Iran Agricultural Research 14:125-138 (1995)

CROP COEFFICIENT OF SUGAR BEET FOR ISFAHAN REGION

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(Received: January 28, 1995)

ABSTRACT

Sugar beet was planted in two lysimeters and the reference crop (lawn) was planted in another three lysimeters. The potential crop evapotranspirations of sugar beet and reference crop were determined for two years in 10-day periods. The 10-day, monthly and seasonal crop coefficients of sugar beet were also estimated. Maximum crop coefficient was 0.98 at about 100-110 days after planting which declined to 0.74 at the end of the growing season.

تحقیقات کشاورزی ایران
۱۴ : ۱۲۵ -۱۳۸ (۱۳۷۴)

ضریب گیاهی چغندر قند برای منطقه اصفهان

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چکیده

بمنظور تعیین ضریب گیاهی چغندر قند در اصفهان، چغندر قند در دو لایسیمتر و چمن (بعنوان گیاه مبنا) در سه لایسیمتر دیگر کاشته شد. تبخیر و تعرق پتانسیل چغندرقند و گیاه بمـدت دو سـال بطور روزانه اندازه گیری شد. ضریب گیاهی چغندرقند برای فواصل ده روزه، ماهانه و برای فصـل زراعی تعیین گردید. حداکثر مقدار ضریب گیاهی چغندر قند ۰/۹۸ بر آورد شد کـه بیـن ۱۰۰ تـا ۱۱۰ روز پس از کاشت بدست آمد پس از آن، مقدار ضریب گیاهی کاهش پیداکرد به طوری کـه در پایان فصل رشد به ۰/۷۴ رسید.

INTRODUCTION

Water is the most valuable resource for the agriculture in Iran. In spite of the scarcity of water in this country, the irrigation efficiency is as low as 30% (2). The water loss at the farm can be reduced by taking certain precautions and accurate estimation of crop water reqirement. Potential crop evapotranspiration (ETc) may be estimated by computing the potential reference crop evapotranspiration (ETo) and multiplying it by the crop coefficient (Kc) expressed as:

$$ETc = Kc . ETo \qquad [1]$$

Several different equations have been developed for estimation of ETO (4) but not all of them give an accurate estimate for a specific region. Rahimzadegan (5) verified the accuracy of some of these equations for Isfahan region and concluded that the Jensen-Haise equation gave the best estimate of ETo for that region.

Many tables and curves are available for general values of crop coefficients (3,4). However, verification of their values for a specific region and crop is necessary. Therefore, this study was conducted to determine the crop coefficient of sugar beet in Isfahan. Sugar beet is an important crop produced in Isfahan. Presently, the area under this crop is reported to be 200000 ha in Iran and 15000 ha in Isfahan(1).

MATERIALS AND METHODS

Five lysimeters with a surface area of 1.5×1.5 m and depth of 1.2 m were built (Fig. 1). The bottoms of the lysimeters were inclined to convey the

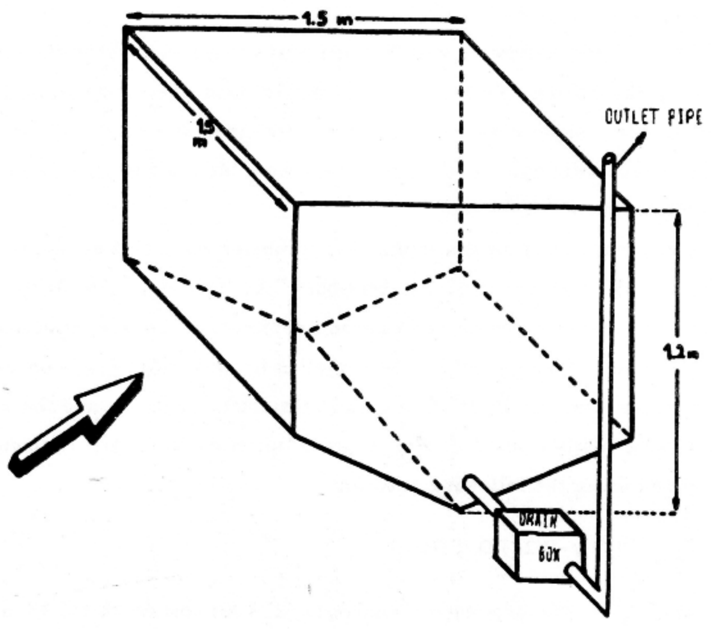

Fig. 1. Schematic sketch of lysimeter used for the measurement of potential evapotranspiration.

