Irrigation Basics for Eastern Washington Vineyards

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Introduction

For crop production, water is everything. Although water is critical to plant growth and survival, water sources and control over them can vary substantially across the production regions of the world. For grapes, many regions in New World production areas would not be so successful without irrigation and the control over grape growth and productivity it has provided. Irrigation has significantly changed the way grapes are grown and managed in large-scale production systems by allowing grape production to expand into arid regions and by improving control of plant nutrient status, water status, and frost and disease management. Grape producers in Washington State commonly use irrigation for either juice or wine grapes. However, the various irrigation options available can often appear contradictory, or are poorly explained in terms of practical application.

This Washington State University Extension publication presents and further clarifies irrigation options and strategies for both juice and wine grape production in Washington State. Companion pocket manuals that supplement this publication include the USDA-NRCS Program Aid 1619: *Estimating Soil Moisture by Feel and Appearance*, and the National Center for Appropriate Technology: *Water Management: The Pacific Northwest Irrigator's Pocket Guide*. Both manuals are available upon request through Washington State University's Irrigation Extension website at http://irrigation.wsu.edu.

Irrigation Strategies for Wine and Juice Grapes

Wine grapes (*Vitis vinifera*) adapt well to water stress because their roots can effectively search out moisture. In general, when supplied with enough or excess water, all grape varieties preferentially grow vegetatively (e.g., shoots).

Irrigation strategies for wine grapes in arid grape-growing regions are designed to optimize fruit quality, influence potential wine style, and control canopy vigor. For example, many components of wine aroma come from the production of isoprenoid compounds (e.g., monoterpenoids). These aromatics are typically produced late in the berry-ripening period. Some are produced in the skin of the grape berry, others in the flesh of the berry. Consequently, changes in berry volume (size) may alter the ratios of these particular compounds, which can be productive or counterproductive, depending on wine-style goals. Alterations in canopy development, and thus, canopy microclimate and fruit exposure, can also alter the production of these compounds, as many of them are light-sensitive. If water stress is severe enough to reduce plant metabolic processes in the ripening berry, there may also be an associated reduction in the development of aromatic compounds.

Juice grapes (*Vitis* x *labruscana* 'Concord' and 'Niagara') are better adapted to the typically high annual precipitation of eastern North America (30 to 50+ inches). Irrigation strategies for juice grapes reflect this evolutionary difference and are designed to optimize sugar accumulation and encourage high yields.

General Irrigation Strategies in Grape Production

Understanding the way vines use water is paramount to understanding irrigation strategies. During different stages of vine development, water is needed for different physiological processes. These water requirements can be manipulated to control vegetative and reproductive growth of the vine. Since these plants have adapted to water stress, mild water stress can actually help the plant become more efficient in its use of water. It does this because stress increases abscisic acid (ABA), a plant hormone that is commonly produced as a response to environmental stressors, and in this case, is produced in the roots as a result of dry soil. The ABA is transported through the plant xylem (water-conducting vessels) to the shoots of the plant, signaling the leaves to close their stomata (tiny pores on the undersides of leaves that facilitate the intake of carbon dioxide (CO_2) and export of water and oxygen). ABA can inhibit shoot growth and may also inhibit other hormonal activity. Unfortunately, one consequence of this reaction to water stress is that while the closing of stomata prevents water loss, it also reduces the intake of CO_2.

This reduction in CO_2 intake reduces photosynthesis and subsequent carbon assimilation (production of carbohydrates for immediate use and storage) in the plant.

Budbreak to bloom. At the beginning of the growing season, water uptake by the plant roots is required to hydrate young buds and aid in an even budbreak. Water is also essential for the uptake of soil-available nutrients. Thus, early-season fertilization will be ineffective, unless it is applied with appropriate levels of plant-available water.

Between budbreak and bloom, the vine is undergoing many developmental changes that are sensitive to plant water levels. Shoots are growing rapidly, and the development of a fully functional canopy that maximizes sunlight absorption is critical (Figure 1A). This rapid growth also requires substantial nutrient uptake from the soil, which is achieved through nutrient solubility in water. When flowers are actively forming pollen, adequate water is critical to reducing the development of sterility. Cell division is also occurring in the inflorescence anthers and ovaries. Thus, water stress at this time can reduce nutrient availability to developing tissues, induce pollen sterility, and reduce the number of potential cells in the resulting berry, and potentially reducing final berry size.

