PO Box 3114 Bundeena NSW 2230 Australia
Phone +61 2 9527 0826
Fax +61 2 9544 3782
www.ahr.com.au
ABN: 94 073 642 510

AHR Confidential Report

Summary of Key Results from Drip v's CRZI research on Grapes.

AHR *CropScience*
"Applied Horticultural Research"
PO Box 3114
Bundeena NSW 2230 Australia
phone +61 2 9527 0826
fax +61 2 9544 3782

Field Work:

Sigfredo Fuentes (B. Ag Sc.)
Stuart Little (Bsc. Hons. 1.)
Dr Georgina Kelly (PhD)

Report:

Sigfredo Fuentes (B. Ag Sc.)
Dr Gordon Rogers (PhD)

Authorised:

Dr. Gordon Rogers (B. App. Sc., PhD)

Introduction

The CRZI sub surface irrigation system uses trickle irrigation tube covered with geotextile layer to improve capillarity movement of water and reduce tunnelling. It also has a plastic film running along the drip-line in the surface and underneath to reduce percolation.

The plastic film underneath the drip-line produces a clear ascending capillarity movement of water from the beginning of the irrigation. The effect of the geotextile is to enhance the movement of water along the drip-line thereby wetting a larger volume of soil than drip irrigation.

Methods

The 3 year experiment was established in August 2001 at the Horticulture Field Research Site at the University of Western Sydney, Hawkesbury campus, Richmond NSW. Grapevines (cv. Shiraz on Ramsey rootstocks) were planted in 1999 in rows 3.0 m apart, using a vertical shoot positioning (VSP) trellising system. Soils were Red Kandosol with a B horizon extending to at least 1.5m depth.

Each treatment consisted of nine vines in three trellis panels and there were 8 replicate plots of each treatment. To avoid any effects from neighbouring treatments, only the three vines in the centre panel of each treatment were used for physiological measurements.

Irrigation

Vines were irrigated by either surface drip emitters or subsurface irrigation (CRZI, Irrigation and Water Technologies, Sydney). 2 L/h surface drip emitters were placed every 1.0 m (essentially one emitter either side of the vine, approximately 0.5 m from the stem). Subsurface irrigation was buried at a depth of 0.3 m, parallel to the vine rows and 0.4 m from the stems. Emitters were spaced every 0.5 m and emitted water at a rate of 1.1 L/h.

Irrigation events were scheduled three times per week for 2 hours in the control treatment, and 2.2 hours in the subsurface treatment, so that both treatments received the same volume of water.

Fertiliser was added to the vines via the irrigation water (fertigation) 3 times during the season as potassium nitrate on November 27 and 8 December, and ammonium nitrate on 19 December.

Leaf Water Potential

One youngest fully expanded leaf per plot was sampled for leaf water potential on the same days that gas exchange measurements took place. Measurements were made using a standard Scholander pressure chamber (ref?) at four times during the day: pre-dawn, 1000, 1300 and 1530h.

Plant Nutrient Status

During the post-verasion measurement period, one youngest fully expanded leaf from each treatment plot was sampled for nutrient analysis. Samples were dried at 65°C for 5 days and ground to pass a 1mm sieve. Analysis was carried out by Waite Analytical Services by complete combustion gas chromatography for nitrogen.

Harvest and Grape Quality

Fruit was harvested in February 2002, 2003 and 2004. Bunches were removed from the three vines in the centre panel of each treatment plot and counted. A random sample of 30 bunches from each plot were individually weighed, and total yield from each plot was also recorded.

Standard wine grape quality criteria (Brix, pH, titratable acidity, phenolics and anthocyanin) were measured using standard spectrophotometric techniques, refractometer and pH meter.

Key Results

The key outcomes from the project can be divided into 5 main areas: These are:

1. Soil wetting pattern analysis.
2. Grapevine growth, yield and quality responses to PRD v's normal irrigation and subsurface
3. Extent of the root system from Drip and CRZI irrigated grape vines
4. The effectiveness of PRD as an irrigation strategy. CRZI v's drip irrigation.
5. The effects on berry Pathogenesis–Related (PR) protein expression and amino acids.

1. Soil Wetting Pattern Analysis

A technique has been developed which allows false-colour images to be produced dynamically from soil moisture data collected from soil capacitance probes. The probes were arranged in a grid pattern with sensors at 4 soil depths, and between 3 and 8 probes (12-32 sensors) per emitter.

