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Evapotranspiration Estimates and Crop Coefficients for Linseed under Various Soil Moisture Regimes in Central India

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Abstract

The reference crop evapotranspiration (ETo) of linseed crop was determined by most commonly and widely accepted empirical/climatic methods. ETo values were fairly low (< 3.75 mm/day) and constant during early half spell period (up to 55 DAS), thereafter, increased till crop maturity. Field and climatic estimates of evapotranspiration (ET & ETc) values increased with plant age up to 55 DAS and may continued up to 65 DAS under different regimes. The magnitude of decline of field estimated values was relatively smaller in drier regimes than those recorded from moist regimes. The ratio of field and climatic estimates (ET/ETc) were fairly higher during initial crop age & continued to decrease with plant age up to 30 DAS. In drier regimes the ET/ETc ratio attended relatively static value closer to unity, during peak rate of ET. Under moderate moist regimes the ratio stabilized closer to the value of 1.9-2.5, which decreased sharply near maturity. In general, the ET/ETc ratios of field estimates with Radiation estimates were closer to the unit value than the other climatic estimates, in all regimes. The crop coefficients (Kc) for the actual field conditions, and variable moisture regimes seems to be most realistic, particularly the radiation methods which gave crop coefficients closer to the field estimates of linseed crop.

Key Words:- Evapo-transpiration, ET/ETc ratio, Crop coefficient (Kc).

Introduction

The evapotranspiration rate and, thus, the water consumption by the crops in a watershed is an essential component for an effective and judicious water management. Empirical estimates are commonly used for the purpose, yet their reliability and precision depend on how best the empirical estimates are tested with the field estimates. However, due to limited precise data on the effect of soil moisture status on the actual water use of linseed crop in field conditions, the development and application of decision support systems, for conditions where shortage of water is important, gets hindered[2]. Only few comparisons under limited field situations are available. It also takes into account site specific crop coefficient which plays a great role in estimating actual crop evapotranspiration[5]. This study aims to determine reliable estimate of evapotranspiration and appropriate crop coefficients for linseed crop grown in various soil moisture regimes for central India.

Materials and Methods

The soil moisture profiles were estimated from the linseed plots of different soil moisture regimes (dry, moderate, and moist). These values were used in the computation of the actual 'ET' rates for different crop growth stages using the predetermined field estimated hydraulic properties[7]. The obtained ET rates were taken as the field estimates and were used for comparisons with following most commonly and widely accepted empirical/climatic estimates (Modified Penman, Blaney-Criddle, Radiation, Modified Hargreave's, Christiansen and Pan-evaporation methods) of evapotranspiration. For this purpose the available measured climate data (max.-min. temperature, max.-min. relative

humidity, wind velocity, sunshine hours and pan-evaporation) of corresponding linseed growth period (First week of December to Second week of March) have been collected from Department of Physics and Agrometerology, JNKVV, Jabalpur (M.P.) India.

After determining the reference crop evapotranspiration (ETo) by above methods[3]. The ETc rate was predicted using the crop coefficient (Kc) values.

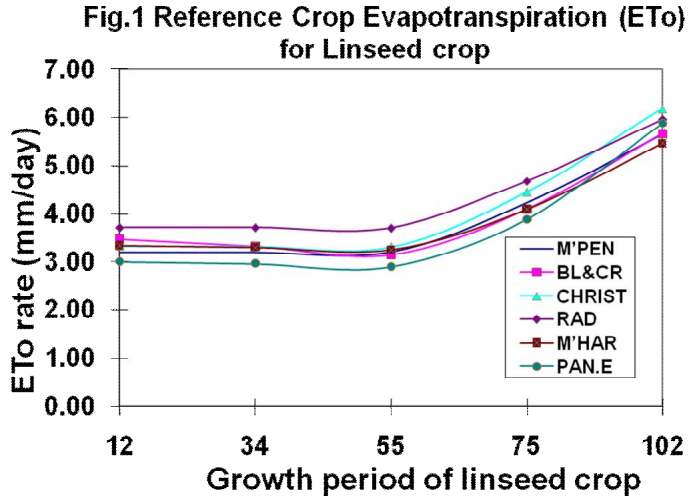
To Interpret and gain understanding of the complex behavior of both type of estimates the available data were analyzed statistically and obtained statistical parameters were tabulated. To evaluate appropriate field estimated linseed crop coefficients (Kc) under various soil moisture regimes for central India, the Kc was calculated as ET/ETo and compared with reference values.

