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Short communication

Estimation of maximum evaptranspiration for cotton by modified Penman method and its validation with Lysimetric data

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It is a well known fact that estimation of evapotranspiration (ET) of a crop with its distribution among various growth stages has a significant role in efficient water management; crop management and fairly good harvest of crop. Research workers have tried to estimate evapotranspiration in various crops by different methods, mainly include simple gravimetric soil moisture estimation (Dastane, 1967) open pan evaporimeter (Patil, 1978) and Lysimetric method (Mehta and Mistry, 1983). Gravimetric soil moisture estimation is quite cumbersome. Availability of open pan evaporimeter even at research stations is many times an hurdle, even through the method is accurate. However, installation of Lysimeter itself is a very costly affair. Also, they are available only at few stations. Under these circumstances at times, it becomes difficult even for research workers to estimate the crop ET all over different phenophases. In order to overcome, an efforts were made to estimate crop ET by modify Penman method and validate the same with lysimetric data. The method can be employed as it has shows strong validation.

Procedure for estimation of maximum evapotransporation (ETm) envolved estimation of potential evapotrasporation (PET) by modified Penman method (Abbi *et al.,* 1978). These estimations are carried out during different phenophases as well as growth period of cotton. The weather data required. Air temperature (^{0}C), maximum and minimum relative humidity (%), number of bright sunshine hours (h) and wind speed (mph). Crop reference evapotransporation (ETo) was estimated on weekly basis after applying the adjustment factor (c) to the corresponding PET values in order to compensate the day and night weather effect, (Doorenbos, J. and W.O. Pruitt. 1977).

The ETm represents the rate of evapotransporation of a healthy crop, grown in large field, under optimum of agronomy management including irrigation. It was included phenophasewise by using the crop factor (Kc) values for corresponding phenophases of cotton. The Kc values for various stages viz., seedling to square formation, square formation to flowering, flowering to boll setting, boll setting to boll bursting, boll busting to first picking and first picking to last picking were 0.3-0.6, 0.7-0.8, 1.00-1.15, 0.7-0.8 and 0.4 respectively (Doorenbos and Kassam 1979). The Kc value for the total period used was 0.45-1.00. The first in each of the above ranges of Kc value used for mean relative humidity (%) was more than 70% with low wind speed (less than 5 m sec^{-1})., whereas the second value used when mean relative humidity (%) was less than 20% with strong wind speed (more than 5 m sec^{-1}). The ETm was estimated using ETm = Kc (ETo).

The crop stages considered are as below:

(i) Seedling to square formation
(ii) Square formation to flowering
(iii) Flowering to boll setting
(iv) Boll setting to boll bursting
(v) Boll busting to first picking
(vi) First picking to last picking

The ETm values so arrived for different phenophases of cotton were validated with the actual values obtained from the Lysimetric data by making simple comparison and also by finding regression equation of mean maximum evapotranspiration (ETm) over mean Lysimetric ET and coefficient of correlation. The Lysimetric data on cotton crop were separately obtained from the experiment conducted during 2001-02 to 2006-07 in Agricultural Meteorology Scheme, Department of Agronomy, Dr. PDKV, Akola.

The values of crop factor (Kc) during six phenophases of cotton, ETo by modified Penman method, ETm and Lysimetric ET along with means over six years and percentage of mean maximum evapotranspiration to the corresponding Lysimetric evapotranspiration are presented in Table 1.

When the mean values for ETm, Lysimetric ET and percentage of ETm to Lysimetric ET were compared, data revealed that the estimation of ETm was, in general, underestimated during all the phenophases of cotton except during crop development stage. This may be attributed to

Table 1 : Crop confticient (Kc), ETo ETm and Lysimeter ET of cotton.

Sr. No.	Phenological stages of crop	MW	Kc	Penman's ETo	ETm	Esmated ETm (mm/stage)	Lysimetric ET	% of mean ETm to ET
1	Seedling to square formation	26	0.45	12.2	5.4	65.8	60.7	108.4
		27	0.45	19.6	8.8			
		28	0.45	20	9.0			
		29	0.45	19.6	7.8			
		30	0.45	19.1	7.6			
		31	0.45	24.1	10.8			
		32	0.70	17.9	12.5			
		33(1)	0.70	5.3	3.7			
2	Square formation to flowering	33(6)	0.75	11.2	7.8	67.1	61.3	109.4
		34	0.75	22.1	15.4			
		35	0.75	22.9	17.1			
		36	0.75	21.5	16.1			
		37(1)	0.75	14.1	10.5			
3	Flowering to boll setting	37(6)	0.75	15.5	11.6	74.2	84.3	88.0
		38	0.75	17.8	13.3			
		39	1.15	25.5	29.3			
		40(5)	1.05	19	19.9			
4	Boll setting to boll bursting	40(2)	1.05	12.3	12.9	75.9	88.9	85.3
		41	1.15	15.1	17.3			
		42	1.15	20.5	23.5			
		43	1.15	11.2	12.8			
		44(2)	1.15	8	9.2			
5	Boll busting to first picking	44(3)	1.15	7.9	9.0	24.0	21.4	112.2
		45	1.15	9.7	11.1			
		46	1.15	3.3	3.7			
6	First picking to last picking	47	1.15	8.8	10.1	49.7	65.9	75.4
		48	0.85	7.3	6.2			
		49	0.85	7.8	6.6			
		50	0.85	5.4	4.5			
		51	0.85	4.8	4.0			
		52	0.85	3.8	3.2			
		1	0.85	5.7	4.8			
		2	0.85	5.7	4.5			
		3	0.67	5.4	3.6			
		4	0.67	2.8	1.8			

the full ground coverage by the crop canopy during crop microclimate as compared to the data on relative humidity and wind speed recorded outside the crop (in Agrometeorological Observatory) which, in turn, caused variation (ETo/ETm).

The percentage estimation of ETm to Lysimetric ET ranged 70 to 97 during different phenophases. The percentage of ETm to Lysimetric ET was 70 i. e. estimated ETm was only 10 % lower than the experimental/ Lysimetric ET. Regression equation of mean ETm values (Y) over mean

Lysimetric ET values (X) from Table 2 is expressed as Y= 1.1188x-2.476 having coefficient of correlation (r) equal to 0.9153.

Looking to the circumstances under which the present method is proposed to be advocated for ETm estimated in cotton crop, it appears that the estimated ETm over the crop period is quite accurate and estimation over different phenophases may be considered as rational.

Thus, the methodology used in this study may be adopted to predict the ETm or water requirement of any crop during the different phenophases or total period of the crop.

Variation of ETm from a actual ET values may be attributed to the microclimate of the crop/atmospheric demand of the crop grown in the field than the theoretical values over a large sheet. Secondly, the equation of regression of mean ETm values over mean ET values was Y=0.7213x + 2.3302 having coefficient of correlation (r) as 0.6847. It was concluded that the methodology used in this study may be adopted to predict the maximum evapotranspiration (ETm) or water requirement of cotton or any other crop during the different phenophases/total period of the crop under normal condition.

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