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L E T T E R S

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ESTIMATION OF EVAPOTRANSPIRATION IN A MOLLISOL OF TARAI REGION OF UTTRAKHAND FROM CHICKPEA (*Cicer arietinum L.*)

1. Chickpea is one of the important pulse crops of *Tarai* and other regions of Uttrakhand. It is an essential winter season crop grown from November to April (rabi crop) of this region. Water has unique properties that promote a wide variety of physical, chemical, and biological processes. These processes greatly influence almost every aspect of soil development and behavior, from the weathering of minerals to the decomposition of organic matter and the growth of plants to the pollution of groundwater. Water requirement includes the losses due to evapotranspiration and the losses during application of irrigation water and the quantity of water required for special operations such as land preparation and puddling for transplanting rice etc (Michael *et al.* 1977).

The term 'evapotranspiration' is used to describe the total process of water transfer into the atmosphere from vegetative and land surfaces (Rosenberg 1974). Crop evapotranspiration is the basic process which is responsible for creating water demands and is prerequisite for biomass production. Potential evapotranspiration is largely controlled by water and vegetation and soil factors play only a minor role (Penman 1963). Net solar radiation and mean air temperature were highly correlated with evaporation and PET (Balogun 1974).

The direct measurement of ET is expansive and needs elaborated experiments set up. Therefore, considerable amount of scientific efforts have been devoted to develop empirical equations for estimating ET from meteorological observations. However, most of these equations cannot be applied universally and need screening, standardization and calibration under different agroclimatic conditions. Evaporation is either measured by weighing lysimeter or estimated from climatological data or water balance method. A lysimeter provides a precise and direct measurement of the amount of water supplied to and lost by the crop, often encounters a number of problems (Coleman 1946).

2. *Materials and methods* - The present study was conducted in co-operation with the India Meteorological Department (IMD) at the Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar which is situated at 29° N latitude, 79.3° E longitude and at an altitude of 243.8 m above mean sea level. The area lies in 'tarai' belt located in foot hills of the Himalayas. The area has a sub-humid subtropical climate. The annual total rainfall in the area is about 1400 mm of which 80 per cent is received from mid June to September. Chickpea (*Cicer aritetinum*) genotype Pusa-364 was grown in *Rabi* season. The sowing of Chickpea geneotype was done at 3rd December 2004. The same crop was also grown around the lysimeters to provide a natural and identical environment to the crop grown in the lysimeters.

The ET of Chickpea was estimated separately on weekly basis by the following mathematical models:

(*i*) Thornthwaite method (Thornthwaite, 1948)

(*ii*) Turc method (Turc, 1961)

(*iii*) Stephens and Stewart method (Stephens and Stewart, 1963)

(*iv*) Jensen and Haise method (Jensen and Haise, 1963)

(*v*) Blaney-criddle method (Blaney and Criddle, 1950)

(*vi*) Modified Penman method (Doorenbos and Pruitt, 1977)

3. *Results and discussion* - The outcomes have been presented through tables. The salient findings of experiment have been categorized and presented as under :

3.1. *Evapotranspiration (ET) of Chickpea measured with lysimeter* - The data on the measured ET (per day, weekly total and cumulative) of Chickpea are given in Table 1. The cumulative ET of Chickpea during Chickpea crop season was 342.1 mm. The weekly total ET increased as the age of the crop increased. The average daily rate of ET during Chickpea crop was 2.53 mm/day. In the early stage of the crop, the daily ET rate increased as the crop attained maturity. The average daily rate of ET during Chickpea crops was maximum during 14th week. The weekly total ET was relatively higher during 9th to 14th weeks.

3.2. *Pan evaporation measured with USWB class-A pan evaporimeter* - The data on the measured pan evaporation (EP) (per day, weekly total and cumulative) at

TABLE 1

Daily, weekly and cumulative evapotranspiration (ET) and evaporation (EP) of chickpea measured by lysimeter and pan evaporimeter (2004 to 2005)

Std. week 2004-05	Weeks	Average ET (mm/day)	Weekly total (mm)	Cumulative ET (mm)	Cumulative EP (mm)
49	2-8 Dec	1.8	13.4	13.4	12.8
50	9-15 Dec	1.9	13.2	26.6	26
51	16-22 Dec	1.5	10.4	37	35.3
52	23-31 Dec	1.4	8.8	45.8	42.8
1	1-7 Jan	1.5	7.8	53.6	54.5
2	8-14 Jan	1.2	11.7	65.3	62.5
3	15-21 Jan	1.8	9.8	75.1	74.1
4	22-28 Jan	1.7	11.8	86.9	81.7
5	29 Jan 4 Feb	1.6	12.4	99.3	92.4
6	5-11 Feb	1.8	13.9	113.2	104.4
7	12-18 Feb	2.5	17.1	130.3	121.6
8	19-25 Feb	2.7	19.1	149.4	139.8
9	26 Feb 4 Mar	3.3	27.2	176.6	166.7
10	5-11 Mar	3.0	24.6	201.2	189.9
11	12-18 Mar	3.3	25.8	227	211.6
12	19-25 Mar	3.4	27.2	254.2	235.7
13	26-25 Mar	5.2	39.6	293.8	274.5
14	2-8 Apr	6.2	48.3	342.1	321.6
Mean		2.53			

