Vol.10 No. 2, Page No. 80–84 (2021)
Received: September, 2021; Accepted: October, 2021

Growth Stage Specific Crop Coefficients of Wheat for Varying Soil Moisture Regimes in Central India

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Abstract

The object of the present study was to determine appropriate growth stage specific crop coefficients (Kc) of wheat corresponding to various methods of evapotranspiration estimates under different soil moisture regimes for central India. The Kc was computed for each growth stage as the ratio of field estimated actual evapotranspiration (ETa) to that of reference evapotranspiration (ETo). The field estimated values of evapotranspiration for wheat crop growth period under different soil moisture regimes computed by root water uptake method were taken asthe actual evapotranspiration (ETa). The reference evapotranspiration (ETo) values were estimated by using various prediction models (Modified Penman, Blaney-Criddle, Radiation, Modified Hargreave's, Christiansen and pan-evaporation) for corresponding growth period of wheat crop. The crop coefficients (Kc) for the actual field conditions and moisture regimes seems to be most realistic, particularly the Radiation method which gave crop coefficients closer to the field estimates of wheat crop.

Key Words: - Reference evapotranspiration, Actual evapotranspiration and Crop coefficient.

Introduction

Wheat (*Triticumaestivam*) is the most important food crop after rice in India and other South Asian countries. Yield and grain quality of wheat often suffers due to improper irrigation water management. The knowledge of crop water requirements is an important practical consideration which helps to improve irrigation management practices in limited water supply conditions[2]. To estimate crop water requirements, for irrigation scheduling and water allocation on a regional scale, the growth stage specific crop coefficients (Kc), which is the ratio of field estimated actual evapotranspiration (ETa) to that of grass reference evapotranspiration (ETo), is needed[6].

Reference crop coefficients are derived from literature may provide practical guideline for irrigation planning, but considerable error can takes place in determining crop water requirement due to their empirical nature. Therefore, it is essential to make corrections in crop coefficients values as per local environmental conditions for better determination of the actual crop water requirement[5].The present study has been under taken to determine appropriate growth stage specific crop coefficients (Kc) of wheat corresponding to various methods of evapotranspiration estimates under different soil moisture regimes for central India.

Materials and Methods

The field estimated values of evapotranspiration for wheat crop growth period (Last week of November to first week of April) under different soil moisture regimes (moist, moderate and drier) computed by root water uptake method were taken as the actual evapotranspiration (ETa). The reference evapotranspiration (ETo) values were estimated by using most commonly

accepted standard prediction models (Modified Penman, Blaney-Criddle, Radiation, Modified Hargreave's, Christiansen and pan-evaporation method) for corresponding growth period of wheat crop[2]. Both set of data (Eta & ETo) are presented in Table-1.

Table 1 Actual and Reference evapotranspiration (mm/day) for wheat crop growth period

DAS	Actual evapotranspiration (ETa)			Reference evapotranspiration (ETo)					
	Moist	Moderate	Drier	M-Pen	BL & CR	Radiation	M Harg.	Christ.	Pan-E
11	2.59	2.57	2.55	3.41	3.69	3.8	3.59	3.49	3.03
27	4.44	4.39	4.34	3.14	3.45	3.61	3.39	3.22	2.65
39	5.39	4.96	4.56	3.13	3.38	3.63	3.44	3.23	3.13
52	7.12	6.31	5.14	3.11	3.31	3.65	3.48	3.24	3.09
68	7.02	6.23	6.02	3.67	3.69	4.27	3.97	3.91	3.93
82	6.68	6.21	4.83	4.39	4.18	5.06	4.59	4.78	3.93
99	5.23	4.38	3.32	5.41	5.27	5.9	5.65	6.02	5.53
125	3.36	2.43	1.5	6.49	6.4	6.72	6.41	7.45	8.79

To evaluate appropriate growth stage specific (initial,crop development, reproductive and crop maturity) field estimated wheat crop coefficients (Kc) corresponding to various methods of evapotranspiration estimates under different soil moisture regimes for central India, the Kc was computed as the ratio of field estimated periodic values of actual evapotranspiration (ETa) under different soil moisture regimes (drier, moderate and moist)to the corresponding values of reference evapotranspiration (ETo) i.e. Kc = ETa/ETo (Table-2) and depicted in Fig 1 to 3 , along with the reference crop coefficients values for their better inter comparison[3].