The soil wetting patterns can be used to calculate the volume of wetted soil. Five hours of drip irrigation wetted 700L of soil per dripper. The same length if irrigation using CRZI wetted 980 L of soil per dipper, a 40% increase in the volume of soil wetting for the same volume of water applied.

This is a significant increase in soil wetted volume, since application of water in this case was at a rate of 1.1 L h^{-1} for CRZI compared to 2 L h^{-1} of surface drip. This means that with almost half of the water applied the volume of wetted soil for sub-surface irrigation was 1.4 times bigger than surface drip irrigation.

CRZI had four drippers per vine (separated every 0.5 m) and for surface drip there were 2 drippers per vine. Therefore total water applied to a single grapevine for a five-hour irrigation was 20 L per vine for drip irrigation and 22 L per vine for sub-surface irrigation.

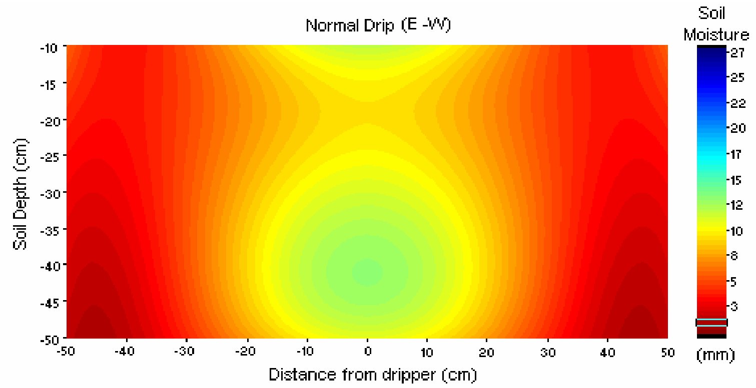
CRZI offers another advantage compared to surface irrigation, as demonstrated using WPA© visualisations. CRZI can leave a dry layer on the soil surface approximately 5 cm deep. This dry soil layer has two advantages of drip irrigation:

1. The dry soil layer reduces water evaporation from deeper in the soil profile, and
2. Dry surface soil can be used to control weed growth under vines.

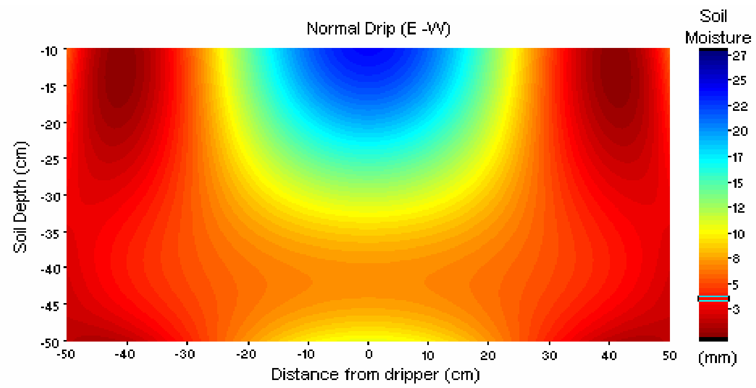
Irrigation type	Volume of water per emitter (L/h)	Volume of soil wet per emitter (L/irrigation	No. of emitters per vine	Volume of water applied per vine (L/ irrigation)	Volume of soil wet per vine (L/irrigation)
CRZI	1.1	980	4	22	3920
Drip	2.0	700	2	20	1400

