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Improving Water Efficiency: The Irrigation Advisory Service of Crete, Greece

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Abstract

This work presents the development and operation of a tele-information system to farmers for irrigation scheduling in two areas of Crete, Greece. The area is a semi-arid region with a total of 53,000 ha irrigated with localized systems. The farmers irrigate empirically and tend to “play safe”, increasing irrigation water amount, especially when water price is low. As a result about 25 % of water applied is lost, while at the same time tensions and conflicts with other sectors (urban, tourism) arise. After a study for the variability of climatic conditions in each study area for a period of 30 years (1975-2004), automatic meteorological stations were installed for monitoring the climatic data. Soil map database in GIS form has been created using the results of soil analysis for each area. Daily crop evapotranspiration (ETc) is calculated using reference evapotranspiration (ETo) and crop coefficient (Kc) for each growth stage, based on the literature and experience in the area. An automated interactive telephone service has been installed to give, upon request, the irrigation information to the farmers at any time through speech recognition technology. The farmers of the study areas are trained for the use of the automated telephone based service, to give to the system the required information (place of the farm, crop, soil type, system of irrigation, date of last irrigation). Demonstration fields (olive, avocado, citrus and grapevines) are installed in order to check if the suggested irrigation doses by the system are sufficient for optimal crop growth and production. During the first year (2005) the calculated irrigation requirements by the system were 9-20% less, depending on the crop, than those applied empirically by the farmers, especially when there were no limitations in water supply by the network. The technical, social and economic limitations for the advisory system are discussed.

Keywords: Advisory system, Irrigation, Water saving.

Introduction

The sustainable use of water is a priority for agriculture in water scarce areas. In developed agriculture, crop losses related to water availability continue to exceed those from all other causes (Passioura, 2002). So, under scarcity conditions, considerable effort has been devoted over time to introduce policies aiming to increase water efficiency through better management.

In Crete, Greece the major water user is agriculture (81.2%), although its contribution to island's GDP is 13%. The demand for irrigation water is high (66% of the demand is met), while only 33.4 % of the cultivated land is irrigated (Chartzoulakis et al, 2001). Due to lack of irrigation scheduling information (when and how much water to apply), farmers irrigate empirically and tend to "play safe", increasing irrigation water amount, especially when water price is low. As a result about 25 % of water applied is lost, while at the same time tensions and conflicts with other sectors (urban, tourism) arise. Irrigation advisory services can play an important role in assisting farmers to adopt new technologies and increase water efficiency, minimizing environmental risks and contributing to the sustainability of agricultural sector (Smith and Munoz, 2002).

This work, carried out within the BEWARE project, presents the development and operation of an advisory system for tele-information of farmers for irrigation scheduling, based on real-time (climatic) soil and crop data using modern technologies aiming to promote sustainable and rational use of irrigation water.

Materials and Methods

a. Description of the study areas

The tele-information system is applied in two study areas in the island of Crete differing in water availability (Figure 1). The 'Varypetros' plain (11,927 ha), located at the north-western part of the island, with abundant water resources (annual rainfall ranges from 600 to 800 mm) and the 'Messara' valley (40,933 ha) in the southeast with limited water resources (annual rainfall ranges from 300 to 450 mm). The main part of 'Varypetros' plain is cultivated with citrus, olives and avocados, while for 'Messara' the main crops are olives, grapevines and vegetables. Both areas have modern pressurized irrigation networks, operated by local irrigation boards (TOEVs).

A GIS-based soil database has been created using the results of soil analysis for each area (Figure 2). Soil database includes information on soil texture, permeability, specific weight, field capacity, wilting point, porosity, draining capacity, parent material, slope, at different depths.

After a study for the variability of climatic conditions in each study area for a period of 30 years (1975-2004), automatic meteorological stations were installed (two in Varypetros and three in Messara) for monitoring the climatic data (temperature, RH, net radiation, wind velocity, direction, rainfall, A pan evaporation) within the study areas. Data are stored in a data logger and transferred to a computer through a wireless network.

b. Crop irrigation requirement's calculation and farmer's information

Daily crop evapotranspiration (ETc) is calculated as ETc= Kc*ETo, where ETo is the reference evapotranspiration and Kc the crop coefficient, that varies with the crop and its growth stage. ETo is calculated with real-time data for each meteorological station by modified Penman-Monteith method (Allen et al., 1998). The crop ETc for different crops in each area is determined from the crop Kc for each growth stage, based on the literature and experience in the area (Doorenbos and Pruitt, 1992; Tsanis et al., 1997). The irrigation requirements are then calculated as the difference between ETc and effective rainfall (0,8 of actual), while the irrigation dose is determined according to the soil type.

