EFFECT OF MULCHING ON MELON (CV.CAMPERO) CROP COEFFICIENT

Nataša Čereković[1], Mladen Todorović[2], Richard L. Snyder[3], Sretenka Marković[4], Francesca Boari[5], B. Pace[5], Vito Cantore[5]

[1]*University of Aarhus, Faculty of Agricultural Sciences, Department of Horticulture, Årslev, Denmark (Natasa.Cerekovic@agrsci.dk)*
[2]*CIHEAM – Istituto Agronomico Mediterraneo di Bari, Via Ceglie 9, 70010 Valenzano (BA), Italy (mladen@iamb.it)*
[3]*Department of Land, Air and Water Resources, University of California, Davis, California, USA (rlsnyder@ucdavis.edu)*
[4]*University of Banja Luka, Faculty of Agriculture, Banja Luka, Bosnia and Herzegovina* (sretenka25@yahoo.com)
[5]*Istituto di Scienze delle Produzioni Alimentari, CNR, Via Amendola, 122/D – 70125 Bari, Italy (francesca.boari@ispa.cnr.it; vito.cantore@ispa.cnr.it; b.pace@ba.iac.cnr.it)*

Abstract

The measurements of the main weather parameters for melon crop (cv. Campero) data were collected in 2002 at experimental meteorological station "E. Pantenelli" of Bari University and CNR-Bari near Policoro (Southern Italy) to investigate the influence of weather and management on crop growth and development parameters which can contribute in difference of K_c values for this climatic region.

Since the crop is mostly bare soil during initial growth, the $K_{c\ ini}$ is mainly determined by the wetting frequency through irrigation and precipitation, the fraction of soil wetted by irrigation, and the ET_o rate.

The $K_{c\ mid}$ values determined with equations are average adjustments for the mid-season period for the melon crop in Policoro, taking in consideration relevant weather data for wind speed and relative humidity as averages for these period.

High K_c values were related to irrigation events. $K_{c\ end}$ values depend mainly on water management practices during the end of the season.

A review of K_c for melon grown under mulch and the results of investigations on Policoro data confirmed relevant difference in the length of the growing period in respect to the data presented in FAO 56. Therefore, careful consideration of all growing and management parameters is needed when crop evapotranspiration has to be estimated under local conditions.

This work has shown that peak K_c estimation can be improved by applying the corrections for relative humidity, wind speed and plant height as it suggested in FAO 56. This improvement is particularly important because midseason K_c refers to the

peak K_c values and relies on the period of growing season that is usually the most important for irrigation and the most sensitive to water stress, thus when an accurate scheduling should be applied.

Overall results indicate that improvments in genetics and crossbreeding techniques, crop management, climatic conditions changes (temperature, relative humidity, wind speed) and irrigation technique have a significant impact on the crop development and crop coefficient value.

Key words: crop coefficient, crop evapotranspiration, Mediterranean, melon (cv. Campero), mulch, irrigation

Introduction

Crop evapotranspiration (ET_c), which is a key factor to determine proper irrigation schedules is affected by meteorological, biological, and soil factors (Amayreh i Al Abed, 2005; Hanson and May, 2006; Todorović 2006).

While reference evapotranspiration (ET_o) is estimated using weather data, it provides an estimate of the ET of at 0.12 m tall, coolseason grass that is not water stressed and has fixed characteristics during the whole year. FAO-24 (Doorenbos and Pruitt, 1977) predicted the effect of climate on ET_o. Later the modified Penman-Monteith equation (Allen *et al.*, 1998; Allen *et al.*, 2005) was developed to better estimate ET_o from weather data.

Crop coefficients are an important factor for irrigation scheduling and water allocation and they differ under different environmental conditions and management practices. Difference between the crop canopy and aerodynamic resistance relative to the reference crop are accounted for within K_c. In fact, K_c serves as an aggregation of the physical and physiological differences between crops, corresponding management techniques and effects of climatic conditions on flower biology and crop growth, etc. (Vilallobos *et al*., 2003; Amayreh and Al-Abed, 2005; Lovelli *et al.*, 2005).

