ESTIMATED CROP EVAPOTRANSPIRATION IN THE IMPERIAL VALLEY, CALIFORNIA

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Introduction

This report presents estimated monthly and growing season total evapotranspiration (ET) rates for 19 crops grown in the Imperial Valley. For each of three recent years, the aggregated acreage for those 19 crops represented over 90 percent of the total crop acreage within the Valley.[1/]

A method for estimating effective precipitation is suggested and effective precipitation for the "average" rainfall year was calculated. Methods used for estimating crop ET and effective precipitation are described below.

Locally Measured Crop ET

Over the last ten years, Carl F. Ehlig, Robert D. LeMert, Burl D. Meeks, and their colleagues at the U. S. Department of Agriculture (USDA), Imperial Valley Conservation Research Center (CRC), have determined ET rates for several important crops grown in the Valley. Reliable ET measurements have been made for alfalfa hay, barley, cotton, sugar beets, and wheat.

The measured monthly ET rates were used for these crops. Slight adjustments were made to account for differences between actual growing season of the measured crop and the growing season assumed to characterize current prevalent cultural practices.

Leonard Erie and his associates in the USDA Agricultural Research Service have published semimonthly ET values for a number of crops measured in southwestern Arizona (11).[2/] Observed ET rates for crops measured in both the Imperial Valley and southwestern Arizona are in reasonable agreement. Thus ET rates for other crops measured in Arizona should also be reasonable values for the Imperial Valley.

Estimated Crop ET

There were no ET measurements made in the southeastern California desert area for many crops grown in the Imperial Valley. Estimates of ET for these crops were made. Generally, regional estimates of crop water use made by the Department of Water Resources (DWR) are based upon measured evaporation from Class 'A' pans within the specific area and the relationship between measured crop ET and measured evaporation determined at ET field plot sites. As evaporation from pans is markedly influenced by the immediate pan environment, the validity of this method is dependent upon the evaporation pans within the region having the same surroundings as the pans at the ET field plot locations. The prescribed environment for the Class 'A' pan at a Department agroclimate station is a large well-managed irrigated pasture (6).

1/ Imperial Irrigation District, Annual Inventory of Areas Receiving Water. Years 1978, 1977, and 1976. I. Crop Survey.

2/ Numbers in parenthesis refer to publications listed in "References".

In the Imperial Valley, the paucity of evaporation data measured under the prescribed environmental conditions excluded the ET/evaporation method for estimating crop ET (7 and 15).

In 1975, the United Nations Food and Agriculture Organization published a paper that describes a method of estimating crop ET from measured (or estimated) ET of a grass reference crop (9). The grass crop must have a smooth surface, be sufficiently large in size to minimize local advective effects, provide 100 percent ground cover, and be adequately supplied with soil moisture to prevent plant moisture stress. ET of grass meeting those criteria is defined as potential evapotranspiration (PET).

Potential ET was estimated for the Imperial Valley using six different methods. Four estimates were calculated using methods described in the United Nations publication and local climate records. One estimate was based upon ET of alfalfa measured in the Imperial Valley and one estimate was made using the Blaney-Criddle formula with crop coefficients determined from alfalfa ET measured in southwestern Arizona and adjusted for cutting and regrowth cycles.

Monthly estimates of PET calculated by each of the six methods were in reasonable agreement. Those estimates are listed in Table 1. Table 2 lists souces of climate data used in making PET estimates by the four methods described in the United Nations publication.

Crop ET was estimated from average monthly PET and coefficients (Kc) relating crop ET to PET. The crop Kc's were obtained from the United Nations publication.

Local growing seasons for field and truck crops were obtained from a bulletin published by the Imperial Irrigation District in cooperation with the University of California Cooperative Extension and from a University of California publication (13 and 14).

Crop growing seasons used are shown in Table 3. Table 3 also shows the estimated total growing season ET for the 19 selected crops. Estimated monthly ET for nine field crops is presented in Table 4. Table 5 lists estimated monthly ET for nine truck crops. Table 6 presents estimated monthly ET for citrus -- the major tree crop in the Imperial Valley.

Effective Precipitation

A casual examination of precipitation records for five locations in the Imperial Valley (see Table 2) indicates that rainfall there is both sparse in amount and unpredictable as to time of occurrence. The long-term average annual precipitation is only 2.27 inches.

Except for delays in irrigations following the infrequent occurrence of heavy rains (1 inch or more), growers most probably disregard rainfall when scheduling irrigations. However, 2.3 inches of precipitation over the approximately 480,000 cropped acres in the Valley amount to about 90,000 acre-feet of water -- an amount too large to ignore.

Estimates of effective precipitation for an "average" rainfall year are shown for each crop in Table 3. The rationale used for estimating effecting precipitation is described in the following paragraph.