Drip irrigation wetting patterns

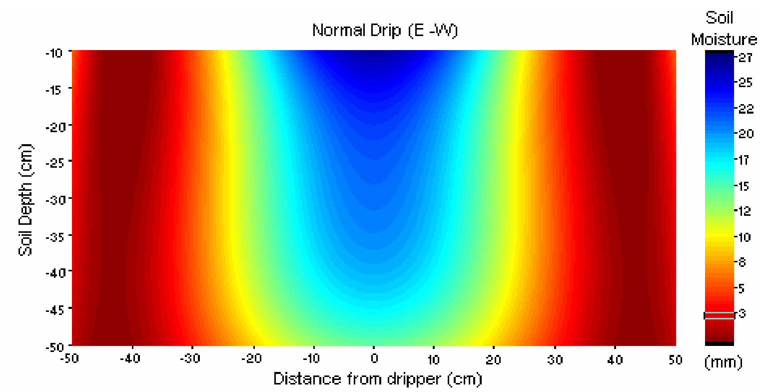
Start of irrigation



2.5 hours of irrigation

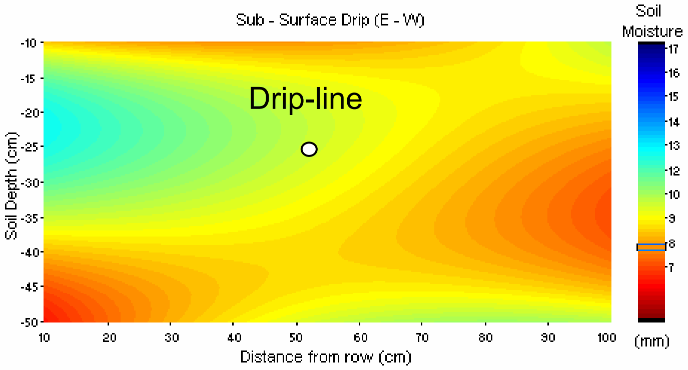


5 hours of irrigation

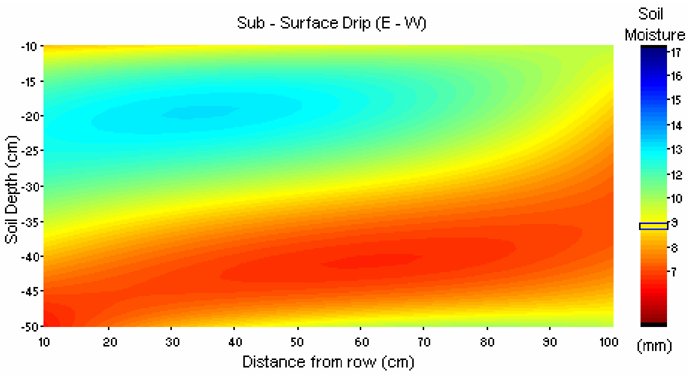


CRZI – subsurface irrigation wetting patterns

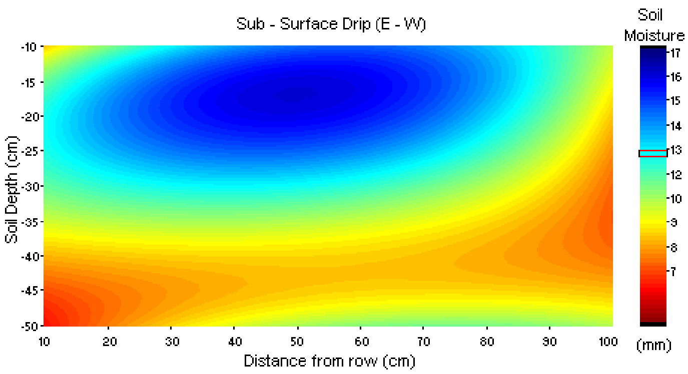
Start of irrigation



2.5 hours of irrigation



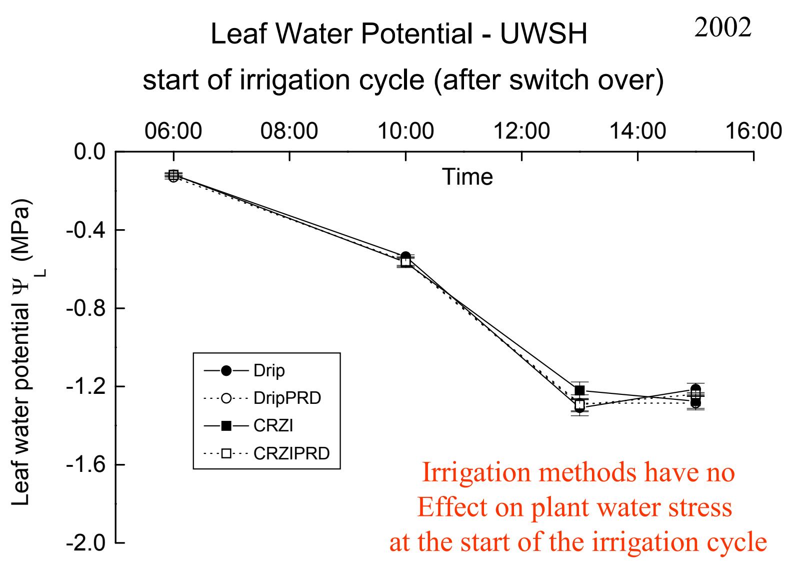
5 hours of irrigation

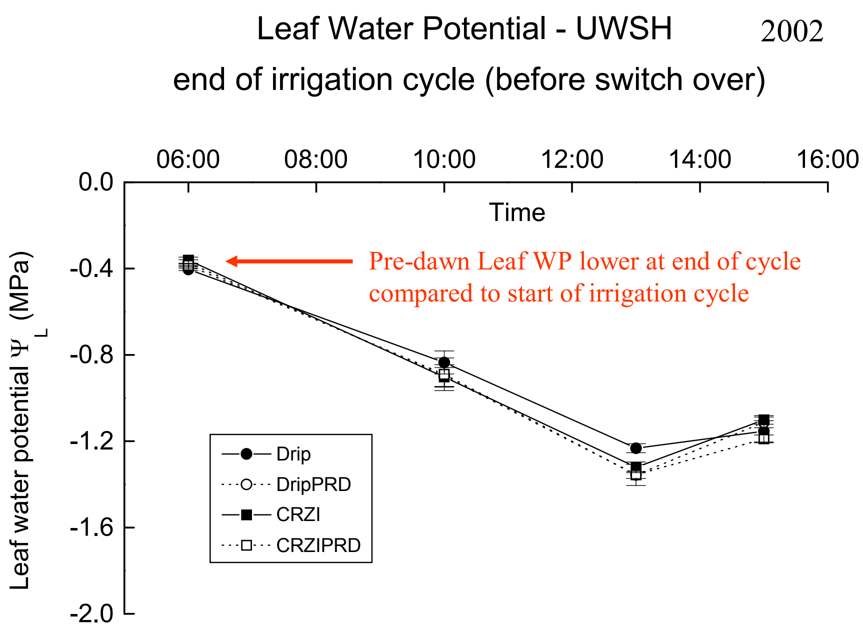


Both CRZI and Drip Irrigation irrigating plants effectively

The figures below show plant water stress status at the start and end of an irrigation cycle for Drip and CRZI, PRD and non-PRD.

They show normal reduction in plant water potential over the day at the start and end of the irrigation cycle with no difference between treatments. This means that the four irrigation strategies are maintaining the plants at he same level of water stress.





2. Grapevine Responses to PRD Versus Normal Irrigation and Subsurface Versus Drip Irrigation

Growth and yield

In the first year of trials (2001-02), PRD reduced shoot length when applied by either drip or subsurface irrigation. In early growth after budburst, shoot growth was unaffected by irrigation treatments. Around 30 days after budburst (flowering), shoot growth rate began to slow and treatments effects were evident. By the end of the shoot growth period, both PRD and subsurface reduced shoot growth, with the greatest reduction in shoot growth occurred when PRD was applied using subsurface. Grape yields were reduced by PRD and by subsurface due to reductions in both berry size and weight, rather than bunch number.

During the 2002-03 season, shoot length was again reduced by PRD and subsurface treatments, however there was no difference in yield between the treatments. Bunch weight was slightly reduced ($P < 0.05$) in the subsurface treatments, with average bunch weight being 94 g in the two subsurface treatments, compared with 108 g for the Control Drip treatment.

