Focus Orchard Case Study: Water Budgeting

Orchard: Sanders, Three Bridges, Victoria

Orchardists: Peter, Bob and Kevin Sanders

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Figure 1: Bob and Peter Sanders

Objective

To optimize irrigation water and maximize Gala fruit size.

Background

Sanders fruit size on their Gala blocks came in under target in 2012 and again in 2013. The Future Orchards team questioned the irrigation water volume and needed to understand whether irrigation was one of the limiting factors. Although Sanders were using a Gopher capacitance meter for soil moisture monitoring, we recommend also running a simple water budget alongside. Often under micro irrigation, where a small proportion of the soil volume is wetted, placement of the soil monitoring device can give a poor guideline of the trees needs. A simple water budget running in tandem can act as a good cross-check.

What is a Water Budget?

A water budget looks at the water coming into the growing system as either rainfall or irrigation, and compares it to the water going out as evapotranspiration (ET). Water optimisation for a crop is often close to 100% of ET, eg, a grass sward, however this percentage, called the Crop Factor does vary depending on crop and time of the season. Permanent tree crops often have crop factors less than 1.0. Research work in Australia has indicated a crop factor for pipfruit of 0.7 or 70% to optimize the crop. This assumes water supply is unlimited and a sprinkler system wetting more than 40% of the total land area. Well managed drop systems can have lower crop factors. Crop factors do vary. Growers should seek advice to determine a likely crop factor on your orchard.

Water Budget Calculation

To calculate a simple water budget, we need 4 pieces of information:

1. Evapotranspiration (ET)
2. Rainfall
3. Irrigation applied
4. Crop Factor

Evapotranspiration and Rainfall

Both ET and Rainfall are measured as mm and are publicly available nationwide through the BOM website and many other sources. There are numerous automatic weather stations across Australia both publicly and privately available. Clearly a weather station close to your own orchard will be the most accurate, however the BOM network is very extensive and there's sure to be one station close that will suffice, particularly for ET.

Evapotranspiration data can be accessed through the link: http://www.bom.gov.au/watl/eto/ . Three Bridges closest station was the Coldstream logger.

Rainfall can vary widely from one valley to another and in the case of the Sanders, a daily measurement with a simple rain gauge is the most accurate, as it will be for most growers.

Irrigation Applied.

- To calculate your irrigation system output per hour, simply divide the dripper or sprinkler output (l/hr) by the irrigated area (m2).
- The irrigated area is the row width multiplied by the sprinkler/emitter spacing down the row.

Handy Tip: 1mm of rainfall is equivalent to 1 l of water being applied to 1 m^2 (l/m^2 = mm)

Example 1: Block RAJ ~ Open V with mini sprinklers every 5th tree. Row spacing 4.5 m, tree spacing 0.75 m (Fig 3)

Irrigation output/sprinkler:	30 l/hour (Fig 2)
Surface area covered/sprinkler	4.5m x 0.75m x 5 trees = 16.9 m2
Effective irrigation= 30L/h/16.9m2	1.78 mm/hour

Important Note: This is calculating the irrigations equivalence to rainfall in mm. In the case of partial soil wetting, the application rate will be higher on the area that is actually wetted.

Irrigation midsummer was often running 7 hrs per week which is equivalent to (1.78 mm/hour x 7h/week) = **12.46 mm/week**

Figure 2: Mini sprinkler 30 l/hr output

Figure 3 RAJ Block with one mini sprinkler every 5th tree.

Example 2: Block FTW ~ Mini Sprinklers every 2nd tree. Row spacing 4.5 mm, tree spacing 2.0m

Irrigation output/sprinkler	30 l/hour
Surface covered/sprinkler	4.5m x 2m x 2 trees = 18 m2
Effective irrigation = 30L/h /18m2	1.67 mm/hour

This block was irrigated midsummer at 10 hrs per week which is equivalent to (1.67*10) = **16.7 mm per week.**

Sanders Water Budget

Peter Sanders went through his records, captured the ET data from the nearest BOM logger and developed the Water Budget for RAJ block (Table 1 below). We assumed that the soil profile was at Field Capacity on the 8th October 2012. This is verified by the Gopher reading. We also assumed a Crop Factor of 70% of ET to calculate an accumulated water deficit. The table also shows the Gopher readings and the fruit growth rate in mm/week.

