Observations on the water-use, water-use efficiency and total water footprint of a "cripps pink" apple orchard in the winter rainfall region of the Western Cape

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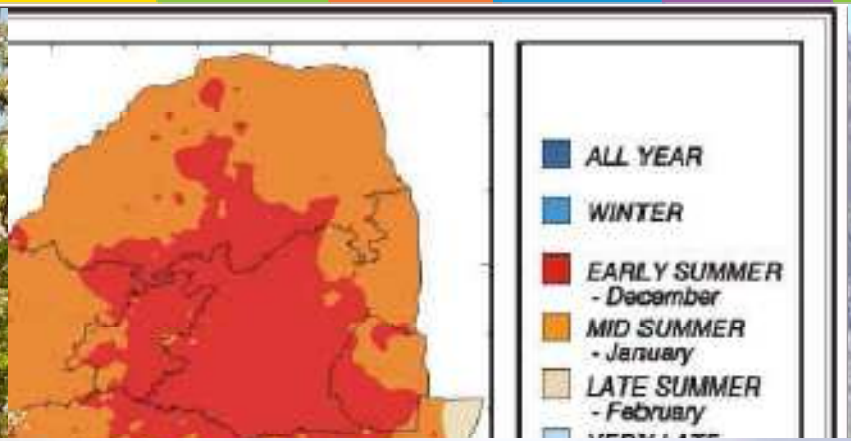
Apple orchard water-use, efficiencies & footprint

Site selection



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Site selection

- ‘Cripps Pink’ (‘Pink Lady’) on M793, Nooitgedacht Farm, Koue Bokkeveld
- 2.3ha, 13-yrs old (planted 1997), 5m tall, 1.25m X 4m (2000 spha), 60t/ha
- Automated Micro-spray fertigation system – short range Gyro’s

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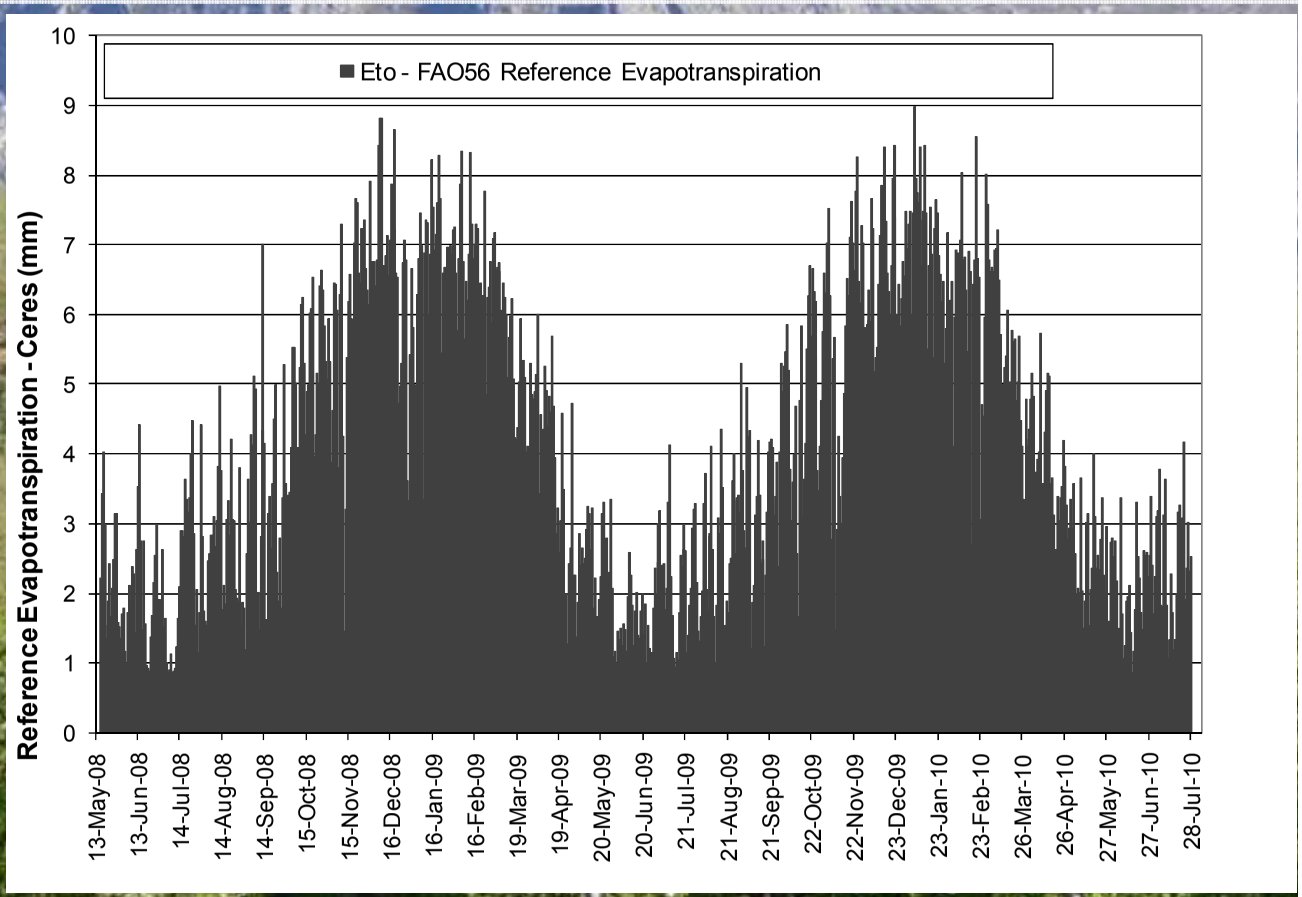
Weather measurements

