Irrigation Planning in Command Areas Using Crop
Coefficient Model

G. Thiyagarajan1*, M.V. Ranghaswami2, D. Rajakumar1 and R. Kumaraperumal3
1Water Technology Centre, 2Department of Soil and Water Conservation Engineering
3Department of Soil Science and Agricultural Chemistry
Tamil Nadu Agricultural University, Coimbatore-641 003

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 (ETc) to estimated or measured
reference evapotranspiration (ETo). 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
(ETc) for any time periods between two successive
soil moisture measurements dates, components
of water balance equation were monitored. Reference
evapotranspiration (ETo) for all the
periods were estimated as the product of pan
evaporation and pan coefficients (Kp). Crop
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.

\[
Y = 1.25 \times 10^{-7}d^4 - 2.82 \times 10^{-5}d^3 + 1.8 \times 10^{-3}d^2 - 2.49 \times 10^{-2}d + 0.3792 \ (R^2 = 0.9805) \quad \text{(Summer season)}
\]

\[
Y = 1.32 \times 10^{-7}d^4 - 2.99 \times 10^{-5}d^3 + 1.96 \times 10^{-3}d^2 - 3.02 \times 10^{-2}d + 0.4 \ (R^2 = 0.9734) \quad \text{(Rabi season)}
\]

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.

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.

References
Williams, L.E. and Ayars, J.E. 2005. Grapevine water use and the crop coefficient are linear functions of the shaded area measured beneath the canopy. Agriculture, Forestry and Meteorology, 132: 201-211.