CROP COEFFICIENT OF SUGARCANE (RATOON) IN HAFT TAPPEH OF IRAN

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Abstract.

Crop coefficient of sugarcane is necessary for the water requirement estimation in irrigation water planning and management. This study has been initiated to determine the crop coefficient (Kc) of sugarcane (Ratoon) in Haft tappeh climate. The relationships between Kc, ETc/Ep, length growth, days after cutting (DAS) and percent days after cutting (%DAS), were also investigated.

The mid-season and late-season Kc values for sugarcane were 1.45 and 1.14, respectively. These values are somewhat higher than those values that recommended by FAO. The ratio of ETc/Ep varied between 0.64 to 1.10 from the beginning to the end of the growing season .

The maximum ratios of ETc/ET0 and ETc/Ep occurred at a length growth of 126 cm. Furthermore, second order polynomials were presented to predict the Kc values from days after cutting (DAS) and percent days after cutting (%DAS).

Keywords: Sugarcane, Haft tappeh, Crop coefficient, Irrigation and Evapotranspiration

1 INTRODUCTION

Sugarcane is an irrigated cash crop usually planted in khouzestan of I.R. of Iran. Therefore, it should be included in crop pattern of irrigation projects in these regions, and its water requirement estimated for irrigation water planning and management. Crop coefficient is required for estimation of crop water requirement. As far as authors are aware, there is little data if any reported on the water requirement of sugarcane (Cp48-103) in I.R. of Iran and other parts of the world.

Crop coefficient is the ratio of actual crop evapotranspiration (ETc) to reference crop evapotranspiration (ET0). The reference crop is usually grass (Doorenbos and Pruitt, 1977). The pan evaporation method is a simple method to predict of evapotranspiration. This method has been modified by FAO(1998). Different methods estimating ET0 values have been used for the study area but a suitable method is still in doubt.

This study was initiated to measure the ETc of sugarcane using two lysimeters and to estimate the ET0 using the pan evaporation method to compute the crop coefficient of sugarcane in Haft tappeh area. The relationships between Kc and days after cutting and length growth were also investigated for sugarcane.

2 METHODS AND MATERIALS

Crop coefficient (Kc) can be estimated by,

$$Kc = \frac{ETc}{ET0} \qquad (1)$$

Therefore, the ETc and ET0 values were determined at the various stages of growth.

2.1 ETc measurement

The study was conducted in Haft tappeh, I.R. of Iran. The area is a flat at 32.07(degree, N) and 48.35 (degree, E) and an altitude of 63.1 m. Climate of the study area has warm summers and most of the rain occurs in the winter months. Temperature, relative humidity, wind speed at 2 m height and sunshine duration on a daily basis were collected during the study period. A summary of the weather data is shown in Table 1.

Table 1. Summary of meteorological parameters for Haft tappeh area.

Parameters	Unit	Maximum	Minimum	Annual
Temperature	C	50	0	-
Humidity	%	99	18	56
Sunshine	hours	9.8	4.8	-
Wind speed (U2)	m/s	3.09	1.45	-
Precipitation	mm	-	-	291

ETc of sugarcane was measured by two drainable lysimeters surrounded by sugarcane plantation. The lysimeters and surrounding sugarcane plantation were located in between of a field of sugarcane during the growing season of 2000-2001(April to November). The average depth and dimension of the lysimeters were 1.9 m and 4×4.5 m^2, respectively. A Cp48-103 cultivar of sugarcane was cutted on 23 December 2000.

The weight method was used to measure the volumetric soil water contents before and after growing season. These measurements were used to determine the amount of ETc in lysimeters during the growing season. ETc was calculated by the following equation:

$$ETc = I + P - D + (M1 - M2) \quad (2)$$

Where I, P and D are irrigation, precipitation and deep percolation (mm), respectively, M1 and M2 are volumetric soil water content, cm^3 / cm^3 ,at times one and two (before and after growth season). D was measured from the drain pipe, which was connected, to the lysimeters.