- Automatic weather station for hourly measurements of rainfall, solar radiation, temperature, relative humidity, wind speed & wind direction (FAO56 Ref Et_o)



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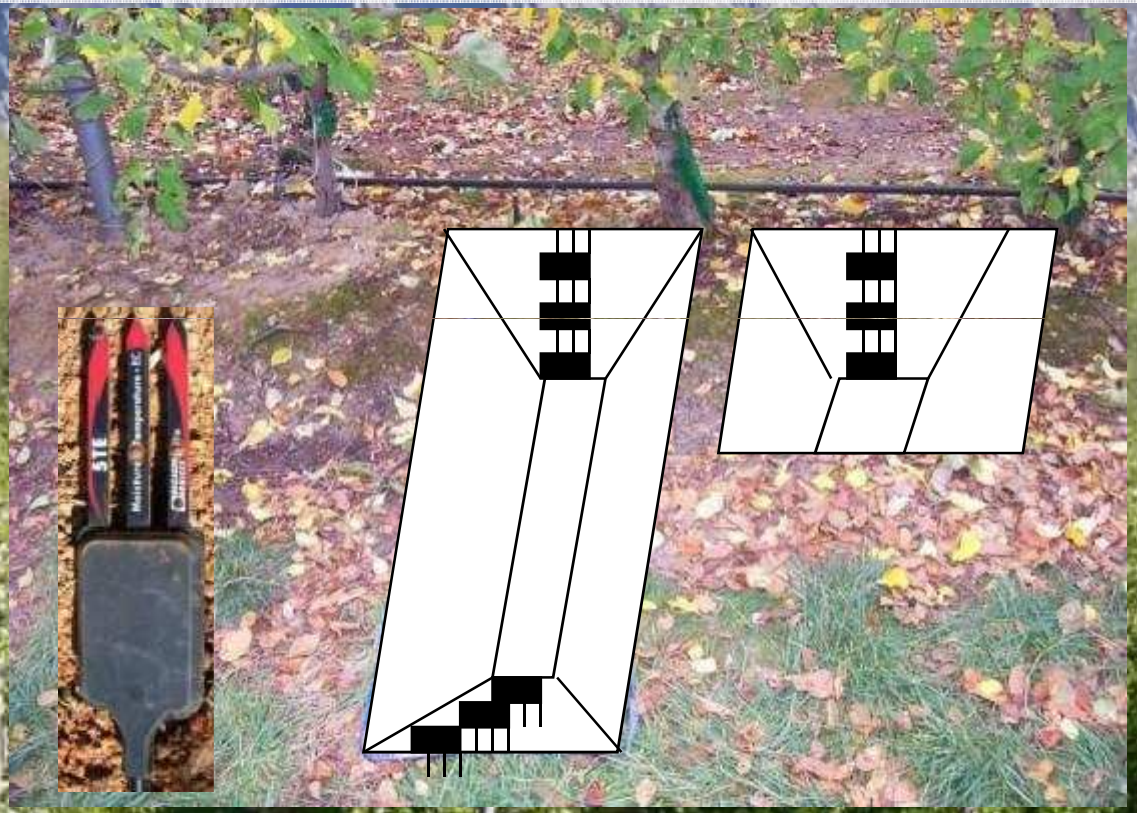
- Decagon probes for soil water measurements
- CS616 TDR probes for volumetric soil water content (top 10cm only)
- Irrometer and logger for timing of irrigation events



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Water-use measurements

- Heat Pulse Velocity systems for continuous hourly sap flow (T) measurements
- Energy balance measurements to derive total evaporation (Eddy Covariance technique) – short-term seasonal monitoring

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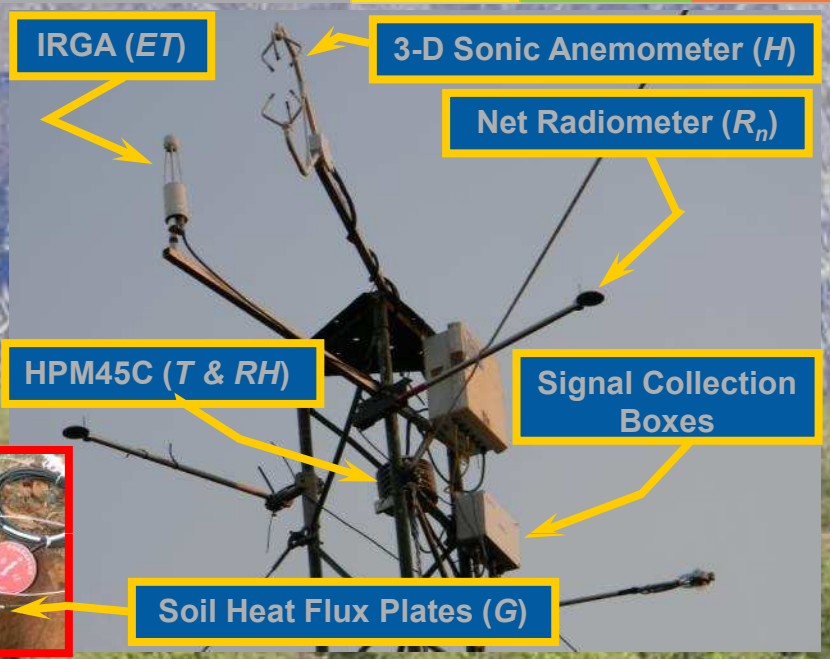
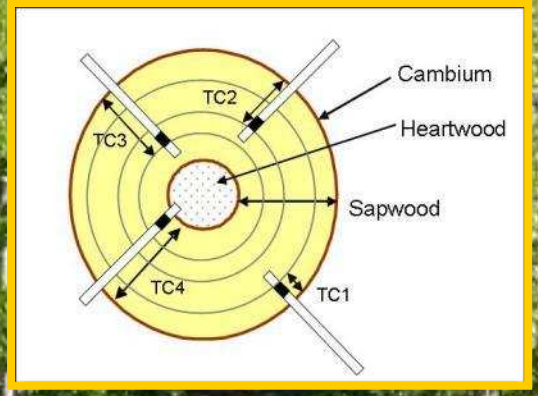
T & ET measurement



