

Irrigation at Squire Estate

(Year 3)

**M. Greven, S. Neal, B. West, M. Roberts, S. Green, B. Clothier,
P. Davidson**

January, 2005

Interim Report to New Zealand Wine Growers

**HortResearch Client Report No. 16752
HortResearch Contract No. 20060**

HortResearch Corporate Office
120 Mt Albert Rd, Private Bag 92169
Mt Albert, AUCKLAND, New Zealand
Tel: +64-9-815 4200
Fax: +64-9-815 4201

M. Greven, S. Neal, B. West, M. Roberts
HortResearch Marlborough
Marlborough Wine Research Centre,
85 Budge Street, P.O. Box 845
Blenheim, New Zealand
Tel: +64-3-577 2370
Fax: +64-3-578 0153

S. Green, B. Clothier
HortResearch Palmerston North
Batchelar Research Centre
Private Bag 11030
Palmerston North, New Zealand
Tel: +64-6-356 8080
Fax: +64-6-354 0075

P. Davidson
Marlborough District Council
P.O. Box 443
Blenheim, New Zealand
Tel: +64-3-578 5249
Fax: +64-3-578 6866

DISCLAIMER

HortResearch does not give any prediction, warranty or assurance in relation to the accuracy of or fitness for any particular use or application of, any information or scientific or other result contained in this report. Neither HortResearch nor any of its employees shall be liable for any cost (including legal costs), claim, liability, loss, damage, injury or the like, which may be suffered or incurred as a direct or indirect result of the reliance by any person on any information contained in this report.

This report has been prepared by The Horticulture and Food Research Institute of New Zealand Ltd (HortResearch), which has its Head Office at 120 Mt Albert Rd, Mt Albert, AUCKLAND. The report has been approved by:

Research Scientist

Group Leader, Quality Systems

Date: _____

Date: _____

CONTENTS

	Page
EXECUTIVE SUMMARY	1
INTRODUCTION	2
METHODOLOGY	3
RESULTS AND DISCUSSION.....	5
Climate.....	5
Irrigation	5
Yield and fruit quality.....	11
CONCLUSIONS	16
ACKNOWLEDGEMENTS.....	16
REFERENCES	17

EXECUTIVE SUMMARY

Irrigation at Squire Estate (Year 3)

Interim Report to New Zealand Wine Growers

M. Greven, S. Neal, B. West, M. Roberts, S. Green, B. Clothier, P. Davidson
January 2005

This report presents the results from the 2003-2004 season, the third season of a Regulated Deficit Irrigation (RDI) trial in Marlborough on a 10 year old Sauvignon blanc vineyard. This season, Partial Rootzone Drying (PRD) has been added as a treatment to the research.

In 2003/04 the treatments evaluated were irrigated at 20% (IR-20), 40% (IR-40), 60% (IR-60), 80% (IR-80), 100% (IR-100, control), and partial root zone drying at 60% (PRD-60), 80% (PRD-80).

The main findings were:

- During the whole season, all vines received approximately 730 L water from rainfall. Rainfall this season was particularly high in the latter part of the season.
- December, January and early February were fairly dry. Only during this part of the season, was irrigation applied. Control vines (IR-100) received 570 L of water from irrigation, compared to IR-80, which received 460 L while IR-60 and PRD-60 received 340 L, IR-40 received 360 L and IR-20 only 275 L of irrigation water.
- Yield and vegetative growth was similar under all irrigation treatments including Partial Rootzone Drying.
- Both 60% irrigation methods (IR-60 and PRD-60), almost doubled the water use efficiency (kg fruit per litre of water) of Sauvignon blanc grapes despite not applying irrigation applications after 20 February because of sufficient rainfall.
- The Partial Rootzone Drying treatment showed delayed maturity and resulted in significantly lower soluble sugars at harvest compared to all other treatments, including IR-60 which received the same amount of irrigation.
- A good relationship was found between Point Quadrat measurements and the more labour intensive canopy measurements of fortnightly measuring shoot length, leaf number and leaf area.
- In 2003/04 bigger differences were found between PRD-60 and the other irrigation methods as compared to the 2003/04 season when PRD-80 was used. However, more work is needed, under drier conditions, to determine the full potential of PRD in New Zealand.
- Good relationships were found between transpiration measured by stem sap flow and both leaf area and ET_{crop} calculated from $ET_o \times$ crop light interception. This enables us to use canopy measurements as a reliable method to estimate vine water use.
- A workable irrigation model has been produced from the data that have been gathered over the last three years. This model will need further testing in the coming season.

For further information contact:

Marc Greven
HortResearch
P O Box 845, Blenheim
Tel:
E-mail mgreven@hortresearch.co.nz

INTRODUCTION

When discussing the need for irrigation in Marlborough many overseas people question the need for irrigation as Marlborough with 650 mm annual rainfall is not considered very dry. While Marlborough may not be very dry on average, rain distribution over one season and between seasons is very irregular. There are often periods with very little rain and other times with an abundance of it. This irregular rainfall combined with a high evapotranspiration rate over summer which can be as high as 8 mm in a day and very free draining soils, results in regular periods of water stress at certain times of the year. This means that irrigation has to be in place in most areas in Marlborough but irrigation is not needed continuously during the season or even every season.

From 2002, in addition to Regulated Deficit Irrigation (RDI), Partial Rootzone Drying (PRD) has been incorporated into this research. Although PRD is not widely used in New Zealand it has achieved some success in Australia (Loveys, 2000; Loveys *et al.*, 1998). PRD is likely to be less successful in New Zealand where irrigation is used to complement rainfall rather than being the sole source of soil moisture. However, because of the 50% reduction in irrigation water use PRD needs to be investigated as a means of reducing irrigation requirements (Krstic *et al.*, 2002).

The principle behind PRD is to subject roots to water stress. Roots then send a signal to the leaves to close the stomata to reduce water consumption. Leaves have to balance the drive of the plant for maximum photosynthesis for which the stomata have to be open to take up carbon dioxide, and their need for water conservation by reducing transpiration and hence close the stomata. This signal is a chemical signal which is provided by abscisic acid (ABA) (Davies *et al.*, 1993; Dry and Loveys, 1999). Although only half the roots are dry at one time, these dry roots produce sufficient ABA to trigger the leaves into water stress mode and thereby reduce transpiration. To maintain an appropriate level of ABA production the wetted portion of roots is alternated; based on time (e.g. fortnightly) or on soil moisture (e.g. when the dry side soil moisture reaches refill point).

The research described here is a continuation of research carried out over the last few years at the request of the Marlborough District Council, to elucidate the amount of water that is actually needed by grapevines (Greven *et al.*, 2003a). The trial has become a melting pot of several different approaches of how to establish the ideal irrigation regime. Initially it was centred on Regulated Deficit Irrigation (RDI). Different irrigation treatments were applied to measure their impact on vegetative growth, yield and fruit quality. This work continues to be supported by a number of organisations including FRST (Foundation for Research, Science and Technology, Marlborough District Council, Marlborough Research Centre (MRC) Trust¹ and New Zealand Winegrowers.

¹ Now the Marlborough Wine Research Centre Trust

METHODOLOGY

The trial was installed at Montana's Squire Estate in Marlborough (Sauvignon blanc on 5C grown on Wairau silt loam). The RDI trial consisted initially of full row irrigation of 6 different water application levels or methods, with 3 replicates of 4 vine rows each. The control IR-100, applied sufficient water for 100% compensation for crop evapotranspiration or ET_{crop} . ET_{crop} is an estimation of the amount of water the vine is transpiring under the prevalent conditions and growth stage, based on a crop factor K_c multiplied by the calculated potential evapotranspiration ET_{pot} . The other RDI treatments were IR-80, which would be 80% of ET_{crop} and similarly, IR-60 deficit irrigation.

