A NEW TECHNIQUE FOR EVALUATION OF CROP COEFFICIENTS:A CASE STUDY

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ABSTRACT: -In order to plan for irrigation schemes, scheduling and drought situation, it is imperative to have a precise idea about exact water requirement for different crops under various climatic conditions. It necessitates an accurate estimation of crop evapotranspiration, which is based upon reference evpotranspiration and crop coefficient. The present study arrives at a suitable empirical model for calculation of crop coefficient fortnightly for different crops during different season. The development of this model has given accurate, quick computation of crop coefficient, which will be useful to obtain Net Irrigation Requirement for crop. An attempt has been made to compare the developed method with FAO method.

Key-Words -: *Crop Coefficient, Evapotranspiration*.

1 Introduction

An estimate of optimal crop water requirement is a main aspect of the design and management of irrigation system. The output of crop is maximum when water is applied optimally and any deficiency or excess amount of water usually reduces the output. The optimal crop water requirement mainly depends upon the accurate estimation of evapotranspiration and crop coefficient. The method developed should produces good result with minimum climatic data and represent the one, which can be applied over a wide range of climatic data. The reference evapotranspiration is calculated by using Modified Penman method. Based upon this, the crop coefficients are computed for different crops fortnightly by the graphical method suggested by FAO and the Empirical relationship between days and crop coefficient has been established. The estimated crop coefficients are compared and appropriateness of these equations are discussed.

2 FAO Method For Selection of Crop Coefficients

To account for effect of crop coefficient characteristics on crop water requirement, crop coefficients are used to relate reference evapotranspiration ETo to crop evapotranspiration ETc. When crop is growing in large fields under optimal growing condition. ET crop is found by

ETcrop= Kc x ETo …..(1)

Factor affecting the value of crop coefficient Kc are mainly the crop characteristic, sowing date rate of development, length of growing season and climatic condition. ETcrop is the sum of transpiration by the crop and evaporation of soil surface.
The crop-growing season is divided into four stages. Crop coefficients for given stage of crop development and different climatic conditions for development of irrigated crop is stressed.

The four stages of crop development are described herein as

1) Initial stage
2) Crop development stage
3) Mid season stage
4) Late season stage

2.1 Steps

1) Establish planting or sowing date from local information or from practices of similar climatic zones
2) Determine total growing season and length of crop development stages from local information.
3) **Initial stage**
   Predict irrigation frequency for predetermined ETo values, obtain Kc from relation recommended in form of curves between Eto, Kc and frequency of watering
4) **Mid season stage**
   For a given climate, select Kc value from table recommended by –FAO and plots a straight line.
5) **Late season stage**: -
   For time of full maturity, select Kc value from table recommended by FAO for given climate and plot the value at the end of growing season or full maturity. It is a straight line between Kc value at the end of midseason period and at end of growing season
6) **Development stage**
   Assume straight line between Kc value at the end of initial to the start of mid season stage. For required period, Kc value can be obtained from prepared graph. A smooth curve might be drawn. Although this may have little effect in terms of accuracy as far as final results are concerned

3 Methodology

3.1 Study Area

The study has been carried out for various crop for Nagpur district of Maharashtra region with latitude 21°06'N and longitude 79º03'N Water is supplied through canal at twelve days of frequency of watering.

3.2 Data Collection

The station characteristics and meteorological data are collected from Meterogical Dept, Nagpur. The monthly climatic data for Nagpur station for a period 1989-2004 is used. It contains max and min temp, max and min humadity, wind speed, sunshine hours.

3.3 Computation of evapotranspiration

Modified Penman Method calculated the reference evapotranspiration for a Nagpur district. This method can be easily accepted and provides more satisfactory result where measured data on temperature, humidity, wind, sunshine hours are available.

The modified penman equation is as

$$ETo=c\ \{(W\ xRn)+(1-W)\ f(u)\ (ea-ed)\} \quad \ldots\ldots(2)$$

Where

Eto = Evapotranspiration in mm/day

c = Adjustment factor for day and night wind velocity and humidity

W = Weighing factor for altitude and temperature effect on radiation

Rn = Net radiation in equivalent evaporation in mm/day

f(u) = Wind function expressed in terms of equivalent evaporation in mm/day

(ea-ed)= Vapour pressure deficit expressed in mbar,

Ea = Saturation water vapour pressure of the air

ed = Saturation vapour pressure at mean air temperature.

