

Maximising irrigation savings in grape vines and the effect on yield and wine quality SFF Project 03/100 -Extension

**Results
Year Four
2006/07**



Prepared By:
Jim Mercer, Greg Dryden and Murray Neal

EXECUTIVE SUMMARY

At the beginning of this trial funding was sought for a three year project looking at sub-optimal levels of irrigation in vineyards. The reasoning behind this was that considerable research work had taken place to establish the optimal levels of irrigation for a grapevine but little seemed to have been done to establish what the consequences were of irrigating at lower levels. These lower levels of irrigation may come about by necessity where water is not available from say drought conditions or it could come about as a matter of choice by winemakers wanting a particular wine style.

A trial was set up on a commercial vineyard to establish the affects of irrigation reductions from around 110mm per year down to around 20mm per year. The results showed that while the vines adapted to the reduced irrigation and produced a crop there were serious consequences on the vines and fruit. Among the results was a reduction in yield of up to 45%. There were also carry over affects for the coming year with reduced cane available to tie down and reduced quality of cane. There was a belief that these negatives may be able to be compensated for by an improvement in wine quality. Small batches of wine were made (around 500 litres per treatment) to establish the affect on wine quality. A number of objective and subjective measures of wine quality were used. The results showed that there was certainly an effect on wine composition. Generally the very low yields, while producing wines of an acceptable standard, were not up to the top quality Sauvignon Blanc that can be grown in the district. Comments from winemakers were that they were of a standard that they would use in the blending process rather than as a selection in its own right.

The conclusion of the trial was that if water was a very scarce resource careful timing of application could result in the production of a useable wine at a yield that should ensure the grower covers enough costs to get through the season. This is an important result as some of the irrigation applications were very small in comparison the district average and the vines survived the process although they certainly looked stressed for much of the season. Full trial results are available from the authors.

After concluding the trial the question was asked as to how well the vines would recover from the water stress of three years. An extension to the project was sought to effectively water the block at normal levels for a season and monitor the results. This report largely covers that work.

The results showed that the vines recovered surprisingly easily. Shoot growth was back to normal, in fact the lower treatments had more vigorous shoot growth and ended up with higher soil moisture, indicating that the vines had started to compensate for the lower levels of irrigation. Yields, bunch weights and berry weights evened out as did the juice composition. These results show the adaptability of grape vines and are encouraging for the grower. Should the grower be restricted in the amount of water they can use in a one year there are likely to be consequences, however the vines quickly adapt, reducing the impact and then when balance is restored they revert to their normal state.

INTRODUCTION

Nationally and internationally water is becoming a limiting resource to the production of quality wine grapes. In New Zealand rapid expansion in this industry has seen growth into previously considered water-short areas and exploitation of previously considered large aquifer reserves. Currently irrigation research is focused on water use in grape vines with the aim to reduce water inputs whilst maintaining or improving wine quality but not adversely affecting yield. As water becomes a more scarce resource then this approach may not give adequate water savings to enable sustainable production.

Our experience in both running/using an irrigation scheduling service and an SFF project looking at vine water use (00/294) tells us that vines are basically water hogs and will take almost anything that you can give them. This is not new, it has been known for some time, but gives us an important clue when it comes to the possibilities in this area of water management.

The aim of the first three years of this project was to set up a replicated scientifically sound trial on a commercial vineyard looking at pushing the boundaries of water application to find out what the limits and effects are.

This report is for the fourth year of the trial (which is an extension of the original project) making the most of the invaluable research opportunity created by the first three years. The primary aim was to assess the response of all the deficit treatments when returning irrigation to 'normal' levels. This will replicate the situation that would likely occur in vineyards where irrigation restrictions have been implemented and then these restrictions removed the following season, e.g. if the Southern Valleys scheme was turned off in a dry year and then back on the following season.

Table one lists the measurements taken at the trial site this season.

Table one: Measurements taken at the trial site.

