Citrus – Washington Navel Orange

Water Use Study

Lower Chittering, Western Australia

This project is supported by Perth Region NRM, through funding from the Australian Government's Caring for our Country.

Irrigation System and Orchard Details

Citrus Park is situated in the Chittering Valley on the banks of the Brockman River. Citrus Park grows several varieties of citrus including Imperial and Hickson mandarin, Washington navels, Verna lemons, Tahitian lime and Star Ruby grapefruit. The Washington navel block is irrigated with pressure compensated in-line dripper with one dripline per row of trees. On average, each dripper delivers 3.5 L/hour and drippers are spaced at 0.5 m intervals along the line. The pressure compensated dripline operates at 180 – 205 kPa (26-30 psi) and the Distribution Uniformity (DU) of the dripline is 96%.

In the orchard, trees are spaced at 3 m intervals along the row and there is 5 m between the rows. This gives a tree density of 666 trees/hectare. The trees form a continuous hedge row which is approximately 2 m wide. This gives a canopy area of 6 m^2 (3 m tree spacing x 2 m canopy diameter). The trees are approximately 7 years old and are grafted onto Troyer Citrange rootstock.

Soil Water Properties

The soil at Citrus Park has a field texture of clay loam. From field texture analysis of the soil, the following characteristics of the soil were noted: soil forms a coherent ball, ball can be rolled into a thick cylinder and thread, thread can be formed into a horseshoe without cracking, thread can be formed into a 2.5cm diameter ring without cracking, gritty feel. The Available Water (AW) content of clay loam is approximately 150mm/m and the Readily Available Water (RAW), is approximately 55mm/m (55 L per cubic metre of soil). The wetting pattern from the dripline forms a continuous wetted strip 1.5 m wide. With a tree spacing of 3 m, a wetted area of 1.5 m, a rootzone depth of 0.4 m and RAW of 55mm/m, the amount of water that can be held in the rootzone equals 99 Litres (3 m x 1.5 m) x (0.4 m x 55mm/m).

Soil Moisture Monitoring

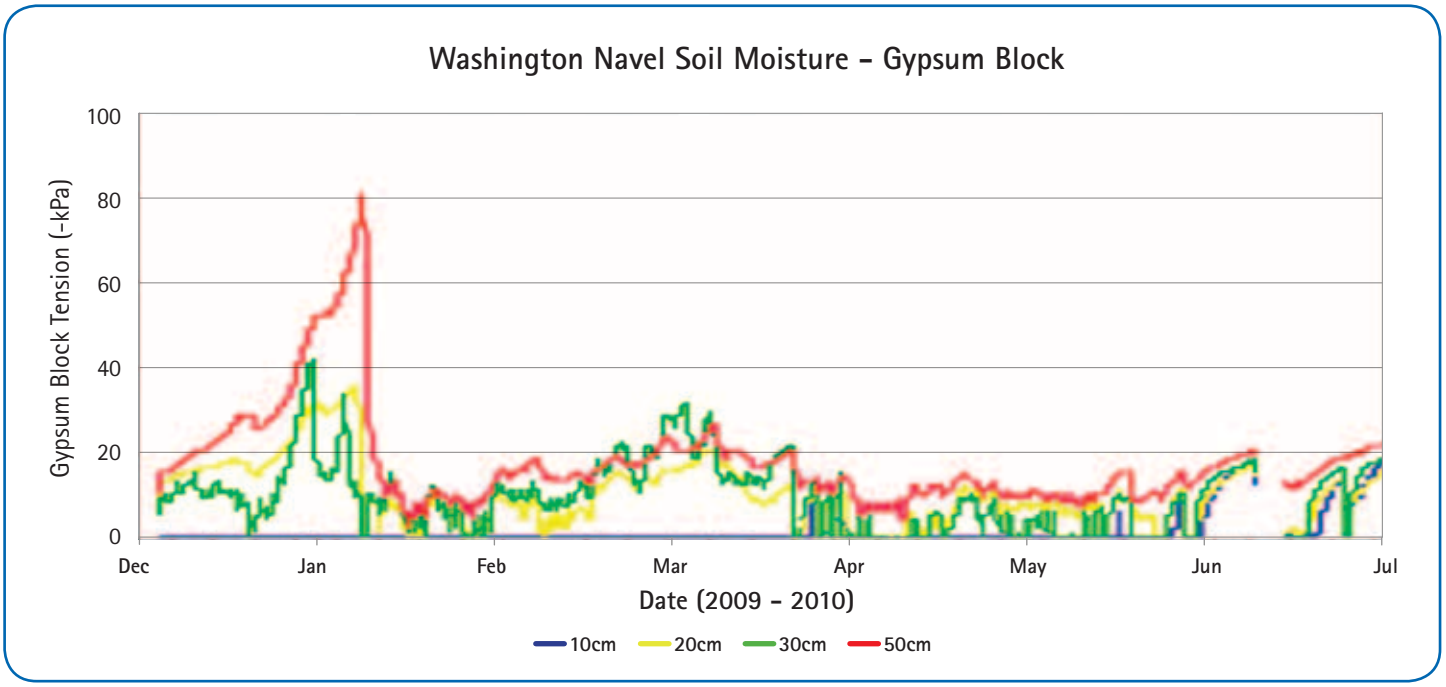
MEA GBug loggers with Watermark gypsum block soil moisture sensors have been used in the orchard since early 2009. The sensors have been installed at 10cm, 20cm, 30cm and 50cm. Gypsum block technology logs soil moisture in kPa tension, representing the suction that the plant needs to exert through the roots to obtain water. This scale is a reliable indicator of plant stress and available soil moisture in the root zone. Saturation for the clay loam is 2kPa, field capacity is 8 kPa and the refill or irrigation point is 30 kPa. The graph shows the soil moisture profile during the summer growing period. From the trends, the soil moisture at 10cm was always at saturation. Late December to early January was the only time that soil moisture decreased to approximately 40 kPa in the 20 - 50cm profile.