drainage water to a box. A vertical pipe was connected to the box making it possible to pump out the drainage water. The lysimeters were buried into the soil up to their top edge at a field belonging to Isfahan University of Technology (IUT). The lysimeters were filled with 30 cm of sand at the bottom and 90 cm of Lavark soil at the top. The Lavark soil is typical of the region. The lysimeters were irrigated a few times, allowing soil settlement before planting and were refilled up to the edge. The field capacity, permanent wilting point and the bulk density of the soil were measured to be 28% on dry weight basis, 10% on dry weight basis, and 1.19 g cm^{-3}, respectively. The soil moisture characteristic curve was prepared in the laboratory. This curve was then used to convert the reading of tensiometer to soil moisture contents.

Three of the lysimeters with 7-m margins around them were planted with lawn in the spring. Two of the lysimeters with the same margins were planted with sugar beet. The lawn was maintained at a height of 7 to 10 cm during the experiment. Three tensiometers were installed in each lysimetrs at the soil depths of 15, 45, and 75 cm.

To prevent stress on the plants, the lysimeter was irrigated if any of the tensiometers showed 45-55 centibar. As the top soil dries faster, practically the tensiometer at 15 cm soil depth controlled the irrigation time in this study. Enough water was applied in each irrigation to ensure that some water entered the drain box. The tensiometer readings and the drained water were daily measured. The evapotranspiration from each lysimeter was calculated using the following equation :

$$ET = [\sum_{i=1}^{n} (W1_i - W2_i) D_i] Dd \qquad [2]$$

in which i is the tensiometer number (1, 2, 3 for soil depth 15, 45, and 75, respectively), $W1_i$. and $W2_i$.are volumetric soil moisture content (cm^3 cm^{-3}) on the previous day and the day of evapotranspiration estimation, respectively . D_i is the soil layer thickness represented by ith tensiometer equal to 30 cm, Dd is the depth of daily drained water (cm) obtained by dividing the volume of drainage water by the surface area of lysimeter and ET is evapotranspiration (cm day^{-1}) which is ETo for the lawn lysimeters and ETc for the sugar beet lysimeters.

The evapotranspiration computed by Equation [2] was checked with the difference between the amount of water applied to lysimeter and the amount drained out. Soil moisture was measured by the gravimetric method and error was corrected if any significant difference between the computed ET from Equation [2], and the check value were observed. The hole created for sampling was refilled with an equal amount of soil which was originally removed for sampling.

The crop coefficients of sugar beet were calculated for different time intervals using Equation [1] considering average of the evapotranspiration from the three lawn lysimeters as ETo and average of the evapotranspiration from the two sugar beet lysimeters as ETc. Daily climatological data were collected from the weather station of IUT during the experiment.

RESULTS AND DISCUSSION

The evapotranspiration was measured on daily basis, but the data were analyzed for the time intervals of 10 days, months and growing season. Daily changes of crop coefficient were very small and most of the time insignificant. Besides, on some days, the moisture change in soil profile was not reflected by any of the tensiometers. For example, if water evapotranspired from 0 to 10 cm depth, none of the tensiometers would show the moisture change. Long term computation of moisture change in the soil profile compensated for this error, because it is most probable that the moisture change in the soil profile was reflected by the tensiometer in a few days.

The climatological data are presented in Table 1. The values of measured

Table 1. Average monthly climatological data from weather station of IUT.

Month	$T^{\dagger}$ °C	RH %	V $m\ sec^{-1}$	S %	Rs $cal\ cm^{-2}\ day^{-1}$	Rn
			First Year			
May	22.1	22.2	2.4	91.6	674	492
June	25.5	23.7	2.2	92.8	730	535
July	29.6	22.8	1.9	94.8	704	515
Aug.	27.8	23.1	1.9	95.8	654	477
Sept.	23.7	23.9	1.5	99.7	593	430
Oct.	18.1	31.0	1.4	93.4	455	326
Nov.	11.4	37.2	1.6	76.5	332	232
			Second Year			
May	20.4	29.0	2.0	81.7	629	458
June	26.5	20.0	1.9	97.8	754	553
July	29.3	18.7	1.9	97.6	717	525
Aug.	27.9	20.1	1.5	97.0	659	481
Sept.	23.4	22.3	1.7	99.3	591	429
Oct.	18.0	29.9	1.4	97.2	466	335
Nov.	10.9	54.5	1.3	75.0	328	229

† T = temperature, RH = relative humidity, V = wind velocity, S = percent sunshine hours, Rs = ground level solar radiation and Rn = net radiation.

