Seasonal consumptive use of water by bell and Cubanelle peppers in semiarid and humid coastal sites in Puerto Rico[1]

Megh R. Goyal and Eladio A. González[2]

ABSTRACT

Consumptive use (CU) values were estimated for transplanted bell and Cubanelle peppers having a 120-day growing cycle with 24 planting dates and 2 locations (Fortuna Substation, Juana Díaz and Isabela Substation, Isabela). Modified Blaney-Criddle model was used to estimate monthly consumptive use (CU) with temperature and rainfall data. CU at Fortuna was greater than CU at Isabela in all planting schedules. CU varied from 401 to 524 mm at Fortuna and 365 to 484 mm at Isabela. An example is presented to estimate seasonal net irrigation requirements (NIR) with CU.

RESUMEN

Consumo estacional de agua para el pimiento en regiones semiáridas y húmedas de Puerto Rico

Se estimó el consumo de agua (CU) para la época de siembra del pimiento en las Subestaciones de Fortuna e Isabela, Puerto Rico. La Subestación de Fortuna, Juana Díaz, está localizada en la costa semiárida del sur y la Subestación de Isabela en la costa húmeda del norte. Se utilizaron 24 fechas de siembra de pimiento de trasplante para hacer el estudio. El modelo modificado de Blaney-Criddle se utilizó para estimar el uso consuntivo (CU) mensual utilizando los datos de temperatura y lluvia. El CU fue mayor en la Subestación de Fortuna para todas las fechas de siembra, varió de 401 a 524 mm. en Fortuna y en Isabela de 365 a 484 mm.

INTRODUCTION

Adequate water supply for the entire growing season is essential for optimum vegetable production. Crop water requirement is supplied from rainfall and irrigation. In locations where sufficient rainfall is distributed throughout the growing period, irrigation need is minimal. In Puerto Rico, rainfall is unevenly distributed throughout the year (4) thus requiring functional irrigation facilities for successful vegetable production on the south and north coasts of Puerto Rico. For good water management and irrigation planning the irrigation requirements of crops must be

[1]Manuscript submitted to Editorial Board 10 May, 1988.

This study was conducted under USDA Grant No. 85-CSRS-2-2664, project CBAG-PR-23, "Irrigation Requirement Estimations in Puerto Rico".

[2]Associate Agricultural Engineer and Research Assistant, Agricultural Experiment Station, University of Puerto Rico, Mayagüez Campus, Río Piedras, P. R.

known or estimated (1, 6). USDA Technical Release No. 21 covers procedures to estimate irrigation water requirements on a farm or on a project (6). Hackbart (3) has developed a computer program to estimate net irrigation requirements for various crops with the Blaney-Criddle model (1) and USDA Technical Release 21.

This study estimated total consumptive use of transplanted bell and Cubanelle peppers for 24 planting schedules at Fortuna and Isabela Agricultural Experiment Substations in Puerto Rico.

MATERIALS AND METHODS

Table 1 shows average temperature (5), average rainfall (2) and percent day light (6) for Fortuna and Isabela agricultural experiment substations. Monthly consumptive use of sweet peppers was estimated with climatic data in table 1, computer program (3) and the following relationship (6):

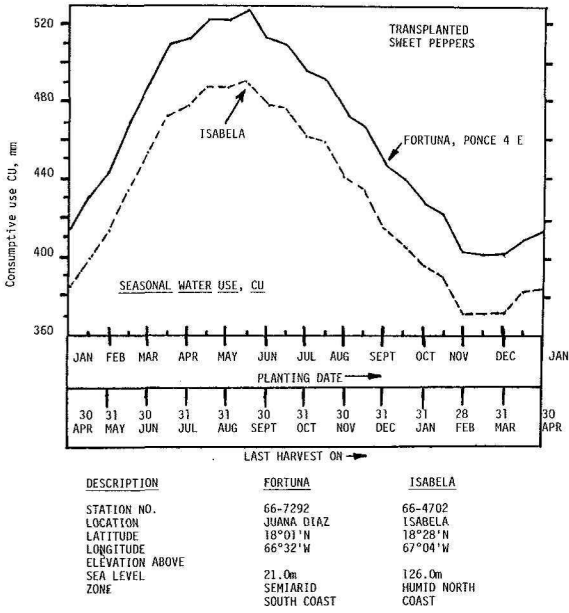
$$CUm = K_c \times K_t \times H \times p \times (0.455 \times T + 8.128) \quad \text{..... /1/}$$

where CUm = monthly consumptive use (mm), K_t = a climatic coefficient which is related to mean air temperature (6), H = humid area factor of 0.8, p = monthly percentage of daylight hours in the year (1, 6), T = mean air temperature in °C, and K_c = crop coefficient reflecting growth stage (6). K_c was 0.53 for 0-30 days, 0.78 for 31-60 days, 1.02 for 61-90 days and 0.95 for 91-120 days. Average K_c was 0.82.

