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Recognize the Symptoms and Causes of Stunted Growth in Vineyards

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Spring frost, herbicide drift, water or nutrient stress, diseases, and insect and mite pests can cause similar symptoms of stunting or distorted growth in grapevines. Recognizing the symptoms and distinguishing their causes is the first step in diagnosing problems and developing a management plan. This publication will help you identify probable causes of distorted shoot and vine growth in vineyards and direct you to other resources that can lead to solutions. Remember that plant problem diagnosis is a skill developed over time. Consult with OSU Extension personnel or crop advisors when you encounter signs of damage and are unsure of the causes.

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Spring frost damage

Newly emerging shoots can be damaged shortly after bud break if exposed to frost. The damage is most prevalent in vineyards with low-lying areas where cold air accumulates, and can be common in regions subject to early season frosts.

Green tissues can be damaged when temperatures fall to 28°F or below for extended periods. Susceptibility depends on the stage of bud swell; vines that have not broken bud are less prone to damage. Frost damage can vary dramatically from plant to plant. Even in low areas, it is not uncommon to see one vine barely affected while adjacent vines show much more severe damage (Figure 1, page 2).

Shoot tips and leaf margins may have areas of dead tissue (Figure 2, page 2). In the most severe cases, primary shoots simply fail to grow because of damage

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to the growing point of the shoot. In such cases, a secondary bud may begin growing, although fewer clusters develop within these secondary buds, and the vine's yield is reduced. If both primary and secondary buds are damaged, growth may emerge from the tertiary bud, but these shoots often do not bear fruit.

Frost damage that occurs during the growing season shows most often at the tips of shoots, which turn from green or light brown to dark brown or black over time.

Spring frost damage: Distinguishing from other causes

- The key differences between frost-related shoot damage and damage by other causes are the type of tissue damage and patterns observed in the vineyard. Unlike nutrient deficiencies, water stress, or vine imbalance, which can occur across a large area of the vineyard, frost damage will usually be confined to distinct areas, such as the bottom of hills or other places where cold air pools.
- Under severe frost conditions, damage may occur across entire vineyards that are located in low-lying areas.
- Consult weather records to determine whether a frost event occurred near bud break or whether severe low temperatures occurred during dormancy.

Photo by Patty Skinkis, © Oregon State University

Figure 1. Cold temperatures can lead to sporadic vine damage, depending on the vine growth stage. Shown here is an area of the vineyard where frost damaged vines earlier in the growing season. Some vines show severe damage and no growth while others appear healthy.

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Figure 2. The shoot on the right shows frost damage, while the shoot on the left develops normally. The shoot on the right may have been damaged at an earlier stage of development. Note the secondary bud developing from it. The shoot on the left was likely more advanced when freezing occurred. Note the dead tissue on the basal leaf.

Herbicide damage

Damage can be caused by herbicides applied inside or outside of the vineyard. Direct drift occurs at the time of herbicide application. Volatilization and vapor drift of growth-regulator herbicides such as 2,4-D, clopyralid, dicamba, MCPA, and triclopyr can occur for several days after application under favorable conditions. Damage may result from applications of these products far from the vineyard.

Herbicide damage symptoms and their distribution within a vineyard may vary, depending on the active ingredient and when, where, and how it was applied. Grapevines with green, growing tissues can be damaged by herbicide exposure at any time, but they are most sensitive from bud break through bloom. Damage to the canopy during this stage may appear as stunting and deformation of shoots, spotting, and distortion of leaves

including curling, fringed edges, wrinkling, twisting, and leaf cupping (Figure 3a). Flower clusters that are exposed to herbicides can have poor fruit set, resulting in clusters with fewer berries and reduced yield (Figure 3b). Damage symptoms usually appear within days or weeks of exposure (although damage caused when glyphosate penetrates trunks may not appear until the year following application).

Misapplication of herbicides commonly used in vineyards may result in damage to vines. For example, glyphosate is often applied in the vine row, and it can cause severe damage to young vines that lack adequate bark development. Multiple variables that are not fully understood at this time can contribute to glyphosate damage in vineyards. Growers are cautioned to use great care when applying any herbicide in the vineyard. Avoid herbicide application in the afternoon and early evening, when conditions commonly favor volatilization and drift. Extreme caution is advised when using growth-regulator herbicides in vineyards due to the high sensitivity of grapevines to their active ingredients.

Generally, herbicide damage may be sporadic within the vineyard due to a bouncing spray boom and intermittent drift resulting in contact with some vines but not others. Weather conditions at the time of exposure, including temperature and humidity, can affect symptoms and amount of damage as well.