Measurement	Sample location
Weekly soil moisture	3 monitor bays per plot
Shoot numbers	4 monitor vines per plot
Weekly shoot measurements until trimming	4 shoots from all 4 monitor vines per plot
Pre-harvest juice analysis	30 berries from all 4 monitor bays per plot
Harvest juice analysis	100 berries from each treatment
Harvest bunch number and bunch weight	4 monitor vines in every plot
Harvest variation data between bays	Total weight per bay, 2 bays per treatment
Pruning weights	4 monitor vines in every plot

RESULTS AND DISCUSSION

Soil moisture and Irrigation

Full points on all sites are relatively similar with initial estimates of FULL varying between 214mm and 245mm. The soil is an Awatere series soil described as a shallow and stony soil with a sandy loam A horizon overlying C horizons of stony loamy sand. As such Permanent Wilting Point (PWP) was estimated as 50% of the FULL points and Readily Available Water (RAW) was estimated at 35% of FULL (approximately 80mm). For the previous three years suggested irrigation strategies were put in place at the beginning of the season with the intention of modifying as soil moisture or seasonal influences dictated. A summary of the strategies for the six treatments is shown in Table two. These strategies were essentially the same for the first three years of the trial.

Table two: Irrigation strategy for each treatment.

Treatment	REFILL	Strategy description
1	65% of FULL	Standard Sauvignon Blanc strategy ¹ . Good soil moisture over flowering, slowly drying profile to refill point until Veraison and holding until harvest.
2	54% of FULL	Standard strategy with lower refill point
3	54% of FULL	Lower refill point & lower allowable soil moisture over flowering
4	54% of FULL	Lower refill point, lower allowable soil moisture over flowering & drying to refill by December end.
5	65% of FULL	Standard strategy switching when dry side hit lower strategy line
6	54% of FULL	Same as treatment 4 with mulch applied early November.

In this the fourth year of the trial the aim was to irrigate the whole block to Treatment one levels, i.e. 60% of estimated crop use - (approx) 100 mm per year. The soil moisture readings for Treatment one (original Control plot) were used as the basis of deciding how much irrigation to apply to the whole block.

Graph one shows the soil moisture readings for all the treatments. It is clear that the higher deficit treatments for the past three years consistently had higher soil moisture levels this year. This indicates the previously deficit irrigated vines were not using as much water as the original control (treatment one). It appears that those vines are using less water because they have adapted somewhat to having much less in the previous years. It is also important to note that in this year there were good regular amounts of

¹ See Appendix One for graphs outlining irrigation strategies.

spring and early summer rainfall which kept soil moisture close to Full point through flowering.

Graph one: Soil moisture readings 2006-07 (relative to FULL point)