$$R_n - G - H - LE = 0$$

$$LE\,(ET) = R_n - G - H$$



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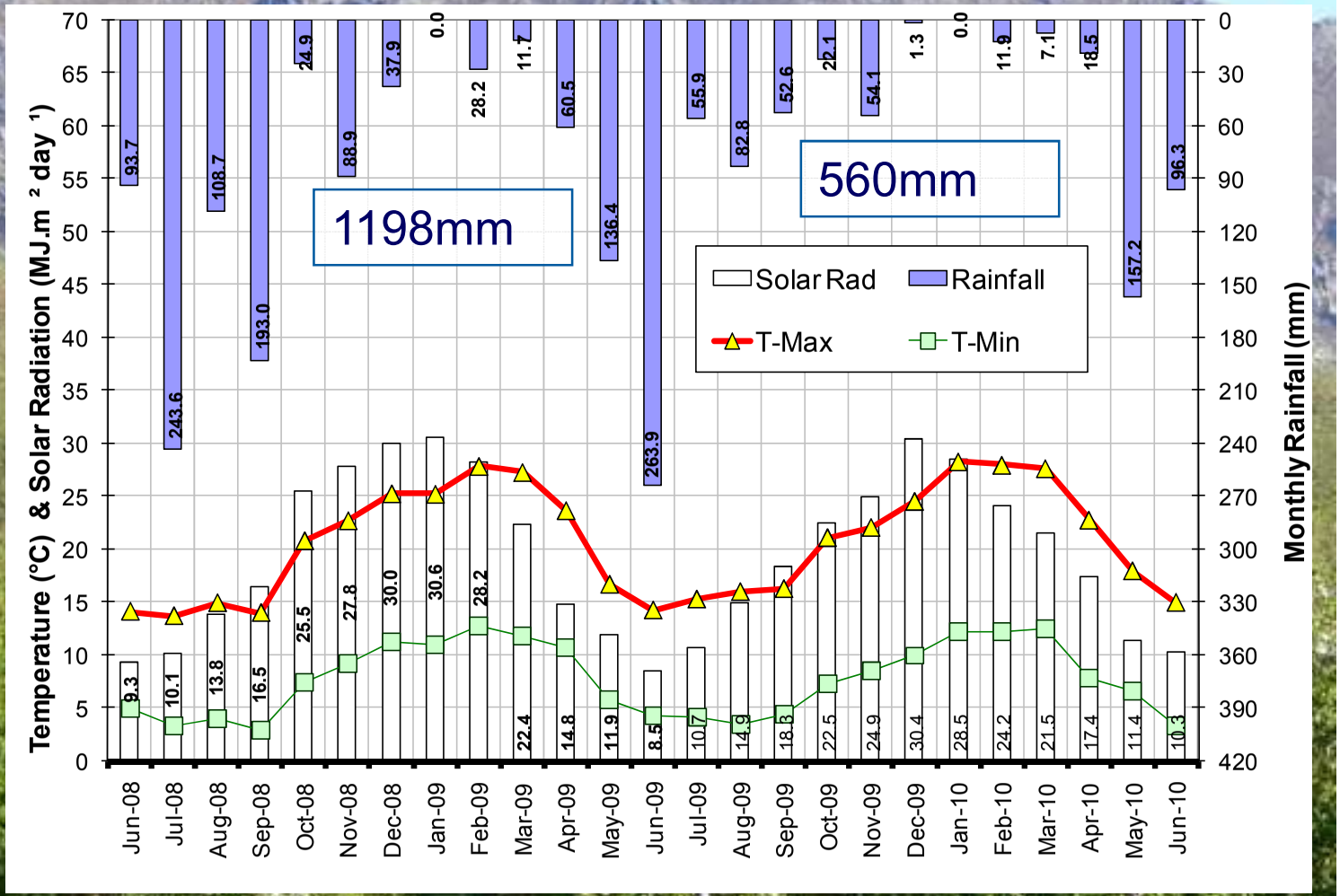
Weather results



