to workers who are expected to work in treated fields within 30 days of the ap-

plication. 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 workers other than those involved in the application must not be exposed to drift.

Licensing

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. 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.

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.

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. A grower may apply pesticides on the lands of another on tradework 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 specifies 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 Tom Hoffmann, WSDA, 509-766-2574.

The state of Washington has declared certain pesticides to be restricted for the protection of groundwater. These may only be used by certified applicators. The complete list of pesticides follows (not all are registered for use on grapes):

Common Chemical Name	Also Known As*
alachlor	Lasso
aldicarb	Temik
atrazine	
bromacil	Hyvar, Krovar
carbofuran	Furadan
1,3-dichloropropene	Telone
disulfoton	Di-Syston
diuron	Karmex, Krovar
hexazinone	Velpar
metolachlor	Dual
metribuzin	Sencor
oxamyl	Vydate
picloram	Tordon
prometon	Pramitol
simazine	Princep
tebuthiuron	Spike

*This column is to be used only as a guide and may not include all brand or trade names under which these chemicals are distributed.

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 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 material safety data sheets (MSDS). MSDS 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 MSDS 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 MSDS are kept available to workers. How to obtain more information on the chemical and how to use that information.

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

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 360-902-5419, or call toll-free within Washington: 1-800-547-8367. For more information, visit the Worker Right-to-Know Act website at <http://www.lni.wa.gov/Safety/Topics/AtoZ/WorkerRTK/default.asp>.

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 commis-

sioners, 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.

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