Growing Winegrapes in Maritime Western Washington

WASHINGTON STATE UNIVERSITY EXTENSION • EM068E

Growing Winegrapes in Maritime Western Washington

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Growing Winegrapes in Maritime Western Washington

Introduction

There are many aspects to consider in order to be successful at growing grapes in the maritime climate areas of the Pacific Northwest (PNW). Typified by cool summers, mild winters, and variable precipitation throughout the growing season, these climate conditions resemble those of classic winegrape regions of Europe such as Champagne and Burgundy in France, the Ahr and Franconia areas of Germany, Vinho Verde in Portugal, and the areas on Lake Geneva and Lake Zürich in Switzerland. This suggests that the maritime PNW has potential for producing grapes and wine types similar to those areas.

Quality winegrapes can be grown in western Washington, provided careful consideration is given to choosing the appropriate site, variety, **rootstock**, and cultural practices. There are several limiting climatic factors, however, that impact the success of growing winegrapes in maritime areas of western Washington, including temperature, growing season length, and amounts of precipitation.

Since temperature is a major limiting factor in cool-climate viticulture, accurate measurement of heat accumulation at a potential vineyard site is important. Heat units in the maritime PNW region can vary from 1400 to 2300 **growing degree days** (GDD; base 50ºF). Once the GDD of a site is determined, the process of selecting varieties that are best suited for that site will allow you to concentrate on producing high quality grapes.

Length of the growing season is another major determinant in successfully establishing vineyards. Generally, winegrape cultivars need a minimum of 160 frost-free days. Except at some high elevations in the foothills of the Cascade and Olympic mountains and in some low-lying areas, the PNW offers a long enough growing season for winegrapes.

Precipitation can be another limiting factor in quality grape production. Rainfall in the coastal region can vary from approximately 12 to 50 inches per year. The Washington State University Northwestern Washington Research and Extension Center (WSU NWREC) in Mount Vernon has recorded a 40-year annual precipitation average of 32 inches. Most of the precipitation in western Washington falls as rain from late autumn to early spring, with occasional brief intervals of snow. Summers are relatively dry, particularly from early July to early September.

Mesoclimate, or specific local climates that vary from site to site, can also be a significant influence on grape development. Especially in western Washington, mesoclimates are often determined by changes in altitude and in hill aspect (geographic direction that a slope faces; this controls the angle and amount of sunlight received). Variations due to different altitudes can be striking, from valley floor to 400- to 700-foot elevations, and involve both unique soil types and wide variation in daytime temperatures. Similarly, differences due to hill aspect—facing north, south, east, or west—are large and can be decisive for grape variety selection.

Getting Started

When preparing to establish a new vineyard in western Washington, due diligence is necessary for success. The two largest preparation decisions are site selection and choosing which varieties to grow. Each of those decisions entails numerous considerations and choices.

Site Selection and Preparation

Site selection is one of the most critical decisions you will make. Factors that influence the suitability of a site include: temperature and **microclimate**, slope and aspect, soil drainage, and soil chemical and physical properties. The availability of water for irrigation also must be considered for sites that are likely to experience long dry periods during late summer.

Temperature and Microclimate. Temperature is critical during grapevine development and fruit production. It can determine the type of cultivars and species that can be grown successfully in a given area, because some cultivars require more heat than others or ripen later in the season, or both. (See Appendix A for an annotated list of grape cultivars.) Slight adjustments in row orientation and trellising can be made to minimize or maximize the amount of heat available at a site.

In addition to in-season temperature, winter temperatures significantly influence vine growth. Most areas in western Washington are not subject to damaging low winter temperatures; however, insufficient cooling in some areas can exacerbate erratic vine development in the spring.

To accurately measure temperatures at a site, a data logger that records temperature is necessary. From the data gathered, you can calculate the accumulated growing degree days for your site. (See "Calculating Growing Degree Day.") Data loggers range both in price and in types of data they record. In general, daily recording of minimum and maximum temperature is all you need; but hourly temperature information is better. Precipitation and humidity sensors are variable, but it may be better to invest in a high-quality stand-alone temperature logger, than to spend more money on a mediocre all-in-one station.

Aspect and Slope. South-facing to west-facing slopes are the best for maximizing GDD accumulation and sun exposure (Figure 1). When laying out your vineyard, a north-south row direction (or modification thereof) helps to balance sun exposure on the east and west sides of the future vine canopy. Very steep land (with greater than 10% slope) should be avoided unless you plan to terrace, because steep slopes hinder vineyard equipment operation and can cause potentially hazardous working conditions.

Slopes can aid in cold air drainage, which is a critical factor in reducing frost and freeze risk. When considering air drainage from a vineyard site, make sure that cold air can flow away from the vineyard and does not have a location to accumulate or "pond." Commonly, areas of cold air ponding are low-lying points in the vineyard, at the bottom of a slope (if followed by extended area of level ground), and areas where air drainage is blocked by a hedgerow.

Vineyards planted on slopes may have the rows going up and down, since this is thought to allow cold air to drain down-slope (Figure 1) between the rows. However, it may be more practical to let rows follow the land contour, to make machine operation more feasible. In most vineyard layouts, some compromise among the various elements will be necessary, as few sites are ideally situated.

Drainage. Most grape species do not tolerate poor drainage for long periods of time. Also, try to determine the depth of the water table. While most grapevine roots are at a soil depth of 18 inches, they can grow deeper (up to 40 feet) in search of water. If a water table is shallow, controlling grapevine canopy development will become increasingly difficult (canopies will grow to excessive sizes with unrestricted groundwater). Sites with shallow water tables should be avoided, as not much can be done to mitigate their effects on grapevine growth and development.

Soil Chemical and Physical Properties. There is a wide range of soil types in the maritime PNW, and soil

Calculating Growing Degree Day

Begin by calculating the GDD for each day, using this equation:

Average daily temperature – 50 = GDD for that day

where,

average daily temperature (°F) is the average of the maximum and minimum temperatures for that day:

$$\frac{(T_{max} + T_{min})}{2}$$

and

50 is the base temperature at which grapevines grow (50 °F).

Example: if the average daily temperature is 55 °F, the GDD unit for that day is 5:

$$55 - 50 = 5$$

Add the daily GDD units from 1 April to 31 October for the accumulated GDD of that location.

Data loggers that can record and store this information range in price, depending on the size, style, and functionality, but they are worth the investment.

AgWeatherNet (AWN), online at http://weather.wsu.edu, is Washington State University's weather network. It has GDD calculators for each of its weather stations. In addition, the Integrated Plant Protection Center (IPPC) at Oregon State University has an interactive website where you can map GDD for the entire state and PNW region. Those maps can be generated at: http://uspest.org/cgi-bin/usmapmaker.pl.

Figure 1. Slope, and aspect of that slope, are important in viticulture. Here, a slope in the Snipes Mountain AVA of Washington is less than a 10% grade, which is low enough to allow mechanized operations, but steep enough to facilitate cold air drainage. This slope is south-facing, allowing maximum heat accumulation and sunlight exposure. Photo by Michelle Moyer.

type greatly influences the chemical properties of local soil. Check with your local Extension office (http://extension.wsu.edu/locations/Pages/default.aspx) for a detailed soil map of your county. The National Resources Conservation Service has an online "Web Soil Survey" (WSS) for both desktop and mobile devices that allows you to search for a number of different soil properties specific to your area of interest. See *References and Resources* for more information.

Some grape hybrids and ***Vitis vinifera*** (European winegrape) vines are adapted to higher **pH** soils. A pH of approximately 6.5 to 7.5 is ideal; some own-rooted *V. vinifera* varieties can survive in soils with pH as high as 8.0. Low soil pH (less than 6.5) can adversely affect both vine health and juice quality in winegrapes. Increasing the soil pH when it is below 6.5 is often beneficial for row-middle cover crops as well. This may be a result of increased availability of phosphorus. Note that if limestone is added to increase soil pH, it moves slowly into the soil—it may require one to two years or longer before effects of the application are noticeable.

Preplant Soil Assessments. A thorough assessment of the soil at a potential vineyard site is highly recommended before planting. This includes assessments of organic matter, soil pH, soil compaction, and soil nutrient status, as well as checking for the presence of parasitic nematodes. These test results are critical in determining what preplant remediation may be necessary. However, it is important to remember that a soil sample is just a limited snapshot of the soil profile at that particular time. After planting, soil tests should be made approximately every 5 years, and tissue testing to determine vine nutrient status should be done annually. See *References and Resources* for a complete description of how to properly sample soil for testing, and how to interpret soil test results; Davenport and Horneck (2011), and Horneck et al. (2011) are good references.

Proper vine nutrition is critical for successful vineyard establishment. In western Washington, soils tend to be high in organic matter, which typically results in adequate nitrogen supply, but the low soil pH found in most areas can be a limiting factor for other nutrients such as phosphorus and calcium. See Table 1 for a brief list of recommended amounts of certain nutrients for both pre-plant and established vineyard soils.