Using above method, average fortnightly reference evapotranpiration was estimated as shown in fig-1.

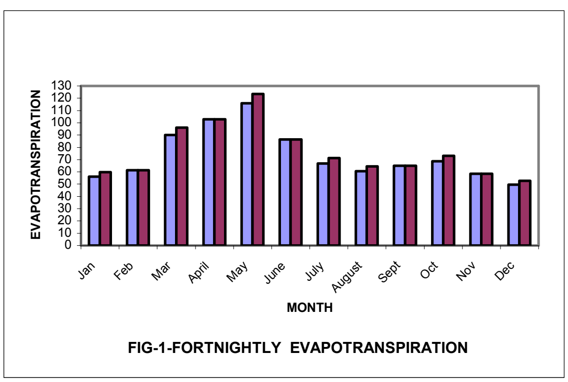


Fig 1 Fortnightly Evapotranspiration

4 Crop Coefficient

For optimal water requirement for each crop, it is necessary to determine accurate estimation of crop coefficient. The present study deals with the comparative study of crop coefficient computed by FAO and models suggested

A) FAO Method

As discussed in methodology of FAO method, the following procedure is adopted

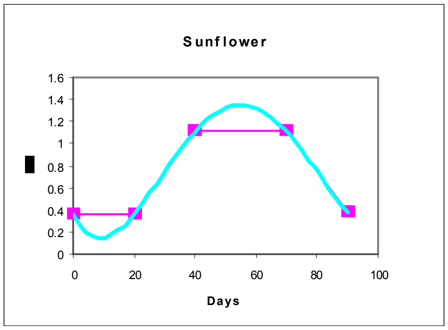
1) The fortnightly evapotranspiration for Nagpur station is calculated by modified Penman method

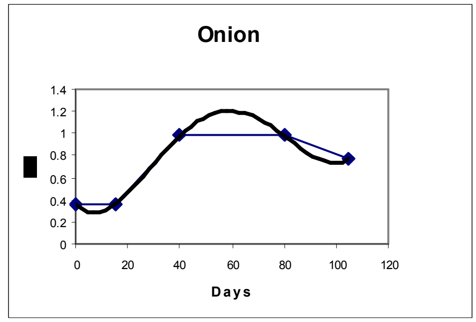
2) Using predetermined ETo, crop coefficient for initial stage for twelve days frequency of watering was calculated using ETo and crop coefficient curve.

Similarly, pertaining to relative humidity and wind speed of that region, crop coefficient for midseason stage, late season stage is calculated and graph is prepared and then straight line is joined from end of initial stage to start of midseason stage which gives the crop coefficient value for crop development stage and the smooth curve is drawn

From the curve drawn for fortnightly crop coefficient for different crop is calculated as shown in Fig-2

A)





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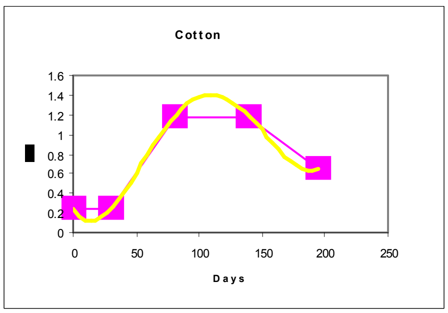