ETo, ETc and the computed values of the crop coefficient (Kc) for the ten-day intervals are given in Table 2. The variations of Kc are also presented in

Table 2. **Reference crop potential evapotranspiration (ETo), potential crop evapotranspiration (ETc)and crop coefficients of sugar beet in Isfahan at 10-day intervals.**

Days after planting	ETo (mm)		ETc (mm)		Crop coefficient (Kc)		
	First year	Second year	First year	Second year	First year	Second year	Average of two years
0-10	71.2	56.4	16.4	11.3	.23	.20	.22
11-20	88.2	63.5	19.4	13.3	.22	.21	.21
21-30	95.2	67.7	27.6	21.7	.29	.32	.30
31-40	102.4	70.5	43.0	28.9	.42	.41	.41
41-50	95.8	87.6	51.7	54.3	.54	.62	.58
51-60	106.7	94.9	75.8	68.4	.71	.72	.72
61-70	114.5	97.3	91.6	79.8	.80	.82	.81
71-80	107.4	81.5	96.7	73.4	.90	.90	.90
81-90	101.6	81.9	91.4	71.3	.90	.87	.89
91-100	100.0	78.8	93.0	79.6	.93	1.01	.97
101-110	96.5	78.9	91.4	74.2	1.01	.94	.98
111-120	72.2	77.2	65.0	79.5	.90	1.03	.96
121-130	76.7	68.9	68.3	65.5	.89	.95	.92
131-140	58.0	55.5	46.4	48.3	.80	.87	.83
141-150	42.6	52.8	31.1	40.6	.73	.77	.75
151-160	37.7	45.9	26.4	36.7	.70	.80	.75
161-166	21.9	23.2	15.8	17.7	.72	.76	.74
Seasonal	1388.6	1182.6	950.9	864.3	.68	.73	.71

Fig. 2. The values of ETo and ETc during the second year of the experiment

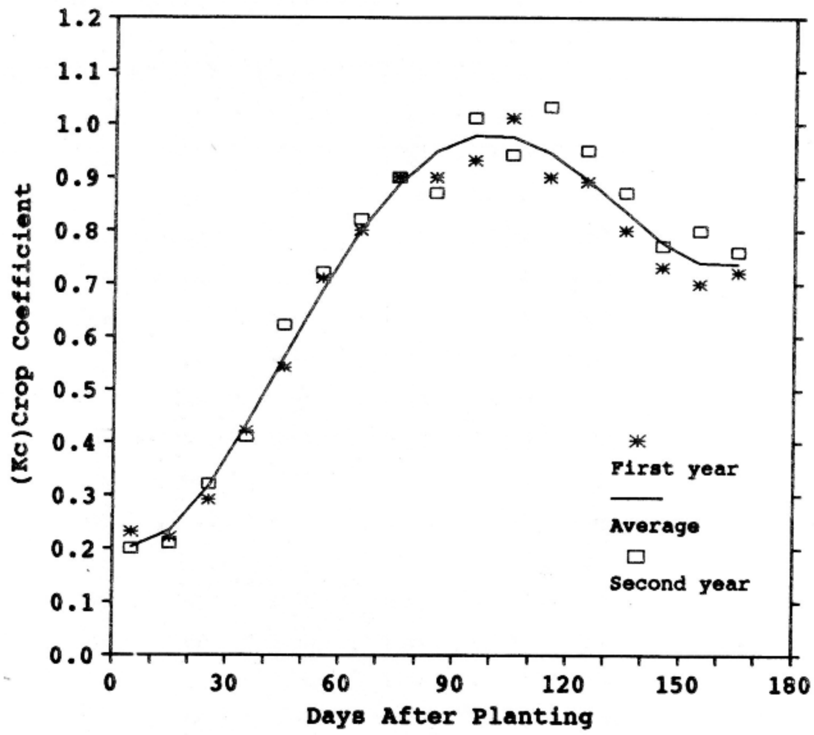

Fig. 2. Average crop coefficient of sugar beet in Isfahan region at 10-day intervals.

