FARM: Effective water management practices for alfalfa

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In California, alfalfa used to be the largest agricultural water user due to its high acreage and long growing season. Alfalfa accounts for about 30 percent of the crops grown, and is the dominant water user in the Imperial Valley. Although alfalfa is considered to have high seasonal water use, it is one of the most water-efficient crops due to its high yield, perennial nature, deep roots, and the fact that the entire above-ground portion is harvested as an economic product. Despite the advantages of alfalfa with regards to water, the improvement of water-use efficiency through effective water management practices are highly recommended. Perhaps, it can be one of the reliable solutions for the resiliency of agricultural production under an increasing water-use competition in the low desert region.

It is more difficult to schedule irrigations for alfalfa than other crops because alfalfa is harvested multiple times per season. Irrigation water cannot be applied too close to a cutting and fields cannot be irrigated while the alfalfa is curing until the hay is removed from field. Depending on soil type and irrigation practices, there is typically a six- to even 20-day period during which fields cannot be irrigated. This can make irrigation scheduling extremely challenging, especially when irrigation is due to occur around the time of cutting.

Knowing how much water alfalfa really needs is critical. Weather parameters (solar radiation, air temperature, humidity and wind speed), crop characteristics, management and environmental aspects are factors affecting crop evapotranspiration (ET) or crop water use. Crop ET for a daily period at the farm level may be estimated by multiplying daily reference evapotranspiration (ETo) by a crop coefficient (Kc) which is specific for each crop.

The reference ET is derived from a well-watered grass and may be obtained from the nearest CIMIS (California Irrigation Management Information System) station. There are three CIMIS stations in the Imperial Valley including Calipatria (CIMIS #41), Seeley (CIMIS #68), and Meloland (CIMIS #87). Data from the CIMIS network is available at www.cimis.water.ca.gov

The average ETo values in the Imperial Valley may vary between a maximum of 0.36 inch per day during June-July and a minimum of 0.07 inch per day in December (Figure 1). The cumulative annual ETo is approximately 78 inches (6.5 ac-feet/ac).

Because of frequent harvesting events, alfalfa Kc value goes up and down over the year and even within a month (Figure 2). Over each harvesting period, it ranges from 0.4 - 0.5 after hay is cut, to 1.2 - 1.25 at full canopy. The crop coefficient values reflect local cultivation conditions in terms of climate, soil, and water and crop management. Alfalfa has also seasonality in terms of Kc, which means lower values at the early and late season and higher values in mid-season. While we still need to conduct more measurements in the Valley to discover more accurate Kc values for alfalfa, the preliminary results of a research conducted at UC Davis shows the seasonal crop coefficient value for non-dormant alfalfa could be about 0.85-0.86. Considering a value of 0.85 as the seasonal alfalfa crop coefficient and 78 inches as annual ETo, the seasonal alfalfa ET (crop water use) in the Imperial Valley is an estimated 66 inches (5.5 ac-feet/ac). Alfalfa consumes more water during June and July, while an average daily value of 0.33-0.34 inch should be a good estimation for this period. Figure 3 demonstrates a cumulative ET curve estimated for non-dormant alfalfa in the Imperial Valley. It is concluded that about 16 percent of alfalfa seasonal water use occurs in winter, 16 percent in fall, and the rest (68 percent) during spring and summer. For now, let's consider these values as rough estimations, whilst they need to be evaluated through more field measurements. These numbers may be considered as a guideline for alfalfa crop water needs over a growing season.

From a practical point of view, CIMIS ET data is a good guideline for planning irrigations as bottom line, but actual alfalfa ET can be plus or minus 15 percent. Thus, we must check soil moisture and irrigation uniformity over the season for effective irrigation scheduling and to maximize yield and efficiency.