Surface drip

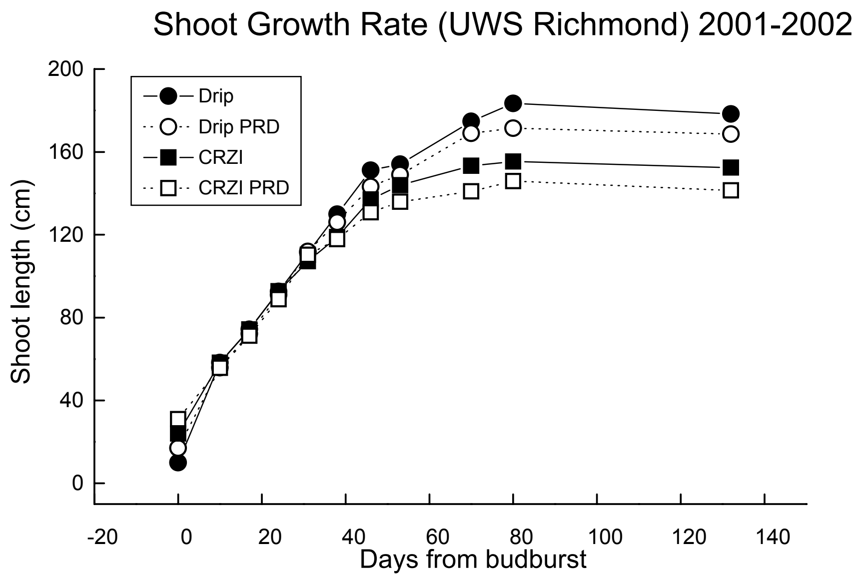
An average of 6 days elapsed between the end of an irrigation and the soil drying down to the refill point on sandy loam soils at Richmond in summer. The water moved rapidly into the soil profile and an increase in stem water potential (SWP) occurred within one hour of starting the irrigation. Maximum SWP (-0.6 MPa) was reached within 4 hours of starting irrigation.

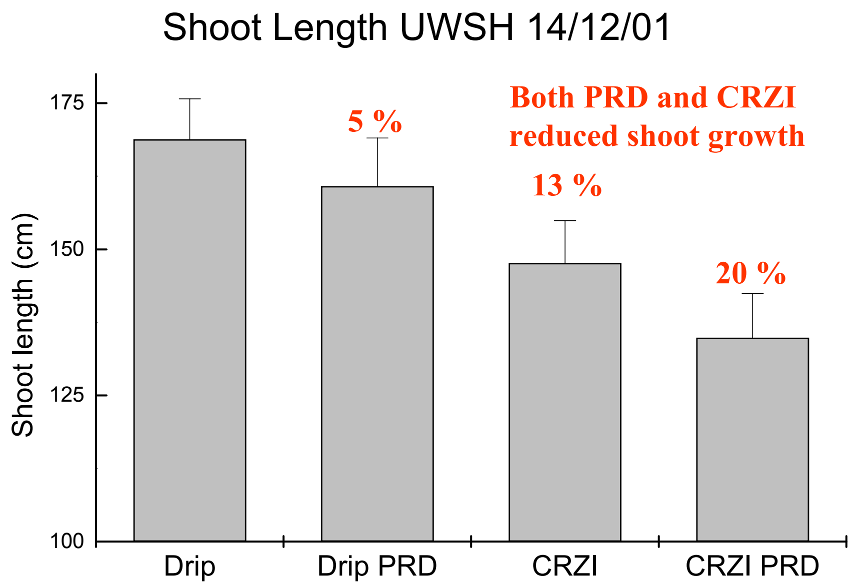
Sub-surface drip

After irrigating mature vines to field capacity, it took 15 days for the soil to dry down to the refill point. On re-wetting, vine SWP took 3 hours to respond, but within 4 hours SWP had increased to the maximum value of (-0.57 MPa).

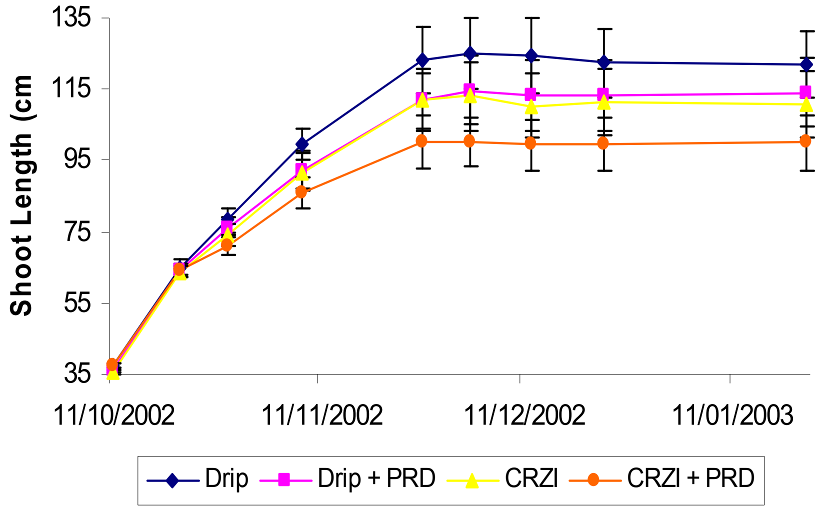
The shape of the soil wetting pattern formed an elongated strip of soil about 80cm wide and 30cm deep along the length of the buried irrigation line and the soil surface remained dry. The total soil wetted volume per vine was similar for both drip and sub-surface irrigated vines, however percolation losses were greater for drip than subsurface irrigation.

