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Crop Water Requirement and Crop Coefficients of Chickpea under Subtropical Rainfed Condition

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Abstract

The crop water requirement i.e. crop evapo-transpiration (ETc) of chickpea crop growth cycle were predicted by different internationally recognized empirical/ climatic models (Modified Penman, Blaney-Criddle, Radiation, Modified Hargreave's, Christiansen and Pan-evaporation method).The actual water requirement i.e. actual evapo-transpiration (ETa) under field conditions for chickpea growth cycle were determined by root water uptake method. The periodical behavior of empirical/climate estimates (ETc) was similar to the field estimate (ETa) except that the values of ETa were instantaneously high during most of the crop growth period. However, it was symmetrical during late season stage. The behavior of ETa/ETc ratios corresponding to various climatic estimates was generally identical throughout the chickpea growth cycle. The ratios of field estimates with Radiation estimates were closer to the unity than the other climatic estimates. The field estimated crop coefficients (Kc) corresponding to Radiation estimate were much closer to the FAO's crop coefficient values during all growth stages of chickpea crop.

Key Words: Crop water requirement, Actual water requirement, ETa/ETc ratio, Crop coefficient (Kc).

Introduction

The precise assessment of crop water requirement is an important factor for judicious water management. The irrigation scheduling based on crop evapo-transpiration (ETc) is widely used by hydrologist in a watershed. Many empirical models built on climatic data are commonly used for the estimation of Etc[3]. Yet, their accuracy and precision depend on how best these estimates are tested with the field measured actual values of evapo-transpiration (ETa).Only few comparisons under limited field situations are available[8]. It also takes into account that location and growth stage specific crop coefficient plays a great role in accurate estimation of crop water requirement[6]. This study aims to assess accurate estimate of water requirement and crop coefficients for chickpea (*Cicer arietinum*) crop grown under subtropical rain fed condition of Central India.

Materials and Method

The crop water requirement (ETc) of chickpea crop growth cycle (first week of December to third week of March) were predicted by multiplying the reference evapo-transpiration (ETo) values with the FAO's values of crop coefficients (Kc). For this purpose, ETo values of corresponding chickpea crop growth cycle were estimated by different internationally recognized empirical evapotranspiration (ET) models/climatic estimates (Modified Penman, Blaney-Criddle, Radiation, Modified Hargreave's, Christiansen and Pan-evaporation method) and

presented in Table-1 with the FAO's crop coefficients (Kc) values obtained[3].

Table 1 Reference Evapotranspiration (mm/day) and Kc values for chickpea crop growth period

PERIOD (DAS)	M'PEN	BL&CR	CHRIST	RAD	M'HAR	PAN.E	FAO's Kc values
06	3.20	3.47	3.33	3.72	3.34	3.0	0.25
22	3.20	3.42	3.33	3.72	3.33	3.0	0.67
42	3.21	3.14	3.31	3.71	3.25	2.9	1.14
62	3.89	3.77	4.07	4.36	3.81	3.6	0.93
85	4.69	4.58	5.01	5.1	4.53	4.5	0.50
113	6.68	6.94	7.77	7.03	6.38	7.8	0.27

The actual water requirement (ETa) under field conditions for corresponding chickpea crop (irrigated as pre-emergence) growth cycle were determined by root water uptake method[5]. The computed ETa were taken as the standard for comparison with the ETc obtained by different climatic estimates (Fig.1).The ETa/ETc ratios were also illustrated (Fig.2) for their better comparison. The growth stages (initial, development, mid and late season) specific crop coefficients (Kc) as the ratio of actual evapotranspiration (ETa) to reference evapotranspiration (ETo) were also developed for subtropical rain fed condition of Central India and compared with FAO's Kc values (Fig.3).

Results and Discussions

Empirically Estimated Crop water requirement (ETc)

The periodic behavior of the various empirical/climate estimates(Table-2) indicated that the ETc values sharply increased with chickpea crop growth period and continued till it attained peak value at about 42 DAS(Fig.1). Thereafter, it remained merely constant up to 62 DAS (3.89 to 4.97 mm/day) and then registered a sharp decrease with crop maturity. The Radiation method was predicted maximum value (4.23 mm/day) of ETc, followed by Christiansen and Modified Hargreave's method. However, other estimates rarely approached up to 3.60 mm/day. Pan-evaporation estimates normally occupied the lowest position during most of the chickpea growth period[8].