2.2 ET0 calculation

ET0 for each irrigation interval was determined using the pan evaporation method that modified by FAO (1998).

$$ET0 = Kp \times Ep \quad (3)$$

Where,

ET0: reference evapotranspiration (mm/day)

Kp: pan coefficient

Ep: pan evaporation (mm/day)

Class A pan with dry fetch applied. Kp was calculated by the following equation.

$$Kp=0.61+0.00341(RHmean)-0.000162(U2)(RHmean)-0.00000959(U2)(FET)+0.00327(U2)(LnFET)-0.00289(U2)Ln(86.4U2)-0.0106Ln(86.4U2)Ln(FET)+0.00063(Ln(FET))^2 Ln(86.4U2) \quad (4)$$

Where,

RHmean: average daily relative humidity (%)

U2: average daily wind speed at 2 m height (m/s)

FET: fetch, or distance of green agricultural crop

2.3 Length growth

Length growth of a plant from each lysimeter was measured by a ruler at 7-days intervals throughout the growing season.

3 RESULTS AND DISCUSSION

Using the monthly weather data, the amount of monthly ET0 was calculated and the amounts of monthly were determined. These results and measured values of class A pan evaporation (Ep)and lysimeter actual evapotranspiration (ETc)are shown in Fig.1. In general, the pan evaporation (Ep) was higher than the ETc and ET0.

3.1 Sugarcane crop coefficient

The ratio of ETc to ET0 by pan evaporation and the ratio of ETc to Ep are given in Fig.2.Furthermore, the values of Kc for all of the growing season which is not compatible with the values of Kc for sugarcane reported by FAO (1998).

The ETc and ET0 by pan evaporation and Kc values for different stages of sugarcane growth period are shown in Table 2. The values of Kc for all of the growing season are somewhat higher than that reported by FAO (1998). Therefore, these Kc values may be used for sugarcane in area of similar environmental conditions (Table 1) which occur in vast areas of I.R. of Iran and in other parts of the world.

The variation in Kc may be shown as a function of days after cutting (DAS) or Julian date (Wright,1982) and fraction of growing season (%DAS)(Elliott et al.,1988). In this study, Kc as a function of DAS and %DAS was obtained by a multiple regression procedure as follows :

$$Kc=-0.0003(\%DAS)^2+0.0451(\%DAS)-0.4189 \quad (5)$$
$$R^2=0.9257 \qquad n=7$$

$$Kc=--3^{-5}(DAS)^2+0.0138(DAS)-0.4258 \quad (6)$$
$$R^2=0.9317 \qquad n=7$$

Second-order polynomial equations (Eqs. (5) and (6)) were obtained with higher coefficients of determination (R^2). The calculated values of Kc from Eqs. (5) and (6) are shown in Figs. (4) and (5) as curves which are skewed and fitted better to the data points. A third-order polynomial equation was also proposed for Spanish peanuts by Elliott et al (1988).

The monthly Kc values were calculated and the results are presented in Table 3. These values of Kc are commonly used in water requirement computation for irrigation water resource allocation projects. It also seems that there is a relationship between crop coefficient (Kc) and length growing. This relationship for sugarcane (Ratoon) was obtained as follows (Fig.3):

$$Kc=-0.8095(\text{length growth})^2+1.4053(\text{length growth})+0.7747 \quad (7)$$

$$R^2=0.6277 \qquad n=8$$

The value of ETc/ET0=Kc is nearly equal to 1.4 at a length growth of 1 meter. In plant growth models where the evapotranspiration is estimated by length growth, Eq.(7) can be used for sugarcane.

3.2 ETc/Ep for sugarcane

The measured pan evaporation rates (Ep) during the growing season are shown in Fig.1. The values were often greater than the ETc for sugarcane. The ETc/Ep ratios for sugarcane were computed at Haft tappeh and the results are presented in Fig. 2. The minimum and maximum values of ETc/Ep ratios were 0.64 and 1.10 which occurred at the beginning and middle of the growing season, respectively.

Monthly ETc/Ep ratios were also computed. The results are given in Table 4. The minimum and maximum ratios were 0.64 and 1.10 respectively, which occurred at the beginning and middle of the growing season. The ratios of ETc/Ep at different growth stages of crops are useful as a practical tool for estimating the seasonal crop evapotranspiration where the pan evaporation data are available (Venkatachari and reddy,1978; Rao et al., 1990).

There also seems to be a relationship between ETc/Ep and length growth. This relationship for sugarcane was obtained as follows (Fig.6):

$$ETc/Ep=-0.5987(\text{length growth})^2+1.0975(\text{length growth})+0.5358 \quad (8)$$

$$R^2=0.7932 \qquad n=8$$

The value of ETc/Ep is nearly equal to 1.10 at a length growth of 1.27 m. In plant growth models, where the evapotranspiration is estimated by pan evaporation rate and length growth, Eq. (8) can be used for sugarcane (Ratoon).