Therefore, the main objective of this work is to contribute to water saving in the region through a better estimate of crop coefficients and crop water requirements of typical Mediterranean crop (melon) grown under different environmental and management conditions.

Materials and methods

The trail was carried out in 1999 at the agrometeorological station in the area of Policoro located 15 m above sea level and is characterized by sub-humid climate according to the De Martonne classification (Cantore *et al*., 1987).

Daily lysimeters data for the crop evapotranspiration were taken from two weighing lysimeters, having a surface of 2 x 2 m^2 and a depth of 1.3 m.. The resolution of the lysimeter weighing system was 200 g corresponding to 0.05 mm of water that is lost by evapotranspiration or accumulated with precipitation or irrigation. Every 8-10 days, the phenological stages of the crop, the cover index (CI), LAI (leaf area meter LICOR), and epigeal biomass on three plants were observed on each sampling date. Leaf area index provides indication of the plant growth.

The Policoro data included information from 356 days recorded over one study year (1999). The data sets included the irrigation dates. Measurements of daily values of maximum and minimum air temperature and relative humidity, solar radiation, wind speed, precipitation and leaf area index were used for the model calculation. The weather station was located above a grass surface at about 30 m from the lysimeter. The annual precipitation of the study year was 366.1 mm and the distribution was similar to normal. The highest rainfall was 78.1 mm in July and the lowest was 2.1 mm in May. Mean daily air temperature varied from 7.1°C in February to 25.2°C in August. Mean daily maximum air temperature ranged from 12.3°C in January to 30°C in August. Mean daily minimum air temperature varied from 1.8°C in February to 20.3°C in August.

The soil was fertilized before the transplant with 120 and 133 kg ha^{-1} of N and P_2O_5, respectively, utilizing 0.29 t ha^{-1} of di-ammonium phosphate 18-46% and 0.26 t ha^{-1} of ammonium nitrate 26-27%.

The seeds of melon (*Cucumis melo* L.) cv. Campero were planted in polystyrene trays on April 8, and seedlings were grown in greenhouse. On May 10, seedlings were transplanted in the field at plant density of 1 plant m^{-2} in rows 2 m apart with 0.5 m between plants in the row and mulched with a black PVC film 0.80 m large.

The irrigation was applied with polyethylene drip tubing that was place along each row with emitters having a delivery of 4 L h^{-1} and space 0.3 m in the row. When water loss by evapotranspiration (ET_c) reached 40% of the maximum available water contained in the soil root-zone, water was applied to restore 100 % of the water lost. Irrigation was cut off 10 and 14 days before harvest and 9 and 11 irrigation applications were applied to give seasonal irrigation volumes of 1770 and 1930 m^3 ha^{-1}, respectively. Harvest took place on July 18.

Results and discussion

The daily crop evapotranspiration was measured daily at seven a.m. by the weighing lysimeters while reference evapotranspiration was estimated using FAO Penman-Monteith equation (Monteith 1973; Monteith and Unsworth, 1990; Alen *et al*., 1998; Allen *et al*., 2005) with input data from the meteorological station. Crop coefficients were determined as the ratio of ET_c to ET_o. The crop coefficients measured were related to those proposed by the FAO Irrigation and Drainage Paper 56.

The trends in K_c during a season consist of three values for K_c that are required to describe and construct the crop coefficient curve. The K_c values are need during the initial stage ($K_{c\ ini}$), the mid-season stage ($K_{c\ mid}$) and at the end of the late season stage ($K_{c\ end}$). To identify the $K_{c\ ini}$, $K_{c\ mid}$ and $K_{c\ end}$ for a melon crop, the season was separated into four stages including the initial, rapid development, mid-season, and late season. Straight line segments were constructed for each stage where $K_{c\ ini}$, was a fixed value from planting until about 10% cover, the K_c increased linearly from $K_{c\ ini}$ to $K_{c\ mid}$ during rapid growth from 10% cover to about 75% cover, $K_{c\ mid}$ was a fixed value from 75% cover to the onset of senescence, and the K_c decreased linearly from the onset of senescence to $K_{c\ end}$ at the end of the season.

