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Seasonal variation of soil moisture in irrigated olive trees

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Abstract

Olive growing counts as one of the most significant agricultural activities in Greece, from a financial, social and ecological point of view. Modern olive culture often includes exhaustive use of the available water resources having as a result adverse effects for production cost and the environment. This paper evaluates seasonal soil moisture content at three different soil depths (10, 30, 40 cm), in relation with rainfall and irrigation in an olive cultivar “Kalamon” orchard. Our results indicate strong variation of soil moisture as affected by season and irrigation. In addition, the role of drip-irrigation on soil moisture content appears to be more significant at soil depths up to 30 cm compared to lower soil zones. Specifically, at soil depth of 40 cm the soil moisture curves close to irrigation lines seems to coincide compared to these far away from the irrigation line.

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Keywords: irrigation line; monitoring soil moisture; soil moisture with depth

1. Introduction

One of the most important factors that can limit crop production is the limitation of water. Long and intense dry periods followed by heavy erosive rainfalls can also cause extensive soil losses [1,2]. High temperature and salinity magnify impacts of drought on crop growth and fruit production [3-6]. Consequently, soil water status...
monitoring is essential for evaluating soil water dynamics, for scheduling irrigation events and for supporting optimum plant growth and yields. According to [7] the application of the various soil water sensing and measurement systems (gravimetric analysis of soil samples, weighing lysimeters, capacitance probes, time domain reflectometry tensiometers) in commercial farms (although costly, time and labor consuming and not entirely precise due to technological or spatial constraints) is essential in order to have a real-time diagnostic tool for assessing the irrigation needs and for minimizing water drainage, nutrient leaching, and groundwater contamination.

The capacitor usually takes the form of a polycarbonate cylinder with electronic sensors arranged at fixed intervals along its length. The probe uses electromagnetic signals to measure the permittivity of the soil, which is dominated by water, and implements a calibration curve of the measured electrical value against volumetric soil water content. Although, there is a considerable disagreement amongst authors as to the accuracy of the method, [8] and [9] reported that the capacitance probe method (CPM) is independent of soil type within a wide range of soil moisture levels. On the other hand, according to [10] and [11] the capacitance probe results are influenced by soil type, and in addition [12], [13] reported that capacitance probes are sensitive to soil salinity. The CPM method has been developed and used increasingly the last years, since it provides automatic acquisition of data at short time interval, minimal soil disturbance and enhancement of depth resolution.

The aim of the present study was to investigate the spatial and temporal variation of soil moisture in a Mediterranean olive grove. Irrigation frequency and load could be optimized based on monitoring seasonal precipitation and water storage in the tree root zone in the soil. Consequently, water used for irrigation will be distributed more efficiently during the dry season and losses through evaporation or drainage will be reduced.

2. Methodology

In this study 3 plots with 4 olive trees cv Kalamon each were selected in order to measure soil moisture at three different soil depths (10, 30, 40 cm). In each plot traditional agricultural practice of soil tillage was applied. Each plot has an area of 200 m². A typical plot scheme indicates the positions of soil measurements one close to irrigation-line (approximately 30 cm) and one far away from drip irrigation-line (in the centre of the plot), (Fig. 1). This experiment was designed in order to investigate the influence of irrigation on soil moisture content based on time and different soil depths. Apart from soil moisture rainfall was measured. The rainfall data that were used came from a surrounding meteorological station. Volumetric soil moisture content was assessed using a commercial PR2 profile probe system (Delta-T 2005). The PR2 was combined with an HH2 readout unit which enables a single probe to be used at different locations of the study area.

Soil moisture measurements took place from May 2013 up to August 2014 at 20 days intervals, in order to capture the variability of soil moisture content based on different meteorological conditions. Regarding the irrigation season (May to September) drip irrigation was applied for one day every week, while moisture measurements took place after the applied irrigation. All plots have the geomorphological characteristics with same soil type which is characterized as sandy clay loam. In this study the seasonal soil moisture content with soil depth close to and far away (centre of the plot) from drip irrigation-lines was investigated and analyzed based on rainfall data.

3. Results and Discussion

Figure 2 shows the seasonal rainfall during the experimental period while analysis of seasonal soil moisture content profile for 3 soil depths (10, 30 and 40 cm) is presented in Figure 3. Our data revealed a systematic variation of seasonal rainfall in the area under study characterized by a marked excess of precipitation during winter and spring and a significant deficit during summer, whereas autumn rainfall shows a great variability in trends.

Differences in soil “wetness” in the first soil depth (10 cm) between Summer 2013 and Summer 2014 could be related to the higher precipitation values observed during the Spring of 2013. During periods of high rainfall, higher moisture values in the soil profile were recorded in the deeper layers (30 cm and 40 cm) away from drip irrigation-line, while during the low rainfall period (irrigation period), a clearly increased response of volumetric soil water content to the position of soil moisture measurement was observed, since capacitance probes reported higher values close to the irrigation-line. When comparing soil moisture at the different depths, the deepest layer (40 cm) showed
the greatest soil moisture content, followed by the intermediate layer (30 cm) and the surface layer (10 cm), irrespective of the season of the measurement.

From our data, we also observed that there exists a significant influence of rainfall in soil moisture content with seasonally changing characteristics, since in addition to the rainfall-soil moisture connection during the wet season (winter-autumn), as expected, we also found significant correlation in summer when the precedent spring was characterized by high rainfall.

We also would like to highlight that during the dry season, in addition to the depletion of soil water of the surface layer (10 cm), a deep soil water uptake (30 cm and 40 cm) was also observed. The higher soil moisture content...
recorded at the center of the plot as compared to the value near the irrigation-line during the wet seasons could be ascribed to the rainfall interception at the tree canopy level. Research is ongoing to comprehend the effects of rainfall and irrigation in the soil moisture profile in years of different climatic characteristics. Irrigation frequency and load could be optimized based on monitoring seasonal precipitation and water storage in the tree root zone in the soil. Consequently, water used for irrigation will be distributed more efficiently during the dry season and losses through evaporation or drainage will be reduced. Especially in years such as 2015-2016 with historically high temperature levels and low precipitation levels it is of great importance to optimize water use efficiency in agriculture.

![Soil moisture content at different depths under irrigated or rainfed conditions.](image)

Fig. 3. Soil moisture content at (a) 10 cm; (b) 30 cm; (c) 40 cm soil depth under irrigated or rainfed conditions. Each bar is mean ± standard error for each treatment. Bars with the (*) were significantly different at p<0.05.

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