To learn more about symptoms and types of herbicide damage to grapes, see "For more information," page 14.

Photo by Patty Skinkis, © Oregon State University

Figure 3a. Herbicide drift damage includes abnormal venation and distortion of leaves including curling, fringed edges, wrinkling, twisting, and leaf cupping. Damaged flower clusters lead to poor fruit set and reduced yields.

Photo by Patty Skinkis, © Oregon State University

Figure 3b. Herbicide drift can cause portions of fruit clusters to die.

Herbicide damage: Distinguishing from other causes

- Damage from off-site herbicide applications is often found on vines at the ends of rows or at the edges of the vineyard, as they often are exposed to higher concentrations of herbicide drift from a nearby source. However, damage symptoms from vapor drift may appear in interior areas of vineyard blocks and are often found sporadically throughout the vineyard.
- Exposure to certain growth regulator herbicides causes leaf distortion that is distinct from other causes.
- Exposure to other types of herbicides often results in different leaf deformation patterns that are consistent with herbicide type.

Vine balance

A healthy canopy is required for the production of carbohydrates needed for the development of shoot and fruit growth and bud development for the following year. Carbohydrates are stored and used in early spring the following season to ensure healthy growth post-bud break. Over-cropping and lack of water or nutrients can lead to reduced amounts of carbohydrates stored in the roots and trunk for the next season's growth. Reduced carbohydrate storage and nutrient reserves may lead to delayed bud break and reduced shoot growth, fruitfulness, and fruit set the following season.

Inadequate water and nutrients at specific times of the season can lead to reduced canopy growth, fruit set, or fruit development and ripening. In high-yielding cultivars or years, allowing vines to carry too much fruit relative to the vine's size, age, or health (over-cropping) can weaken vines in the short- and long-term.

Symptoms of vine stress due to over-cropping, water, or nutrient limitations may appear relatively uniform across an area of the vineyard with the majority of vines exhibiting weak growth. Within the vine, all shoots will be stunted (Figures 4a and 4b). In this case, a management program review is necessary to determine which factors may have contributed to the symptoms.

In most cases, a well-managed vineyard of mature vines (>5 years old) with adequate canopy, acceptable crop levels, and ability to ripen fruit is considered to be in balance. To assess vine health and balance, refer to vineyard yield and dormant pruning weight records. Pruning weights are helpful in determining potential vine size or vigor.

To learn more about vine balance, pruning weights, and how to use and interpret these data, see "For more information," page 14.

Photo by Patty Skinkis, © Oregon State University

Figure 4a. Stunted shoots in mid-July as a result of water stress.

Photo by Patty Skinkis, © Oregon State University

Figure 4b. The weak shoot growth is likely a result of low carbohydrate reserves. This vine was top-grafted and supplied with inadequate irrigation in the year prior to the photo. Water stress and a poor graft union reduced canopy growth and carbohydrate reserves available to support health canopy growth in the current season.

Vine balance: Distinguishing from other causes

- Over-cropping, inadequate water, and/or inadequate nutrients lead to weak growth (smaller shoots, leaves, fruit, and roots). Sustained vine stress typically results in stunted shoots, reduced fruitfulness and yields, and low pruning weights over time.
- These stressors do not cause the deformation of leaves or stem scarring that is found with insect or mite feeding or herbicide drift.
- Signs of water stress in vines include wilting tendrils (Figure 5), yellowing basal leaves (Figure 6), and abscission of the shoot tip (Figure 7). See "Vine nutrition," below, for more information about symptoms of nutrient stress.
- Damage to the vine's vascular system from winter damage, crown gall, or trunk disease may also lead to vine stress, as water and/or nutrients cannot be delivered throughout the vine. In such cases, the damage may not be apparent until later in the season, when the canopy is larger and has greater demand for water and nutrients.

Photo by Patty Skinkis, © Oregon State University

Figure 5. Hanging tendrils are a sign of water stress.

Photo by Patty Skinkis, © Oregon State University

Figure 6. Basal leaves become yellow and may drop prematurely in water-stressed vines.

Photo by Patty Skinkis, © Oregon State University

Figure 7. The shoot tip of water-stressed vines stops growing, dries up, and may fall off the vine.

Vine nutrition

Grapevines require nutrients for healthy, sustained growth. Without adequate nutrition, vines may have weak growth and reduced yields.