In 2003/04 the original IR-70 treatment was discontinued in favour of partial row irrigation treatments of 40% and 20% of ET_{crop} (IR-40 and IR-20 respectively), also with three replicates of each.

The irrigation rate of each treatment is achieved by installing appropriate irrigation lines with dripper spacings and output that provide the required water application per vine for each treatment with all vines irrigated at the same time. The layout now also includes three replicates of Partial Rootzone Drying (PRD), each containing three vine rows irrigated using PRD tape (Netafim New Zealand) applying water at 60% of IR-100. Partial Rootzone Drying is achieved by watering one side of the root system at one time while the other side is left to dry. When the minimum soil moisture threshold was reached on the dry side the irrigation was alternated to the dry side. The practical application of PRD is through a double irrigation line that has drippers alternated between a left and a right line (Figure 1).

Soil moisture content (SMC) measurements were undertaken in the centre rows of each three-row plot of IR-100, IR-60, IR-20 and PRD-60, using Time Domain Reflectometry (TDR). Probes were installed under the dripper line at 15 cm depth intervals to 105 cm, on both sides of the vines for averaging the RDI treatments and to take account of the alternating wet and dry treatment in the PRD treatment. TDR probes also measured SMC in the grassed inter-rows. A meteorological station was installed on-site to record global radiation, air temperature, relative humidity, wind speed and rainfall. An array of light sensors were installed across the inter-row for continuous measurement of the light interception by the vines.

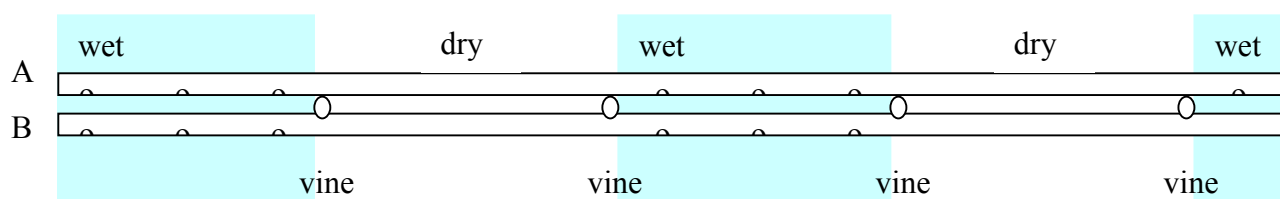


Figure 1: Schematic lay-out of double PRD irrigation line with 60 cm between drippers and 180 cm between vines (not drawn to scale). Line A is used for irrigation until the dry portion of the roots (those that are only irrigated by line B) are considered dry enough to have started ABA production. Shortly after this, irrigation will be switched from line A to line B until the dry portion of the roots (those irrigated by Line A) produce ABA and vice versa to maintain the ABA signal to the leaves.

For monitoring purposes, at the beginning of each season vines were selected with an average bud-count of between 45 and 50. Vegetative growth rate was assessed by weekly measurements of shoot and leaf development. Summer pruning weights were established for

all treatments and winter pruning dry weight was used to assess total vegetative growth. From mid-January onwards, canopy leaf area was also measured using the Point-Quadrat (PQ) technique. The last PQ measurement was compared with total leaf area measured at harvest (Smart and Robinson, 1991).

Transpiration was measured by means of stem sap flow in IR-100 and IR-60 treatments. To assess the impact of the various irrigation treatments on the level of moisture stress, midday leaf water potential (LWP) was measured on a weekly basis during January and February.

For winemaking, 3 replicates of 50 kg of grapes were harvested from each treatment and processed by the micro-vinification unit at NMIT. These wines are to be tasted by a professional panel and chemically analysed under the Quality New Zealand Wines Programme.

RESULTS AND DISCUSSION

Climate

Initially, the 2003-2004 season was drier than average (Figure 2). Unseasonal rainfall after mid-February (Figure 2) severely reduced the differences found among the treatments earlier in the season. Potential evaporation was similar to the long-term average. Air temperatures later in the season were slightly lower than long-term average. In the 2003/04 season a total of 1248 growing degree days (GDD: accumulation of daily $[T_{\text{mean}} - 10^{\circ}\text{C}]$) were recorded, compared to 1276 GDD for the 2002/2003 season and 1260 GDD for the long term-average.

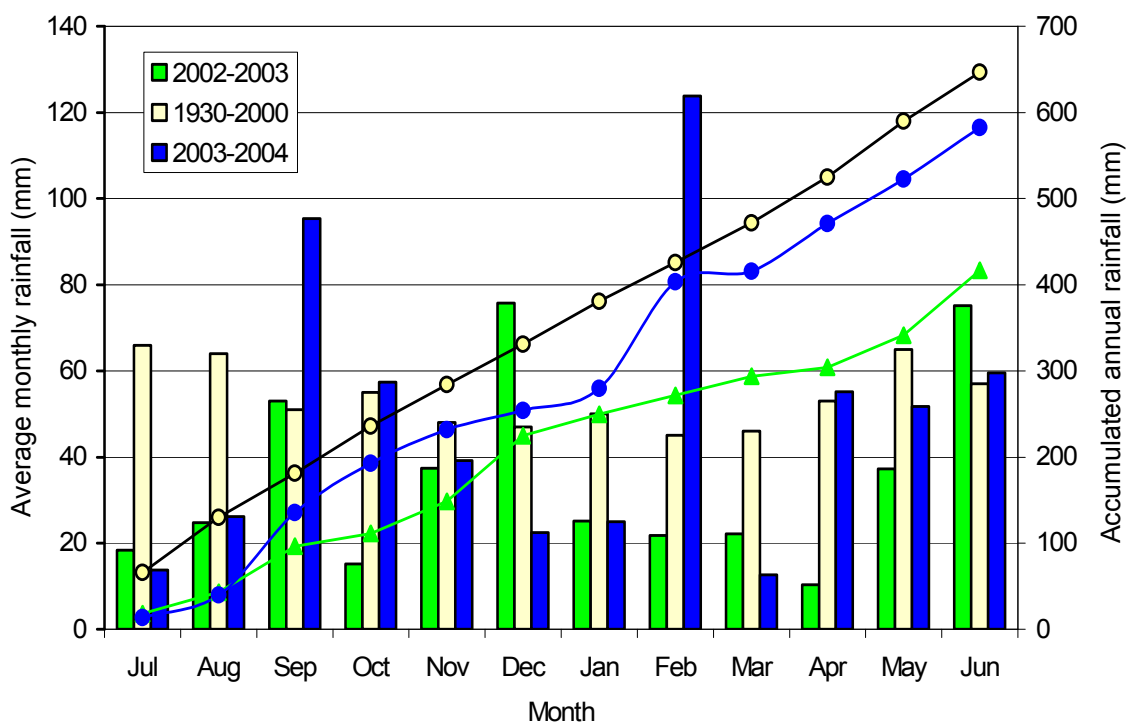


Figure 2: Average and accumulated monthly rainfall over the last two seasons compared to long-term average.

