Development of an irrigation scheduling recommendation for pomegranate trees (*Punica granatum*)

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Abstract. Pomegranate culture in Spain is concentrated in the south east, where water available is scarce. There is a need for providing growers with some irrigation recommendations for improving water use efficiency. For this purpose, information from indicators of the continuous soil-plant-atmosphere is being used in a commercial drip irrigated pomegranate orchard, for delivering to growers a weekly irrigation recommendation, taking into account the reference evapotranspiration, plant water status determined via stem water potential measurements and the soil water available to plant obtained from capacitance probes that measured soil water content at different depths. Watering recommendations are calculated in order to fulfil crop water requirements and also avoid water percolation. The average annual water application has been around 425 mm. The information obtained has been transferred by means of an experimental crop coefficient (Kc) integrated in a dissemination tool for calculating water crops requirements. Experimental Kc values increased from 0.32 in March to 0.74 in July, decreasing to 0.42 in November.

Keywords. Soil capacitance probes – Crop coefficient – Stem water potential.

I – Introduction

Pomegranate trees are considered as a culture crop tolerant to soil water deficit and high soil salt levels (Holland *et al.* 2009). Because of this, in Spain, its culture is concentrated in the south east, where fresh water available for agriculture is very scarce. However, very little is known about *Punica granatum* orchard water management. Currently, the most widespread methods for irrigation scheduling is based on the combination of a parameter that depends on the weather, the reference evapotranspiration (ETo), together with a parameter specific for each culture, the crop coefficient (Kc) as suggested by Allen *et al.* (1998). However, for pomegranate trees, Kc are not listed in the FAO water use book by Allen *et al.* (1998). Because of this, in the Alicante and Murcia area growers normally schedule irrigation of pomegranate trees as it is done for citrus trees. However, there are obvious differences between both cultures; thus irrigation management can and should be different.

The adequacy of an irrigation scheduling procedure to the orchard soil characteristics and the actual plant water needs can be tested by checking the plant and soil water status. Regarding the measurement of soil water content, the multi-sensor capacitance probes are one of the most commonly used devices because of their effectiveness (Starr and Paltineanu, 1998a,b). For determining plant water status, stem water potential is nowadays the benchmark indicator (McCutchan and Shackel, 1992).

This manuscript summarizes the research conducted by the Valencian Institute for Agricultural Research for transferring to growers an irrigation scheduling recommendation for pomegranate trees.

II – Materials and methods

The experiment was performed in a commercial mature pomegranate tree orchard (*Punica granatum*, L cv. 'Mollar de Elche') at Elche, Alicante, Spain, (38ºN, elevation 97 m). The soil was sandy-loam with an effective depth over 120 cm. The irrigation water had a moderate risk of salinization with an average electrical conductivity, EC at 25 ºC of 2.63 dS m^{-1} and an average Cl^- and Na concentration of 43.5 and 326.3 mg/l^{-1}, respectively. Trees were planted in 2000 at a spacing of 5 x 4 m and average tree shaded area was 56% of the soil allotted per tree. Trees received 100, 40 and 80 kg ha^{-1} $year^{-1}$ of N, P_2O_5 and K_2O, respectively. Agricultural practices followed were those common for the area.

Weather was recorded at an automated weather station near the orchard. Meteorological variables measured included, solar radiation, air temperature, air humidity, wind speed and direction and rainfall. This weather station belongs to the Spanish national weather station net for irrigation recommendations.

Plant water status was determined by occasional determinations of midday stem water potential (Ψstem, McCutchan and Shackel, 1992) carried out by means of a pressure chamber (Soil Moisture Equip. Corp. mod. 5100A). Two mature leaves per tree, from the north face near the trunk, were enclosed in plastic bags covered with silver foil at least two hours prior to measurements, which were between 1112:30 and 1314:00 h solar time GMT. Measurements of Ψstem were carried out approximately every week from May to October in a total of 4 trees.