Excess irrigation for salinity management in the Valley is necessary. Keep in mind that excess water for salinity management in the low desert region can be considered beneficial water use. A 3-inch annual rainfall of the region is insufficient to accomplish this task. In other words, 5.5 ac-feet/ac is just an estimation of seasonal crop water use. It needs to apply excess water for salinity control purposes. The amount of additional irrigation water to drain salt from the effective crop root zone depends on the soil circumstances and level of salinity.

Monitoring soil moisture status is a significant tool to avoid water stress or waterlogging. Soil texture will determine how much water we can store in the crop root zone, and how fast water infiltrates when it moves over the field. Soil-based measurements may be a far more practical and easy method for alfalfa growers to use to schedule irrigations and assess current irrigation practices. Growers and farm managers typically evaluate soil moisture by probing with a shovel or auger or monitoring with sensors. In the past, the primary barriers to more widespread use of soil moisture sensors in irrigation management have included both cost as well as labor required for the installation, removal, and collection of readings. In recent years, there has been a proliferation of commercially available soil moisture monitoring systems for agriculture. Many sensors interface with dataloggers and wireless communication systems to provide near real-time status of soil moisture from several depths and locations within a field. Data is automatically uploaded by radio or cell phone communications to cloud-based computer servers and is accessible through apps on smartphones and tablets. These communication advancements greatly improve the convenience of accessing data and can be configured to provide timely alerts when crops require irrigation.

Utilizing affordable soil moisture sensing tools is very important in alfalfa fields. Soil moisture sensors such as Watermark which estimates soil moisture tension in centibars, may be very useful if it is properly installed and maintained, and the data is effectively interpreted. The centibar reading at which irrigation is necessary depends on soil type (Table 1). Soil moisture sensors may not be useful for very sandy soils with extremely low water holding capacity, as the sensors might not respond quickly enough to the rapid decline in soil moisture. The key to proper irrigation management using the soil moisture sensors is to irrigate when the centibar readings are in the desired range for your soil type. Irrigating when the soil moisture readings are beyond the desired range may result in crop stress and yield loss. Irrigation before the readings reach the desired range may result in excessive irrigation.

At the start of the growing season, depending on the soil moisture status, we need an irrigation to bring back soil moisture to the readings less than 20 centibars, indicating the soil profile is refilled. Figure 4 shows soil moisture readings from four Watermark sensors (depths of 12", 24", 36", and 48") in an alfalfa field under sprinkler irrigation practice from early season to mid-September (Sacramento Valley). In this case, a decent rain which occurred in early March, refilled the soil profile. Gradually the soil dried and the readings increased, beginning with the sensor located at a shallow depth following by the deeper depths. When the soil moisture reading dropped to near 80, the first irrigation was applied, April 19, and the centibar readings at individual depths returned to below 20. The drying cycle is resumed until a partial irrigation has occurred as the next irrigation event. A partial irrigation was applied to replenish enough soil moisture to carry the crop through the harvest period without excessive soil moisture depletion and crop stress. After the first cutting, irrigation events are resumed in the same way for each harvesting period. Most likely, under a check flood irrigation practice depending on cutting schedule, we should have 2 — 3 irrigation events per harvesting cycle. It means that we should see more extreme conditions of deep and/or water stress than what figure 4 demonstrates.

Irrigations need to be implemented as uniformly as possible. The usual measure of field uniformity is the distribution uniformity (DU) which may be calculated through the following equation:

DU (percent) = 100 x (low quarter infiltration / average whole field infiltration)

If we have 80 percent DU, and we infiltrate an average depth of 5 inches, that means the tail-end quarter of the run averaged 4 inches and the head end got 6.3 inches — a 50 percent difference from the dry to wet side. Installing a tail-water return system and increasing on-flow rates can boost DU to 90 percent using optimal scheduling and a quarter-mile or shorter runs. Automation of surface irrigation is another effective tool to reduce tail-water and improve distribution uniformity over the entire field. Switching to subsurface drip irrigation (SDI) also promises to enhance water distribution uniformity over time and space in alfalfa fields.

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