Irrigation

Irrigation was started on 5 December 2003 when SMC dipped under the 200 mm/m level in the IR-100 plot, which was considered the maximum allowable water stress level before flowering. Initially the irrigation rate was 8 L/d, which increased to 11.2 L/d during flowering from 8 December until 22 December. After flowering light moisture stress was deemed acceptable and irrigation was continued daily from 24 December until 31 January (except for 2 days) at the lower level of 8 L/d. During February, for 11 out of the first 19 days the vines were irrigated at 8 L/d, with no further irrigation after that. For the PRD, the first change over from B to A (Figure 1) was made 25 days after the start of irrigation on 5 December when the SMC in the PRD plot had reached 150 mm/m (Figure 3). This resulted in a very fast water uptake by the vine from the PRD-B area. The second change over from A to B occurred on 2 February. After irrigation was stopped on the 19 February, both sides of the vines showed the same trends in SMC (Figure 3). Under the drippers, one side of the root-zone stayed wet while the other side dried out. Under the vines and hence under the dripper line, SMC varied considerably among the irrigation levels (Figure 4). However, outside the dripper zone (between rows) SMC generally did not vary among the treatments (data not shown) and was uniformly much lower than under the dripper zone. This indicates that all vines obtained the majority of their water from under the inter-row.

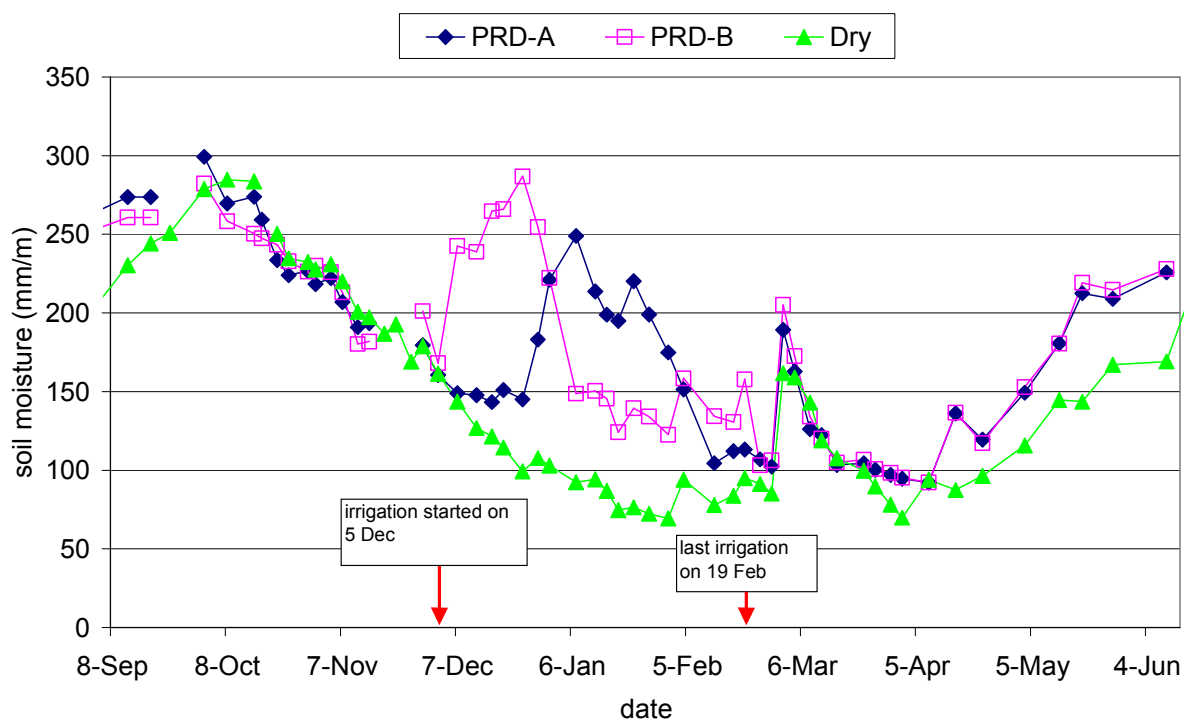


Figure 3: Soil moisture over time in the top 60 cm of the soil profile measured away from the drippers (Dry), and during both cycles under the drippers (PRD-A and PRD-B).

From 1 September 2003 to 1 June 2004, each vine across all treatments received approximately 490 L water from rainfall (Figure 2). Low rainfall in November, December and January suggested that water stress would become important after veraison. Therefore, for this season, in addition to rainfall, irrigation was applied at rates varying from 570 L of water (IR-100) to only 275 L of water (IR-20) per vine (Table 1). Beyond 20 February, when there was high rainfall, potential risk of a drought quickly disappeared and vines that had received low amounts of irrigation were able to compensate for the earlier water shortage. This was obvious from monitoring SMC (Figures 3 and 4), as well as vine stress by means of leaf water potential (LWP, Figure 5).

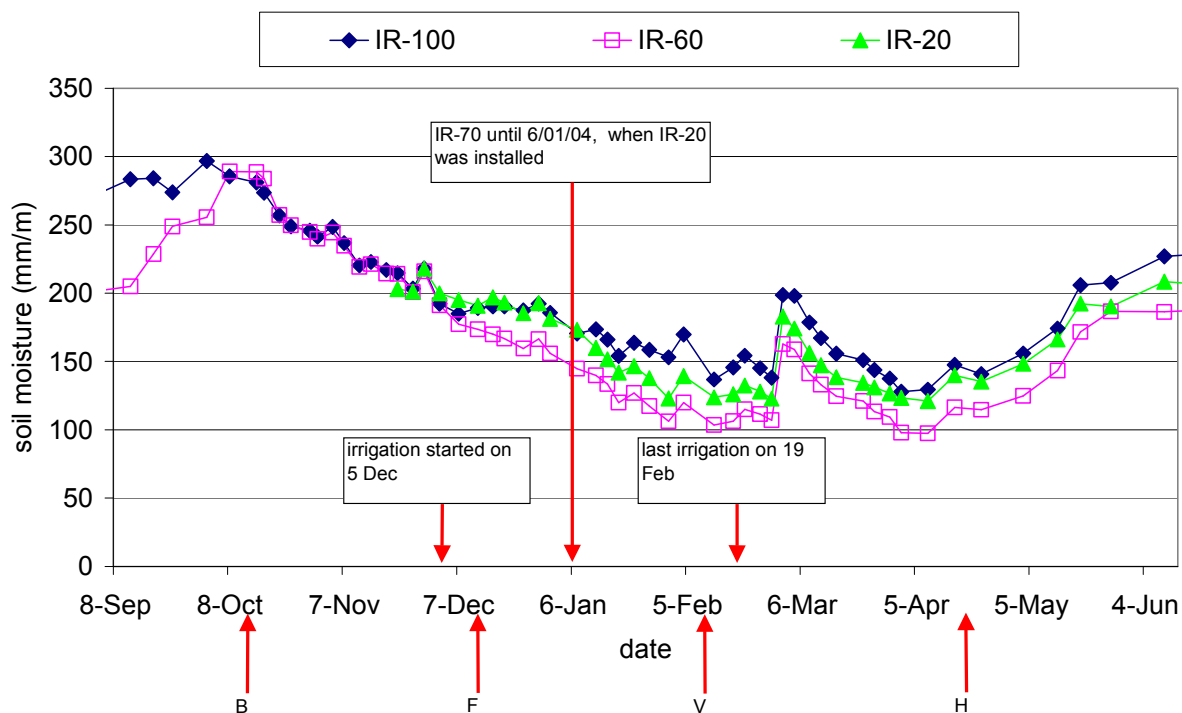


Figure 4: Soil moisture content over time under control (IR-100) and RDI at 60% (IR-60) and at 20% (IR-20) as well as rainfall over the same period. Irrigation was started on 5 December but IR-20 was only installed in an IR-80 treatment on 6 January (B = bud break, F = flowering, V = veraison, H = harvest).