In cases of reduced water availability in the area (dry years), instead of the full irrigation requirements, those satisfying the water needs for the critical growth stages of each crop are calculated. The data are stored in a database in a way that in every single call the system compiles all the relevant information in order to calculate the optimum irrigation dose.

An automated interactive telephone service has been installed to give, upon request, the irrigation information to the farmers at any time through speech recognition technology. The farmers of the study areas are trained for the use of the automated telephone based service, to give to the system the required information (location of the farm, crop, soil type, irrigation system, date of last irrigation). The general operation of the information system is shown in Figure 3.

c. Demonstration fields

Demonstration fields (olive, avocado, citrus in Varypetro and olive, grapevine in Messara) are used in order to check if the suggested irrigation doses by the system are sufficient for crop growth. Each demonstration field is divided into two parts; the first one is irrigated according to the evaportranspiration losses and the other one with empirical water application. A network of access tubes has been installed under the plant canopy, for soil moisture monitoring at root zone up to 1 m depth, using a moisture probe, in both parts of the field. In addition, plant water status is also measured. Irrigation water applied in each part of the field is also monitored using water meters.

Results and Discussion

One of the main tasks of the information system is to assess the water requirements of the crops, using real-time data and provide information about the irrigation scheduling. During the first year (2005) the calculated irrigation requirements by the system were applied to only demonstration fields (not communicated to farmers) and the data obtained for seasonal irrigation depths were promising. The calculated irrigation requirements by the system were 9-20% less than those applied empirically by the farmers, especially when there were no limitations in water supply by the network (Table 1).

The application of suggested irrigation doses by the system in the demonstration fields maintain the soil water content at optimum levels for plant growth at the depth of 0-100 cm (data not shown). Furthermore, the plant water status (leaf water potential) and gas exchange (photosynthesis, stomatal conductance) data recorded confirmed that the plants are grown at optimum soil water condition (Fig. 4). Although the tele-information system has been advertised through the media (newspapers, radio, television and leaflets), the participation of farmers in the diffusion workshops organized to present the information service were not satisfactory. The main reasons could be irrigation tradition, expertise level and age of the farmers, absence of irrigation technicians in the irrigation consortium, etc. However, during the 2006 and 2007 irrigation campaign, with the dial-up automated information system in operation, the number of farmers interested in using the system increased, giving promises for an efficient use of the system in the pilot areas during the following years.

However, most of irrigation advisory services had disadvantages of very different matters, which in several occasions limit their efficient performance. In some occasions the advisory services died for their own contradictions, already presented from their beginning. The Institute had found limitations more or less important. These limitations are: Sociologic, like culture and irrigation tradition; formation level and age of the farmer, the presence of technicians in Farmers Associations; and assurance levels and their maintenance. Financial like high investment requirements; local and particular experimentation; staff needs; demonstration effect among farmers; diffusion (courses, congresses, talks, leaflets, etc.); and linking and collaboration with research Institutes and Universities. A higher integration of the Farmers Associations is absolutely necessary, taking the responsibility, along with the Regional Agricultural and Environmental Council.