When establishing a new vineyard, incorporate any recommended amendments into the soil before planting. If soil tests indicate that the soil is low in either nitrogen (N), phosphorous (P), or potassium (K), then a balanced fertilizer can be incorporated into the soil pre-planting (for example, 10-10-10, N-P-K). If pre-plant soil tests do not indicate a deficiency in all of the elements in these balanced fertilizers, then only add fertilizers containing the elements that were considered deficient.

In established vineyards, amendments are typically applied directly to the soil surface, shanked into the

Table 1. Pre-plant soil fertility guidelines (adapted from Soil Test Interpretation Guide *OSU #EC1478; Horneck et al. 2011). Post-planting fertilization decisions should be based on vine tissue tests.*

Nutrient	Minimum Soil Requirement (Pre-plant)
Macronutrients	
NO_3^-–N (nitrate–nitrogen)	10–20 ppm
P (phosphorus)	20–40 ppm
K (potassium)	60–250 ppm
Ca (calcium)[1]	1,000–2,000 ppm
Mg (magnesium)	60–300 ppm
Micronutrients	
B (boron)[2]	0.5–2 ppm
Zn (zinc)	>1 ppm
Cu (copper)	>0.6 ppm
Mn (manganese)[3]	1–5 ppm

[1]Calcium deficiencies are typically only found in very acidic soils or in soils high in magnesium.

[2]Boron deficiencies can result in poor fruit set, but high levels are phytotoxic. Adjust boron based on tissue tests and use foliar applications.

[3]Manganese deficiencies typically only occur in soils with pH greater than 8.0.

row middles, or applied through a drip irrigation system. Another option is to plant a cover crop that will be incorporated into the soil as a green manure; however, this method gives less control over nutrient release.

Once a vineyard is established, fertilizing regimes should be based on tissue analyses, rather than soil tests. Tissue tests should be performed annually. More information on tissue tests and typical nutrient composition in winegrapes can be found in the *Sampling Guide for Nutrient Assessment of Irrigated Vineyards in the Inland Pacific Northwest,* PNW622 (Davenport and Horneck 2011). While acceptable nutrient content may differ slightly for maritime grapes, the sampling methods and guides discussed in PNW622 are still applicable.

Rootstocks and Varieties for Western Washington

After site selection, the next major deciding factor for vineyard success is selection of the appropriate variety and clone (and potential rootstock) for the chosen site. This decision needs to be made well in advance of planting because nurseries typically need about one year to fulfill plant orders. On average, nurseries will need 8 to 10 months advance notice for the production of own-rooted grapevine cuttings, and need 12 to 16 months for grafted, rooted grapevine cuttings. If you wait until the last minute to order plant material, you will likely find that nothing is available, or that the remaining available stock is of low quality.

While it is legal to plant grapevines that have been propagated in Washington, you are encouraged to only purchase grapevines from a reputable nursery that supplies *certified* plant material. Currently, plant material is only certified if it has gone through a rigorous certification program; *certified* plant material is only acceptable (legally) from nurseries in Washington, Oregon, or California. While obtaining cuttings from an existing vineyard may seem like a fast, cheap, and easy way to go, *you will inherit any diseases and problems* that may be associated with that vineyard. In addition, if that vineyard is not in Washington, bringing that plant material across state lines without going through appropriate quarantine is *ILLEGAL*.

The Clean Plant Center–Northwest Grapes, located at WSU IAREC in Prosser, Washington, provides a list of nurseries in Washington and Oregon that carry certified nursery stock; this list is updated annually on their website. See *References and Resources* for more information.

> Bringing uncertified plant material into Washington State, without going through appropriate quarantine, is *illegal*.

Do you need to use a rootstock? While own-rooted cuttings are typically cheaper and easier to obtain, there are many advantages to using rootstocks, especially in western Washington. Many rootstocks are bred for resistance to the root aphid **phylloxera** as well as to nematodes, which are parasitic worms that feed on vine roots and can spread certain virus diseases of grapes. For a complete description (with full-color photographs) of phylloxera and the various nematodes impacting grapes in Washington, please refer to the *Field Guide for Integrated Pest Management in Pacific Northwest Vineyards,* PNW644 (Moyer and O'Neal 2013). Rootstocks have also been selected for tolerance to different soil pH and for their ability to impart different attributes to the **scion**, such as reduced **vigor** or earlier ripening.

Currently, phylloxera is established in the Willamette Valley in Oregon, and has the potential to spread to both western and eastern Washington. This, combined with both the generally low soil pH (less than 6.0) west of the Cascade Mountains and the presence of nematodes, is a good reason for western Washington viticulturists to consider planting vines grafted on rootstocks. While grafted vines cost more than ungrafted vines, the cost of replanting due to a phylloxera outbreak far outweighs the cost difference of planting grafted stock.

In addition, particular rootstock choices may speed the onset of ripening, which is a benefit in the cooler growing conditions of western Washington. Rootstocks can also help improve vine tolerance to late-summer droughts that can often occur in the region.

Rootstock choices. The choice of a rootstock for a particular location depends on the complex interactions between soil (type, depth, physical and chemical properties), pests, diseases, water availability, climate, and other environmental factors. To determine the best rootstock for a particular site, a mini on-farm trial is recommended.

Rootstocks that have performed well in western Washington trials include Millardet et de Grasset 101-14, Couderc 3309, and Millardet et de Grasset 420A. A partial list of rootstocks that may do well in western Washington is shown in Table 2.

Table 2. Potential rootstocks suitable for western Washington.

Rootstock	Parentage	Low soil pH tolerance	Phylloxera Resistance	Nematode Resistance	Notes
Millardet et de Grasset 101-14	*Vitis riparia x Vitis rupestris*	No	Yes	Moderate to High	Cold tolerant, advanced maturity, low vigor
Couderc 3309	*Vitis riparia x Vitis rupestris*	Yes	Yes	Low	Drought resistant, low vigor
Millardet et de Grasset 420A	*Vitis berlandieri x Vitis riparia*	No	Yes	Low to Moderate	Moderate tolerance to wet soil, low vigor
Riparia Gloire	*Vitis riparia*	Yes	Yes	Low to Moderate	Low tolerance to wet soil, advanced maturity, low vigor
Schwarzmann	*Vitis riparia x Vitis rupestris*	Yes	Yes	Moderate to High	Moderate vigor

Table 3. Variety guidelines according to growing degree day accumulation[1].

1600–1650 GDD	1651–1900 GDD	Above 1900 GDD
Siegerrebe (W)[2] Madeline Angevine (W) Burmunk (W) Iskorka (W) Ortega (W)	***Everything to left, plus:*** Chardonnay Dijon clones (W) Auxerrois (W) Müller-Thurgau (W)	***Everything to left, plus:*** Sauvignon Blanc (W) Pinot Gris (Ruländer) (W) Pinot Blanc (W) Sylvaner (W) Kerner (W)
Muscat of Norway (R)[2] Rondo (R)	Pinot Noir clone Mariafeld (R)[3] Pinot Noir Precoce (R)[3] Regent (R) Garanoir (R) Golubok (R) Agria (R) Leon Millot (R)	Pinot Noir clone Mariafeld (R) Pinot Noir Precoce (R) Pinot Noir Dijon clones (R) Dornfelder (R) Gamaret (R) Zweigelt (R)

[1]Base 50°F; 1 April–31 October.

[2](W)=White variety, (R)=Red variety.

[3]For sparkling wine production; may not adequately ripen for quality table wine production at this GDD level.

Best varieties for a maritime climate. See Appendix A for basic information on different *Vitis vinifera* varieties and *Vitis* hybrids that may be suitable for the maritime PNW. This list is not all-inclusive. Several varieties may be worth trialing; however, the major limiting factor in the maritime region is adequate heat accumulation during the growing season.

Since the major limiting factor in western Washington is in-season heat accumulation, Table 3 is designed to help you select the grape variety that may be more suitable for a given location. If a site receives less than 1600 GDD (base 50°F, from 1 April to 31 October), it is not a suitable location for grape production without significant intervention such as high tunnel use or tenting.

Vineyard Establishment

After selecting varieties, your next decisions relate to actual vineyard establishment: trellis design and then the row and vine spacing.

Trellis Systems

It is helpful to select a training system as early as possible since this will affect the plant spacing and trellis requirements. In addition, treated-wood posts are not allowed in organic production systems, so the choice of whether to go organic or not needs to be made prior to vineyard trellis installation. For a thorough review of many trellis and training systems, see "Trellis Selections and Canopy Management" in *Wine Grape Varieties in California* (Christensen et al. 2003).

Trellis Support Posts. A reliable trellis system is constructed with well-anchored, heavy wood end posts or metal end posts (Figure 2). Improperly installed end posts can result in trellis collapse. In addition, soil type can play a significant role in determining the type of end post and anchor used. For example, silt soils are considered "weak" in structure, and do not provide much holding power for screw anchors; therefore, anchor posts buried 6 feet in the ground are more appropriate. Clay soils are very strong

Figure 2. Trellis end post design comes in many forms. Soil structure, cost, and whether you plan on doing organic production will influence your end post selection. A and B are examples of H-posts, C and G are examples of post anchor design, and D, E, and F are screw anchor trellis end post designs. Photos by Michelle Moyer.