4 CONCLUSION

The seasonal ETc for sugarcane (Ratoon) in the study area with an eight months growth period was 1925 mm. The pan evaporation method was preferable for estimating ET0. The mid-and late-season Kc values for sugarcane (Ratoon) were 1.45 and 1.14,respectively. These values are somewhat higher than those values that recommended by FAO. The monthly values of Kc and ETc/Ep ratios are also presented. The ratio of ETc/Ep ratios is also presented. The ratio of ETc/Ep varied between 0.64-1.10 from the beginning to the end of the growing season .

The relationship between Kc and ETc/Ep ratio and length are also shown. The maximum ratios of ETc/ET0 and ETc/Ep occurred at a length growth of 126 cm. Furthermore, second-order polynomials are presented to predict the Kc values from days after cutting (DAS) and percent days after cutting (%DAS).

Table 2. ETc, ET0 and Kc for sugarcane (Ratoon) at different stages of growing season

Stage	Period(days)	ETc(mm)	ET0(mm)	Kc
Initial	185	996.51	932.55	1.07
Crop development	62	788.53	593.78	1.33
Mid-season	41	378.33	261.99	1.45
Late-season	45	126.16	143.38	1.14

Table 3. ETc,ETo and Kc for sugarcane (Ratoon) for different months of growing season.

Month	ETc	ET0	Kc
April	202.58	225.7	0.90
May	319.76	301.7	1.06
June	416.95	339.12	1.23
July	407.21	316	1.29
August	383.89	281.08	1.37
September	315.55	220.37	1.43
October	168.76	130.70	1.29
November	36.2	63.28	0.57

Table 4. ETc,Ep and ETc/Ep for sugarcane (Ratoon) for different months of growing season.

Month	ETc	Ep	ETc/Ep
April	202.58	314.67	0.64
May	319.76	431	0.74
June	416.95	473.27	0.88
July	407.21	414.34	0.98
August	383.89	370.15	1.04
September	315.55	300.45	1.05
October	168.76	153.55	1.10
November	36.2	39.07	0.93

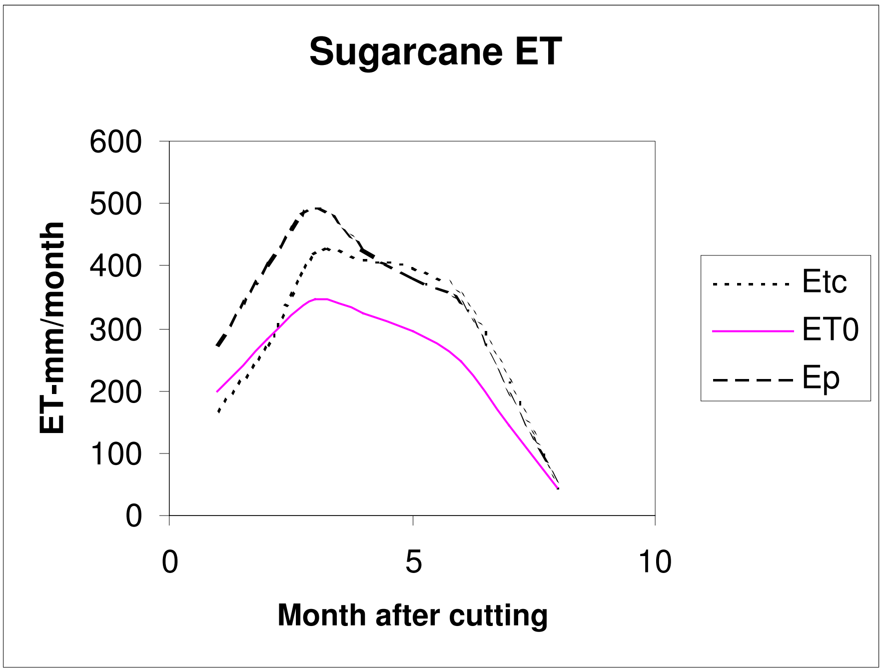

Fig.1. ETc,ET0 and Ep as a function of months after cutting.