Monthly CUm was then summed to obtain totaled consumptive use (CU). The twenty-four planting schedules were the 1st and 16th of each

TABLE 1.—*Climatic data for Fortuna and Isabela Substations*

	Fortuna			Isabela		
Month	Temperature °C	Rainfall cm	Daylight %	Temperature °C	Rainfall cm	Daylight %
January	24.5	2.18	8.00	23.1	9.65	7.97
February	24.3	2.72	7.18	23.0	8.48	7.18
March	24.8	1.55	8.25	23.6	8.26	8.26
April	25.7	5.79	8.28	24.2	12.29	8.30
May	26.5	11.40	9.16	25.1	21.44	9.17
June	27.2	8.92	9.18	25.7	19.15	9.16
July	27.5	6.96	8.92	26.2	12.70	8.95
August	27.6	11.91	8.72	26.2	16.97	8.75
September	27.4	15.06	8.25	26.1	17.53	8.25
October	27.1	13.49	8.24	25.7	16.56	8.23
November	26.3	9.40	7.91	25.0	13.77	7.88
December	25.2	3.40	7.91	23.9	10.97	7.88
Annual	——	92.79	——	——	167.77	——



DESCRIPTION	FORTUNA	ISABELA
STATION NO.	66-7292	66-4702
LOCATION	JUANA DIAZ	ISABELA
LATITUDE	18°01'N	18°28'N
LONGITUDE	66°32'W	67°04'W
ELEVATION ABOVE SEA LEVEL	21.0m	126.0m
ZONE	SEMIARID SOUTH COAST	HUMID NORTH COAST

FIG. 1.—Total consumptive use of peppers for 24 planting dates at Fortuna and Isabela Agricultural Experiment Substations, Puerto Rico.

month January through December. Last harvest was 120 days after transplanting.

RESULTS AND DISCUSSION

Table 1 shows climatic data for Fortuna and Isabela agricultural experiment substations. Mean monthly temperature was higher at Fortuna than at Isabela for January through December. Lowest temperature was in February and highest temperature was in July. Mean monthly temperature variation between Fortuna and Isabela was 1.2 to 1.5 °C in January through December. Annual rainfall was 1,678 mm at Isabela and 928 mm at Fortuna. Percent day light difference between Fortuna and Isabela was 0.03 percent in January, November, December; 0.0 in February,

June, September; 0.01 in March, May; 0.02 in April; 0.03 in July, August; and 0.01 in October.

Figure 1 shows total water use (CU) for 120-day transplanted sweet peppers and 24 planting dates at Fortuna and Isabela agricultural experiment substations. CU varied from 402 to 526 mm at Fortuna, and 372 to 490 mm at Isabela. CU was minimum when peppers were transplanted 16 November. It was maximum for transplanting 16 May because of high temperatures. For all 24 planting dates, CU at Fortuna was greater than CU at Isabela. This difference is due to higher monthly temperatures at Fortuna than at Isabela.

Because of higher commercial yield, better fruit quality and lesser cost per hectare, peppers are generally transplanted in November through February in the ecological zones of Fortuna and Isabela[3]. It is therefore advised to consult the local agricultural extension agent for optimum planting date before selecting CU for a particular season. However, small farmers plant during other months. Experimental research to determine K_c in Puerto Rico is lacking. These CU values were estimated with K_c corresponding to areas similar to Puerto Rico. The following examples indicate how to utilize CU for irrigation requirements.

Example I. Estimate the consumptive use for transplanting sweet peppers on 1 December at Fortuna and Isabela. Use an average K_c of 0.79 instead of 0.82.