Water Quality – Salt

Surface and groundwater sources are used for irrigation at Citrus Park. Both sources are quality tested twice a year in February and June. Regular salinity measurements are also taken. Some results are listed in the table below.

Table 1: Salinity measurements for surface and groundwater for Citrus Park

Salinity Analyte	Ground water	Surface Water	Notes
Chloride	520mg/L	1019mg/L	300mg/L threshold for troyer rootstock
Sodium	322mg/L	536mg/L	If trees can withstand Sodium levels >458mg/L, they are considered tolerant
EC (mS/cm)	1.7 mS/cm	3.3 mS/cm	1.6-4.8mS/cm = brackish
Total Dissolved Salts	935mg/L	1815mg/L	500-1000mg/L = medium salinity risk
Sodium Adsorption Ratio	7.7	12.1	<10 = safe to irrigate with no soil structure deterioration 10-18 = hazard on fine textures soils with high cation exchange capacity



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Depending on the availability and quantity of irrigation water reserves, Citrus Park uses predominantly groundwater until February then a combination of groundwater and surface water is used to irrigate the citrus trees up until harvest.

Irrigation Schedule

Bud Formation and Flower Initiation (July–August)

Depending on seasonal conditions and market pressures, picking of previous years fruit occurs during July and August. Regular effective rainfall events were recorded during July and August with a total of 285mm of rainfall collected. In the two months, 30 rain days were recorded. No irrigations were scheduled during July and August.

Flowering and Fruit Set (September–October)

Irrigations commenced in late September. Two rain days were recorded in September with more than 10mm of rainfall. 119mm of rainfall was recorded in the month of September and 15.6mm of rain was recorded in October which is well below the mean of 52mm. With a crop factor of 0.7, the crop water demand was 90mm in September and 130mm in October. 10.5L/tree/day was applied in September and 21L/tree/day was applied in October.