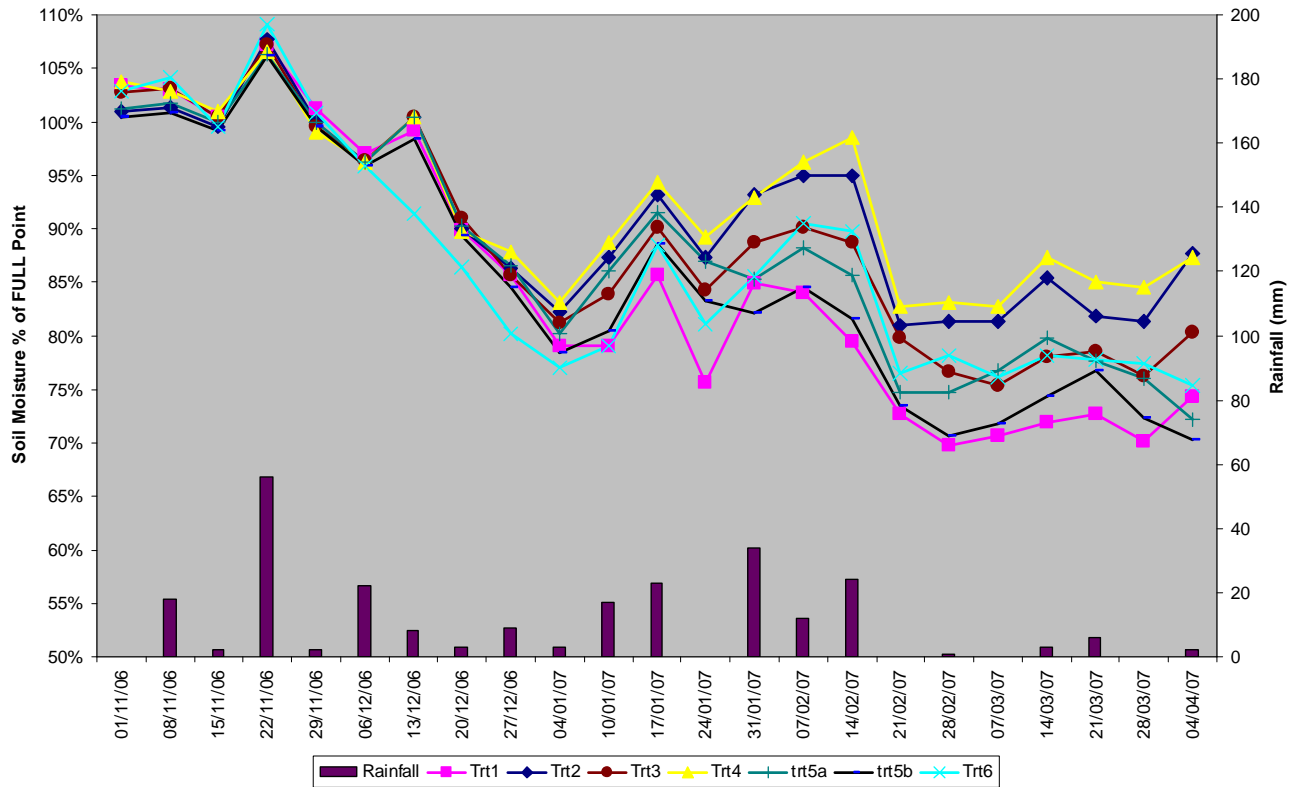


Table three shows the actual weekly irrigation applied to all the six treatments in the 2006/07 season. As far as was practicable all the treatments received the same amount of water.

Table three: Irrigation application 2006-07 (litres per vine for week ending).

Date	6-Dec	13-Dec	20-Dec	27-Dec	4-Jan	10-Jan	17-Jan	24-Jan	31-Jan	7-Feb	14-Feb	21-Feb	28-Feb	7-Mar	14-Mar	21-Mar	28-Mar
1	0	25	6	20	15	31	31	31	31	31	31	0	15	31	31	31	31
2	0	25	6	20	15	31	31	31	31	31	31	0	15	31	31	31	31
3	0	26	6	20	16	38	39	38	38	39	38	0	19	38	39	38	38
4	0	25	6	20	15	31	31	31	31	31	31	0	15	31	31	31	31
5	0	25	6	20	15	31	31	31	31	31	31	0	15	31	31	31	31
6	0	25	6	20	15	31	31	31	31	31	31	0	15	31	31	31	31

Irrigation began the week ending 13th December which is later than the previous two seasons due to good levels of spring rainfall.

Table four shows seasonal crop water use, rainfall and irrigation application for the six treatments. Crop water use has been calculated using the soil based model developed during the previous Sustainable Farming Fund project 00/294.

Table four: Estimated Crop Water Use, Rainfall and Irrigation application from 1st November 2006 until harvest.

