

Evaluation of evapotranspiration and crop coefficient values for Sonalika wheat (HD 1553)

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(Received 23 January 1981)

सार - सोनालिका गेहूँ के फसल गुणांक और वाष्पोत्सर्जन के मानों को ज्ञात करने के लिए जबलपुर में तीन वर्ष तक लायसीमीटर अध्ययन किए गए। सोनालिका गेहूँ का औसत वाष्पोत्सर्जन 410.58 मि०मी० पाया गया और परिसीमा 353.51 मि०मी० से 488.51 मि०मी० तक रही। जबलपुर में सोनालिका गेहूँ के वाष्पोत्सर्जन के आकलन के लिए तीन वर्ष के आंकड़ों से ज्ञात किया गए फसल गुणांक के मान काफी हद तक समुचित हैं तथा यह संकेत मिला कि जबलपुर और उसके आस पास के क्षेत्रों में उसी पैदावार के सत्र में इसका उपयोग गेहूँ की अन्य किस्मों के लिए उपयोग में लाया जा सकता है।

ABSTRACT. For evaluation of evapotranspiration and crop coefficient values for Sonalika wheat, lysimeter study was done for three years at Jabalpur. The average evapotranspiration of Sonalika wheat was found to be 410.58 mm and the range was 353.51 mm to 488.51 mm. The crop coefficient values as evaluated from the three years' data were found quite suitable for estimating the evapotranspiration of Sonalika wheat at Jabalpur and it is suggested, can be used for other wheat varieties having the same growth season, at Jabalpur and nearby areas.

1. Introduction

The knowledge of evapotranspiration (ET or consumptive use) of wheat is necessary in planning farm irrigation and scheduling of irrigation. The consumptive use of water by wheat is dependent on the stage of growth of the crop, climatic factors and length of growth period. It increases with increase in plant growth, reaches a peak during mid-part of the growth period and then starts decreasing upto harvest.

Many research workers have estimated the evapotranspiration of wheat (Singh and Dastane 1971) at Delhi (Gupta 1975) at Jabalpur (Garg and Srivastava 1971) and (Kumar *et al.* 1974) at Hissar and have reported the consumptive use of water by wheat as 47.00, 41.00 (for Hira) and 40.07 cm (for Raj 911), 52.20 cm (at 60 per cent available soil moisture water regime) and 51.21 cm (for dwarf wheat HD-1941) respectively by soil sampling for soil moisture depletion approach by gravimetric method and by Blaney-cridle formula (Bapna and Khupse 1980) reported the ET of 35.88 cm and 39.12 cm at 60 and 80 per cent available soil moisture water regimes by soil sampling method respectively. The consumptive use of 46.00 cm for Sonalika wheat at Delhi, 46.60 cm for UP-215 wheat at Pune and 46.60 cm for Sonalika wheat at Akola based on lysimeter measurements was reported by India Met. Dep. Pune (Rep. No. 76/16) but

K-factor (crop coefficient) values were not reported.

The crop coefficient (*K*-factor value) which is defined as the ratio of evapotranspiration from the crop to the evaporation from a USWB class A pan has also been reported by a few research workers (Rajput 1979) reported the seasonal *K*-factor value of 0.98 and periodic values of 1.10, 1.30, 1.40, 1.30, 0.90 and 0.40 for 4 Jan, 24 Jan, 4 Feb, 14 Feb, 6 Mar and 25 Mar respectively for wheat grown in clay soil from field experiments at Jabalpur. As detailed values of ET and *K*-factor values are not available for each 5 or 10 per cent growth season values, an effort has been made to determine these values precisely from lysimeter study at Jabalpur.

The evaluation of *K*-factor values from the lysimeter study for 3 years' period at Jabalpur is the first scientific attempt, as far as the authors are aware, for finding out the *K*-factor values for each 5 or 10 per cent growth season values of Sonalika wheat.