An inadequate nutrient supply may be associated with low (<5) or high (>7) soil pH, inadequate irrigation, or competition from weeds or cover crops. The most common nutrient deficiencies found in Oregon include nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), boron (B), and zinc (Zn).

When nutrient deficiency is the suspected cause of weak vine growth, submit vine tissue samples for nutrient analysis. Collect tissue samples at bloom and/or véraison and take a measure of vine growth, such as shoot length and leaf size. Tissue analysis combined with vine growth observations and measures can confirm a nutrient deficiency and support development of a fertilization plan to correct it.

Nitrogen

Nitrogen (N) is the most important plant nutrient for a healthy, productive grapevine. Vines without adequate N have reduced shoot growth, fruitfulness

(reduced number of clusters per vine), and fruit set (smaller clusters) and thus reduced yields. The leaves of N-deficient vines are more yellow or chlorotic than healthy vines, as N is required for chlorophyll production.

Older leaves at the base of the shoot are the first to show N-deficiency symptoms. Fruit produced on these vines may have reduced N and may contribute to reduced yeast-assimilable nitrogen concentrations (YAN) that require nutrient additions in the winery to avoid fermentation problems.

Phosphorus and potassium

Phosphorus (P) and potassium (K) are also key macronutrients that may become limiting in vineyards. The general symptoms associated with low P are not easy to distinguish, as low P may simply show as a decline in vine vigor. Low vine K also causes reductions in vine growth, fruit set, and yield, and can prevent fruit from ripening. K and Mg deficiencies are not consistently associated with shoot stunting. For most of Oregon's winegrowing regions, low P and K have not led to significant reductions in vine growth or yield.

Boron and zinc

Boron (B) and zinc (Zn) are required for the production of auxin, a plant hormone that drives cellular division and expansion, especially in the shoot tip. If B and Zn are deficient, less auxin is produced, and shoot growth slows or stops. As a result, the shoot appears stunted, with short internodes and a zigzag growth pattern. Both B and Zn deficiency can lead to poor fruit set, resulting in clusters with few berries or small "shot" berries that remain small and green.

Photo by Patty Skinkis, © Oregon State University

Figure 8a. Pinot noir leaves exhibiting symptoms of boron toxicity in late spring. The leaves have a distorted shape that is atypical for the cultivar, and the leaf blades are cupping downward.

Photo by Patty Skinkis, © Oregon State University

Figure 8b. A Pinot noir leaf exhibiting more severe symptoms of boron toxicity in late spring, including deformed leaf shape, necrotic margins, and a slightly downward cupping of the leaf.

An excess of any micronutrient can cause toxicity symptoms, and the signs will be specific to that nutrient. In the case of B toxicity, leaf edges fail to grow and expand, while the internal cells of the leaf blade continue to grow, causing cupping (Figure 8a). Necrotic spots (dead tissue) may form along the leaf margins and within the leaf blade if the toxicity is particularly severe (Figure 8b).

To learn more about visual symptoms of nutrient deficiencies, collecting tissue samples, and interpreting the results, see "For more information," page 14.

Vine nutrition: Distinguishing from other causes

- Vines with significant nutrient deficiencies have shoots that remain stunted throughout the entire growing season compared to healthy canopies (Figure 9).
- Weak growth is consistent across an entire block or a particular area of the vineyard rather than sporadic, as is seen with insect-, mite-, or disease-related issues.
- No scarring of stem or leaf tissue is observed with nutrient deficiencies.

Photo by Vaughn Walton, © Oregon State University

Figure 9. Stunted internodes and small leaves due to boron or zinc deficiency.

Insect and mite damage

Insect and mite pests feeding on vine tissues can stunt shoots or deform leaves. In Oregon, the most common pests associated with shoot stunting are Eriophyid mites, thrips, cane borers, and phylloxera.

Mites

Two Eriophyid mite species, the grape rust mite (*Calepitrimerus vitis*) and grape bud mite (*Colomerus vitis*), can damage the bud or young shoot. Feeding by either mite species can lead to stunting and deformity of shoots and leaves, particularly in early spring. Damage and symptoms are random within the vine and across the vineyard for rust mites and bud mites alike (Figure 17, page 10). Microscopic viewing is necessary to confirm which mite is the source of the damage in spring.

Photo by Patty Skinkis, © Oregon State University

Figure 10. Uneven bud break and buds that fail to grow are symptoms of grape rust or bud mite infestations.