Figure 3. In-line posts can be made of metal or wood (left and right). Metal posts that are pre-notched (left) make in-season canopy management such as tucking and training, very easy. Some inline posts also have modifications such as the addition of cross-arms (center) to help with canopy density. Photos by Michelle Moyer.

and can support either anchor screws or anchor posts. Sandy or gravel soils are considered medium strength, and, therefore, can handle anchor screws, provided they are installed at a greater depth than one would use in clay soils. Soils that are prone to high levels of moisture, such as those in maritime Washington, may need additional support (that is, deeply buried end/strain posts plus anchor posts or anchor screws) to help prevent post-heaving during periods of high rainfall when saturated soils become structurally weak. Spending the time and money for appropriate end posts is critical.

For interior support posts (in-line posts), use either smaller diameter wood posts or metal posts that are pre-notched to facilitate the raising of catch wires (Figure 3). Interior posts are usually set 24 to 30 feet apart along a row. In addition, each plant normally has an individual stake (usually bamboo) set next to it at planting or shortly after. This stake is fastened to the fruiting wire and is used to train the trunk of the new plant.

Trellis Wire. There are two basic functions for wires in a vineyard trellis system. The first is to train **cordons** or **canes** by use of a fruiting wire, designed as a location, and which will support the weight of the developing fruit. For this, the use of high-tensile wire is necessary (12.5 gauge). This wire is also what places the most stress on the end posts because their load increases as **clusters** develop and they gain weight.

When deciding where to place the fruiting wire, there are many choices depending on the trellis design (discussed briefly below). Theoretically, setting the fruiting wire low, about 12 inches above the ground, utilizes heat from the ground to advance fruit maturation, particularly if the site is not windy. This depends to some degree on the soil type; a darker soil absorbs more radiation while lighter soil reflects it. However, harvesting the grapes on low wires becomes challenging. When the fruiting wire is 28 to 32 inches from the ground, harvest and canopy management become much easier.

The second function of wires above the fruiting wire is to help direct canopy growth. These wires do not carry as much load and are generally just 14 gauge; high-tensile wire is not necessary. The design of these wires is either in the form of single wires, to which **shoots** can attach, or double "catch wires" to gather the canopy into a vertical wall. Catch wires are typically placed starting at 8 to 12 inches above the fruiting wire, with multiple catch wires placed at equal intervals up from that. One or two sets of catch wires are recommended for western Washington because they aid in fruit exposure to sunlight and wind, reducing disease pressure and enhancing ripening. Single wires, which result in a more sprawling canopy, may not be appropriate.

Trellis Design for Canopy Management. If using a **vertical shoot positioning** (VSP) method (Figure 4) of training, the fruiting wire is typically placed at approximately 30 inches (28–32 inches) above the ground and canopies are trained to a total height of 5 to 6 feet. This allows for sufficient leaf area to help mature developing clusters (approximately 15 leaves per shoot; more in cooler climates). Two to three catch wires are used to help maintain a vertical plane with the canopy.

The VSP system can improve spray penetration into the fruit zone, provided that the grape canopies are

Figure 4. Two views of vineyards using vertical shoot positioning, a common training system in climates with short, cool growing seasons and low levels of light. Photos by Jacqueline King (WSU NWREC) and Michelle Moyer.

properly maintained and not overly vigorous. One caution with the VSP system is that over-exposure of fruit to sunlight can be a problem, particularly on the western sides of rows, and especially so if sudden sun exposure occurs near véraison.

Another way to increase yield and still maintain quality is to use a divided canopy system, discussed in *Sunlight into Wine* (Smart and Robinson 1991). The **Scott-Henry system**, and variations of it, such as the Smart-Dyson system, can reduce vine vigor and increase yield while maintaining good fruit quality (Figure 5). This is because these divided systems allow growers to leave more **buds** (that is, more shoots) on each individual vine without overcrowding canopy trellis space. These additional buds allow for a more even distribution of nutrients throughout the plant when growth resumes in the spring.

Figure 5. Using a divided canopy system (for instance, the Scott Henry system, pictured here) can increase yields while managing vine vigor and canopy development. However, there can be differences in ripening of clusters grown on the bottom vs. the top fruit zone, as well as reduced vigor in the downward-facing shoots. Photo by Jacqueline King (WSU NWREC).

Most of these divided systems can be converted from a VSP system. However, divided systems can have fruit quality differences among the different canopy segments (for instance, downward positioned shoots in the Scott Henry system have markedly less vigor than the upward-positioned shoots), and are more labor-intensive than VSP systems. Scott Henry systems have two fruiting wires, one placed approximately 28 inches above the ground and the other 8 to 12 inches higher. There is one set of catch wires placed at approximately 16 inches (for downward training of shoots), and two sets of catch wires placed at regular intervals above the top fruiting wire (Figure 5) for a total of 5 wires.

Spacing Considerations

Row Spacing. Optimizing fruit quality requires getting sufficient sunlight to the canopy. Space between rows should be dictated by the expected height of the vine canopy, aiming for a 1:1 ratio (Figure 6). This helps prevent each row from casting a shadow onto the adjacent row. In addition, it allows proper clearance for equipment between the rows.

As a baseline recommendation, start with a VSP system, spacing the vines 4 to 6 feet apart in the row and allowing 7 to 8 feet between the rows. When defining the row spacing, consider the size of the vineyard equipment (sprayer, mower, etc.) to be used. Determine the row spacing using horticulturally sound information. Equipment has been designed for narrow row spacing, but if given the opportunity to establish a vineyard, consider the benefits (and cost-effectiveness) of standard to wide row spacing.

Vine Spacing. Unlike orchard systems, high-density vineyards do not always translate into improved control over vigor. Spacing between vines ranges from 2 to 8 feet, depending on site vigor, with 5 to 6 feet as a good compromise. A common myth is

Figure 6. In an ideal situation, the final canopy height should be equal to or less than the space between the rows, giving a nearly 1:1 ratio. On the left, wide row spacing allows for mechanical operations, but is too wide for hand-operations, thus wasting space. On the right, ultra-narrow row spacing prevents mechanical operations and causes extended shadow effects on the fruit zone of the next row in both morning and afternoon, which can slow the rate of ripening. Photos by Michelle Moyer.

that if more vines are planted into a given area (for example, 3 feet or less between vines), that the vines would compete for available nutrients, and thus, control the vigor of neighboring vines. However, vines are rarely in competition for nutrients and water (except in strictly irrigated systems where water can be completely controlled); instead, they are more apt to compete for sunlight. In vineyard systems, high-density planting on normal to high vigor sites results in excessive vigor of each individual vine, because there is insufficient trellis space for each plant to maintain the appropriate number of shoots.

Planting and Post-Planting

Planting Time. In most areas of western Washington, planting can be done during the dormant season (December to April) when the ground is workable. Newly grafted vines, or mist-propagated vines can be planted up until early June, but special attention is needed towards irrigation management as water is critical for these actively growing vines. To enhance soil warming, enable drainage, and help in water management, plants can be set in raised beds. The beds are raised after soil amendments are incorporated, but before planting.

Planting Methods. When planting grafted vines, make sure the **graft union** is above the ground (preferably 4 to 6 inches above the ground; Figure 7) to prevent the scion from rooting. Make sure the planting hole is deep enough to prevent root folding. If necessary, trim roots to avoid self-girdling.

After planting, make sure no air gaps exist around the roots. A thorough water application can help soil adequately settle around the new vines' roots. After planting, prune the scion back to two buds (Figure 7) and place a 3-foot stake next to the new vine to encourage upright growth towards the location of future (or existing) training wires. Alternatively, run

Figure 7. Prune newly-planted vines back to two dormant buds. These two buds will develop shoots that will eventually serve as the basis for the vine trunks. Photo by Jacqueline King (WSU NWREC).

twine from the vine to the fruiting wire if the trellis is already installed.

Irrigation. During vineyard establishment, irrigation is necessary, regardless of vineyard location. Young, newly grafted plants are especially sensitive to drought and need ample, regular watering to produce a vigorous root system in the first year. Starting off a vineyard with strong vines that come into production earlier is worth the additional cost of installing irrigation.

After a vineyard is established, irrigation tends to be supplemental in western Washington. Sites where the soil has low water-holding capacity and sites that experience prolonged summer dry periods will benefit from supplemental irrigation. Drip irrigation is the preferred system, as it is very efficient in water usage and is fairly amenable to fertigation (fertilization through an irrigation system). Drip lines can be left in place after the vineyard is established for use as needed.

Carefully monitor soil moisture, particularly in areas of the vineyard that tend to dry out more quickly (for instance, in sand or gravel streaks). Most of the wine varieties that grow well in cooler climates, in addition to 'Pinot Noir' and 'Pinot Noir Precoce' are drought sensitive, so water management is essential for the optimal growth of these varieties.