The season started on May 11 and finished on August 2. The initial stage that lasted for 20 days during the first twelve days with large fluctuations in K_c values from 0.14 to the 0.81. Since the crop is mostly bare soil during initial growth, the $K_{c\ ini}$ is mainly determined by the wetting frequency through irrigation and precipitation, the fraction of soil wetted by irrigation, and the ET_o rate. Using the $K_{c\ ini}$ values from Table 12, the adjusted $K_{c\ ini}$ is calculated as the product of the table $K_{c\ ini}$ and a wetting function (f_w) as:

$$K_{c\ ini} = f_w\ K_{c\ ini} \qquad (1)$$

where, f_w = the fraction of surfaced wetted by irrigation or rain (0-1), $K_{c\ ini}$ = the value for $K_{c\ ini}$ from the Table 12 or Figure 29 in FAO 56.

Taking in consideration that average ET_o for the initial period was 4.42 $mmday^{-1}$ and that irrigation events were every two days, the K_c value was 0.85 (picture 29, FAO 56). From the table 20 (FAO 56), the fraction f_w of soil surface wetted by drip irrigation was 0.4, and, therefore,

$$K_{c\ ini} = 0.4 \times 0.85 = 0.34 \qquad (2)$$

The rapid development stage starts on May 31 and finishes on June 20. The mid-season stage was 25 days long from June 20 to July 15 with an average K_c value of 1.10. The mid-season K_c was adjusted according to FAO 56 by means of air relative humidity and wind speed as:

$$K_{c\ mid} = K_{c\ mid\ (Tab)} + [0.04(u_2-2)-0.004(RH_{min}-45)]\left(\frac{h}{3}\right)^{0.3} \qquad (3)$$

where, $K_{c\ mid}$ = value for $K_{c\ mid}$ season taken from FAO 56 (Table 12, page 110), u_2 = mean value for daily wind speed at 2 m height over grass during the mid-season growth stage (ms^{-1}), for 1 $ms^{-1} \leq u_2 \leq 6$ ms^{-1}, RH_{min} = mean value for daily minimum relative humidity during the mid-season growth stage for 20% ≤ RH_{min} ≤ 80%, and h = mean plant height during the mid-season stage (m) for 0.1 m < h < 10 m.

The $K_{c\ mid}$ values determined with equations are average adjustments for the mid-season period for the melon crop in Policoro, taking in consideration relevant weather data for wind speed and relative humidity as averages for these period and presented following the previous equations as:

$$K_{c\ mid} = 1.05+[0.04(3.17-2)-0.004(36.27-45)]\left(\frac{0.4}{3}\right)^{0.3} =1.09 \qquad (4)$$

Since many locations have only 24-hours wind speed data, the determination of $K_{c\ mid}$ was done also considering 24 hours wind in Policoro area as:

$$K_{c\ mid} = 1.05+ [0.04(2.41-2)-0.004(36.27-45)]\left(\frac{0.4}{3}\right)^{0.3} =1.08 \qquad (5)$$

The difference between two $K_{c\ mid}$ values was small, but the lack of day-time wind speed data could provoke a slight underestimation of mid-season K_c.

