Water Use Estimates for Sugarcane in the Imperial Valley

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With the increasing interests in producing ethanol from sugarcane and other crops, we often receive questions about the consumptive water use of sugarcane in the Imperial Valley. There has been very little work done locally on the consumptive use of sugarcane. Sugarcane water use can be estimated from reference evapotranspiration (direct evaporation from soil/plant surfaces and transpiration through crop leaves) and crop coefficients. Reference Evapotranspiration (real time ETo or normal ETo) and crop coefficients (Kc) are commonly used to predict the consumptive water use (ETc) for a particular crop.

Evaporation in a plant-soil system occurs mainly from three system components. Evaporation from the soil is basically affected by soil moisture content, soil type, and surface conditions such as the presence of mulch. Evaporation from plant surfaces is affected by plant coverage and other environmental conditions. The third form of evaporation is from the atmosphere that is mostly associated with sprinkler irrigation. After rainfall or irrigation events, the amount of evaporation depends mostly on weather conditions or the amount of energy available for the transformation of water from liquid to vapor. The amount of energy available for evaporation depends on four main factors; solar energy, temperature, relative humidity and wind. Therefore, crop water use for a particular crop depends on the climatic conditions, crop type, irrigation system, and other crop management factors.

To estimate sugarcane water use in the Imperial Valley under surface irrigation systems, we used average ETo values for the Imperial County (Table 1) and sugarcane development stages (Table 2) from the United Nations Food and Agriculture Organization (FAO) publication 56 (FAO 56). The crop coefficients from FAO 56 are used as estimates of sugarcane crop coefficients (Kc). The Kc values for sugarcane during ‘initial’, ‘mid’, and ‘final’ growth phases are 0.4, 1.25, and 0.75, respectively. Crop water use for sugarcane was estimated from the following equation using the FAO 56 guidelines on determination of water requirements for various crops including sugarcane (Allen et al. 1998):

ETc = ETo x Kc

We used the development stages in Table 2 to estimate the development stages for a sugarcane crop planting on 4/15 with a first harvest date approximately 13 months after planting. The development stages along with crop coefficients and average ETo values for Meloland CIMIS station number 87 were used to estimate sugarcane water use. Based on our estimates, the crop water requirements during the first 13 months of production is about 78 inches (approximately 71.6 inches/year).

Using the same crop coefficients and planting date of October 1 and harvest date of 13 months after planting, the estimated crop water requirements for sugarcane is about 82 inches (approximately 78.4 inches/year). The average Kc during the first year for the above two planting dates is 1.06 (Table 3). The ‘mid’ season Kc value published in FAO56 is 1.25, however, the maximum Kc value for most commercial crops in the desert region does not exceed 1.1 to 1.15. Therefore, we estimated the crop water requirements for sugarcane using a ‘mid’ season Kc value of 1.1. The estimated crop water requirements for sugarcane using a maximum Kc value of 1.1 are shown in Table 3. Estimates of leaching requirements and irrigation system application efficiency are required to estimate the total amount of water needed to grow a crop. The additional water needed for leaching and the extra amount of water needed to compensate for uneven water distribution in the field (application efficiency) must be added to estimate gross water application requirements.

The above values are estimates for sugarcane production based on the above assumptions. Actual crop water requirements of sugarcane may be higher or lower than the above figures and vary based on soil type, planting date, irrigation system, weather conditions, and other management practices. Research conducted in Australia and Swaziland (Inman-Bamber and McGlinchey, 2003) on sugarcane crop coefficients provided confirmation of the current FAO 56 crop coefficients for sugarcane during the 'initial' (0.4) and 'mid' (1.25) growth phases. However, the FAO 56 crop coefficient for the 'final' stage (0.7) was not supported. The researchers instead suggested using a value of 1.25 but 0.7 may be used for irrigation scheduling in order to impose stress on the crop to enhance sucrose content. Using a value of 1.25 for 'final' stage crop coefficients will drastically increase the estimated water use figures in Table 3. In a research study conducted in Texas, Wiedenfeld (2004) found that sugarcane growth measurements and yields were the highest with the highest water applications. Local research is needed to estimate crop coefficients and the consumptive water use of sugarcane in the Imperial Valley under surface and drip irrigation systems.

