Determination of Soil-Plant-Water Dynamics of Mature Pistachio Orchards Grown under Saline Conditions

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INTRODUCTION

A significant percentage of pistachio acreage in California is grown in areas with naturally high and induced soil salinity. Irrigation management in these areas is based on information (Kc values) developed for nonsalt affected soils and water supplies, and for infrequent irrigation methods, such as surface and sprinkler irrigation.

Since 2015, our team has been measuring the evapotranspiration (ET) of microirrigated mature pistachio orchards grown on soils with increasing salinity levels (ECe from 1-2 up to 8-10 dS/m). The field data we collected during the first three crop seasons (2015, 2016 and 2017) show that salt affected orchards have 10-30 percent lower water use, reduced canopy cover and light interception by up to 45 percent and significantly increased plant stress than nonsaline orchards. While differences between nonsalt-affected and salt-affected orchards are evident, the mechanisms for how different levels of soil-water salinity affect water productivity are complex and less clear.

Salinity has multiple impacts on plant water use: a direct effect on ET due to lower soil water potential, which results in less water uptake, and an indirect effect on ET due to reduced plant growth and canopy size, resulting in less light (energy) interception that leads to reduced crop transpiration. Additionally, the high variability of soil structure, induced by salinity, further complicates the estimation of orchard water use in saline-growing environments.

METHOD

Within this project, funded by the California Pistachio Research Board, besides continuing the field measurement of actual evapotranspiration of three well-watered mature pistachio orchards, our team investigated the specific effects of the physical (canopy size) and physiological (soil osmotic effect on stomatal conductance) limitations to water uptake and crop evapotranspiration under saline conditions, with the aim to improve the accuracy and reliability of information on ET and Kc of mature pistachio orchards as a function of increasing soil-water salinity.

To this aim, our team instrumented, with a full-flux ET station, an additional nonsalt-affected mature pistachio orchard with similar canopy size (45-50 percent canopy cover) and structure to a salt-affected orchard that was already under ET monitoring, within our ongoing study. Both the orchards were well watered and not subjected to water supply limitations over the entire 2017 season. At the additional non salt-affected orchards, our team conducted a soil survey in collaboration with scientists from the USDA Salinity Lab, in Riverside, CA, using the electromagnetic induction (EMI) technique, followed by soil sampling and laboratory analysis to determine relevant physical and chemical parameters to characterize soil-water salinity. Also, the Mobile Lab of the Northwestern Kern County Resources Conservation District, in order to determine the average water application rate and distribution uniformity, conducted an irrigation system evaluation at the orchard. In addition, we installed trunk dendrometers at three individual trees within each of the footprint areas of the different ET stations over the four study orchards, and collected weekly measurements of the midday stem water potential to estimate the plant water status over the course of the entire crop season, and to correlate the values of maximum daily trunk shrinkage from dendrometers with values of midday stem water potential. Finally, at the high-saline orchard we set up two experimental sub-canopy ET stations, one within a high-canopy cover area and the other in a low-canopy cover area, respectively, to estimate the soil evaporation (E) and its relative contribution to the total ET fluxes.

RESULTS

The ET and Kc values our team measured, over the 2017 crop season, from the three study orchards are consistent with the values measured in 2016. Increasing level of salinity had the effect of reducing the actual ET by 10 to 40 percent, and this reduction was observed along with a progressive reduction of canopy cover from 35 to 65 percent.

Measurement of ET at the additional nonsalt-affected orchard, with 45-50 percent canopy cover (CC) enabled us to estimate the effect of canopy size and of soil osmotic potential due to salinity on ET. Specifically, over the 2017 season, the 50 percent CC nonsaline orchard used 11 percent less water than the 75 percent CC nonsaline orchard. In both these nonsalt-affected orchards the stem water potential and the dendrometers did not evidence any water stress, suggesting that trees were transpiring water at their maximum physiological potential. Under such circumstances, we can say that the observed 11 percent difference in ET is due to the different canopy size and resulting different light interception of the two orchards.

Comparing the seasonal ET of the nonsalt-affected and salt-affected orchards, both with 45-50 percent CC, we found a 13 percent difference in ET, meaning that the soil osmotic potential due to salinity reduces water uptake and ET.

Measurements from the two sub-canopy ET stations show that the estimated soil evaporation counts for about 5-15 percent of total ET in the areas, with 65-75 percent CC up to 30-40 percent in the areas where canopy cover was strongly reduced by salinity.

CONCLUSION AND APPLICATIONS

Canopy cover and light interception are the main drivers of crop ET. These parameters are significantly affected by soil-water salinity, and such influence must be considered, for accurate irrigation scheduling in orchards grown under saline conditions. Salinity has a direct effect on ET, but we also think that salinity may not be the only factor affecting tree performance—the other being sodium absorption ratio (SAR), root asphyxia, and specific ions toxicity, such as sodium, boron and chloride. Root asphyxia, due to excessive water application in degraded structure in deflocculated (sodic) soils, may have a predominant and long-term adverse effect on tree performance.