RESEARCH BULLETIN

Separating almond evapotranspiration into soil water evaporation and crop transpiration

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Summary

The estimation of crop water use is a key input into much of the software which supports irrigation management. The most common method used to derive this estimate is to calculate it from weather data and coefficients specific to crop type and growing stage. This approach does not allow for the separate quantification of productive water use—crop transpiration, and non-productive water use—evaporation of water from the soil. Separate quantification can be achieved by applying a recent alternative approach known as the dual crop coefficient approach, which separately estimates crop transpiration and soil water evaporation.

This student project was undertaken by Samantha Conner as part of the ongoing SARDI/PIRSA project, Developing a reliable model of drainage production from irrigated horticulture at the farm and district level, which provided measures of total crop water use. The goal of this project was to measure evaporation rates from soil and the associated measure of soil shading in an almond orchard to enable measures of the total orchard evapotranspiration to be separated into productive and non-productive components. These measures will be used to determine the applicability of both single and dual crop coefficient approaches to the estimation of almond crop evapotranspiration.

Samantha Conner digging hole for Lysimeter

NATIONAL PROGRAM FOR Sustainable Irrigation

Measuring evaporation in an almond orchard

Mini-lysimetry was used to measure soil water evaporation during mid-summer in a mature sprinkler irrigated almond orchard in South Australia's Riverland. Lysimeters change weight in response to irrigation, rain, drainage and evaporation The evaporation is calculated for each lysimeter from the weight change. The change in mass over time is converted to millimetres evaporated.

The effect of tree canopy shade on evaporation rates was investigated by placing lysimeters at four different sampling positions across the row. Figure 1 shows the design of the Lysimeters used for the project.

Incident radiation (energy from the sun) was also measured at three locations to quantify the amount of radiation over the day in respect to shading. This improves the understanding of the amount of evaporation across a row of almond trees. Radiation at the almond orchard floor was expressed as a percentage of the above canopy radiation, which was measured at an automatic weather station located in a field south east of the orchard.

Irrigation distribution was measured with an array of catch-cans. Areas of high or low distribution were found to be caused by low branches. The irrigation volume was found to be sufficient so that all lysimeters would be filled to field capacity.

Supplementary data was supplied by Dr Ewenz from the eddy co-variance project, consisting of crop evapotranspiration (ET) from the flux tower and reference evapotranspiration (ETo) from the nearby automatic weather station.¬ ETo was calculated according to the Food and Agriculture Organisation Irrigation and drainage paper 56 (FAO-56, Allen et al. 1998). ET measurements have not been quality controlled at this stage. Data quality control, filtering and backfilling will be undertaken as part of the eddy covariance project.

Results

As expected, the soil water evaporation rate was highest in the centre of the row (Figure 2). This coincided with the radiation measurements, which also yielded the highest amount of incident radiation in the centre, between two tree lines. On a clear sky day, the average radiation received for the entire surface level was 28% of the solar radiation received at the top of the canopy. More shading under the trees compared to the mid-row yielded a daily average incident radiation of 15% under the trees compared to 35% at mid-row. This doubling of radiation only increased the evaporation rate itself by 28%, that is, evaporation from lysimeters located under the tree was four-fifths of the evaporation from lysimeters located in the mid-row. Soil water evaporation rates remained constant over the irrigation interval, during which time the cumulative depletion of water reached 12 mm. The soil evaporation at the time was not limited by factors such as the availability of water at the surface.

Variation in crop evapotranspiration (ET) and reference crop evapotranspiration (ETo) were also evaluated during the study period. ET varied with wind conditions and irrigation patterns,