The water stress levels achieved (pers. comm. Girona, 2004) were:

- after flowering mild water stress ($-0.6\text{MPa} > \text{LWP} > -0.8\text{MPa}$).
- after veraison moderate water stress ($-0.8\text{MPa} > \text{LWP} > -1.2\text{MPa}$).
- severe water stress with $\text{LWP} < -1.2\text{MPa}$ was reached early in February.

Although the level of SMC again reduced after that, the irrigation threshold was only reached for two days in late February. No more irrigation was applied after that. SMC was measured under the vines and in the inter-row, both for the depth of 0-50 cm and for 50-100 cm as illustrated in Figure 6. The important contribution of the inter-row moisture to the vine water supply is shown in Figure 7. This is especially true for the 50-100 cm region where all water uptake would have been by the deep rooting vines. For the 0-50 cm region of the soil profile it is impossible to establish the share of the water uptake by the vines as the vine / grass root ratio is not known. Further soil coring will be needed to get a better appreciation of the water uptake by the vine roots in this area of the soil profile.

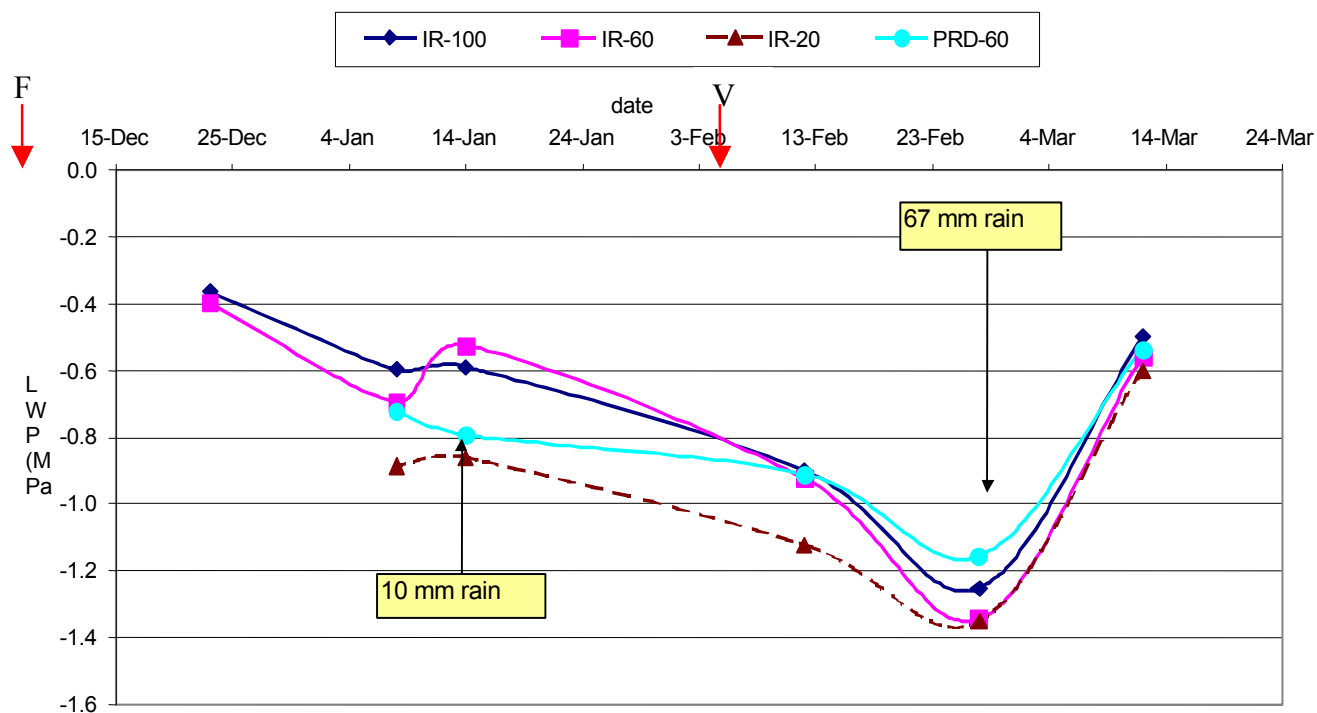


Figure 5: Mid-day Leaf Water Potential (LWP) as an indicator of vine stress. Mild water stress: $(-0.6\text{Mpa} > \text{LWP} > -0.8\text{ MPa})$, moderate water stress: $(-0.8\text{Mpa} > \text{LWP} > -1.2\text{ MPa})$, severe water stress: $(\text{LWP} < -1.2\text{ MPa})$ (Girona *et al.*, 2004). Rainfall had a big impact on the level of vine stress that was reached under the different irrigation levels. As vine stress was eliminated after the late February rainfall, no further measurements were taken.

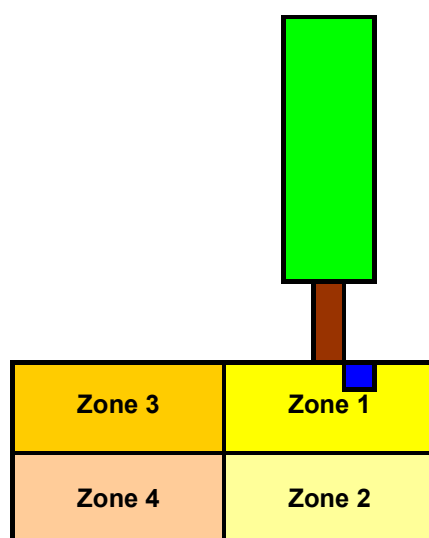


Figure 6: Schematic two-dimensional representation of the soil area around a grapevine. The vine obtains most of its water from zones 1 and 2. The vine will also take up a significant amount of water from zone 4. Some water will be drawn from zone 3 but most of the moisture from this zone will evaporate or be taken up by inter-row vegetation.

Figure 8 shows the accumulated SMC changes over time from 21 September. Irrigation was only applied during a limited time, therefore rainfall was the most important contributor to soil moisture. SMC prior to 21 September was used for initial growth by both the inter-row vegetation and the vine. The importance of water uptake by the inter-row vegetation is further illustrated in Figure 8 when mid-May vine water uptake stops but the uptake from the inter-row increases. Both Figures 7 and 8 indicate that a significant amount of the water is taken up by the vines from the inter-row, hence the importance of measurements of inter-row SMC has to be emphasised, especially in a relatively wet season when rainfall contributes more to vine water availability than irrigation.