Results and Discussion

The reference crop evapotranspiration (ETo) values were fairly low (less than 3.75 mm/day) and constant during early half spell period (up to 55 DAS), thereafter, increased till crop maturity (Table-1). The values for Radiation (4.68 mm/day) and Pan-E estimates (3.89 mm/day) were the highest and lowest at pod development stage, respectively. However, Christiansen estimates approached maximum ETo rates (6.19 mm/day) near crop maturity (Fig. 1). Such a nature of ETo estimates is attributed to their dependence on climatic variables[8].

Table 1 :Reference crop Evapotranspiration (ETo) for linseed crop (mm/day)

DAS	M'PEN	BL&CR	CHRIST	RAD	M'HAR	PAN.E	Referance Kc values
12	3.2	3.47	3.33	3.72	3.34	3	0.32
34	3.2	3.32	3.32	3.72	3.3	2.96	0.72
55	3.21	3.14	3.31	3.71	3.25	2.9	1.14
75	4.23	4.09	4.45	4.68	4.09	3.89	0.7
102	5.65	5.66	6.19	5.96	5.46	5.88	0.26



Crop evapotranspiration

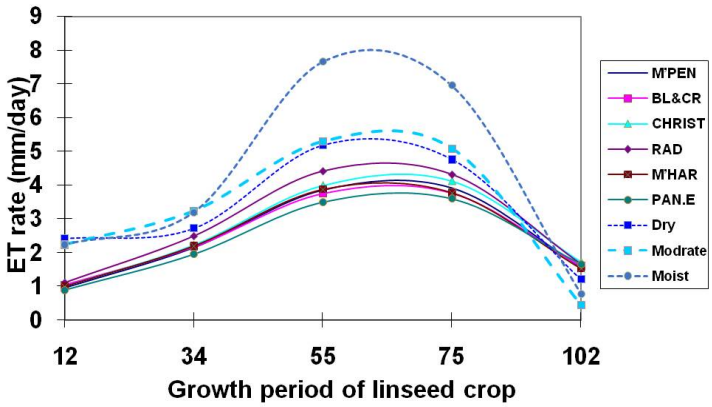
The data of linseed crop evapotranspiration rate (ET) indicated the ET values of field estimates and climatic estimates (Table 02) increased (4.8 to 6.56 mm/day and 3.31 to 4.41 mm/day) with plant growth up to 55 DAS and may

continued upto 65 DAS. Thereafter, the value started declining (Fig. 02) . The magnitude of decrease in the field estimated values were relatively smaller in drier regimes than those from moist regimes .The values of climatic estimates (ETc) were less than 5 mm/day despite more than 6.0 mm/day value recorded in case of field estimates (ET). Similar observation was also reported earlier[4].

Table 2: Evapotranspiration (mm/day) for irrigated linseed crop

	CLIMATIC ESTIMATES (ETc)							FIELD ESTIMATES (ET)		
DAS	M'PEN	BL&CR	CHRIST	RAD	M'HAR	PAN.E	Dry	Modrate	Moist	
12	0.96	1.04	1.01	1.11	1.01	0.9	2.42	2.24	2.24	
34	2.15	2.17	2.23	2.49	2.2	1.96	2.72	3.24	3.19	
55	3.85	3.76	3.99	4.41	3.87	3.5	5.18	5.3	7.65	
75	3.91	3.77	4.12	4.31	3.77	3.6	4.76	5.09	6.95	
102	1.57	1.59	1.73	1.66	1.53	1.66	1.21	0.45	0.79	

Fig. 2 Field and Climatic Estimates of Evapotranspiration (ET&ETc) for Linseed crop



Comparisons of Field and Climatic estimates

To compare the behavior of two groups of estimates amongst themselves, and between the estimates, the ratios of ET/ETc were plotted (Fig 2 to 5) for dry, moderate and moisture regimes respectively. The nature of ratios representing the various climatic estimates were generally identical in different moisture regimes and throughout the crop growth period. The ratio (ET/ETc) of field and climatic estimates were fairly higher during initial crop age which continued to decrease up to 30 DAS. In drier regimes (Fig. 3), the ratio attended relatively static value (1.1 to 1.7) during peak rate of ET. Later, it decreased marginally with crop maturity. However, in moderate moisture regimes (Fig. 4), the ratio reflected typical behavior as it initially increased up to 30 DAS (1.9 to 2.5) and then decreased continuously up to crop maturity. In case of moist moisture regimes (Fig. 5), the ET/ETc ratio registered a marginal decrease (1.7-2.1 to 1.1-1.4) during early 55 DAS and then stabilized in the range of 1.0 to 1.4. Later a second rise during the peak rate of 'ET' was recorded.