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Sap flow results

Annual T = 4 000 L / 825 mm (2008/2009)
Max = 42 L.day^{-1}

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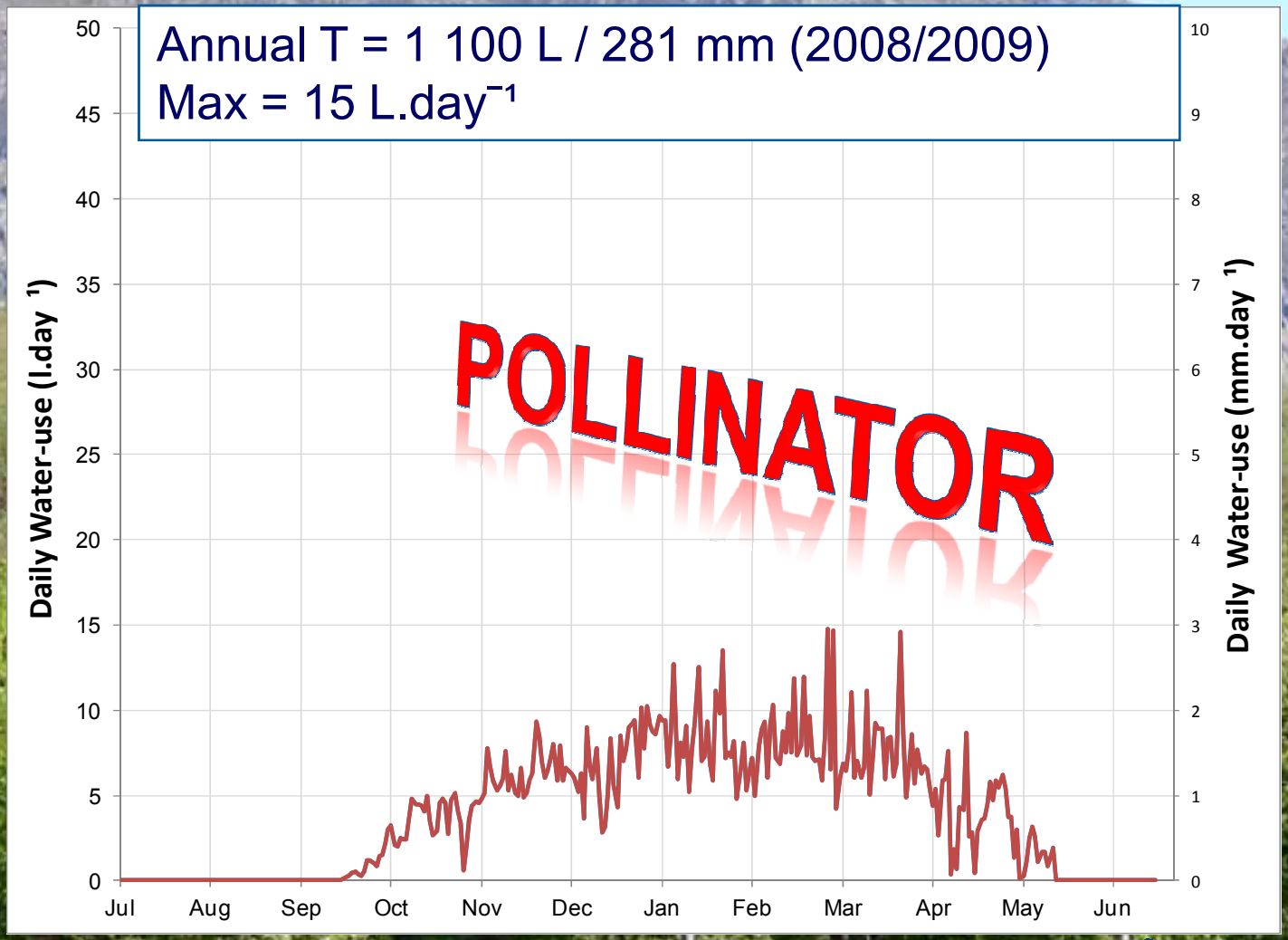
Sap flow results

Annual T = 1 100 L / 281 mm (2008/2009)
Max = 15 L.day^{-1}



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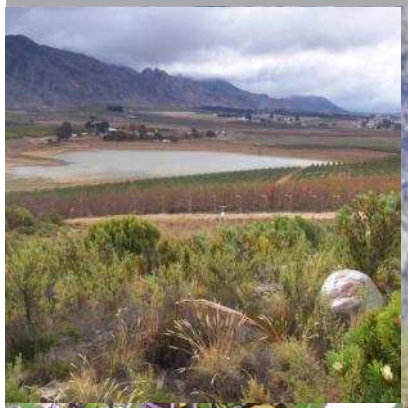
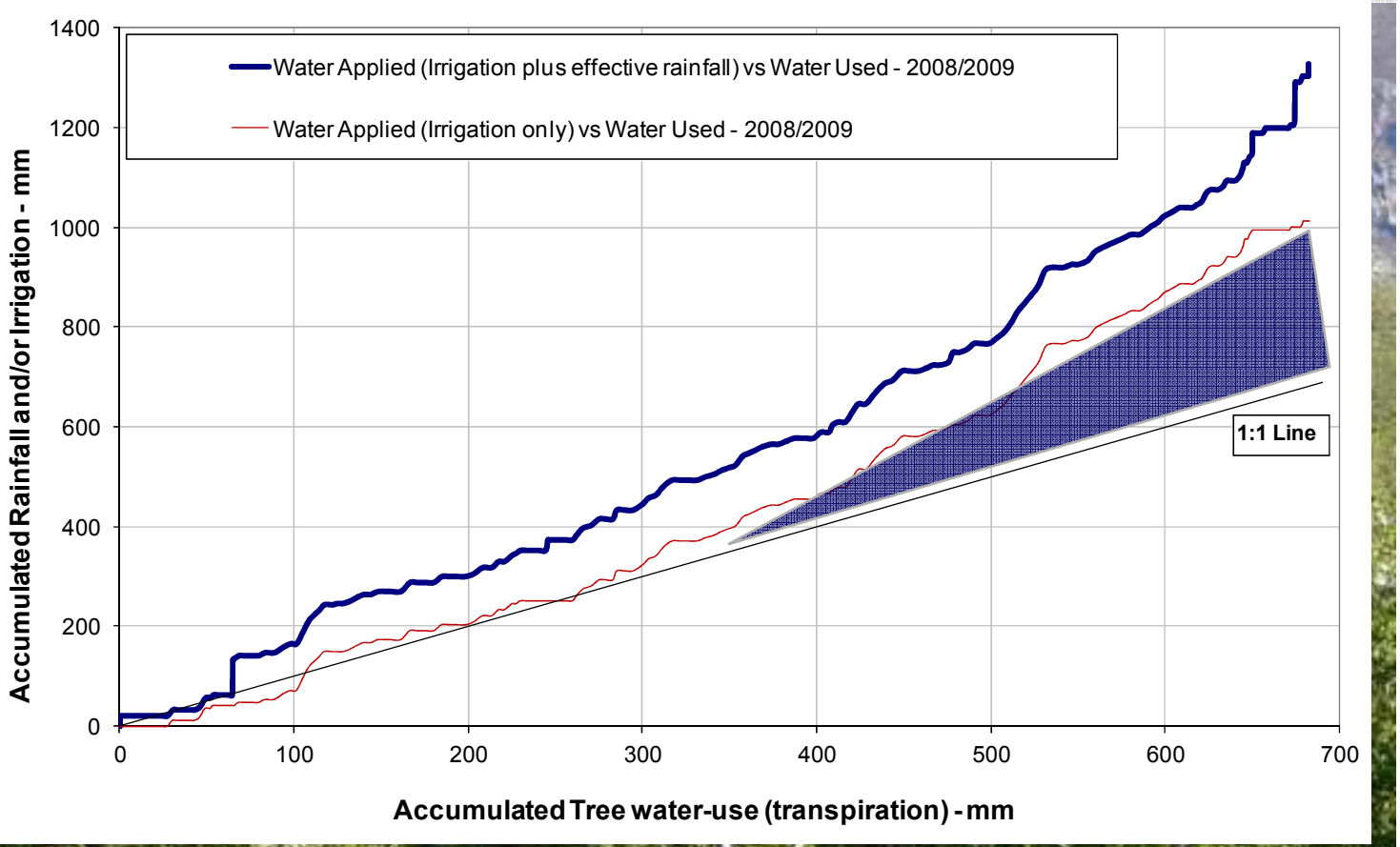
Efficiencies