2. Methods and materials

Weighing type lysimeters, two in number, having dimensions of 90 cm × 90 cm × 180 cm each, installed by the India Meteorological Department, Pune at J. N. Krishi Vishwa Vidyalaya Research Farm, Jabalpur were used for

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measuring the evapotranspiration (ET) of Sonalika wheat (HD 1553) for three years as given below :

year	Sowing date	Starting date of ET Measurement	Harvesting date
1976-77	11 Nov 1976	19 Nov 1976	24 Mar 1977
1977-78	13 Dec 1977	24 Dec 1977	7 Apr 1978
1978-79	15 Nov 1978	26 Nov 1978	3 Apr 1979

The Sonalika wheat was also grown in the area surrounding the lysimeters to the extent of 3 to 4 hectares. The daily ET measurements were recorded from two lysimeters at 7.30 A.M. and evaporation was recorded from USWB class A Pan installed in the nearby observatory. The rainfall data were also obtained from the observatory at J. N. Krishi Vishwa Vidyalaya Research Farm. There was no need to drain out excess water from the lysimeters.

From the ET and pan evaporation data, the crop coefficient values were calculated for three break-ups (a), (b) and (c) of the total growth period of 126 days in 1976-77, 105 days in 1977-78 and 129 days in 1978-79 as per standard procedure given in Bulletin No. 2, *A Guide for estimating irrigation water requirements* by Water Management Division, Ministry of Agriculture (Dep. of Agriculture), New Delhi. The three break-ups of the total growth period are (a), (b) and (c) which are given below :

For 126 days of 1976-77 — (a) 12+15+16+15+16+15+13+15+9=126 days, (b) 10+10+10+10+10+10+10+10+10+10+6=126 days and (c) 20+20+20+15+20+15+16=126 days;

For 105 days of 1977-78 — (a) 8+15+16+15+13+15+16+7=105 days, (b) 10+10+10+10+10+10+10+10+5=105 days and (c) 20+20+15+15+15+10+10=105 days;

For 129 days of 1978-79 — (a) 5+15+16+15+16+15+13+15+19=129 days, (b) 10+10+10+10+10+10+10+10+10+10+9=129 days and (c) 20+20+20+20+20+15+14=129 days.

These break-ups of total growth period were made to get as many crop coefficient values (*K*-factors) as possible for small growth periods from 10 to 20 days each. The *K*-factors obtained for small growth periods from ET and evaporation values for those periods (29 values for 1976-77, 26 values for 1977-78 and 29 values for 1978-79) were plotted against per cent growth season (per cent G.S.) separately for each year and best fit line was drawn. From the best fit lines, the *K*-factor values were read for 5, 10, 15,.....95 and 100 per cent G. S. for 1976-77, 1977-78 and 1978-79 years.

TABLE 1

Irrigation water applied, rainfall received, ET and wheat yield

Year	Water (mm) applied				Actual ET measured (mm)	Wheat yield (q/ha)
	(a)	(b)	(c)	Total		
1976-77	50.00	410.80	86.0	546.80	467.62	24.20
1977-78	75.00	123.48	160.2	358.68	322.85	21.60
1978-79	50.00	277.34	157.7	485.04	433.10	23.80

- (a) = Depth of irrigation water applied at sowing,
 (b) = Irrigation water applied later on and
 (c) = Rainfall received.

The *K*-factor values thus obtained for three years were again plotted against the per cent G.S. values in one graph and one best fit line was drawn through the points and *K*-factor values were read from it. The ET values were calculated by using the evaluated *K*-factor values and pan evaporation for three break-ups of the total growth season (a), (b) and (c) for each year for comparing with the actual ET values obtained from the lysimeter study for deciding the suitability of the evaluated *K*-factor values.

3. Results and discussion

Irrigation water was applied to lysimeters in addition to the rainfall received in three years as given in Table 1.