Below are symptoms commonly associated with mite infestation:

- Failure of buds to break in spring, resulting in "blind" sections on the cane or spur (Figure 10)
- Stunted shoots (less than 10 mm long) in early spring when normal shoots are 10 to 30 mm long (Figure 11, page 8)

- Shoots growing in a zig-zag pattern
- Short internodes (Figure 11)
- Puckered, curled, or cupped leaves (Figure 11)
- Abnormally fuzzy shoots that are grey-green in color (figures 11 and 12)
- Shoot-tissue scarring that may be similar to thrips damage (Figure 13, page 9)
- Sparse clusters on stunted shoots are more often associated with bud mites. (Figure 14, page 9)
- Leaf stippling observed in late spring or early summer is associated with rust mites. The greater the stippling, the greater the mite population per leaf. (Figure 15, page 10)
- Rust mite feeding can cause leaf blackening and bronzing later in the summer. (Figure 16, page 10)

Photo by Patty Skinkis, © Oregon State University

Figure 11. Shortened internodes and malformed, cupped leaves are characteristic of grape rust mite feeding on young shoots.

Photo by Patty Skinkis, © Oregon State University

Figure 12. A shoot infested with a high number of grape rust mites (left) is stunted. The fuzzy appearance is caused by a high density of plant hairs. To the right of the shoot is a newly emerging secondary bud.

Thrips

Early season thrips damage can be difficult to differentiate from early season rust mite damage. Thrips feeding early in the season can cause symptoms such as shoot scarring, stunted shoots, and puckered leaves. Thrips can leave surface scars on leaves and berries (Figure 18, page 11) but do not usually damage the flower cluster or reduce yield. Early season damage due to thrips typically is not severe enough to cause economic impact. However, in years with a cool, wet spring, some shoot stunting due to thrips feeding has been observed.

Cane borers

The branch and twig borer (*Melalgus confertus*) is a wood-feeding insect. Adults feed on tissues and burrow inside the cane. Developing buds can be damaged, and shoots above the borer's exit hole fail to grow. They also may cause shoot stunting or death when damage occurs to a cane after shoot growth begins in spring (Figure 19, page 11). Infested vines may be isolated; rarely is an entire vineyard block affected. Random shoots and buds within an individual vine may be damaged.

Borer damage may be present in vineyards close to riparian or wooded areas, old orchards, wood piles, abandoned vineyards, or recently logged forestland where these insects thrive. Infested grapevine prunings must be removed from the vineyard before spring to avoid reinfestation. If wood is to remain in the vineyard, flail pruning wood and incorporate into the soil before adults emerge in spring.

Phylloxera

Grapevine phylloxera feeds on the roots of own-rooted *Vitis vinifera* grapevines. This pest causes generalized stunting of the vine with overall reduced canopy size (shoot length and leaf area) and reduced yields. It may take from a few years to more than a decade to completely kill vines.

To learn more about grapevine mite and insect pests, see "For more information," page 14.

Photo by Patty Skinkis, © Oregon State University

Figure 13. Brown scar tissue caused by grape rust mites is visible on a Chardonnay's shoot early in the growing season. The puckered lower leaves also are a sign of grape rust mite feeding.

Photo by Vaughn Walton, © Oregon State University

Figure 14. Flower and fruit clusters damaged by grape rust mite feeding.

Insect and mite damage: Distinguishing from other causes

- Insect or mite damage is sporadic within the vineyard.
- Cane borers leave signature holes at the base of canes.
- Rust mites and thrips can cause shoot stunting that may also be accompanied by leaf distortion and scarring of the stems of young shoots. Rust mite stunting is most visible in early spring, before the average shoot length is 6 inches. Stunting is usually unevenly distributed within a vine and across the vineyard. Often the most stunted shoots are near the head of the vine in cane-pruned vineyards. Visual symptoms of rust mites will persist throughout the summer if populations are present, including stippled leaves in late spring to early summer and progressing to blackened and bronzed leaf surfaces late season.
- Because thrips and rust mite damage may look similar, scouting for these pests is required to determine necessary action. Monitor for thrips with a sweep net, or shake the vine canopy to dislodge thrips onto white paper or a white sheet for collection and identification (Figure 20, page 11). Conversely, bag individual small shoots or leaves and use an isopropyl alcohol and water wash to capture mites, thrips, or other pests from the leaf surface.
- View thrips and mites under a stereoscope with 45X or greater magnification. Thrips are visible at lower magnification (or with a hand lens), but higher magnification is required to observe rust mite presence.
- The eXtension publication Grape Rust Mite (eXtension node 33107) describes identification methods that can be used to confirm the presence of grape rust mites.

