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# Water Management in Desert Agriculture

Following more than two decades of drought in the western U.S., many watersheds are experiencing critical water shortages. In the Colorado River basin, the two largest reservoirs, Lakes Powell and Mead, are now at less than 20% capacity. In contrast, these reservoirs were nearly full in 2000. With agriculture responsible for 70-80% of the Colorado River water diversions, a great deal of scrutiny is being applied to crop production systems in this region.

Crop production systems in the desert Southwest are experiencing increasing pressure to document and improve irrigation efficiency. There are several ways to define irrigation efficiency. The primary definitions for irrigation efficiency include orientations with water conveyance and delivery systems (engineering efficiency), and also agronomic, economic, and environmental efficiencies.

It comes as no surprise that as an agronomist and soil scientist I tend to focus on the agronomic efficiency of irrigation for the benefit of the crop being grown. The crop plants are the centerpiece of the production process and the soil-plant system itself represents the primary objective of irrigation management.

## Agronomic Irrigation Efficiency

Agronomic (crop and soil) considerations are centered on our ability to provide irrigation water for the sustainable production of a crop in the field. The three primary demands for crop water management include: 1) providing water for seed germination and stand establishment, 2) providing irrigation water to match crop-consumptive water use and avoid crop water stress, and 3) provide sufficient irrigation water to leach soluble salts from the root zone so that the soils can support crop production in a sustainable manner (Figure 1).

Agronomic efficiency at the field level focuses on the **crop water demand** (CWD) through crop consumptive use (**crop evapotranspiration**, ETc, which is the combination of evaporation and transpiration from the crop) and **leaching requirements** (LR) which are dependent upon the crop and salinity of the irrigation water.

**Agronomic efficiency can be estimated by considering the difference between ETc + LR = CWD** and the volume of irrigation water applied (IWA).

Equation 1: $$Agronomic\ Efficiency = \left(\frac{CWD}{IWA}\right) X\ 100$$

The leaching requirement (LR) can be estimated by use of the following calculation:

Equation 2: $$LR = \frac{ECw}{(5\ X\ ECe) - ECw}$$

Where:

$EC_w$ = salinity of the irrigation water, electrical conductivity (dS/m)
$EC_e$ = critical plant salinity tolerance, electrical conductivity (dS/m)

This is a good method of LR calculation that has been utilized extensively and successfully in Arizona and the desert Southwest for many years. We can easily determine the salinity of our irrigation waters ($EC_w$) and we can find the critical plant salinity tolerance level from readily available tabulations of salinity tolerance for many crops (Ayers and Westcot, 1989). Additional direct references are from Dr. E.V. Maas' lab at the University of California (Maas, 1984: Maas, 1986; Maas and Grattan, 1999; Maas and Grieve, 1994; and Maas and Hoffman, 1997).

To deal with crop water management at the field level agronomically, the crop and soil factors, there are some fundamentals that we can refer to for assistance.

Dr. Jeremy Weiss, program manager for the University of Arizona AZMET system, has recently developed two valuable tools that provide actual crop evapotranspiration (ETc) estimates from several AZMET sites in the lower Colorado River Valley and for several key vegetable crops, including lettuce (iceberg and romaine), broccoli, cauliflower, cabbage, and spinach.

The first tool provides accumulations of ETc values over the previous week and a range of dates and the planting date selected by the user. In both models, the Kc values presented in FAO-56 are used for appropriate stages with each crop. The reference evapotranspiration (ETo) measurements are taken directly from each AZMET site listed. Thus, by this method ETc estimates are made by use of equation 3.

Equation 3: $$ETc = Kc \ X \ ETo$$

To access this first crop-water estimate tool please refer to the following link:

https://viz.datascience.arizona.edu/azmet/azmet-crop-water-use-estimates/

The second tool provides accumulations of ETc values over the crop production cycle from planting (or the wet date) and the date of harvest.

This second tool gives us the opportunity to estimate agronomic efficiency of irrigation management. With this tool we can review total crop water use estimates (ETc) and include the leaching requirements (LR) to compare with the irrigation water applied (IWA) as described in Equation 1.

https://viz.datascience.arizona.edu/azmet/azmet-crop-water-use-estimates-post-harvest/

For example, using lettuce (either iceberg or romaine) with a 10 October 2022 planting date through 9 January 2023, we can see from this model the reference evaporation, listed as "water use" (ETo) and the cumulative crop evapotranspiration (ETc, or total crop-water use) of lettuce since the selected planting date.

Since planting on 10 October 2022 through 9 January 2023, a total crop water use (evapotranspiration), or the ETc, has been 11.27 ~ 11.3 inches in the Yuma Valley. We can also determine crop water use (ETc) last week (3-9 January), has been 0.52 inches in the Yuma Valley.

Similar estimates are provided by this model for several AZMET weather stations in the Yuma production area: Roll, Yuma North Gila, Yuma South, and the Yuma Valley. The Yuma Valley station is at the University of Arizona Yuma Agricultural Center and the Yuma South site is near Somerton, Arizona. A map of AZMET sites can be found in the following link:

https://ag.arizona.edu/azmet/mapsites.htm

When we include the leaching requirement for the crop, an overall estimate of field level irrigation efficiency can be made. We can estimate the leaching requirement as follows assuming an electrical conductivity for Colorado River water of 1.1 dS/m and the lettuce crop salinity tolerance of 1.3 dS/m.

Leaching Requirement (LR) = ECw/((5 X ECe)-ECw)

LR = 1.1 dS/m / (5 X 1.3) – 1.1 = 1.1/5.4 = 0.20 = 20% leaching requirement

LR = 11.3 X 0.2 = 2.26 ~ 2.3 inches

Thus, total crop water demand in this case = 11.3 + 2.3 = 13.6 or ~ 14 inches total

Contrasting this estimate of total crop-water use with the amount of irrigation water that was applied to the field can provide an estimate of the agronomic efficiency for a given field of lettuce.  We can do the same thing using this tool for other primary leafy green vegetable crops.

We are working in times of decreasing water availability and increasing scrutiny in agriculture. It serves us well to measure and understand the relationship between crop demand (consumptive use plus leaching requirements) versus the irrigation water that is applied to a given field.

**References**


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