International Journal of Environmental Engineering and Management.
ISSN 2231-1319, Volume 4, Number 5 (2013), pp. 523-528

http://www.ripublication.com/ ijeem.htm

Estimation of Crop Evapotranspiration of Cotton using Remote Sensing Technique

S.K. Singh*[1], Sujay Dutta[2] and Nishith Dharaiya[1]

[1] *Dept. of Life Science, Hemchandracharya North Gujarat University, Patan, Gujarat.*
[2] *Space Applications Centre (ISRO), Ahmedabad, Gujarat.*

Abstract

Crop coefficient values are used to estimate crop evapotranspiration (ETc) for determining irrigation scheduling. Many important crop biophysical properties such as Percentage Vegetation Cover and Leaf Area Index can be estimated from remotely sensed Vegetation Index, in order to quantify real time vegetation growth dynamics. The objective of this study was to understand the effectiveness of basal crop coefficient (K_{cb}) values estimated from remote sensing and their application in real time crop water requirement. The study was carried out for Cotton crop in Sirsa district of Haryana. Spectral index such as SAVI (Soil Adjusted Vegetation Index) and Fractional Vegetation Cover (F_c) were used to estimate K_{cb} value. High spatial resolution Landsat TM5 images were used to generate spectral profile of NDVI, SAVI and Fc for different crop cover. Using, available empirical models from literature, crop coefficient was derived from SAVI values. Reference Crop Evapotranspiration (ET_0) was estimated using Blaney-Criddle Method, taking weather data from ICAR Research Station Observatory. The crop coefficients derived from Remote Sensing data were used along with ET_0 values to estimate crop evapotranspiration (ETc). The result showed that the spatial distribution of seasonal ETc varied between 317 to 534 mm for growing season of cotton depending upon sowing date and other condition. The estimated crop evapo-transpiration (ET_c) pattern was compared with fractional vegetation cover. Spatial distribution map of cotton ET_c, basal crop coefficient and fractional vegetation cover showed areas of high and low water demand. This work can help in water management practices for better irrigation management.

Keywords: Crop Evapotranspiration (ETc), SAVI, NDVI, Basal crop Coefficient, Fractional vegetation Cover and Remote sensing.

1. Introduction

Cotton is an important fibre crop in the world (Texier 1993).Being a warm climate crop, it is grown dry sub–tropical climates having adequate rainfall and ample sunshine during the growing period. Air temperature of 32^0 C to 35^0 C is considered optimum for normal growth of cotton plants with a minimum and maximum range 16^0 C to 38^0 C (Wright and Sprenkle 2005). Transpiration is an important variable in efficient planning and management of irrigation water in arable crops.it represents a major part of consumptive use of water supplied through irrigation and rainfall (Burt *et* al. 2005).

2. Materials and Methods

2.1 Study area and data description

Sirsa district in Haryana state, India, has been taken as study area .The time of cotton sowing is from May to June and the picking is done in the month of October-November. Daily meteorological data were collected from AWS station, Central Institute of Cotton Research, sirsa from July to November, 2009.Air temperature was used to compute Reference crop evapotranspiration (ET_o).Landsat TM5 images were used in analysis. Empirical Equation used for calculation of basal crop coefficient Kcb is taken from (Gonzalez-Dugo et al., 2008)

$$\mathbf{Kcb} = \mathbf{Kcb}, \mathbf{max} * \frac{(\mathbf{SAVI} - \mathbf{SAVImin})}{(\mathbf{SAVImax} - \mathbf{SAVImin})} \qquad (1)$$

Where Kcb =Basal crop coefficient

Kcb,Max=basal crop coefficient at effective full ground cover, 1.30 (D.J.Hunsaker, 1999)

SAVImax=Maximum value of SAVI associated with dense vegetation

SAVImin=Minimum value of SAVI associated with bare soil. Blaney Criddle method was used for calculation of reference crop evapotranspiration (ET_0).

