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YIELD PREDICTION OF SUGARCANE *(SACCARUM OFFICINARUM)* AS RELATED TO EVAPOTRANSPIRATION (ET) IN PAKISTAN

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Relative yields and evapotranspiration (ET) of sugarcane were determined under different climatic conditions using the model PLANTGRO which was developed in Western USA. Field measurements of ET from Bhalwal, Mianchannu, Faisalabad and Bhakkar in the Punjab were used to verify the predictions. Computed seasonal ET for Bhalwal, Mianchannu, Faisalabad and Bhakkar was 122.5, 133.4, 142.5 and 150.3 cm, respectively, and was within average measured ET. Since prediction were accurate, the model can be used to aid in crop management and irrigation scheduling.

INTRODUCTION

Crops like sugarcane which are drought and waterlogging sensitive, require special water management to maintain the proper soil water environment. Methods and models are available to facilitate irrigation scheduling at farm level (Jenson *et al.*, 1970; Allen and Lambert, 1971). Most of these methods require a knowledge of water requirement of crop, and soil and climatic behaviour of a particular site.

Crops differ for their water demand. If ET is known for a particular crop, yield can be predicted. Relationship between seasonal ET and dry matter and grain yield of many crops can be represented by a linear function when irrigation scheduling is optimal (Rajput and Singh, 1986). Hanks (1974) developed a model, PLANTGRO, which used some crops soil and climate data as input to estimate ET and relative yield. Thus the same model, PLANTGRO, was used for this study to predict yield of sugarcane under different climatic, soil and irrigation management conditions prevailing in Pakistan.

MATERIALS AND METHODS

For this study, model PLANTGRO was used to predict sugarcane yields in locations where the model has not been tested earlier. Different input data required in the model were collected from Bhalwal, Bhakkar, Faisalabad and Mianchannu. Values of input data with computer output for Bhakkar (as an example) are shown in Table 1. Original model is quite large (Hanks, 1974), however, a brief discussion of the parameters used is given below:

DA = Length of season in days.
AD = The maximum amount of water (cm) that can be evaporated from top layer.
AF = The ratio of relative water content in a layer below which transpiration will be less than potential (0.5 in the example, Table 2).
RM = The time (days) required to reach maximum root depth.
PP = A coefficient to convert relative seasonal transpiration into per cent yield (always 100).

Table 2. Comparison of predicted and measured ET (cm) for sugarcane

Station	Predicted	Measured				
		1976	1977	1978	1979	Average
Bhalwal	122.5	121.5	123.2	-	117.0	120.7
Bhakkar	150.3	-	151.0	147.0	146.5	148.2
Faisalabad	142.5	-	-	106.0	172.0	139.0
Mianchannu	133.5	-	-	134.0	-	134.0

VA = A coefficient to convert evapotranspiration pan data to evaporation pan data (1.0 in the example, Table 1).

CY = a counter to tell number of days between programme print out (10 days in the example, Table 1).

THK ARRAY = The thickness of the soil layers (cm) starting from the top (30, 30, 45, 45, in the example, Table 1).

WHC ARRAY = The fractional volumetric available water content for each depth increment.

BGMS ARRAY = Beginning soil water content at planting time.

The other input data include rainfall (RAIN), pan evaporation (EP), potential evaporation from a wet soil surface (ESP) and irrigation (IRR). Average values of rainfall and potential evaporation were taken over a 15-year period from the standard climatic information collected by WAPDA (1984) for Bhalwal, Bhakkar, Mianchannu and Faisalabad areas. The separation of EP from ESP and potential transpiration (T_p) from the plant were made as advised by Hanks (1974). The T_p was assumed to be equal to zero from planting until start of the growth. Computed data were compared with the actual field data for the same locations (PARC, 1982).

RESULTS AND DISCUSSION

Measured field data for ET and model simulations for Bhalwal are presented in Table 2 and Figures 1 and 2. For the three years data available, there is excellent agreement of measured and computed results throughout the growing season. Results for Bhakkar are depicted in Table 2 and in Figures 3 and 4. Field data were available for the years 1977 through 1979. Field data for all the three years agree closely to computations on a yearly as well as on an average bases. Table 2 and Figures 5 and 6 show a comparison of measured and computed ET data for 1978 and 1979 at Faisalabad. The computed data are in accordance with the measured data for the average of two years. However, the measured data show poor agreement with the computed data, especially after 100 days of planting. There is a large difference between years, as cumulative ET for year 1978 was 106 cm and for 1979 it was 172 cm. This difference indicates a possibility of involvement of some environmental, crop or soil

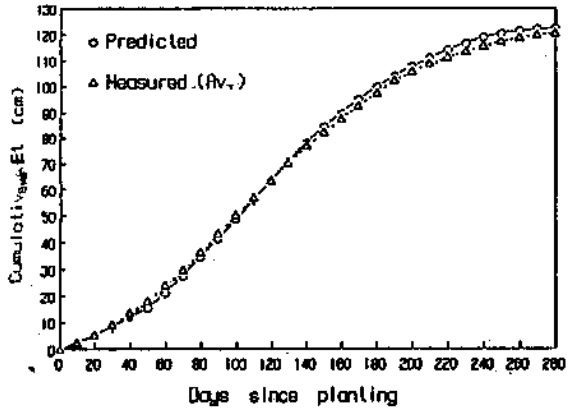

Fig. 1. Comparison of simulated and average of measured evapotranspiration (ET) for sugarcane at Bhalwal.

