CASE STUDY
BRIAN CADDY

Winegrape Grower; Barmera SA.

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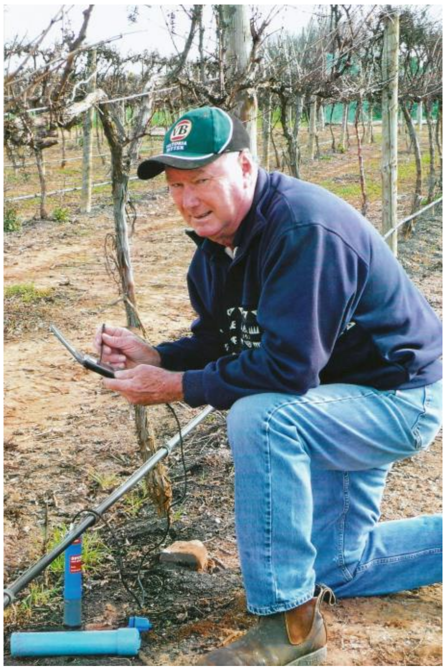
Caring for Our Country project:
Adopting Best Practice to Enhance Soil Condition in Horticultural Systems

Project ID OC12-00346

IMPROVING SUSTAINABLE VINEYARD PERFOMANCE
(When bulk compost is not affordable)

Brian Caddy and his challenging vineyard



When Brian bought his vineyard in 1965 it was producing grape varieties for drying. The property was originally set up by a 'soldier settler' (Brian says he probably would not have worked the original plots if he had begun with a soil survey! The previous owners planted in unsuitable sites, the biggest issue being shallow impervious limestone layers.)

He began converting the property to wine grapes in 1973 when he also replaced his furrow irrigation system with overhead sprinklers. He now has 7.04 Ha under winegrape production. Like most growers in the late 70's Brian began replacing the 'own' rooted plants with grafted root stocks and now only has one small block of Cabernet Sauvignon with original rooted plants.

'Yes, Brian had some major challenges in front of him which soon began to unlock the 'researcher-pioneer' in him'.

Brian began with the aim of reducing water use by understanding actual plant needs and how to monitor and control water in the soil profile to meet those needs efficiently. He expanded this to managing all aspects of the soil profile, including nutrients and salts. This then progressed to a highly modified nutritional program. Brian is convinced that understanding soils is the foundation for effective crop management in all of these areas. He began by comparing plant health and yields at different sites over time, and used expert advice to identify and measure underlying issues affecting plant performance. He assessed his irrigation, soil condition (esp. salinity) and nutrient supply giving him the capacity to plan trials for testing new management strategies and assess the results. Brian also wanted to find out if he could achieve some of the benefits of compost without the high cost of transporting bulk material to his farm. He did not just try out the best sounding new product or practice but collected data on his inputs and yield outcomes on several blocks of vines to measure any significant changes he was able to generate by changing his management.

This approach has enabled Brian to answer questions about his farming system, measure the impact of modifications, and establish an ongoing program of improving his management practices. This has been a long process beginning in the mid 70's which has achieved dramatic water savings and significantly reduced fertilizer inputs. ***Rather than his yields decreasing as a result of reducing his inputs, they are gradually lifting in response to very targeted management of his inputs to meet plant needs.*** In spite of major water savings from 2003 on, it was not until 2008 that Brian felt he was really putting it all together when he saw very positive results to major changes in his fertilizer program, but read on …………

A HISTORY OF CHANGES MADE
TO IMPROVE FARMING EFFICIENCY AND SUSTAINABILITY

Brian began realizing in the mid 70's that Riverland growers, like himself, had some sustainability issues. Like most others he was applying 5 general (furrow) irrigations per season and additional 'special' irrigations if necessary. In the mid 1970's he converted from furrow to overhead sprinklers. This was potentially a more efficient way of irrigating and required less cultivation and furrow maintenance.

But Brian found he continued using just as much water. He would also apply 'feel good' fertilizer and then irrigate and effectively wash it out of the root zone! But the water supply was not guaranteed and would need to be used more efficiently in the near future, including for leaching salts. Fertiliser's were also becoming more costly and yields seemed to have peaked. Involvement with the River Murray Water resources Committee from 1989 made him realize that these practices were terribly inefficient and unsustainable.