Fruit Growth – Cell Division (November– December)

During this period the fruit size grows to approximately 36mm in diameter. Daily evaporation averages 7.3mm/day in November and 9.3mm/day in December with spikes up to 13mm/day. Rainfall in November supplied 32.4mm of which only 2 rainfall events were effective. 0.2mm of rain was recorded in December. Most of the crop water requirement for November-December was supplied via irrigation. 31.5 L/tree/day was applied to the trees during this period. In December, soil moisture at 10cm remained saturated while 20-30cm ranged from 5 - 40kPa. Soil moisture at 50cm peaked at 50 kPa during December.

Fruit developing in February 60-73mm diameter

Fruit Growth – Cell Expansion (January–April)

January: No rainfall was recorded in January. Daily maximum temperatures fluctuated from 26^{0}C to 44^{0}C. Daily evaporation averaged 9.7mm/day and the crop water requirement equalled 7.0mm/day. 7.0mm crop water requirement equalled 41 L/tree/day that needed to be applied through the dripline. The same schedule as December was used and 31.5 L/tree/day was applied in the orchard. With high crop water use and lower than expected irrigation amounts, soil moisture at 20-30cm deep remained around 30 kPa while the 50cm depth increased to 80 kPa in early January. From mid January, soil moisture stabilised at all depths at approximately 10 kPa.

February: Hot and dry conditions were recorded in February (taken from Pearse RAAF Base Bureau of Meteorology Weather Station) with no rainfall observed. Average daily evaporation was 9mm with average daily maximum temperatures of 35^{0}C. Crop water requirement was 6.1mm/day which equalled 36 L/tree/day. 31.5 L/tree/day was again scheduled during February. 882 litres were applied to each tree during the month of February. The 10cm soil moisture probe remained saturated, while 20, 30 and 60cm depths remained between 2 kPa and 30 kPa.

March: Total rainfall in March equalled 25mm which was slightly above the average of 19mm but this 25mm fell in 1 day and no other significant rainfall was recorded. The crop water requirement for the 6 m^2 canopy area was 4.7mm/day or equivalent to 28 L/tree/day. 1.5 hours of irrigation was scheduled each day, equal to 31.5 L/tree/day. Twenty seven irrigation days were scheduled in March which totalled 850 L/tree. Up to the 22nd March, soil moisture at 10cm remained at saturation (1kPa) but levels at 20 and 30cm ranged from 9 to 20 kPa. After the 25mm rainfall event on the 22nd March, no irrigations were scheduled for the next 4 days.

April: Evaporation in April averaged 5.1mm/day. The citrus crop factor remains at 0.7 and irrigation must continue to replace 70% of the evaporative losses from the tree. Crop water requirement equalled 106mm and 13mm of rainfall was recorded but was not effective so all of the crop water requirement must be delivered through irrigation. Irrigations were scheduled for one hour duration (21 L/tree/day) which equalled the daily irrigation requirement.

Fruit Maturation (May–June)

Mild weather conditions were recorded in May and June with average maximum temperatures of 19-22^{0}C and average soil temperatures of between 14-17^{0}C. 66mm of rainfall was recorded in May and 35mm recorded in June. Total rainfall for May and June was below the average of 103mm and 155mm. Fruit size now averages 80mm and is approaching harvest size. From the 66mm of rainfall recorded in May and corresponding soil moisture levels, no irrigations were scheduled in May. Soil moisture at 10 to 50cm fluctuated between 1 - 17kPa. Even through only 35mm of rainfall was recorded in June, no irrigations were scheduled as soil moisture did not go above 20 kPa at 30cm deep. If there was no rainfall in May and June, 9 L/tree/day and 8 L/tree/day would have been required via irrigation in the two months. Fruit size at harvest ranged from 70mm to 95mm.

Note: Due to the high salinity concentration of the irrigation water, the soil moisture content must remain close to field capacity to reduce salt accumulation in the rootzone. The irrigation schedule adopted was successful at maintaining soil moisture at field capacity but the amount of water lost due to deep drainage is unknown.