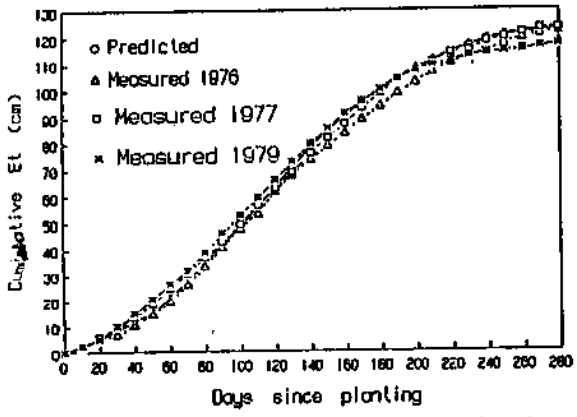

Fig. 2. Comparison of ET simulated and measured in 1976, 1977 and 1979 for sugarcane at Bhalwal.

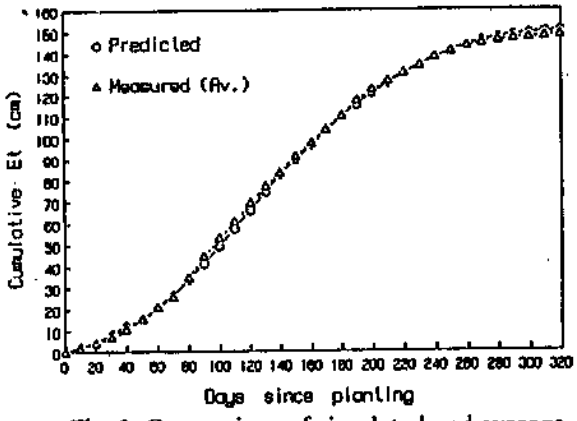

Fig. 3. Comparison of simulated and average of measured evapotranspiration (ET) for sugarcane at Bhakar.

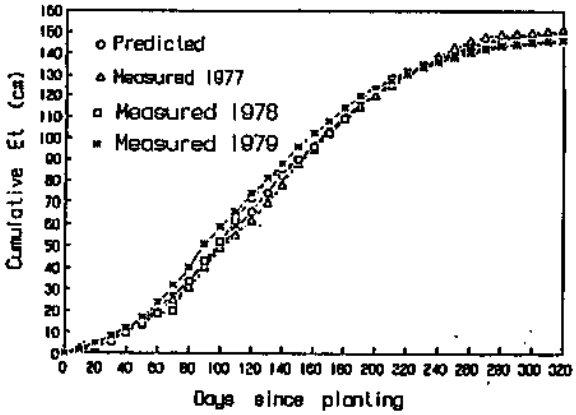

Fig. 4. Comparison of ET simulated and measured in 1977, 1978 and 1979 for sugarcane at Bhakar.

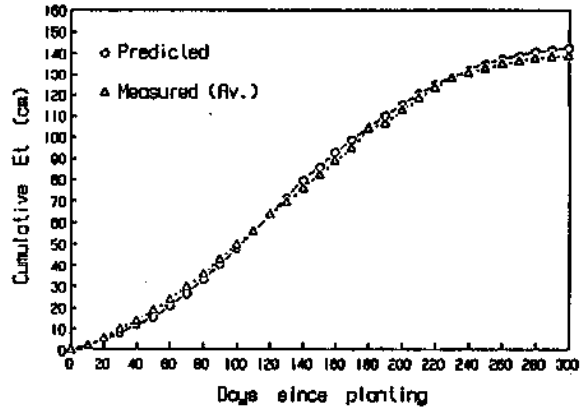

Fig. 5. Comparison of simulated and average of measured evapotranspiration (ET) for sugarcane at Faisalabad.

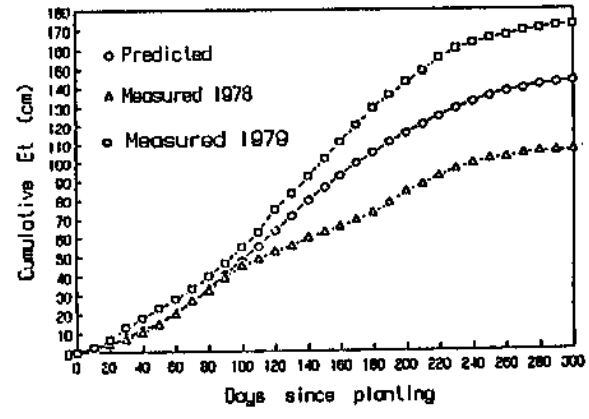

Fig. 6. Comparison of ET simulated and measured in 1978 and 1979 for sugarcane at Faisalabad.