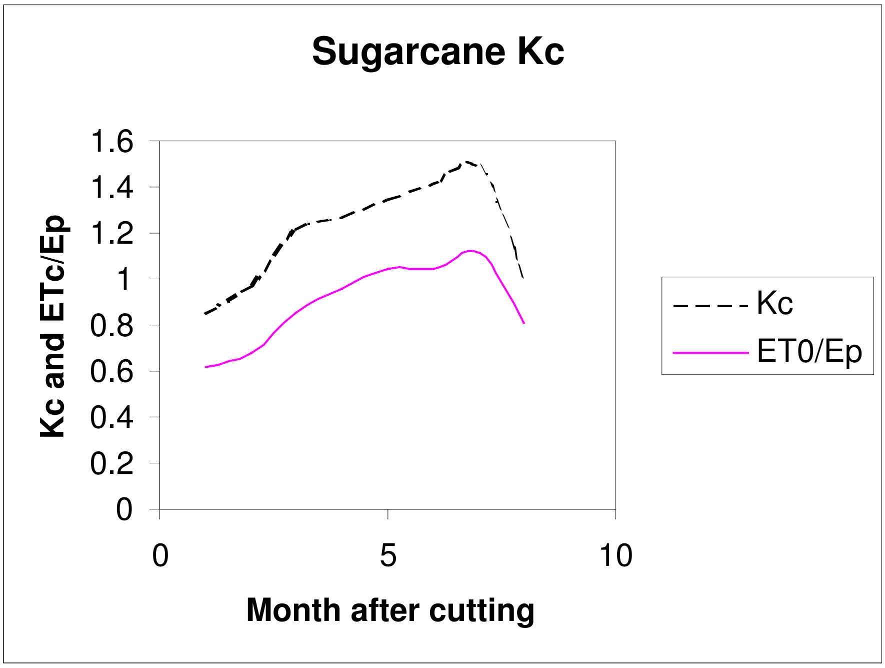

Fig.2. Kc and ETc/Ep ratio as a function of months after cutting

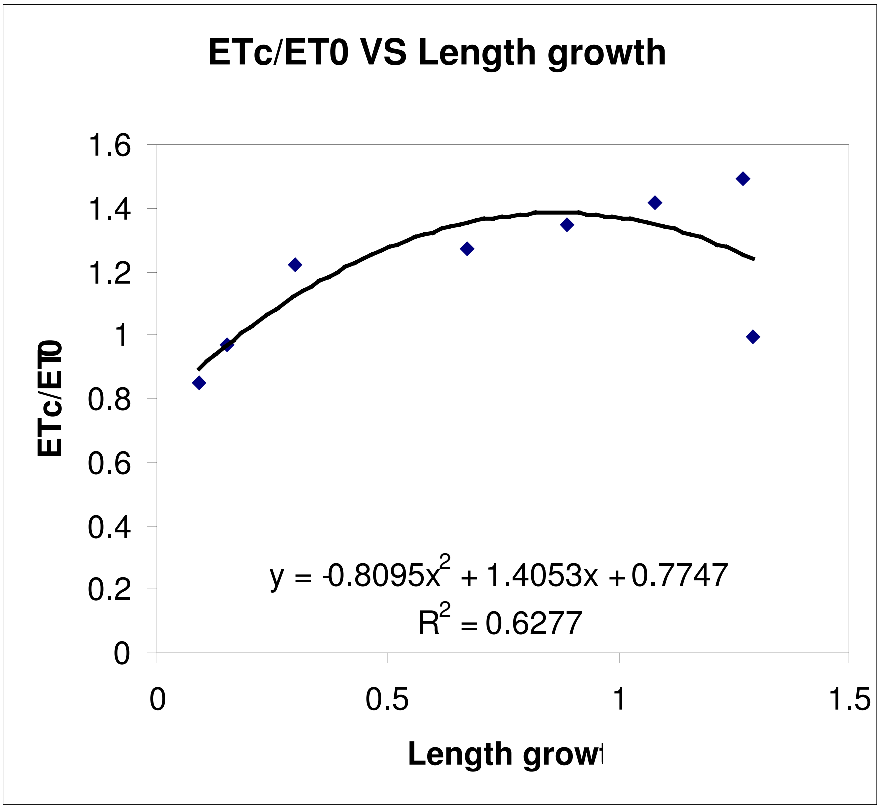

Fig.3. Measured and optimized values of Kc (ETc/ET0) as a function of length growth.

