Mausam, (1985), 36, 1, 67-70

631. 92: 632. 116

Prediction of ET of some crops under semi-arid and dry sub-humid climates of Maharashtra

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(Received 18 April 1983)

सार — डूरेन्बोस तथा प्रइट (1977) के सिद्धांतों का उपयोग करते हुए जलवायु प्राचलों से महाराष्ट्र के तीन अर्धशुष्क तथा एक शुष्क एवं अल्पार्द्र जलवायु की जगहों में कुछ फसलों के वाष्पोत्सर्जन आकलित किये गए। ये मान खरीफ फसल के धान के लिये 483- 541 मि० मी०, गेहूं के लिये 278- 373 मि० मी० तथा ज्वार के लिये 373- 447 मि० मी० थे। जब इन आकलित मानों की लाइसीमीट्रिक प्रेक्षणों से तुलना की गई, तो ये मानों धान के लिए लगभग बराबर, गेहूं के लिये कम और ज्वार के लिए अधिक पाये गए। इस प्रकार अर्धशुष्क तथा शुष्क एवं अल्पार्द्र जलवायु के क्षेत्रों की विभिन्न फसलों के वाष्पोत्सर्जन में व्यापक विचरण का अनुमान किया जा सकता है।

ABSTRACT. The ET of some crops in three semi-arid and one dry sub-humid climatic locations of Maharashtra were obtained from climatic parameters using the guidelines suggested by Doorenbos and Pruitt (1977). The values were 483-541 mm for kharif rice, 278-373 mm for wheat and 373-447 mm for kharif jowar. When compared, the estimated values with lysimetric observations, the values were in close agreement for rice, lower for wheat and again higher for kharif jowar. A wide variation in crop evapotranspiration was observed from semi-arid to dry sub-humid climates.

1. Introduction

Information on evapotranspiration of crops of a region are needed for design and operation of irrigation projects. Knowing the area under each crop and their water requirements, it is possible to plan the water resources for storage and distribution from the reservoirs, ponds, lakes etc.

The crop evapotranspiration is defined as 'the depth of water needed to meet the water loss through evapotranspiration (ET crop) of a disease-free crop, growing in large fields under non-restricting soil conditions including soil water and fertility and achieving full production potential under the given growing environment' (Doorenbos and Pruitt 1977).

Owing to the difficulty of obtaining accurate field measurements, crop evapotranspiration is generally predicted based on climatic parameters. In a vast region like Maharashtra where the diversity of climatic and soil conditions are more, the estimations should be location specific. In the present paper the evapotranspiration of some crops at four locations in Maharashtra have been estimated and discussed in the following.

2. Methodology

The guidelines and methodology given by Doorenbos and Pruitt (1977) was followed for estimating the crop evapotranspiration (ET crop) of principal crops grown at Pune (Lat. 18°32'N & Long. 73°51' E; ht. above msl 559 m), Jalgaon (Lat. 21° 03' N & Long. 75° 34'E, ht. amsl 201 m), Akola (Lat. 20°42' N & Long. 77° 02' E, ht. above msl 282 m) and Nagpur (Lat. 21° 09' & Long. 79° 07' E, ht. above msl 310 m). The three step procedure was as follows :

(i) *The prediction of reference crop evapotranspiration (ET)*

The effect of climate on crop evapotranspiration was accounted by the reference crop evapotranspiration (ET) which is defined as 'the ratio of evapotranspiration from an extensive surface of 8 to 15 cm tall green cover of uniform height, actively growing, completely shading the ground and not short of water'. Out of the four methods, *viz.*, Blaney and Criddle, Radiation, Penman and pan evaporation methods recommended by them, the Penman's method has been used in the present anlysis.

The reference crop evapotranspiration has been computed using the weekly meteorological data (1946-1976) during different crop phases for principal crops grown at Pune, Jalgaon and Akola (semi-arid regions) and Nagpur (dry sub-humid). For the climatic conditions at these stations, the adjustment factor *C* ranges from 0.85 to 1.05 during non-rainy days and from 0.99 to 1.10 during rainy days. A mean value of 0.95 during 40th-22nd weeks and 1.05 during 23rd-39th weeks have been used.

