Drought Information
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Managing On-Farm Water during a Drought

By Dan Munk

The San Joaquin Valley is one of the most productive agricultural regions in the world. The combination of rich soils, ideal Mediterranean climate and favorable water sources, creates an environment where the quality of agricultural commodities produced here is among the highest in the world. But the valley does not have an inexhaustible source of water and agricultural water requirements are significant.

Currently, California is in its third year of below-normal precipitation and suffers from very low water storage in it's reservoirs. This has led most federal and state water contractors to reduce surface water deliveries to the irrigation districts they serve. The resulting reductions in water deliveries leaves growers with difficult choices in how to best respond to these changing conditions and find ways to supplement their supply or reduce the amount of water they use on farm. While some crops can tolerate water stress better than others, the simple fact remains that crop yield and quality are compromised when water applications are reduced below the *crop water requirement*.

Every crop has a unique water requirement that varies depending on it's size, shape, and ability to transmit water from the soil to it's leaves and eventually to the atmosphere. The crop water requirement is also highly dependent on the atmospheric conditions that help drive the diffusion of water from the microscopic cavities in it's leaves (stomata), to the atmosphere. If soil water is not replaced in a timely manner, the root system cannot keep up with the removal of water from the plant canopy and the stomata are forced to close as internal water stresses build. This can have negative consequences for the crop and its ability to photosynthesize atmospheric carbon and water to create the basic sugars needed for plant growth and maintenance.

While there are no perfectly efficient agricultural systems, we can imagine the benefits realized in an ideal system. In terms of farm irrigation management, the ideal water management system is one in which:

1. Water is applied uniformly
2. The amount of water applied meets the crop water demand
3. Irrigation events are timely, minimizing deleterious stress events
4. Periodic leaching can occur to move salts below the root zone

If any one of these goals is not met, the result is either a loss in the water resource or reduced productivity.

Uniform Application

Each irrigation system has its draw backs and benefits in terms of it's ability to distribute water to the crop. Surface irrigation systems have been widely used in the region because they are inexpensive, relatively simple to operate and under certain conditions can be offer reasonable uniformity throughout the field. But these systems are often found to irrigate soils that are variable in nature and therefore experience variability in their infiltration rates and abilities to store soil water. This creates a situation where some parts of the field are beginning to develop water stress while other parts of the field can last many days before requiring additional water.

Estimating Field ET

Meeting the crop water demand requires a knowledge and understanding of how individual fields use water during the cropping season. Not only does each crop have unique Evapotranspiration (ET) characteristics over the course of the year, plant water consumption varies from week to week depending largely on canopy characteristic and the climatic. What this translates to is not only an appreciation for, but an active effort to continually monitor weather conditions and estimate the amount of ET occurring throughout the season. Vigilant efforts are therefore needed to monitor the evaporative capacity of the atmosphere and apply an appropriate canopy factor for the field being managed.

Atmospheric conditions during the late winter and spring months can vary dramatically making ET estimates anything but routine. Weather systems arriving from the Gulf of Alaska, Pacific westerly wind patterns and rapid changes in day length contribute to these erratic changes in spring climate. This often results in large daytime swings in temperature, humidity and wind speed; the primary driving mechanisms for Evapotranspiration. Average potential ET (ET_o) typically doubles from February to March and again from March to April at any one location. It is not uncommon for daily ET_o to vary by 20, 30, or even 40 percent, as a result of the changes in local weather. But the rapidly changing atmospheric conditions is not the only reason for the variation in crop water use.

The growth and development of the crop canopy is dynamic and each crop responds differently. Walnuts for instance begin to leaf out and increase their water use at a much later date than say almonds or peaches. Cotton and tomatoes have very different rates of canopy development with canopy development significantly affected by the date of planting. Furthermore, year to year variations in a single crop can have a very significant effect on crop development and therefore water use. Even with similar planting dates, the date of first flower for cotton (and canopy size) often varies from 5 to 15 days each year with a maximum range of 30 days. This can have a tremendous impact on the amount of water used in a field from year to year.

Timing Irrigation events

Knowing how much water the crop has used since its last irrigation is important because we need to know how much water to replace with an irrigation, but unless we time the irrigation events in a manner that matches the crop needs, the resultant impacts on crop quality and yield can be economically disastrous. Proper irrigation timing limits the potential downside of cooling soil temperatures prematurely and causing water losses below the root zone when too frequent, and limits the downside of accruing plant water stressed caused by potentially damaging water stress levels. For the reasons stated above, it is often not appropriate to initiate irrigation activities on the same date each year and the timing of individual seasonal events is best made after an evaluation of the individual field's capacity to release water as the plant requires it.