'Brian started looking for a better way to do some of these things and began with a direct attack on water use efficiency issues without wanting to compromise yields'.

Improved drainage, soil surveys and ICMS plan

In 1990 he conducted soil surveys across his property to identify variations in soil type so he could calculate any differences in water holding capacity (Readily Available Water (RAW)). At first he did this just to demonstrate best practice because he was on the River Murray Water Resources Committee but it became a major turning point in his farm management. He began to see the importance of understanding soil-water and drainage and in 1992 began redeveloping a really tough part of his block into what became a local showcase of very healthy vines. He spent $40,000 on a vacant degraded, highly saline 2.5Ha parcel of land. Brian installed drains in deep furrows, applied grape mark, gypsum and sorghum to improve the soil condition and removed rocks in truckloads. He brought in some red sand and planted new vines in holes drilled through a limestone shield. He leached the system heavily at first to get the salts down into the drains. The vines took off and his efforts paid off returning his money in no time at all. PIRSA and TAFE now use this site as an example of effective land reclamation for horticultural use!

In 1993 PIRSA and SARDI experts assisted him to develop an integrated irrigation, drainage and management plan (IDMP) for his irrigation system across his property. They helped him to identify that his distribution efficiency was inconsistent, which was preventing him from achieving a uniform irrigation delivery at desired application rates. Amongst other things he needed to install bigger valves and pumps.

At this stage he was still using sprinklers to irrigate with. In spite of this valuable knowledge Brian found he still could not improve his water use to the benchmark 85% efficiency and yields elsewhere on the farm continued to decline. He knew he was missing key insights into what was going on in his soil at critical depths with water, nutrients and salinity. Just applying more or less water was not the whole answer. Brian realized he needed to develop ways to measure these critical factors and control things like timing and depth more effectively.

In 1998-99 Brian decided he needed to make further major changes because he saw the future was not sustainable using 10 + ML/Ha/annum. Now he wanted to know how the whole system worked.

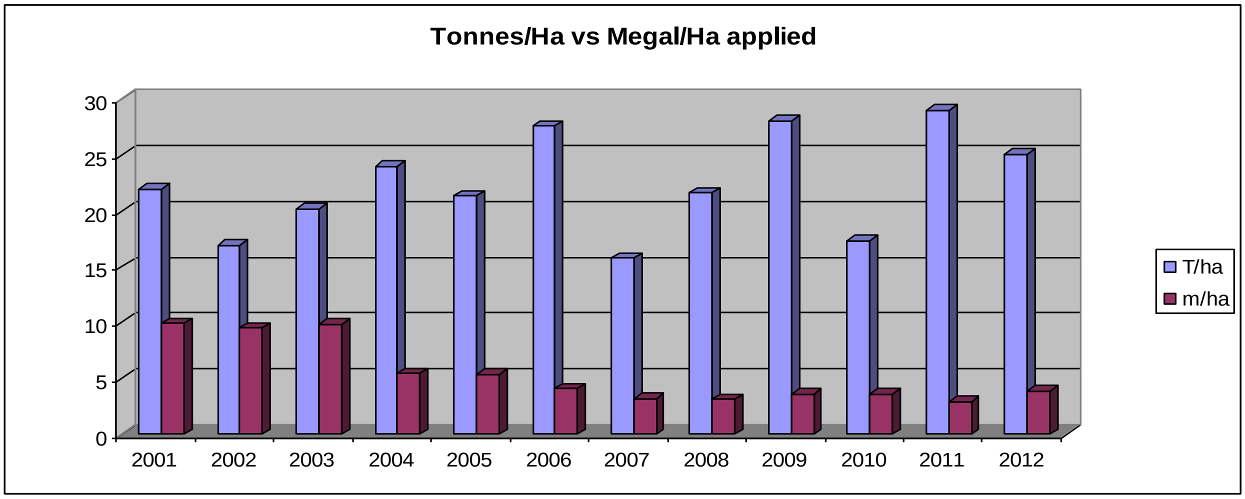
Installing drippers for greater efficiency