Photo by Patty Skinkis, © Oregon State University

Figure 15. Leaf stippling due to rust mite feeding can be observed in late spring to early summer.

Photo by Amy Dreves, © Oregon State University

Figure 16. High populations of rust mites feeding on leaves cause the leaf surface to turn black in mid- to late summer.

Photo by Patty Skinkis, © Oregon State University

Figure 17. Normal and stunted shoots are found on the same vine. The stunted shoots (right) had a greater number of mites per shoot than the normal shoots on the left.

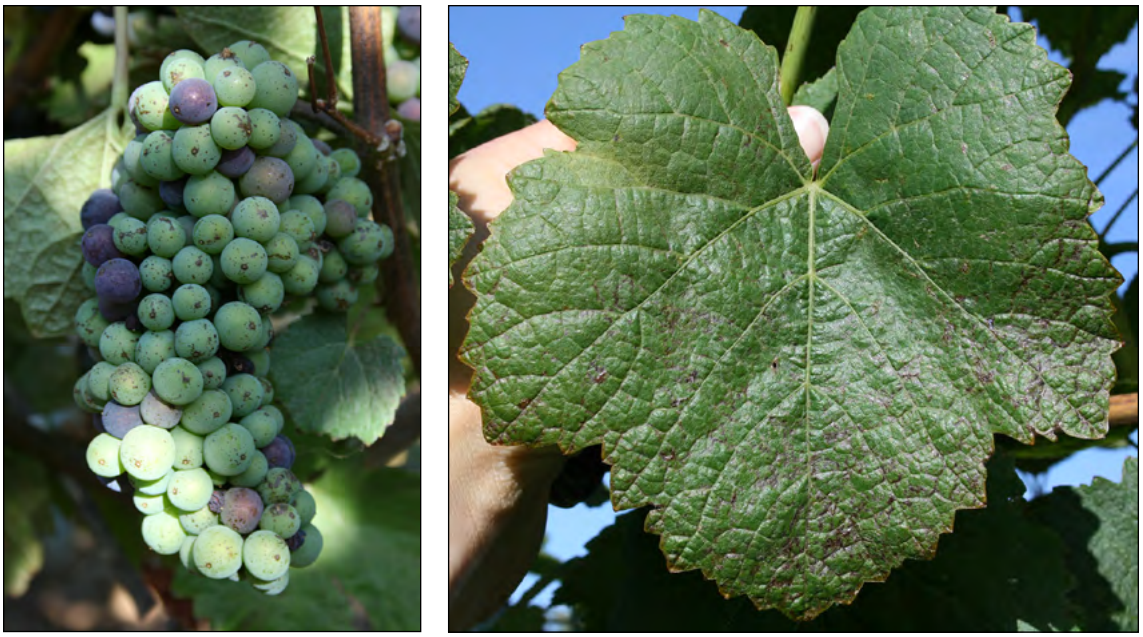

Figure 18. Thrips feeding on berries (left) or leaves (right) can lead to scarring.
Photos by Patty Skinkis, © Oregon State University

Figure 19. A cane damaged by cane borer feeding.

Photo by Patty Skinkis, © Oregon State University

Figure 20. Use a light-colored sheet to collect thrips and other pests dislodged from the vine canopy. Once insects are collected, use magnifying loupes or glasses to identify the pests on the sheet.

Photo by Amy Dreves, © Oregon State University

Vine diseases

Grapevines can experience decline in growth due to bacterial and fungal disease. The following are diseases commonly found in the Pacific Northwest. Visual observation may not be diagnostic of any of these problems; diagnosis must be confirmed by laboratory tissue analysis.

Crown gall

Crown gall is a bacterial infection caused by *Agrobacterium vitis*. Although it is found in all grapevines (except those cultured to be free of it), it does not express itself unless a stressor, such as cold injury or some other wound, initiates it. Formation of a gall blocks the vine's vascular system. Galled vines may display poor shoot growth with wilting, yellowing, and death occurring above the gall, especially if the gall girdles the trunk or cordon. Dramatic reduction in yield is possible. Galls typically develop within 2 feet of the soil line or may be found along the trunk, cordon, or cane if cold damage has occurred (Figure 21).