- End of season leaf senescence / drop
- Potential savings in irrigation volumes



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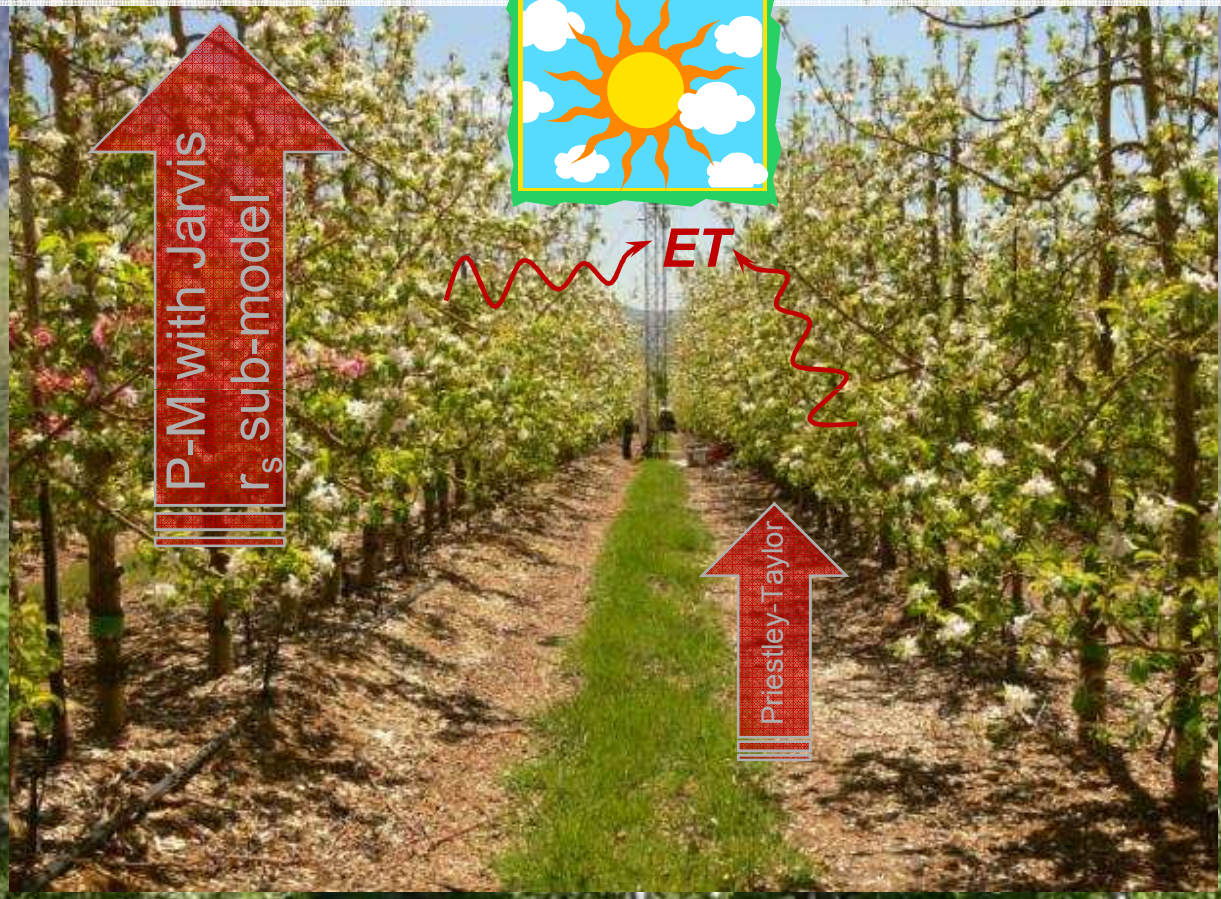
Modelling

- Use of 2-source model to simulate ET from trees & below canopy surfaces – calibrated & verified with observed data