Table 1 reveals that 410.80 mm irrigation water was applied in addition to 50.00 mm irrigation water applied just after sowing and 86.0 mm rainfall water, making total water application of 546.80 mm in 1976-77 with total growth season of 126 days. As rainfall received was only 86.0 mm during the growth season of 1976-77, total irrigation water applied was 460.80 mm in addition to rainfall of 86.0 mm and actual ET measured was 467.62 mm in 1976-77 for 126 days total growth season. During the growth season of 1977-78, the total irrigation water applied was 198.48 mm in addition to timely rainfall of 160.2 mm in 105 days making the total water application of 358.68 mm and actual ET measured was 322.85 mm. The actual ET of 322.85 mm in 1977-78 was less than 467.62 mm in 1976-77 and 433.10 mm in 1978-79 because of the total growth period of 105 days as compared to 126 days in 1976-77 and 129 days in 1978-79. Similarly during the growth season of 1978-79, the total irrigation water applied was 327.34 mm in addition to rainfall of 157.70 mm, making the total water application of 485.04 mm and actual ET of 433.10 mm in total growth season of 129 days. The wheat yields obtained from lysimeters were 24.20, 21.60 and 23.80 quintals per hectare in 1976-77, 1977-78 and 1978-79 years respectively.

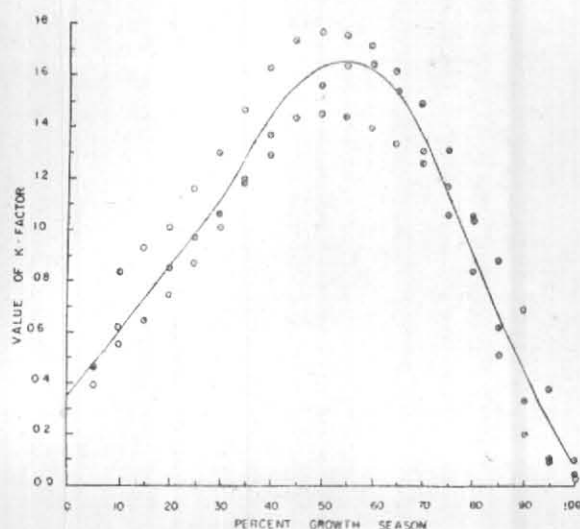


Fig. 1. Plot of per cent growth season vs K-factor values for three years period

TABLE 2
Values of K-factors evaluated from lysimeter study

Percent growth season	Values of K-factors for years				K-factor values read from best fitted curve
	1976-77	1977-78	1978-79	Average	
5	0.46	0.39	0.73	0.53	0.47
10	0.55	0.62	0.83	0.67	0.60
15	0.64	0.73	0.93	0.73	0.73
20	0.74	0.85	1.04	0.88	0.85
25	0.86	0.96	1.16	0.99	0.97
30	1.01	1.06	1.30	1.12	1.12
35	1.19	1.18	1.47	1.28	1.28
40	1.37	1.29	1.63	1.43	1.44
45	1.43	1.43	1.74	1.53	1.56
50	1.45	1.56	1.77	1.59	1.63
55	1.44	1.64	1.76	1.61	1.65
60	1.40	1.64	1.72	1.59	1.62
65	1.34	1.54	1.62	1.50	1.53
70	1.26	1.31	1.50	1.36	1.37
75	1.17	1.06	1.31	1.18	1.15
80	1.04	0.84	1.05	0.98	0.90
85	0.88	0.62	0.51	0.67	0.66
90	0.69	0.33	0.20	0.41	0.45
95	0.38	0.09	0.10	0.19	0.25
100	0.10	0.02	0.04	0.05	0.10

TABLE 3

Estimated and actual evapotranspiration values for three years

Year	Total growth period (days)	Estimated ET values for 3 break-ups of total growth season (mm)			Average	Actual ET value from lysimeter (mm)
		(a)	(b)	(c)		
1976-77	126	487.86	480.51	497.16	488.51	467.62
1977-78	105	352.33	355.09	353.73	353.51	322.85
1978-79	129	388.78	399.99	379.76	389.51	433.10
Average	120	409.657	411.863	410.217	410.58	407.86

(a)=126 days (9 break-ups), 105 days (8 break-ups) and 129 days (9 break-ups),

(b)=126 days (13 break-ups), 105 days (11 break-ups) and 129 days (13 break-ups) and

(c)=126 days (7 break-ups), 105 days (7 break-ups) and 129 days (7 break-ups).

The K-factor values were calculated from ET and pan evaporation data for three break-ups (a), (b) and (c) of total growth season of each year for three years separately. These K-factors (29 values for 1976-77) were plotted against per cent G.S. of three break-ups in one graph and best fitting curve was drawn through the points and values of K-factors were read from the best fit curve for 5, 10, 15....95 and 100 per cent G. S. values.