Results and Discussion

Growth stage specific (Kc)

During the initial stage of crop growth covered the period from sowing through 28 DAS, the values of field estimated wheat crop coefficients increased from 0.68 to 1.3 in all the soil moisture regimes (Table-2). It could be due to low leaf area index during this stage of growth. During the crop development stage (35 to 70 DAS). Field estimated Kc values further increased from 1.2 to 1.77 in all the soil moisture regimes. It could be mainly due to soil heat flux that contributed energy for crop ET during wheat growth season which raised the Kc values to >0.1 from 5 to 10 week after sowing[8]. After 52 DAS, maximum crop coefficients values (1.47 to 2.25) were determined under different soil moisture regimesin all the methods of estimation. During the reproductive growth stage starting from 82 DAS, the values of field estimated wheat crop coefficients decreased slightly to 1.04 to 1.48. The values of crop coefficients declined rapidly to 0.35 to 0.38 in drier, 0.53 to 0.57 in moderate and 0.88 to 0.96 in moisture regimes during the crop maturity stage covering the period of 99 to 125 DAS[7].

Table 2 Crop Coeffcients (Kc =ETa/ETo) for Wheat under different moisture regime

DAS\ Kc	Mpen	BL&CR	Radition	Harg	Christ	Pan-E	Ref. Kc
Drier Regime							
11	0.75	0.69	0.67	0.71	0.73	0.84	0.3
27	1.38	1.26	1.20	1.28	1.35	1.64	0.5
39	1.46	1.35	1.26	1.33	1.41	1.46	0.7
52	1.65	1.55	1.41	1.48	1.59	1.66	0.88
68	1.64	1.63	1.41	1.52	1.54	1.53	1.05
82	1.10	1.16	0.95	1.05	1.01	1.23	0.85
99	0.61	0.63	0.56	0.59	0.55	0.60	0.65
125	0.23	0.23	0.22	0.23	0.20	0.17	0.2
Moderate Regime							
11	0.75	0.70	0.68	0.72	0.74	0.85	0.3
27	1.40	1.27	1.22	1.29	1.36	1.66	0.5
39	1.58	1.47	1.37	1.44	1.54	1.58	0.7
52	2.03	1.91	1.73	1.81	1.95	2.04	0.88
68	1.70	1.69	1.46	1.57	1.59	1.59	1.05
82	1.41	1.49	1.23	1.35	1.30	1.58	0.85
99	0.81	0.83	0.74	0.78	0.73	0.79	0.65
125	0.37	0.38	0.36	0.38	0.33	0.28	0.2
Moist Regime							
11	0.76	0.70	0.68	0.72	0.74	0.85	0.3
27	1.41	1.29	1.23	1.31	1.38	1.68	0.5
39	1.72	1.59	1.48	1.57	1.67	1.72	0.7
52	2.29	2.15	1.95	2.05	2.20	2.30	0.88
68	1.91	1.90	1.64	1.77	1.80	1.79	1.05
82	1.52	1.60	1.32	1.46	1.40	1.70	0.85
99	0.97	0.99	0.89	0.93	0.87	0.95	0.65
125	0.52	0.53	0.50	0.52	0.45	0.38	0.2

Comparison of Field estimated and Reference Crop Coefficients

In general, the values of field estimated wheat crop coefficients corresponding to various methods of ET estimates under different soil moisture regimes were quite higher (0.7 to 1.6 or 2.2) than the values of referenced crop coefficients (0.3 to 1.0), irrespective of the moisture regimes during early 80 days crop growth period**(Fig.1 to 3)**. Yet, the nature of both types of coefficients was identical during this early crop growth period.The differences between fields estimated crop coefficients and reference crop coefficients were maximum (nearly double) during peak values of evapotranspiration. In later period (close to maturity), the field estimated crop coefficients values for moderate and drier moisture regimes were merely equal or even less than the reference crop coefficients. However, the moist regime still maintained the highest values, in case of the most of the estimates. Further, the difference amongst the crop coefficients of different levels of moisture regimes were

not so apparent up to 70 days wheat growth period and did appear thereafter[1].