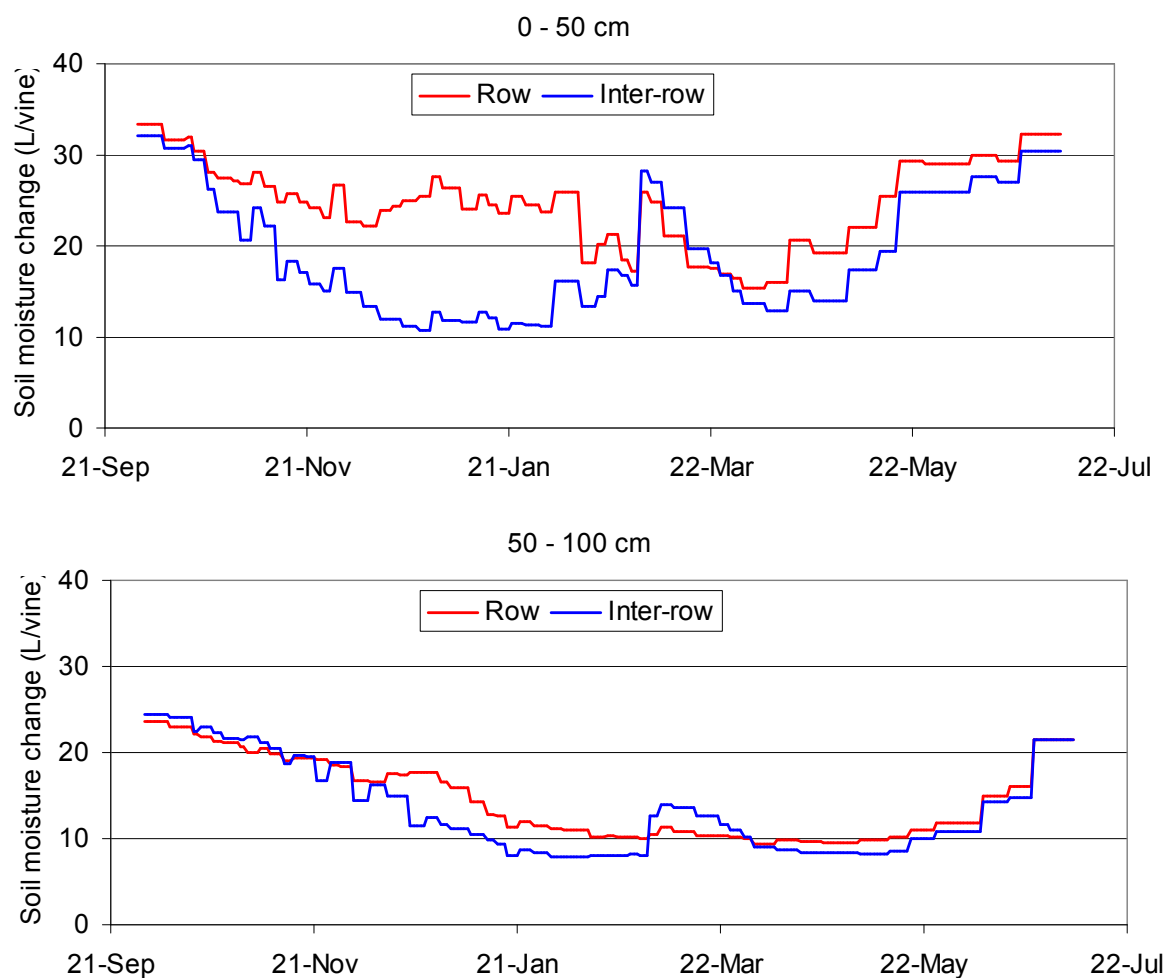


Figure 7: Soil moisture change in the vineyard for the 0 - 50 cm and the 50 - 100 cm part of the soil profile, both under the vine row and under the inter-row.

A model has been developed that accurately predicts the soil moisture status of the vineyard (Figure 9). This was developed by using information on:

- water use from under the vines and the inter-row,
- by the vine and the inter-row vegetation,
- the canopy development of the vines and the inter-row vegetation and
- comprehensive climatic data.

This model will enable the vineyard manager to anticipate irrigation needs depending on crop management practices. Further confirmation of this model will be carried out during the 2004-05 season.

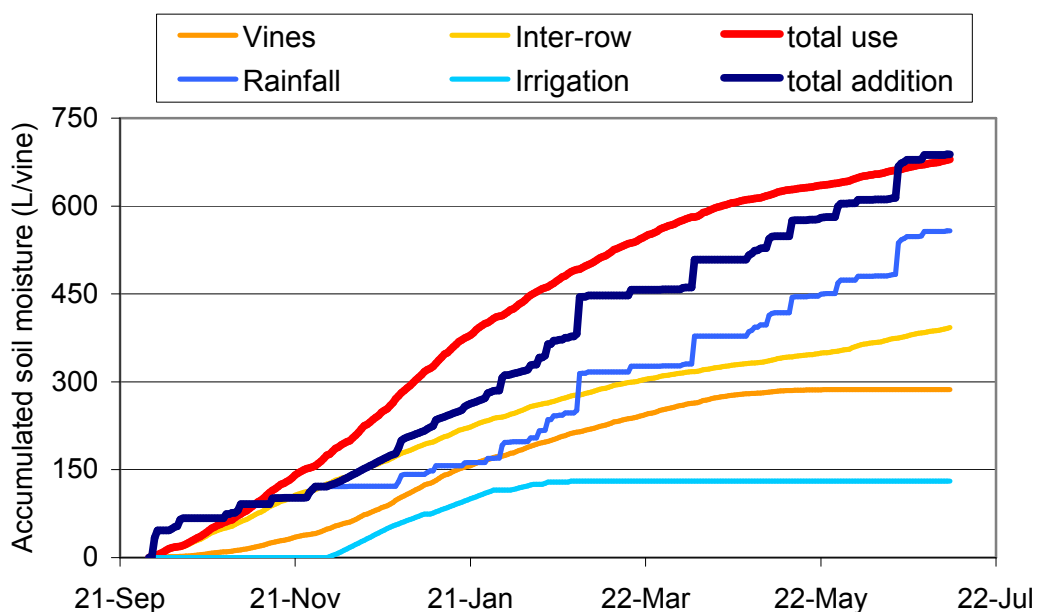


Figure 8: Total water use (and the relative importance of the vines and the inter-row crop) compared to the total amount of water added to the soil (and the relative contributions of rainfall and irrigation).

When studying stem sap flow over a long period of time the causal relationship between leaf area and transpiration becomes clear. This relationship is shown by measured leaf area, stem sap flow and $ET_{pot} \times LAI$ (Leaf Area Index, Figure 10). As has been shown before, light interception is an important component of the crop factor K_c (Green *et al.*, 2002). Using $LAI \times ET_{pot}$ instead of $K_c \times ET_{pot}$ to determine the crop evapotranspiration is therefore an acceptable approximation (Figure 10). At Squire Estate in Blenheim, vines were planted at a spacing of 1.8 m, in rows that are 2.4 m apart. The daily water use of these vines in early January is about 1.2 L per hour (~2.7 mm per day). The leaf area in early February was reduced from 12 to just 8 m² and vine water use drops to ~1.8 mm per day. This corresponds roughly with a reduction of water use from 12 to 8 L/ vine or 1 L/ m² of leaf area per day.