Effects on vegetative growth

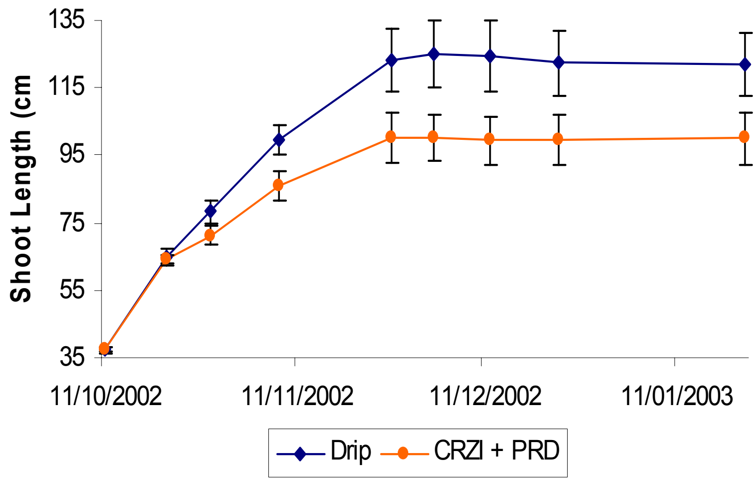




Effect

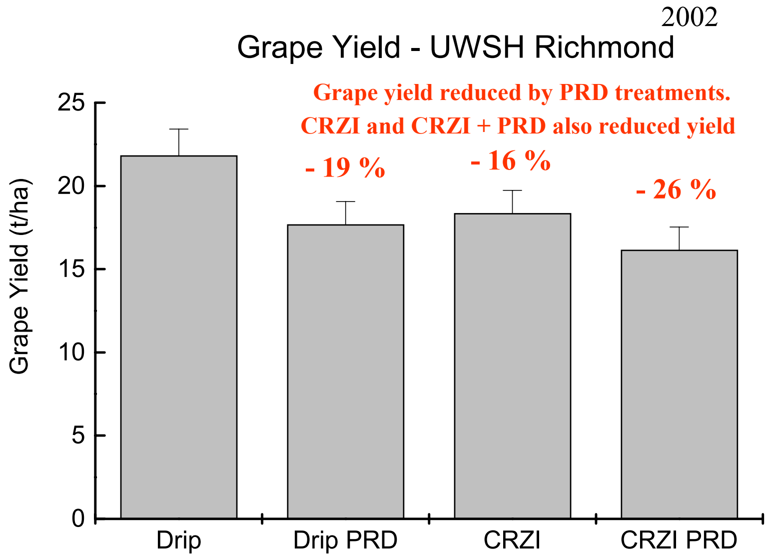


Shoot Length (cm
135
115
95
75
55
35
11/10/2002
11/11/2002
11/12/2002
11/01/2003
Drip
Drip + PRD
CRZI
CRZI + PRD



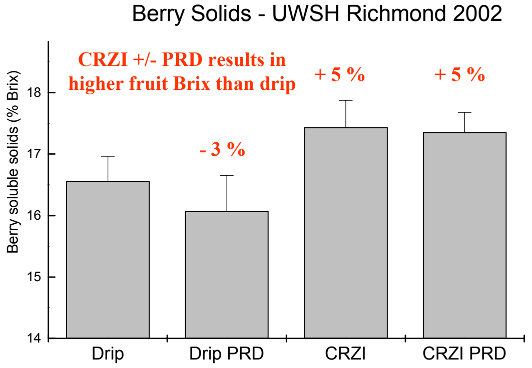
Shoot Length (cm
135
115
95
75
55
35
11/10/2002
11/11/2002
11/12/2002
11/01/2003
Drip
CRZI + PRD