Bloom to véraison. Between bloom and véraison, the grapevine canopy can continue to grow, and in some cases, can cause excessive shading of the clusters (Figure 2). This is also a time when overwintering compound buds are being formed. These buds house the following year's clusters (inflorescence primordia) or tendrils (tendril primordia). The buds exposure to sunlight and warmer temperatures favor the development of inflorescence primordia, while cooler temperatures and shading favor the development of tendril primordia. In addition, the degree of branching within a forming primordial is regulated by hormone interactions, which can be negatively affected by the over-production of ABA.

In wine grapes, deficit irrigation is practiced during this time to maintain a canopy size that is adequate for properly ripening a given crop, while, at the same time, attempting to reduce overall canopy growth and prevent excessive shading of the fruit zone. Grape berries are also going through a series of developmental changes; cell expansion occurs after fruit set, followed by a period of slow growth (termed lag-phase) right before véraison. Water stress during the first few weeks following fruit set can reduce

Root Development in the Early Growing Season

Root growth typically starts around budbreak, but is most active at bloom and will continue as long as there is water and adequate soil temperatures (50 °F or higher). A well-developed root system is critical to long-term grapevine health. Grapevines can also selectively grow roots in the search for water, which increases their ability to survive drought stress. For example, vineyards with drip irrigation systems are most likely to have a majority of the vine root mass concentrated below the drip emitters, whereas roots in non-irrigated vineyards typically have root systems that extend beyond this zone (horizontally and vertically) as they search for water.

Figure 1. Shoots rapidly develop early in the growing season; however, water stress can limit this growth. A) The presence of long tendrils, specifically tendrils that extend beyond the growing tip of the shoot is a sign of adequate water status and active growth. B) The lack of shoot-end tendrils and short internodes on a grapevine shoot are a sign of water stress and reduced or halted growth. Photos by Michelle Moyer.

Figure 2. Vitis vinifera *'Merlot' planting where the canopy is reaching 8 feet. A) Given sufficient water, grapevines will continue to grow vegetatively, producing large canopies. B) Excessive canopy development severely shades the fruit zone, reducing fruit set and cluster ripening. Photos by Michelle Moyer.*

cell division (reducing the total number of cells in a berry) and cell expansion (i.e., the size of these cells), thus limiting the ultimate volume of the final berry. Berry volume continues to increase before the onset of véraison, so water stress before véraison can also reduce a berry's cell expansion.

Véraison to harvest. After véraison, berries become unresponsive to vine and soil water levels. They no longer predominately import water through the xylem (typically the water-conducting vessels of the vascular tissue), but rather, import water and carbohydrates through the phloem (the sugar-conducting vessels of the vascular tissue). Phloem tends to be more resistant than xylem to changes in vine water levels (Keller 2010). A common concern during this period is that additional water will result in berry splitting or dilution of flavors or sugars. Typically, this only occurs with heavy watering after prolonged, relatively severe water stress, or as a result of water on berry surfaces (due to precipitation or overhead irrigation).

In addition, the vine is beginning the process of slowing growth in preparation for winter dormancy. Excessive water and nitrogen during this period stimulates vine development and can impede this acclimation process. Mild water stress, by inhibiting shoot growth, can aid in "shutting down" the vines in preparation for winter dormancy.

Harvest through dormancy. As vines move into dormancy, they finish their final cycle of returning nutrients to storage organs and are showing increased signs of acclimating for winter. While the plant is not actively growing aboveground during this time, water is still critical because there can be a second flush of root development. Over the dormant period, adequate winter soil moisture is also critical because it helps protect a plant from cold damage to its roots (the water acts as an insulator). From a production standpoint, these late-season water applications prior to irrigation shut-off may be the only moisture readily available for the upcoming spring development and budbreak (i.e., the period prior to the restarting of seasonal irrigation or the start of spring rains).

Irrigation for Wine Grapes

As mentioned earlier, irrigation strategies are used for wine grape production to maximize various parameters associated with berry development and wine quality. Full irrigation is often used from budbreak through fruit set to ensure good canopy development, fertile pollen, and adequate flower pollination (Figure 3).

Shortly after fruit set, many viticulturists in Washington State will switch to *regulated deficit irrigation* (RDI) and will continue this practice until harvest. Observed vine responses are often used to determine the timing and severity of RDI (see *Pictorial Guide to Water Stress in Grapes* on page 5). Typically, RDI strategies aim to reduce active shoot-tip growth by véraison (Figure 1B). Targeted overall shoot lengths range from 36 to 50 inches, with internode spacing (segments of the growing shoot that separate leaves, clusters, and/or tendrils) between 2.5 and 4 inches. Additional information on canopy management, including definitions for canopy terms, can be found in *Washington State University Extension Publication* EB2018E: Canopy Management for Pacific Northwest Vineyards. With RDI, only 50% to 75% of the water used by a fully irrigated grapevine is replaced; this controls canopy and berry size. RDI-induced stress in a plant also makes it more water efficient because it stimulates the production of ABA, as noted earlier.

