ADVANTAGES AND LIMITATIONS OF ET-BASED IRRIGATION SCHEDULING

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A key ingredient for improving irrigation water management to help conserve water resources is utilizing crop water use information, often referred to as evapotranspiration (ET). This information can be used by growers and their advisers to understand daily crop water use for scheduling irrigations and to determine the amount of water to apply to replenish soil water depletion.

Many resources have been used to develop, promote, and make available ET information for irrigating farmers in Eastern Colorado. Recent survey results suggest that this effort has had some success, but ET-based scheduling has not gained wide acceptance as a primary method for timing irrigations (Figure 1). Rather, a greater number of producers in Eastern reported they use weather station ET as a secondary method of scheduling irrigations, supplemental to

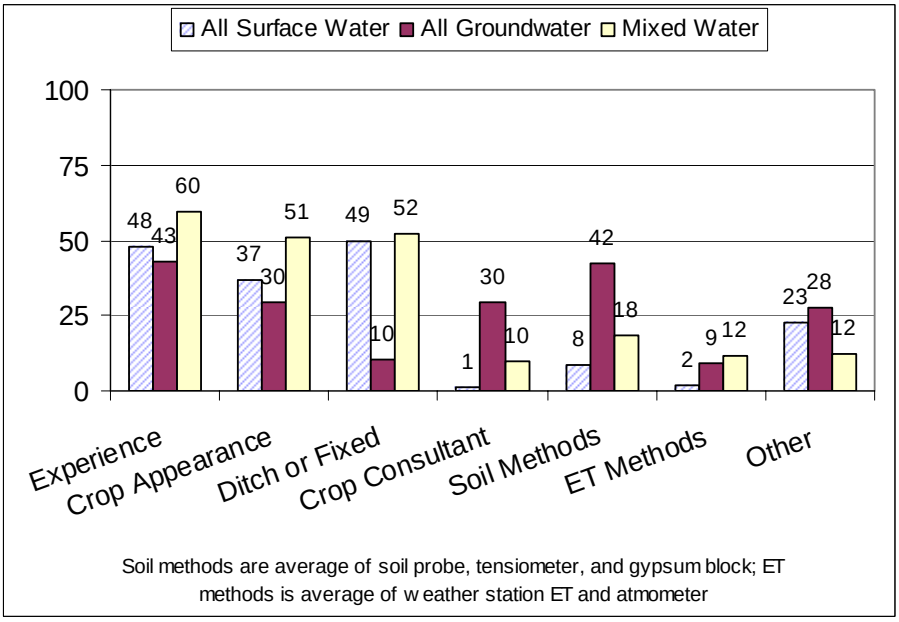

Figure 1. Irrigation scheduling methods chosen by Colorado irrigators in a 2002 mailed survey. Responses are an average of all Colorado regions by primary water source.

other information or methods (Table 1). Likewise, only a minority of growers (seven to nine percent) reported knowing the crop water use of their 2001 irrigated crop in the same survey (Table 2). This suggests that tracking ET through the growing season and scheduling irrigations accordingly is not a frequently used practice. As shown in Figure 1, experience, crop appearance, and ditch or a fixed-day schedule are the most frequently used irrigation scheduling methods used by Colorado irrigators. However, water source (ground or surface water) had a large impact on which methods producers use. These survey results suggest that growers may find ET-based scheduling unattractive and perhaps more work should be done to make ET information more convenient and understandable.

Table 1. Use of ET-related irrigation scheduling methods as found by 2002 Colorado irrigation survey.

	-------- Region --------			
	South Platte	Eastern Plains	Arkansas Valley	Colorado*
	---------- Percent of Respondents Using ---------			
Primary Method				
Crop Consultant	6	34	8	7
Weather Station ET	2	2	3	3
Atmometer	1	0	0	< 1
Computer Program	0	0	0	0
Secondary Method				
Crop Consultant	5	11	6	4
Weather Station ET	16	19	7	12
Atmometer	2	0	1	1
Computer Program	2	0	0	1

*State average includes other regions of the state not shown (n = 1271).

Table 2. Colorado irrigation survey respondents reporting knowledge of crop water use, application amounts and irrigation records (n = 1271).