A comparison of field estimated crop coefficients and the reference crop coefficients of wheat crop **(Fig.1 to 3)**clearly indicated that the field estimated crop coefficients corresponding to Radiation estimate were much closer to the reference crop coefficient during all crop growth stages, and in all regimes[9]. The differences amongst the reference & field estimated crop coefficient were maximum in case of Pan-evaporation.Field estimated crop coefficients values for Modified Penman estimate and Christiansenestimate showed much similarity, however,Modified Penman estimate was more symmetrical than Pan-evaporation estimates.Actual field estimated wheat crop coefficients values of Radiation estimate was much similar to Modified Hargreavesestimate, as it also expressed more symmetry than Blaney – Criddle estimate during wheat growth period. Similar trend has also been reported for winter wheat[4].The result of this study can be used for similar environmental conditions and could help improve the link between crop coefficients and empirical approaches to assess the water requirement of wheat crop over the growing season.

FIG 1 Crop Coefficients (Kc) for Wheat crop growth period under moist regime

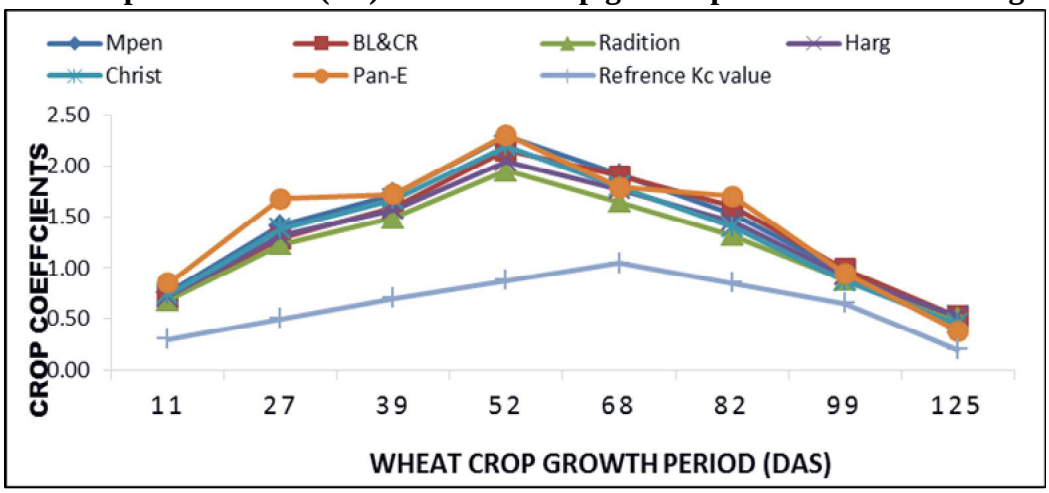


FIG 2 Crop Coefficients (Kc) for Wheatcrop growth periodunder modrate regime

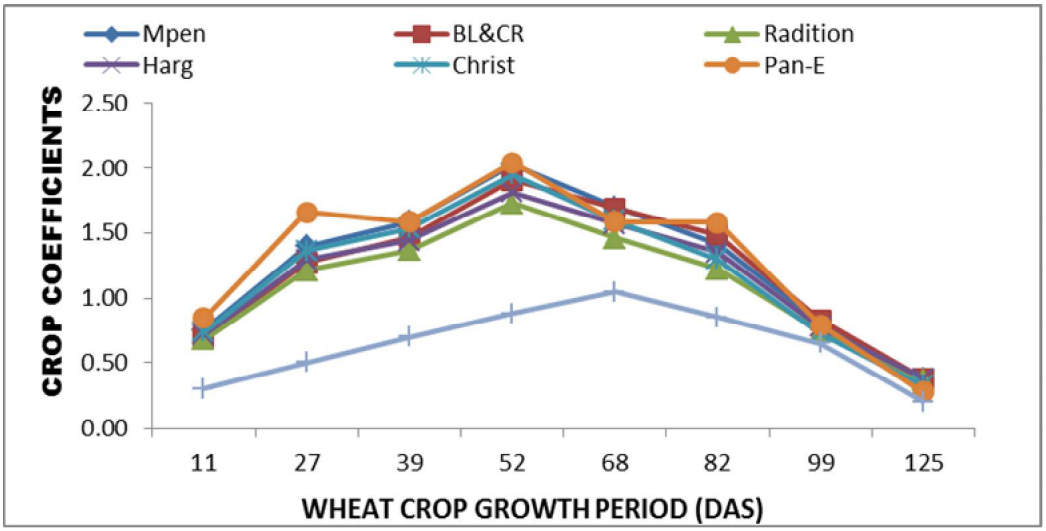
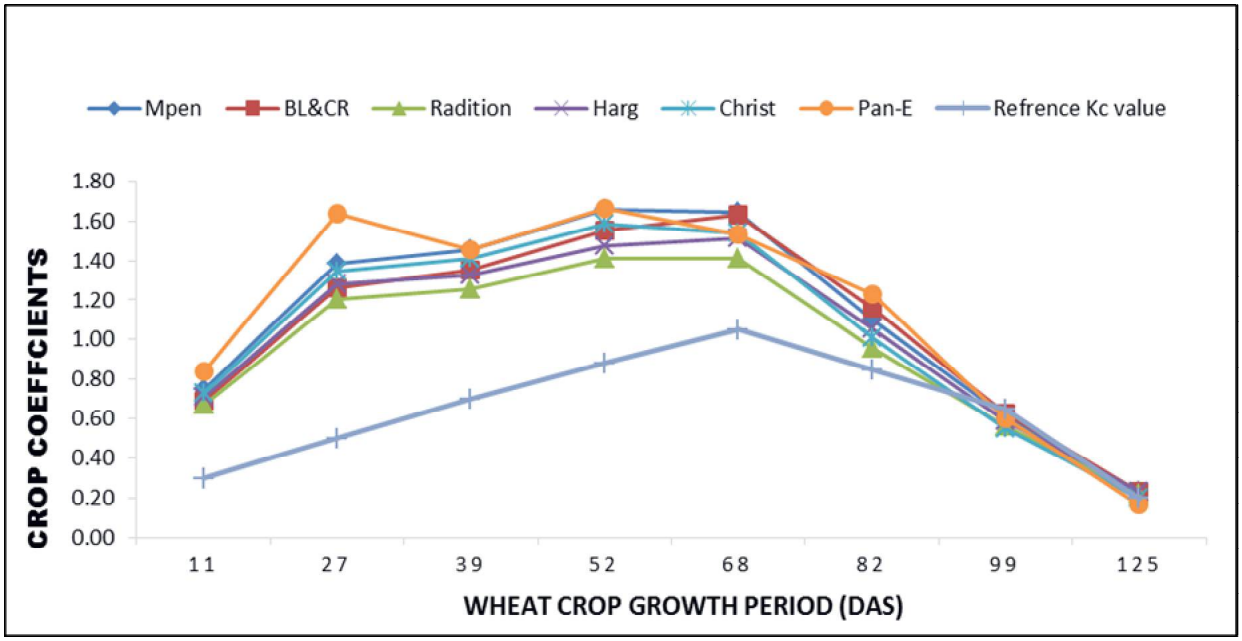


FIG 3 - Crop Coefficients for Wheat crop growth period under drier regime



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