After harvest, and prior to irrigation shut-off (the timing of which is often legally determined based on irrigation water source, typically in October for most of eastern WA), the top 24 to 36 inches of the soil profile should be filled to field capacity. This helps prevent root injury from cold, dry winter weather, which is common in the Inland Pacific Northwest. This practice also provides a water reserve for budbreak the following spring (if winter precipitation is lacking).

Most RDI practices in Washington State have been designed to optimize parameters associated with quality for red grape varieties (i.e., reduced berry size to increase the skin-to-volume ratio). Unfortunately, little research has been done to determine the best irrigation strategies for white wine grapes. Poor water management, particularly when it results in water

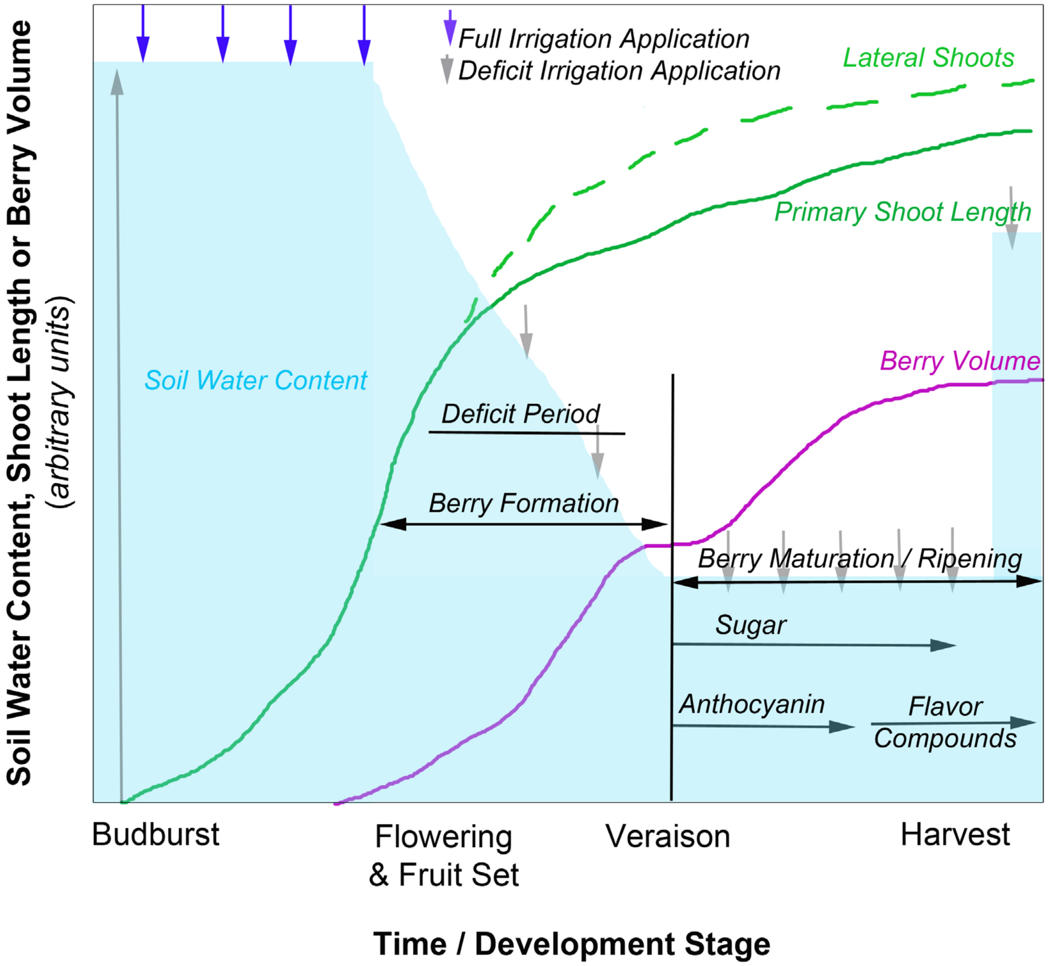

Figure 3. A pictorial description of common regulated deficit irrigation strategies used in wine grapes. Graphic by Rick Hamman.