TABLE 2

Relation between measured and estimated ET by different mathematical method for Chickpea crop

	Blanney-Criddle	Jensen-Haise	Stephens-Stewart	Turc	Thornthwaite	Modified Penman
No. of pairs	18	18	18	18	18	18
Mean measured ET (mm/day)	2.53	2.53	2.53	2.53	2.53	2.53
Mean estimated ET (mm/day)	2.12 (ETu)	2.26 (ETj)	2.71 (ETss)	3.24 (ETt)	1.61 (ETth)	2.41 (ETp)
Over (+) under (-) estimation (%)	-16.3	-11.71	7.11	3.24	-36.37	-4.75
Correlation Coefficient	0.591*	0.749*	0.703*	0.662*	0.847*	0.878*
Regression equation	ET = 1.260ETu -0.136	ET = 1.217ETj +0.221	ET = 0.751ETss +0.501	ET = 0.629ETt +0.173	ET = 1.734Eth +0.255	ET = 0.834ETp +0.527
T value	5.32	5.18	4.89	4.76	6.57	7.06

standard weeks during Chickpea growing season are given in Table 1. The total cumulative pan evaporation (EP) during Chickpea season was 321.6 mm. The maximum weekly total EP was recorded 6.7 mm during 14th week. It was maximum (6.7 mm/day) during 14th week and minimum (1.1 mm/day) during 52, 2, and 4th week. The average daily EP was 2.5 mm.

3.3. *Relationship between measured ET and estimated ET by different mathematical methods* : *Relationship between measured ET and estimated ET by Blaney-Criddle method* - A simple correlation and linear regression analysis of measured ET with estimated ET by Blaney-Criddle method for Chickpea is given in Table 2. The data in Table 2 indicated that this method underestimated evapotranspiration by 16.3 per cent for Chickpea crop. For Chickpea the average ET was 2.53 mm/day but the method estimated it as 2.12 mm/day. A positive correlation was found between measured ET and estimated ET. The value of '*r*' was significant for chickpea.

3.4. *Relationship between measured ET and estimated ET by Jensen-Haise method* - A simple correlation and linear regression analysis between measured ET and estimated ET by Jensen-Haise method for Chickpea is given in Table 2. The data in Table 2 show that this method provides a good estimation of ET in Chickpea. The average measured ET was 2.53 mm/day while this method estimated at 2.26 mm/day. This method underestimated ET by 11.7 per cent. The correlation coefficient (*r*) is 0.749. For Chickpea '*r*' values are significant and there is positive correlation between measured ET and estimated ET. Similar results for Chickpea reported at Pantnagar (Singh 1974).

3.5. *Relationship between measured ET and estimated ET by Stephens-Stewart method* - A simple correlation and linear regression analysis of measured ET with estimated ET by Stephens-Stewart method is given in Table 2. An evident from the data in the Table 2, provide reasonable estimation of ET in chickpea. The measured ET was 2.53 mm/day and estimated ET by this method was 2.71 mm/day, so, this method overestimated ET by 7.11 per cent. The correlation coefficient between measured and estimated ET was 0.703, and was significant. This method overestimated measured ET and this overestimation of ET by this method is mainly attributed to the fact that short term mean temperature is not a suitable measurement of incoming radiation (Ayoade 1976).

3.6. *Relationship between measured ET and estimated ET by Turc method* - The correlation and linear regression of measured ET and estimated ET is given in Table 2. It was found that, this method overestimated the measured ET. The ET rate was 2.53 mm/day while this method estimated ET 3.24 mm/day thus it overestimated ET by 28.06 per cent. The correlation coefficient between measured ET and estimated ET by this method was 0.662, which was significant.

3.7. *Relationship between measured ET and estimated ET by Thornthwaite method* - A correlation and regression analysis of measured ET and estimated ET by Thornthwaite method is given in Table 2. This method estimated the average rate of ET 1.61 mm/day while the average measured ET by the lysimeter was 2.53 mm/day. This method highly underestimated the ET by 36.37 per cent for chickpea. The correlation coefficient between measured ET and estimated was significant. The value of '*r*' was 0.847 and showed a positive relationship with the estimated ET and measured ET. The over estimation of ET by this formula reported during summer season (Ward 1963).

3.8. *Relationship between measured ET and estimated ET by Penman method* - The relationship between measured ET by lysimeter and the estimated ET by Penman method was shown by a simple correlation and linear regression analysis given in Table 2. The data in Table 2 indicate that this method provides a reasonable effect. This method underestimated ET by 4.75 per cent. The correlation coefficient between measured ET estimated and ET showed significant value of '*r*', and it was 0.878.