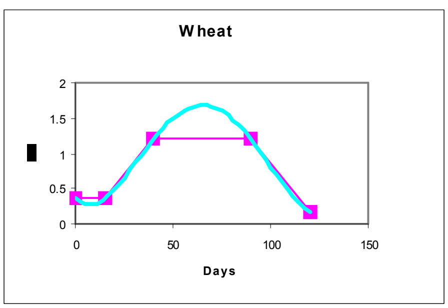

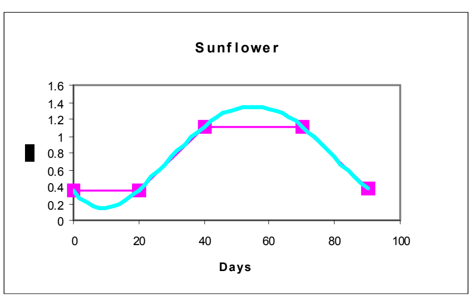

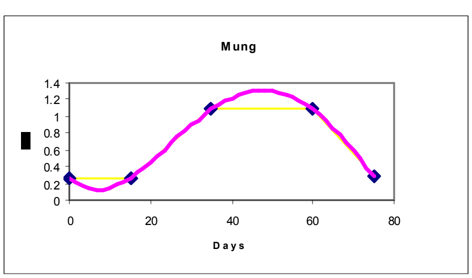

Fig. 2 Crop coefficent curve (FAO method)

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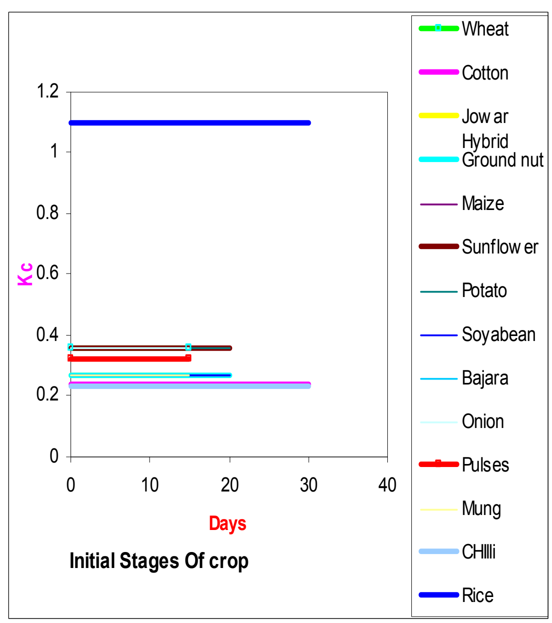
4. Empirical method

The models were prepared for each stage of development of crop for various crop i.e. initial stage, crop development stage, mid season stage and late season stage using Microsoft Excel based upon the Kc value recommended by WALMI which gives the relation between days and crop coefficient as shown in Fig-3. Using the relation given in table 1 Fortnightly crop coefficients were calculated.