Pictorial Guide to Water Stress in Grapes

Visual estimation is one of the best ways to quickly and cheaply determine the extent of water stress in vines. Symptoms of water stress in order of increasing severity are pictured.

A) Flaccid and wilting tendrils. Tendrils are one of the first sacrifices a vine makes in an effort to conserve water.

B) Cluster and flower loss. If severe water stress occurs during flowering, partial or whole clusters can be lost.

C) Wilting and death of young tissue. Young tissue is a major water and nutrient sink. If a vine is experiencing severe water stress, young tissue will show symptoms well before older tissue does.

D) Leaf orientation. Under moderate water stress, leaves will orient themselves away from the sun to help prevent water loss.

E) Leaf chlorosis and necrosis. Mild to severe water stress will reduce the photosynthetic capacity and viability of leaves. Chlorotic (yellow) leaves indicate mild water stress, while the development of marginal to full leaf necrosis (dead tissue) indicates severe water stress.

F) Berry shriveling, desiccation, and drop. With severe water stress at pre-véraison, berries can dehydrate and water content can be lost through transpiration. Water can also be preferentially recycled to more actively growing areas of the plant.

Photos A, C, and D by Michelle Moyer. Photos B, E, and F by Markus Keller, Washington State University.

Tools for Measuring Plant Moisture Status

There are many techniques besides observing visual symptoms that can be used to obtain a more precise measurement of vine water status. Some of these techniques, however, are costly or require special training, and, therefore, may be practical only for larger operations. Currently, there is much debate over which measurements are the most appropriate and when measurements should be taken (i.e., predawn or midday).

Pressure Chamber ("Pressure Bomb"): This equipment measures leaf- or stem-water potential by exerting a pressure on the tissue being tested to determine the level of pressure it takes to cause the tissue to exude sap. This pressure is equal but opposite to the tension in the xylem vessels. Irrigation is typically not needed for wine grapes until midday water potential exceeds approximately -1.0 MPa (-10 bars) (Williams 2001). This threshold can differ depending on grape variety and management choices. A threshold of approximately -1.5 (-15 bars) MPa is considered the point at which severe water stress is indicated (Keller 2010).

Psychrometer: This instrument measures the vapor pressure of air around a tissue that is still attached to the vine. It does this by factoring the temperature difference between ambient air temperature and surface temperature due to evaporation. This method is extremely sensitive to temperature changes and may not be practical under rapidly changing vineyard conditions.

stress, has been associated with Atypical Aging (ATA), also referred to as Untypical Aging, in white wines (Henick-Kling et al. 2005). Atypical aging is a flavor defect in white wines where varietal characteristics are lost more rapidly than normally expected. More research is needed to determine the optimum irrigation regime for white grape varieties. Currently, suggested best practice for white wine grape irrigation is to operate RDI at a 75% level or above to optimize canopy control without inducing excessive water stress, especially just before and during véraison. If ATA is a problem in wines from specific blocks, then practicing RDI with higher water-replacement percentages, or by fully irrigating these blocks, may be an appropriate choice.

Drip irrigation systems are the most effective way of implementing RDI because they allow better overall control of water delivery. In addition, the use of cover crops or natural vegetation within vineyard rows can also help regulate vine available water within a vineyard. (For more information, see *WSU Extension Publication* EB2010: Cover Crops as a Floor Management Strategy for Pacific Northwest Vineyards.)

Irrigation for Juice Grapes

The goal of juice production is high yields and sufficient sugar accumulation, so deficit irrigation is not typically practiced since smaller berry size is not desirable. In addition, drought stress before véraison can exacerbate symptoms of Blackleaf in Concord vines (Smithyman et al. 2001). Irrigation for juice grapes is typically used to replace 100% of the water lost and to minimize overall vine water stress.

Calculating Water Use

Reference Evapotranspiration:

Evapotranspiration (ET) is the combined loss of water from soil evaporation and vine transpiration. When there is limited leaf area on a vine, most of the water is lost through soil evaporation. However, when there is a full canopy, most of the water lost is through leaf transpiration (Allen et al. 1998). High ET values are associated with sunny, warm, dry, long (daylength), and windy days, whereas low ET is associated with cloudy, cool, humid, short (daylength), and calm days. Logically, plants dehydrate more rapidly under high ET conditions.

Vine water use is often estimated by comparing it to the quantity of water used by full-grown alfalfa (ET_r) or clipped grass (ET_o). Reference Evapotranspiration (ET_r) is typically calculated using the Penman-Monteith equation, which uses air temperature, humidity, solar radiation, and wind speed. These weather parameters are common for most modern electronic weather stations.