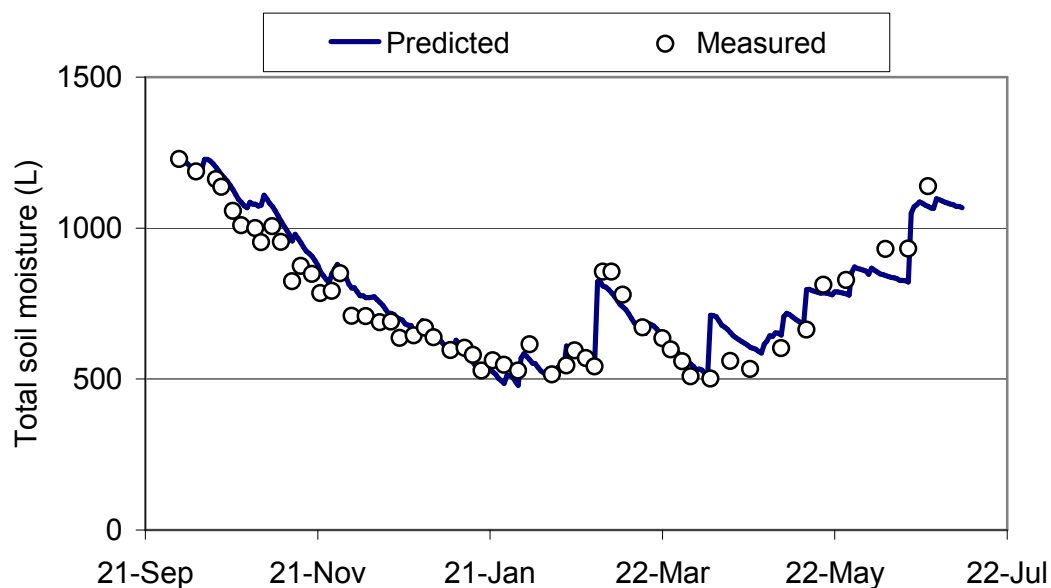


Figure 9: Measured root-zone soil water by means of an array of 48 TDR probes, 2-3 times weekly, compared to the predicted change in soil moisture using climatic measurements, irrigation data and understanding of the crop development of both the vines and the inter-row cover crop.

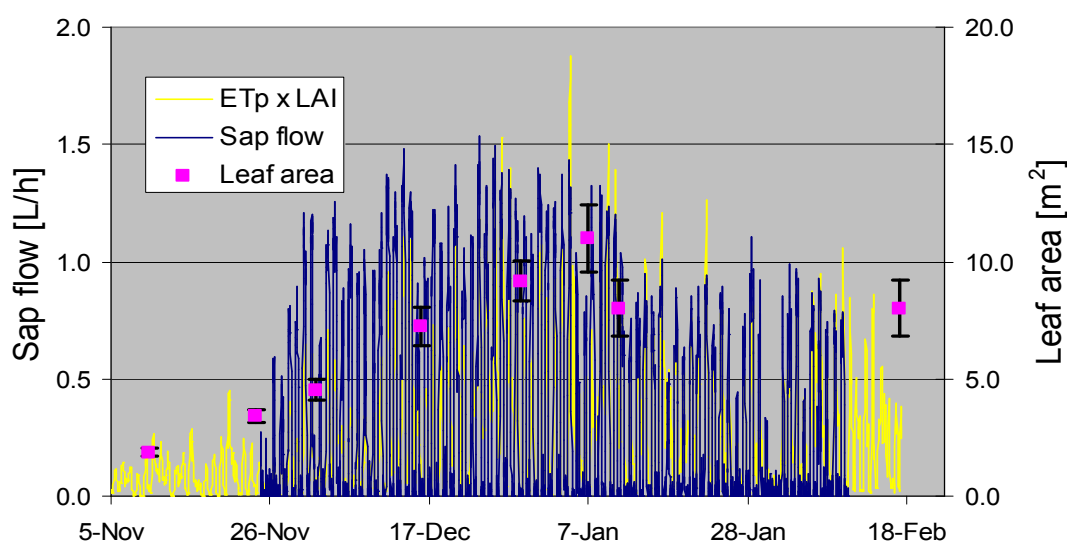


Figure 10: Seasonal pattern of vine water use by Sauvignon blanc vines at Squire Estate, Blenheim.

Yield and fruit quality

No significant difference in vine yield was found among the treatments (Figure 11), if anything, the highest irrigation levels tended to have lower yields per vine. The IR-100 and IR-80 treatments only produced 9.40 and 8.10 kg/vine respectively, compared to over 10.00 kg/vine for all the lower irrigation treatments. Also no differences were found in the number of bunches/vine or the fruit weight/bunch (Table 1).

In Portugal where the summer is invariably without any rain, a reduction of irrigation by 50% by using RDI or PRD reduced LWP more consistently compared to full irrigation (de Souza *et al.*, 2003; dos Santos *et al.*, 2003). However, both in Marlborough and in Portugal, yields from vines under RDI and PRD, were found to be very similar to IR-100 and hence demonstrated an increase in water use efficiency (litre of water used per kg fruit produce).

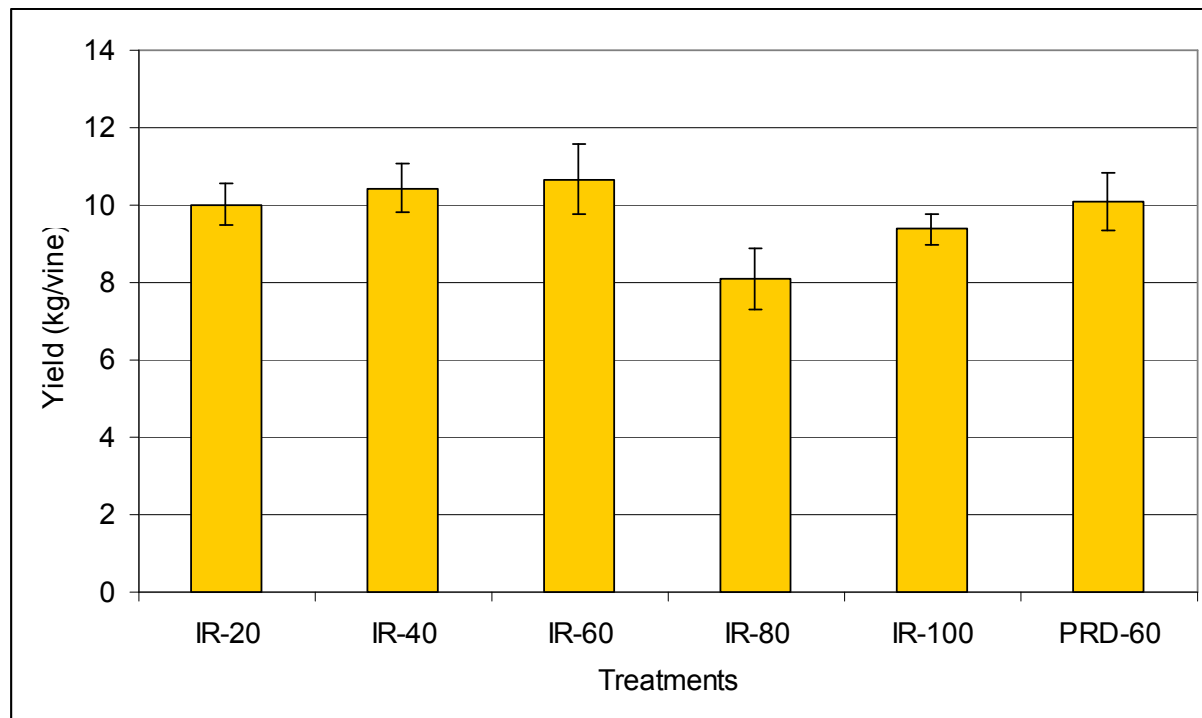


Figure 11: The 2003/04 Sauvignon blanc vine yield at different irrigation levels.

There were also no differences in pH or berry weight among the PRD and the five RDI treatments at harvest time (Table 2). However, significant differences in soluble sugars ($^{\circ}$ Brix) and a slight increase (not sign.) in titratable acidity (TA) at harvest time suggested delayed maturity for the PRD treatment. It was especially noticeable that the 60% RDI treatments, contrary to the PRD treatment, showed an advanced maturity despite receiving the same level of irrigation.