Treatment	CWU	Rainfall	Irrigation (L/vine)	Irrigation (mm)
1	309	245	423	82
2	281	245	423	82
3	302	245	510	94
4	234	245	423	82
5	325	245	423	82
6	360	245	423	82

The aim was to give all the treatments the same amount of irrigation. There was some variation with treatment three but this was not significant for the purposes of this trial

Shoot Numbers

On the 10th January shoot numbers per monitor vine were counted and the results can be seen in Table five:

Table five: Average shoot numbers using the four monitor vines per treatment

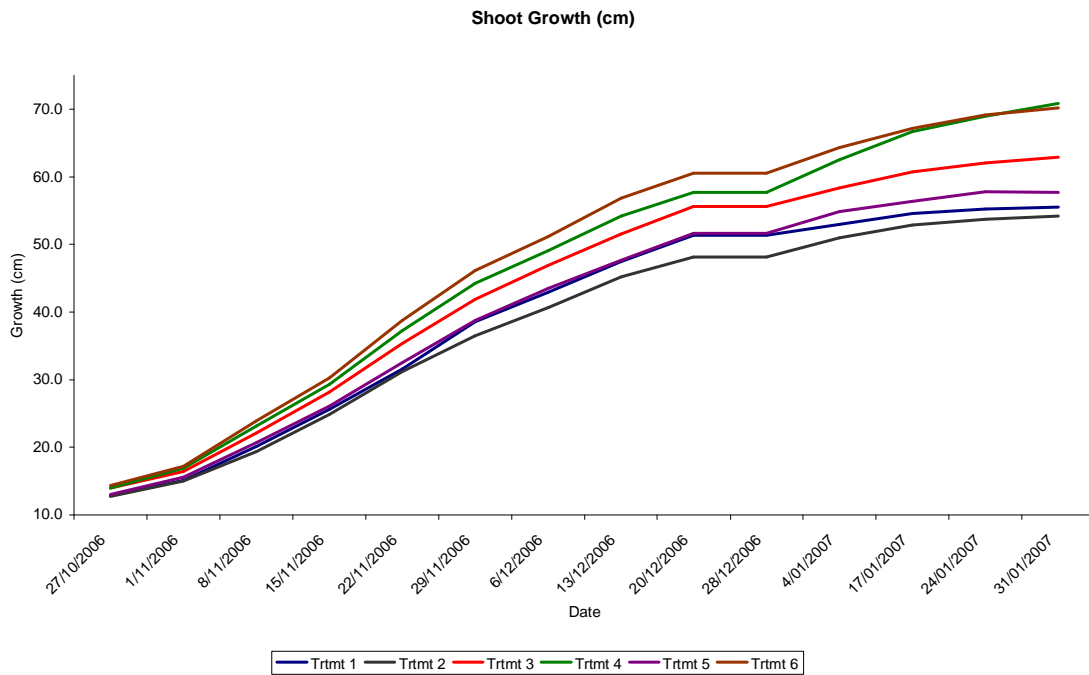
Treatment	1	2	3	4	5	6
Ave shoots/vine	55	56	51	46	51	47

The previously lower irrigation treatments are showing lower shoot numbers per vine, the reasoning for this is that it is an effect of poorer cane growth in the previous season on those treatments affecting the quality and numbers of canes laid down at pruning in winter 2006.

Shoot Measurements

Shoot measurements were taken from four shoots from every monitor vine making a total of 48 measurements per treatment. These measurements were taken from 27th October until the 7th February, trimming occurred in that first week of February. Shoot growth curves are shown in Graph two and it is clear that treatments three, four and six had significantly longer average shoot growth than the other treatments.

Graph two: Shoot growth curves 2006/07



The trends in the previous three years had suggested these lower irrigation treatments had lower growth rates although there was some variation – Table six shows the average shoot growth rates (cm/day) for 2003-2006 and 2006/07.

Table six Average shoot growth rates (cm/day) for 2003-2006 and 2006/07.

