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Title: **"Grapevine water use and the crop coefficient are linear functions of the shaded area measured beneath the canopy"**

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The authors determine the relationship between canopy size - as measured by the amount of shade cast on the ground- and vine water use. This can greatly help with irrigation scheduling.

• The amount of canopy covering a vineyard floor can vary widely depending on factors like row spacing, trellis type, and stage of crop growth. As a reference, small, low, vase-pruned vines in La Mancha, Spain, cover 10%; overhead arbor trellis cover over 90%; and a 3m row-spaced VSP about 30%. The amount of ground cover is going to determine how much water the vineyard would lose to its environment, and in turn, is its irrigation needs.

• Crop evapotranspiration (ETc), or the amount of water that a given crop loses through evaporation and transpiration, is calculated by knowing 1) the water use data for a reference crop growing in the same climatic situation (ETo), and 2) the crop coefficient for that crop (Kc).

$$ETc = Kc \times ETo$$

Since each crop has a unique Kc, we could just as well be writing the equation slightly differently for grapevines.

$$ETv = Kg \times ETo$$

where ETv= vineyard evapotranspiration
Kg= crop coefficient for grapevines

• Obviously, it is difficult to know the water consumption, or ETc, of a whole vineyard, but perhaps not so difficult to know the water consumption of just two vines. Why two? Because that is the number of vines that the authors have in their experimental lysimeter, located at the Kearny Agricultural Center, Parlier, CA. A lysimeter is a devise that measures weight changes hourly as a given crop growing in it uses water, thus allowing the researchers to calculate evapotranspiration. As for values for the reference evapotranspiration, ETo, the authors obtained them from a nearby CIMIS station (California Irrigation Management Information System). By dividing ETo (reference evapotranspiration) by ETc (vineyard evapotranspiratio n), the authors were able to calculate Kg (crop coefficient for grapes).

• To be able to compare water use parameters with growth parameters, the authors measured 1) leaf area and leaf area index, and 2) percent shade beneath the vines. Finally, they measured soil water content to have a reference of how rain might have affected the soil water profile on both seasons, and therefore vine growth. Let's take a look at how the authors measured the first two important parameters.

• To measure leaf area, the authors used a non-destructive method for most of the season. This consisted of measuring the number and length of shoots in the lysimeter at various times during the growing season. Because the authors knew from vines in the surrounding area what leaf area was associated with a particular shoot length (measured destructively with a leaf area meter), they were able to apply the same relationship to the vines in the lysimeter. Once they knew the leaf area, they calculated **leaf area index** (LAI) by dividing the leaf area by the soil surface allocated to each vine.

• To measure shaded area the authors used 2 techniques. For the 1998 season, shade was measured by placing a grid inscribed on a wood board under the vine. The shade within each square was estimated in increments of 10%. Total shade was then calculated by multiplying the percent shade of each square by the number of squares. For 1999, they calculated shaded area by taking a picture of the area beneath the vine, converting the color picture into a gray scale, and then digitizing the area that was shaded. Once they knew the shaded area, they calculated **percent shaded area** by dividing the shaded area by the area allocated to each vine.

• Now on to the results. The authors found that water use increased almost linearly over the growing season, averaging 42 liters per vine per day in the later part of the season. Accordingly, crop coefficient (Kc) also increased in the same way, reaching a value of 0.9 in early July, when 800 degree days of heat were reached. The authors also found that shaded area increased almost linearly from budbreak until about 750 degree days at the end of June. As a reference, values of shaded area went from 0.8 m2 in April to 4.8 m2 in early August. After June, the amount of shade showed large fluctuations due to hedging and shoot re-growth. The authors also noticed a linear relationship between shaded area and estimated leaf area.

• But what is probably the most important finding of this paper is that **grapevine water use is a linear function of percent shaded area.** Water use was also linearly related to leaf area. But the relationship (correlation coefficient) between percent shaded area and water use was closer than the relationship between leaf area and water use. In other words, **shaded area was a better indicator of vine water use than leaf area.**

• I think it is worth emphasizing the difference between **shaded area** and **percent shaded area.** I will use an example discussed by the authors. Even though a vine in a VSP trellis with a 1.5 m row spacing may cast the same shadow (shaded area per vine) than a similar vine in a 2.5 m row spacing, the *percent shaded area*, and therefore the calculated Kc, would be greater for the vine at the narrower row spacing. In other words, vines spaced closer together use more water.

• At some point in the growing season, the authors decided to raise the canopy curtains of the vines inside the lysimeter - with the help of a wooden frame- to see how this would affect water use. And what did they find? They found that water use increased from 42 to 60 liters per vine per day. Shaded area also increased from 4.2 to 5.7 m2 per vine. Obviously, changing shoot direction did not affect the “amount” of canopy, so leaf area stayed the same. When the authors lowered the canopy curtains two weeks later, these values were similar to what they had been prior to the curtains being raised. What this showed was that **it is the amount of leaf area exposed to direct sunlight (effective leaf area), and not the total amount of leaf area per vine, that determines water use.**

This work has immediate practical application for irrigation scheduling. As the authors point out, vineyard managers could estimate their own individual vineyard Kc by measuring the shade cast on the ground. A digital camera, and the corresponding software to digitize the pictures, would be helpful, but the measurement could also be done directly using a grid on the vineyard floor. Then, using the relationship between percent shaded area and Kc given in this paper, they could get an estimate of grapevine water use at 100% ETc. They could then reduce that full water usage, depending on the particular deficit irrigation, or %ETc, they wish to apply to achieve their quality goals.

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