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Crop Coefficients of Summer Mung for Different Soil Moisture Regimes in Central India

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Abstract

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

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

Introduction

Mung (Vignaradiata L.) is the most important pulse crop after chickpea and pigenpea in India .Usually, there are two season for the mung cultivation in central and northern part of country i.e. summer and kharif, for which the mung production is higher as compared to kharif season. The reason behind for this, the monsoon oriented problems like greater insect-pest attack and disease infestation, whereas, short duration summer mung varieties have not faced such problems due to harsh temperature and low relative humidity (Bhat et al,2021). Yield and grain quality of summer mung often suffers due to improper irrigation water management. Therefore, the frequent irrigation is very essential for the growth and development of summer grown crop (Rao and Singh, 2003).

To estimate actual crop water requirements for irrigation scheduling and water allocation on a regional scale, the growth stage specific crop coefficients (Kc) is a key factor, which dictates the evapotranspiration of the crop with the change in crop canopy and local climatic conditions (Allen et al,2011a) . But there is no specific crop coefficient for summer grown mung crop. Reference crop coefficients values of mung crop published by FAO are valid for kharif season and not for summer. Therefore, the present study aimed to determine new crop coefficient values of summer mung for better estimation of the actual crop water requirement corresponding to various prediction methods and soil moisture regimes in central India.

Materials and Methods

To determine appropriate growth stage specific (initial, development, mid season and late season) crop coefficients (Kc) of summer mung for different soil moisture regimes corresponding to various methods of evapotranspiration estimates in central India, the Kc was computed as the ratio of field estimated periodic values of actual evapotranspiration (ETa) under different soil moisture regimes to the corresponding values of reference evapotranspiration (ETo).Thus, Kc = ETa/ETo.

The field measured values of evapotranspiration for summer mung crop growth period (First week of April to last week of June) under different soil moisture regimes (drier, moderate, moist) computed by root water uptake method (Kauraw and Gupta, 1985) were taken as the actual evapotranspiration (ETa) in this study. The reference evapotranspiration (ETo) values were estimated by using most commonly accepted standard evapotranspiration estimates (Modified Penman, Blaney-Criddle, Thornthwaite, Radiation, Modified Hargreave's, Christiansen and pan-evaporation method) for corresponding growth period of summer mung crop. Both set of data (ETa&ETo) are presented in Table-1.

The computed Kc values of summer mung for different soil moisture regimes (drier, moderate, moist) corresponding to various methods of evapotranspiration estimates are presented in Table-2 and depicted in Fig. 1 to 3, along with the reference crop coefficients values for their better inter comparison.