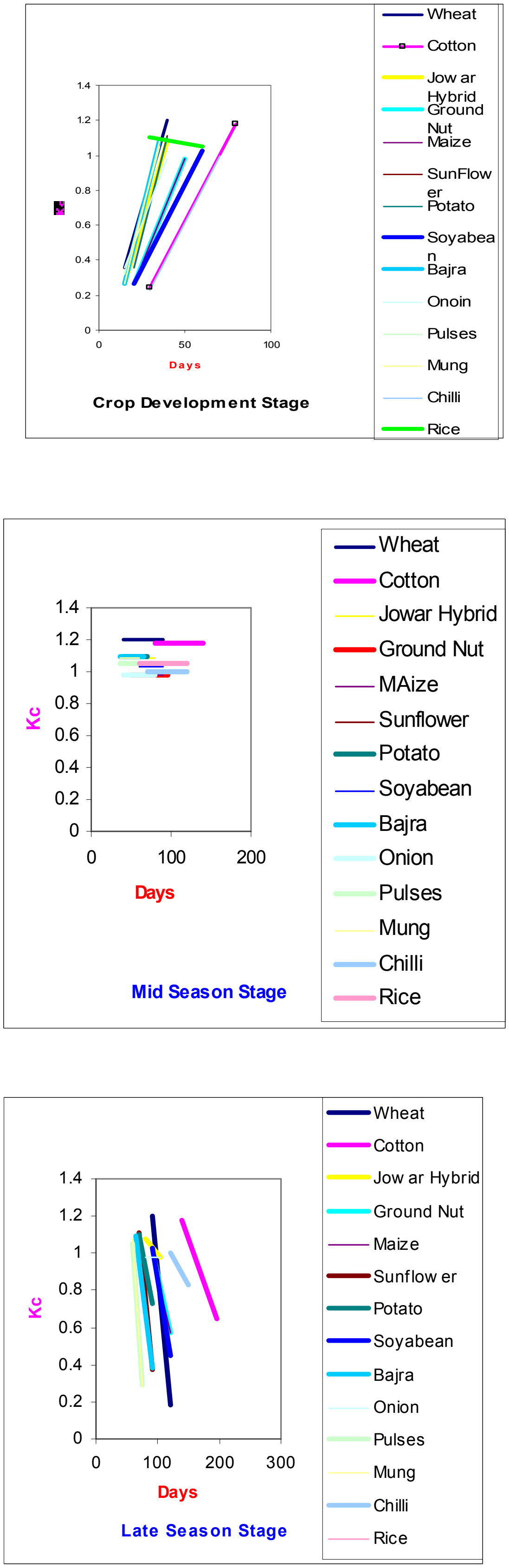


Fig 3 .Crop coefficient curves for different stages

5. Comparison: The comparison is made between crop coefficients obtained by both the methods used in the study for fortnightly crop coefficient for different crop. It is found that that both the values depict very close to each other or presented in fig-4.

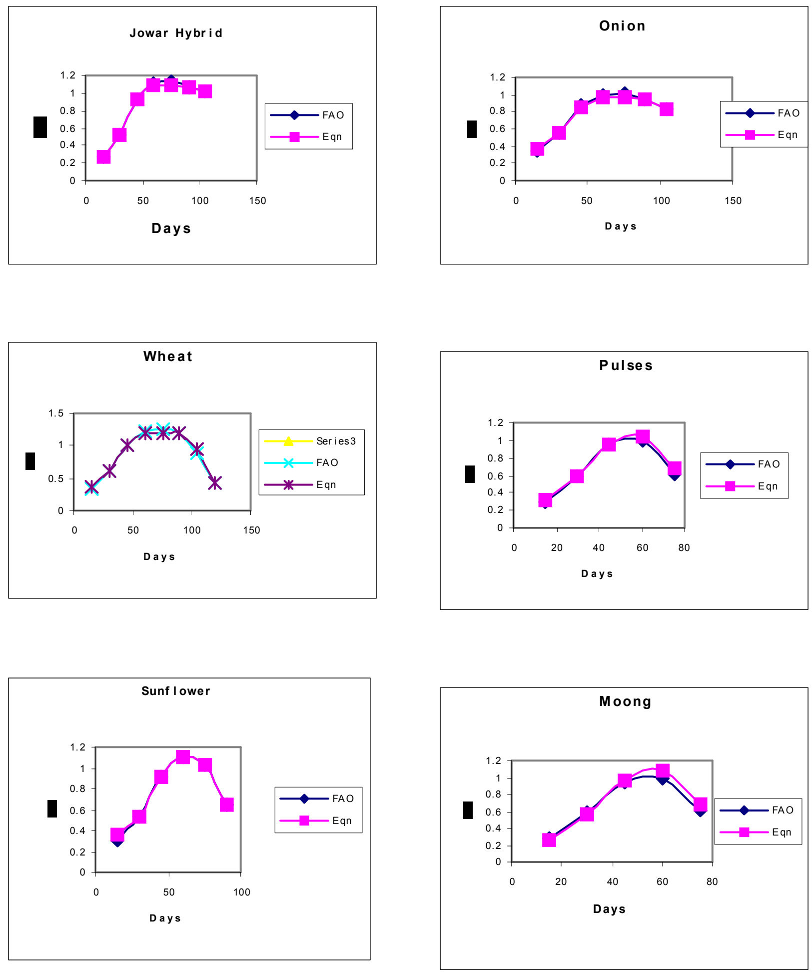


Fig-4 Curves showing comparison of crop coefficient

6 Analysis & discussion

The reference evapotranspiration by using Modified Penman method for Nagpur district was computed. It is observed that reference evapotranspiration is maximum in the month of May. The crop evapotranspiration is estimated by multiplying reference evapotranspiration with crop coefficient. But the accurate computation of ETc is mainly based upon accurate value of crop coefficient. The fortnightly crop coefficients for different crops in Nagpur district were computed using graphical method recommended by FAO as presented in Fig-2. The FAO suggested to consider crop coefficient value of smooth curve only. This study recommends linear regression analysis in Microsoft Excel to develop the relationship between days & crop coefficient within the range presented in Table-1 for computation of crop coefficients. . This inter relationships provides an 'easy to use' method to obtain crop coefficient. Comparison is made between computed values using relations with calculated value from FAO as shown in Fig-4. It depicts the closeness of values and thereby reflects the appropriateness of the method However it may be noted that as these empirical equations recommended are site specific and hence calls for developing the same for other regions as well.

