Using AccuPAR to Find Crop Coefficients for Irrigated Grapevine Production

GOOD IRRIGATION MANAGEMENT requires the answer to two questions: when do I turn the water on, and when do I turn it off?

Answering those questions correctly is serious business to modern vineyard managers. With the right knowledge and the right tools, irrigation can be managed to control vine growth, maximize fruit set, and regulate fruit quality. Water management in annual crops, like potatoes or sugar beets, requires irrigating so that the crop is never stressed for water. Grapevine production is more complicated. Stress needs to be avoided during flowering, but is used later to control assimilate partitioning and vine growth. Canopy size and shape, and a variety of fruit quality factors depend on maintaining precise stress levels. But how can that be done in the face of wildly varying water supply and evaporative demand?

Growers use a variety of methods to decide when to turn the water on. Some involve monitoring the plant. Stress is indicated by changes in the rate of shoot elongation and leaf expansion, by reduction in stomatal conductance (which leads to increase in leaf temperature), and by more negative leaf water potentials. It can also be inferred from soil moisture measurements. They often use estimates of evaporative demand to decide when to turn the water off (or how much water the crop needs).

Evaporative demand is typically computed as the product of a crop coefficient, Kc, and the potential evapotranspiration, PET. Values for PET are available (sometimes as a fee service) from local weather stations. Light interception, wind speed, vapor pressure deficit, available water, and air temperature all can affect Kc, but the most important of these is light interception by the crop. Recent studies show that variation in light interception accounts for more than 85% of the variation in crop coefficient (L.E. Williams, 2001; Johnson, 2000). This makes sense, since evaporation requires energy, and the energy comes from the sun.

Your canopy and water loss.

To make this a little clearer, evapotranspiration is the total evaporative water loss from a field. It consists of evaporation (loss from the soil) and transpiration (loss from the crop or vegetation). To a good approximation, the fraction of PET that is transpiration is equal to the fraction of incoming solar radiation that is intercepted by the crop. When the soil is wet, the non-intercepted fraction all goes to evaporation, but when the soil is dry, evaporation from the soil is much smaller than the potential rate. When the soil surface is wet, Kc is around 1.0, but when the soil surface is dry and the canopy is sparse, Kc can be much smaller than 1. The value of Kc therefore varies depending on whether drip or overhead irrigation is used, and on frequency of irrigation, but is mainly dependent on interception of radiation by the crop canopy.

Several methods exist for measuring interception. Williams (2001) photographically measured the shaded area under the canopy around mid-day and developed correlations between these values and Kc. These mid-day values are directly proportional to the whole-day interception (see the DECAGON AccuPAR operator's manual). Other methods use light measurements above and below the canopy.

Computing crop coefficient.

AccuPAR is an instrument for measuring light in plant canopies. It measures photosynthetically active radiation (PAR) in the waveband 0.4 to 0.7 micrometers. Eighty sensors in an 80 cm long probe are averaged, so the highly variable light levels below a canopy are easily and quickly averaged. Interception is computed as 1 - t, where t, the fractional transmission, is the ratio of one or more measurements below the canopy to one or more measurements above. The procedure for computing a crop coefficient for a vineyard using the AccuPAR and Williams (2001) correlation is as follows. Make measurements on a clear day within a couple of hours of noon. Make one PAR measurement above the canopy and several equally spaced measurements below the canopy from row center to row center following the instructions in the AccuPAR manual. Don't sample preferentially in sun or shade areas, and take enough samples to give a good average for the area. The AccuPAR automatically computes t. Subtract this value from 1.0 to get the interception. Williams' (2001) correlation multiplies this value by 1.7 to get Kc, so, if t were 0.60, interception would be 1 - 0.60 = 0.40, and Kc would be 1.7 x 0.40 = 0.68.

When to turn the water off.

To summarize, let's return to the questions we started with: when to turn the water on and when to turn it off. Managers monitor vine growth rates, leaf water potential, or stomatal conductance to decide when to begin irrigation. They decide when to turn the water off by knowing the rate of water application, the storage capacity of the soil, and the rate of vine water use. The rate of use is the PET (computed from local weather data) multiplied by the crop coefficient. The crop coefficient is directly proportional to the intercepted radiation, which is measured with AccuPAR.