The breakthrough came when he joined a PIRSA/SARDI irrigation efficiency project in 2002 that was supported by training in the use of various monitoring and decision tools. This technical support helped Brian to realise that there could be no future using sprinklers in a restricted water environment, and he changed to drip irrigation in 2002-3 with immediate results improving his yields modestly while using much less water. Brian's change to drippers also meant that he stopped irrigating his mid row and abandoned his efforts to maintain a cover crop. In a single year Brian reduced his water application from 9.8ML to 5.42ML per Ha. Brian has a water allocation of 79ML water per year, but up to the end of March 2013 he has only used 17ML despite this season being the driest and hottest year on record.

By the 2005-06 season, Brian was only using 4.08ML/Ha and got 27.91 T/Ha of chardonnay, and by 2006-7 he was down to 3ML/Ha. This was typical of other varieties with a farm average of 26 T/Ha in the early 2000's rising to around 28 T/Ha or more in recent years. This was all achieved by using management tools that allowed him to check soil moisture from 1,000km away by using his lap top to run the Enviroscan irrigation monitoring program.

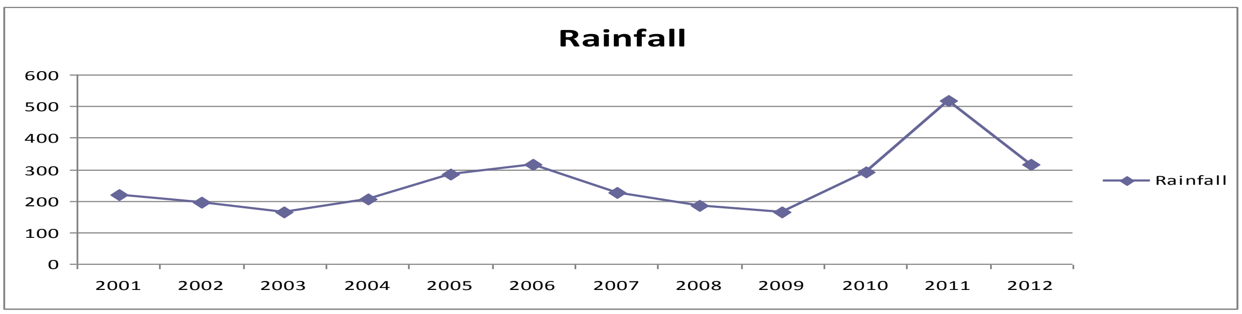
Below in Fig 1 is a graph comparing yields/Ha and ML/Ha applied for 2001 - 2011.

Fig 1: Tonnes per ML, per Ha



Rainfall is graphed below for the same period

Fig 2: Rainfall 2001 - 2011



Notes:

- ***Yields are sustained in spite of low irrigation and low rainfall during the drought!***
- ***2010 was a year of restricted intake by the wineries suppressing the harvest count.***

Salinity well in check in spite of using less water

From this time Brian also began applying fertilizers direct to the root zone through his drippers. He also replaced acidic fertilizers with humate based products that add less salt. By reducing his water and fertilizer inputs to only what the plants needed, he reduced his salt inputs and made it easier to keep his nutrients in the root zone, and apply less water for leaching applications.

Brian monitors salinity and (sometimes his nutrients) using soil water extractors at 30, 60 and 90cm enabling him to see what is happening throughout the soil profile. He uses a salinity calculator developed for the SARDI designed "Solu-Sampler" extractors and does 2 monitoring extractions per year. Salinity data from across his farm has been collated. Brian used to leach annually but using this information he only leaches if his data indicates that he is heading to undesirable salinity levels, which is not often! ***Brian's annual petiole testing shows no substantial change in petiole Na or Cl despite an over 50% reduction in irrigation inputs.***