Although PRD and IR-60 behaved similarly as far as both fruit and vegetative growth was concerned, there were differences for fruit quality. Similarly, Gu *et al.* 2004 reported that when working on Sauvignon blanc, no differences were found in yield, when comparing 80% ET_{crop} irrigation with 40% ET_{crop} irrigation either under a RDI or a PRD system. However, contrary to our findings they found berry weight to be smaller for the lowest irrigation levels of both RDI and PRD in two years out of three. In addition, vegetative growth was significantly reduced each year by both RDI and PRD 40% irrigation treatments. These clear differences however, were achieved in Fresno, California, where summers are very dry and hot compared to Marlborough.

Table 1: Sauvignon blanc vine yield parameters, with IR-20 and IR-40 only installed on 6 January after receiving 70% and 80% of ET_{crop} irrigation until that time. Where WUE = water use efficiency.

Trmt	Irrigation (L)	bunches/vine	wgt/bunch (g)	fruit wgt/vine (kg)	WUE
IR-20	275	76.4	131.2	10.00	28.2 a
IR-40	360	76.1	139.7	10.43	28.9 a
IR-60	340	81.2	129.9	10.66	36.1 a
IR-80	460	66.7	119.6	8.10	65.2 b
IR-100	570	69.9	136.1	9.38	61.2 b
PRD	340	72.5	140.2	10.10	38.6 a
Significance		ns	ns	ns	***
Lsd (5%)					10.08

*** = $P < 0.001$; ** = $P < 0.01$; * = $P < 0.05$; ns = non significant

¹ results followed by the same letter are not significantly different

It should be kept in mind that the IR-20 and IR-40 irrigation treatments were only applied from 6 January onwards, prior to this IR-70 and IR-80 treatments were effective. These vines had therefore IR-70 and IR-80 irrigation pre-veraison (Table 1). This may explain the lack of difference between IR-60, IR-40 and IR-20 treatments, as most of the post-veraison influence on IR-20 and IR-40 was nullified by the excessive rains during February. It will be very interesting to see the IR-20 and IR-40 results next year when the treatments will have also been imposed during the pre-veraison stage. Dryden and Neal (pers. comm.) found in a parallel trial on a very stony site in Marlborough, that 30 and 40% IR applied pre-veraison, reduced vegetative growth, resulted in smaller berries and reduced yields.

Table 2: Berry quality parameters at harvest.

Trmt	Berry wght (g)	°Brix	TA	pH
IR-20	1.66	21.2 ab	8.6	3.1
IR-40	1.82	21.2 ab	9.6	3.1
IR-60	1.67	22.4 a	8.6	3.1
IR-80	1.89	21.3 ab	9.6	3.1
IR-100	1.87	21.5 ab	9.5	3.1
PRD	1.95	20.2 b	10.0	3.0
Significance	ns	*	ns	ns
Lsd (5%)		1.23		

*** = $P < 0.001$; ** = $P < 0.01$; * = $P < 0.05$; ns = non significant

¹ results followed by the same letter are not significantly different

Some considerable differences among the treatments was found in the Point Quadrat (PQ) measurements (Figure 12). From immediately after trimming, PRD vines had a more open canopy (lower leaf layer number, LLN), less leaves and hence less internal leaves. This

mirrored the differences found in pruning measurements (Table 3) where PRD had the lowest shoot weight. As the main canopy development took place well before IR-20 and IR-40 were installed, these treatments were left out of the analysis. Conversely, the IR-80 vines had a denser canopy with higher LLN (Figure 12), higher number of leaves and more internal leaves, which related well to the highest pruning weight (Table 3). The LLN in IR-60 and IR-100 were intermediate and not different from either IR-80 or PRD. Although this is an indication that PQ can be used for estimates of vegetative growth, the correlations with actual leaf numbers picked from neighbouring vines, was poor (data not shown). No strong relationship was found between yield and the number of clusters measured through PQ.

Table 3: Sauvignon blanc pruning weights.

Trmt	Shoot weight (g)	Cane weight (g)	Total shoot length (cm)	Total 'cordon' length (cm)
IR-60	1491 ab ¹	504	3123	358.5
IR-80	1703 a	443	3340	351.3
IR-100	1287 b	458	2726	337.6
PRD	1288 b	467	2814	335.0
Significance	*	ns	ns	ns
Lsd (5%)	332.9			

*** = $P < 0.001$; ** = $P < 0.01$; * = $P < 0.05$; ns = non significant

¹ results followed by the same letter are not significantly different

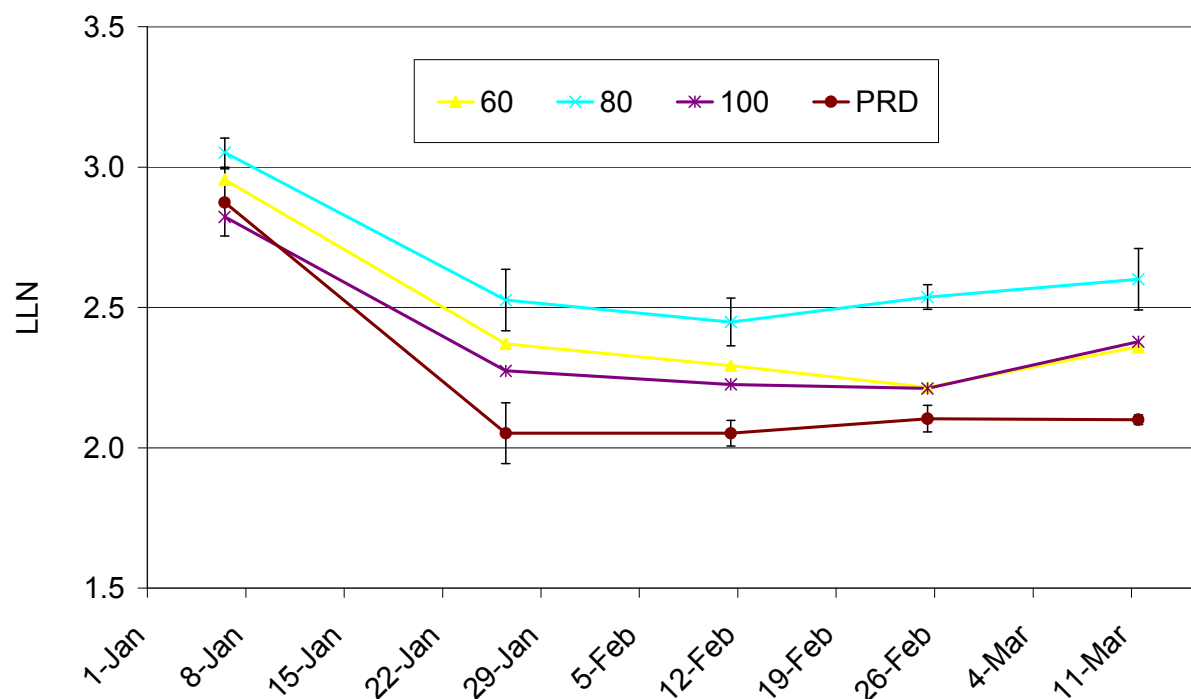


Figure 12: Point Quadrat parameters with 18 probes per vine, with only significant differences between IR-80 and PRD (LLN = leaf layer number).

There is a question why IR-80 produced the lowest yield and highest vegetative growth. One indication could be that IR-80 is at least as effective as IR-100 suggesting that in future the control treatment should only be 80% of crop evapotranspiration to avoid over-irrigation. Further research with more severe treatments is necessary to confirm this.