Blaney Criddle method was used to compute reference evapotranspiration (ETo), this method use only air temperature. Reference

Formula used in Estimation of crop evapotranspiration

$$ETc=Kcb*ETo \qquad . (2)$$

Where

ETc = crop evapotranspiration (mm/day)

Kcb-basal crop coefficient based on remote sensing

ETo=Reference crop evapotranspiration

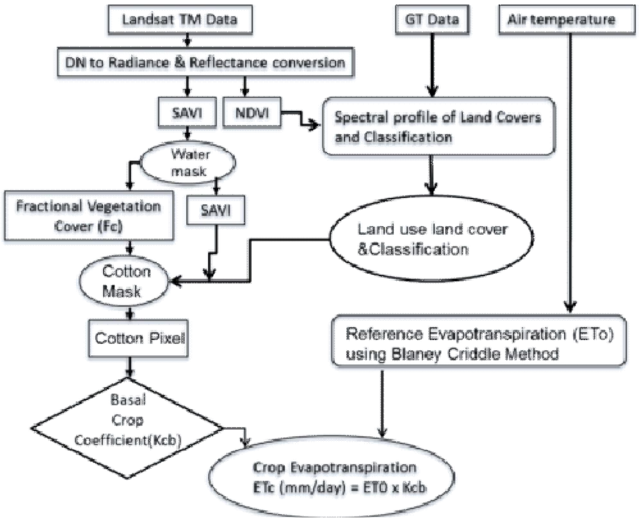

Figure 1: Flow chart of Methodology.

3. Result and Discussion

3.1 Seasonal variation of NDVI pattern of cotton

Analysis of seasonal variation of NDVI throughout the season shows different sowing dates in the study area. Higher NDVI indicates greater level of photosynthesis activity (Tucker *et* al. 1979).Different NDVI profile of 10 classes of cotton show different growth, which indicate different cotton sowing dates in study area, from May 1st fortnight to June 1st fortnight. But growth pattern was similar only the difference was vegetative growth. NDVI value also indicates Peak was occurs at 112 days from June 1st, mean at 21 September.

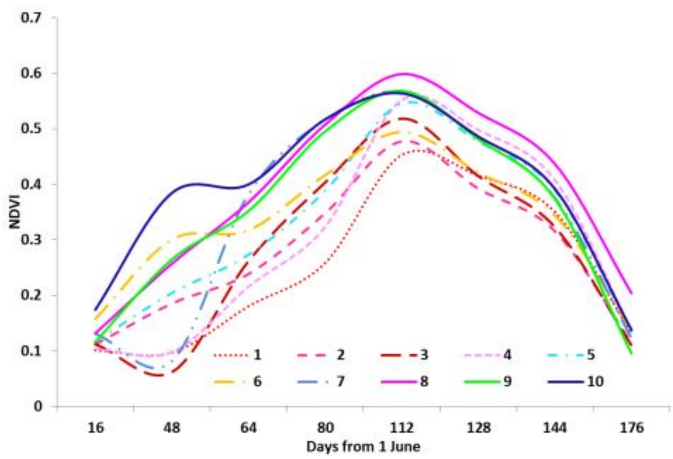

Figure 2: Seasonal variation of NDVI profile of cotton crop.

Decline starts from 21 September and harvested in November. The dip in NDVI value in classes mainly 3 and 7 at Day 48, it was because of scattered cloud over the study area on 19 July, 2009 shown in Figure.2.Interclass variability is due to differences in agricultural practices such as sowing date, irrigation and fertilization.

