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Irrigation Scheduling for Furrow Irrigated Vineyards

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Good water management for San Joaquin Valley vineyards, the kind that's necessary for maximum production and quality, requires that adequate soil water be available for vine uptake. To accomplish this, growers must answer two questions: when to irrigate and how much water to apply.

In determining the amount of water to apply, both crop water use and the unavoidable losses during irrigation, mainly deep percolation of water below the root zone and runoff, must be considered. Generally, the magnitude of these losses, which is expressed as irrigation efficiency, depends on how uniformly water is applied to a vineyard. Therefore, it's related to the irrigation method. Even properly designed and managed irrigation systems have efficiency limitations and, on the average, drip and sprinkler are more efficient than furrow or border strip. Since it's both relatively difficult to estimate surface irrigation efficiency and unavoidable water losses can be sizeable, it's more difficult to use crop water use (ET) information for scheduling irrigation with these methods than it is for drip. The following discussion explains the factors that must be considered for scheduling irrigations for mature, surface irrigated vineyards. Examples are presented for typical soil types, rooting depths, and irrigation efficiencies.

Water Budget

One popular method of scheduling irrigations is based on knowing crop water use rates and the size of the soil water reservoir. With this information, we are able to replace the soil water before it reaches critical levels and, at the same time, not overirrigate.

Given adequate water, vine transpiration is the same for all soil types, but the amount of water that is stored in the profile and available for plant uptake is drastically different. This available water can be thought of as the difference between field capacity and the permanent wilting point. It's highest for clay soils and lowest for sands. Therefore, the soil type and depth of the root zone determine the "total available water content" in a given vineyard. Total available water can be thought of as the size of the soil water reservoir. However, we don't usually allow all of this water to be used between irrigations because adverse plant stress in vines occurs after 50 or 60 percent of the soil water reservoir is depleted.

Allowable depletion percentages depend on soil type. Table 1 shows typical values of allowable depletion, available water content and effective root zone depth for the following broad soil textural groups: sand, sandy loam, loam and clay.

Vineyard water use depends on the climatic conditions and the size and stage of development of the crop canopy. Young vineyards or those just leafing out in the spring have small canopies and, therefore, use less water than mature vineyards in the midsummer. Field measurements of vine water use indicate that there's less than 10 percent variation between long-term average ET and current season (real time) ET, so we used a 10-year average ET in the examples that follow.

How Much to Apply

Using typical conditions found in the San Joaquin Valley (Table 2) gives recommended irrigation amounts for each soil type and estimated irrigation efficiency. Using an irrigation efficiency of 50 percent for sand compared to 75 percent for clay indicates that half the water applied to sand is lost below the root zone, whereas only 25 percent is lost with the clay soil.

Irrigation losses depend on soil texture, the length and slope of the run, water discharge rate (onflow) into and configuration of border or furrow, set time, and recovery and reuse of tailwater. Using the typical efficiencies shown in Table 2 resulted in application amounts for each irrigation of 4.6, 4.6, 5.0, and 5.1 inches per acre for sand, sandy loam, loam, and clay soils respectively. Also shown are irrigation amounts in units of gallons per acre to simplify calculating pumping time. For example, to apply 125,000 gallons per acre (4.6 inches) using a pump discharging 450 gallons per minute, 4.6 hours is required.

When to Irrigate

Irrigation dates are identified when cumulative ET since the last irrigation equals the amount of allowable depletion. Therefore, the larger the soil water reservoir, the less frequent are the irrigations. Figure 1 illustrates the relationship between soil type, irrigation dates, and the amount of water application for our hypothetical examples. Note that the number of irrigations per season ranges from 11 to 6, reflecting the influence of increasing available water from sands to clays. The fact that indicated amounts of applied water for each irrigation vary only modestly illustrates the relative inefficiency of surface irrigating sandy soils and the fact that high efficiency and water holding capacity are both usually associated with heavier soils. Indeed, the seasonal irrigation amount for the clay soil totals 31 inches, compared to 46 for the sandy soil.

Summary

Presented in this article are vineyard irrigation scheduling regimes for typical conditions found in the San Joaquin Valley. They were developed based on normal water use rates for mature vines and factors associated with different soil types. Indicated irrigation dates and amounts should, of course, be adjusted to accommodate the harvest. And as with any method of irrigation scheduling, verification (checks) of the accuracy should be made periodically through the season. Soil-based measurements, either by soil sampling with a soil tube, auger, or shovel, or with tensiometers, gypsum blocks, or other devices, would be appropriate.

Table 1. Representative values for available water content, rooting depth, and allowable depletions for different soil types

Textural class	Available water (in/ft[1])	Root zone depth (ft)	Allowable depletion	
			Percentage[2]	Amount[3]
Sand	1.0	4.5	50	2.3
Sandy loam	1.6	3.5	50	2.8</TD< tr>
Loam	1.9	3.5	50	3.5
Clay	2.3	3.3	50	3.8

[1]Available water can be thought of as the difference in volumetric water content between field capacity and permanent wilting percentage.

[2]Percent allowable depletion represents how much available water you will allow extracted before irrigation. Defoliation would occur if all the available water were allowed to be depleted.

[3]Values obtained by multiplying available water X root zone depth X percent allowable depletion. Irrigation must take place after the vineyard has evapotranspired this amount.

Table 2. Recommended irrigation amounts for varying soil types and corresponding irrigation efficiency

Textural class	Irrigation efficiency[1] (%)	Allowable depletion[2] (inches)	Irrigation amount[3] (inches)	Irrigation amount[4] (gal/a)	Number irrigations per season	Total water applied for season (inches)
Sand	50	2.3	4.6	125,000	11	46
Sandy loam	60	2.8	4.7	127,000	8	38
Loam	70	3.5	5.0	135,000	7	35
Clay	75	4.8	5.1	138,000	6	31

[1]Irrigation efficiency is defined as the percentage of applied water that remains in the root zone and is available for crop uptake.

[2]Values obtained from Table 1.

[3]Values obtained by dividing allowable depletion by irrigation efficiency and indicate how much water should be applied each irrigation.

[4] Values obtained by multiplying acre-inch by 27,000 gals/acre-inch to determine gallons. Working with gallons rather than inches is sometimes more useful. For example: To apply 125,000 gallons per acre using a pump discharging 450 gals/min will require 277 minutes. By keeping record of the number of hours a pump is used on a block of grapes, the application amount can be easily determined.

Figure 1. The relationship for surface irrigated, mature vineyards between irrigation amount, date, and soil type for typical conditions in the San Joaquin Valley.