Vines that had the least vegetative growth had the highest yields, which points to source limited development. Besides reducing yield, excessive vegetative growth will also increase shading of the fruit, which in its turn could influence grape quality especially soluble sugars. Highest yields (not sign.) were achieved by the three lowest irrigation levels (Table 1). However, as discussed before, IR-20 and IR-40 irrigation were still influenced by the IR-70 and IR-80 pre-veraison irrigation regimes. The yields from both IR-60 RDI and PRD-60 were very similar and above 10 kg per vine. Similar results were also reported by Krstic *et al.* (2002) in Australia. Reducing irrigation by 40% and increasing the yield by 10% enabled the vines to almost double the water use efficiency (WUE) from around 63 L/kg for IR-80 and IR-100, to around 36 L/kg of grapes produced with IR-60 (Table 1). These results are very much inline with our results from previous years (Greven *et al.*, 2003b).

Research with red grapes in Australia showed that PRD increased the WUE of Shiraz and Cabernet sauvignon, compared to 100% irrigation (du Toit *et al.*, 2003). Recent research using RDI, and PRD at the same irrigation levels, showed that both irrigation techniques improved WUE by 50% compared to control plants (Krstic *et al.*, 2002). Stomatal closure did not account for all the water savings being made with PRD. Alternatively, Krstic *et al.* (2002) suggests that control plots might have been irrigated too heavily and any reduction, whether made using RDI or PRD techniques, would therefore improve WUE.

De Souza *et al.* (2003) raised the possibility of more subtle differences between PRD and RDI than between PRD and full irrigation when photosynthesis, stomatal conductance and pre-dawn leaf water potential were measured. Most of the significant differences achieved in their research on Shiraz would not be apparent in our research on Sauvignon blanc grapes. This was because they found lower anthocyanin and total phenolic levels in the 100% irrigation compared to any of the 50% irrigation treatments for Shiraz. However it is possible to influence berry weight, Brix and pH by reducing irrigation, although not all of these differences were statistically significant (Table 2). Reducing irrigation, whether by RDI or PRD, was found to have the potential to influence berry characteristics (Krstic *et al.*, 2002).

Although wine has been made from the grapes harvested from this experiment, the wine evaluation is still to be completed and once this is done an Appendix will be prepared to this report along with summary comments.

More work is required to find out whether the quality improvement found in red grapes could also be achieved in white grapes in different seasons and different regions and whether PRD offers significant advantages over RDI in achieving these quality improvements.

CONCLUSIONS

During the 2003-2004 season, an increase in yield and a reduction of vegetative growth of Sauvignon blanc grape vines was found under a reduced irrigation regime but not necessarily due to partial rootzone drying (PRD).

Both RDI and PRD at 60% of ET_{crop} , almost doubled the water use efficiency of Sauvignon blanc grapes during 2004, despite ceasing irrigation after 20 February due to unseasonal rainfall.

The PRD treatment this year showed delayed maturity with significantly lower soluble sugars than all other treatments including IR-60.

A good relationship was found between Point Quadrat measurements and other more labour intensive canopy measurements.

More work is needed, under drier conditions to determine the full potential of PRD under New Zealand conditions. Research should be aimed at further reducing irrigation through PRD to closer to 50% of control.

Good relationships were found between transpiration measured by stem sap flow and both leaf area and ET_{crop} calculated from ET_{pot} (Penman-Monteith) by crop light interception.

A workable irrigation model has been produced from the data that have been gathered over the last three years. This model requires further testing in the coming season.

ACKNOWLEDGEMENTS

We thank the Marlborough District Council, New Zealand Winegrowers and the Marlborough Research Centre Trust for their funding of this project as well as Allied Domecq Wines New Zealand Ltd. and the staff at Stoneleigh/Squire Estate in Marlborough for the use of the vineyard and their cooperation during the experiment. We are also very grateful to Netafim New Zealand for supplying some the irrigation equipment needed for this research project.

REFERENCES

- Davies, W. J., F. Tardieu, C. L. Trejo, L. Fowden, T. Mansfield, and J. Stoddart, 1993: Chemical signalling and the adaptation of plants to conditions where water availability is restricted. In Fowden, L., Mansfield, T., Stoddart, J. (eds.) *Plant adaptation to environmental stress*, pp 209-222.
- de Souza, C. R., J. P. Maroco, T. P. dos Santos, M. L. Rodrigues, C. M. Lopes, J. S. Pereira, and M. M. Chaves, 2003: Partial rootzone drying: regulation of stomatal aperture and carbon assimilation in field-grown grapevines (*Vitis vinifera* cv. Moscatel). *Functional Plant Biology*, **30**, 653-662.
- dos Santos, T. P., C. M. Lopes, M. L. Rodrigues, C. R. de Souza, J. P. Maroco, J. S. Pereira, J. R. Silva, and M. M. Chaves, 2003: Partial rootzone drying: effects on growth and fruit quality of field-grown grapevines (*Vitis vinifera*). *Functional Plant Biology*, **30**, 663-671.
- Dry, P. R. and B. R. Loveys, 1999: Grapevine shoot growth and stomatal conductance are reduced when part of the root system is dried. *Vitis*, **38**, 151-156.
- du Toit, P. G., P. R. Dry, and B. R. Loveys, 2003: A preliminary investigation on Partial Rootzone drying (PRD) effects on grapevine performance, nitrogen assimilation and berry composition. *South African Journal of Enology and Viticulture*, **24**, 43-54.
- Green, S., M. M. Greven, S. Neal, and B. Clothier, 2002: Regulated deficit irrigation (RDI) as a management tool to reduce water usage and achieve high yields of quality wine grapes. HortResearch Client Report No. 2002/385.
- Greven, M. M., S. Neal, B. West, and S. Green, 2003a: The use of partial rootzone drying (PRD) in Sauvignon blanc grapes in Marlborough. Client Report to New Zealand Wine Growers. HortResearch Client Report No. 2004/11449.
- Greven, M. M., S. Green, S. Neal, B. Clothier, P. Davidson, D. Martin, M. Neal, and G. Dryden, 2003b: The effect of reduced irrigation on yield and quality of Sauvignon blanc grapes in Marlborough, N.Z. *The Australian and New Zealand Grape Grower and Wine Maker*, **474**, 101-104.
- Gu, S., G. Gu, D. Zoldoske, A. Hakim, R. Cochran, K. Fugelsang, and G. Jorgenson, 2004: Effect of irrigation amount on water relations, vegetative growth, yield and fruit composition of Sauvignon blanc grapevines under partial rootzone drying and conventional irrigation in the San Joachuin Valley of California. *Journal of Horticultural Science & Biotechnology*, **79**, 26-33.
- Krstic, M., Y. Chalmers, G. Kelly, and L. Mitchell, 2002: Field responses of vines to partial rootzone drying (PRD). *Annual Romeo Bragato Conference, 2002*, Christchurch.
- Loveys, B., 2000: Development of methods for the control of vine vigour and water use optimisation based on the concept of Partial Rootzone drying, CSIRO, Plant Industry, September 2000.
- Loveys, B., Stoll M., Dry P., and McCarthy M., 1998: Partial rootzone drying stimulates stress responses in grapevine to improve water use efficiency while maintaining crop yield and quality. *The Australian Grapegrower and Winemaker*, 108-113.
- Smart, R. and M. Robinson, 1991: *Sunlight into wine; A handbook for winegrape canopy management*. *Winetitles*, 88 pp.