FIG 1 - CROP COEFFICIENTS OF SUMMER MUNG FOR DRIER REGIME

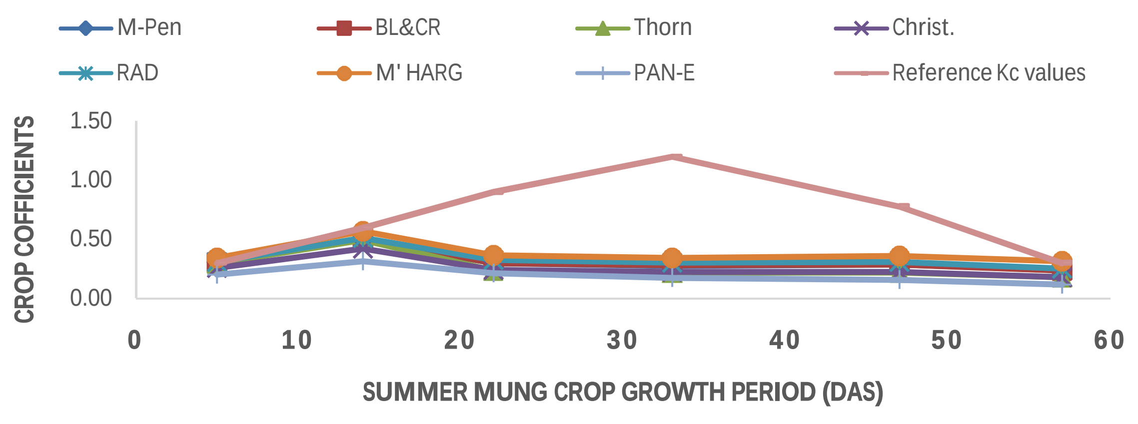
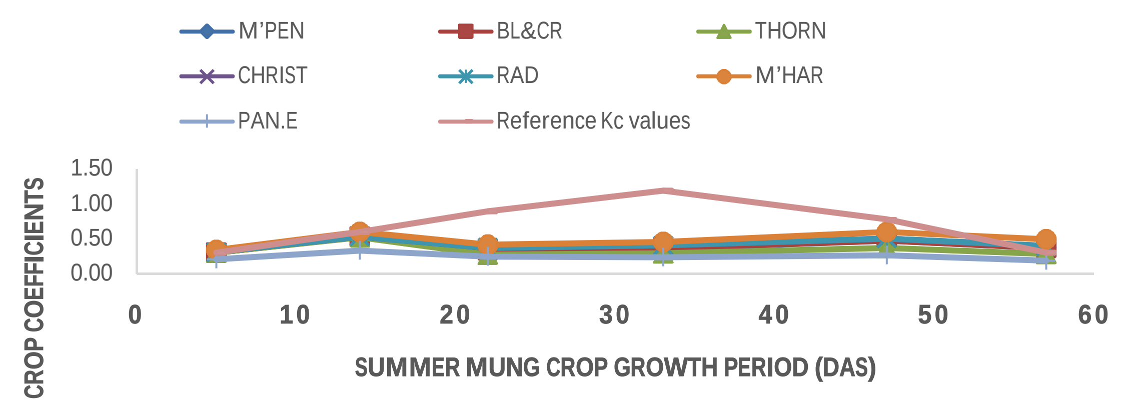
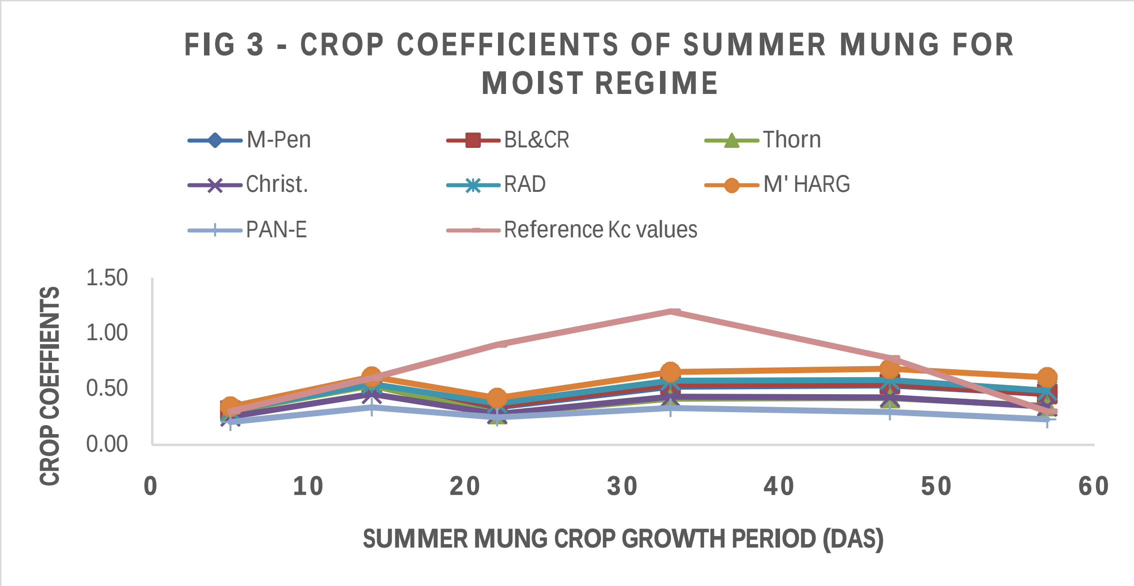


FIG 2 - CROP COEFFICIENTS OF SUMMER MUNG FOR MODERATE REGIME





Results and Discussion

Reference crop evapotranspiration (ETo)

The ETo values (Table-1) representing the various empherical/climatological estimates were fairly higher (6 to 14 mm/day) even early plant growth period (70 DAS) of summer mung crop. Such a nature of ETo is due to high atmospheric demand normally prevailing during this period (Dixit et al., 2003). Also these estimates possessed an increasing tendency with advancing crop growth period mainly due to the increase in air temperature, wind velocity and decrease in relative humidity. The values for Pan-E estimates were the highest and ranged between 11.3 to 14.3 mm/ day. Thronthwaite or Christiansen estimates occupied the next position with minimum values (5.4 to 6.8 mm/day) in Modified Hargreave's estimates. In agreement to that Singandhupe andAnand (2016) also observed similar behavior of the various reference evapotranspiration (ETo) model for the actual atmospheric evaporative demands (AED).

Table 1 Actual and Reference evapotranspiration (mm/day) for summer mung growth period

DAS	Actual evapotranspiration (ETa)			Reference evapotranspiration (ETo)						
	Drier	Moderate	Moist	M-Pen	BL&CR	Thorn.	Christ.	Radiation	M Harg.	Pan-E
05	2.30	2.30	2.30	7.56	7.48	7.65	8.99	7.44	6.69	11.28
14	3.80	4.01	4.10	7.56	7.48	7.65	8.99	7.44	6.69	12.12
22	2.48	2.83	2.89	8.45	8.21	10.44	10.25	7.66	6.82	11.65
33	2.34	3.11	4.47	8.54	8.28	10.72	10.38	7.68	6.83	13.46
47	2.26	3.73	4.27	7.95	7.81	10.16	10.04	7.29	6.23	14.32
57	1.71	2.68	3.30	7.17	7.18	9.42	9.59	6.77	5.42	14.40

Actual crop evapotranspiration (ETa)

Actual evapotranspiration (ETa) values of summer mung crop indicated a sharp increase with plant age during early 20 days period (Table-1). They attained peak value (about 4 mm/day) in all soil moisture regimes. However, this rise of

'ET' values continued only in moderate and optimum moisture regimes for a longer growth period up to 50 DAS. if soil moisture conditions have not significantly restricted the water supply to the plant root. In case of drier regimes, actual ET values decreased significantly (up to 1.71 mm/day) at any crop growth stage under water stress condition. Such a behavior of 'ET' is attributed to the prevailing high atmospheric evaporative demand at early plant age of summer mung which further continued to increase till the pod development stage and marginally reduced near crop maturity (Rao and Singh,2003) and its interaction to the soil factors under limiting soil moisture conditions.