In the above examples, we used normal or average ETo figures for a specific location (Meloand). Real time ETo values should be used instead of normal ETo to calculate crop water requirements during the growing season. Real time and normal ETo values are available from California Department of Water Resources (http://www.cimis.water.ca.gov) and the University of California. Crop water use during early growth stages varies widely and depends mostly on wetting frequency (irrigation management or rainfall frequency) of bare or nearly bare soil, amount of energy available for evaporation (weather conditions) and soil type (soil hydraulic properties). Estimating evaporation from a bare soil is also important for many agricultural applications. Such applications include agricultural operations after leaching irrigation to minimize soil compaction and estimating upward movement of salts from water table (groundwater) after irrigation termination (soil evaporation between the end of one growing season and the beginning a new growing season).

Table 1. Monthly Average ETo (in) values for weather stations in Imperial County

Station No.	Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
17	El Centro	2.32	3.20	5.13	7.32	8.67	8.74	8.91	8.30	6.61	5.00	3.07	1.95	69.22
18	Westmorland	2.44	3.31	5.25	6.85	8.67	9.57	9.64	8.67	6.85	5.00	2.95	2.20	71.40
41	Calipatria/Mulberry	2.40	3.20	5.13	6.78	8.62	9.18	9.19	8.63	6.97	5.22	3.08	2.25	70.65
68	Seeley	2.66	3.54	5.94	7.74	9.72	10.14	9.31	8.33	6.93	5.45	3.41	2.22	75.39
72	Palo Verde	2.41	3.23	5.59	7.22	8.78	9.42	9.58	8.61	6.58	4.74	2.94	2.25	71.35
87	Meloland	2.47	3.24	5.50	7.45	8.92	9.17	9.02	8.46	6.77	5.30	3.09	2.22	71.61
127	Salton Sea West	2.40	3.20	5.13	6.78	8.62	9.18	9.19	8.63	6.97	5.22	3.08	2.25	70.65
128	Salton Sea East	2.40	3.20	5.13	6.78	8.62	9.18	9.19	8.63	6.97	5.22	3.08	2.25	70.65
175	Palo Verde II	2.41	3.23	5.59	7.22	8.78	9.42	9.58	8.61	6.58	4.74	2.94	2.25	71.35
180	Westmorland West	2.44	3.31	5.25	6.85	8.67	9.57	9.64	8.67	6.85	5.00	2.95	2.20	71.40
181	Westmorland North	2.44	3.31	5.25	6.85	8.67	9.57	9.64	8.67	6.85	5.00	2.95	2.20	71.40
185	UC-Mex	2.47	3.24	5.50	7.45	8.92	9.17	9.02	8.46	6.77	5.30	3.09	2.22	71.61
186	UC-San Luis	2.47	3.24	5.50	7.45	8.92	9.17	9.02	8.46	6.77	5.30	3.09	2.22	71.61
201	UC-Andrade	2.47	3.24	5.50	7.45	8.92	9.17	9.02	8.46	6.77	5.30	3.09	2.22	71.61

* Source: CIMIS (California Irrigation Management Information system; http://wwwcimis.water.ca.gov)

Table 2. Lengths of crop development stages for sugarcane for various climatic regions (days)

Crop	Init. (L_{ini})	Dev. (L_{dev})	Mid (L_{mid})	Late (L_{late})	Total	Plant Date	Location
Sugarcane, virgin	35	60	190	120	405		Low Latitudes
	50	70	220	140	480		Tropics
	75	105	330	210	720		Hawaii, USA
Sugarcane, ratoon	25	70	135	50	280		Low Latitudes
	30	50	180	60	320		Tropics
	35	105	210	70	420		Hawaii, USA

* Source: Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and Drainage paper 56.

Table 3. Estimates of sugarcane development stages and crop water requirements in the Imperial Valley for various planting dates and crop coefficients

Crop	Init. (L_{ini}) (days)	Dev. (L_{dev}) (days)	Mid (L_{mid}) (days)	Late (L_{late}) (days)	Total days	Planting Date	Crop Coefficients (Kc1, Kc2, Kc3)	Average Kc	Crop water requirements (in/year)
Sugarcane, virgin	34	59	185	117	395	April 15	0.4, 1.25 , 0.75	1.06	71.6
	34	59	185	117	395	October 1	0.4, 1.25 , 0.75	1.06	78.4
	34	59	185	117	395	April 15	0.4, 1.1 , 0.75	0.95	64.4
	34	59	185	117	395	October 1	0.4, 1.1 , 0.75	0.95	70.1

* Source: Estimates based on FAO Irrigation and Drainage paper 56 for low latitudes sugarcane planted in April or October with first harvest 13 month after planting.

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