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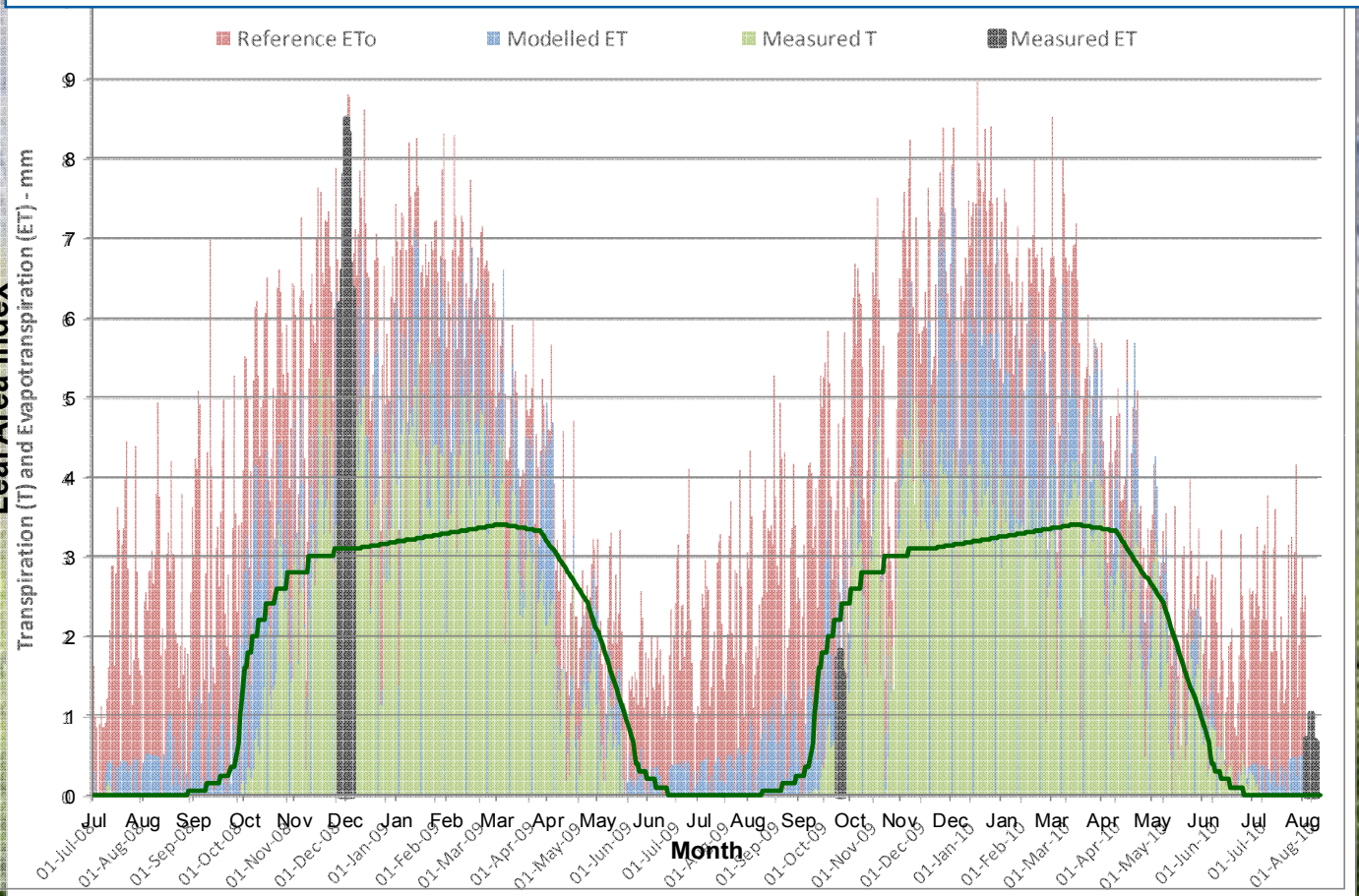
ET_o, ET & T results

