How to Determine When and How Much to Irrigate

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The purpose for irrigation is to ***limit plant stress*** -- by ***maintaining* ideal soil moisture***,* especially during the critical periods of crop growth. In addition to reduced yields, plant stress causes defects such as misshapen fruit, toughness, strong and off flavors, poor shell/pod/tip fill, and cracking; it increases susceptibility to diseases and pests, reduces soluble solids, and shortens shelf life. When soil moisture is ideal (1) plants use a minimum amount of their own energy to obtain water from the soil, (2) optimum conditions exist for the best possible plant health, (3) production and quality are maximized, (4) pests and disease are mitigated, (5) energy, water, plant nutrients, and other resources are efficiently utilized and not wasted, and (6) pollution is minimized.

Plant stress will be minimal and yields and quality maximized when soil moisture *content/tension* is maintained in a narrow range *near* field capacity (when the plant can *readily/easily* get soil moisture). At field capacity the soil is moist but water will no longer drain due to the force of gravity. To maintain (all the time) soil moisture *near* field capacity requires uniform, frequent, and precisely timed water applications/irrigations (and good surface and subsurface drainage).

Applying the correct amount of water at the correct time is critical for minimizing plant stress. Irrigation scheduling (i.e., when to irrigate and how much water to apply) is governed by (1) the crop water requirement, termed evapotranspiration, **ET**, and (2) the ability of the soil to hold/release water. The ability of a soil to hold and release water is governed by its texture. ET is (1) the soil water that the crop (and weeds) transpire/give-off, plus (2) the soil water that is drawn to and evaporated through/from the soil surface. Numerous factors govern ET including ground cover, solar radiation, day length, air temperature, wind speed, humidity level and crop and weed species, growth stage, canopy size and shape, and leaf size and shape.

As a "**rule-of-thumb**" for crops grown in the humid regions of the US, the peak/maximum water need, or ET_p, reaches about **0.3 in/day**. In other units or terms, this ET_p value of 0.3 in/day is about 2 in/wk, or 60,000 gal/ac/wk, or 8000 gal/ac/day, or 200 gal per day per 1000 ft^2, or a pumping/supply rate of 6 gpm/ac continuously (*24/7).* For other ET_p values the required pumping/supply rate is

$$Q_m = (k)\frac{(A)(ET_p)}{(t)(IE)} \quad \text{where}$$

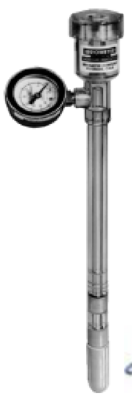
Q_m = the peak/*minimum* irrigation system capacity needed, gpm
A = the area irrigated by the system, ft^2
ET_p = the peak evapotranspiration, in/day
t= a decimal representing the portion of time that the system is irrigating/operating
IE = a decimal representing the irrigation efficiency
k = (7.48 gal/ft^3) **/** [(1440 min/day) X (12 in/ft)] = 4.33×10^{-4}

If A is acres rather than square feet, the value of k is [(4.33×10^{-4}) X (43560 ft^2/ac)] = 18.86.

Also, more than one irrigation event per day may be needed to maintain ideal soil moisture. This is particularly true when fruits and vegetables and other succulent crops are grown in soils that have limited water holding capacity (such as sandy loams). For emphasis, more frequent irrigation events of smaller amounts are better than delaying until the soil is dry; the total amount of water required is the same regardless of frequency of irrigation events. In fact, applying greater amounts of water per event usually decreases irrigation efficiency because some water ends-up wasted, outside/below the crop's active/current root-zone. By the way, once an irrigation system is installed, the length/time of an irrigation event governs the amount of water applied.

Good crop production can be obtained by basing irrigation scheduling on soil moisture content alone (as measured by science-based instruments rather than by simply feeling the soil and/or observing plants; if you're sensing cues/suggestions of water stress you have already lost yield and quality). Soil moisture monitoring should include data from both *in* root-zone and *below* root-zone. The *in* root-zone data is needed to determine how readily available the soil moisture is to plants and when to apply more water. The *below* root- zone data reveals if too much water has been added, and lost/wasted (e.g., to deep percolation).

If both the amount and the availability of the soil moisture at all locations in the crop area are the same and if the irrigation scheduling scheme is the same for all zones, monitoring the soil moisture status at just one site is adequate. Otherwise multiple sampling sites should be established so that data is collected where soil moisture and/or irrigation schemes differ.



Among the instruments available to measure soil moisture, tensiometers and electrical resistance-based sensors are most often used in crop production. These sense the ease/difficulty of removing water from soil, which is a measure of the amount of their own energy that the plants have to expend/use to get water. Data from tensiometers and electrical resistance-based sensors can be read manually or collected automatically and transmitted electronically (Figure 1). Detailed information about these instruments, how they are used, and how to use the information they provide is readily available from many sources (e.g., instrument manufacturers, irrigation dealers, and University Extension personnel). [When possible, irrigation events should be scheduled to keep the gauge readings on tensiometers between about 5 and 20 (i.e., 5 to 20 centibars tension, or negative pressure); begin irrigating before the crop has to use too much of its own energy to extract water (before the soil moisture tension exceeds 20 centibars) and stop before too much water has been added (before the tension will drop below 5 centibars); at and below 0 centibars the soil is saturated.]

Figure 1 - Field Station automatically measuring and transmitting tensiometric soil moisture and other soil indices at various depths.

Irrigation scheduling can be improved by augmenting soil moisture data with weather data such as solar radiation, wind speed and direction, rainfall, and in- and above-canopy temperature and humidity (Figure 2). Weather data helps predict how fast the crop is using water and may give early indications of whether irrigation events should be delayed, omitted, or lengthened/shortened. Monitoring salinity and/or electrical conductivity can reveal additional information on where the irrigation water, fertilizers, etc., ends-up in the soil profile, and if they are available to the crop or wasted.

Figure 2 - Field Station continuously measuring and transmitting volumetric soil moisture and salinity (at various depths), weather (in and out of canopy), and irrigation system pressure (indicating when irrigation is occurring).