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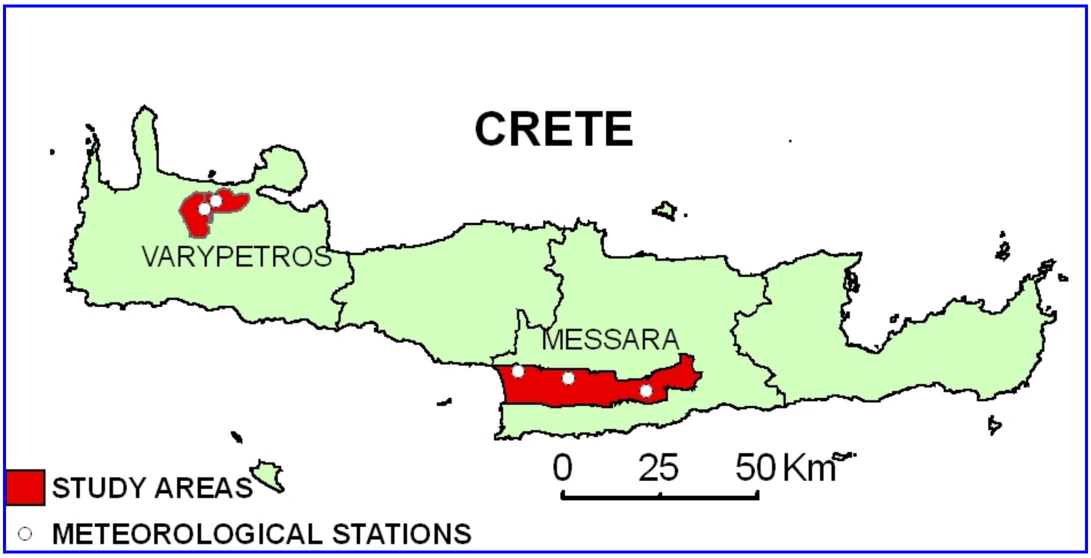