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(*ii*) *Selection of crop coefficient* k_c

The crop coefficient k_c relates the predicted reference crop evapotranspiration (ET) to evaportranspiration of a disease free crop grown in large fields under optimum soil water and fertility conditions and achieving full production potential under the given growing environment. Therefore, ET crop was obtained by :

$$\text{ET crop} = k_c\text{ET}$$

The crop coefficients k_c will vary during different crop stages and hence the following stages of crop development were taken into account :

(*i*) Initial stage : Germination and early growth when the soil surface is not or is hardly covered by the crop.

(*ii*) Crop development stage : From end of initial stage to attainment of effective full ground cover.

(*iii*) Mid-season stage : From attainment of effective full ground cover to time of start maturity.

(*iv*) Late season stage : From end of mid season stage until full maturity or harvest.

The information on normal planting weeks for principal crops has been collected from the Agricultural Meteorology Division of India Meteorological Department, Pune. The k_c values for initial and development stage have been taken from the graph (Doorenbos and Pruitt 1977). The reference ET during initial crop stage was related to the k_c value for an assumed irrigation or rainfall frequency of 7 days. The k_c values for mid and late seasons have been taken as per the suggestion of Doorenbos and Pruitt (1977) whereas for the crop development stage by means of graphical smoothing.

(*iii*) *Factors affecting ET crop*

The important factors with which ET crop gets affected (Doorenbos and Pruitt 1977) are variations with time, distance and altitude, size of irrigation development-advection, level of available water, ground water, salinity of water etc.

Since the above factors singly or in combination modify the ET crop, these factors should be considered while applying the above information to specific locations and over larger areas.

3. Results and discussion

The estimated normal crop evapotranspiration (mm) for the principal crops grown at Pune, Akola and Jalgaon (semi-arid) and Nagpur (dry sub-humid) are given in Table 1.

The evapotranspiration values of kharif rice at Pune and Nagpur were 541.4 and 483.4 mm respectively. The predicted values for Pune were in agreement with measured ET values of 480 mm for rice in a similar climatic condition reported by Vamadevan and Dastane (1968). They also reported that out of the 1680 mm of water needed for rice 1200 mm were lost through percolation, and only 480 mm were actually used consumptively.

The estimated evapotranspiration of wheat crop were 309.8, 372.8, 293.0 and 278.3 mm at Pune, Jalgaon, Akola and Nagpur respectively. Lad and Kolbhor (1976) have been reported that the total consumptive use of water for wheat variety NI 744-19 sown at Pune, was ranging from 472 to 656 mm. The estimated values were lower than the reported values by 162 to 346 mm per season. The ET of wheat crop at Pune and Akola were examined by Venkataraman *et al.* (1976) based on the lysimetric observations during 1975-76. At the time of establishment of seedling the ET of wheat crop at Akola was 1.5 mm per day (against the estimated normal value of 2.0 mm per day) and it rises to about 4 mm/day (against the estimated normal value of 3 mm/day), when the crop is about 45 days old. From then ET rises from 5.5 to 11 mm/day (against 3-4 mm/day) of estimated normal values. The seasonal consumptive use value for wheat at Akola was 520 mm which is higher than the estimated value by 227 mm, and at Pune it was 460 mm which is also higher by 150 mm. Higher ET values of 1-2 mm/day measured from small lysimetric tanks can lead to higher seasonal consumptive use of the order 230-240 mm. At Rahuri in the State, the weighing lysimetric observations indicated the seasonal consumptive use of wheat as 404 mm during 1977-78 (Rajput 1981). The value was lower by 56-116 mm than the values reported by Venkataraman *et al.* (1976). Hence, it is necessary to use crop coefficients 1.15 and 1.25 during crop development and mid-season stages instead of 0.90 and 1.10 (Doorenbos and Pruitt 1977) to overcome the lower estimated values of crop ET for wheat.

