Reduced irrigation and site/soil effects on Pinot Noir vine pruning weight and soil nutrient status

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A study in the Waipara region of North Canterbury in New Zealand is investigating the interaction between three different soil types and different irrigation volumes on vine responses.

INTRODUCTION

The influence of soil on wine qualities is generally agreed upon, but not so well documented. The interactions of vine roots with soil result in direct effects (such as nutrient availability) and indirect effects (such as influences on vine vigour and resulting changes in fruit exposure). Soil characteristics, such as texture, structure, water holding capacity and nutrient content, have been used to describe wine differences within and between different vineyards (de Andrés-de Prado *et al.* 2007), and this is logical given the influence these factors have on vine growth. In addition, vine management practices, particularly irrigation, influence vine responses in interaction with the soil environment.

Measurements of vine water status have definite correlations with vine performance, grape characteristics and wine composition (e.g. Chaves *et al.* 2007, Poni *et al.* 1993, Roby and Matthews 2004). As well, there are site-related factors influencing grape and wine quality, which have also been the subject of international research (e.g. Conradie *et al.* 2002, Morlat and Bodin 2006, van Leeuwen *et al.* 2004). As the climate and soils of New Zealand make irrigation a necessity for the majority of its vineyards, some researchers have studied the effects of site on wine-related parameters, e.g. Imre and Mauk (2009) in Central Otago, Bramley *et al.* (2011) in Marlborough, and Tesic *et al.* (2002) in Hawke's Bay. However, there remains much to discover about the interaction of soils and irrigation.

We have been conducting a study in the Waipara region of North Canterbury where vines growing in three distinct soil types were irrigated to commercial or to approximately half of commercial rates. The sites were separated by relatively small distances to keep the regional climate the same. The treatments allowed the authors to examine the interaction between soil type and irrigation on vine responses. This article reports on a component of this research project.

MATERIALS AND METHODS

The vineyard areas were located in the Waipara area of North Canterbury, in New Zealand. Three sites, each with distinct soil types, were chosen for the study:

- Gravelly sandy loam (GSL), characterised by large amounts of rounded stones, no limitations to rooting depth and generally low water holding capacity. Alluvial in origin.
- Clay loam type 1 (CL1), characterised by a clay loam horizon of about 30cm with swelling clays underneath. Rooting depth is generally greater than one metre. Developed from soft calcareous rocks of alluvial origin.
- Clay loam type 2 (CL2), which is similar to CL1, but with shallower rooting depth of 50cm due to the presence of fractured rock beneath.

Each site was planted to VSP-trained Pinot Noir, clone 115, vines of similar ages (around nine years at the start of the experiment). Rootstocks were 101-14 at CL1 and CL2, but 3309 at GSL. The GSL site was under different management from the CL sites (for example, vines at GSL were three-cane pruned and those at CL sites spur pruned), which was also reflected in different irrigation strategies.

Four replications of five contiguous vines each (with buffer vines on either side) were used as controls and another set of four replications for the reduced irrigation (RI) treatment. The latter consisted of removing every other irrigation emitter. Irrigation amount and frequency was determined by each property's vineyard manager.

The maximum distance between sites was 5.4km, and because meso-climate has a significant effect on vine growth and management, weather data was collected from close-by weather stations, as well as from temperature loggers placed in the canopy at each site.

Treatments were in place from December 2013 through to post-harvest 2016 (following pruning data collection).

RESULTS AND DISCUSSION

There were some differences in temperature between sites. For example, in the 2014-2015 season GSL was the coolest, with a growing degree days (GDD) of 1290, CL1 was the warmest (1490 GDD) and CL2 was in-between (1330 GDD). These differences were partly caused by slope, as GSL is on flat land, while both CL sites are on north-facing slopes.

Water balance figures for 2014-2015 were also different between the sites (Figure 1, see page 40). There was 192mm of rain at the GSL site and the amount at the CL sites was very close to this (less than 5 per cent lower), so irrigation made up the largest changes in terms of water balance. The approximately 50% reduction in irrigation due to the RI treatments resulted in less than a 10% difference in monthly water balances.

