Hass Avocado Crop Water Use:

An Analysis for California Production Systems

By Ali Montazar
UCCE Irrigation and Water Management Advisor in San Diego, Riverside, and Imperial Counties

& Ben Faber
UCCE Subtropical Crops Advisor in UCCE Ventura and Santa Barbara Counties

Introduction.

In California, avocado is primarily grown in the southern and central parts of the state along the coast where 88% (USDA-NASS, 2023) of the avocados are grown in the United States. These regions have semi-arid Mediterranean climates with winter-dominant rainfall, and currently face uncertain water supplies, mandatory reductions of water use and rising costs of water. Consequently, efficient use of irrigation water is one of the highest conservation priorities. Moreover, due to increasing salinity in water sources and the fact that avocado trees are sensitive to salinity, effective irrigation is more critical to ensure optimal yield and high-quality avocado fruits. Many avocado growers have developed irrigation practices that enable good profitability; however, the continuing increase in water costs and water restrictions due to drought and climate change have placed pressure on the industry to further enhance water use efficiency. Accurate information on crop water use along with irrigation best management practices are the immediate needs of the avocado industry under the current fluctuations in water availability, reliability and quality to sustain the profitability and sustainability of production in California.

This article presents some results from our irrigation study, quantifying crop water consumption of California Hass avocados. More comprehensive data and information will be available in the near future.

Experimental sites and measurements.

The data used in this analysis are from the research conducted at "Hass" avocado orchards in four avocado sites in southern California, here referred to as site A (the San Pasqual Valley, Escondido), site B (the Via Vaquero, Temecula), site C (the Orchard Hills, Irvine) and site D (the West Saticoy, Ventura) (Table 1). The sites consisted of a wide range of climates, slopes and elevations, soil texture and conditions, tree spacings and water sources, and therefore they may provide a good representation of the Hass avocado production systems in California.

Table 1. General information about experimental avocado sites.

Experimental Site	Age of trees (in 2014)	Tree spacing (ft x ft)	Elevation of the monitoring station (ft)	Row aspect & slope (%)	Dominant soil texture (0-2 ft)	Water source
Site A	13-year	19×19	758	South, 44%	Coarse sandy loam	District water
Site B	10-year	15×18	1490	Southeast, 20%	Rocky loam	District water
Site C	7-year	15×19	450	Southwest, 12%	Loam	Reclaimed water
Site D	7-year	12×14	164	Southwest, 3%	Loam	District water and groundwater

Elevation of the monitoring station is expressed as the distance above mean sea level. District water has surface water source.

A combination of surface renewal and eddy covariance equipment (flux tower, Fig. 1) was utilized to measure actual crop water consumption at each avocado site over a three-year period. Several other sensors and equipment were used to monitor soil and plant water status, soil salinity and chloride, and high-resolution images were captured by unmanned aerial systems to evaluate canopy features.

Fig. 1. A demonstration of one flux tower monitoring station and some of the instrumentation setup.

Daily crop water use.

While a similar crop water use pattern was found over the course of the measurement seasons in experimental sites, daily crop water consumption was generally greatest at site A. Variable daily crop water use was observed on each site over the season/s. For instance, it varied from 0.03 in d^{-1} to 0.18 in d^{-1} with an average of 0.11 in d^{-1} in the 2023 season at site A (Fig. 2). Considering the tree spacings at this site, the crop water use ranged between 6.7 and 40.5 gallons per tree with average crop water needs of 24.6 gallons per tree in 2023. The values were, as expected from the weather data, lower in late fall and winter when conditions were cooler, and the days were shorter. Also, more uniform daily crop water consumption occurred during the summer months as compared to winter and part of the spring when the weather conditions were more unstable.

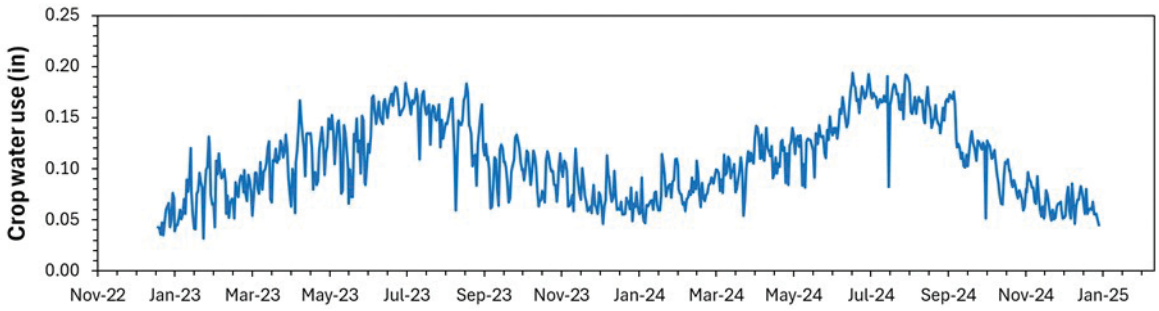

Fig. 2. Daily actual crop water uses at site A over the 2023 and 2024 seasons.

Seasonal crop water use.

