THE INFLUENCE OF WATER QUALITY ON THE HYDRIC PROPERTIES OF OLIVE GROVE SOILS IRRIGATED BY DRIP IRRIGATION.

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Introduction

Water demand is increasing worldwide due to the rapid growth in population, improved living standards, expansion of irrigation schemes and global warming (IPCC, 1996; UN Population Division, 1994). In regions affected by water scarcity such as the Mediterranean basin, water supplies are already degraded, or subjected to degradation processes, which worsen the shortage of water (Chartszoulakis et al., 2001; Attard et al. 1996). Reduced water supplies induce restrictions on water usage and allocation policies among sectors. In such regions, the competition for scarce water resources among users will inevitably reduce the supplies of freshwater available for crop irrigation. As a consequence, agriculture will increasingly be forced to utilize marginal waters such as brackish water or reclaimed effluent to meet increasing demands, which in turn increases the risk of soil salinization and yield reduction.

There is some evidence of this in the increased levels of fertilizer components such as nitrates, phosphorous and potassium, along with higher rates of salinity, which is probably due to the direct addition of salts to the water (Oster, 1994).

Accumulation of salts in the root zone affects plant performance through the development of a water deficit and the disruption of ion homeostasis (Zhu, 2001; Munns, 2002). These stresses change hormonal status and impair basic metabolic processes (Loreto et al. 2003), resulting in inhibition of growth and reduction in yield (Mass, 1977; Paranychianakis et al., 2004, 2006).

In the Mediterranean basin, and particularly in Spain, olive farming is of great economic relevance. Though traditionally considered a crop for unirrigated land, at present it is the most irrigated crop in Andalusia. Most of the newly irrigated olive groves have incorporated modern, efficient drip fertigation methods, but in many cases neither the irrigation nor the fertilization are correctly programmed.

Regarding olive tolerance to salts, FAO (1985) classifies it as a moderately tolerant crop, with an electrical conductivity threshold of the saturation extract of between 3 and 6 dS m^{-1}. Similar values were given by Bernstein (1964), Maas and Hoffman (1977) and Aragües et al. (2004); while Soltanpour and Follet (2001) put the threshold at 2.7 dS m^{-1} and Hassan et al. (2000) at 1.2-2.5 dS m^{-1}. On the other hand, Aragües et al. (2005) observed that this threshold tends to decrease with time of exposure to salinity. According to Bernstein (1965) this value can be as high as 6-8 dS/m in soils with high calcium status. Recent studies suggest that olives can be irrigated with water containing 3200 mg/l of salt (ECw of 5 dS m^{-1}). Salinity reduces the fruit weight and oil content while increasing the moisture content of fruits (Chartzoulakis, K.S., 2005).

Nevertheless, the oil yields can be maximized over a rather broad range of applied water, because increases in fruit yield with more water can be offset to a large extent by the reduction in the percentage of oil extracted. Oil quality must also be considered when optimizing the amount of water applied (Grattan et al., 2006).

Materials and Methods

The olive grove studied is located in the desert of Tabernas (Almería, Spain). During summer, each tree received 3000 litres of water a month. Fertigation water (water + fertilizer) had a pH of 6.1, electrical conductivity (EC) of 3.0 dS m^{-1} and was dominated by ions Na^+ (17.1 mmolc dm^{-3}) and NO_3^- (26.1 mmolc dm^{-3}), with a sodium adsorption ratio (SAR) of 18.7. In this olive grove we chose a plot of 15 m^2 (3 x 5 m), which included the typical ridges and troughs which are formed throughout the studied grove. In this plot 12 access tubes were placed for the PR1 probe, with a view to monitoring the soil humidity at different depths. The infiltration rates were determined using a double ring infiltrometer.

Soil samples were taken from the ridges and troughs with a single gouge auger and were then dried and sieved to 2mm in the laboratory. The pH of the sieved soil was measured in H_2O (1:2.5) and saturation extracts were prepared in order to measure the EC and the concentration of the different dissolved ions. The anions were determined by ionic chromatography in a Dionex 120. Ca^{++} and Mg^{++} were measured by atomic absorption, while Na^+ and K^+ were estimated by flame photometry.

Results and Discussion

The high SAR of the irrigation water gave rise to disperse soil structure just below the outlet, which in turn led to a reduction in the volume and formation of the troughs. The surface of these troughs was covered with clay sheets, which considerably reduced the infiltration rate (<3 mm h^{-1}) in comparison to the ridges (24.0 mm h^{-1}).

The low infiltration rate in the troughs, together with the high quantity and frequency of irrigation, meant that the soil in the troughs was permanently waterlogged. Under such conditions of humidity and high ETP (350 mm in the months of July, August and September), the water and salts of the fertigation tend to rise to the soil surface due to capillary action (both in the troughs and in the ridges), but while in the troughs the next irrigation washed away the salts in depth, in the ridges this does not occur and the salts accumulate producing saline efflorescences and increasing EC considerably in comparison with the troughs.

As regards the nature of the salts, the troughs are predominantly Cl^- on the surface and NO_3^- at depth, though never more than 200 $mmol_c$ dm^{-3}. However, in the ridges the salts are always predominantly NO_3^- at much higher concentrations than in the troughs (> 1300 $mmol_c$ dm^{-3} on the surface of the ridges).

The greater humidity and lower salinity of the troughs mean that trees tend to concentrate their roots in the damp zone which is produced under the trough; nevertheless, the rainwater tends to wash away the salts from the ridges and accumulate them in the troughs. This gives rise to an increase in salinity in the root zone, obliging the grower to irrigate after each rainfall, with the concomitant increase in expenses.

Conclusions

According to these results, the high SAR of the irrigation water, excessive irrigation and the water's high salts content are causing the formation of troughs and ridges. In the former, irrigation water accumulates and later evaporates, and in the latter salts (fertilizer) accumulate, which means that neither the humidity nor the nutrients are being used efficiently.