Table 2 Crop Evapotranspiration (mm/day) and field values for chickpea crop growth period

DAS	M'PEN	BL&CR	CHRIST	RAD	M'HAR	PAN.E	FIELD ET
06	0.8	0.87	0.83	0.93	0.84	0.75	2.11
22	2.14	2.29	2.23	2.49	2.23	2.01	3.64
42	3.66	3.58	3.77	4.23	3.71	3.31	6.53
62	3.62	3.51	3.79	4.05	3.54	3.33	4.1
85	2.33	2.29	2.51	2.55	2.27	2.25	2.58
113	1.8	1.87	2.01	1.9	1.84	2.11	1.94

Field Measured Actual water requirement (ETa)

The periodic behavior of the field measured values of actual water requirement (ETa) emphasized that the magnitude of increase in ETa values (Fig.1) were instantaneously high (6.53 mm/ day) at crop development stage (42 DAS).It is attributed to large leaf area index at this stage of growth (Mehta et al, 2016) . Thereafter, a sharp decline of ETa rate was noticed at mid season growth stage. However, the magnitude of decline at the late season stage was symmetrical in both types of ET estimates.

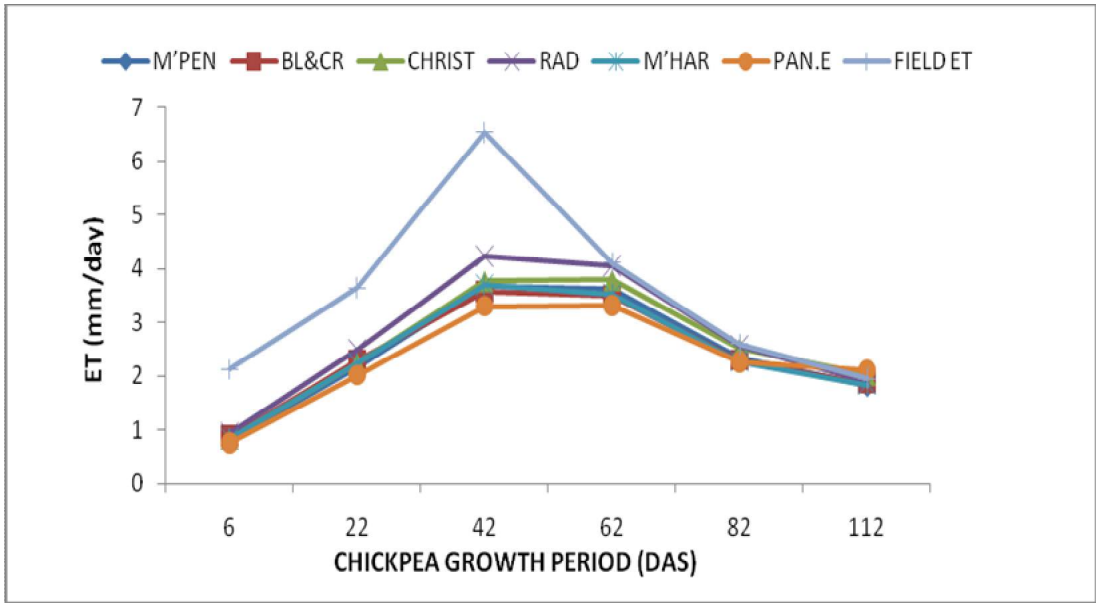

Fig-01 ET Estimates for Chickpea growth period

ETa/ETc Ratios

The ratios amongst the field estimates (ETa) to each of the climatic estimates for concurrent crop growth period were plotted (Fig 2). The behavior of ETa/ETc ratios corresponding to various climatic estimates were generally identical and throughout the chickpea growth cycle. The ratio (ETa/ETc) of field and climatic estimates were fairly higher during initial plant age and continued to decrease up to 22 DAS. Thereafter, the ratios attended relatively static value (1.5 to 1.9) during crop development stage up to 42 DAS. Yet a sharp decline of the ratios was observed at about the pod development stage of crop growth up to 62 DAS. Later, it again stabilized closer to unity with crop maturity.

Amongst the six empirical/climatic modals, the Radiation modal predicted field measured values more precisely (nearer to the unity) during all the stage of chickpea growth cycle and the Pan-E estimate deviated the most. Remaining empirical modals (Blany-Criddle, Modified Hargreaves, Christiansen and Modified Penman methods) were observed to the identical with each other irrespective of gram growth stages[2].