The late season stage was from July 15 to August 2 (18 days) with an average K_c = 0.82. High K_c values (0.92 to 1.20) were related to irrigation events. $K_{c\ end}$ values depend mainly on water management practices during the end of the season. If the crop is irrigated frequently until harvested fresh, the topsoil remains wet and the $K_{c\ end}$ value are relatively high. On the other hand, crops that are allowed to senesce and dry out in the field before harvest will generally have low $K_{c\ end}$ values. Consequently, both the soil surface and vegetation are dry and the value for $K_{c\ end}$ will be relatively small. According to K_c data from Policoro we noticed that the late season stage for the last days of the crop season had very high values and for this reason an adjustment of $K_{c\ end}$ should be applied, according to FAO 56 by means of air relative humidity and wind speed as:

$$K_{c\ end} = K_{c\ end\ (Tab)} +[0.04(u_2-2)-0.004(RH_{min}-45)]\left(\frac{h}{3}\right)^{0.3} \qquad (6)$$

where, $K_{c\ end}$ = value for $K_{c\ end}$ season taken from FAO 56 (Table 12, page 110), u_2 = mean value for daily wind speed at 2 m height over grass during the late season growth stage (ms^{-1}), for 1 $ms^{-1} \leq u_2 \leq 6$ ms^{-1}, RH_{min} = mean value for daily minimum relative humidity during the late season growth stage (%), for 20% ≤ RH_{min} ≤ 80%, and h = mean plant height during the end season stage (m) for 0.1 m < h < 10 m.

The $K_{c\ end}$ value was determined taking into consideration relevant weather data for wind speed and relative humidity as averages for the period. The calculated $K_{c\ end}$ was:

$$K_{c\ end} = 0.75 + [0.04(2.85-2) - 0.004(41.17-45)]\left(\frac{0.4}{3}\right)^{0.3} = 0.78 \qquad (7)$$

Since for many locations are available only 24-hours wind speed data, the determination of $K_{c\ end}$ was done also considering 24 hours wind in Policoro area as:

$$K_{c\ end} = 0.75 + [0.04(2.42-2) - 0.004(41.17-45)]\left(\frac{0.4}{3}\right)^{0.3} = 0.76 \qquad (8)$$

There was only a small difference between the two $K_{c\ end}$ values, however, that the lack of missing of day-time wind speed data could provoke a slight underestimation of mid-season K_c.

After adjustment of the $K_{c\ end}$ values, taking into consideration mean values for daily wind speed (u_2) and daily minimum relative humidity (RH_{min}) the standard four-stages crop coefficient curve is presented as given (Fig. 1).

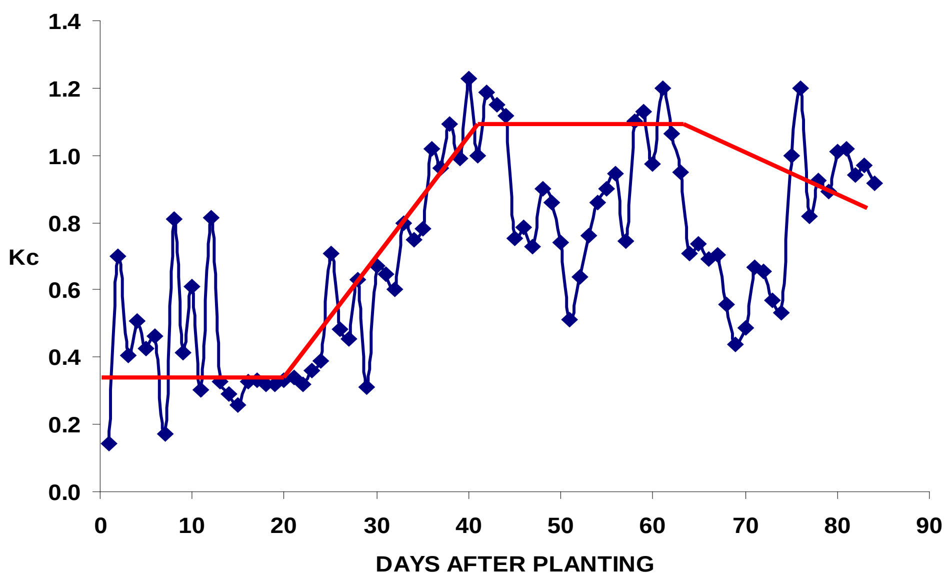

Fig. 1. Standard four stages K_c curve adjusted for the melon crop for $K_{c\ ini}$, $K_{c\ mid}$ and $K_{c\ end}$ using the data from 1999 non-mulched experiment