Treatment	1	2	3	4	5	6
Average	0.69	0.64	0.58	0.58	0.76	0.65
2006/07	0.48	0.46	0.54	0.62	0.50	0.62

Berry weights

Berry weights were measured twice in the month prior to harvest and another sample was weighed on the day of harvest. The pre-harvest samples consisted of 120 berries per replicate, 360 berries per treatment. The harvest day sample was 100 berries per treatment.

Table seven shows there was little difference between the treatments this year but most importantly the treatments under previously deficit irrigation had at least equal if not higher berry weights than the original higher irrigation treatments. In the previous three seasons the lower irrigation treatments had shown consistently lower berry weight and reduced berry diameter. It is clear that this effect has not continued when ‘normal’ levels of irrigation have resumed.

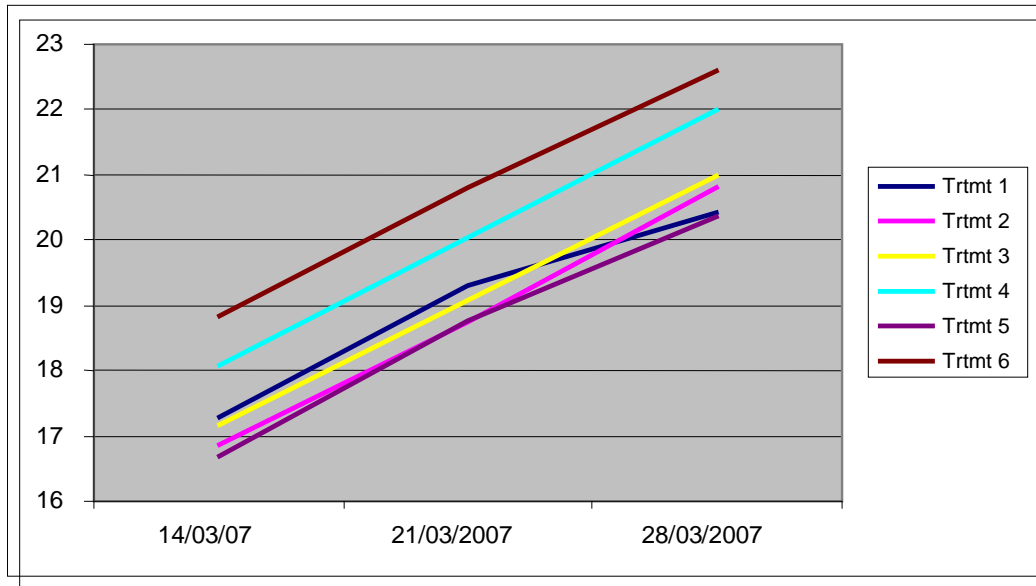
Table seven: Pre and post harvest berry weights

Treatment	Ave berry weight 14/03 (g) Pre-harvest	Ave berry weight 28/03 (g) Pre-harvest	Ave berry weight 30/03 (g) Harvest
1	1.84	1.88	1.84
2	1.84	1.87	1.87
3	1.92	2.13	1.99
4	1.89	2.04	2.03
5	1.82	1.95	2.06
6	1.86	1.92	2.02