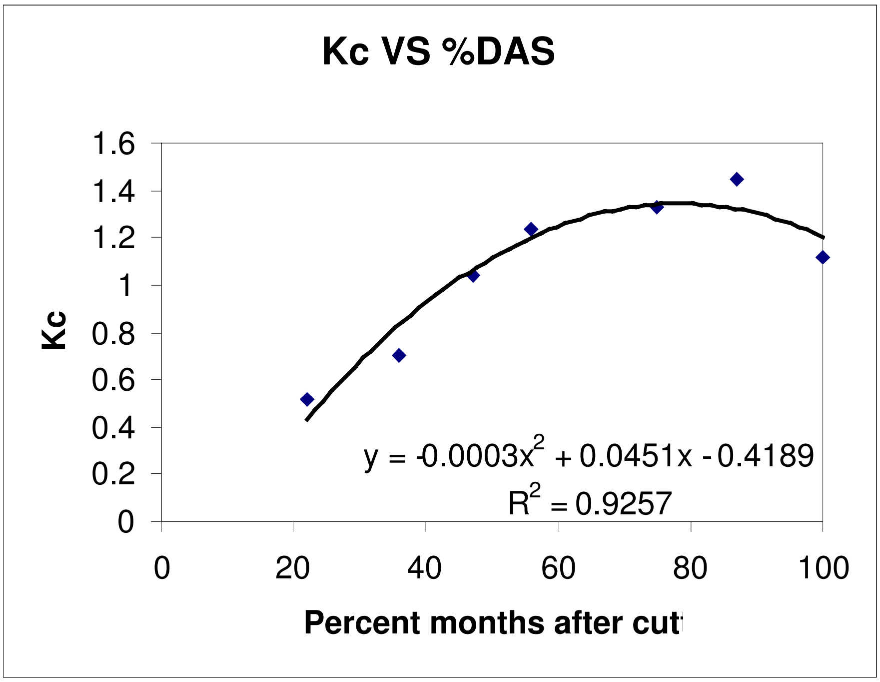

Fig.4. Measured and ooptimized valuesof Kc (ETc/ET0) as a function of percent months after cutting.

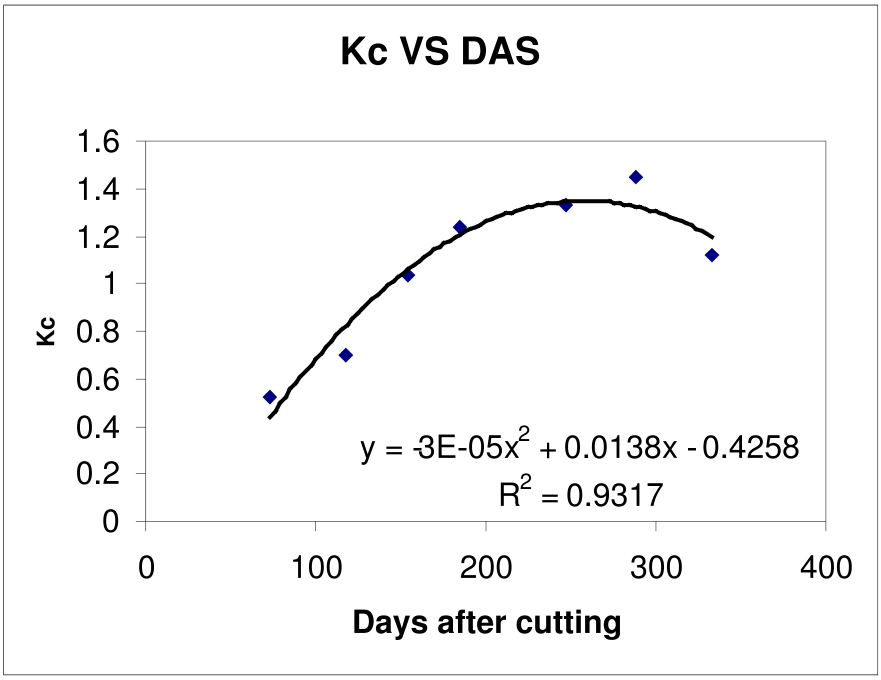

Fig.5. Measured and optimized values of Kc as a function of days after cutting.