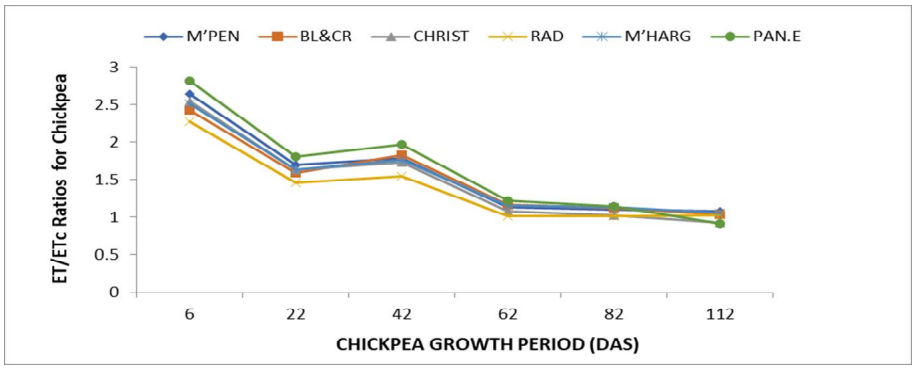

Fig-02 ETa /ETc ratios for Chickpea growth period

Crop Coefficients (Kc)

The periodic behavior of field estimated crop coefficients of chickpea corresponding to different climatic estimates with FAO's crop coefficients was not symmetric. During initial stage the FAO's crop coefficients was about 0.25, whereas field measured values ranged between 0.57 (Radiation) to 0.70 (Pan-E). It could be due to small leaf area during this stage of growth (Mehta et al, 2016). During the crop development stage (22 to 42 DAS) the differences between field estimated crop coefficients and the FAO's crop coefficients were maximum (nearly double). At peak rate of evapotranspiration (42 DAS), the FAO's crop coefficients was 1.14, and the field estimated crop coefficients values recorded minimum in case of Radiation (1.76) and maximum in case of Pan-E (2.25). It could be mainly due to large leaf area, which provides maximum opening of stomata for transpiration and simultaneously soil factors also governed evapotranspiration rate during this growth stage[6]. During the mid-season (reproductive growth) stage starting from 62 DAS, the values of field estimated chickpea crop coefficients decreased slightly to 0.94 to 1.18. The values of crop coefficients declined rapidly to 0.51 to 0.25 in all the climatic estimates during the late season (crop maturity) stage covering the period of 82 to 113 DAS. Similar trends of chickpea crop coefficients[7, 4].

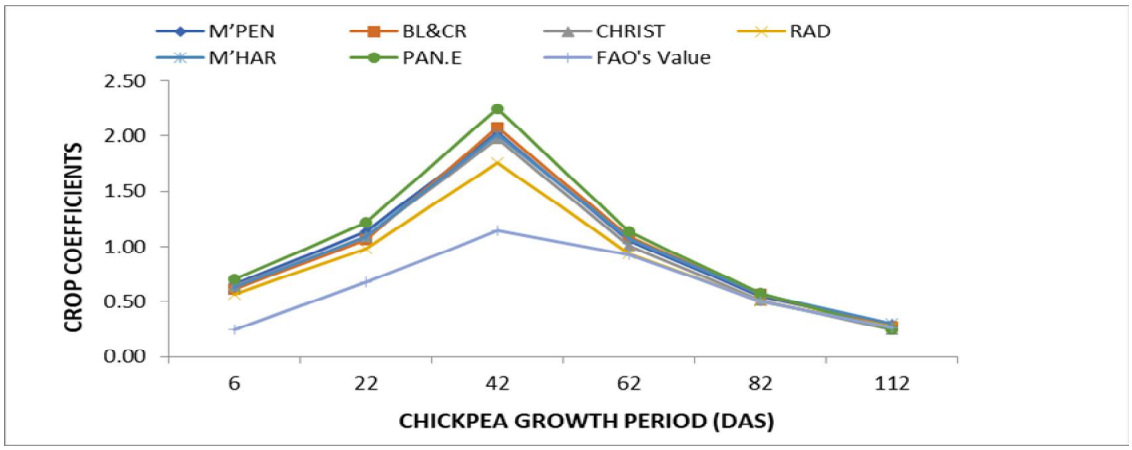

Fig-03 Field estimated crop cofficient for Chickpea growth period

A comparison of field estimated crop coefficients and the FAO's crop coefficients of chickpea crop (Fig. 3) clearly indicated that the actual values of field estimated crop coefficients corresponding to Radiation estimate were much closer to the FAO's crop coefficient values during all crop growth stages. Whereas, the differences were maximum in case of Pan-evaporation estimates. However, the field estimated crop coefficients evaluated for Christiansen, M'Hargreaves, M'Penman and Blaney & Criddle, estimate were quite symmetrical in nature. Pimpale et al (2014) also reported similar trend of spatial crop coefficients values over the chickpea crop growth cycle. The result of this study can be used for similar environmental conditions for precise assessment of the water requirement of chickpea crop over the growing season.

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