7. Conclusion

The changing climate plays significant effect on evapotranspiration and hence there is a need to estimate continuously updated evapotranspiration, which is required to determine accurate crop coefficient, which in turn useful to estimate accurate crop water requirement. In the present study the ETo is computed by modified Penman method and mathematical Model are developed .The crop coefficients values calculated for various crop by both methods are shown in fig-4.are nearly same. It is suggested to use empirical equations to determine accurate value of crop coefficient. It is also suggested that, as this equations are applicable to Nagpur zone of Maharashtra, It may be also applied to other regions, which are climatically similar. It is also suggested to develop such empirical equations for different crop season for other region of Maharashtra.

Appendix I

TABLE NO-1 Stage wise Crop Coefficient Equation for Various Crop

S. N.	CROP	Initial Stage	Range	Crop Development Stage	Range	Mid Season	Range	Late Season Stage	Range
1	Wheat	Kc=0.36	D=0-15	Kc=0.0336D-0.144	D=15-40	Kc=1.2	D=40-90	Kc=-0.034D+4.26	D=90-120
2	Cotton	Kc=0.24	D=0-30	Kc=0.0188D-0.324	D=30-80	Kc=1.18	D=80-140	Kc=-0. 0096D+2.5	D=140-195
3	Jowar Hybrid	Kc=0.27	D=0-15	kc=0.0324D-0.216	D=15-40	Kc=1.08	D=40-80	Kc=-0.004D+1.4	D=80-105
4	Ground nut	Kc=0.27	D=0-20	Kc=0.0237D-0.2033	D=20-50	Kc=0.98	D=50-95	Kc=-0.0164D+2.5	D=95-120
5	Maize	Kc=0.27	D=0--20	Kc=0.0237D-0.2033	D=20-50	Kc=0.98	D=50-90	Kc=-0.0137D+2.2	D=90-120
6	Sunflower	Kc=0.36	D=0--20	Kc=0.0375D-0.39	D=20-40	Kc=1.11	D=40-70	Kc=-0.037D+3.7	D=70-90
7	Potato	Kc=0.36	D=0--20	Kc=0.037D-0.38	D=20-40	Kc=1.1	D=40-70	Kc=-0.0185D+2.3	D=70-90
8	Soya bean	Kc=0.27	D=0-20	Kc=0.019D-0.11	D=20-60	Kc=1.03	D=60-90	Kc=-0.0193D+2.7	D=90-105
9	Bajara	Kc=0.27	D=0--15	Kc=0.041D-0.345	D=15-35	Kc=1.09	D=35-65	Kc=-0.0284D+2.9	D=65-90
10	Onion	Kc=0.36	D=0--15	Kc=0.0248D-0.012	D=15-40	Kc=0.98	D=40-80	Kc=0.98	D=80-105
11	Pulse	Kc=0.32	D=0--15	Kc=0.0365D-0.2275	D=15-35	Kc=1.05	D=35-60	Kc=-0.0507+4.09	D=60-75
12	Mung	Kc=0.27	D=0--15	Kc=0.0405D-0.3375	D=15-35	Kc=1.08	D=35-60	Kc=-0.0533D+4.2	D=60-75
13	Chili	Kc=0.36	D=0--30	Kc=0.016D-0.12	D=30-70	Kc=1.00	D=70-120	Kc=-0.0057D+1.6	D=120-150
14	Rice	Kc=1.1	D=0--30	Kc=-0.0017D+1.15	D=30-60	Kc=1.05	D=60-120	Kc=-0.0033D+1.4	D=120-150

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