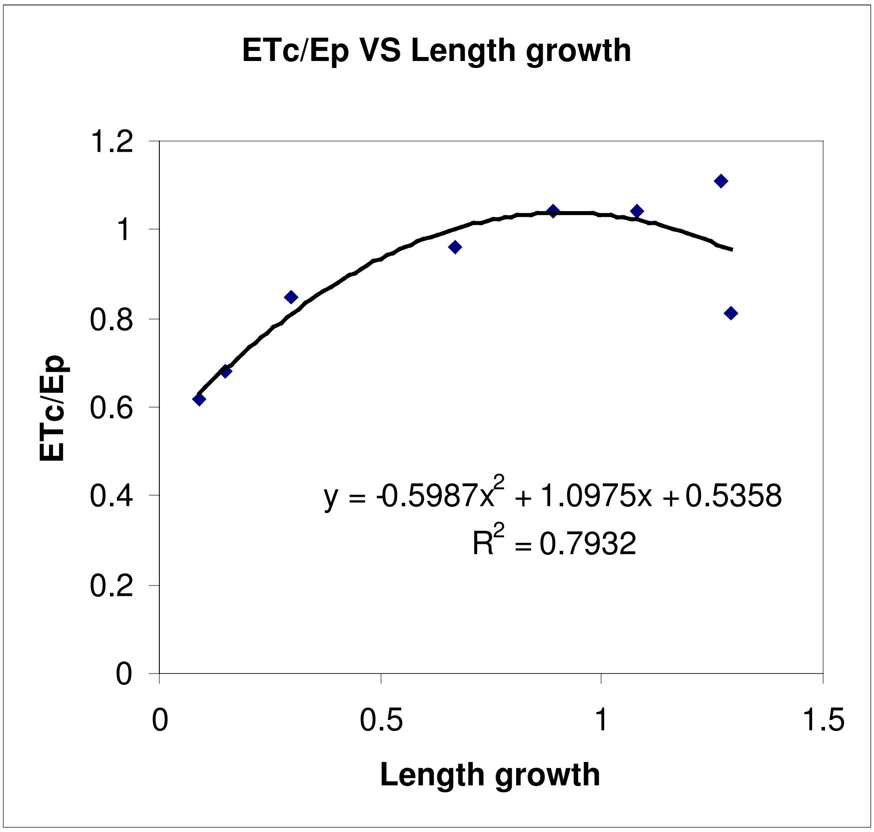

Fig.6. ETc/Ep ratio as a function of length growth.

5 REFERENCES

Aboukhaled.A.,Alforo.A,Smith.M.,1982. Lysimeters:irrigation and drainage. Paper No.39,FAO,Rome,Italy.,1-20.

Allen,R.G., Pereira,L.S., Raes,D., and Smith,M.,1998. Crop evapotranspiration: irrigation and drainage. Paper No.56,FAO,Rome,Italy., 65-78.

Andam, M., 1994. .Measurement of evapotranspiration, Transpiration, Crop coefficient and other parameters required in irrigation management of sesame field., Shiraz,Iran.,53-115.

Doorenbos,J.,Pruitt,W.O.,1977. Crop water requirement: irrigation and drainage .Paper No.24,(Review).FAO, Rome, Italy. P. 144.,60-70.

Elliott,R.L.,Harp,S.L.,Grosz,G.D.,Kizer,M.A.,1988. Crop coefficients for peanut evapotranspiration. Agric Water Management.15,155-164.

Goodwin, I., 2000. Construction of an evaporation pan for irrigation scheduling. Irrigated Agriculture,Tatura.1-5.

Haft tappeh research center.,2000, Annual meteorological data.

Haft tappeh research center.,2000, Annual report.,1-40.

Kashyap,P.S.,Panda,R.K.,2001. Evaluation of evapotranspiration estimation methods and development of crop-coefficients for potato crop in a sub-humid region. Agricultural Water Management.50(2001),9-25.

Rao,V.P.,Raikhelkar,S.V.,Sondge,V.D.,1990. Evaluation of Penman, radiation and evaporation methods for predicting sesame evapotranspiration. J.Res.APAU.18,131-134.

Sarami, M., 2001. Water used determination of sugarcane cultivars. Agriculture research center of Ahwaz.

Sepaskhah,A.R., and Andam,M.,2000. Crop coefficient of sesame in a semi-arid region of I.R.Iran. Agricultural Water Management.49,(2001),51-63.

Venkatachari,A.,Reddy,K.A.,1978. Relationship of evapotranspiration with pan evaporation and evaluation of crop coefficient. Acta Agronomica Academica Scientiarum Hungaricae 27,107-110.

Wright.J.L.,1982. New evapotranspiration crop coefficients. J. Irrig. and Drain. Div. ASCE. 108,57-74.