So the reader can follow the math, in the week ending 8/10/12, the deficit is calculated as follows:

(ET * 0.70) - Rain- Irrigation or 23*0.7-4-0= 12.1mm.

The following week 15/10 the calculation is (16*0.7)-30.4-0+12.1 = -7.1

Note in the second week we add the deficit from the week before to calculate the accumulated position.

Table 1 Sanders RAJ Block Water Budget 2012/13

RAJ Block											2012/13								
Date	8-Oct	15-Oct	22-Oct	29-Oct	5-Nov	12-Nov	19-Nov	26-Nov	3-Dec	10-Dec	17-Dec	24-Dec	31-Dec	7-Jan	14-Jan	21-Jan	28-Jan	4-Feb	11-Feb	Total (mm)
ET (mm/week)	23	16	23	23	30	26	29	27	36	37	33	44	44	58	47	50	44	31	58	
RAIN (mm/week)	4	30.4	13.6	11	19.8	10	4.4	5.2	18.2	10.2	10.2	7.8	0.8	16.2	7.2	11.2	0.8	0.8	0.2	
Irrigation (mm/week)										4	12.5	11.8	17.5	27.5	23.75	25	17.5	12.5	17.5	170
Gopher Reading (Full Point = 122	118	122					98	106	107	100	92	89	87	104	96	107	96	93	105	
Fruit Growth Rate (mm/wk)	3	3	4	5	4	5	3	5	4	4	4	3	3	4	2	2	2	2	62	
Accumulated Deficit	12.1	-7.1	-4.6	0.5	1.7	9.9	25.8	39.5	46.5	58.2	58.6	69.8	82.3	79.2	81.15	79.95	92.45	100.85	123.75	
Theoretical Irrigation								9.5	7	15.7	12.9	23	30	24.4	25.7	23.8	30	10	20	216
Accumulated Deficit	12.1	-7.1	-4.6	0.5	1.7	9.9	25.8	30	30	30	30	30	30	30	30	30	30	40.9	61.3	

Toward the end of December, deficits of greater than 70mm were running. Gopher readings hit their lowest point of 87 and fruit growth rates had dropped to 2-3 mm/week. Even allowing for some soil profile storage, all the evidence suggests that soil moisture was inadequate to maximize the crop. The first thing that suffers in an apple crop is fruit size.

From analysis of all the data, it appears likely that inadequate irrigation is one of the reasons why the Gala fruit size came out below target.

Water Storage

It's all very well saying Peters needs to apply more irrigation, but the limiting factor for the Sanders, as with many Australian orchardists, is inadequate storage to meet the needs of a dry year. To calculate the storage volume required in ML.

Volume in megalitres (ML) = depth of water (mm) * Area (ha) / 100

Eg: Assuming RAJ was 1 ha, the Sanders applied 170mm x 1.0 / 100 = 1.7ML per ha in the 2012/13 growing season.

In table 1 above we did a calculation to work out how much water might have been required to optimize the crop. The added assumption was that the soil has a capacity to hold 30mm available moisture, hence we're happy to go to a 30mm deficit but not below. We calculated that to maintain a deficit of 30mm until close to harvest would have required 216 mm or 2.16ML per ha a 27% increase over the actual irrigation.

Recommendations

- Irrigation volume was inadequate in 2012/13 to maximize the crop.
- All blocks irrigation system should have their application rate in mm calculated to be able to run a simple water budget.
- Next year, the Sanders Bros will run simple water budgets across a few indicator blocks to double check the Gopher.
- Gopher monitoring will continue but care will be taken on the monitor site positioning.
- Water storage improvements are being investigated to ensure there is enough water for a 1 in 5 drought year which we estimate will require 3ML per ha storage.