From figure 1, CU is 374 mm at Isabela and 403 mm at Fortuna with average K_c of 0.82 and 01 December transplanting. CU at Isabela = $(374/0.82) \times 0.79 = 360$ mm and CU at Fortuna $(403/0.82) \times 0.79 = 388$ mm during the growing cycle. This example shows procedures of how to estimate CU with a new K_c.

Example II. Estimate total water requirement for a low pressure trickle irrigation system with the following data:

Description	Fortuna	Isabela
Soil pH	7.9	5.4
Soil type	San Antón (Mollisol) (fine-loamy, montmorillonitic, isohyperthermic, Cumulic Haplustolls)	Coto clay (Oxisol) (kaolinitic, isohyperthermic, Tropeptic Haplorthox)
Field capacity, depth	7.5 cm	7.5 cm
Root depth	60 cm	60 cm
Allowable depletion	50%	50%
Initial soil moisture	3.75 cm	5.0 cm
Irrigation method	drip line with 60 cm orifice spacing	

[3]Personal communication. Vegetable Program, Office of the Land Authority of Puerto Rico, Santa Isabel, P. R.

Irrigation efficiency (1)	80%	80%
Crop	Peppers	Peppers
Growing Cycle	120 days	120 days
Planting date	1 December	1 December
Last harvest	31 March	31 March
Row spacing	180 cm	180 cm
Plant spacing	30 cm	30 cm
Planting pattern	Zizgag on both sides of drip line	
Plants per ha	37,037	37,037
Average Kc	0.82	0.82

From figure 1, CU is 374 mm at Isabela and 403 mm at Fortuna with an average K_c of 0.82 and 1 December transplanting. Effective rainfall (ER), net irrigation requirements (NIR), gross irrigation requirements (GIR) were estimated with a computer program (6) and the following equations (1,3,6):

$$ER_m = (0.70917 \times I^{0.82416} - 0.11556) \times 10^{0.02426CUM} \times f \quad \text{/2/}$$

$$f = 0.531747 + 0.295164 \times D - 0.057697 \times D^2 + 0.003804 \times D^3 . \quad \text{/3/}$$

$$ER = (ER_{Dec} + ER_{Jan} + ER_{Feb} + ER_{Mar}) \times 25.4 \quad \text{/4/}$$

$$NIR = (CU - ER) \quad \text{/5/}$$

$$GIR = NIR/IE \quad \text{/6/}$$

where, ER_m = monthly effective rainfall (inches), I = monthly mean rainfall (inches), CU_m = given by equation /1/ and divided by 25.4 (inches), f = given by equation /3/, D = net depth of application (inches), ER = total effective rainfall (mm), NIR = total net irrigation requirements (mm), CU = total consumptive use (mm), GIR = gross irrigation requirements during the crop (mm) and IE = irrigation effeciency (in fraction).

ER is 133 mm at Isabela and 48 mm at Fortuna. NIR is 241 mm at Isabela and 355 mm at Fortuna. Gross irrigation requirement during the 120-day crop is therefore 444 mm (= 355/0.80) at Fortuna and 301 mm (= 241/0.80) at Isabela. This example shows the procedure of how to utilize CU, rainfall data and management factors for estimating gross total irrigation requirements.

LITERATURE CITED

1. Burman, R. D., P. R. Nixon, J. L. Wright and W. O. Pruitt, 1980. Water requirements. *In*: Design and Operation of Farm Irrigation Systems, edited by M. E. Jensen. American Society of Agricultural Engineers, St. Joseph - MI, Monograph No. 3, Pages 189-225.
2. Climatography of the United States No. 86-45 of Puerto Rico and U. S. Virgin Islands. *In*: Climatic Summary of the US-Supplement. United States Department of Commerce, Washington, D. C.
3. Hackbart, C. A., 1987. Conuse and SCS User's Manual. USDA-SCS, Fort Worth, Texas.
4. Ravalo, E. J., M. R. Goyal and C. R. Almodóvar, 1986. Average monthly and annual rainfall distribution in Puerto Rico. *J. Agric. Univ. P. R.* 70 (4):267-75.

5. Temperature data. Puerto Rico and U. S. Virgin Islands, updated 1984. National Climatic Data Center, Asheville, NC 28801.
6. United States Department of Agriculture - Soil Conservation Service, 1970. Irrigation water requirements. Eng. Div. Tech. Release No. 21. U. S. Govt. Printing Office, Washington, D. C.