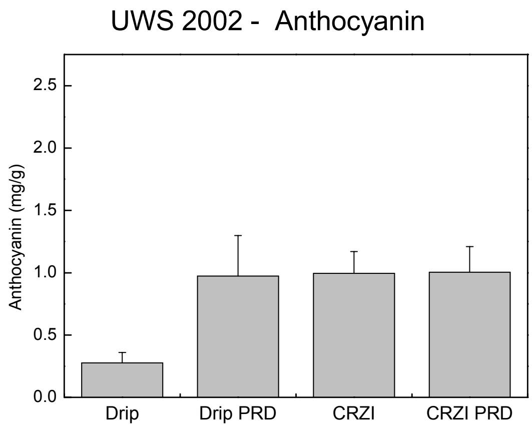
Yield

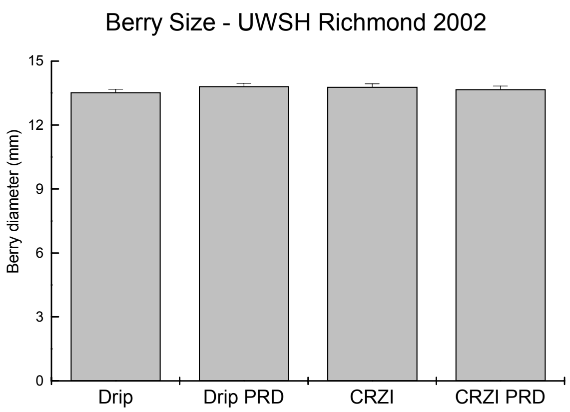


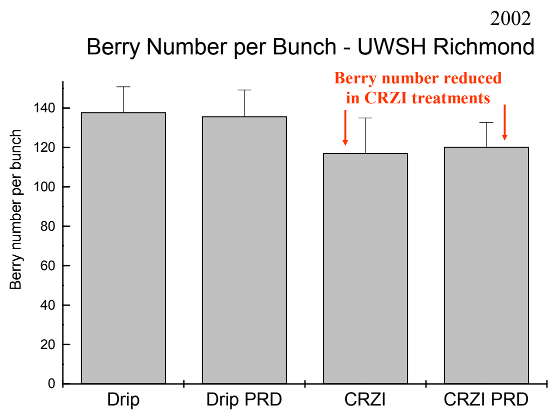
2002
Grape Yield - UWSH Richmond
Grape yield reduced by PRD treatments.
CRZI and CRZI + PRD also reduced yield
- 19 %
- 16 %
- 26 %
Grape Yield (t/ha)
25
20
15
10
5
0
Drip
Drip PRD
CRZI
CRZI PRD

Grape quality









3. Extent of the root system from Drip and CRZI irrigated grape vines

CRZI Root Pattern

Drip Root Pattern

CRZI Root Pattern Detail

Roots in geotextile but not penetrating irrigations tape area.

Irrigation Tape Emitters clear of soil and roots after 3.5 years.

4. The Effectiveness of PRD as an Irrigation Strategy.

We were able to measure a reduction in shoot growth due to PRD, but not the reduction in stomatal conductance we were expecting. At the Richmond site, PRD caused a reduction in transpiration, measured by heat-pulse sap flow sensors. This reduction in transpiration did not occur at the Benalla site where PRD had no effect on either transpiration or yield. Our conclusion was that PRD was not an effective strategy for increasing irrigation water use efficiency; however deficit irrigation was a useful tool for improving berry quality and controlling vine growth.

5. The Effects of irrigation type on Berry PR Proteins and Amino Acids

Neither irrigation type or PRD affected levels of the PR-protein CHV5 (Chitinase). Subsurface irrigation however, resulted in an increase in ammonium in the berries compared with drip irrigation. The higher ammonium-nitrogen in subsurface irrigation berries was due to higher amino acid concentrations, principally arginine and proline.

The project produced novel information on 3-D, real time wetting patterns in soils using different irrigation treatments. Importantly, we showed that there was no effect of the PRD on leaf stomatal conductance as was originally expected. Our results have recently been confirmed by others (Irrigation Symposium). However, sap flow data showed a PRD effect on whole-plant transpiration at one site (Richmond), but not the other (Benalla). The use of thermal imaging to measure plant water status looks promising.

These results suggested that CRZI-irrigated plants might take up more nutrients from the soil because the root stem was more extensive under CRZI compared to drip irrigation. Leaf samples were analysed for mineral nutrients but there were no significant differences between CRZI and drip irrigated vines.