3.2 Evaluation of relationship between SAVI and Crop Coefficient

The reflectance based crop coefficient developed by Neale et al. 1989 was based on NDVI. But NDVI was found to be very sensitive to optical properties of soil background at incomplete vegetative cover condition (Bausch 1993). The dip in SAVI and basal crop coefficient (Kcb) value in classes mainly 3 and 8 at Day 48 was because of Scattered cloud over the study area on 19 July as shown in Figure 3. We have used SAVI as vegetation index to estimate fractional vegetation cover, basal crop coefficient (K_{cb}) because SAVI was not affected by wet soil surface in the background while NDVI is Sensitive to dry and wet surface. NDVI is more susceptible to non-ideal sky condition than SAVI. Additional calibration of K_{cb} estimated from SAVI was not required for soil background conditions. SAVI is less sensitive to optical properties of soil background than NDVI (Bausch 1993). Since the SAVI does not saturate at effective cover (LAI=3), estimated K_{cb} from NDVI will be higher compared to SAVI. Average maximum and minimum Kcb value at peak was 0.96 and 0.68 while SAVI was 0.42 and 0.31. Crop coefficient and SAVI curve follow the pattern of growth curve and decline from 21 September because senescence of the cotton starts after 21st. September.

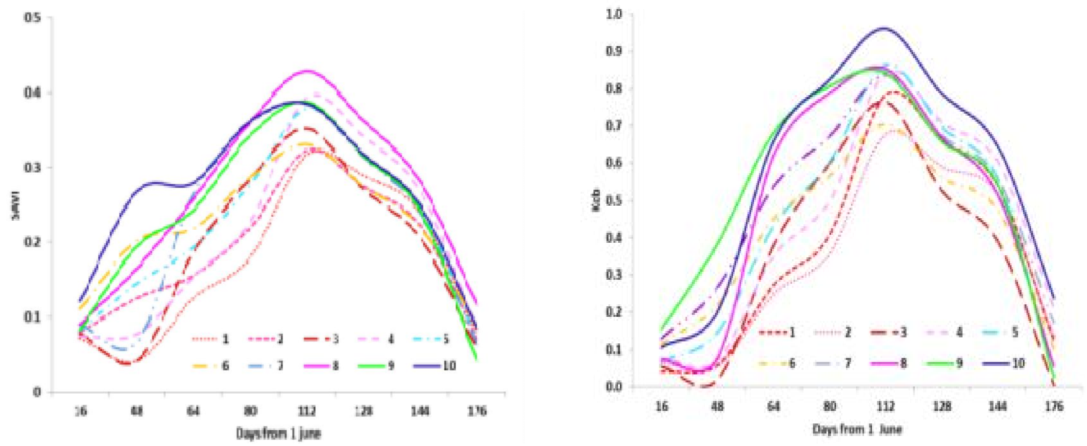

Figure 3: Seasonal variation SAVI and crop coefficient Evaluation of relationship between ETc and crop fraction

The dip in Fractional vegetation cover in classes mainly 3 and 8 at Day 48 was because of scattered cloud while dip in ETc classes 1& 2 was due to low vegetation cover. Dip in ETc class 8 was also due to cloud only. Spatial variation of crop water requirement and seasonal water requirement is show in figure 6.

Maximum and minimum value of fraction cover at peak means at 21 September was 0.74 and 0.52 .while ETc was 5.76 & 3.98 mm/day.Dip in ETc class 8 was also due to cloud only Monthly and spatial variation of crop evapotranspiration ETc is shown in Figure.5 & 6.

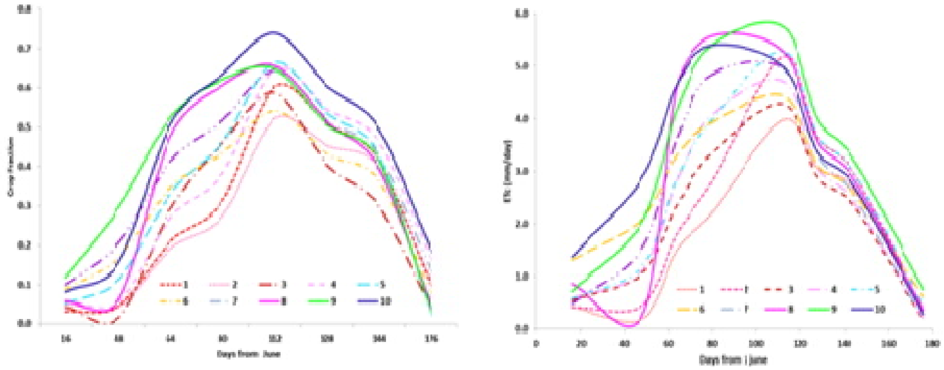

Figure 4: Seasonal variation of ETc and crop fraction.