were considerably lower than the first year, but the values of the crop coefficients were very close to each other during both years of experiment, because the parameters controlling ETo also controlled ETc (except crop factors). The climatological parameters were not significantly different within the two years of the experiment and the difference between ETo within the two years of experiment was most probably related to the soil. The ETc values also were different within the two years of experiment for the same reason. All of the lysimeters were filled with the same type of soil and at the same time. Therefore, the physical changes of the soil were expected to have the same trend for both the lawn and the sugar beet lysimeters . The soil bulk density was higher in the second year for all of the lysimeters (1.26 g cm^{-3} in the second year in average compared to 1.19 g cm^{-3} in the first year), because of secondary soil settlement. Although the values of ETo and ETc most probably were affected by changes of soil properties within two years, the Kc values were not affected by this physical phenomenon. Enough data was not obtained in this study for determination of the effect of the soil properties on evapotranspiration. It needs another study with the experiments arranged for that purpose.

The crop water requirement can change considerably from year to year depending on climatological conditions or for other reasons. The crop coefficient would however change very little over the years (Table 2 and Fig. 2). Therefore, instead of using crop evapotranspiration (ETc) as a reference for crop water requirement for the future, it is better to use the crop coefficient and the reference crop potential evapotranspiration (ETo) to determine the future crop water requirements.

It was observed in this study that the effective cover of the sugar beet reached 75 days after planting. The crop coefficient was estimated 0.9 at the end of this stage. This is comparable with the widely used crop coefficient value proposed by Jensen (4) for this stage. The crop coefficient continued increasing even after this stage and reached the maximum value of 0.98 at about 100 to 110 days after planting (Table 2 and Fig. 2) .Then, Kc values decreased with a mild slope and reached 0.75 at the end of the growing season .This is different from the Kc values proposed by Jensen(4). According to Jensen(4), Kc value reaches 0.9 at the end of the effective cover stage and remains 0.9 until the end of growing season. According to

Doorenboos and Pruitt (3), the maximum value of Kc for sugar beet grown in Isfahan is expected to be about 1.15 which is also different from the result obtained in this study. However, the values of the Kc computed in this study should be more representative of Isfahan, as these values were obtained from a regional study.

The Kc values for 10-day intervals are recommended for using in irrigation scheduling, considering normal irrigation intervals. The 31-day crop coefficients from planting to harvest time, and the crop coefficients for different months are presented in Tables 3 and 4, and their variations are shown in Fig: 3 and 4. These Kc values might be used for water resources planning. It can be observed from Fig. 3 that most of the time the Kc values

Table 3. Reference crop potential evapotranspiration (ETo), potential crop evapotranspiration (ETc) and 31-day values of crop coefficient of sugar beet in Isfahan.

31-day periods after planting	ETo (mm)		ETc (mm)		31-day crop coefficient		
	First year	Second year	First year	Second year	First year	Second year	Average of two years
1	264.6	194.6	67.0	48.8	.25	.25	.25
2	317.3	266.5	184.5	164.1	.58	.62	.60
3	331.5	263.6	289.7	232.2	.87	.88	.88
4	269.6	241.3	248.6	239.7	.92	.99	.96
5	165.0	171.6	133.0	144.3	.81	.84	.82
6(11 days)	40.7	46.0	28.2	35.3	.69	.78	.74

Table 4. Reference crop potential evapotranspiration (ETo), potential crop evapotranspiration (Etc) and crop coefficients of sugar beet in Isfahan, for different months of the year.

Month of the year	ETo (mm)		ETc (mm)		Monthly crop coefficients		
	First year	Second year	First year	Second year	First year	Second year	Average of two years
Ordibehesht (11 days) (May)	79.1	62.9	18.2	12.9	.23	.21	.22
Khordad (May - June)	299.5	210.0	97.2	72.3	.32	.34	.33
Tir (June - July)	331.0	290.4	238.1	212.8	.72	.73	.73
Mordad (July - August)	314.7	246.3	290.3	232.1	.92	.94	.93
Shahrivar (August - Sept.)	239.0	224.1	213.9	214.9	89	.96	.92
Mehr (Sept. - Oct.)	123.6	144.9	90.2	116.3	.73	.80	.76