Orchard Annual T = 700 mm, ET = 950 mm, ET_o = 1580 mm



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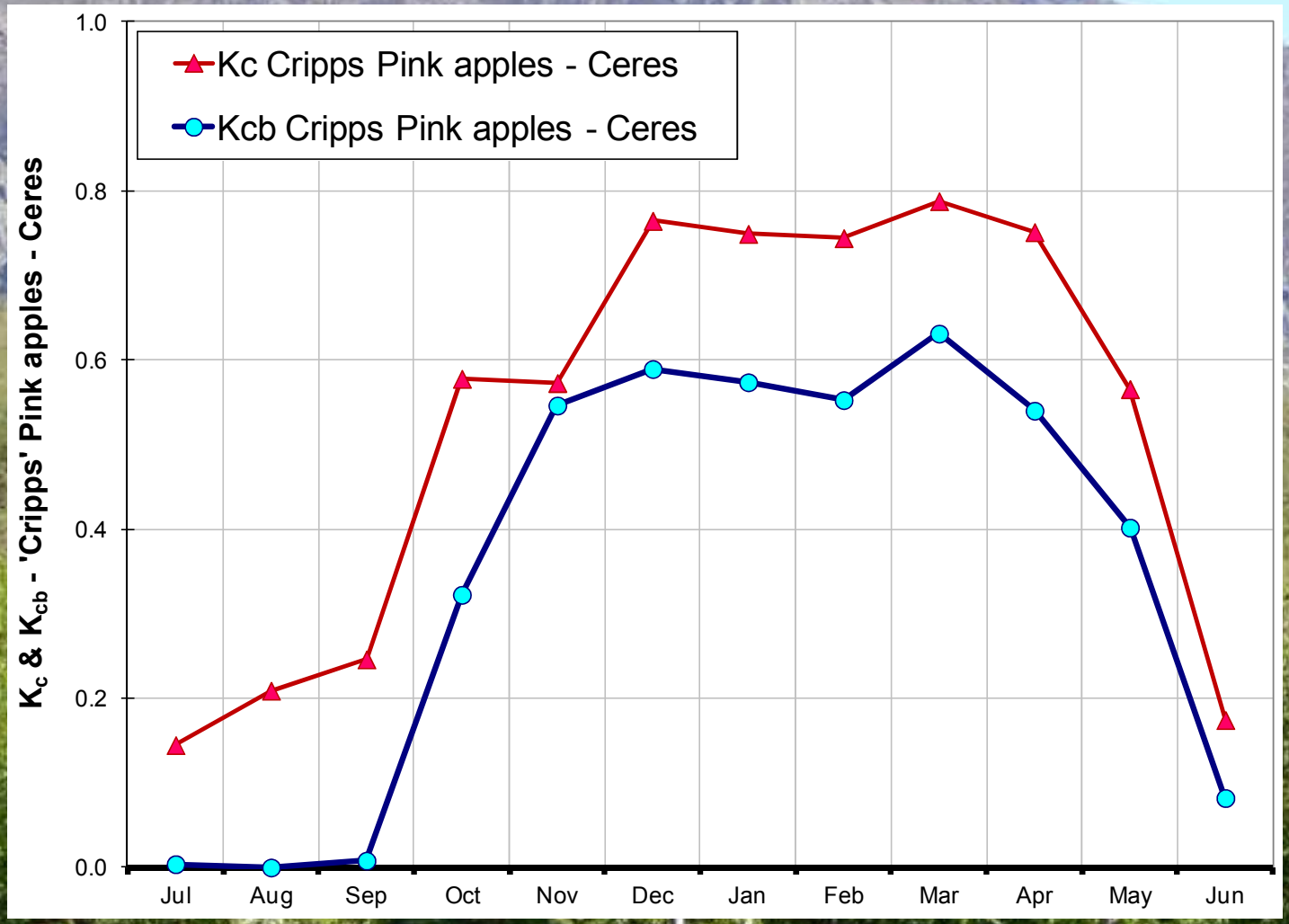
Crop coefficients



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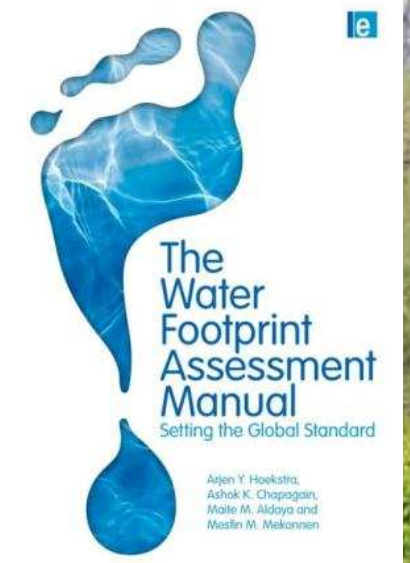
Water footprint research



Goal

- Improved understanding of water-use along the entire production chain of selected fruit tree species to assist in addressing the challenge of limited water resources by improving efficiencies and sustainability, with economic & environmental benefits.

Research Question

- Can we further develop Water Footprinting as a tool for water use assessment in South Africa, starting with the fruit tree industry-specifically apples & nectarines? What data, measurements and information is needed to accurately quantify footprints, and how can this best be used to improve water-use efficiency?

Focus

- Blue water footprint

► volume of surface or groundwater evaporated, incorporated into product or transferred to another catchment or the sea.

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Water footprint research

- Orchard Evapotranspiration (ET)
- Evaporation from storage dam
- Timber poles
- Spraying Micronutrients
- Spraying Fungicides
- Spraying Pesticides
- Spraying Herbicides
- Chemical Fruit Thinning
- Fruit Washing
- Packhouse Water-use
- Orchard Worker water use
- Packhouse worker water-use

- Water footprint assessments / certification can address the challenge of increasing water stress by rewarding companies / farms for reducing water wastage and increasing water-use efficiency, leading to product preference, with economic & environmental benefits.

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Interim results

Water-use Component	Water volume (L/tree/yr)	%	Water volume (mm/yr)
Transpiration	3414		683
Irrigation Applied	5070		1014
Rainfall	5990		1198
Orchard ET	4725	93.27%	945.0
Evaporation from storage dam	63	1.24%	12.6
Timber Poles	263	5.18%	29
Spraying Micronutrients	3.5	0.07%	0.7
Spraying Fungicides	3.0	0.06%	0.6
Spraying Pesticides	1.8	0.03%	0.4
Spraying Herbicides	1.3	0.02%	0.3
Chemical Fruit Thinning	2.0	0.04%	0.4
Fruit Washing	0.3	0.01%	0.1
Packhouse Water-use	2.7	0.05%	0.5
Orchard Worker water use	0.7	0.01%	0.1
Packhouse worker water-use	0.3	0.01%	0.1
Total	**5066**	**100.00%**	**990**