Figure 1. The study areas in Crete

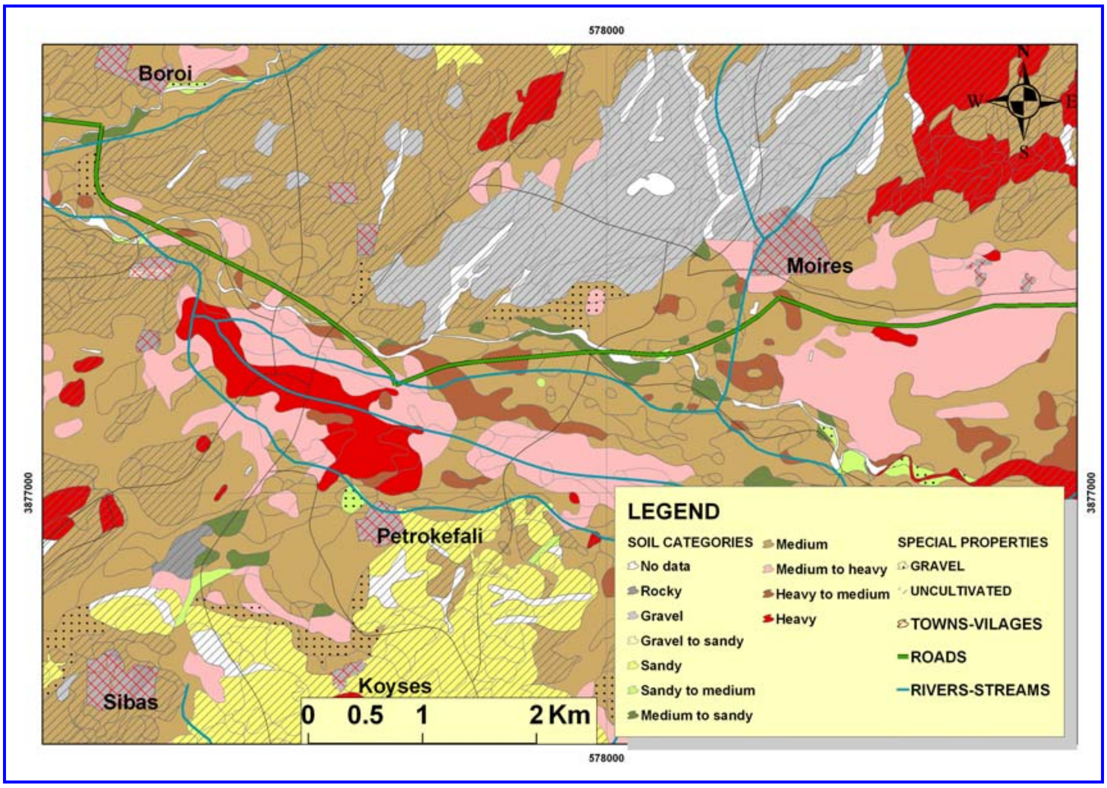

Figure 2. GIS-based soil map for a part of the Messara study area

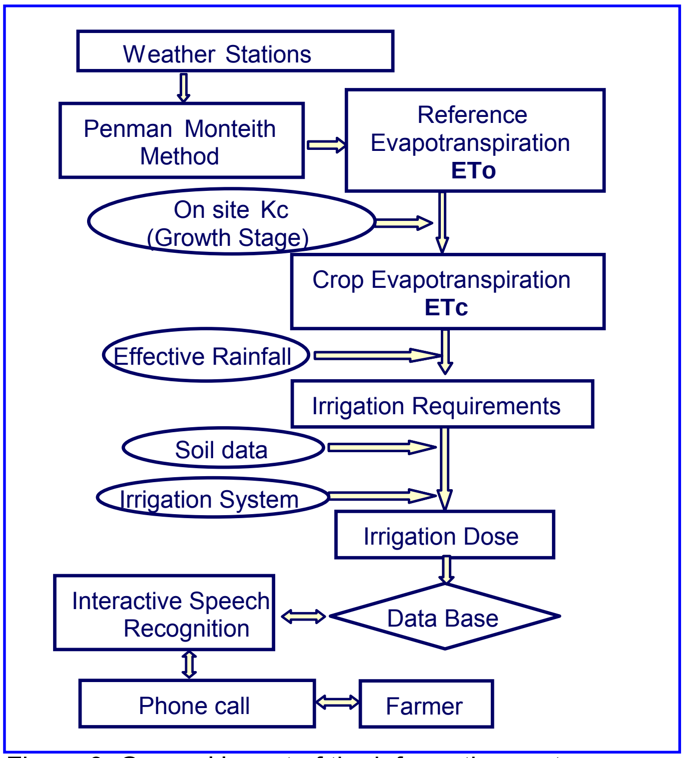

Figure 3. General layout of the information system

Table 1. Amount of irrigation water applied to different crops in the demonstration fields

Crop	Consultive irrigation (mm)	Empirical irrigation (mm)	Water saving (%)
Avocado	545	681	20.0
Orange tree	501	586	14.5
Olive Tree	228	244	9.3
Grapevines	452	540	16.3

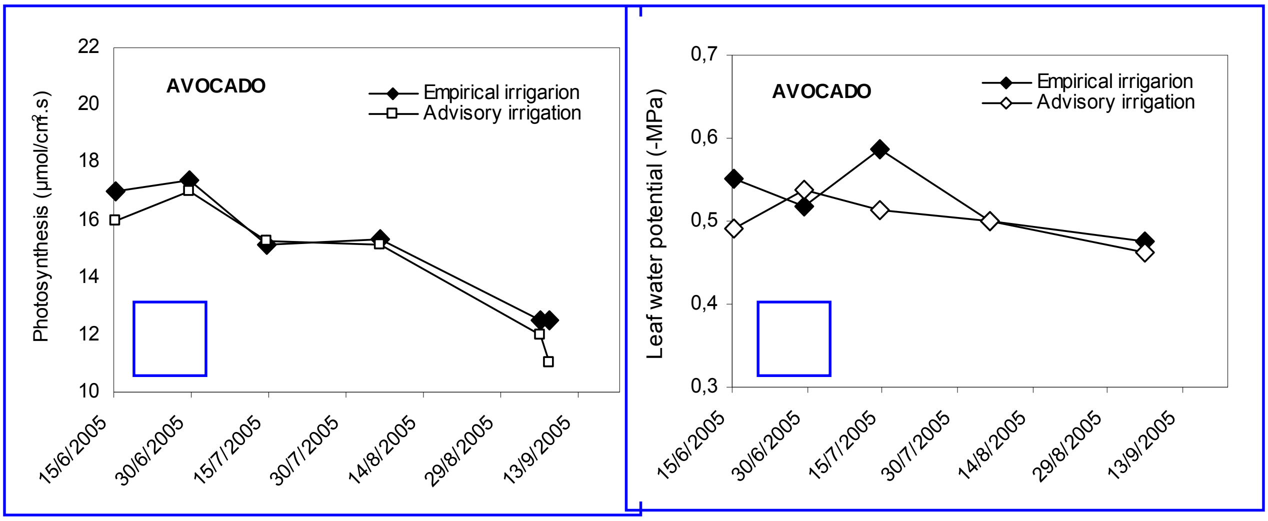

Figure 4. Evolution of photosynthesis (a) and leaf water potential (b) of avocado plants irrigated empirically and through the advisory system.