Evapotransiration of crops and mechanical soil composition in Rhodes island

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Abstract

The aim of this paper is to evaluate the green (from rainfall) and blue (from irrigation) evapotranspiration of the most widespread crops (olives, citrus, soft and hard wheat, watermelons/melons, barley, grapes, vegetables, winter/summer and spring potatoes, fodder crops, rest annual crops) in the geographical area of Rhodes island. While the soils of the island belong to the same category, according to the classification "USDA Texture Classification" and could be roughly considered as a homogeneous medium soil (loam) in CROPWAT software, a separation takes place in four categories, in order to investigate whether the evapotranspiration of crops varies, even in the same ground category, depending on the relation of the mechanical soil composition. Furthermore a comparison takes place with the medium soil default value of CROPWAT. The examination included the separation of irrigated and dry crops at the scale of municipal unit. Calculations were made on the basis of the irrigation schedule approach, which includes a dynamic water balance of the soil profile and monitors soil moisture content over time.

Keywords: Evapotranspiration, CROPWAT, soil, crops, Greece, Rhodes.

1. Introduction

This study attempts to analyze the blue and green actual evapotranspiration (Eta) of all the main crops in the Rhodes island, with a separation into rainfed and irrigated ones, per municipal unit (MU), for the year 2013. Soil characteristics include the influence of mechanical soil composition and soil organic matter and takes into account further separation in similar soil category (loam). Furthermore, a comparison takes place with the medium soil default value of CROPWAT, which is used in ET calculations of crops (Vashisht & Satpute, 2015; Sikirica, 2011), in order to examine potent variations between ET values.

2. Methodology and Data

Rhodes belongs administratively to the South Aegean region and constitutes one of the river basins of the River Basin District of the Aegean Islands. The estimation methodology, evolves spatial analysis utilizing the ArcMap software, through the formation of new layers including combined information of soil characteristics per crop and per MU. Main categories of soils found on the island of Rhodes due to the international soil classification system 'The World Reference Database (WRB)', obtained from 'European Soil Data Centre' (Panagos et. al., 2012). Mechanical soil composition properties are calculated from the 'Harmonized World Soil Database Viewer Version 1.2' (FAO, 2012), while the soil's hydraulic properties are calculated with the 'Soil Water Characteristics' software, which is included in the USDA 'Spaw Hydrology' model. The distribution of agricultural land is taken on the basis of CORINE Land Cover, 2012. Agricultural data of croplands and crop production are taken by ELSTAT. For crops with no high resolution maps, data are obtained from the "Escalation maps of cultivation in Greece", of the Ministry of Rural Development and Food. For the estimation of ETa, crops are divided into rainfed and irrigated, taking into account ELSTAT data and according to the Directorate General of Regional Agricultural Economy and Veterinary, of the Region of South Aegean. Meteorological data for the period 2000-2014, are obtained from the meteorological station of the Hellenic National Meteorological Service (HNMS), which is based in the MU of Rhodes. Based on climatic data, the CROPWAT 8.0 software calculates the reference evapotranspiration (ET_0) with the FAO Penman-Monteith method (Allen et. al., 1998). The actual evapotranspiration of Eta was evaluated according to 'irrigation schedule' approach of Cropwat. The estimations are performed following a combination methodology of excel spreadsheets, Cropwat and ARCMap software (new layers of spatial units were created from the layers of land uses and geological backgrounds). Incoming data to CROPWAT were derived from Papazafeiriou (1999), FAO technical datasheet (Allen et. al., 1998) and the CROPWAT software libraries.

Due to the adaptation of the simulation software to calculate the evapotranspiration for the drip irrigation method and in order to take account of the reduction in evaporation for this irrigation method, the planting factors for irrigated crops were adjusted taking into account the reduction factor against Papazafeiriou (1998), according to which:

$$ET_t = \text{ET} * \frac{Pc}{85}, \qquad \frac{Pc}{85} \leq 1, \tag{1}$$

where ET_t: evapotranspiration under drip irrigation conditions, ET: evaporation diffusion calculated by various methods and Pc: is the percentage of the area covered by the projection on the soil of the foliage of the crop.

The coverage of the soil according to the crops and the stages of their development were taken according to Papazafeiriou (1998). Considering the aforementioned approach (Equation 1) for the drip irrigation method, the plant coefficients as incoming data in the simulation software for all irrigated crops were adjusted as a function of the specific irrigation technique used, expressed as the following equation:

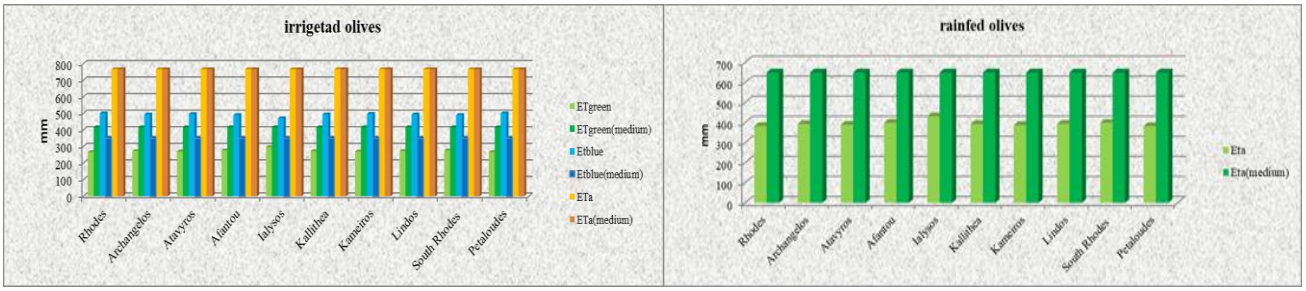
$$k_{ct} = k_c * \frac{Pc}{85}, \qquad \frac{Pc}{85} \leq 1. \tag{2}$$

3. Results

Evapotranspiration values for each water consumption resulted from an analysis of the distribution of the respective soil, per MU and per crop. In Figure 1 (a & b), the values of the actual evapotranspiration are presented indicatively for irrigated and rainfed olives respectively, as the most prevailing crops in the island. A comparison takes place among ETgreen, ETblue components and Eta, concerning the soil of the study area and Etgreen(medium), ETblue (medium) and Eta (medium), regarding the medium soil default value of the software. As presented in Figure 1a regarding irrigated olives, the values of consumptive blue and green (ETblue + ETgreen) water evaporation (Eta) are similar to the values obtained from CROPWAT medium soil, while the individual blue and green components differ. ETgreen in all MUs is much smaller compared to Etgreen(medium) values and conversely, the ETblue values are consistently higher than Etmedium. Concerning rainfed olives (Figure 1b), the value for total evapotranspiration (Eta) is consistently much lower compared to Eta (medium) values in every MU.

4. Conclusions

In conclusion, in rainfed crops, it is useful to consider the soil profile analytically, otherwise an over-estimation of the total evaporation of the crop can be overestimated. When considering the total water consumption by evaporation of irrigated crops, there are no deviations and therefore the soil profile in relation to its mechanical composition does not affect the results, nevertheless in case of crops that do not depend to a large extent on blue water use, such as irrigated olive groves, grapes and citrus, it is useful to examine the soil profile in order to draw conclusions about the type of water consumption (blue/ green). Finally, the green component of evapotranspiration tends to be more affected by the mechanical soil composition of soils, compared to the blue component.



(a) (b)

Figure 1. Actual evapotranspiration rates per MU for: (a) irrigated olives, (b) rainfed olives.

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