	---------- Region ----------			
	South Platte	Eastern Plains	Arkansas Valley	Colorado*
	---- Percent (%) of Respondents ----			
Know Crop Water Used (ET)	7	9	7	7
Know Amount of Water Applied	48	63	39	41
Keep Records of Water Applied	21	25	25	23

*State average includes other regions of the state not shown (n = 1271).

Understanding the processes that impact crop ET should help growers and consultants make better use of ET information. Daily ET rates for a given crop depend upon the local weather conditions and the cropping system for which

estimates are needed (type of crop, planting date, etc.). Local weather conditions are important because ET is driven by weather factors that determine the drying power of the air. Solar radiation and air temperature provide the energy required to vaporize water. Water vapor loss from the soil or plant is determined by the difference between the water vapor pressure (relative humidity) at the evaporating surface and the surrounding atmosphere. As ET proceeds, the air surrounding the leaf or soil surface becomes gradually saturated and the process will slow down. The ET process might stop if the wet air is not transferred to the atmosphere. The replacement of saturated air close to the plant or soil surface, with drier air from above, explains why wind speed also impacts ET.

With the four weather variables mentioned above; solar radiation, air temperature, humidity, and wind; we can produce a reasonable estimate of daily ET. When measured under a standardized set of conditions, the values obtained from this process provide a measurement of ET that is referred to as reference ET. Reference ET values apply to a specific reference crop grown (usually alfalfa or grass) under a set of local weather conditions. To use reference ET for other crops, we must convert the values using a crop coefficient that provide daily adjustments to the reference ET values generated each day throughout the growing season. In practice, the coefficient is simply a multiplier. The actual daily ET for a given crop on a specific day of the season is the product of the reference ET obtained for that date multiplied by the crop coefficient for that same date. Crop coefficients are sometimes the “weak link” in ET-based irrigation scheduling because they must match the crop growth stage in order to be accurate. Furthermore, coefficients for a few crops in the Great Plains (sunflowers) have not been thoroughly researched and developed.

In order to utilize ET-based scheduling, a reliable source of ET data is required. Colorado has a network of weather stations, called CoAgMet, that provide ET values. CoAgMet is currently accessible on the Internet (www.CoAgMet.com), by an email listserv, and from county Cooperative Extension Offices. CoAgMet provides local reference and crop ET values on a daily basis during the growing season. Currently, the ET reports are calculated using the 1982 Kimberly Penman method. There are crop ET reports for alfalfa, corn, dry beans, small grains, sugar beets, potatoes, and onions. Crop ET reports are also available in a new and original format. The new format for the crop ET reports allows users the ability to select individual stations and crop(s) of interest. Users can also adjust the planting date for a more customized ET estimate. One weakness of the CoAgMet network is that several of the stations are located in areas that are not ideal for reference ET. Therefore, users should investigate stations to see if they are located in a predominately irrigated or dryland area. The CoAgMet network also operates on very limited resources. When station instruments go down during the season, the ability of the network cooperators to provide timely service can be limited.

Table 3. Eastern Colorado CoAgMet stations reporting crop ET.

Station ID	Station Name	Location
ALT01	Ault Station	1 mi SE of Ault
AVN01	Avondale	1 mi SE of Avondale
BRL01	Burlington North*	18 mi NNE of Burlington
BRL02	Burlington No. 2*	6 mi SE Burlington
FTC03	Fort Collins ARDEC	6 mi NE of Fort Collins
FTL01	Fort Lupton	6 mi SSW of Lupton
FTM01	Fort Morgan	8 mi W of Ft Morgan
GLY03	Greeley	2.5 mi NE of Greeley
HLY01	Holly	5 mi NW of Holy
HXT01	Haxtun	2.5 mi NW of Haxtun
HYK02	Holyoke	12 mi SE Holyoke
IDL01	Idalia	2 mi N of Idalia
KRK01	Kirk*	3 mi W of Joes
KSY01	Kersey	2 mi SE of Kersey
LAM02	Lamar #2	7 mi NNE Lamar
PAI01	Paoli*	RD U and 59
PKH01	Peckham	3.5 mi ENE of Peckham
RFD01	CSU Rocky Ford Expt	2.5 mi SE of Rocky Ford
RFD02	Rocky Ford NRCS	2.5 mi SE of Rocky Ford
WRY01	Wray	10 mi N of Wray
YUM02	Yuma #2	2.5 mi N of Yuma

*These stations are located in areas that are predominately non-irrigated. Users should be aware that ET values from these sites will typically be higher (10-15%) than reference ET.