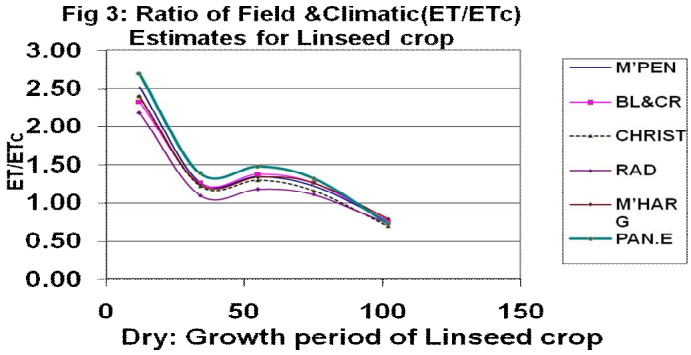
The ET/ETc ratio for linseed crop (Fig.3 to 5) also emphasized that in general, ETc values are more precisely estimated under drier moisture regimes by any of the method of estimation. It was attributed to the dependence of crop coefficient values on the data from drier situations under which the linseed crop is normally raised. Amongst the various

empirical estimates, the Radiation estimates were more closer to unity (means closer to field estimates) than the other climatic estimates in all regimes. The ET/ETc ratio of Pan –E estimates deviated maximum from unity. Ratios corresponding to the rest of the climatic estimates i.e. Blany-Criddle, Modified Hargreaves, Christiansen and Modified Penman methods occupied the next positions from Radiation estimates, and were interchanging during different growth stages and moisture regimes.

The values of correlation and regression coefficients along with the standard error of estimates for the climatic and field estimates of linseed crop (Table-3) reflects a linear correlation amongst themselves as [y=a+bx]. It means, the magnitude of change in ET rate was slow and static[1,5]. The correlation coefficients for dry as well as moist regimes were highly significant for most of estimates. However the relative positions of the various estimates were different in drier regimes (Radiation 0.920, Pan –E 0.876) than the moisture regimes (Radiation 0.950, Pan-E 0.914).

Table 3 : Correlation between Field and Climatic Estimates

	M'PEN	BL&CR	CHRIST	RAD	M'HAR	PAN.E	Dry	Modrate	Moist
M'PEN	1	0.999857	0.999457	0.998284	0.998619	0.997100519	0.906103	0.877245	0.939123
BL&CR	0.999857	1	0.998811	0.999103	0.999359	0.996084995	0.909285	0.881617	0.941766
CHRIST	0.999457	0.998811	1	0.995855	0.996517	0.998877795	0.895002	0.863194	0.929971
RAD	0.998284	0.999103	0.995855	1	0.99989	0.991701651	0.920658	0.896418	0.950785
M'HAR	0.998619	0.999359	0.996517	0.99989	1	0.993049793	0.916308	0.890164	0.94747
PAN.E	0.997101	0.996085	0.998878	0.991702	0.99305	1	0.876062	0.838883	0.914469
Dry	0.906103	0.909285	0.895002	0.920658	0.916308	0.876062459	1	0.981995	0.996144
Modrate	0.877245	0.881617	0.863194	0.896418	0.890164	0.838882569	0.981995	1	0.973557
Moist	0.939123	0.941766	0.929971	0.950785	0.94747	0.914469482	0.996144	0.973557	1



Crop Coefficients (Kc)

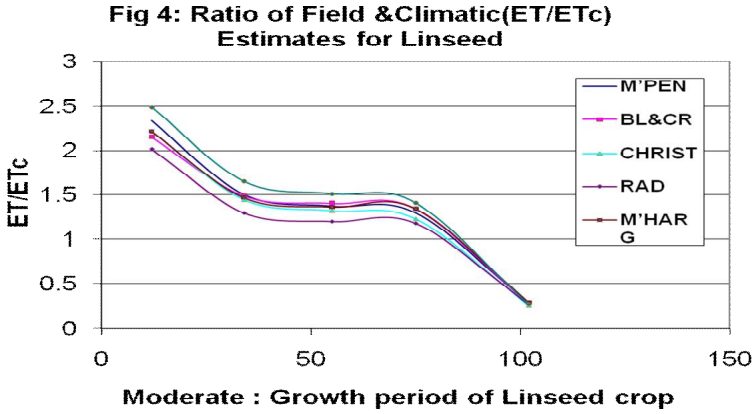
The field estimated linseed crop coefficients of different soil moisture regimes were marginally higher than the referenced crop coefficients during early growth period and the differences amongst field estimated crop coefficients are with referenced crop coefficients continue to increase till they approached the peak values when the crop attended full ground cover or the maximum growth rate. Subsequently, the differences amongst the various crop coefficients started declining as the crop advanced to the seed formation stage and maturity.