Soil water content (SWC) was measured by using two multi-sensor capacitance probes C-Probe (Agrilink Inc., Adelaida, Australia). Each probe had four sensors located at 10, 30, 50 and 70 cm depth. Probes were installed inside a PVC tube located at 10-15 distance from the emitter guarantying a tight contact between the soil and the probe. Data were obtained every 15 minutes and could be visualized using the manufacturer software addVANTAGE Pro 5.1.

In 2009, as a starting point and in the absence of a specific guideline for pomegranate water needs, irrigation scheduling was applied as the farmer's own standard. However, recommendations were given to the grower in order to maintain SWC in the first 0.6 m of soil between field capacity and a theoretical refill point, fixed in 85% of the field capacity. In addition, plant water status determinations were also used to maintain crop water status at appropriate levels. In 2010, taking into account the water applications made in the previous season, we obtained some tentative experimental crop coefficients that were used as a baseline for irrigation scheduling. In addition irrigation dose and frequency were finally adjusted taking into account the seasonal trends of soil water content, plant water status and the weather forecast prediction for the following week This was reflected in a recommendation report, which was supplied to farmers for their knowledge and application in the plot. In 2011, the updated crop coefficients were used after taking into account results obtained in 2010. Again the information from plant and soil water status was considered.

III – Results and discussion

By the end of the 2009 season, irrigation applied was 434 mm (Fig.1). The reference evapotranspiration was 1130 mm while total yearly rainfall was 349 mm. The seasonal (March to November) rainfall was 256 mm. Ψstem varied along the season from –0.85 MPa registered by the end of October (week 44) down to –1.65 MPa registered at the beginning of the summer (week 26, Fig. 2).

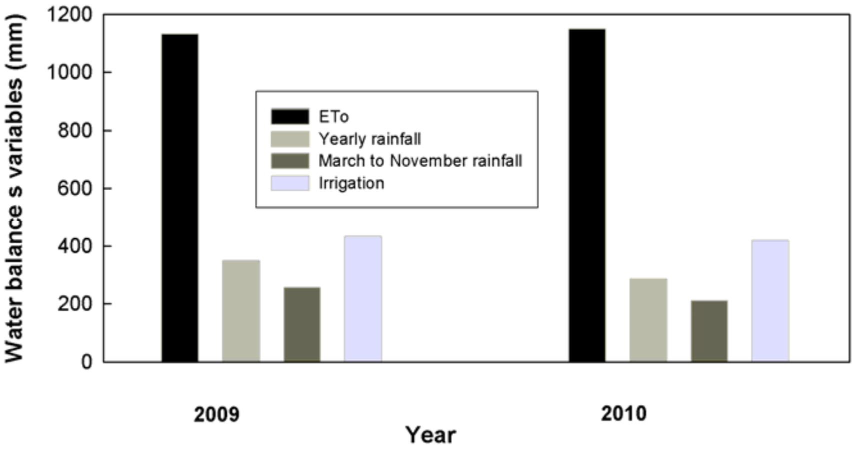

Fig. 1. Reference evapotranspiration (ETo), yearly rainfall and seasonal rainfall during the 2009 and 2010 growing seasons.

During 2010, irrigation applied was 420 mm, ETo 1149 mm, while rainfall was equal to 287 mm, of which 211 occurred during the March to November period (Fig. 1). Ψstem varied between –0.68 MPa registered at the beginning of the fall (week 39) and -1.68 MPa at the end of august, week 35 (Fig. 2).