Similarly K-factor values were obtained for other two years 1977-78 and 1978-79 and they are given in Table 2 for three years and three years average values of K-factors were obtained as shown in Table 2.

The K-factor values of three years as given in Table 2 were again plotted against per cent G. S. values in one graph as shown in Fig. 1 and best fitting curve was drawn. The values of K-factors were read from this curve for 5, 10, 15....95 and 100 per cent G.S. values and they are given in Table 2. It was observed from Table 2 that the average K-factor values were very close to the values obtained from the curve and in some cases they were having the same values.

For checking the suitability of the K-factor values obtained from the best fitted curve, back calculations were done for estimating ET values for the three break-ups (a), (b) and (c) of the total growth season of 1976-77, 1977-78 and 1978-79 years for comparison with actual ET values obtained from the lysimeters and they are given in Table 3.

It is seen from Table 3 that the three years' average ET value of 410.58 mm was very close to the actual three years' average ET value of 407.86 mm. The three years' average values of

ET from three break-ups (a), (b) and (c) were 409.657 mm, 411.863 mm and 410.217 mm respectively were also very close to the actual three years' average ET value of 407.86 mm. The yearly average values of ET of 488.51 mm, 353.51 mm and 389.51 mm for 1976-77, 1977-78 and 1978-79 were also close to actual ET values of 467.62 mm, 322.85 mm and 433.10 mm respectively. Thus it was ascertained that the K-factor values obtained from the curve were quite suitable for estimating the ET values for Sonalika wheat at Jabalpur.

4. Conclusion

The evaluated crop coefficient values of 0.47, 0.60, 0.73, 0.85, 0.97, 1.12, 1.28, 1.44, 1.56, 1.63, 1.65, 1.62, 1.53, 1.37, 1.15, 0.90, 0.66, 0.45, 0.25 and 0.10 for per cent growth season of 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95 and 100 respectively were found quite suitable for estimating evapotranspiration of Sonalika wheat at Jabalpur and nearby regions. In absence of such data, these values can be used for other wheat varieties having about the same growth season for determining the evapotranspiration values. The evaluated crop coefficient factors for wheat crop are also very useful for determining evapotranspiration by the accepted methods such as modified Penman and Christiansen methods from pan evaporation or climatic data for Jabalpur and nearby regions for the purpose of scheduling irrigation and planning irrigation systems in irrigation project.

Acknowledgement

The authors express their gratitude and thanks to Shri P. G. Thorat, Scientific Officer and the Director of Agricultural Meteorology, India Met. Dep., Pune for supplying data and permission to prepare this paper.

References

- Bapna, J. S. and Khuspe, V. S., 1980, Effect of different soil moisture and nitrogen levels on moisture use by dwarf wheat, *The Mysore J. Agric. Sci.*, 14, 2, pp. 211-214.
- Garg, A. K. and Srivastava, S. P., 1971, Response of wheat (*Triticum aestivum* L.) to soil moisture regimes and N and K fertilization, *Univ. of Udaipur, Res. J.*, 9, p.80.
- Gupta, K. R., 1975, Effect of varying schedule and frequency of irrigation on growth, yield and quality of wheat varieties Hira and Raj 911, Unpublished thesis submitted for M.Sc. (Ag.) degree to J.N. Krishi Vishwa Vidyalaya, Jabalpur.
- Kumar, V., Bishnoi, O. P. and Moolani, M. K., 1974, Evapotranspiration for dwarf wheat (HD 1941) as related to pan evaporation and empirical methods, Inter-disciplinary UNDP Seminar on soil and water Management held at H.A.U., Hissar.
- Rajput, R. K., 1979, Research on Water Management and Soil Salinity, Progress Report of Integrated Project for Research on Water Management and Soil Salinity 1977-79, presented at Annual Workshop held at Hyderabad.
- Singh, N. P. and Dastane, N. G., 1971, Effect of moisture regimes and nitrogen levels on growth and yield of dwarf wheat varieties, *Indian J. Agric. Sci.*, 41, pp. 952-957.