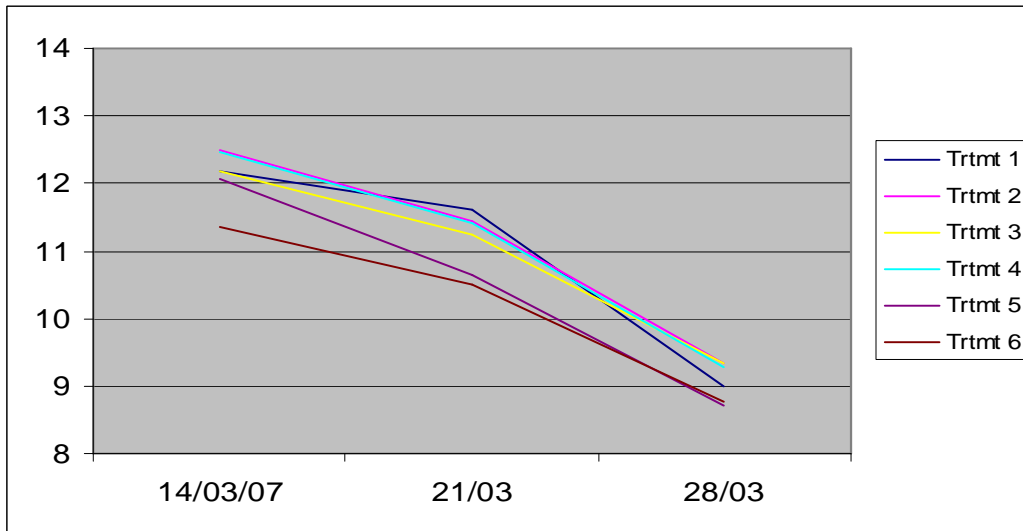
Pre Harvest Juice analysis

Berry samples were taken on the 14th, 21st and 28th March and analysed by Nautilus Estate. For each treatment 360 berry samples were taken (120 from each replicate). These were selected from vines in the same bay as the monitor vines. Graphs four, five and six show the brix, titratable acidity and pH of the pre harvest berry samples.

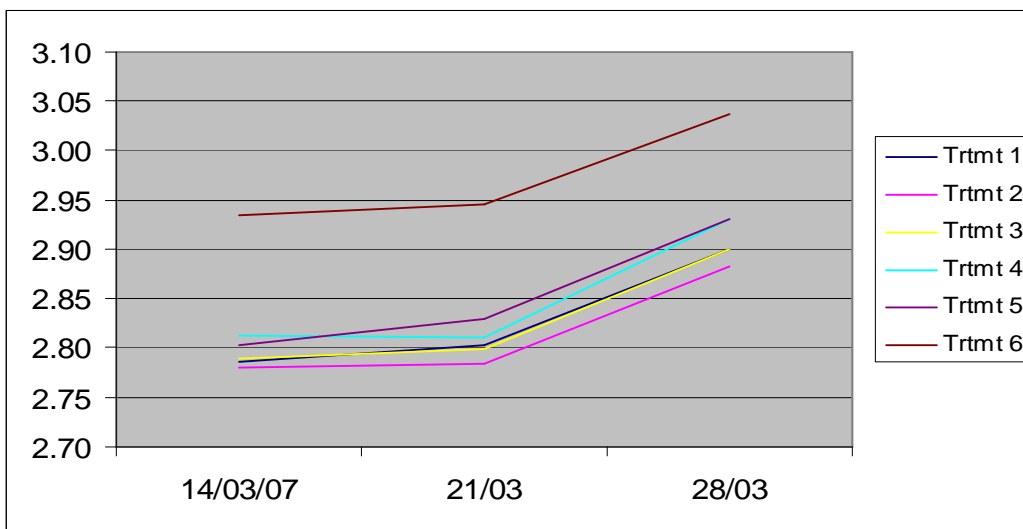
Graph four: Brix levels of sampled fruit



Graph five: Titratable acidity levels of sampled fruit



Graph six: pH levels of sampled fruit



In previous years the lower irrigation treatments tended to have lower titratable acidity and higher pH. This trend is not nearly so marked this year except in the case of treatment six which shows much higher pH than the other treatments and is the joint lowest titratable acidity, making the results for treatment six very similar to the 2005/06 season. There is also a marked difference in the brix levels in the case of treatments four and six with both treatments showing significantly higher levels than the others. This was much less so in the previous two years but in year one higher brix levels were evident on the lower irrigation treatments.

Harvest Juice Analysis

Pre-harvest juice analysis on the 28th March had shown that all the treatments had reached the target parameters set to determine harvest in the previous years. These were:

Brix - approx 21

TA - < 10g/L

Flavours - mix of herbaceous and tropical characters but without excessive greenness

Harvest was carried out for all treatments on the 30th March. For each treatment a 100 berry sample was analysed at harvest by Nautilus Estate. Table eight presents the analysis results:

Table eight: Analysis of the 100 berry sample at harvest.