Spatial variation of crop water requirement

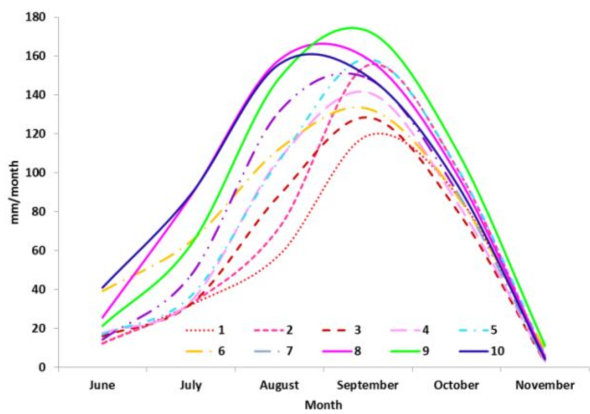

Figure 5: Monthly variation of Etc.

4. Conclusion

The remote sensing based K_{cb} estimation technique has the potential to provide the ability to detect and quantify the spatial differences in ETc information and crop growth stages. This technique could eliminate the additional filed observations. Remote sensing based Kcb estimation follow the similar pattern of seasonal variation of crop fraction, SAVI and NDVI.

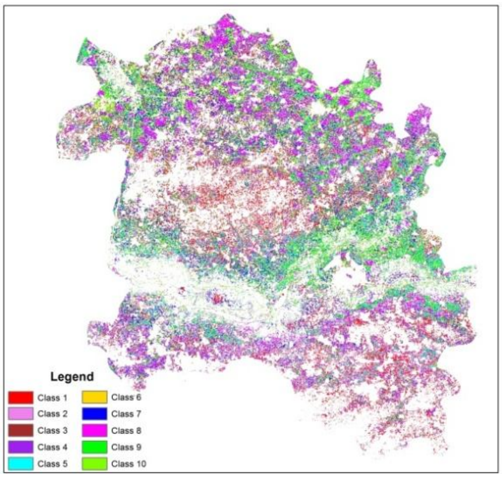

Figure 6: Spatial variation of Crop water requirement.

5. Acknowledgement

Authors are thankful to NASA for their services of free remote sensing Landsat data availability.

References

[1] PH Texier (1993), The Cotton fifth largest producer of edible oil. Cotton Development 8,pp. 2-3.

[2] WC Bausch (1993) ,Soil background effects on reflectance-based crop coefficients for corn. Remote Sens. Environ, 46,pp.213-222.

[3] CJ Tucker (1979), Red and photographic infrared linear combinations for monitoring vegetation. Remote Sens. Environ.8,pp.127–150.

[4] MP Gonzalez-Dugo and L Mateos (2008), Spectral vegetation indices for benchmarking water productivity of irrigated cotton and sugarbeet crops. Agr. Water Manage, 95,pp. 48-58.

[5] DL Wright and RK Sprenkel (2005), Cotton growth and development. Agronomy department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida

[6] CM Burt, A J Mutziger, RG Allen and TA Howell (2005),Evaporation research: review and interpretation. Journal of Irrigation & Drainage Engineering, 131,1,pp.37-59.

[7] DJ Hunsaker, PJ Pinter and BA Kimball (2005), Wheat basal crop coefficients determined by normalized difference vegetation index. Irrig. Sci , 24,pp.1–14.