Soil water storage assessments are therefore a routine component of the irrigation schedule determination. And it is not too difficult to imagine why each soil has its own ability to store and release water. Soils high in sand content, loamy sands for example, typically hold no more than 1 to 1.2 inches of water per foot of soil while soils high in clay can hold as much as 2.4 inches of water per foot. Irrigating sandy soils more frequently is therefore a necessity and must be accounted for when determining the best timing to irrigate. Similarly, determining the crops access to stored water in the soil is not complete without access to information on the depth and distribution of rooting at any point in time during the season.

Both annual and permanent crops have a dynamic root system that grows and decays over time. For most crops there is a flush of growth that coincides with the expanding plant canopy with the plant gaining access to deeper soil water later in the cropping season. While internal water stresses will build following any irrigation event, they will build at a much slower rate as the plant begins to tap into deeper soil layers. This is fortunate for the water manager because there is typically a larger crop ET demand for water as the season progresses allowing some increased flexibility to the late season irrigation schedule. The power of establishing estimates of soil water storage by using rooting depth and soil water storage is that the manager can now set reasonable limits, based on the crop's sensitivity to water stress and the cost of resources that results in an informed risk management decision.

Finally, timing irrigation events can be driven by the type of irrigation systems being used and the forces that govern its management. Constraints on various surface irrigation systems including furrow and flood systems can especially influence timing later in the season as water supply can be limiting during a time of high ET demand. Particularly in the case where wells are used primarily to supply the field water, capacity limitation can be significant and irrigation schedules might be determined by decisions based on which field will be less impacted by a delay in ideal irrigation date. This may mean integrating information on a fields ability to store deep water and a crops ability to withstand moderate to more severe water stresses.

Of course greater flexibility can be gained with low volume irrigations systems including drip and micro-sprinkler and even with solid set, center pivot and linear-move sprinkler systems; there is often greater flexibility on the timing with a limited water supply. Pressurized irrigation systems offer the flexibility to be operated at lower flow rates, though applied over a longer run set time. This assists in allowing water to be allocated to a larger acreage at any given time and reduces the high on-flow rates often required to efficiently operate many surface irrigation systems.

Leaching Salts

Particularly when moderate to high TDS waters are used to irrigate a field, incorporating a leaching component is essential to the long-term viability of the land as a productive soil resource. There are numerous strategies and approaches to leaching soil salts, but the important thing is to develop a strategy that allows flexibility to limit the leaching of soil salts during drought periods, and incorporate beneficial leaching when there is more flexibility in the use of a water supply.

Tools and Techniques for Managing Water during a Drought

1. **CIMIS California Irrigation Management Information System**

The Department of Water Resources irrigation management system that allows water users to access information on crop water consumption. It is particularly useful in estimating ET_o at many locations throughout the state.

2. **Soil water status monitoring**

Typically conducted at multiple locations within a field to assess soil water status at multiple depths and determine the ideal irrigation amount and timing as well as assess a soil's ability to buffer plant impacts when irrigation delays are initiated.

3. **Plant moisture stress monitoring**

A more direct way to assess the plants water stress response as irrigation schedules vary. Typical methods include the measurement of the crop's leaf or stem water potential and plant canopy temperature measurement.

4. **Monitoring field applied water**

Very precise measurements of field applied water assist in identifying potential problems with irrigation scheduling activities and are essential when measuring pump performance or monitoring irrigation system performance. Measuring pump output or water flow onto a field is conducted in various ways depending whether the conveyance is by pipeline or open ditch. But in either instance, relatively accurate methods exist to measure flow and volume onto a field.

5. **Irrigation system evaluation**

Irrigation system evaluations assist in making reproducible comparisons of the evenness and efficiency of a field's irrigation events. They can be used to develop information on individual irrigation events, or overall seasonal performance. They can often highlight where there is potential for system management improvement or when system modification is required. Some of the most vital and telling results of a good irrigation system evaluation is the development of distribution uniformity (DU) data and application efficiency (AE) data that is useful in assessing how this system performs relatives to other systems with similar site characteristics. The information can be used to estimate water losses to deep percolation or runoff during an irrigation event and allow the field manager to weigh the costs and benefits of system modifications.

6. **Integrating available tools**

Individually, the tools described above are limited in their ability to make a good determination of whether field water management is efficient while optimizing the use of water from an economically successful standpoint. Integrating water use estimates with soil moisture depletion information can provide a simultaneous confirmation of water use during the season while an independent evaluation of how soil water resources and plant water stress interact. Measuring the irrigation system performance parameters can similarly assist in identifying cause and effect relationships by identifying system vulnerability and potential benefits gained through operational or structural modifications. Integrating these tools in a coordinated manner can have a significant impact on crop economic returns and resource use efficiency goals, especially during drought periods.

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