Vine Training—Year 1

New, grafted vines are planted with the graft union approximately 4 to 6 inches above the ground (Figure 8-A). New vines are pruned back to two buds before the first growing season starts (Figures 7, 8-B).

As the vines begin to grow, select the two dominant shoots (or a single dominant shoot if going for a single-trunk vine) and affix them to the stake or twine (Figure 8-C). Because grapevines exhibit **apical dominance**, their shoot growth is stronger when shoots are positioned vertically. Throughout the growing season, the developing shoots may need additional ties to keep the developing trunks straight.

As the season progresses, summer **lateral shoots** may start to develop along the trained shoots (future trunks). These shoots are competing for nutrients, so remove the shoot tip on these laterals to reduce competition, while still leaving plenty of leaves to support plant growth and add to carbohydrate accumulation (Figure 8-C).

The objective is to get each trunk-in-training to the fruiting wire within the first year. If the developing shoots do not make it to the fruiting wire by the end of the first season, prune them back to 4 inches below the fruiting wire during the dormant period, between Year 1 and Year 2 (Figure 8-D). If the vines develop poorly and do not reach the fruiting wire, they can be pruned back to two buds and the training process can start over in Year 2 (Figures 8-A, 8-B). If, by the end of Year 2, the vines still do not grow to the fruiting wire, then they should be removed and the vineyard should either be replanted with healthier plant stock, or the site potential for grape production should be reevaluated.

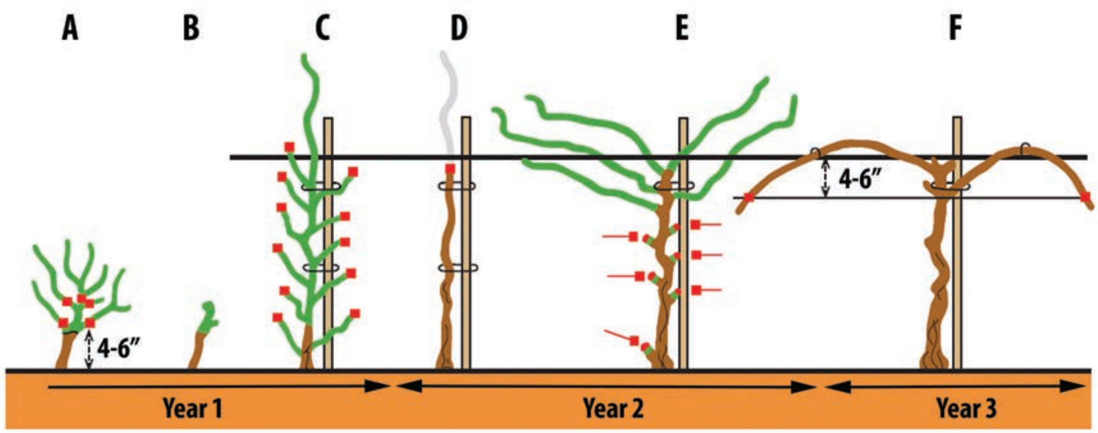


Figure 8. The goals of the first 3 years of establishment are to develop a healthy root system and get the young vines trained up to the fruiting wire. It can take several years to correct mistakes that were made during the establishment phase. In this diagram, green indicates the current year's growth, brown indicates the previous year's growth, and brown with black accents indicate 3+ years of growth. Red squares indicate points of pruning.

Vine Training—Year 2

If not already done, the trellis wires and posts should be installed early in Year 2. If growth in Year 1 was acceptable, then start the growing season off with a trunk that has been pruned back to about 3 to 4 inches below the fruiting wire (Figure 8-D). The top three to four buds on the trunk will push new shoots. Shoots emerging lower on the trunk (often termed "**suckers**") should be removed (Figure 8-E).

The new shoots will become fruiting canes in the following year (Figure 8-F) and form the basic structure for vine renewal in succeeding years. Any fruit clusters that develop on these shoots should be removed, unless canopy growth is overly vigorous. If that is the case, the fruit can be retained until **véraison** (onset of ripening) to act as an energy sink to help control vigor.

Pruning Styles. The dormant season between Year 2 and Year 3 will likely be the time to choose the pruning style. Two main styles of pruning exist: cane pruning and **spur** pruning (Figure 9). Cane pruning keeps more of the previous year's growth (Figure 9, yellow lines, lower photos) and the only permanent wood remaining after pruning is the main trunk (Figure 9, lower left photo, blue lines). Spur pruning maintains more older wood, including cordons (horizontal extensions of the trunk), leaving only very short sections of the previous year's growth (Figure 9, lower right photo).

Cane pruning is recommended for western Washington due to the cool springtime temperatures there that suppress cluster formation in the lower buds on canes. This results in unfruitful lower buds. On warmer sites, permanent cordons may be established and spur pruning (leaving 2 to 4 bud spurs) may be an option; however, spur pruning keeps only the lower buds. Spur pruning is less labor intensive, so growers might consider testing both pruning strategies in the vineyard to see which works the best.

Vineyard Management

After the establishment phase, vineyard management will fall into a fairly regular pattern of training and

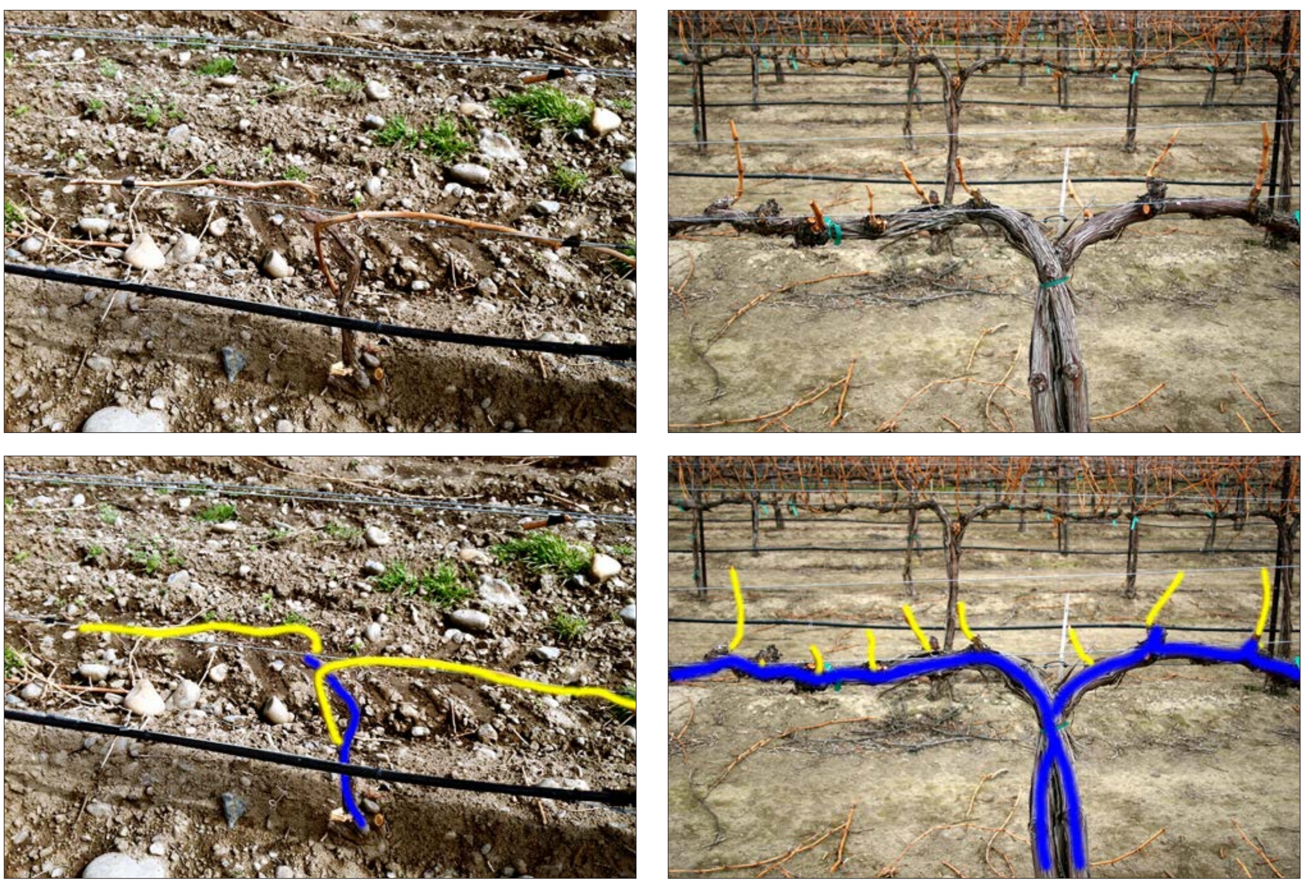


Figure 9. While there are many different types of trellising and training styles, there are two main dormant pruning styles: cane pruning (left) and spur pruning (right). In the lower photos, blue lines indicate permanent wood and yellow lines indicate previous year's growth kept for the next growing season. Photos by Michelle Moyer.

