IRRIGATION MANAGEMENT

With the ETgage (A Modified Atmometer)

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- Colorado State University Cooperative Extension Article (June 1999): *Atmometers – A flexible tool for irrigation scheduling*

Importance of ET in Irrigation Management

99.9 % of the water used by a lawn or crop is drawn through the roots and transpires through the leaves. Wet soil surfaces also evaporate water. This transpiration and evaporation process is called Evapo-Transpiration (ET).

ET information helps apply the correct amount of irrigation water at the right time. Your best irrigation efficiency comes when you just refill the root zone by the amount of water lost through ET since the last irrigation.[1]

Irrigation efficiency is ET divided by the amount of irrigation water applied. High irrigation efficiency means minimum waste. Excessive deep percolation below the root zone and excessive surface runoff is waste.[2] Minimizing waste saves water, fertilizer, energy, and labor.

Maximum irrigation efficiency for surface irrigation systems using furrows or borders occurs when ET empties the root zone to a lower limit. This limit is called the allowable depletion, and beyond this limit crop yield will fall. See Table A to find allowable depletion for your soil and plant types.

Irrigation systems with greater control over water application (center pivots, lawn sprinklers or drip systems) can irrigate at maximum irrigation efficiency for root zones that are not emptied to the lower limit. When you irrigate every few days with sprinklers or every day with drip, fill the root zone with the amount of ET since the last irrigation.

By knowing your ET and striving for a high efficiency, you can cover the most acres with your water supply. See table *Farm Water Supply Required to Meet ET at a Given Efficiency*.

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Reference ET can be calculated from equations that use weather station data for sun, wind, temperature, and humidity. The ETgage directly simulates ET. *It responds as crops do to sun and weather.*

For young crops with incomplete canopies, ET (Reference or ETgage) should be adjusted by a crop coefficient. See information later in this manual or the article *Atmometers - A flexible tool for irrigation scheduling,* also in this manual.

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1 Always start the season with a root zone filled to field capacity. Once full, you can manage later irrigations efficiently using ET values.

2 For furrow and border irrigation, some deep percolation at the top of the field and some surface runoff is needed to get a uniform irrigation. In addition, some deep percolation below the root zone may be required for salt leaching.

Water Management

Soil water is depleted by evapotranspiration and refilled by irrigation and rain. Evapotranspiration is the process by which water transpires through plants and evaporates from the soil.

Where irrigation water goes:

(1) stored in the root zone (to supply ET)

(2) lost by surface runoff

(3) lost by deep percolation

(4) lost by spray evaporation from sprinklers.

ET + surface runoff + deep percolation + spray loss = rain + irrigation

Without losses:

ET = rain + irrigation

Therefore:

Irrigation = ET - rain

RULE #1 for efficient irrigation, apply (ET - rain) since the last irrigation. Be sure to start the season with a root zone filled to field capacity.

Lawn and Turf-grass

To simulate grass ETo (grass reference evapotranspiration) mount the ETgage in a place where it gets the same sun and wind as the grass. Use the #30 canvas evaporator cover.

Keep track of ET over a period of time, and compare it to the amount of water applied by sprinklers and rain. The period can be as short as between two irrigations, or as long as an entire season.

Finding the amount of water actually applied requires knowledge of both application rate and area. If the delivery system doesn't have a flow meter, an inexpensive method for measuring rate is placing tin cans under the sprinklers to sample the application rate directly.

For this method, use a number of identical cans, such as soup cans, to broadly sample the area for good aerial average. Run the sprinklers for fifteen minutes, combine the collected water into one can, measure the water depth and divide by the number of cans to get the average depth delivered in fifteen minutes. Multiply by four for delivery per hour. With this application rate, and knowledge of the total time the sprinklers have run during the period of ET measurement, you can find the total application (inches/hour x hours = inches applied).

With a flow meter, inches applied is gallons times 1.61 divided by the number of square feet in the irrigated area.

Divide ET (minus rain) by the total application to find efficiency.

Spray loss from sprinklers can be 5% at night with low wind, 10% for cool days with low wind, and up to 30% for hot, dry windy daytime conditions. Use lawn sprinklers at night or during low wind to minimize the spray loss.

Agricultural Crops

The ETgage with the #54 canvas cover will simulate ETr. The ETr of a crop (alfalfa reference evapotranspiration) is the ET rate for well-irrigated agricultural field plants that shade at least 75% of the ground. This is the rate for most hay, grain, and row crops.

For row crops not yet at full ground cover, ETr should be multiplied by a crop coefficient to get crop ET (ETc). This manual contains Picture Indexes and Tables for determining these multipliers.

Soil Water Balance

Soil Water Balance sheets, included in this manual for copying, help determine Irrigation Water Requirements (IWR). They have columns for recording the necessary field data and for the calculations to reveal cumulative depletion. The sheets help decide when to irrigate to avoid water stress. You can also compute irrigation application efficiency.

A Soil Water Balance sheet keeps track of the loss of water from the soil profile by showing its Cumulative Depletion balance. This is sometimes called a checkbook method. ET increases the Cumulative Depletion while rainfall and irrigation decreases it.

