Madras Agric. J., 97 (1-3): 43-45, March 2010
https://doi.org/10.29321/MAJ.10.100339

# Irrigation Planning in Command Areas Using Crop Coefficient Model

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**In the Lower Bhavani Project command area, Tamil Nadu an investigation was carried out to develop crop coefficient model for groundnut. With the obtained crop coefficient values, crop coefficient curve was derived as a function of days after sowing (DAS) and polynomial model was fitted. Using the derived polynomial equation, crop coefficient values of this crop for any day after sowing can be estimated for LBP command. The equation of the regression model of crop coefficient can therefore, be used for estimation of water requirement of this crop grown in LBP command area. It could also be valid for other areas having similar climatic conditions where such data are either not generated experimentally or available at all.**

**Key words:** Groundnut, crop coefficient, irrigation planning

Groundnut (*Arachis hypogaea* L.) is a prominent crop grown in the Lower Bhavani Project (LBP) command area of Tamil Nadu. For better crop production, water should be applied according to consumptive demand (crop evapotranspiration) of the crops. Depending on the level of crop evapotranspiration and water holding capacity of the soil, intervals vary from 6 to 14 days up to 21 days for loam soils, with shorter intervals during flowering when depletion of available soil water should not exceed 40 percent. In the case of supplemental irrigation, best results are obtained when water is applied during the flowering period. It is explicitly evident that estimation of crop evapotranspiration is necessary for efficient planning and proper management of irrigation water. The crop evapotranspiration estimates require specific values of crop coefficient for a particular crop.

Crop coefficients are the empirical ratios of crop evapotranspiration ($ET_c$) to estimated or measured reference evapotranspiration ($ET_o$). The values of crop coefficient vary mainly with the crop characteristics, crop sowing or planting date, rate of crop development, length of growing season and prevailing climatic conditions. Crop coefficient values for different crops were worked (Wright, 1982; Husain and Pawade, 1990). For water balance irrigation scheduling, crop evapotranspiration is estimated from crop coefficient curves, which reflect the changing rates of crop water use over the growing season. Crop coefficient curves as a function of day after planting for different crops using fifth order polynomial were derived (Steele *et al.,* 1996; Hunskar, 1999). Hence, the present study was undertaken to determine consumptive use and crop coefficient values and to develop crop coefficient curve for groundnut crop under LBP command area of Tamil Nadu.

## Materials and Methods

The present study was conducted at the Agricultural Research Station, Bhavanisagar during summer and *Rabi* seasons of 2005-2006. The experimental area is located at 11°29' N latitude, 77°08' E longitude and at an altitude of 256 m above the mean sea level. The climate of the area concerned is semi-arid.

The experiment was laid out with groundnut var. TMV 7 released from Oilseed Research Station, Tindivanam. The crop was sown on April 25, 2005 and harvested on August 10, 2005 for summer and for *Rabi* sown on December 12, 2005 and harvested on March 31, 2006. The measured quantity of irrigation water using a water meter was applied time to time in order to bring the soil moisture to field capacity. Soil moisture content was measured using gravimetric method for which soil samples were collected from 0-15, 15-30, 30-45 and 45-60 cm soil depths on different dates during the growing season. Soil moisture depletion from the effective rootzone depth for different periods between two successive soil sampling was calculated.

In order to determine crop evapotranspiration ($ET_c$) for any time periods between two successive soil moisture measurements dates, components of water balance equation were monitored. Reference evapotranspiration ($ET_o$) for all the periods were estimated as the product of pan evaporation and pan coefficients ($K_p$). Crop

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coefficient values ($K_c$) for all the time periods were determined using following equation (Allen *et al.,* 1998):

$$K_c = \frac{ET_c}{ET_o} \quad (1)$$

Where, $ET_c$ = crop evapotranspiration (mm) and $ET_o$ = reference evapotranspiration (mm)

The crop coefficient values were plotted with respect to time *i.e*. days after sowing (DAS). While plotting the crop coefficient values for a particular period, the mid point of that particular period was taken. Polynomial function was fitted to these data, keeping in view the scatter of the crop coefficient ($K_c$) values, with respect to time (DAS).

## Results and Discussion

Evapotranspiration of groundnut crop showed an increasing trend with the advancement in crop growth up to physiological development and after that it started declining (Table 1). The mean crop evapotranspiration over the growing season for groundnut were computed to be 4.73 and 4.49 mm day$^{-1}$ for summer and *Rabi* seasons, respectively. Similar trend of crop evapotranspiration were obtained and reported for various agroclimatic zones in India (Arulkar Kavita *et al.,* 2008; Bandyopadhyay *et al.,* 2005).