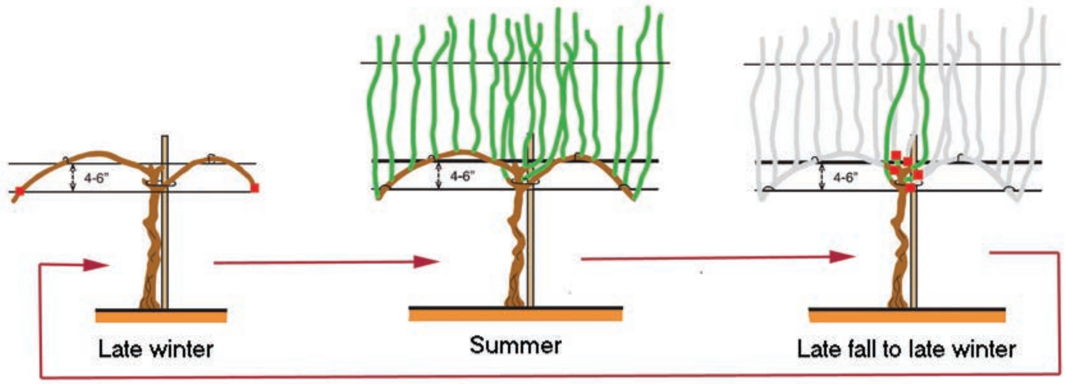


Figure 10. Typical yearly sequence of vine development and pruning with cane pruning style, which is recommended for western Washington vineyards.

maintenance (Figure 10). Much of this maintenance is working to produce a healthy and harvestable crop, rather than developing the structure of the vine which was the case during establishment.

Please see Appendix B: *Vineyard Management Calendar* at the end of this manual for a month-by-month listing of vineyard management chores.

Vine Training Year 3 and After

After the basic vine structure is established (a strong trunk, or trunks, with fruiting canes renewed annually at the level of the fruiting wire) in Year 2, future annual pruning and training is relatively easy.

For cane style pruning (recommended for maritime western Washington vineyards), two fruiting canes from the previous growing season will be saved and bent down in opposite directions along the row and attached to the fruiting wire (Figures 8-F and Figure 10). Ideally, these canes should reach close to the canes of adjacent vines, to ensure that the trellis row develops a continuous wall of leaves in the summer. In vineyards with divided canopies, this will require four fruiting canes per vine. The canes should be bent so their tips are below the wire (Figure 10) to prevent terminal bud dominance and promote even budbreak along the cane in the spring. To help with this process, a second wire can be strung 4 to 6 inches below the fruiting wire to attach the cane ends.

In the spring, new shoots will emerge from each of the nodes (locations of buds) along these fruiting canes. As the growing season progresses for vineyards using the VSP training system, these developing shoots will need to be “tucked” inside the trellis catch wires to promote vertical development (refer back to Figure 4). Another shoot positioning method is to tie the shoots to a top wire using a tape-stapler similar to that used for tying tomato plants.

Each dormant season, select two canes (from growth that occurred the previous summer), to serve as fruiting canes for the next year (Figure 10, Late fall to late winter). In selecting new fruiting canes, choose those that originate closest to the main trunk and have adequate space (3 to 4 inches) between their buds; this bud spacing will translate into next year’s shoot spacing.

Since canes may crack when they are bent down to the wire, keep an extra cane “in reserve” on each side, and prune the rest of the canes. These reserve canes should be pruned back to a two-bud spur when they are no longer needed—after the first-choice canes have shown they've survived and are healthy. This is typically done between BBCH 13 and 55. (See Appendix C for illustration of key BBCH stages.)

Over the years, try to keep the "head" of the trunk(s) approximately 3 inches below the fruiting wire. If, after several years, you notice the head and spur renewal positions working their way up to the fruiting wire, retain canes and renewal spurs that develop lower on the trunk, and cut back to these new cane positions during dormant pruning.

Pruning and Vine Balance

“Balance” is a common term used in viticulture, to help define the relationship between vegetative (canopy) growth and reproductive (fruit) growth. There are many ways to describe or define balance, but the common theme is determining what it takes to get the vegetative vs. reproductive relationship to harmonize and grow both healthy vines and high quality fruit. A thorough discussion of vine balance can be found in *Understanding Vine Balance: An Important Concept in Vineyard Management* (Skinkis and Vance 2013).

A common way to assess balance is to compare the amount of fruit that was harvested from a vineyard (yield, or reproductive growth) to the amount of vegetative (cane) tissue that is pruned from the vines during the next dormant period (termed "pruning weights"). Different grape varieties and growing conditions call for different ratios in this fruit-to-pruning-weight ratio. The most common range is between 4:1 and 10:1 harvested fruit weight to pruning weight. For cooler climates the ratio is on the lower end of the range. In warm, sunny climates, the ratio is on the higher end. Generally, if ratios fall much below 4:1, it is an indication that, for the vegetative size of the vine, it is under-cropped (that is, not producing enough fruit). However, in cool climates such as the Willamette Valley in Oregon, typical ratios for high quality Pinot Noir are more like 1.5:1 to 2.5:1. If the ratio is higher than 10:1, the vine might be over-cropped and crop thinning may be necessary or, when pruning, fewer buds should be left. Practices that encourage canopy growth, such as increased nitrogen application, increased water, and decreased weed competition, may help lower this ratio.

Another means for determining vine balance is to compare pruning weights on a per-row-foot basis. There are many assumptions in this assessment, though, so it is typically not favored. However, it can be coupled with the fruit weight : pruning weight ratio to help determine balance. Known standard pruning weights per foot of row fall in the range of 0.15 to 0.35 lb per foot. If pruning weight per foot of row exceeds 0.35 lb, this is also a sign of excessive vegetative development, or vigor.

When vines are overly vigorous, the excessive growth can be controlled or reduced in several ways. Vineyard managers or growers may reduce soil moisture, reduce fertilizer (nitrogen) applications, leave additional buds, switch from spur to cane pruning (if spurs are unfruitful), change to a divided canopy system such as Scott Henry or Smith-Dyson, or, if in a high-density situation, remove every other vine to allow for greater per-vine space allocation.

A note of caution: Vineyard managers and growers should not strictly rely on numbers when determining vine balance. If the numbers indicate an under-cropping or over-cropping situation, but vine health (for example, vine size) and fruit quality is satisfactory, then there may not be a need to adjust management strategies.

Figure 11. Evenly spaced shoots along the fruiting cane allow for adequate light exposure of developing fruit clusters. Photo by Jacqueline King (WSU NWREC).

Shoot Spacing

Proper shoot spacing is essential for good light penetration (Figure 11) into the canopy, increasing photosynthetic capacity of interior leaves, improving bud fruitfulness, increasing cluster exposure to sunlight, and reducing pressure of diseases like grapevine powdery mildew and Botrytis bunch rot.

Shoot thinning can be done at several different times. If a vine is vigorous, shoot thinning should be delayed until after fruit set, because these additional developing shoots can act as a "nutrient sink" and help reduce the overall growth of other shoots. If the vine is low-vigor, then shoots can be removed earlier to help stimulate growth of the remaining shoots. When thinning, prune only shoots that do not contain clusters.

Canopy and Cluster Maintenance

Good canopy management is essential for good quality fruit. For greatest photosynthetic efficiency, keep all leaves well exposed and the canopy open. In addition, good sunlight exposure of the current year's developing buds is essential for cluster primordial development, which will become next year's crop.

Fruit-Zone Leaf Removal. Fruit-zone leaf removal is the act of removing leaves on the basal ends of shoots immediately surrounding the clusters (Figure 12). Fruit-zone leaf removal aids in the quick drying of clusters to reduce disease, enhances light exposure, and can improve color development in the berries. Typical timing for this practice is between bloom and 3 weeks after fruit set (BBCH 65 and BBCH 73).

A note of caution: The leaves that develop on the same shoot as the fruit clusters are the primary source of carbohydrates to ripen those clusters. Ap-

Figure 12. Remove leaves in and around the fruit zone to improve light penetration and air circulation. Early season leaf removal (left) improves disease management and allows for sufficient exposure at véraison (right) without major risk of sunburn. Photos by Michelle Moyer and Jacqueline King (WSU NWREC).

proximately 12 to 14 well-exposed leaves per shoot are needed to support these grape clusters to full ripeness in warm, sunny climates; 15 to 20+ leaves may be necessary in cooler climates or those with low sunlight. Summer lateral shoots and leaves count when assessing the number of leaves on a shoot.

Cluster Thinning. In some cases, reducing the amount of developing crop in a vineyard can improve the quality of the remaining crop. Cluster thinning is one way to modify this crop load. Depending on your cropping goals, 1 to 2 clusters can be left per shoot (fewer clusters in cooler climates; Figure 13). Remove all clusters on weak shoots. Cluster thinning can occur as early as bunch closure (BBCH 77), and can be done up until véraison (BBCH 83).

To further enhance fruit quality, the greener clusters or parts of clusters can be removed at véraison. Within any given bunch, one section or "shoulder" may flower later, and thus be further behind in development; these parts can be removed (Figure 14). Appropriate crop thinning can improve sugar accumulation and speed of ripening for remaining clusters. All these practices aid in creating a more uniform crop by allowing for selective removal of clusters that are not developing at an appropriate speed.