GSL, due to the free-draining soil, received the most water through irrigation (135mm for the season). CL1 received 39mm and CL2 78mm due to the higher water holding capacity of the soil and a different water management strategy at that property. Therefore, the differences in the amount of irrigation water delivered between the control and RI treatments at any site were relatively small compared with the entire water budget. ▸

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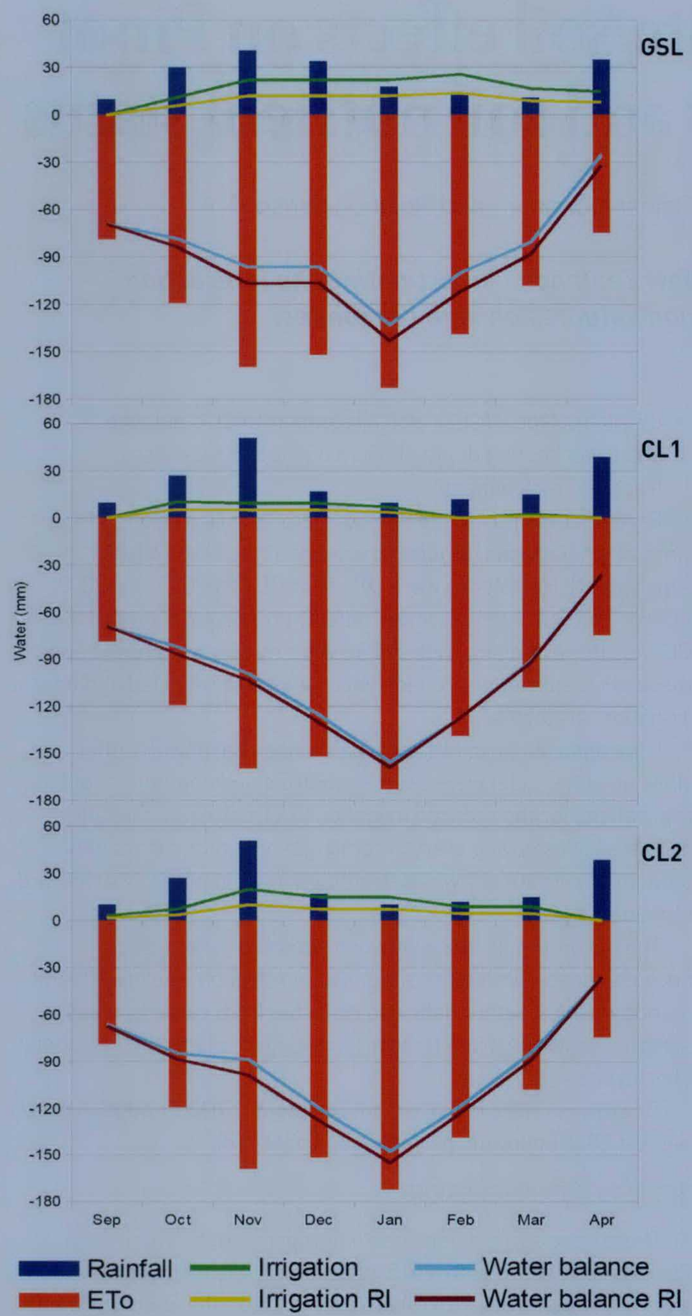

Figure 1. Water balance for the three soil/site/treatment combinations in the 2014-2015 season. Values corresponding to RI indicate reduced irrigation treatments.

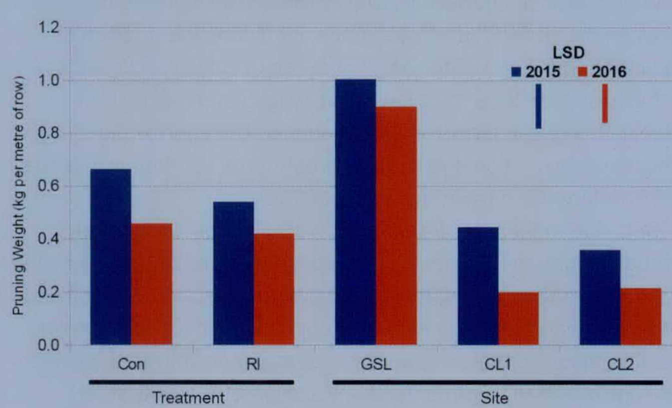

Figure 2. Vine pruning weights, on a kilogram per metre of row basis, between the treatments and sites for 2015 and 2016. There was a significant treatment effect in 2015, but not in 2016. Between site effects were significant in both seasons.

Vine pruning weights for the second and third years of the trial are shown in Figure 2. Vines at the GSL site were considerably more vigorous compared with either CL site, with significant ($p=<0.001$) differences in weights. An irrigation treatment effect was evident in 2015, but not statistically significant in 2016, though the same trend was there. Vine size decreased across the board between the second (2015) to the third season (2016) of the trial, possibly due to low crop loads in all vines in the 2015 harvest season. The small crop was caused by widespread and early season frost damage (Mejias-Barrera 2016), which resulted in compensating vegetative growth.

