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Modeling to evaluate and manage climate change effects on water use in Mediterranean olive orchards with respect to cover crops

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Rainfed olive orchards in Southern Spain constitute the main socioeconomic system of the Mediterranean Spanish agriculture. This system has an elevated level of complexity, requiring accurate handling of soil water for insuring yields and survival of the trees in a rainfall limited environment additionally characterized by large year to year variability. Traditionally soil management based on tillage has been used to prevent competition for soil water by weeds, which has resulted in severe erosion problems. The use of cover crops (usually winter grasses or natural vegetation cover) killed in late winter or early spring, spraying herbicide or mechanically mowed, to prevent competition for soil water has been progressively introduced to cope with those erosion problems, as well as for enhancing biodiversity in olive growing areas.

Characterization of crop, climate and soil components for a correct management of this system under different soil management alternatives has been tried through a combination of agronomic and hydrologic experiments. However, the large variability in soil, climate and olive orchard configuration within Andalusia, combined with the added uncertainty of projected climate change, makes extremely complicated a proper understanding of the impact of soil management on tree transpiration and through them on olive yields.

This communication presents an alternative approach based on a complete water balance model that it has been developed, calibrated and validated for the semi-arid conditions of Southern Spain, called WABOL (Abazi et al., 2013). This model is complemented with an relationship between tree transpiration and olive yield developed from the original proposal provided by Moriana et al. (2003) linking evapotranspiration of the orchard with yield.

Using these tools, an analysis for current and projected climate scenarios for five locations representative of conditions for rainfed olive cultivation in Andalusia was made, considering two different soil management scenarios: tillage and cover crops as described above. Climatic scenarios came from four different climatic models from the FP6 European Project ENSEMBLES being bias corrected for temperatures and precipitation (Dosio and Paruolo, 2011; Dosio et al., 2012) and, subsequently, used as inputs for the WABOL model. This analysis was completed by a sensitivity analysis of soil depth decrease for the two different soil management scenarios (tillage and cover crop chemically killed in early Spring) and two different locations: one representative of mountainous olive production, and a second one of orchards in less sloping areas on better soils.

All the model predictions indicates a significant reduction in precipitation for the period 2068-2098 compared to the reference period from 1971-2000. This reduction ranged, approximately from 12 to 29% depending on the location and the climatic model considered. It is also expected an increase in potential evapotranspiration ranging from 9 to 24%. This indicates a reduction in water availability which is translated into a reduction of expected olive transpiration, and then yield, for both soil management alternatives.

Analysis of site to site differences in olive transpiration between the two soil management alternatives indicates a slight increase on olive transpiration when a proper cover crop management is implanted compared to tillage. This can be explained by the partial compensation of cover crop transpiration by reduced evaporation from bare soil and runoff compared to the tillage management. Also by the limitation of cover crop transpiration in Spring. These results are consistent with reviewed published experiments indicating similar, or even slightly higher

yields in cover crop managed orchards compared to tilled ones when control of cover crops in early spring is made.

The communication deepens into the variability of the results for individual years and its potential impact on yields, as well as the challenges to translate these results at farm scale.

References

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