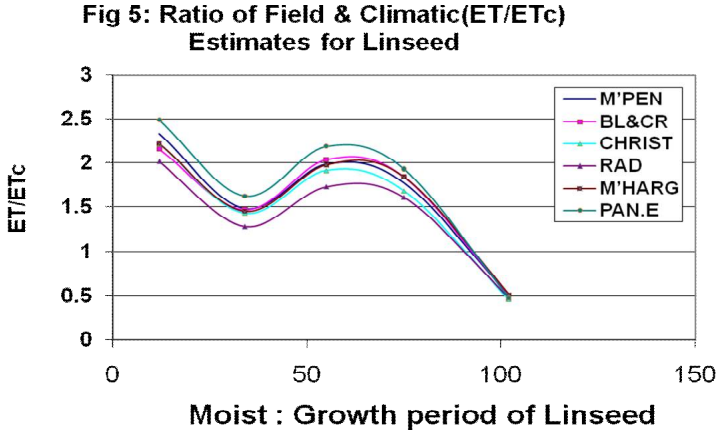
The differences amongst the crop coefficients under drier regimes (field measured & reference vales), even at the peak crop growth period (up to 55 DAS), were the lowest (1.39) in case of Radiation followed by the Christiansen (1.56),

M'Hargreaves (1.56), M'Penman (1.61), Blaney & Criddle (1.64) and Pan evaporation (1.78) estimates. Similar trends were also observed in case of moderate and moisture regimes (Table 04).

Table 4: Crop Coefficient (Kc) for linseed crop estimated from field values

			DRY			
DAS	M'PEN	BL&CR	CHRIST	RAD	M'HAR	PAN.E
12	0.75625	0.697406	0.726727	0.650538	0.724551	0.806666667
34	0.85	0.819277	0.819277	0.731183	0.824242	0.918918919
55	1.613707	1.649682	1.564955	1.396226	1.593846	1.786206897
75	1.125296	1.163814	1.069663	1.017094	1.163814	1.223650386
102	0.214159	0.213781	0.195477	0.20302	0.221612	0.205782313
			MODRATE			
12	0.7	0.645533	0.672673	0.602151	0.670659	0.746666667
34	1.0125	0.975904	0.975904	0.870968	0.981818	1.094594595
55	1.65109	1.687898	1.601208	1.428571	1.630769	1.827586207
75	1.20331	1.244499	1.14382	1.087607	1.244499	1.30848329
102	0.079646	0.079505	0.072698	0.075503	0.082418	0.076530612
			MOIST			
12	0.7	0.645533	0.672673	0.602151	0.670659	0.746666667
34	0.996875	0.960843	0.960843	0.857527	0.966667	1.077702703
55	2.383178	2.436306	2.311178	2.061995	2.353846	2.637931034
75	1.643026	1.699267	1.561798	1.485043	1.699267	1.786632391
102	0.139823	0.139576	0.127625	0.13255	0.144689	0.134353741





A comparison of field estimated crop coefficients and the reference crop coefficients of linseed crop 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. The differences amongst the reference and field estimated crop coefficient were maximum in case of Pan-evaporation. Further, the difference amongst the crop coefficients of different moisture regimes were not so apparent[2, 6].

References

1. Black, T. A. (1979). Evapotranspiration from Dougles fir stands exposed to soil water deficits. Water Resource Research, 15:164-170.
2. Casa, R., Russell, G. and Lo Cascio, B. (2000). Estimation of evapotranspiration from a field of linseed in central Italy. Agricultural and forest meteorology, 104: 289- 301.
3. Dixit, B.K., Kauraw, D.L. and Nema, H.R. (2003). Estimating potential evapotranspiration using meterological methods for Central India. JNKVV Research Journal, 37 (1) : 20-23.
4. Gupta, R.K. and Agrawal, C.G.(1977). Consumptive use of water by gram and linseed. Indian Journal of Agriculture Science, 47: 22-26.
5. Hank, R. J., Gardner, H. R., and Florian, R. L. (1969). Plant growth – Evapotranspiration relations for several crops in the central great plain. Agronomy Journal, 61:30-34.
6. Kar, G., Kumar, A. and Martha, M. (2007).Water use efficiency and crop coefficients of dry season oil seed crops. Agriculture Water Management, 87: 433-451.
7. Kauraw, D.L. and Gupta, Ram K. (1985).Prediction of in situ measured hydraulic conductivity of a swelling clay soil. Indian Journal of Soil Conservation, 13: 32-38
8. Smajstrla, A. G., Zazueta, F.S. and Schmidt, G. M. (1987). Senstivity of potential evapotranspiration to four climatic variable in Florida. Soil and Crop Science Social Florida, 46 :21-26.