See Figs 2a & 2b below – graphs of Sodium and Chloride for two different patches

Fig 2a: Chardonnay

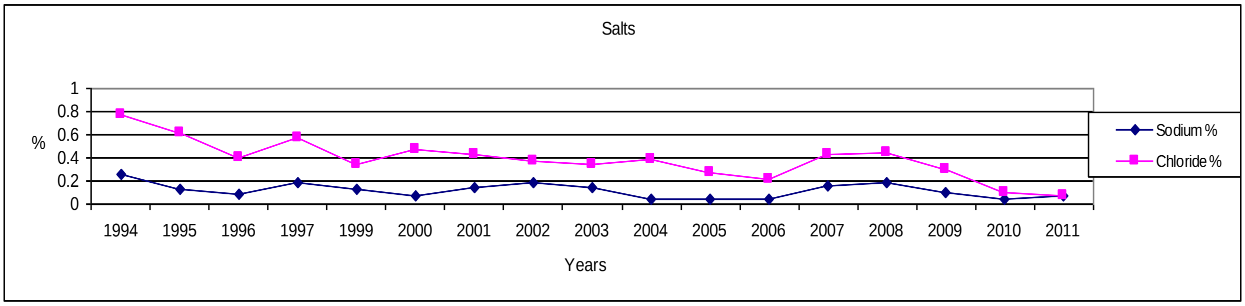
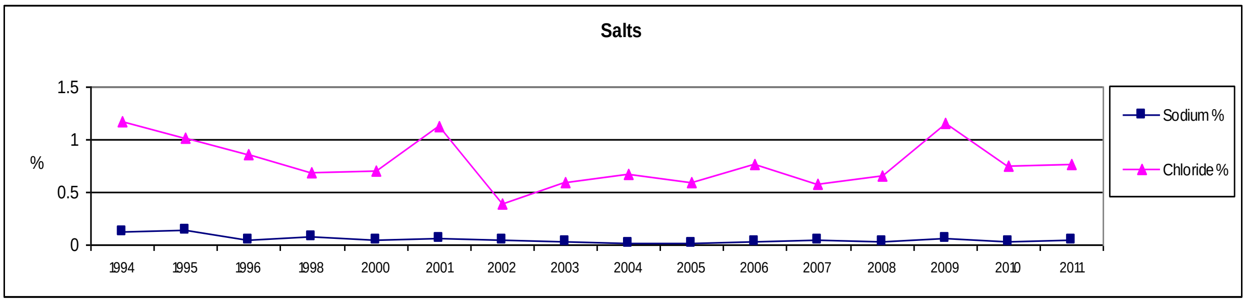


Fig 2b: Cab Sav



Interestingly Brian's trigger points for irrigation have not changed since he did his ICMS plan and (IDMP) in 1993-4. He simply has more targeted control of water applications using drip irrigation. This saved him from applying soluble fertilizer and water over the whole of the block. So in contrast to his days of heavy applications and guesswork using furrow and sprinkler he now targets the active root zone with precision and regularly waters down to 30cm to meet plant moisture needs and keep fertilizer in the root zone for as long as possible. So he irrigates little but often, always keeping an eye on the weather to ensure that the vines have adequate moisture within the root zone to protect them from stress, especially in dry conditions.

'Brian had been worried about reducing the wetted area to 30%, but his yields improved immediately while using less water and therefore leaching less nutrients and salt into the wider environment! His motto now is 'Make the plant happy in the top 30cm"!

Brian attributes a significant part of his gains in soil water efficiency to his use of Humic, Fulvic acid and FF50 used little but 'often'. His agronomist understands that they act like a sponge enabling the soil to hold more water. Brian has no direct data to confirm this but results have been positive since replacing conventional fertilizers with these products. Trace elements are still applied as per soil and petiole tests as required. More below ………

Improving soil water retention, improving nutrient efficiency and reducing salt inputs

Between 1990 and 2003 Brian was practicing typical conservative management with no cultivating, a permanent mid row cover crop (clover & fescue) and putting out 43 T/Ha/yr of grape mark for many yrs, together with 4 tons gypsum/Ha.

He was not doing much soil testing because he did not see the need, thinking that petiole analysis was better value. But because he was seeking improved water retention and nutrient efficiency he considered using compost to raise the organic matter (OM) in his soil which would help in achieving these goals. Bulk OM can be relatively quickly obtained by adding compost but Riverland growers tend to view transport costs as prohibitive and have not yet seen any costed vineyard trials to change this view.