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Interim results

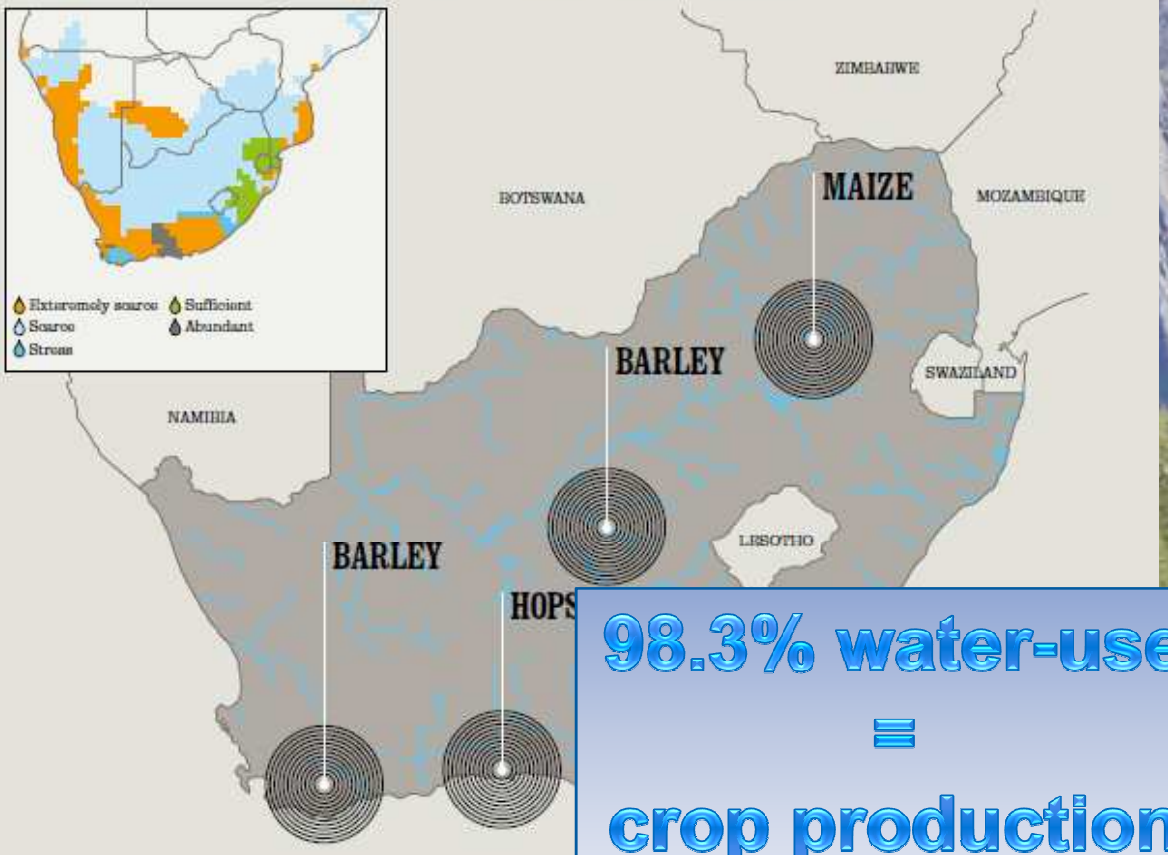
Interim Results – Water Footprint linked to Yield / Production

	Apples ('08/'09)	Apples ('09/'10)
Yield (Tons/ha)	54	69
Average Single Fruit Weight (g)	160	158
Trees per hectare	2000	2000
No. fruit per hectare	337500	436709
Fruit per tree	169	218
Total water-use per tree (L)	5066	5172
Water Footprint (L water/fruit)	**30**	**24**
Water Footprint (L water/kg fruit)	**188**	**152**

- Year-to-year variation (dependent upon water-use & yield)

SAB Miller - Water Footprint Report

FIGURE 5: CROP GROWING REGIONS ACROSS SOUTH AFRICA
INSET MAP: ANNUAL RENEWABLE WATER SUPPLY PER PERSON (PROJECTION FOR 2025)



98.3% water-use

=

crop production

FIGURE 6: WATER USAGE ACROSS THE VALUE CHAIN (DATA 2007)

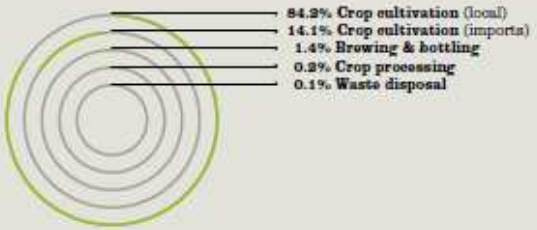
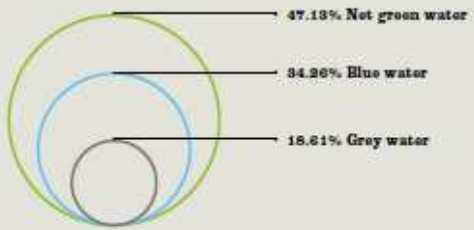


FIGURE 7: SPLIT BETWEEN NET GREEN, BLUE AND GREY WATER FOR SAB LTD (DATA 2007)



SAB LTD: CALCULATED WATER FOOTPRINT FOR ONE LITRE OF BEER

155 litres

SAB MILLER

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Conclusions

Water-use

- A 2000 spha 14 yr old 'Cripps Pink' apple orchard transpires:
  - ± 20-30 L water/day in summer (max 42 L)
  - ± 4000 L water/yr (Pollinator = ± 1100 $L.yr^{-1}$)
  - ± 4-6 mm water/day in summer
  - ± 680 mm/yr (6800 $m^3.ha^{-1}$) (Pollinator = ± 2800 $m^3.ha^{-1}.yr^{-1}$)
- However, orchard Total Evaporation = 950 mm/yr (9500 $m^3.ha^{-1}$)

Water-use efficiency

- Use refined crop factors and FAO56 approach to plan irrigation
- Potential late season irrigation savings – declining tree vigour / T
- Transpiration (mm) ≠ Irrigation (mm) due to <100% IE
- Option for pollinator-specific irrigation applications?

Water footprint

- Blue water footprint - 94% ET, 6% other. FSC-type certification?
  - Virtual water = ± 27 L water per apple (170 L/kg apples)
  - Remember water-use natural vegetation

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  - Louis Reynolds, Arno Marais (du Toit Agri)

Thank you!

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