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Water Use Results

Table 2: Summary of water use results for Citrus Park

Average Evaporation (mm)	Rainfall (mm)	50% Effective Rainfall (mm)	Irrigation Requirement (mm) minus effective rainfall	Irrigation Requirement (Litres/tree)		Irrigation Requirement (kL/ha)	
2125	592	0.5 x 592 = 296	1487mm – 296mm = 1191	Calculated	Actual	Calculated	Actual
				1191mm x 6 m^2 = 7146	1037mm x 6 m^2 = 6226	7146L x 666 trees/ha ÷ 1000 = 4759 (or 4.759 ML/ha)	6226L x 666 trees/ha ÷ 1000 = 4146 (or 4.146 ML/ha)

The annual crop water requirement for the Washington navels was 7146 L/tree or 4759 (kilolitres) kL/ha. The actual (in field) irrigation amount applied was 6226 L/tree equal to 4146 kL/ha or 4.146 megalitres/ha (ML). No irrigations were scheduled during July and August and May and June. These calculations were based on an average canopy size of 6 m^2 and an average dripper output of 21 L/tree/hour.

Water Use Efficiency (WUE) Results

For this water use study, WUE is a comparison between the volume of irrigation water applied (ML) and total weight of crop production (tonnes). It is often difficult to increase water use efficiency with water quality and quantity restrictions and variable climatic conditions.

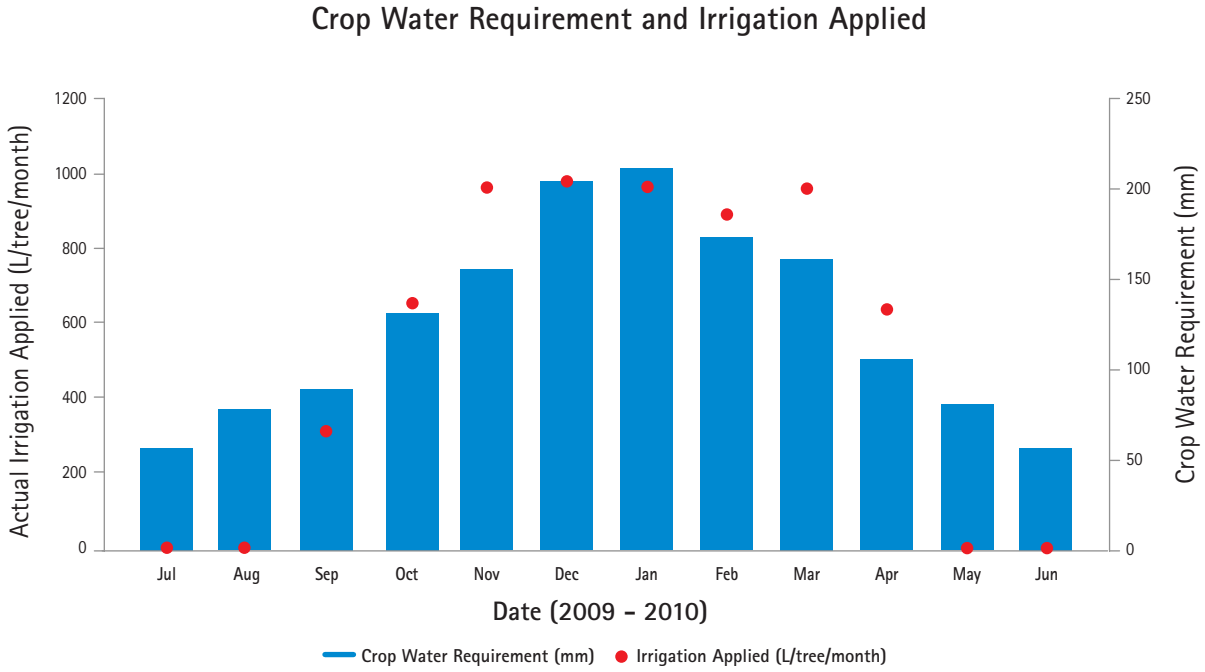
From harvest records and irrigation application over the growing season, the Irrigation Water Use Efficiency was 6.653 t/ML. Production of packed or marketable fruit per ML was not able to be calculated but if this data is available, it can also be used as an indicator of irrigation WUE.