Nutrition and Pest Management

Refer to WSU Extension Publication *Pest Management Guide for Grapes in Washington* (EB0762; Hoheisel and Moyer, updated annually) for a calendar guide of nutrient and pest management regimes. There are also numerous documents regarding pest management for vineyards in the Pacific Northwest.

In maritime Washington, the most common pests are birds and fruit flies, while the most common diseases are Botrytis bunch rot, powdery mildew, and an assortment of virus diseases. Please see *References and Resources* for a list of documents containing detailed, specific information on pest management.

Figure 13. Reducing the number of clusters per shoot from 2-3 (left) to 1 (right) near véraison can help enhance ripening of the remaining clusters. Photos by Michelle Moyer.

Figure 14. Remove cluster shoulders because these will often develop and ripen at a slower rate than the rest of the cluster. Photo by Jacqueline King (WSU NWREC).

Figure 15. Bird netting helps to protect the crop from bird damage. Photo by Jacqueline King (WSU NWREC).

Birds such as starlings, crows, and robins can do significant damage in a ripening vineyard virtually overnight. Bird netting is the most common approach to preventing bird damage. Available in various string gauges, net pore sizes, widths, and lengths, it can be applied and removed fairly effectively using a mechanized system with a tractor or all-terrain vehicle (ATV; Figure 15).

Properly fasten all nets that do not reach the ground because some birds, particularly robins, can be very persistent at net invasion. Wider nets that drape on the ground minimize the need for fastening and reduce the labor involved, but they are more expensive. If shoots have spread out into the rows, mechanical pruning or hedging may be necessary prior to net installation.

Determining Harvest

After clusters in the vineyard have passed 100% véraison, they should be sampled periodically to determine whether they are ready to pick. To do this, walk through the vineyard and randomly select 50 to 100 berries from different clusters on both sides of the vine, from shaded and fully exposed clusters, and from various parts of the cluster (e.g., tip, shoulder, mid-section). Crush the berry samples together in a plastic bag or container to obtain the juice. Use this juice to determine **Brix**, **TA**, and pH.

Sample and test frequently and keep careful record of the results in order to evaluate and compare with the specific target range of values for harvesting each variety. Be sure to also taste the fruit, because harvest numbers are only a part of the determination for harvest date; pay attention to the flavor development in the skin and pulp of the berries.

Grapes typically stop actively importing sugar at around 23–25°Brix; sugar content above that is typically the result of berry dehydration. It is important to keep in mind that in cool growing regions like the maritime PNW, grapes typically do not accumulate as high a sugar content as they do in warmer regions. Instead, they will develop ripe flavors at a lower sugar content. If striving only for high sugar content, the most attractive aromas (particularly in floral, aromatic varieties) can be missed. Typical sugar content for ripe grapes can also vary considerably between cultivars. This is especially true for many of the cool climate varieties listed in Appendix A.

> Cool-climate grapes can develop ripe flavors at a lower sugar content than grapes grown in warmer climates.
>
> The most reliable indicator for ripeness is taste. The pH range is also very helpful. Grapes with pH below 3 are, in almost all cases, unripe. Typical pH ranges for grape juice at harvest are between 3.1 and 3.4, and TA from 7 to 10 g/L for whites (0.7–1.0%), and 6 to 8 g/L (0.6–0.8%) for reds. If fruit juice is not in these typical ranges, adjustments in the winery (chaptalization/adding sugar, pH adjustments, deacidification/removing acid) may be necessary.

Appendix A. Winegrape Varieties for Western Washington

Photos by Jacqueline King, unless otherwise indicated. Photos are of vines grown in either Mt. Vernon or Everett, Washington, with the exceptions of 'Müller-Thurgau', 'Sylvaner', and 'Kerner', which are courtesy of Dr. Joachim Schmid, Hochschule Geisenheim University, Germany.

White Wine Varietals		
Image	**Name**	**Parentage**
	*Vitis vinifera* 'Auxerrois'	'Gouais Blanc' x 'Pinot Noir'
Viticulture Notes	Early ripening, with small, compact bunches. Prefers limestone soils. Grown in Alsace and Chablis, France. Chardonnay is a full genetic sibling of Auxerrois.	
Enology Notes	Flavor quality similar to Chardonnay; strong pear and apple flavors. Good potential based on performance in Chablis, France, and in northern Willamette Valley, Oregon.	
	*Vitis vinifera* 'Burmunk'	*Vitis amurensis* 'Muskat Vengerskij'
Viticulture Notes	Of Armenian origin. Very early ripening and is at high risk for Botrytis bunch rot.	
Enology Notes	This variety has a distinctive aroma—very fruity, sometimes resembling fresh-sliced peaches.	
	*Vitis vinifera* 'Chardonnay' Dijon Clones 75, 76, 77, 95, 96, 98, 277 *Clone 76 shown.*	'Gouais Blanc' x 'Pinot Noir'
Viticulture Notes	These clones are preferred over clones grown traditionally in California. The clusters are smaller and vines are less productive. Use of suitable rootstocks is recommended.	
Enology Notes	The Dijon clones ripen earlier and express more intense and more diverse fruit aromas. Evaluation of several of these clones is recommended as a blend can produce wine with more complex flavor. (Wine flavors noted from comparisons carried out by Thomas Henick-Kling and associates at Cornell University, Geneva, New York.) Dijon 78—spicy, peach, floral, apple and citrus undertones. Dijon 75—lots of fruit, peaches; full mouthfeel. Dijon 76—good body, less fruit forward than clone 75, nectarines, apple, citrus flavors, strong peach, apricot. Dijon 95—green apple, vegetative, green. Dijon 96—vegetative, grassy, some peach. Also, look for wine examples of these clones in the northern Willamette Valley of Oregon.	
	*Vitis vinifera* 'Iskorka'	['17-21-68' × 'Zalagyoegye'] × 'Muskat Odesskii'
Viticulture Notes	Originating in Russia; the name means "sparkle." It is a very early variety that will ripen at most sites.	
Enology Notes	Makes a very fruity wine with orange and honeysuckle notes.	

White Wine Varietals		
Image	**Name**	**Parentage**
	*Vitis vinifera* 'Kerner'	'Trollinger' × 'Riesling'
Viticulture Notes	Early ripening with low GDD. More tolerant of frost than other *Vitis vinifera*.	
Enology Notes	Flavor similar to Sauvignon Blanc; strong spicy, citrus, and grassy aromas. Good mouthfeel.	
	*Vitis vinifera* 'Madeleine Angevine'	'Madeleine Royale' × 'Precoce de Malingre'
Viticulture Notes	Productive and very early ripening, but susceptible to water stress and fruit rot. It has been grown in western Washington for about 25 years.	
Enology Notes	This variety makes a pleasant wine with moderate fruit intensity, and notes of citrus and apricot.	
	*Vitis vinifera* 'Müller-Thurgau'	'Riesling' × 'Madeleine Royale'
Viticulture Notes	Early ripening with low GDD. Does have potential issues with powdery mildew management and Botrytis bunch rot management.	
Enology Notes	Excellent wines from this grape are made around Lake Zurich, Switzerland. Makes attractive, light-textured wines having apple, pear, and mineral flavors. In Germany, it is finding a new popularity under the name 'Rivaner'.	
	*Vitis vinifera* 'Ortega'	'Müller-Thurgau' × 'Siegerrebe'
Viticulture Notes	Tends towards high vigor; canopy and nutrient management is critical. Grown on Vancouver Island, British Columbia, for many years. Is very productive.	
Enology Notes	This variety makes a light, pleasant, fruity and spicy wine.	
	*Vitis vinifera* 'Pinot Gris'	Sport of either 'Pinot noir' or 'Pinot blanc'
Viticulture Notes	Make sure to select an early clone, e.g., German and Alsatian clones 152 and 146. Use of suitable rootstocks is recommended. Usually not as productive as other varieties.	
Enology Notes	Can make an excellent fruity-spicy wine.	

White Wine Varietals		
Image	**Name**	**Parentage**
	*Vitis vinifera* 'Sauvignon Blanc'	Possible descendent of 'Savagnin'
Viticulture Notes	Has good potential, particularly on warmer sites. Find the earliest ripening clones. (Clone 01 appears to have best early-ripening capabilities.) Compact clusters can lead to Botrytis bunch rot problems. Use of suitable rootstocks is recommended.	
Enology Notes	Can express very attractive grassy, herbal, citrus aromas. Wine has fine texture.	
	*Vitis vinifera* 'Siegerrebe'	'Madeleine Angevine' × 'Gewürztraminer'
Viticulture Notes	One of the earliest varieties to ripen, the grapes look and taste very similar to Gewürztraminer. Moderate vigor. It has been grown in western Washington for about 25 years and has gained recognition as a signature white for western Washington.	
Enology Notes	This variety makes an excellent fruity wine with spice and floral aromas. It has good mouthfeel and flavor length.	
	*Vitis vinifera* 'Sylvaner' (Silvaner)	'Traminer' × 'Österreichisch-Weiß'
Viticulture Notes	Early ripening with a low GDD requirement.	
Enology Notes	Wines have ripe plum, pear, floral, and mineral flavors with a good, fine texture.	