TABLE 1

NORMAL POTENTIAL EVAPOTRANSPIRATION[1/]
IN THE IMPERIAL VALLEY
AS ESTIMATED BY VARIOUS METHODS
(inches per month)

Month	Calculation Method							
	Modified Blaney-Criddle[2/]	Radiation[2/]	Modified Penman[2/]	Adjusted Evaporation[2/]	Bulletin 113-3[3/]	Blaney-Criddle[4/]	Average[5/]	Average[6/]
January	2.4	2.3	2.4	2.5	2.7	2.9	2.6	2.6
February	3.0	3.0	3.2	3.5	3.6	3.8	3.4	3.4
March	5.4	6.2	5.4	5.8	5.9	5.9	5.9	5.8
April	8.0	8.9	6.9	6.6	7.6	7.4	7.7	7.6
May	10.5	10.8	9.0	8.5	10.1	9.9	9.9	9.8
June	12.3	11.7	9.8	10.6	11.4	11.5	11.4	11.3
July	11.0	9.8	9.6	9.8	11.6	12.0	10.8	10.9
August	9.9	9.0	8.9	9.2	9.6	10.6	9.7	9.7
September	8.1	7.2	7.0	7.9	8.5	8.1	7.9	7.9
October	4.7	4.8	4.8	6.0	6.3	5.9	5.5	5.6
November	3.0	3.1	3.0	3.7	3.5	3.5	3.4	3.4
December	2.1	2.1	2.1	2.6	2.0	2.5	2.3	2.2
Total	80.4	78.9	78.2	76.7	82.8	84.0	80.5	80.2

1/ Potential evapotranspiration (PET) = ET of large expanse of low-growing clipped grass at 100-percent cover with no moisture stress.
2/ From method described in U.N. - F.A.O. No. 24 (9).
3/ From Table 6, BWR Bulletin 113-3. Estimate of ET grass based upon measured ET alfalfa (6).
4/ Based upon monthly Blaney-Criddle "K's" for alfalfa determined in Arizona and average monthly Blaney-Criddle "f" values calculated for Imperial Valley (1).
5/ Average of PET calculated by the six methods shown.
6/ Estimated PET from smoothed curve of calculated monthly PET.

TABLE 2

CLIMATOLOGICAL DATA USED FOR ESTIMATING
POTENTIAL EVAPOTRANSPIRATION IN THE IMPERIAL VALLEY

Station	Air Temperatures	Wind Movement	Humidity	Solar Radiation	Evapo-ration	Precipi-tation
Brawley 2SW	1/	2/	2/	5/	2/	8/
Calexico	-	-	-	-	-	8/
El Centro 2SSW	1/	-	-	-	-	8/
El Centro 7NW	-	-	-	6/	-	-
Imperial	1/	3/	4/	-	7/	8/
Niland	-	-	-	-	-	8/

1/ Average monthly maximum/minimum air temperatures, January 1970 - December 1978. From U. S. National Weather Service, "Climatological Data - California" (16).
2/ Unpublished field records from USDA Imperial Valley Conservation Research Center, January 1977 - April 1980.
3/ Unpublished field records from Imperial Irrigation District, March 1975 - April 1980.
4/ Unpublished field records from Imperial Irrigation District, January 1970 - May 1980.
5/ From Table 3, DWR Bulletin 187, "California Sunshine, Solar Radiation Data", for period January 1962 - December 1971 (8).
6/ From Table 3, DWR Bulletin 187, "California Sunshine, Solar Radiation Data", for period January 1963 to December 1977 (8).
7/ Unpublished field records from Imperial Irrigation District, August 1974 - April 1980.
8/ Monthly average for period 1941 - 1970. From U. S. National Weather Service, "Climatological Data, California" (16).

TABLE 3

SUMMARY OF GROWING SEASON EVAPOTRANSPIRATION
AND EFFECTIVE PRECIPITATION FOR MAJOR CROPS
IN THE IMPERIAL VALLEY

Crop	Assumed Growing Season	Growing Season ET (inches)	Estimated Effective Precipitation (inches)[1/]
Field Crops			
Alfalfa hay	1/1 - 12/31	80.6	1.0
Barley	12/15 - 5/31	23.4	0.8
Cotton	4/1 - 11/30	40.9	0.8
Forage sorghum	4/1 - 8/31	31.9	0.3
Forage sorghum	4/1 - 11/30	54.0	0.8
Grain sorghum	3/1 - 8/15	28.1	0.4
Grain sorghum	6/1 - 10/15	30.5	0.6
Onions	11/1 - 5/15	25.8	1.1
Sugar beets	7/1 - 4/30	48.0	2.0
Sugar beets	10/1 - 7/15	45.9	1.5
Tomatoes (canning)	2/1 - 6/30	35.2	0.3
Wheat	12/15 - 5/31	25.1	0.8
Truck Crops			
Asparagus	1/1 - 12/31	64.6	1.6
Broccoli	9/15 - 1/31	12.3	1.1
Cabbage	9/15 - 2/15	17.4	1.2
Cantaloupes	2/1 - 5/31	21.4	0.4
Cantaloupes	8/15 - 11/15	15.3	0.3
Carrots	10/1 - 3/31	18.8	1.3
Corn (sweet)	2/1 - 5/15	20.6	0.3
Lettuce	9/15 - 12/15	11.1	0.6
Lettuce	11/1 - 3/15	12.6	1.1
Squash	9/15 - 12/31	11.0	0.8
Squash	12/15 - 3/31	12.5	0.5
Tomatoes (market)	1/1 - 5/15	22.8	0.6
Tree Crops			
Citrus	1/1 - 12/31	46.1	1.9

1/ Based upon long-term average precipitation.