Recording tonnes of fruit per hectare is very useful to know, but with limited water resources and associated water quality issues such as salinity, t/ML is a more important comparison for future irrigation benchmarking at Citrus Park.

Irrigation Tips

- Increasing or decreasing canopy size will have an effect on crop water requirement. If water resources are limited then consider a reduction in canopy size.
- If new irrigation blocks or upgrades are planned, wetting patterns should be maximised by selecting a dripline that has closely spaced drip intervals. In loamy to clay soils, wetting patterns should form a continuous wetted strip with dripper spacing of 0.5-0.7 m. In sandy soils, smaller dripper spacing's of 0.3 m or less may be required to form a continuous wetted strip.

  Note – check maximum run lengths and dripline pressure loss charts or have the system designed by a Certified Irrigation Designer if planning new irrigation blocks.
- Irrigation with slightly elevated chloride and sodium levels is possible with drip irrigation. By scheduling irrigations to keep the root zone moist and within field capacity, the effects of salinity can be reduced and salt concentrations in the root zone can be maintained to the level of the irrigation water. If the soil is allowed to dry, root zone salinity can increase and can reduce the trees ability to extract water from the soil.

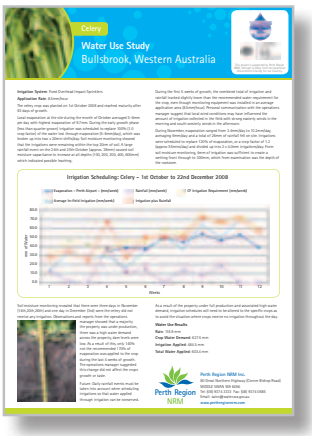


The complete set of Water Use Studies available at www.perthregionnrm.com

Strawberry Neerabup, WA

Cauliflower Bullsbrook, WA

Celery Bullsbrook, WA



Apple Karragullen, WA

Nectarine, Karragullen, WA

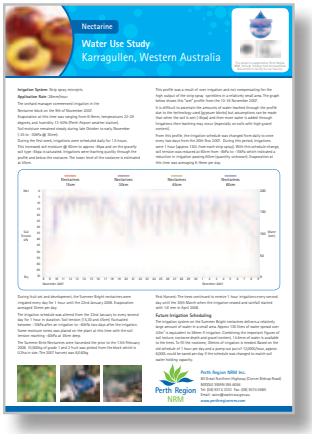
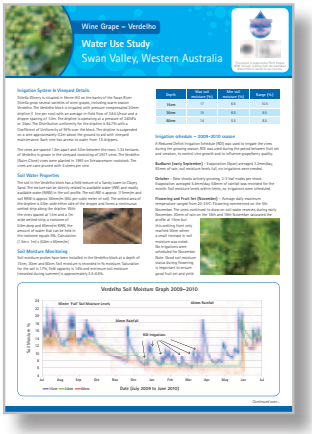


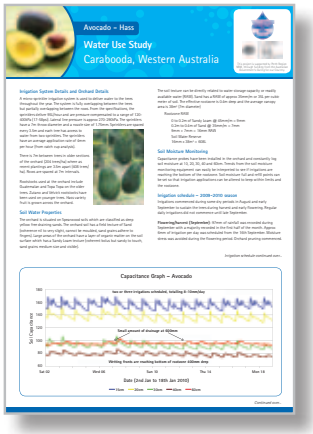
Table Grape West Swan, WA

Cabbage Carabooda, WA

Wine Grape – Verdelho Swan Valley, WA



Avocado Carabooda, WA



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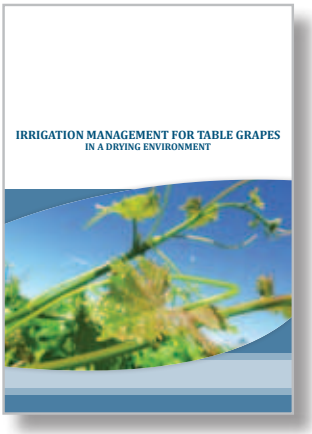
Irrigation Management for Table Grapes



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