### *Development of crop coefficient model*

Crop coefficient values of groundnut was obtained as the ratio of crop evapotranspiration ($ET_c$) and reference evapotranspiration ($ET_o$) and plotted against days after sowing that is presented in Figures 1 and 2 for summer and *Rabi* seasons, respectively. It is revealed from the result that crop coefficient values of groundnut increased gradually from a initial value of 0.27 to a maximum of 1.01 (60-70 DAS) as the crop growth advanced and after that the value started declining to attain a value of 0.36 at the time of harvest during summer season and similarly for *Rabi* season crop coefficient varies from 0.25 to 0.31 with a maximum of 0.97 during pod formation stage. With these observed values a polynomial function was fitted to the crop coefficient values and fourth order polynomial equation found to yield high value of coefficient of determination ($R^2$). The polynomial models of crop coefficients ($K_c$) obtained as a function of time (days after sowing) are given below for respective seasons.

Y = $1.25x10^{-7}d^4 - 2.82x10^{-5}d^3 + 1.8x10^{-3}d^2 - 2.49x10^{-2}d + 0.3792$ ($R^2$ = 0.9805) (Summer season)

Y = $1.32x10^{-7}d^4 - 2.99x10^{-5}d^3 + 1.96x10^{-3}d^2 - 3.02x10^{-2}d + 0.4$ ($R^2$ = 0.9734) (*Rabi* season)

Using this polynomial equation crop coefficient value for any day after sowing can be estimated. In the previous studies a third order polynomial equation for groundnut (Elliott *et al.,* 1988) and a fourth order polynomial equation for wheat and maize (Kumar and Singh, 2006) yielded higher $R^2$. In the FAO reports, the minimum value of $K_c$ in the beginning and the end of groundnut growing season is about 0.4-0.6, and the maximum value of $K_c$ in the mid crop growth stage with a maximum leaf area index is about 1.15-1.20 (Allen *et al.,* 1998; Doorenbos and Kassam, 1979; Doorenbos and Pruitt, 1975). The calculated crop coefficients of the present study are lower than the FAO values. The reason for the lower $K_c$ in all seasons is that the computed reference evapotranspiration is larger in this agroclimatic zone. Many earlier results have also shown that reference evapotranspiration estimated by Penman equation or Penman-Monteith equation was larger than that estimated by other method for similar agroclimatic regions (Rao *et al.,* 1974; CSSRI, 2000). Also, the crop coefficient is related closely to crop phenotype and management practice, which may further influence plant development rate and ground coverage (Allen *et al.,* 1998; Williams and Ayars, 2005). Many other studies have indicated that $K_c$ was related to leaf area index and percentage of ground cover (Al-Kaisi *et al.,* 1989; De Medeiros *et al.,* 2001; Heilman *et al.,* 1982) and DAS (days after sowing). Since this is an empirical equation, it holds good for the areas having similar climatic and cropping conditions.

**Table 1. Evapotransporation (mm) of groundnut at a step period of 10 days**

| Days after sowing | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|
| Summer season | 34 | 40 | 51 | 62 | 73 | 84 | 63 | 43 | 36 | 30 |
| *Rabi* season | 32 | 38 | 48 | 59 | 67 | 76 | 61 | 40 | 33 | 26 |

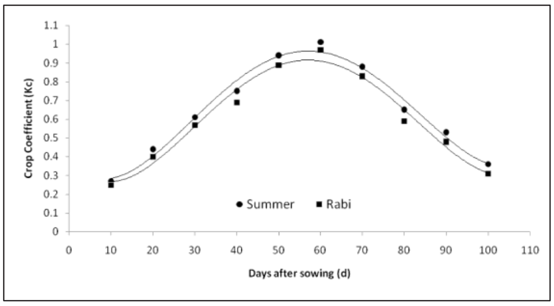


**Fig. 1. Crop coefficient curves for summer and *Rabi* season crops**

## Conclusions

The present study was undertaken to determine the crop coefficient values and to develop crop coefficient model for groundnut under the agro-climatic conditions of LBP command in Tamil Nadu. The results revealed that the crop coefficient values were low initially, which increased to a maximum of 1.01 and 0.97 for summer and *Rabi* seasons, respectively as the crop physiologically fully developed and thereafter decreased to 0.36 and 0.31 for summer and *Rabi* seasons respectively at the time of harvest. Polynomial model was fitted to the crop coefficient values and fourth order polynomial equation was found to be best fitted. The study will be helpful for deciding the irrigation requirement and irrigation scheduling during the life cycle of the crops.

### Acknowledgment

Authors express their gratefulness to University Grants Commission, New Delhi for providing the research grant.

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Received: August 21, 2009; Accepted: March 20, 2010