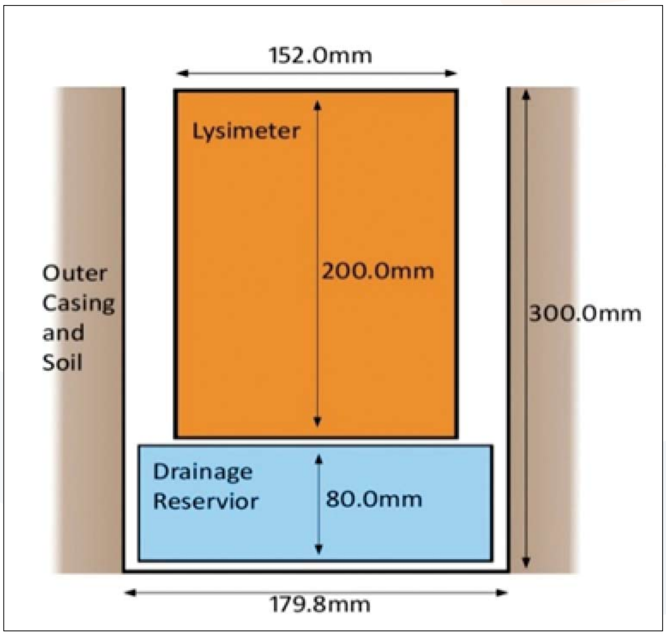

Figure 1: (a) Diagram of lysimeter construction with dimensions and (b) lysimeter deployed in the field

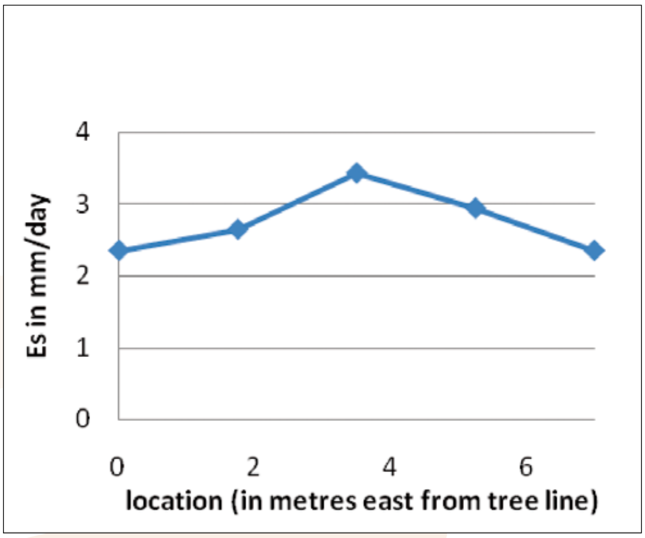

Figure 2: Average evaporation rate across inter-row over all lysimeters

whereas the ETo stayed relatively constant over the same period. Transpiration was calculated by subtracting the evaporation values (lysimeter) from the total evapotranspiration values (eddy co-variance). There was little variation of the transpiration rate for the whole study period.

Using the information presented so far the single crop coefficient for the mature mid-season almond orchard can be calculated on a daily basis. Compared to the evapotranspiration and the transpiration values, soil evaporation values are small, which could be an indicator that a dual crop coefficient system can improve irrigation requirement estimates.

Conclusion

Measurements taken at a mature, sprinkler-irrigated almond orchard in mid-summer showed an average soil water evaporation rate of 2.9 mm/day. The variation in soil water evaporation was investigated as a function of soil surface exposure and evaporable water. During the field work the soil water content never dropped below the readily evaporable water content.

The evaporation across the tree rows displayed a strong correlation with the incoming solar radiation at the surface level, with highest evaporation in the centre of the rows. Utilising this information, the single crop factor was calculated to be slightly higher than that specified by Allen et al (FAO-56, 1998).

Future Work

The information gathered from this project will be explored in more detail as part of an honours thesis. The honours thesis will concentrate specifically on transpiration rates and, combined with the results from this research, will aim to determine whether a dual crop coefficient system can improve irrigation requirements. This will in turn contribute to the objectives of the large ongoing SARDI/PIRSA project "Developing a reliable model of drainage production from irrigated horticulture at the farm and district level", where the eddy covariance method is used in order to measure crop water use over the block size in the almond orchard.

Samantha measuring drainage at the test site



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References

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Stevens R, Ewenz CM, and Grigson G (ongoing), "Developing a reliable model of drainage production from irrigated horticulture at the farm and district level", current SARDI/PIRSA project.

Thanks

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About the Program

The National Program for Sustainable Irrigation defines and invests in research on the development and adoption of sustainable irrigation practices in Australian agriculture. The aim is to address critical emerging environmental management issues, while generating long-term economic and social benefits that ensure irrigation has a viable future.

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