Table 1. Input data and model simulation output for sugarcane crop, Bhakkar

Sugarcane crop Bhakar

Data taken from zone-3, Punjab, Pakistan.

DA = 200, AD = -2, AF = 0.5, RM = 150, PP = 100, VA = 1, CY = 10.

THK Array 30 30 45 45 45

WC Array 0.13 0.12 0.10 0.09 0.08

BGSM Array 3.9 3.6 4.3 3.8 3.4

DAY	RAIN	DAY	RAIN	DAY	RAIN	DAY	RAIN	DAY	RAIN	DAY	RAI	DAY	RAIN
7	1.00	21	0.13	49	0.51	77	0.79	84	0.51	98	0.74	105	1.47
126	4.00	133	3.00	140	1.57	147	1.17	154	2.70	161	3.00	168	3.00
175	2.50	189	3.00	196	1.65	0	0.00	0	0.00	0	0.00	0	0.00

DAY	EP	ESP	DAY	EP	ESP	DAY	YEP	ESP	DAY	EP	ESP	DAY	EP	ESP	DAY	EP	ESP	DAY	EP	ESP
1	0.45	0.45	11	0.57	0.56	21	0.67	0.59	31	0.71	0.57	41	0.73	0.48	51	0.74	0.28	61	0.74	0.16
71	0.76	0.09	81	0.81	0.08	91	0.83	0.08	101	0.86	0.08	111	0.87	0.08	121	0.89	0.09	131	0.87	0.08
141	0.73	0.07	151	0.72	0.07	161	0.69	0.07	171	0.65	0.07	181	0.60	0.06	191	0.57	0.06	201	0.53	0.05
211	0.49	0.05	221	0.44	0.05	231	0.39	0.04	241	0.35	0.05	251	0.27	0.04	261	0.23	0.04	271	0.19	0.04
281	0.14	0.03	291	0.10	0.03	301	0.08	0.02	311	0.08	0.03	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00

DAY	IRR	DAY	IRR	DAY	IRR	DAY	IRR	DAY	IRR	DAY	IRR	DAY	IRR	DAY	IRR
21	4.50	35	4.50	49	5.00	63	7.50	77	8.50	91	9.00	105	9.00	119	8.50
133	7.00	147	7.00	161	7.00	182	7.50	203	7.00	234	8.00	255	8.00	0	0.00

Output-Cumulations of the following:

Day	Irrig.	Rain	Drain	Tact	Tpot	Esact	ETact	ETpot	Epot
10.000	0.000	1.000	0.000	0.000	0.000	2.891	2.891	2.891	4.500
20.000	0.000	1.000	0.000	0.069	0.100	4.779	4.848	4.879	10.200
30.000	4.500	1.130	0.000	0.842	0.900	7.741	8.583	8.641	16.900
40.000	9.000	1.130	0.000	1.903	2.300	10.463	12.366	12.763	24.000
50.000	14.000	1.640	0.000	3.135	4.800	12.490	15.625	17.290	31.300
60.000	14.000	1.640	0.000	7.553	9.400	13.583	21.136	22.983	38.700
70.000	21.500	1.640	0.000	12.815	15.200	14.370	27.185	29.570	46.100
80.000	30.000	2.430	0.000	19.422	21.900	14.781	34.203	36.681	53.700
90.000	30.000	2.940	0.000	26.716	29.200	15.073	41.789	44.273	61.800
100.000	39.000	3.680	0.000	34.216	36.700	15.517	49.733	52.217	70.100
110.000	48.000	5.150	0.000	42.015	44.500	15.899	57.914	60.399	78.700
120.000	56.500	5.150	0.000	49.915	52.400	16.237	66.152	68.637	87.400
130.000	56.500	9.150	0.000	57.915	60.400	16.736	74.615	77.136	96.300
140.000	63.500	13.720	0.000	65.815	68.300	17.200	83.015	85.500	105.000
150.000	70.500	14.890	0.000	72.415	74.900	17.606	90.022	92.506	112.300
160.000	70.500	17.590	0.000	78.915	81.400	17.974	96.889	99.374	119.500
170.000	77.500	23.590	0.000	85.115	87.600	18.415	103.530	106.015	126.400
180.000	77.500	26.090	0.000	90.915	93.400	18.791	109.707	112.191	132.900
190.000	85.000	29.090	0.000	96.315	98.800	19.158	115.473	117.958	138.900
200.000	85.000	30.740	0.000	101.415	103.900	19.490	120.905	123.390	144.600

Yield (T/T_p) was 98.02% of Y_p

factors which caused a large variation within the data for the two years. Since model computations were made on average data, there can be no agreement in individual years due to climatic variability. Table 2 and Figure 7 show a comparison of computed and measured ET data for Mianchannu. Measured data show fairly good agreement with the simulated data all along the year.

The model predicted ET values for sugarcane are well within the range of ET requirements for maximum yield of this crop, reported by Doorenbos and Pruitt (1984) for different parts of the world. Similar results were obtained by Ahmed and Heerman (1988) who in their 10-year study estimated ET and yield for sugarcane crop for Sargodha region using different management strategies.

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