SCHEDULING ALFALFA IRRIGATIONS BY COMPUTER

Richard L. Snyder
Extension Biometeorologist
University of California, Davis

Computers are rapidly becoming a common tool in farm fiscal management, and, hence, it is reasonable to expect that a grower who invests in a computer would also like to use it for irrigation management. Because we anticipate increased interest in the use of computers for irrigation, computer programs are being written by researchers at the University of California to schedule irrigations for all major California crops. These programs will be written to use the home or business microcomputer with an input of crop water use information from the California Irrigation Management Information System, which is currently under development by the University with funding from the State Department of Water Resources.

There are many factors that influence when a crop should be irrigated and several ways to determine how much to apply. But there is general agreement amongst researchers that the best method of scheduling irrigations on a large scale is to use the "water budget" method with occasional field checks to verify predicted soil water content and/or plant water status.

The water budget method of irrigation scheduling is a bookkeeping technique that lends itself well to computer programming. Consecutive daily values of crop water use are totaled from the last date of irrigation to estimate soil water depletion. An allowable depletion of water is selected based on soil, crop, cultural, or irrigation practices, and the crop is irrigated when accumulated crop water use exceeds the allowable depletion. A computer can be a tremendous asset for planning your irrigation and cultural practices by weighting each of these factors to obtain an optimum irrigation and cultural management schedule. It can also be used to adjust your schedule for disruptions and unusual weather conditions.

Each crop has somewhat different irrigation scheduling requirements, and alfalfa has some characteristics that make the use of a computer for scheduling desirable. Because alfalfa is periodically harvested it is unique in that its water-use rate (evapotranspiration or ET rate) varies tremendously over a growing season. It is impossible to disseminate an accurate estimate of actual evapotranspiration to all growers in a region because cutting schedules are variable amongst growers. A reference value of ET, however, can be disseminated and a well-designed computer program can convert to an accurate ET estimate for the alfalfa at any time.

Cutting can also influence your irrigation schedule because the last irrigation before cutting must be completed far enough in advance to avoid compacting the soil with harvesting equipment. Consequently, soils high in a clay content must have more days between the last irrigation and cutting than soils high in sand content. Alfalfa should not be irrigated for five to six days after harvesting to allow recovery from cutting and to reduce susceptibility to scald damage.

The time required to irrigate an alfalfa crop varies depending on the soil water depletion and the amount of time needed to replenish the depleted water. Ideally, water should be depleted to the maximum allowable depletion, which is based on effective root depth and soil water retention (suction) characteristics. However, this may not be possible if poor infiltration rates inhibit water penetration into the soil. Prolonged standing water can lead to serious disease problems, so alfalfa grown on soils with poor infiltration rates should have smaller allowable depletions than if based on root depth and water retention. Once the maximum time to irrigate and avoid prolonged standing water is identified, it can be entered into a computer program to test if an allowable depletion based on time to irrigate is more limiting than a soil based allowable depletion.

Time required to irrigate alfalfa can also be limited by grower convenience. Labor considerations or personal preference can dictate that the alfalfa be irrigated over a fixed amount of time. The fixed time can be entered into a computer scheduling program to determine an allowable depletion based on grower convenience. This allowable depletion can be tested against other allowable depletions to determine which is imiting

When time of irrigation is a factor to be considered in alfalfa irrigation scheduling percentage allowable depletion based on time can be determined using Equation 1:

$$\text{allowable depletion} = \frac{\left(\text{fixed time}\right)\left(\text{application rate}\right)\left(\text{application efficiency}\right)}{\left(\text{field capacity}\right)}$$

where fixed time is in hours, application rate is in inches/hour, application efficiency is a percentage,and field capacity is in inches. This calculation would be difficult to make without a computer because application efficiency varies over the season and field capacity varies with root depth.

In some instances, water is delivered on a regular calendar basis and is not available on demand. Varying the time of irrigation is the only means to improve water management under this situation. Computerized scheduling can be extremely useful for regular calendar deliveries because of improved estimates of ET. If good estimates of application efficiency are known, water delivery requirements can be accurately determined.

Maximum allowable depletion based on root depth and soil water retention can be determined by sampling the soil or can be estimated based on soil textural class and good judgement. The first step with either method is to estimate available water which is the quantity of water that can be extracted by plants from the soil. Available water can be calculated as the difference between field capacity and 15 bars of soil suction. Field capacity is the quantity of water left in the soil after drainage due to gravity. Typical values of available water per foot of soil for a range of soil textural classes are given in Table 1.

Table 1 Typical values of available water by soil textural class.*

Soil textural class	Plant-available water per foot of soil
	inches
Sand/loamy sand	0.75
Loamy sand/sandy loam	1.00
Sandy loam/loam	1.50
Loam/clay loam	2.00
Clay loam/silty clay	2.50
Silty clay/clay	2.75

* Adapted from Grimes et al., 1978

The quantity of available water increases as clay content of soils increase, and alfalfa grown on soils high in clay content are normally irrigated less frequently than on sandy soils. Soils high in clay content have greater soil suction over the range of available water. This leads to greater accumulation of mild stress over the season, and hence, lower yields for alfalfa grown on soils high in clay. Because of differences in soil water retention, the percentage of available water that can be deleted from sandy soils is greater than for high-clay soils. Reasonable values for percentage allowable depletion vary from 70 to 75 percent for sandy soils and 55 to 60 percent for soils high in clay content.

Regardless of which percentage allowable depletion is chosen as the limiting factor to schedule irrigations, the actual amount of water to be replaced (net application) is calculated as in Equation 2:

$$\text{net application} = \left(\text{allowable depletion}\right)\left(\text{available water}\right) \cdot \text{root depth} \div 100$$

where allowable depletion is a percentage, available water is in inches per foot, and root depth is in feet. To schedule irrigations, ET estimates are accumulated from the last irrigation, assuming field capacity as the starting soil water content, until the total equals the net application.

All irrigation methods have innate inefficiencies that can vary tremendously depending on techniques used to distribute the water. Inefficiencies can result from deep percolation below the root zone resulting from over irrigation and/or poor distribution uniformity or from runoff. These losses of irrigation water are not necessarily bad unless they cause detrimental effects from over saturation of the soil, reduced yields from poor distribution uniformity, or increased costs for energy and water. Efficiency does need to be considered when determining the gross amount of water to apply in an irrigation. Application efficiency can be measured or estimated and the gross application can be calculated as in Equation 3:

$$\text{gross application} = 100 \cdot \left(\frac{\text{net application}}{\text{application efficiency}}\right)$$

where the net application is in inches and the application efficiency is a percentage

All of the factors previously discussed can be important in scheduling irrigations, and their relative importance can be weighted and used to determine an optimum schedule with minimal effort using a computer. One-time inputs into the computer program include all of the limiting factors which can be stored in memory and then used to determine a schedule based on climatological normals. This normal schedule will allow for long-range farm management planning.

A major characteristic of California's climate is that it can vary tremendously from year to year. Because of this variability, a network of weather stations is being designed and tested to provide public access to real-time (current) ET information for all major agricultural regions of California. With access to this information normal schedules can be modified to correct for the current weather situation. This will allow alfalfa growers the opportunity to improve yields and reduce costs through better availability of irrigation management information.

REFERENCE

Grimes, D. W., W. L. Dickens, and H. Yamada 1978. Early-season water management for for cotton. Agron. J. 70:1009-1012.