Vine pruning weights at GSL were essentially the same between control and RI in both seasons, most likely because the volume of water being applied in the RI treatment was not yet limiting to vine growth. While there were no statistically significant differences in pruning weight due to irrigation treatment at either CL site in 2016, the vines appearance was substantially different (Figure 3). The lack of a significant result may lie with the very small vine sizes in both treatments in that season: 0.24kg/m row for the control and 0.17kg/m row in the RI. The relative amount of variation between vines when they are this small is higher, leading to less ability to reveal treatment effect.

The impacts on vine carbohydrate status at the end of the third season were also variable across sites and by treatment. GSL vines had the highest level of stored starch (approximately 7.9% of root dry weight), with CL1 and CL2 being significantly lower (7.1 per cent for each). The only irrigation treatment effect on root starch was at CL2, where starch in RI vines was 73% that of the control vines. This was surprising, as the visual difference between control and RI vines at CL1 was as striking as it was at CL2.

A longer-term assessment of vine responses to the treatments would be necessary to determine how much the vines are affected by the reduction in water delivered, especially in relation to their ability to grow shoots and set and ripen fruit. A number of successive drier-than-normal seasons, for example, could result in the RI vines growing much less to the point of severely harming vine health and productivity.

The soil environment is likely to change with soil type and location, but reduced application of water may also cause differences in soil micro-organisms and growth of other plants, leading to soil compositional changes. Soil samples collected in the 2016 dormant season were analysed and the results are presented in Table 1. Reduced irrigation had no effect on soil parameters, but many of these were affected by soil/site. CL2 recorded the highest cation exchange capacity (CEC) and along with this, higher levels of calcium, potassium, magnesium and nitrogen.

Olsen P, organic matter (OM), total base saturation, total carbon and pH measurements were lowest at CL1, but that soil had the highest bulk density.

Given the relatively small differences in total water supplied by the two irrigation treatments, it is perhaps not surprising that soil effects were not detected. However, more than three years of experimentation may be necessary to pick up an effect, as the treatments may take years to result in measurable changes.

CONCLUSIONS

Reduction of water supplied through the irrigation system in three North Canterbury commercial vineyards resulted in relatively small (around 10%) changes to overall vine water balance on a monthly or seasonal basis.

Figure 3. Comparison of control (left) and RI (right) vine at CL1 in April 2016.

Table 1. Soil parameters as affected by site/soil and irrigation treatment. Samples were collected in the dormant season, three seasons after treatments began.

	Treatment			Site		Significance		Units
	Con	RI	GSL	CL1	CL2	Treatment	Site	
CEC	12.67	12.58	11	11.25	15.62	0.878	<0.001	me/100g
Ca Meq	6.38	6.64	5.26	5.07	9.19	0.537	<0.001	me/100g
K Meq	0.655	0.517	0.594	0.185	0.979	0.127	<0.001	me/100g
Mg Meq	1.282	1.335	0.981	1.169	1.775	0.635	<0.001	me/100g
Na Meq	0.209	0.273	0.211	0.21	0.302	0.263	0.319	me/100g
Olsen P	12.1	9.8	13.6	7.4	11.9	0.393	0.155	mg/L
OM	2.39	1.97	2.37	1.67	2.49	0.144	0.06	%
Total Base Satn	66.7	67.9	65	58.5	78.4	0.743	0.002	%
Total C	1.392	1.15	1.387	0.975	1.45	0.161	0.064	%
Bulk Density	1.062	1.072	1.07	1.104	1.026	0.779	0.227	g/mL
pH	5.92	5.97	6.01	5.64	6.19	0.756	0.012	

Medium term (three growing seasons) reduction of irrigation water delivery in three commercial vineyards had varying effects depending on the soil type and irrigation management regime. The soil with the least water holding capacity was watered the most frequently, leading to no effect on vine pruning weights even when the amount of water supplied was reduced by almost half. Both clay loam sites had reduced (although not consistently so) pruning weights with the lesser irrigation treatment, but the largest differences were between sites, with the well-watered GSL vines having significantly higher pruning weights.

Changes to irrigation had no effect on measured soil parameters, but there were large differences between sites/soils. CEC and related parameters were higher at CL2, likely helped by its relatively high organic matter content. Olsen phosphorous measurements was lowest at CL1, along with organic matter, total base saturation, total carbon and pH values. The magnitude of differences between soil parameters were not large, so soil effects were probably mostly due to soil water holding capacity combined with the amount of irrigation water delivered.

The research highlights the importance of matching water delivery to vines with the soils that they are growing in, so that vine growth and productivity parameters can be met.

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