Geophysical Research Abstracts
Vol. 20, EGU2018-14431, 2018
EGU General Assembly 2018

The influence of weeds on evapotranspiration and water use efficiency in an irrigated Mediterranean olive orchard

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Olive orchards are one of the most extensive crops in the Mediterranean region and have important environmental, social, and economic impacts. Due to the common water stress characterizing the Mediterranean region, water supply by irrigation is usually necessary to increase olive crop productivity. In Spain, which has the largest olive crop extension of the Mediterranean region, 29% of the olive cultivated area is irrigated. Conservation practices consisting on the maintenance of weed cover in between trees are being increasingly adopted as a sustainable strategy to increase soil organic carbon content and mitigate soil degradation problems caused by soil erosion. However, the presence of weed covers may also increase evapotranspiration (Et) and the consequent water demand in olive groves. While the influence of weed covers on soil carbon dioxide (CO_2) fluxes and net ecosystem exchange (NEE) in olive groves has been previously reported, their effects on water fluxes at plot and ecosystem scale have been less studied. Moreover, very limited information is available on the influence of weeds on water use efficiency (WUE), defined as the ratio between carbon uptake and Et.
The objective of this study was to analyse the effect of weed covers on Et and WUE both at plot and at ecosystem scale in an irrigated Mediterranean olive orchard (Jaén, SE Spain). Water and CO_2 fluxes were measured in the olive orchard under two management treatments, conservation of weeds and weed removal with a glyphosate-based herbicide. Water and CO_2 fluxes were measured in 0.25 m2 plots over weed-covered and weed-free soils using a transparent transient-state chamber attached to an infrared gas analyzer. Fluxes of CO_2 and latent (LE) and sensible heat (H) were measured at ecosystem scale in the two treatments using two eddy covariance towers. During the period of maximum weed growth (spring), soils covered by weeds showed higher evapotranspiration than weed-free soils. However, while the weed-covered soils showed negative values of NEE (net carbon gain), the weed-free soils showed positive values of NEE or net carbon release to the atmosphere. This resulted in higher WUE in the former than in the latter soils. A similar pattern was found in the olive orchard at ecosystem scale. Both net carbon uptake and Et were higher in the weed cover treatment compared to the weed-free treatment. As a result, ecosystem WUE was higher in the treatment with weeds than without weeds. Besides, the Bowen ratio (H/LE) was lower in the weed-cover than in the weed-free treatment. Therefore, despite the fact that weed covers increase water loss through evapotranspiration, they act as important CO_2 sinks, likely having a positive effect on crop productivity by maximizing the ratio of carbon assimilation to water loss.