Red Wine Varietals		
Image	**Name**	**Parentage**
	*Vitis* hybrid 'Golubok'	(*Vitis amurensis* × 'Seyanets Malengra') × Open pollen *V. vinifera* (some 'Cabernet Sauvignon')
Viticulture Notes	Russian origin; the name means "little pigeon," a term of endearment. A very early-ripening **teinturier** variety, but high in acid. Tight clusters can result in problems with Botrytis bunch rot.	
Enology Notes	Gives dark red juice useful in blending for added color. Flavor has a smoky characteristic.	
	*Vitis* hybrid 'Leon Millot'	Millardet et Grasset 101-14 (*V. riparia* × *V. rupestris*) × 'Goldriesling'
Viticulture Notes	A French-American hybrid. This variety is disease resistant, but has difficulty ripening in western Washington; still grown in area vineyards.	
Enology Notes	Has characteristic interspecific hybrid flavor qualities; tends to lack body.	
	*Vitis* hybrid 'Regent'	('Sylvaner' × 'Müller –Thurgau') × 'Chambourcin'
Viticulture Notes	The vine is very disease resistant and bunches form loose clusters; a very good red for the organic grower and home winemaker. Parent Chambourcin is a French-American hybrid, of various crosses of *V. vinifera, V. rupestris,* and *V. riparia*.	
Enology Notes	This grape has 1/8 hybrid ancestry but tastes like *Vitis vinifera*.	
	*Vitis vinifera* 'Agria' (Turan)	('Teinturier' × 'Kadarka') × ('Medoc' × 'Csabagyongye')
Viticulture Notes	This variety looks promising, a teinturier grape with bright red juice. The skins have high tannin content.	
Enology Notes	This variety offers possibilities for several styles of wine making. When crushed and pressed immediately then fermented like a white, the juice is still dark red but the wine is extremely fruity, with berry and tropical fruit aromas. This grape works well for blending with other red varieties to add additional color in low-color wines.	
	*Vitis vinifera* 'Dornfelder'	'Helfensteiner' × 'Heroldrebe'
Viticulture Notes	The vine is vigorous and makes very large, loose, open clusters. It is very productive and tends to over-crop, thus needing cluster thinning. Sugar content tends to be low but acidity also drops quickly prior to harvest.	
Enology Notes	It makes a fruity wine with flavors of cherries and wild berries; has very soft texture and short length. Has great color. Best to use in a blend.	

Red Wine Varietals		
Image	**Name**	**Parentage**
	*Vitis vinifera* 'Gamaret'	'Gamay Noir' × 'Reichensteiner'
Viticulture Notes	This is a Pinot Noir-type of Swiss origin. Full-sibling variety of Garanoir. Early ripening.	
Enology Notes	Good quality, for blending with Garanoir and Pinot Noir.	
	*Vitis vinifera* 'Garanoir'	'Gamay Noir' × 'Reichensteiner'
Viticulture Notes	This variety is of Swiss origin and is a very early red—one of the first to ripen in western Washington. Its juice does not attain very high sugar content, but acid levels drop quickly as the fruit ripens.	
Enology Notes	It produces attractive fruit, medium body, nicely colored wines and it also does well in blends.	
	*Vitis vinifera* 'Muscat of Norway'	
Viticulture Notes	This is a very early Muscat red grape with unique flavor.	
Enology Notes	Typical Muscat flavors, pretty color, good mouthfeel, surprising color.	
	*Vitis vinifera* 'Pinot Noir Precoce'	
Viticulture Notes	Also known in Germany as 'Frühburgunder.' Berries develop color at least two weeks ahead of regular Pinot Noir. This variety is a good option for cool sites. If the site allows, it would be good to also plant some additional Pinot Noir clones for blending.	
Enology Notes	The weakness of these early Burgundy selections is that they tend to be light in color and texture. They make a pleasant, fruity, light red wine. They work well in a blend with other Pinot Noir clones such as Mariafeld and various Dijon clones.	

Red Wine Varietals		
Image	**Name**	**Parentage**
	*Vitis vinifera* 'Pinot Noir' *Clone 777 shown.*	
Viticulture Notes	Select a mix of early clones. The earliest ripening is Pinot Noir clone Mariafeld, followed by Dijon clones 113, 115, 667, 777. Mariafeld is the most versatile clone in this group. It is also less prone to developing Botrytis bunch rot due to its looser cluster architecture. The Dijon clones have smaller clusters and lower productivity. Use of suitable rootstocks is recommended.	
Enology Notes	It can produce fruity, aromatic, nicely textured wines with good color. It is a very good blender with other Pinot Noir clones and makes a good sparkling wine base. The Dijon clones can bring more aroma diversity and tannins to a blend.	
	*Vitis vinifera* 'Rondo'	'Zarya Severa' × 'St. Laurent'
Viticulture Notes	Has early budbreak, and can be prone to damage from spring frosts. Ripens very early.	
Enology Notes	Nice cherry and earthy, slight hybrid aromas; nice tannins; good body; and soft, good color.	
	*Vitis vinifera* 'Zweigelt'	'Lemberger' × 'St. Laurent'
Viticulture Notes	Tight, large clusters require diligent Botrytis bunch rot control and will benefit from cluster thinning. Good canopy management techniques will get the most out of this variety. Use of suitable rootstocks is recommended. It ripens well in cool climate growing regions such as Wachaua, Austria, where this new grape variety has gained very good acceptance by the public.	
Enology Notes	This grape makes an attractive, fruity, medium body wine. Good color and fine, complete mouthfeel.	

Appendix B. Vineyard Management Calendar

TASK	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
Disease and Pest Managment			Review pest management records; design tentative spray program for upcoming vintage. Order necessary products.	Calibrate spray equipment, including backpack and ATV-mounted sprayers.	Begin disease management; see *Pest Management Guide for Grapes in Washington* (WSU EB0762).	Critical period in disease management; see *Pest Management Guide for Grapes in Washington* (WSU EB0762).
Nutrient Management					Consider micronutrient applications if tissue tests indicate deficiencies; see *Sampling Guide for Nutrient Assessment of Irrigated Vineyards in the Inland Pacific Northwest* (PNW622).	
Weed Management	Begin weed management; see *Pest Management Guide for Grapes in Washington* (WSU EB0762).					Mow if necessary.
Weather Monitoring	Inspect weather stations to ensure proper functioning. Download weather data.			Inspect weather stations to ensure proper functioning. Download weather data. Calculate GDD.		
Canopy Management	Complete dormant pruning.				Remove shoots arising from non-count buds.	Shoot positioning and canopy training. Begin adjusting movable catch wires if necessary. Hedging around bloom (removal of top 2 to 3 inches of shoots) may help with fruit set.
Vineyard Infrastructure Management		Tighten trellis wires. Fix other problems with trellising system if present.				
Irrigation Management						Supplemental irrigation necessary if dry.

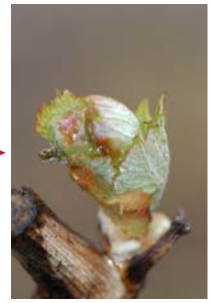
<table>
<tr><th>TASK</th><th>JULY</th><th>AUGUST</th><th>SEPTEMBER</th><th>OCTOBER</th><th>NOVEMBER</th><th>DECEMBER</th></tr>
<tr><td>Disease and Pest Managment</td><td colspan="2">Critical period in general pest management; see Pest Management Guide for Grapes in Washington (WSU EB0762).</td><td colspan="2">Critical period in Botrytis bunch rot management; see Pest Management Guide for Grapes in Washington (WSU EB0762).</td><td></td><td></td></tr>
<tr><td>Nutrient Management</td><td></td><td colspan="2">Conduct a tissue analysis post-véraison to determine nutrient status; see Sampling Guide for Nutrient Assessment of Irrigated Vineyards in the Inland Pacific Northwest (PNW622).</td><td></td><td></td><td></td></tr>
<tr><td>Weed Management</td><td>Mow if necessary.</td><td>Mow if necessary.</td><td>Mow if necessary.</td><td></td><td></td><td></td></tr>
<tr><td>Weather Monitoring</td><td colspan="4">Inspect weather stations to ensure proper functioning. Download weather data. Calculate GDD.</td><td colspan="2">Inspect weather stations to ensure proper functioning. Download weather data.</td></tr>
<tr><td>Canopy Management</td><td>Open canopy by removing unnecessary shoots. Do fruit zone leaf removal. Hedging around bloom (removal of top 2 to 3 inches of shoots) may help with fruit set.</td><td>Shoot positioning and canopy training. Hedge if necessary. Remove excess clusters at véraison, if necessary.</td><td></td><td></td><td></td><td>Dormant pruning can begin; however, delaying pruning until January/ February/March helps to manage potential reaction to late-season cold damage.</td></tr>
<tr><td>Vineyard Infrastructure Management</td><td></td><td>Install bird netting.</td><td colspan="2">Inspect and maintain bird netting.</td><td>Remove and store nets.</td><td></td></tr>
<tr><td>Irrigation Management</td><td colspan="4">Supplemental irrigation necessary if dry.</td><td></td><td></td></tr>
<tr><td>Fruit Quality Assessments</td><td>If bloom is not complete by end of July, then there will be insufficient time for ripening.</td><td></td><td colspan="2">Test grapes for ripeness. Monitor Brix, pH, TA, flavor development, and seed maturation.</td><td></td><td></td></tr>
</table>

Appendix C. Vine Phenology/Seasonal Development

Understanding key stages in yearly vine development is important for understanding and planning management schedules. This development timeline is based on the BBCH scale (Lorenz et al. 1994). The BBCH stage number is listed, along with a basic description of that stage. Diagram by Michelle Moyer.