TABLE 4

SUMMARY OF ESTIMATED MONTHLY ET FOR
MAJOR FIELD CROPS IN THE IMPERIAL VALLEY

Month	PET	Alfalfa hay	Cotton	Grain Sorghum		Forage Sorghum		Sugar Beets		Tomatoes, Canning	Barley	Wheat	Onions
				Spring	Summer	Single	Double	Fall Plant	Summer Plant				
	Estimated ET - Inches 1/												
Jan	2.6	2.6						3.0	2.8		1.8	1.4	2.5
Feb	3.4	3.0						3.9	3.3	1.5	3.2	3.1	3.4
Mar	5.8	6.2		1.9				5.3	5.0	4.2	6.8	5.9	5.8
Apr	7.6	7.0	3.0	9.1		1.1	1.1	8.0	5.7	8.5	9.0	8.5	7.0
May	9.8	9.3	4.9	9.8		7.8	7.8	9.8		12.0	2.1	5.5	4.0
Jun	11.3	10.9	6.0	4.9	3.7	11.6	11.6	8.8		9.0			
Jul	10.9	12.2	7.8	2.4	13.1	7.7	7.7		3.7				
Aug	9.7	8.8	8.1		9.7	3.7	7.4		6.8				
Sep	7.9	9.2	6.9		3.4		11.1		7.9				
Oct	5.6	5.8	2.9		0.6		5.1	1.9	6.4				
Nov	3.4	3.7	1.3				2.2	2.4	3.9				1.4
Dec	2.2	1.9						2.8	2.5		0.5	0.7	1.7
Growing Season Total	80.2	80.6	40.9	28.1	30.5	31.9	54.0	45.9	48.0	35.2	23.4	25.1	25.8

1/ ET for maximum crop yield

TABLE 5

SUMMARY OF ESTIMATED MONTHLY ET FOR
MAJOR TRUCK CROPS IN THE IMPERIAL VALLEY

Month	PET	Asparagus	Broccoli	Cabbage	Cantaloupes		Carrots	Corn, Sweet	Lettuce		Squash		Tomatoes, Market
					Spring	Summer			Fall	Winter	Fall	Winter	
	Estimated ET - Inches[1/]												
Jan	2.6	.8	2.5	2.6			2.8			2.5		2.0	1.7
Feb	3.4	1.0		3.2	1.5		3.6	1.7		3.5		3.0	2.9
Mar	5.8	2.0			3.5		5.6	5.3		2.8		5.3	6.4
Apr	7.6	5.0			7.1			8.4				1.4	8.1
May	9.8	9.0			9.3			5.2					3.7
Jun	11.3	10.7											
Jul	10.9	10.3											
Aug	9.7	9.2				2.7							
Sep	7.9	7.5	1.6	2.3		5.7			2.3		2.3		
Oct	5.6	5.3	2.9	3.9		5.4	2.5		4.3		3.8		
Nov	3.4	3.0	3.1	3.2		1.5	2.1		3.4	2.0	3.0		
Dec	2.2	0.8	2.5	2.2			2.2		1.1	1.8	1.9	0.8	
Growing Season Total	80.2	64.6	12.3	17.4	21.4	15.3	18.8	20.6	11.1	12.6	11.0	12.5	22.8

1/ ET for maximum crop yield

TABLE 6

ESTIMATED MONTHLY EVAPOTRANSPIRATION OF
IN THE IMPERIAL VALLEY

Month	PET	Estimated ET, Citrus Inches 1/
January	2.6	1.3
February	3.4	1.7
March	5.8	3.2
April	7.6	4.2
May	9.8	5.4
June	11.3	6.8
July	10.9	6.5
August	9.7	5.8
September	7.9	4.7
October	5.6	3.4
November	3.4	1.9
December	2.2	1.2
Totals	80.2	46.1

1/ ET for maximum crop yield

Rains occur throughout the year, falling upon both fallow and cropped lands. Rain falling on fallow land is evaporated from the soil surface and does not contribute to meeting crop ET demands, thus none of that ~~preirrigation~~ precipitation is effective. Rain falling on vigorously growing crops at full ground cover is assumed to be 100 percent effective; that is, all of the rainfall contributes to meeting crop ET demand. Some portion of precipitation occurring after crops have been planted, but before they reach maximum vegetative cover, is effective. For this study, 50 percent of the total precipitation falling on crops at less than full cover was considered to be effective. While crop ET in the Imperial Valley probably does not vary greatly between years, precipitation can vary by fairly large amounts from year to year. Effective precipitation should be calculated for each specific year studied.

Both crop ET and effective precipitation are needed to calculate crop irrigation requirements. Estimates of leaching requirements and irrigation application efficiencies are also required. These last two items have not been included in this report.

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