4. *Conclusion* - In this study the total ET was about 342.1 mm during crop season. The average rate of ET was 2.53 mm/day. During early and maturity phase the ET rate decreased. The total pan evaporation during crop season was 321.6 mm. The average pan evaporation was 2.5 mm/day. In crop season low temperature was constrain to evaporation. The ET/EP ratio varied with the growth stage from early stages to peak growth period. The ET/EP ratio decreased to about 0.90 in the maturity phase. Pan evaporation underestimated the measured ET by 1.2 percent. On weekly basis pan evaporation showed a positive correlation with ET. The Thornthwaite method did not give a close estimate of ET (226.1 mm) on seasonal basis. The estimated average daily rate was 1.61 mm/day. Thus this method underestimated ET by 36.37 percent. On weekly basis the estimated values gave good correlation with measured values. The Turc method gave good correlation (positive correlation) with measured ET. The Stephens-Stewart method overestimated Chickpea ET. The seasonal total ET estimated by this method was 458.8 mm which were more than the measured seasonal ET 342.1 mm. This method gave good correlation with measured ET on weekly basis. The Jensen-Haise method was under estimated by 11.71 per cent. The seasonal

cumulative ET estimated by this method was 273.8 mm during crop season. The weekly ET values estimated by this method gave good correlation with measured values but estimated values were much below the measured values. The seasonal cumulative ET estimated by Blaney-criddle method was 275.4 mm and it was lower than the measured ET 342.1. The daily rate of ET estimated by this method 2.12 mm/day was lower than measured daily ET 2.53 mm/day. These methods underestimate the measured ET. The Penman method very closely estimated the ET. The total ET estimated by this method was 330.3 mm. Total measured ET by lysimeter was 342.1 mm; on weekly basis the estimated values gave good correlation with measured values. The evapotranspiration of Chickpea under Uttrakhand *tarai* conditions is about 342.1 mm. The average total rainfall during crop season is 119.4 mm. Thus supplementary irrigation is required during the crop season for better yield**.** Modified Penman and Jensen-Haise method are very suitable for estimation of ET. The modified Penman method is the best method for estimation of ET in *tarai* region of Uttrakhand for chickpea.

References

Ayoade, J. O., 1976, "Evaporation and ET in Nigeria", *J. Trop. Geog.*, **43**, 9-19.

Balogun, C., 1974, "The influence of some climatic factors on evaporation and PET at Ibadan", Nigeria, *Ghana J. Agric. Sci.*, **7**, 1, 45-49.

Blaney, H. F. and Criddle, W. D., 1950, "Determining water requirements in irrigated areas from climatological and irrigation data", *USDA Soil Cons. Serv. Tech.*, 96, 48.

Coleman, E. A., 1946, "A laboratory study to lysimeter drainage under control soil moisture tension", *Soil. Sci*., **62**, 365-383.

Doorenbos, J. and Pruitt, W. O., 1977, "Guidelines for predicting crop water requirements", 95-99, FAO, Rome.

Jensen, M. E. and Haise, H. R., 1963), "Estimating evapotranspiration from solar radiation", *J. Irrig. & Drain. Div. Am. Soc. Civil Engin. Proc.*, 89(IR-4), 15-41.

Michael, A. M., Hukkeri, S. B. and Singh, N. P., 1977, "Estimating water requirement in irrigation management of crops in India", IARI monograph No. 4, Water Technology Centre, IARI, New Delhi, 91-162.

Penman, H. L., 1963, "Vegetation and Hydrology", Common Weather Agriculture Bureau, Technical Communication No. 53, Harpenden, England.

Penman, H. L., 1948, "Natural evapotranspiration from open water, bare soils and grass", Proceedings of the Royal Society of London, Series A Vol. **193**, 120-145.

Rosenberg, N. J., 1974, "Microclimate, In : The Biological Environment", John Wiley and Sons, New York, 159-194.

Singh, R. V., 1974, "Potential evapotranspiration studies in Nainital Tarai", M.Tech, Thesis submitted to G.B. Pant University of Agriculture and Technology, Pantnagar (Nainital).

Stephens, J. C. and Stewart, F. H., 1963, "A comparison of procedures for computing evaporation and evapotranspiration", International Association of Science Hydrol IUGL Barkeley, Publ, No. **62**, 123-133.

Thornthwaite, C. W., 1948, "An approach, towards a rational classification of climate", *The Geograph. Rev.*, **38**, 1, 55-94.

Turc, M., 1961, "Evaluation des Besoins en eau O. Irrigation evapotranspiration potenscalle formula climatique semplifice at misa", *J. Ann. Agron.*, **12**, 13-49.

Ward, R. C., 1963, "Observation of potential evapotranspiration (PE) on the Thames Flood Plain 1959-1960", *J. Hydrol.*, **1**, 183-194.

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