The ET values of kharif jowar were 417.8, 447.1, 386.7 and 372.7 mm at Pune, Jalgaon, Akola and Nagpur respectively. The estimated values for crop

TABLE 1

Evapotranspiration values (mm) of some crops in Maharashtra

Name of crop	Planting week	Initial stage				Crop development stage				Mid-season stage				Late season stage				Total crop duration in weeks	Total crop ET (mm)
		A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D		
(a) Pune (Semi-arid region)																			
Rice	22	3	0.75	143.9	107.9	5	1.00	168.5	168.5	6	1.50	171.9	180.5	3	0.95	89.1	84.6	17	541.4
Wheat	44	2	0.52	50.7	26.4	5	0.90	107.1	96.4	7	1.10	151.8	167.0	3	0.25	80.0	20.0	17	309.8
Kharif Jowar	25	3	0.46	107.3	49.6	5	0.95	164.7	139.4	6	1.05	175.5	184.3	3	0.50	89.0	44.5	17	417.8
Rabi Jowar	38	3	0.52	88.4	45.9	5	0.90	137.1	123.4	6	1.00	124.8	124.8	4	0.50	84.3	42.2	18	336.3
Bajra	38	3	0.42	88.4	37.1	5	0.90	137.1	123.4	4	1.10	114.7	126.2	4	0.50	117.8	58.9	16	345.5
Maize	25	3	0.42	107.3	45.0	5	0.95	146.7	139.4	4	1.10	115.5	127.0	3	0.50	88.7	44.4	15	355.8
Potato (Rabi)	45	3	0.52	66.0	34.3	5	0.81	100.2	81.2	5	1.10	115.5	127.1	3	0.70	90.0	63.0	16	305.6
Cotton	24	4	0.44	151.2	66.5	9	1.00	262.2	262.2	9	1.15	256.0	294.4	8	0.65	166.2	108.0	30	731.1
Groundnut	28	3	0.52	90.7	47.1	5	0.85	142.4	121.0	4	1.00	117.8	117.8	4	0.55	116.6	64.1	16	350.0
Sugarcane	30	6	0.52	171.9	89.4	18	1.00	451.3	451.3	18	1.15	694.1	798.2	10	0.60	394.0	263.4	52	1575.3
(b) Jalgaon (Semi-arid region)																			
Wheat	41	2	0.52	67.8	35.2	5	0.90	143.8	129.4	7	1.10	171.3	188.4	3	0.25	79.2	19.8	17	372.8
Kharif Jowar	25	3	0.48	137.9	66.2	6	0.95	200.8	190.7	4	1.05	130.8	137.3	3	0.50	105.9	52.9	16	447.1
Bajra	38	3	0.42	105.9	44.5	5	0.90	159.3	143.4	4	1.10	103.3	113.6	4	0.50	96.0	48.0	16	349.5
Groundnut	28	3	0.42	107.2	45.0	5	0.85	159.0	135.1	4	1.00	135.7	135.7	4	0.55	135.7	74.6	16	390.4
Sesamum	42	3	0.42	95.9	40.3	4	0.80	108.8	87.0	3	1.00	69.7	69.7	3	0.40	74.2	29.7	13	226.7
Mung	28	2	0.42	71.4	30.0	4	0.85	129.4	110.4	4	1.05	130.8	137.3	2	0.45	70.3	31.6	12	308.9
Cotton	24	4	0.40	199.9	79.9	9	1.00	297.0	297.0	9	1.15	299.8	344.8	8	0.65	199.2	129.5	30	851.2
Banana	26	8	0.50	286.3	143.1	20	1.00	595.2	595.2	20	1.15	1005.0	1155.7	12	1.00	500.0	500.0	60	2394.2
(c) Akola (Semi-arid region)																			
Wheat	42	2	0.52	55.5	28.8	5	0.90	110.6	99.5	7	1.10	133.7	147.1	3	0.25	70.3	17.6	17	293.0
Kharif Jowar	29	3	0.45	94.3	42.4	6	0.95	182.2	173.1	4	1.05	124.6	130.8	3	0.50	80.7	40.4	16	386.7
Sesamum	42	3	0.45	80.7	36.3	4	0.80	86.3	69.0	3	1.00	53.8	53.8	3	0.40	59.9	23.0	13	182.1
Mung	28	2	0.45	67.2	30.2	4	0.85	122.0	103.7	4	1.05	122.6	128.7	2	0.45	62.2	28.0	12	290.6
Groundnut	28	3	0.45	100.0	45.0	5	0.85	150.5	127.9	4	1.00	123.5	123.5	4	0.55	117.9	64.8	16	361.2
Cotton	24	4	0.51	177.9	90.7	9	1.00	279.9	279.9	9	1.15	260.7	299.8	8	0.65	156.2	101.5	30	771.9
(d) Nagpur (Dry sub-humid region)																			
Rice	26	3	0.75	99.9	74.9	5	1.00	138.7	138.7	6	1.05	176.1	184.1	3	0.95	84.9	89.4	17	483.4
Wheat	43	2	0.52	52.5	27.3	5	0.90	104.2	93.8	7	1.10	126.9	139.6	4	0.25	70.6	17.6	17	278.3
Kharif Jowar	29	3	0.52	85.5	44.5	6	0.95	168.0	159.6	4	1.05	121.7	127.8	3	0.50	81.5	40.8	16	372.7
Groundnut	27	3	0.48	92.3	44.3	5	0.85	139.0	118.1	4	1.00	116.2	116.2	4	0.55	120.3	66.2	16	344.8
Cotton	25	4	0.43	139.5	60.0	9	1.00	253.5	253.5	9	1.15	249.9	287.4	8	0.65	146.0	94.9	30	695.8
Banana	25	8	0.50	251.5	125.7	20	1.00	501.4	501.4	20	1.15	682.7	785.1	12	0.80	462.2	369.7	60	1781.9