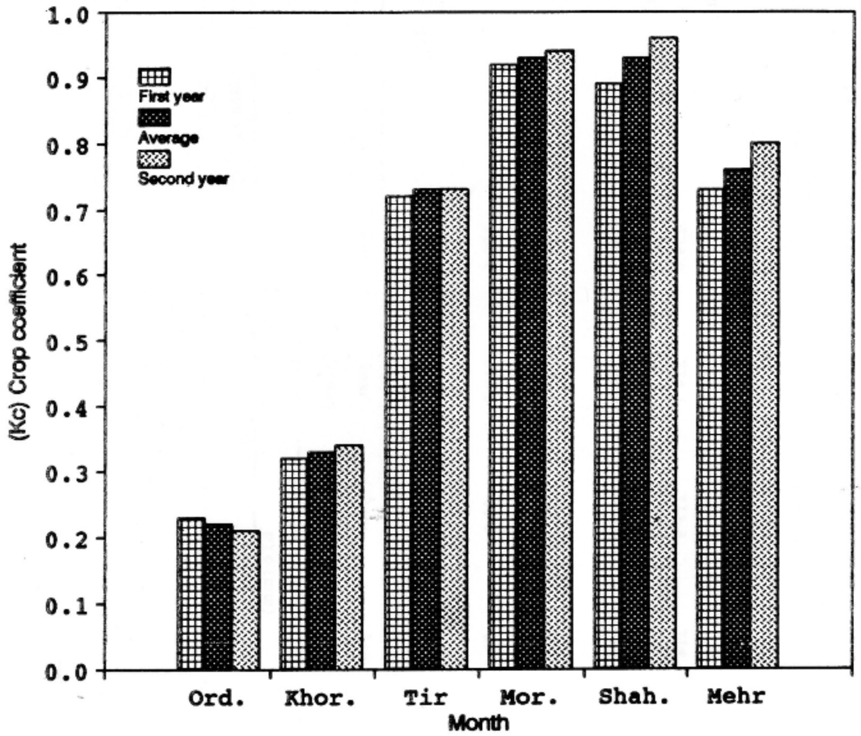

Fig.3. Monthly crop coefficient of sugar beet in Isfahan region.

were close to the maximum value of the crop coefficient, except for the first month after planting and to a small smal extent for the second month. This point is of great importance in water resource planning. The seasonal crop coefficient of sugar beet for Isfahan is estimated to be 0.71.

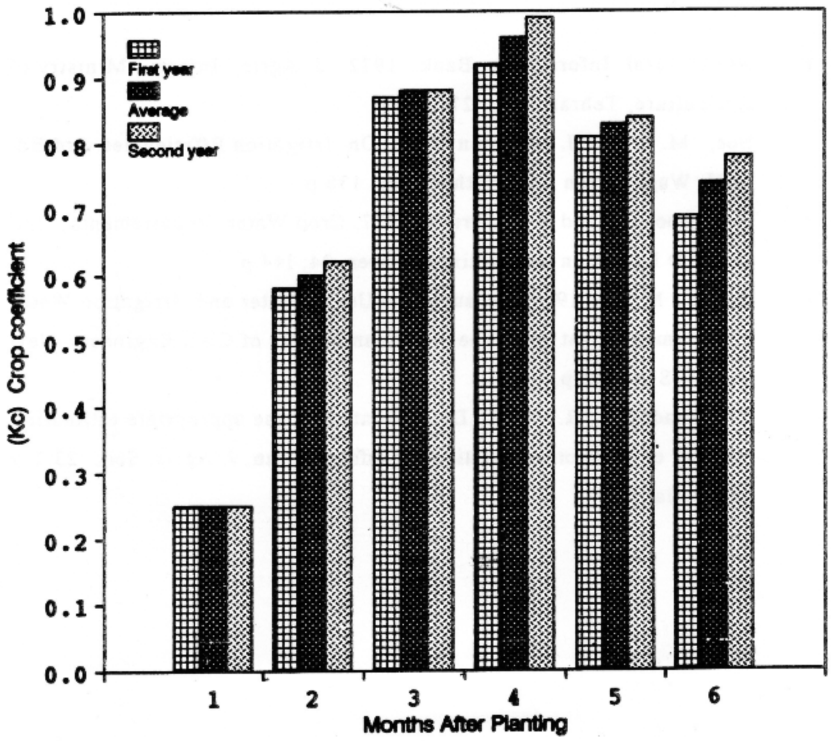

Fig. 4. Crop coefficient of sugar beet in Isfahan region at 31-day intervals.

ACKNOWLEDGEMENT

Appreciation goes to the Research Committee of IUT for its financial support of this research. My gratitude is also extended to Mr. Ramin Jamili for his effort in collecting field data during the two years of the experiment.

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