A variety of daily ET rates are available from Washington State University's AgWeatherNet (http://weather.wsu.edu). Alerts can be set up through an AgWeatherNet account, which will provide daily phone texts or emails with ET values. An irrigation-scheduling tool that is optimized for use on a mobile phone, but is also accessible from any web browser, is also available online at http://weather.wsu.edu/is/ (Peters 2012). This scheduling tool uses the daily calculated ET estimates from AgWeatherNet.

Crop Coefficients (K_c)

The amount of water a vine will lose over a set period of time can vary as the canopy develops. It can vary from species to species as well. Thus, *crop coefficients* (K_c) have been used to adjust the reference ET_r to account for only the amount of water that is actually being used. Wine grapes, in particular, are highly adapted to drought conditions and will transpire less water over the course of a day compared to reference crops (grass or alfalfa). This means that the K_c for wine grapes will be less than 1. The K_c for grapes will change over the course of the growing season as the canopy develops because K_c values are closely related to canopy size. On average, at full canopy, the wine grape K_c for use with ET_r is estimated at 0.65, while the juice grape K_c at full canopy is 0.85.

Vine Water Requirements

The water required to replenish water loss in cropping systems in the United States is defined in terms of inches of water applied everywhere, or, equivalently, acre-inches per acre. To calculate how much water should be applied to a vine to meet its water demands, or to practice RDI, the amount of water necessary to replenish full vine water needs to be determined. Additionally, how much water is lost through irrigation inefficiency, and what level of RDI will be practiced also need to be determined. Understanding how these quantities are calculated will aid in a better overall understanding of irrigation and vine water-use strategies employed in a vineyard. (Note that Table 1 provides common conversion factors used in irrigation calculations.)

$$\text{Water Requirement} = \frac{(ET_r \times K_c)}{Eff} \qquad \text{Equation 1}$$

Where:

ET_r = Reference evapotranspiration in inches for a set time period (one week in this example)
K_c = Crop coefficient
Eff = Irrigation efficiency that is irrigation-system-dependent: Drip (0.85–0.95), Overhead sprinklers (0.60–0.75), and Furrow (0.40–0.50)

Example Equation 1. An example calculation for a grape water requirement at full canopy, under drip-emitter irrigation is:

Cumulative ET_r for the week = 1.5 inches
K_c for wine grapes = 0.65
Eff for drip = 0.95

Estimated water requirement for the week in order to replace used moisture is:

$$\text{Water Requirement} = \frac{1.5 \text{ inches} \times 0.65}{0.95} = 1.02 \text{ inches}$$

Calculating a Changing K_c for a Changing Canopy

The K_c for grapes is related to the size of the canopy and what proportion of it is exposed to light. It can be calculated at any point in the growing season. The Canopy Shade Width K_c Calculation Method (Williams and Ayars 2005) is a simple in-field method for determining the K_c of a particular vineyard block at a specific time of year. This calculation is as follows:

1. Calculate the area that a vine might occupy using row and vine spacing. (*For example purposes, the vine x row spacing is 6 ft x 9 ft = 54 ft*^{2}.)
2. At solar noon (12:30 p.m.–1:30 p.m.), measure the width of the canopy shade underneath the vine. (*For example purposes, the width of the canopy shade is 2.5 ft.*)
3. Calculate the area shaded by a single vine (SSV). This is the width of the shaded area multiplied by the distance between vines as follows:

   SSV = vine space x shade width
   SSV = 6 ft x 2.5 ft = 15 ft^2
4. Calculate percent shaded area (PSA) as follows:

   $$\text{PSA} = \frac{\text{SSV}}{\text{Total Vine Area}} \times 100\%$$

   $$\text{PSA} = \frac{15 \text{ ft}^2}{54 \text{ ft}^2} \times 100\% = 27.8\%$$
5. To calculate the K_c for a grapevine at this stage of canopy development, apply the following equation (modified for simplicity from Williams and Ayers 2005):

   K_c = PSA x 0.017

   Therefore, the vine in our example calculations would have a crop coefficient of:

   K_c = 27.8 x 0.017 = 0.47

Table 1. Conversion table for common units of measure used in irrigation scheduling. (To convert units in the "From" column to units in the "To" column, multiply by the coefficient shown in the "Multiply by" column.)