Treatment	Harvest Date	Brix	T/A	PH
1	30/03/07	20.5	8.3	2.96
2	30/03/07	20.8	8.6	2.94
3	30/03/07	20	8.2	2.95
4	30/03/07	21	9.3	2.91
5	30/03/07	20.2	8.5	2.91
6	30/03/07	21.1	8.7	3.02

There was no significant difference between either the Brix levels or the T/A at harvest, whereas there were significant ($p=0.05$) differences between the lowest and highest irrigation treatments for titratable acidity in the previous year. The pH of the mulch treatment was still higher than the other treatments but not by as much as the pre-harvest analysis. It appears that at harvest there were no significant differences between the juice analysis of the different treatments indicating that the previous years different irrigation strategies were having little effect on juice characteristics at harvest this year.

Splitting

Splitting was not an issue this year and was not measured as a specific parameter

Bunch weight/ Bunch number

The number of bunches and their weight for each of the monitor vines was recorded and can be seen in Table nine. The average berry weight and berries per bunch come from the 100 berry sample collected from each treatment.

Table nine: Bunch number and weight for monitor vines.

Treatment	1	2	3	4	5	6
Bunches per vine monitor vines	71	67	66	54	67	58
Ave bunch weight monitor vines (g)	89	102	109	109	99	99
Average berries per bunch	48	55	55	54	48	49
Average berry weight (g)	1.84	1.87	1.99	2.03	2.06	2.02

In the previous year bunch weight was significantly ($p=0.05$) lower for the lower irrigation treatments. This season there is no significant difference ($p=0.05$) in with bunch number per vine or bunch weight.

Yield Analysis

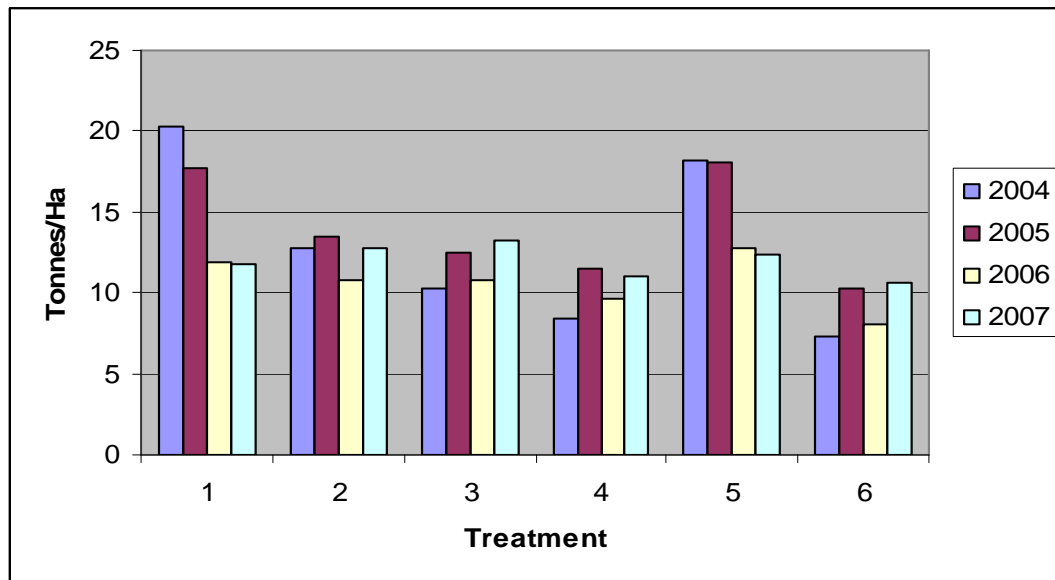
Table ten shows the yields on a per hectare basis for all treatments.

Table ten: Total yield per hectare for each treatment.