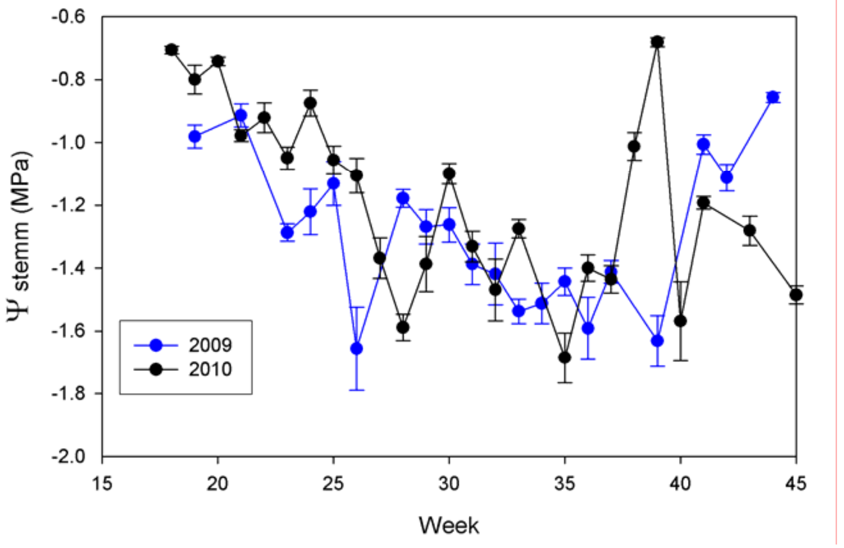

Fig. 2. Seasonal variation of midday stem water potential (Ψstem) during the 2009 and 2010 seasons.

In 2010, soil water content (SWC) was maintained during all the season between field capacity and the refill point without any drainage (Fig. 3). This suggest that the irrigation recommendations given to the grower can be considered as adequate.

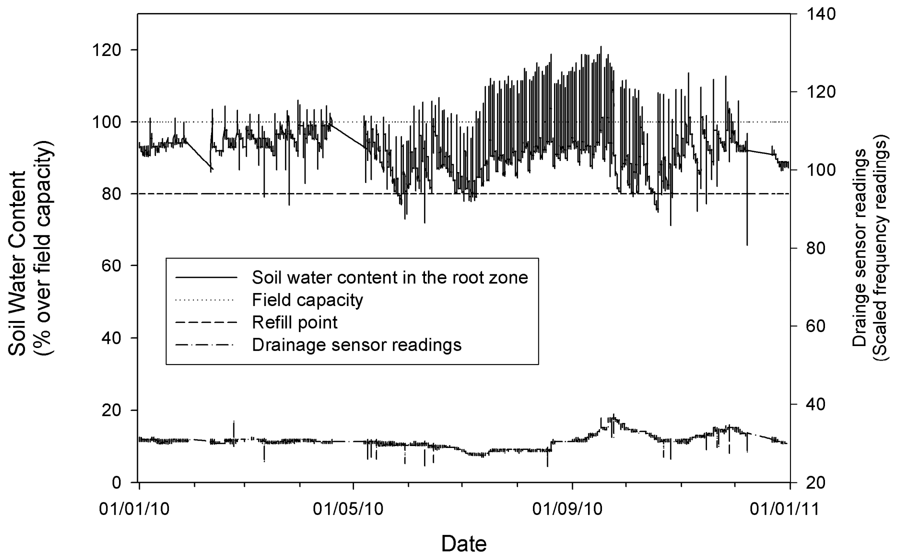

Fig. 3. Seasonal trend of soil water content for the 2010 season. Values are the average of two capacitance probes.

In the 2011 irrigation campaign, using the updated experimental crop coefficient, at 25 august irrigation applications were of 392 mm. From March to August 2011 precipitation was 92 mm. Stem water potential readings varied between –0.57 MPa registered by midday April (week 17) to -1.33 MPa registered by the end of may (week 22, Fig.4). Soil water content, similarly to what occurred the previous season, was kept always within the established range and drainage rarely occurred (Fig. 4).

