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Simulating the effects of microclimate on the water balance of understorey plant communities in orchards

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Abstract: Maintaining a steady supply of water is critical for crop production. Water stress can cause a wide range of physiological responses in plants, leading to reductions in yield and crop quality. It is therefore not surprising that irrigation is one of the most effective ways to improve productivity. However, excess water application can be also detrimental. It can promote excessive vegetative growth, the depletion of soil nutrients via leaching; and increase the risk of diseases. Environmental monitoring and the use of tools to estimate evaporative losses are essential to manage irrigation well and to maintain a balanced soil water status throughout the growing season. The task of estimating water balance can be quite complex in perennial orchard systems. Plant cover is highly variable, both in time and space, and typically crop trees and understorey plant communities, with contrasting canopies and rooting depths, are growing together. The irrigation systems can also be relatively varied too, often with non-uniform application (e.g. drips and micro-sprinklers); all this on top of the natural soil variability and the layout of the orchard itself.

It is important, therefore, to understand the components of the water balance and to verify that our tools can describe well the various processes involved. In orchards, an often neglected component is the influence of soil cover under the trees' canopies. This typically includes a grass-based understorey in the alley and a bare strip sprayed with herbicides along the tree row, although significant variations to this pattern exist. The understorey is usually composed of a variety of species that provide a number of benefits to the orchard ecosystem. These include protection to the soil surface, temperature moderation, nitrogen (N) fixation, and habitat for beneficial insects. However, there are also potential negatives. The understorey plants can harbour pests and, importantly, they compete for water and nutrients with the trees. The environmental conditions that are experienced by the understorey communities are very different from those in open pasture swards, from which a lot of information is available. The trees' canopies, and other structures placed in orchards (e.g. netting), can significantly reduce the amount of radiation reaching the understorey. This changes the energy balance on the soil surface and, alongside changes in temperature, wind, and humidity regimes, may have a considerable effect on water usage by the understorey plants.

In this presentation we show results from an investigation on the effects of microclimate on the water balance of the understorey plant community. We explore whether water balance models can capture the variation in soil water status in conditions mimicking the microclimate under the canopy of apple orchards grown under different training systems (tall spindle and planar cordon). We use data collected in a controlled experiment with understorey plants grown in a rainout shelter facility in New Zealand. This employed netting with different degrees of shading to mimic some of the effects of the trees canopy. Data from actual orchards are used to supplement the analysis. Modelling and sensibility analysis was carried out using the AgPasture model in APSIM (www.apsim.info).

We have identified substantial differences in the microclimate under the canopy compared to open areas and between different orchard training systems. For instance, only 50 and 30% of solar radiation reaches the understorey on tall spindle and planar cordon orchards, respectively. Correspondingly, soil water content changed between systems, indicating a significant effect of under-canopy microclimate on understorey plant water usage. The model was able to replicate these variations after modifications to the microclimate variables (radiation, wind, and temperature). Sensibility analysis is used to explore potential drivers to water usage in the understorey (e.g., row spacing and rooting depth) and potential implications of shading to the understorey plant community. The variability of canopy shape and water availability due to irrigation non-uniformity in real orchards are issues that need additional investigation. Implications for irrigation management and model development are discussed.

Keywords: *Systems modelling, irrigation, crop water use, shading*

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