Treatment	1	2	3	4	5	6
Yield. (t/ha)	11.7	12.7	13.3	11	12.4	10.7
Yield % control	100%	109%	114%	94%	106%	92%

In the previous three years of the trial the lower irrigation treatments showed a lower yield in comparison to the control (Treatment1). Yields this year were generally similar although treatments 4 and 6 show a slightly reduced yield due to lower bunch numbers. This could be an effect of the more limited cane growth in the previous year. The yield data for all four years of the trial are shown in Graph seven:

Graph seven: All four years yield results



The weight of fruit from each bay was also recorded in the previous three years to determine if soil type variability down rows was affecting yield and if there was any difference between irrigation treatments. In the previous three seasons there was consistently more variation in the bay weights in the treatments with lower irrigation levels. The reasoning is that as the soil becomes lighter there is less buffering capacity within the soil to combat the lower irrigation regimes. Hence the effect on variation is more dramatic on the lower irrigation treatments. Table eleven shows the variation in yields per bay for the four years of the trial.

Table eleven: Bay weight variation 2004-2007.

Treatment	1	2	3	4	5	6
2004	5.7	2.8	1.5	1.5	9.5	7.1
2005	3.7	3.7	7.2	6.7	5.3	6.0
2006	0.0	2.5	3.2	4.1	2.5	3.1
2007	0.1	0.4	0.4	0.1	3.4	1.5

The results of this year's assessment show there is little variation in the bay weights recorded except in treatment five and suggests that the previous low irrigation treatments have had less effect on variation now 'normal' levels of irrigation have been restored.

Part of this extension project involved a literature review on vineyard variation and a discussion of the phenomena with industry winegrowers and researchers, the report of which is attached.

Pruning weights

To further assess the effect of this year's 'normal' irrigation levels on vine growth all the monitor vines were pruned by Nautilus staff on 19th June 2007 and the pruning's were weighed. Vines were pruned in exactly the same commercial manner as the rest of the block, with the aim of ending up with four fruiting canes. Wrapping and final cane selection had not been carried out. Table twelve lists the results

Table twelve: Pruning weights

Treatment	1	2	3	4	5	6
Total Kg	10.33	11.11	9.24	8.59	10.9	11.52
Ave per vine	0.861	0.926	0.770	0.716	0.908	0.960

Treatments three and four have lower pruning weight indicating the possibility of some level of growth reducing effect from the previous three years in this season. The mulch treatment however has the highest pruning weight.

CONCLUSION

In general, within the parameters assessed by this trial extension, all the original low irrigation treatments have responded positively to this year's 'normal' irrigation regime. In particular shoot growth and berry weight have shown a marked improvement compared to the previous three years on those treatments and less variation in juice characteristics was found at harvest. In row yield variations appear to be less in comparison to previous years.

Soil moisture levels stayed higher with the original lower irrigation treatments indicating those vines were still using less water despite producing similar yields, berry weight and shoot growth.

Although there is some minor indications that the previous years low irrigation treatments are still having an effect, overall from this work it would seem that vines deprived of water in previous seasons will revert to typical growth and yields when irrigation becomes available again at 'normal' levels.

References:

Dryden et al. 2004, 2005 and 2006. Maximising irrigation savings in grape vines and the effect on yield and wine quality. SFF project 03/100. End of year reports to the Sustainable Farming Fund and New Zealand Wine Growers.

Green S, Greven M, Neal S, and B Clothier, 2002. Regulated deficit irrigation (RDI) as a management tool to reduce water usage and achieve high yields of quality wine grapes. Interim Research Report commissioned by HortResearch and Marlborough District Council. HortResearch Client Report No. 2002/385.

Green S, Greven M, Neal S, and Clothier B, 2004. An assessment of vineyard planting density and the water demand of grapes. Research report commissioned by HortResearch and Marlborough District Council. HortResearch Client Report No. 2004/12344, pp 43.