Crop coefficients (Kc)

The data indicated (Table-2) that the field estimated crop coefficients (Kc) values of summer mung are higher at the initial stage (sowing to 15 DAS) in all soil moisture regimes when soil is wet due to post emergence irrigation, and low when the surface soil is dry due to high evaporative demand. During the crop development stage (16 to 32 DAS), field estimated Kc values decreased in all soil moisture regimes. It could be due to smaller leaf area and reduced transpiration during this stage of growth (Srinivas and Tiwari, 2018).During the mid season stage (33 to 53 DAS), Kc values continued to decrease in drier regime due to soil moisture stress, whereas, significantly increased in moderate and optimum moisture regimes. It could be attributed to increase in crop canopy which raised transpiration (Rao and Singh, 2003). At the late season stage (54 to 67 DAS), Kc values (0.12to 0.61) were decreased steadily due to crop maturity and retarded plant physiological activities under different soil moisture regimes in all the methods of estimation.

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

DAS\ Kc	M'PEN	BL&CR	THORN	CHRIST	RAD	M'HAR	PAN.E	Reference Kc values
Drier Regime								
05	0.30	0.31	0.30	0.26	0.31	0.34	0.20	0.3
14	0.50	0.51	0.50	0.42	0.51	0.57	0.31	0.6
22	0.29	0.30	0.24	0.24	0.32	0.36	0.21	0.9
33	0.27	0.28	0.22	0.23	0.30	0.34	0.17	1.2
47	0.28	0.29	0.22	0.23	0.31	0.36	0.16	0.78
57	0.24	0.24	0.18	0.18	0.25	0.32	0.12	0.3
Moderate Regime								
05	0.30	0.31	0.30	0.26	0.31	0.34	0.20	0.3
14	0.53	0.54	0.52	0.45	0.54	0.60	0.33	0.6
22	0.33	0.34	0.27	0.28	0.37	0.41	0.24	0.9
33	0.36	0.38	0.29	0.30	0.40	0.46	0.23	1.2
47	0.47	0.48	0.37	0.37	0.51	0.60	0.26	0.78
57	0.37	0.37	0.28	0.28	0.40	0.49	0.19	0.3
Moist Regime								
05	0.30	0.31	0.30	0.26	0.31	0.34	0.20	0.3
14	0.54	0.55	0.54	0.46	0.55	0.61	0.34	0.6
22	0.34	0.35	0.28	0.28	0.38	0.42	0.25	0.9
33	0.52	0.54	0.42	0.43	0.58	0.65	0.33	1.2
47	0.54	0.55	0.42	0.43	0.59	0.69	0.30	0.78
57	0.46	0.46	0.35	0.34	0.49	0.61	0.23	0.3

The values of field estimated crop coefficients for different estimates recorded are as follows. The lowest values were recorded in Pan evaporation (0.12 to

0.34) followed by Christiansen (0.18 to 0.46),Thronthwaite (0.18 to 0.54), Blaney-Criddle (0.24 to 0.55), Modified Penman (0.24 to 0.54), Radiation {0.25 to 0.59) , and Modified Hargreaves (0.32 to 0.69). Further, this differences in moist to moderate or drier regimes (these were identical) were generally larger in case of Modified Hargreaves, Modified Penman, Blaney & Criddle, and Radiation estimates, and minimum in case of Pan-evaporation, followed by Christiansen and Thronthwaitemethod's estimates.

To conclude, the field estimated crop coefficients values of summer mung crop are much smaller than the reference values, particularly during peak crop growth period(Fig-1 to 3). It is attributed to the nature of AED which remained quite different in summer season. Therefore, the reported crop coefficients when used, overestimated the actual ET rates. Since, in summer months the prevailing high evaporative demands resulted in to high values of reference evapotranspiration through various estimates. However, the growing crop 'ET' is mainly controlled by the plant factor under optimum soil moisture conditions and, both plant and soil factors under limiting soil moisture conditions (Allen et al, 2011a). In general, the crop plants limit the 'ET' rate at peak values of 'AED' (at noon time) through their physiological processes and adoption. Therefore, the actual crop evaptranspiration rate appeared quite less than the reference values. This requires the smaller values of crop coefficients for summer season crop to ascertain the actual values of 'ET.' Thus, the field values of crop coefficients were evaluated for summer season in the present study.

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