A : Duration in weeks B : k_c value C : Reference crop ET (mm) D : Crop ET (mm)

ET show that the kharif jowar at dry sub-humid climate of Nagpur has lesser value of crop ET than at semi-arid climatic location of Pune, Jalgaon and Akola. Sarker *et al.* (1976) reported that the seasonal consumptive use of water by kharif hybrid jowar at Akola was 330 mm. The water use rises rapidly from 20 days after planting till 65 days and reaches a peak at flowering and remain so till the late dough stage and with advancement of maturity. The ET/EP (EP refers to pan evaporation) ratios rise from 0.45 to 1.15 till the end of 34th week, after which due to moisture stress, decline in consumptive use started. Even at harvest time, the ratio is of the order of 0.95 (Sarker *et al.* 1976). The consumptive values of kharif jowar reported by them corroborates with the estimated normal crop ET at Akola.

Kadam *et al.* (1978) reported the consumptive use of different crops for Parbhani region. The consumptive use values given by them for cotton. H_4, sugarcane (suru) and banana (barai) grown in the area were 837.4, 2237.6 and 2538.3 mm. These values were higher than the present estimates.

Zende (1972) reported results of field investigations on a 12 month sugarcane crop variety Co 419 conducted at Padegaon during 1960-61 to 1962-63. The average water requirement of the crop was 2850 mm. The ET of sugarcane estimated for Pune which is a nearby station to Padegaon was found to be 1575 mm, showing there could be 1275 mm of percolation losses to satisfy a total water requirement of 2850 mm at Pune.

It was interesting to note that the long duration crop banana needs 1782 mm at Nagpur and 2394 mm at Jalgaon to meet its ET requirements. From this one can imagine, the difference in the economics of water to grow banana at two entirely different climatic locations.

The above comparative study between the estimated crop evapotranspiration and the lysimetric data indicate that the crop coefficients suggested by Doorenbos and Pruitt (1977) needs modification to predict the crop water requirements for the stations under study.

Acknowledgements

The authors wish to thank the Director, Agricultural Meteorology Division for kindly making available the weekly meteorological data for this analysis. The junior author duly acknowledges the University Grants Commission, New Delhi for awarding a fellowship during the period of the study.

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