The adjusted K_c data for Policoro were compared with FAO 56 data in relation to both DAP and DOY (Fig. 2). The tabulated FAO K_c values for melon crop were 0.5 for K_c initial ($K_{c\ ini}$), 1.05 and for mid-season ($K_{c\ mid}$) and 0.75 for late season growth stages ($K_{c\ end}$). After adjusting K_c values for actual mean weather data (wind speed and relative humidity) K_c values for melon crop were 0.34 for K_c initial ($K_{c\ ini}$), 1.09 and for mid-season ($K_{c\ mid}$) and 0.78 for late season growth stages ($K_{c\ end}$).

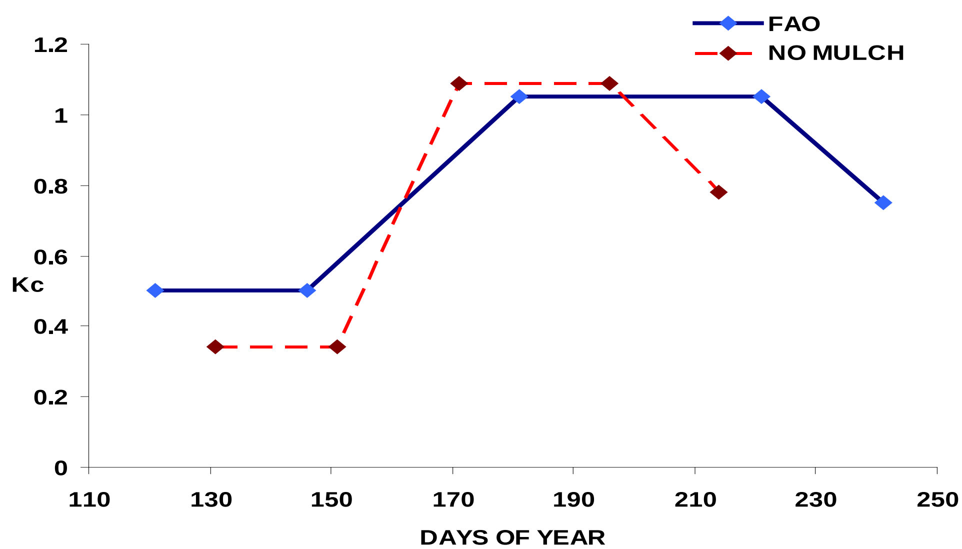

Fig. 2. The comparison between the FAO 56 recommended K_c values and K_c adjusted according to the Policoro experimental work in relation to days of year

FAO 56 proposed 120 days for a growing season of melon in Mediterranean region starting from May. For the Policoro experiment, the season started on May 11 and finished on August 2 (84 days), which was 36 days shorter than proposed by FAO. Starting of the growing season was on May 11 what was ten days later then FAO suggested for the beginning of May. Therefore, higher temperatures and new varieties strongly affected the duration of growing period in Policoro.

Conclusion

The main purpose of the work was focused that the improvements in breeding techniques, crop management, weather conditions (temperature, relative humidity, wind speed) and irrigation management had strong influence on crop development and growth, and hence on crop evapotranspiration and crop coefficient values. The length of growing season was changed (shortened) in respect to the data presented in FAO 56.

Moreover, the K_c of initial growing stage was strongly influenced by modern management practices and irrigation techniques. In fact, a review of K_c for melon and the results of investigations on Policoro data confirmed relevant difference between data measured at different location and under different climatic and management conditions. Therefore, careful consideration of all growing and management parameters is needed when crop evapotranspiration has to be estimated under local conditions.

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