Figure 21. Galling is visible along the base of the dormant vine trunk (left). Crown gall was found on the trunk and cordons of this vine (right) after the sloughing bark was removed mid-summer. The damage to the vine occurred during a freeze event the prior winter.
Photos by Patty Skinkis, © Oregon State University

Trunk diseases

Grapevines infected with various fungal diseases can experience stunted (Figure 22) and deformed shoot growth. In the Pacific Northwest, virtually identical symptoms may occur from diverse fungi such as *Eutypa lata, E. leptoplaca,* and *Botryosphaeria* species. Fruit trees and riparian species commonly found in grape production regions can act as reservoirs for these pathogens. Some common terms associated with trunk diseases include "Bot canker," "Eutypa dieback," and "Esca" fungi.

Fungal infections of *Vitis* trunks are typically associated with chlorotic leaves (Figure 22). The canker that forms in the diseased vine causes a blockage of the vascular system. As a result, shoot growth is stunted, leaves may be deformed, and flowers may fail to develop into fruit. Cankers (dark brown areas of the wood) can be found by inspecting a cross-section cut of canes, cordons, or trunks for discoloration (Figure 23).

To learn more about vine diseases, see "For more information," page 14.

Vine diseases: Distinguishing from other causes

- Trunk disease and crown gall damage are often found in a sporadic pattern within the vineyard (Figure 22).
- Vines with trunk diseases often have cankers found in a cross-sectional cut of the trunk. (Figure 23).
- Crown gall can be visually identified by the presence of galls at damaged areas in the trunk or cordon (Figure 21, page 12). Trunk diseases do not have galling visible on the exterior of the vine.
- To identify the disease agent (bacteria or fungal pathogen), samples must be submitted to an analytical lab, such as the OSU Plant Clinic or other commercial lab.

Photo by Patty Skinkis, © Oregon State University

Figure 22. Two vines near the center of the photo show the first signs of trunk disease, including shorter shoots that are thinner and more chlorotic (yellow) than the neighboring vines. At this stage of the disease's development, stunting may not be apparent all season. However, as the disease progresses, stunting will be apparent throughout the season. This vineyard block had more severely damaged vines that were confirmed to have Bot canker and other trunk disease pathogens.

Photo by Patty Skinkis, © Oregon State University

Figure 23. Vines with trunk disease often have cankers visible when trunks are cut. The darker areas of the cut surface indicate the presence of the trunk disease canker.

Steps toward creating a management plan

There are many causes of stunted and distorted growth in grapevines. Take the following steps to diagnose the cause and create an appropriate management plan:

- Document patterns of symptoms within the vineyard and when they occur.
- Maintain records of management practices, yield, and pruning weights.
- Scout the vineyard for damage, symptoms, and presence of insect or mite pests, and be sure to record the growth stage of vines.
- Log weather patterns, including cold winter events, spring or fall frosts, and rainfall.
- Collect and submit tissue samples to an analytical lab for nutrient testing on a regular basis to manage and maintain vine health.

Be guided by your observations and records when choosing the best management practices to bring vines into good health. If you need further assistance in diagnosis, contact your local OSU Extension horticulturist, an agriculturist, or other local consultant.

For more information

Herbicide damage

Preventing Herbicide Drift and Injury to Grapes (EM 8860)

Pacific Northwest Plant Disease Handbook

Pacific Northwest Weed Management Handbook

Vine balance

How to Measure Dormant Pruning Weight of Grapevines (EM 9069)

The Role of Canopy Management in Vine Balance (EM 9071)

Understanding Vine Balance: An important concept in vineyard management (EM 9068)

Vine nutrition

eXtension

"Monitoring Grapevine Nutrition"

OSU Extension Service

Eastern Oregon Liming Guide (EM 9060)

Evaluating Soil Nutrients and pH by Depth in Situations of Limited or No Tillage in Western Oregon (EM 9014)

Grapevine Nutrition (EM 9024)

Soil Acidity in Oregon: Understanding and Using Concepts for Crop Production (EM 9061)

WSU Extension

Sampling Guide for Nutrient Assessment of Irrigated Vineyards in the Inland Pacific Northwest (PNW 622)

Insect and mite damage

eXtension

"Grape Rust Mite"

OSU Extension Service

"Cane borer" (in *Pacific Northwest Insect Management Handbook*)

Phylloxera: Grape Phylloxera Biology and Management in the Pacific Northwest (EC 1463)

Vine diseases

All entries below link to the *Pacific Northwest Plant Disease Management Handbook.*

"Crown gall"

"Bot canker"

"Eutypa dieback"

"Esca"

Viruses of importance:

"Grapevine leafroll virus"

"Grapevine red blotch disease"

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