You start the soil water balance with zero Cumulative Depletion the day after irrigating has completely refilled the root zone. Keep the record for the first irrigation-set (starting point) in a field. When the Cumulative Depletion balance reaches the Allowable Depletion level, it's time to start another irrigation cycle. Efficient irrigating adds enough water to fill empty profiles without excessive deep percolation or surface runoff.

Follow instructions on the Soil Water Balance Sheet for the calculations. You will find crop coefficients in the tables, and a Picture Index follows this section. Table A provides Allowable Depletion information.

The "Feel Method" can check Cumulative Depletion in the field. Table B shows how to use this method to determine moisture content from a root-zone soil sample taken with shovel or auger. The method should also be used to determine soil water deficits for the following:

(1) The first irrigation of the season

(2) Irrigations where crops have been water stressed

(3) After a heavy rainfall when some of the measured rainfall runs off the land

You can use the sliding red markers on the sight tube of the ETgage to keep a soil water balance – without paperwork. After the first irrigation of an irrigation cycle, slide the top marker to the present water level in the sight tube, and slide the bottom marker to the level you expect for the next cycle. Make the distance between the markers the allowable depletion for your soil. If the crop canopy does not completely shade the soil, ETgage will use water faster than the crop, and the distance between the markers should be increased to compensate for the faster rate. For example, if before the next irrigation your crop will be using on average only 3/4 of reference ET, expand the distance between the markers by a third (4/3 = 1 1/3). If a significant rainfall occurs (>0.1"), you can move the bottom marker down on the sight tube to factor in additional moisture.

Irrigation Application Efficiency

One goal of irrigating is to refill the soil water profile without excessive waste. The amount needed to refill the soil water profile is the Irrigation Water Requirement (IWR), which is the same as the Cumulative Depletion found from the Soil Water Balance sheet. An efficient irrigation applies IWR while minimizing deep percolation below the root zone and surface runoff from the end of the field. The following describes these relationships:

Let: **E** = the Irrigation Application Efficiency

(IWR) = Irrigation Water Requirement (inches or mm)

Q = Quantity of irrigation water applied (inches or mm)

(1) Irrigation application efficiency $E = \frac{(IWR)}{Q}$, usually expressed in percent.

(2) Irrigation application amount required at an irrigation $Q = \frac{(IWR)}{E}$

(3) Amount stored in the soil profile $(IWR) = Q \times E$

Flood irrigation by furrows or borders have application efficiencies varying from 30% to 70%. An efficiency of 20% to 30% for flood irrigation is considered poor because of excessive waste (ie, 80% to 70% of the water applied becomes deep percolation or surface runoff). Changes to improve efficiency might include:

- Irrigating at maximum allowable depletion
- Shorter irrigation set times
- Shorter field lengths and set sizes
- Different flow rates in the furrows or borders
- Irrigating every other furrow
- Re-leveling the field
- Using cutback, surge or reuse systems

60% efficiency is very good for a typical furrow or border irrigation where there is no reuse or cutback. For typical furrow and border irrigating, 75% efficiency or greater may indicate under-watering on the lower end of the field: watch for signs of crop water stress such as small plants or leaves curled, drooped or duller and darker.

Center pivot sprinkler irrigation efficiencies vary between 70% to 90% depending mainly upon the operating pressure. Low-pressure systems, with spray nozzles on drop tubes, have the greatest efficiencies because they have minimal spray loss compared to high-pressure systems which have impact type nozzles placed on their overhead pipes.

Measuring Irrigation Applications

This Irrigation Manual includes various tables for determining flow rates from water sources. There are tables for Parshall flumes, contracted weirs, and suppressed weirs. Siphon tubes are good flow measurement devices, and a table is included to calibrate them. To calibrate gated pipe, use a bucket and stop watch to find flow rate for one opening, then multiply by the total number of openings. Wells should have properly maintained propeller-type flow meters that read both flow rate and cumulative acre-feet.

Following are the basic relationships between flow rate, the time water runs for an irrigation set, and the irrigation application amount:

$$(1)\ \ \text{inches of water} = \frac{\text{acre-feet} \times 12}{\text{acres}}$$

$$(2)\ \ \text{cubic feet per minute} = \frac{\text{gallons per minute}}{450}$$

$$(3)\ \ \text{inches of water} = \frac{\text{cubic feet per second} \times \text{hours}}{\text{acres}} \quad \text{or} \quad \text{hours} = \frac{\text{inches} \times \text{acres}}{\text{cubic feet per second}}$$

- 1 CFS flowing on 1 acre for 1 hour covers the acre to a depth of 1 inch. A CFS flowing on 1 acre for 24 hours covers the acre to a depth of 24 inches or 2 acre-feet per acre.
- 1 acre = 43,560 square feet
- 1 acre-foot = 325,850.6 gallons

For center pivots, see the table derived from these formulae.

The table titled *Farm Water Supply Required to Meet ET at a Given Efficiency* summarizes the relationships in a useful format. This table answers the following questions:

(1) How much water supply is required for a given acreage, ET, and efficiency?

(2) How many acres can be irrigated with a given water supply, ET, and efficiency?