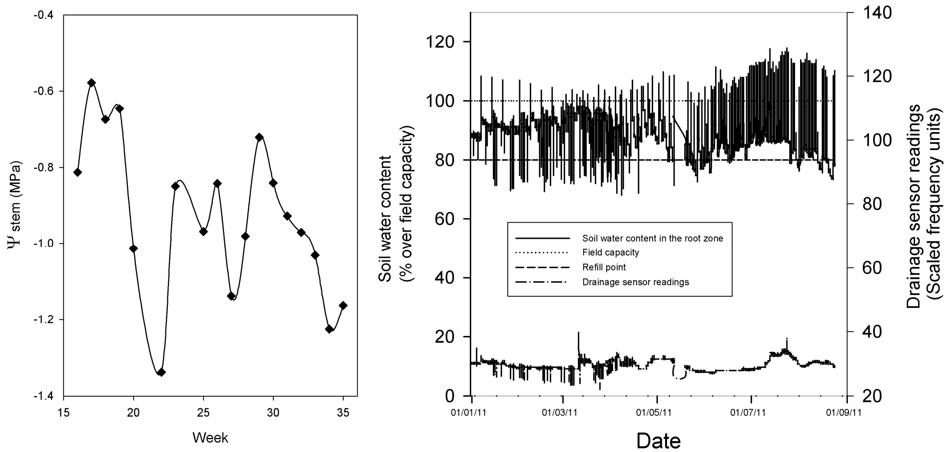

Fig. 4. Seasonal variations during 2011 of midday stem water potential (Ψstem) and soil water content. For Ψstem and soil water content values shown are averages of 8 and two determinations.

Results obtained during the two experimental seasons have allowed to derive some tentative crop coefficient seasonal trends (Fig. 5). These crop coefficient patterns have been transferred to growers by means of an user friendly software that allows calculating the irrigation volumes to schedule in order to fulfil the estimated tree crop water needs.

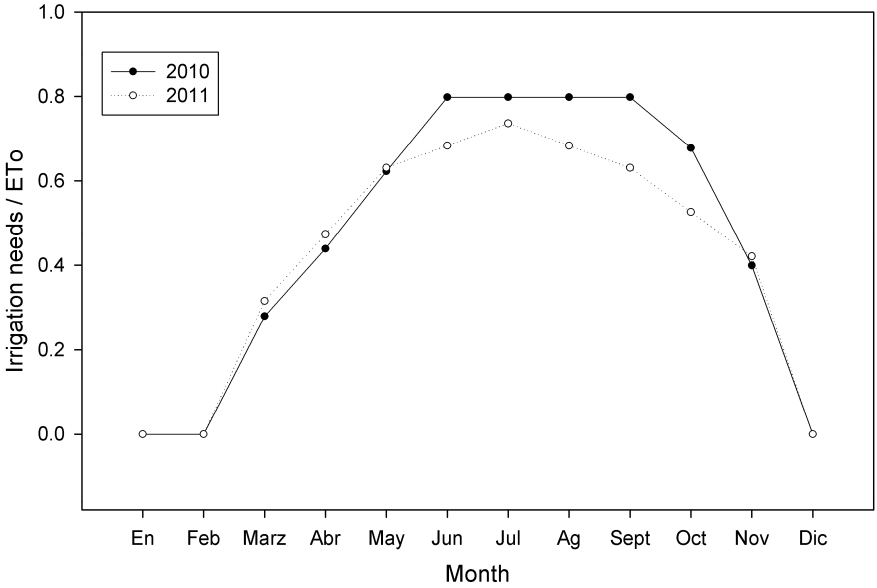

Fig. 5. Seasonal trends of the experimental crop coefficient used during the 2010 and 2011 seasons.

IV – Conclusions

By analysing together the information obtained from the reference evapotranspiration, plant water status and seasonal trends of soil water content, it was possible to derive an irrigation scheduling recommendations to carry out an efficient irrigation management for pomegranate trees. However, in order to finally apply the results obtained at a commercial scale, is important to transfer this information to the grower by means of simple procedures and tools.

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