From	To	Multiply by
acre-inches	gallons	27,154
acre-feet	gallons	325,848
gallons	cubic inches	231
gallons	liters	3.789
acre-inches per day	gallons per minute (gpm)	18.86
inches per day	gpm per acre	18.86
liters per second	gallons per minute (gpm)	15.85
pounds per square inch	feet of water	2.31
pounds per square inch	kilopascals	6.89
acres	hectares	0.4046
acres	square feet	43,560

This water requirement calculation shows the amount of water an unstressed vine would use for the week. For RDI, this amount would need to be reduced based on the current irrigation strategy. For example, if RDI is used at 75% (0.75) of vine ET, then the amount to apply would be:

$$1.02 \text{ inches} \times 0.75 = 0.76 \text{ inches}$$

As seen above, when ET_r for the week is 1.5 inches, practicing 75% RDI for wine grapes actually only replaces 50% (0.76 inches) of the ET_r, whereas practicing "full irrigation" (100%) based on vine water use would only technically be replacing 65% of the ET_r (1.02 inches). This is a key point when thinking about RDI in a vineyard: vine ET (water requirements, Equation 1) already factors in a reduction in water use due to plant efficiency (K_c), but this water use is then reduced even further when implementing RDI strategies.

Application Rates (AR) for Drip Irrigation

After calculating the amount of water needed to meet irrigation goals, the next question is how long to irrigate to meet these goals. To determine this length of time, an irrigation system's *application rate (AR)* (how fast the irrigation system is applying water) must be determined.

For drip irrigation, the AR is calculated using information related to the drip tubing/tape. The information needed is the spacing between the drip emitters (~ 12 to 36 inches for most systems), the spacing between the drip lines (row width), and the emitter flow rate (between 0.5 and 2.5 gallons per hour, or gph). The emitter flow rate is sometimes specified by the manufacturer in gallons per minute per 100 ft of drip tape. This can be converted to gallons per hour for each emitter (Q_e) using Equation 2 as follows:

$$Q_e = Q_l \times 0.05 \times Emit_y \qquad \text{Equation 2}$$

Where:

Q_e = Drip emitter flow rate (gal/hr)
Q_l = Specified flow rate in gallons per minute per 100 ft of tubing (gpm/100 ft)
$Emit_y$ = Distance between drip emitters in line (inches)

Example Equation 2: If the flow rate is given as 0.55 gpm/100 ft, and the emitters are spaced every 36

Calculating Gallons per Vine

After calculating vine water use in acre-inches, individual vine water consumption in gallons can be calculated as:

Water Needed per Vine = 0.623 x Water Use (inches) x Vine Spacing (ft) x Row Spacing (ft)

The constant 0.623 is a conversion factor that combines the conversion of square feet per plant to acres per plant, and acre-inches to gallons. So 1 acre-inch = 27,152 gallons, and 1 acre = 43,560 ft^2.

Example: The calculation for determining gallons of water per vine based on a 6 ft x 9 ft vine x row spacing and the previously calculated water use from Example Equation 1 using 75% RDI is as follows:

$$\text{Water per Vine} = 0.623 \times 0.76 \text{ inches} \times 6 \text{ ft} \times 9 \text{ ft} = 25.6 \ \frac{\text{gal}}{\text{vine}}$$

Therefore, a vine would need 25.6 gal of water to replace water use/loss from the previous week when practicing RDI.

inches along the drip tube, then the individual emitter flow rate will be:

$$Q_e = 0.55 \text{ gpm x } 0.05 \text{ x } 36 \text{ inches} = 0.99 \text{ gph}$$

Emitter flow rates can also be manually measured while the system is running, if specific design records are not available.

Once the emitter flow rate is known, the application rate (AR) can be calculated as follows:

$$AR = 231 \text{ x } \frac{Q_e \text{ x } Eff}{Row_x \text{ x } Emit_y} \qquad \text{Equation 3}$$

Where:

AR = Application rate (in./hr)
Q_e = Drip emitter flow rate (gal/hr)
Eff = Irrigation efficiency (decimal format) (use 0.95 for drip)
Row_x = Distance between drip rows (lines) (inches)
$Emit_y$ = Distance between drip emitters in line (inches)
231 = Conversion factor for gallons to cubic inches

Example Equation 3: If drip tubing with emitters every 30 inches is placed in a vineyard with a row spacing of 9 ft (108 inches), and the emitters are rated at 1.5 gallons per hour, then the application rate is:

$$AR = 231 \frac{in.^3}{gal} \text{ x } \frac{1.5 \frac{gal}{hr} \text{ x } 0.95}{108 \text{ (in.) x } 36 \text{ (in.)}}$$

$$= 231 \frac{in.^3}{gal} \text{ x } \frac{1.425 \frac{gal}{hr}}{3888 \text{ in.}^2} = 0.085 \frac{in.}{hr}$$

(An application rate (AR) calculator is available online at http://irrigation.wsu.edu.)