BBCH 00
Winter buds dormant

BBCH 05
Wooly bud



BBCH 08
Bud break

BBCH 13
3 leaves unfolded

BBCH 55
10″ shoots;
clusters visible

BBCH 57
Rachis elongation

BBCH 69
100% bloom

BBCH 71
Fruit set

BBCH 75
Pea-sized berries;
clusters hang

BBCH 83
Véraison (color change)

BBCH 89
Harvest

Glossary

apical dominance. The tendency of the bud located at the highest point on a cane or shoot to grow the most vigorously.

Brix. A measure of the soluble solid content (predominately sugar) in juice. Typically measured as degrees (°Brix or °Bx), an indication of the percent of solids in a solution. Most grapes destined for still table wines (not sparkling wines) are harvested between 19 and 26 °Brix.

bud. A small organ on a plant shoot or cane that contains developing shoots. Buds that overwinter are called compound buds and contain a primary, secondary, and tertiary bud. The primary bud is usually considered the "fruitful" bud, containing most of the clusters. Secondary and tertiary buds typically will not develop unless the primary bud is damaged or the vine is overly-vigorous. Latent buds, or buds that you cannot see on mature wood (i.e., trunks and cordons), also exist, but these typically do not contain many clusters. These latent buds are also considered non-count buds, as they are typically not counted when determining bud numbers during dormant pruning.

cane. A mature shoot after one growing season; typically a shoot is referred to as a cane after the main stem has turned brown and leaves begin to fall. Cane-base pruning involves leaving these long-mature shoots for the following season; they are shortened to the desired between-vine length and laid down on the fruiting wire. A new shoot will arise from each of the buds.

cation exchange capacity (CEC). The sum total of exchangeable cations (positively charged elements) that a soil is capable of holding. CEC influences the availability of soil-based nutrients for plant uptake. CEC is expressed in centimoles per kilogram (cmol/kg) of soil. This is often used in reporting and interpreting soil test results. In general, the higher the CEC, the higher the soil fertility.

cluster. (also known as a bunch.) In grapes, the entire fruiting structure that contains berries and a **rachis**.

cordon. A long, permanent structure of the vine (typically more than 2 years old) that is trained along the fruiting wire.

graft union. The point on a vine where rootstock and scion (the variety of grape you want) are joined.

growing degree days (GDD). A unit of measurement that allows for comparison of heat accumulated in a growing season. It is calculated by subtracting a base temperature (50 °F for grapes), from the average daily temperature, and summing that remaining number from 1 April to 31 October for each year. GDD can also be calculated in Celcius (base 10 °C); so care must be taken when comparing GDD units from different regions; make sure they are calculated using the same temperature scale.

lateral shoot. A secondary shoot growing from the main fruiting shoot. Lateral shoots often develop on vines with high vigor. In many cases, lateral shoots that occur around clusters are removed as a part of summer canopy management strategies.

macroclimate. Climate in a region. Macroclimate reports are typically measured in square miles, depending on geographic factors.

macronutrients. Nutrients required in larger amounts by plants. In grapes, these include nitrogen, phosphorus, potassium, magnesium, sulfur, and calcium.

mesoclimate. Climate of a particular vineyard. Mesoclimates are typically reported on the scale of an acre. Mesoclimates can vary from the macroclimate they are within due to factors such as slope, aspect, and proximity to water.

microclimate. Climate within a vine canopy. Microclimates are typically reported on the scale of inches to feet. Microclimates can be different from the general mesoclimate they are within due to factors such as sunlight exposure, changes in humidity, and canopy density.

micronutrients. Nutrients required in small amounts by plants. In grapes, these include zinc, boron, iron, copper, and manganese. Over-application of micronutrients can result in plant health issues.

parts per million (ppm). A unit of concentration of ten, used when measuring levels of materials in the air or water. The common unit is milligrams per liter (mg/L). In this case, 1 mg/L = 1 ppm. To compare, in English units, 8.35 lbs in 1,000,000 gallons is 1 ppm.

periderm. On a plant, a protective layer that develops over first-year growth as it transitions to winter dormant tissue. Typically, periderm formation is noted on grape shoots as the transition from green stems to brown stems.

petiole. The short stem connecting a leaf blade to the shoot.

pH. A numerical measure of the acidity or hydrogen ion activity of a substance. It is on a logarithmic scale from 0 (high acidity) to 14 (high alkalinity). Water has a pH of 7.0 (neutral). Being a log scale, small changes in the pH actually indicate large changes in acidity (i.e., a pH of 4 indicates that it is 1000X more acidic than something at a pH of 5). Determination of pH is often used in measuring grape juice, wine or soil acidity.

phloem. The sugar- and nutrient-conducting tissue of a plant.

phylloxera. (*Daktulosphaira vitifoliae*). An aphid or louse-like insect that feeds on grape roots. It is native to the eastern U.S., where American grape species have developed a natural tolerance to its feeding. Susceptible vines (for example, *Vitis vinifera*, the European winegrape) will decline and die from phylloxera feeding on it. Resistant rootstocks are used to reduce phylloxera damage.

rachis. The stem component of a cluster that holds all of the berries together.

rootstock. A plant that is grafted to another, intended to be the root-base only. In grapes, rootstocks are selected for resistance to various pests and diseases, and, in some cases, can influence development of the scion (e.g., reduce vigor or hasten ripening).

scion. A short cane or shoot from a vine that is grafted on to another vine. The scion on a grafted vine is the part that will ultimately develop and bear fruit. For example, a cutting from Cabernet Sauvignon can be used as a scion, grafted to both a Merlot rootstock and to Rootstock 420A. In both cases, the resulting vines would product Cabernet Sauvignon fruit.

Scott-Henry system (SH). A method of vine training that vertically divides a grape canopy. It can be used with both cane pruning and with permanent cordon/spur pruning. This system, developed in Oregon to help manage vine vigor, trains the shoots on an upper set of canes/cordons upwards, and trains the shoots on a lower set of canes/cordons downward. Shoots forced to grow downward typically have reduced vigor.

shoot. A grape stem, during the growing season. After a shoot transitions from being green to brown, and the leaves begin to fall off, it is called a cane.

spur. A very short cane (with fewer than 4 buds) that is left during dormant winter pruning. Spurs are appropriate in varieties that are listed as "high basal bud fruitfulness", or in climates that are warm. Spur-based pruning should only be done in cool climates with caution.

sucker. An unwanted shoot developing on the vine, typically near the soil line.

teinturier. (pronounced "tain toor yay;" French, meaning "to stain") A grape with deep-red colored flesh/pulp. Most red grape varieties (e.g., Merlot, Cabernet Sauvignon) have clear or light-colored pulp/flesh. Teinturier varieties (e.g., Agria, Golubok, or Dunkelfelder) are often blended with other non-teinturier red varieties during fermentation to provide more color to the resulting wine.

terroir. (pronounced "tair wah;" French, meaning "sense of place") Term designating the influence of the particular site (soil and mesoclimate) on the grape, and ultimately, wine style.

titratable acidity (TA). The measure of acid content in juice (typically tartaric acid). TA can be thought of as the measure of acid that one can taste/perceive as "acidic," whereas pH is more a measure of solution favorability (or lack thereof) for yeast or spoilage organisms to grow. Can be measured as grams/liter (g/L), but is often reported as a percent (e.g., 8.0 g/L = 0.80%).

véraison. (pronounced "veh ray zoh;" French, meaning "the onset of ripening") A stage at which grape berries begin to soften, increase sugar content, and change color.

vertical shoot positioning (VSP). A method of vine training where shoots are tucked between multiple sets of wires, located at regular intervals above the fruiting wire, as they grow. This forms vertical "wall" of canopy.

vigor. Used to describe the general growth of a plant. While commonly used to denote healthy growth, in grape production the term can indicate *over*-growth or uncontrollable growth of the vine.

Vitis. The scientific designation (Genus) that includes all grape species.

Vitis vinifera. The European grape species, which are the classic standard for wine making. Many common table grapes and raisin grapes are also *Vitis vinifera*.

xylem. The water-conducting tissue of a plant.

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