Our analysis demonstrates that all the regions associated with the avocado sites A through D had a dry 2022 winter, a wet 2023 winter and a near normal 2024 winter (in comparison with the 10-year average data of 2015-2024). Considerable differences were found in the seasonal crop water use measured across experimental sites and seasons (Fig. 3). The largest difference was 11.4 in. between site A and site D during 2024. However, the seasonal crop water use difference between avocado sites C and D was 2.1 and 2.4 in., in 2023 and 2024, respectively. Overall, greater crop water consumption was observed in each of the avocado sites.

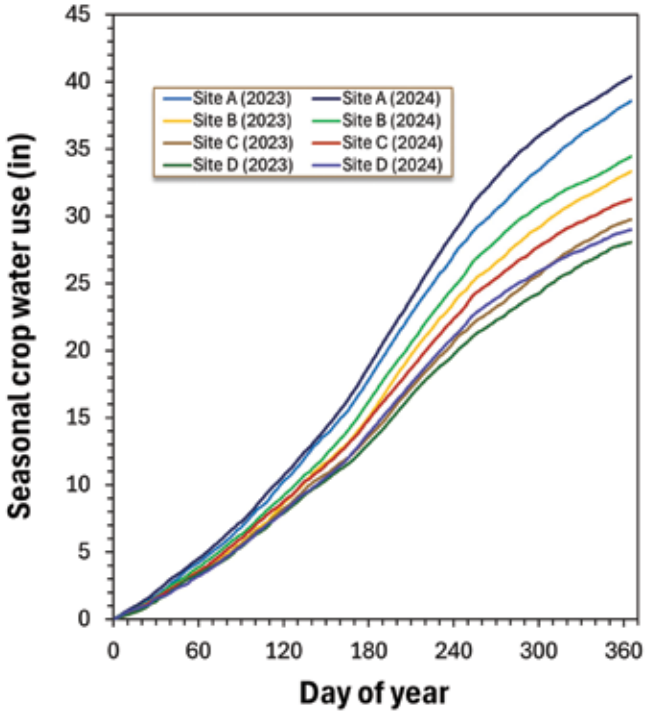

Fig. 3. Seasonal crop water use measured at the avocado sites in 2023 and 2024. The comparison demonstrates that the seasonal consumptive water use at avocado sites varied from 28.1 in. (affected by coastal climate) to 40.4 in. (an inland valley) over the two growing seasons of 2023 and 2024. Considering the tree spacings at the avocado sites, the seasonal crop water requirements may vary from about 3,000 gallons per tree (high density orchard affected by coastal climate) to about 9,000 gallons per tree (low density orchard under growing conditions of inland valley).

The results of this study clearly showed that avocado crop water use varies spatially and temporally (discussed also in Montazar and Faber, 2023). The greatest seasonal crop water consumption was determined at an avocado site (site A) with the features of coarse sandy loam soil texture, 44% south facing slope, average elevation of 758 ft. above mean sea level, plant density of 120 trees per acre, mean canopy coverage of 88.7% and tree height of 23.2 ft. In contrast, the least seasonal crop water use was observed at an avocado site (site D) affected by a coastal climate with the features of loamy soil texture, 3% southwest facing slope, average elevation of 164 ft. above mean sea level, plant density of 254 trees per acre, mean canopy coverage of 75.9% and tree height of 12.5 ft.

Conclusions.

A mean daily crop water use of 0.13 and 0.15 in d^{-1} was found for spring and summer (over the three study seasons), respectively, whilst the value for winter and fall was similar (0.08 in d^{-1}) at avocado site A with maximum values. Considering the tree spacings at this avocado site, the average daily crop water requirements are estimated at 29.2 and 33.7 gallons per tree in spring and summer, and 17.7 gallons per tree in fall and winter. In a winter with normal or wet rainfall conditions, precipitation most likely provides sufficient water to compensate for avocado tree water needs. Our data verifies this for 2023 and 2024 at all avocado sites.

Several factors impact the variability of crop water use in avocado orchards including irrigation management practices, salinity and/or soil differences, slope and row orientation,

elevation, height of trees, and trees canopy coverage that provides a good indication of canopy size and the amount of light interception. If avocado groves are located in similar climatic regions, it appears that slope and row orientation along with canopy coverage percentage are likely the most influential drivers on avocado crop water use. It needs to be noted that in the Northern Hemisphere, midday and daily total solar radiation is mostly greater on southern slopes than on northern slopes and the slope aspect influences incoming light intensity and as a result consumptive water use.

The seasonal crop water uses provided in this article are the seasonal water use measured for avocado orchards across avocado experimental sites. Excess irrigation can be considered beneficial water use for salinity and chloride management in avocado groves. The amount of additional irrigation water needed to effectively drain salt from the crop root zone depends on the soil conditions, effective rainfall and quality of irrigation water. However, the total irrigation water that needs to be applied in an individual orchard over the season depends on seasonal crop water requirements, effective rainfall, water distribution uniformity and salt leaching requirements. Heat waves are another driver that may impact the total applied water in avocado orchards.

NOTE.

A journal article from the findings of this study is under review. This journal article may provide more comprehensive analysis and information on avocado crop water use and irrigation management.

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