The duration at which irrigation would need to be run in order to supply sufficient water can be calculated by dividing the desired amount of water by the application rate as follows:

$$\text{Duration of Irrigation} = \frac{Desired\ Water\ Amount}{AR} \qquad \text{Equation 4}$$

Example Equation 4: With the amount of vine water use shown in Example Equation 1 at an RDI of 75% and the application rate shown in Example Equation 3, the duration of irrigation needed to supply water for that particular vineyard would be:

$$\text{Duration of Irrigation} = \frac{0.76 \text{ in.}}{0.085 \frac{in.}{hr}} = 9 \text{ hrs}$$

Additional information about many aspects of irrigation design and management are available in the Washington Irrigation Guide (USDA-NRCS 1997).

Tools for Measuring Soil Moisture

There are many tools and techniques commonly used for measuring soil moisture. The following two Extension publications thoroughly review these available tools and techniques:

Practical Use of Soil Moisture Sensors for Irrigation. Online at http://irrigation.wsu.edu/Content/Fact-Sheets/Practical-Soil-Moisture-Monitoring.pdf.

This publication covers the use of neutron probes, time domain transmissivity, capacitance sensors, tensiometers, and granular matrix sensors. Ease of use and costs are also discussed.

Vineyard Irrigation Water Management with Soil Moisture Sensors. Available online at http://itc.tamu.edu/documents/demonstrations/Mound%20Prairie%20Vineyard%202011%20Report.pdf.

This publication discusses the use of soil-moisture measurements in determining irrigation scheduling.

Putting Water Management to Work

Whether or not you choose to use a device to measure plant water potential, soil water status, vineyard ET, or visual signs of stress, consistency is key. Always keep records of what you are measuring to help you develop your vineyard-specific thresholds for water intervention.

For example, do you like the wine quality when you placed the vine under stress at a certain point in time (e.g., when at 2 weeks post fruit set you measured/observed: –1.0 MPa)? Or did you like the quality when you allowed dry-down so the tendrils desiccated or when you only replaced 50% ET_r for 3 weeks?

A written history of plant and soil water status, as well as ET records and irrigation application are critical in developing vineyard-specific, optimized irrigation strategies.

Summary and Conclusions

The ability to control water application is one of the most important tools for a Washington State viticulturist. Understanding the nature of vineyard soil, how it holds and releases water, and how plants use and lose water over the growing season are critical to understanding the basics of irrigation scheduling that will lead to quality and profitable grape production. Regulated deficit irrigation (RDI) strategies use the grapevine's natural response to water stress to increase water-use efficiency and to control canopy and berry size. Irrigation strategies for wine and juice grapes differ due to differences in cropping goals. Wine grape production uses RDI to maintain canopy growth and control berry size. Juice grape production does not typically employ RDI, but can use irrigation to maximize berry size and weight. Calculating water use and the duration of irrigation required for a particular vineyard block is a part of good vineyard irrigation management practice. Refer to Grape Irrigation Decision Guide on page 11 to see what questions need to be asked and answered.

