Quantitative Irrigation Scheduling is Simple and Does Work (April, 2003 DWR Office of Water Use Efficiency's quarterly publication "Water Conservation News")
by Kent Frame

A major part of irrigation management is deciding when to irrigate and how much water to apply. Several tools such as such as CIMIS are available to help agricultural growers and turf managers administering parks, golf courses and other landscapes to develop water budgets and plans for determining when to irrigate and how much water to apply.

Other programs such as mobile irrigation laboratories, scheduling software, and Office of Water Use technical assistance can be used to aid in making irrigation and planning decisions. Consultants can also be hired to advise on irrigation scheduling.

What is CIMIS?

CIMIS is an acronym for California Irrigation Management Information System, a program unit in the Office of Water Use Efficiency (OWUE), Department of Water Resources (DWR). It is an integrated network of over 125 automated and computerized weather stations statewide.

By measuring climatic parameters with various sensors, such as wind speed, air temperature, solar radiation, etc., we can calculate Evapotranspiration (ET) and other useful factors. ET is the combined process of water loss the atmosphere by evaporation and water loss to through plant tissues. Reference Evapotranspiration (ETo) is a term used to describe the evapotranspiration rate from a standardized surface, such as grass or alfalfa and is expressed in either inches or millimeters. The ETo for an average year is referred to as normal year ETo. ETo varies by location, time, and weather conditions.

How can I use ETo data for irrigation scheduling?

ETo indicates how much water a reference crop needs over a certain time period for a healthy growth and development. You derive daily Crop Evapotranspiration (ETc) by multiplying ETo by Crop Coefficient (Kc). By adding up daily ETc values and including losses due to system inefficiencies, distribution uniformity, and some basic plant soil relationships, it is possible to know how much water you need to apply and when it is time to irrigate. Although irrigation scheduling can be complicated, it is analogous to balancing your checkbook. The analogy lies in that additions of irrigation water and precipitation can be considered as savings whereas ET, runoff, and deep percolation can be considered as withdrawals. This method of irrigation scheduling is often referred to as a Water Budget.

Some successful examples of water districts utilizing this method include are the Panoche WD, Coachella WD, Santa Clara Valley WD, and the San Benito County Water District.

Water Budget Method

The water budget method is simply an accounting procedure similar to the book keeping required to balance a checking account. For irrigation scheduling, soil water content is balanced. The amount of water that is lost as crop evapotranspiration (ETc) is analogous to writing checks. The water that enters the soil reservoir (as rain or irrigation) is analogous to depositing funds. By keeping records of these transactions, it is possible to know how much water is in the soil reservoir at anytime. The initial balance can be determined by direct observation or assessed after a thorough wetting of the soil by irrigation or winter rains.

Daily quantities of ET are depleted until the soil water has been reduced to a determined level. At that point irrigation should be applied with a net amount equivalent to the accumulated ET and other losses since the last irrigation. The soil profile is thus recharged to field capacity (FC), which is the quantity of water stored in a soil volume after drainage of gravitational water, and the cycle begins again. If full recharge is not desired or not possible, the new balance can be determined from the net irrigation amount or by field observations. This method, however, may not work well at locations where contributions to crop ET from water table or other source cannot be quantified.

Only a portion of the water content can be potentially removed from a volume of soil by a crop and this quantity is called "available water" (AW). The amount of available water within the crop root zone at any given time is often called "soil moisture reservoir". Unfortunately, only a fraction of the reservoir is readily available to the crop without water stress. To prevent yield reducing crop water stress one must know how dry the soil can get before yield reducing crop stress will occur (referred to as the yield threshold depletion or YTD). The value of the YTD is mainly dependent upon the crop sensitivity to stress, root depth and density, and soil type.

The ultimate choice of how much water to deplete before irrigation is made by the irrigation manager and will take into account cultural practices, labor, water deliveries or other considerations. Irrigation is timed depending on a management allowable depletion (MAD), which is the percent of available water which the irrigator will allow plants to deplete before irrigating or the depth of water that the irrigator will allow plants to extract from the root

zone between irrigations. Generally, the MAD is selected to be less than or equal to the YTD. Another term commonly used in the water budget method is soil moisture depletion (SMD). SMD is the amount of water required at any time to fill the root zone to field capacity. Crop water use can be calculated with reference evapotranspiration (ETo) from CIMIS and a crop coefficient (Kc) as ETc = ETo x Kc. These ETc estimates can be used to determine day by day soil water depletion from field capacity and thus can be used to schedule irrigation.

TABLE 1. Water budget-scheduling example for seed alfalfa

Available water (AW) in root zone = 5.0 inches
Management allowable depletion (MAD)= 50%AW = 2.5 inches
Yield threshold depletion (YTD) = 2.6 inches

Date	Effective Rainfall	Irrigation (inches)	Crop ET	Depletion	Before MAD
July 1	0.00	0.00	0.00	0.00	2.50
July 2	0.00	0.00	0.30	0.30	2.20
July 3	0.00	0.00	0.19	0.49	2.01
July 4	0.00	0.00	0.22	0.71	1.79
July 5	0.00	0.00	0.28	0.99	1.51
July 6	0.00	0.00	0.25	1.24	1.26
July 7	0.00	0.00	0.26	1.50	1.00
July 8	0.00	0.00	0.28	1.78	0.72
July 9	0.00	0.00	0.32	2.10	0.40
July 10	0.00	0.00	0.36	2.46	0.04
July 11	0.00	2.50	0.40	0.36	2.14
July 12	0.00	0.00	0.22	0.58	1.92
July 13	0.42	0.00	0.11	0.27	2.23
July 14	0.25	0.00	0.15	0.17	2.33
July 15	0.00	0.00	0.25	0.42	2.08

Other Factors to Consider

The water budget method of irrigation scheduling can be used to determine when irrigation should occur and how much water to replenish. To do this one must take into account many factors including application rates, irrigation efficiency and distribution uniformity. Water that runs off the field, percolates below the root zone, or other factors that contribute to distribution uniformity (DU) of the irrigation water does not contribute to the soil reservoir. For example, if 30% of the water applied is lost to non beneficial uses the required applied water for the July 11 irrigation would be: 2.50 inches / 0.70 = 3.57 inches. Therefore, the grower would need to apply approximately 3.6 inches to replenish the soil reservoir over the entire field. Any application of water over 3.6 inches would result in either further lost water. Determining the efficiency of irrigation can only be done accurately by a system evaluation during irrigation. Depending on the design, maintenance and management of an irrigation system, the efficiency, and DU can vary substantially. There are several government agencies and private consultants who can perform these evaluations or further assist you.

Normal Year Irrigation Schedules

A good planning tool for an irrigation manager is utilizing a normal year irrigation schedule based on historical weather data. This schedule can be developed before the irrigation season and can be used to estimate when irrigations will most likely be needed during the season. Normal year irrigation schedules can be an important part of your management plan assisting in planning the logistics of personnel schedules, fertilization, equipment, and other crop management demands.

A normal year schedule can be updated during the irrigation season using current ETo information resulting in changes of irrigation dates or amounts that reflect current conditions. For example, lower than normal ETo values would result in either more time before the next irrigation or a smaller amount of required water for the same irrigation date. This updating can be done easily on paper or by using a spread sheet on a computer system.

For more information on irrigation scheduling, KC's, information, and contacts, visit the CIMIS web site at; www.CIMIS.water.ca.gov, or these other helpful sites; www.waterright.org; and www.ipm.ucdavis.edu.