Besides the CoAgMet network in Colorado, there are several other sources of ET information in the tri-state area. In the South Platte Basin of Colorado, the Northern Colorado Water Conservancy District (NCWCD) operates a series of weather stations intended to produce ET reports. Their reports are available on the internet (www.ncwcd.org/, click on Weather/ET Info). These weather stations are generally well maintained and reports are provided for the majority of the area's crops using several different planting dates. Kansas State University provides ET reports from their experiment stations at Colby and Garden City. Evapotranspiration is calculated using a modified Penman equation and the reports are available at: http://www.oznet.ksu.edu/irrigate/. Finally, ET reports in Nebraska are available through the Crop Watch weather site available online at: http://cropwatch.unl.edu/weather.htm. Depending upon the site, ET reports are provided for alfalfa, corn, dry beans, soybeans, sugar beets, potatoes, sorghum and wheat. Estimates are given for daily, 3-day and 7-day averages for three different emergence dates.

Another source of ET information for irrigation scheduling is an atmometer (commercial name ETgage®). This instrument is relatively inexpensive (<$200), simple to use, easy to maintain, and provides an accurate, visual estimate of crop water use. The primary benefit of atmometers is their ability to provide reference ET for the actual location where they are installed. This benefit is particularly useful in areas where there is not a nearby weather station reporting ET.

Atmometers have shown close agreement to Penman method ET in several studies. For example, during the 2003 and 2004 growing season, ETgages with logging capability were installed close (within 15 feet) to the Yuma and Peckham CoAgMet Stations in Northeastern Colorado. Penman Monteith reference ET was calculated using weather data from the CoAgMet weather station and compared to the daily ET values obtained from the ETgages. The average daily difference, either positive or negative, between the weather station ET and the ET provided from the ETgage was less than 0.04 inches per day. This difference decreased as the time interval for calculating the average daily difference decreased from one to seven days (Table 4). This was due to the fact that if the calculated weather ET was higher than the ETgage one day, it was often slightly lower the next day. These results show that a well-placed ETgage can provide a very accurate estimate of reference ET.

Table 4. Reference ET from weather stations compared to auto-logging atmometer ET at two Colorado locations in 2004.

	---------- Yuma ----------		-------- Peckham --------	
Time Period	Regression Coefficient	Average Daily Difference*	Regression Coefficient	Average Daily Difference
	R^2	(inches)	R^2	(inches)
Daily	0.80	0.025	0.86	0.036
2-Day	0.82	0.025	0.91	0.029
3-Day	0.87	0.022	0.89	0.029
5-Day	0.82	0.020	0.92	0.028
7-Day	0.72	0.018	0.93	0.023

*Absolute value of difference between atmometer ET and reference ET

A downside of atmometers is that they only provide reference ET. Therefore, prior to canopy closure and late in the season, crop coefficients (a multiplier) are required to get actual crop ET. However, these can be obtained from tables or estimated by canopy cover fraction to get a reasonable estimate of actual crop ET. Another disadvantage of atmometers is that they do require some maintenance and cannot be allowed to freeze, limiting their use early and late in the growing season.

Regardless of where ET information is obtained, users need to be aware of some potential reasons why a reported ET value may not correctly match the crop ET on their field.

Some potential reasons may include:

1. The weather station site is not similar to the field location. Pay attention to ET from surrounding weather stations as well as the closest station to the field. It may not always be the most representative. Weather conditions can vary over short distances due to topography changes and surrounding vegetation (irrigated vs. dryland).
2. The estimate of crop growth stage for the ET report is different from the actual growth stage for the irrigated field.
3. A wet soil surface prior to full canopy will cause actual crop ET rates to be slightly higher than the ET reports.
4. A dry root zone in the field may cause actual crop ET rates to be lower than the estimated ET.
5. A higher or lower plant population in the irrigated field. A higher population will have higher ET and a lower population will have lower ET in the early and late season. Differences during mid-season disappear as both population densities have sufficient leaf area.
6. Automated weather stations can have instrument failure. Contact the ET provider if you suspect data from a particular station is faulty.

A variety of options exist to help producers and their advisors utilize ET-based irrigation scheduling. Taking advantage of these options may help conserve limited water sources.