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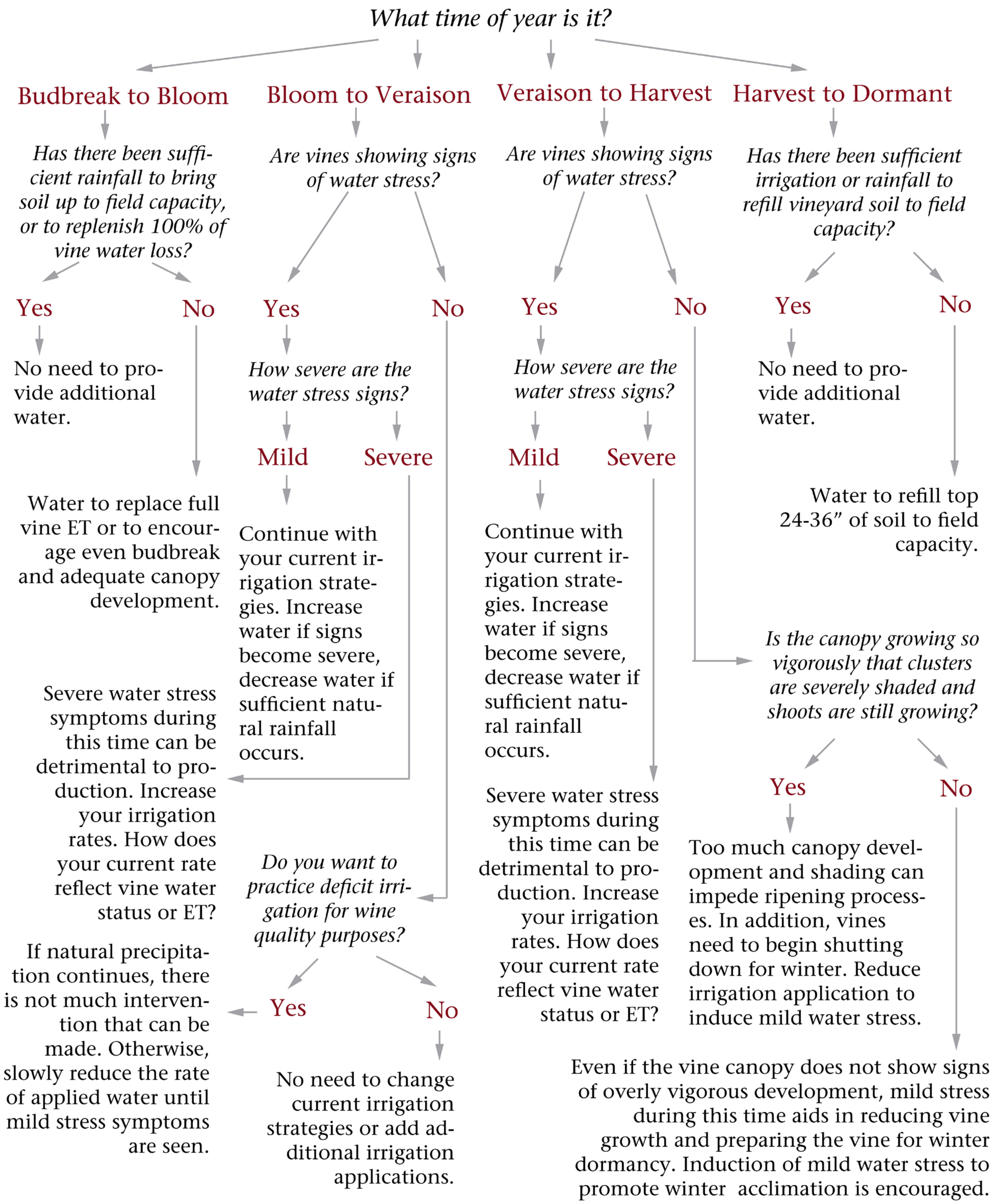
Grape Irrigation Decision Guide



What time of year is it?

Budbreak to Bloom

Has there been sufficient rainfall to bring soil up to field capacity, or to replenish 100% of vine water loss?

Yes: No need to provide additional water.

No: Water to replace full vine ET or to encourage even budbreak and adequate canopy development.

Bloom to Veraison

Are vines showing signs of water stress?

Yes: *How severe are the water stress signs?*

Mild: Continue with your current irrigation strategies. Increase water if signs become severe, decrease water if sufficient natural rainfall occurs.

Severe: Severe water stress symptoms during this time can be detrimental to production. Increase your irrigation rates. How does your current rate reflect vine water status or ET?

No: *Do you want to practice deficit irrigation for wine quality purposes?*

Yes: If natural precipitation continues, there is not much intervention that can be made. Otherwise, slowly reduce the rate of applied water until mild stress symptoms are seen.

No: No need to change current irrigation strategies or add additional irrigation applications.

Veraison to Harvest

Are vines showing signs of water stress?

Yes: *How severe are the water stress signs?*

Mild: Continue with your current irrigation strategies. Increase water if signs become severe, decrease water if sufficient natural rainfall occurs.

Severe: Severe water stress symptoms during this time can be detrimental to production. Increase your irrigation rates. How does your current rate reflect vine water status or ET?

No: *Is the canopy growing so vigorously that clusters are severely shaded and shoots are still growing?*

Yes: Too much canopy development and shading can impede ripening processes. In addition, vines need to begin shutting down for winter. Reduce irrigation application to induce mild water stress.

No: Even if the vine canopy does not show signs of overly vigorous development, mild stress during this time aids in reducing vine growth and preparing the vine for winter dormancy. Induction of mild water stress to promote winter acclimation is encouraged.

Harvest to Dormant

Has there been sufficient irrigation or rainfall to refill vineyard soil to field capacity?

Yes: No need to provide additional water.

No: Water to refill top 24-36" of soil to field capacity.

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EXTENSION

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

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