Triggers for changing nutrient management

In 1998 a soil test returned an Organic Carbon (OM) value of 1.5% which the agronomist at the time thought was pretty good. Results in 2003 showed a drop to 1.2% OC and in 2006 to .76% OC. Brian's organic carbon levels were going down because he had stopped growing cover crops.

In 2006 when Brian was chairing a salinity project involving SARDI researcher Dr. Tapas Biswas, Tapas explained how to use a soil water extractor to determine salt levels at different depths in the soil profile. Brian immediately realized that he could put the extractors to additional use by also measuring nutrients throughout his soil profile from these water samples. He could then link control of both salt and nutrient movement to his irrigation strategies. He was also beginning to question his use of acid based fertilisers and the salts they contained and the cost of what was being locked up in his soil and wasted.

For some time Brian had been using recommendations from an agronomist based on occasional soil tests. From the soil tests he was aware that he had high levels of N, P Fe and Ca Nitrate locked up in his soils. In 2003 he decided to test the next set of recommendations and put out fertilisers (Map Tech, urea, Zn, Mn, Humic, Iron, CaNitrate) at half the recommended rate and did a petiole analysis. He found the plants did not become deficient! (see ATTACHMENT 1. Petiole Analysis 1994 – 2011) His intention was to unlock the fertilisers in his soil and he indeed saw benefits in the first year. Brian had occasionally used some Humic acid prior to this but because of these results and with supporting advice from another agronomist he began applying Humic and then Fulvic acid on a regular basis since 2006. He found that his iron uptake issues were also overcome and he has not required phosphorous in recent years since changing to these products.

Humic and fulvic acids are 'natural' soluble soil nutrients released as the organic material reaches an advanced stage of breakdown from biological activity. Humic and fulvic acid are essentially a concentrated end product of decomposing organic matter that can be transported with lower bulk costs than compost. As with compost these forms of active organic carbon help to unlock nutrients which were in Brian's soil in abundance. Regular use of Humic and Fulvic acids has enabled Brian to significantly replicate the role of adding bulk organic matter to his soil.

When feeding his vines Brian applies **Fulvic acid then Humic acid** combined with molasses 7 days later. He does this at bud burst to set the plants up for the season ahead. He also applies a late season dose of nutrients in early March when he puts out urea, molasses and humic acid (there is no point putting out Fulvic late in the season) and waters to 30cm and waters again in late March to the same depth. This enables him to perch his fertilizer in the top 30cm setting up for next season when these nutrients will be at their most bio-available.

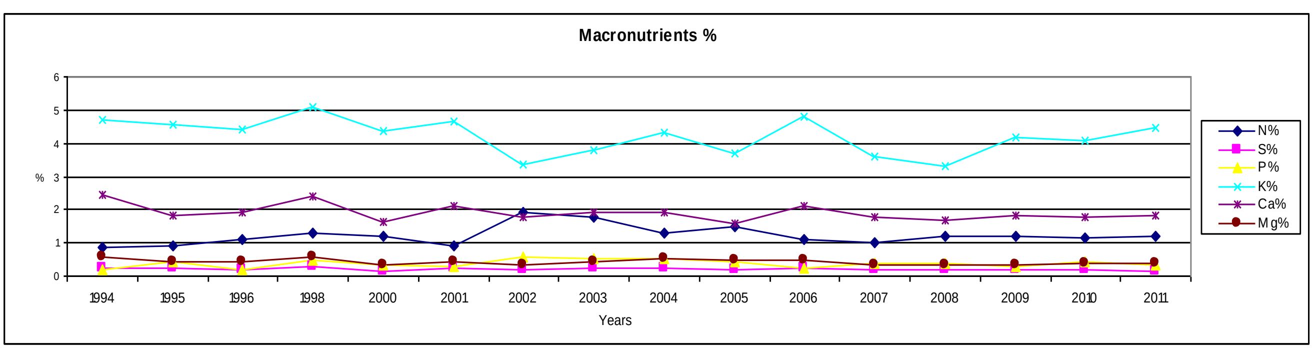
Since 2006 Brian has also begun using FF50 as a slow release source of humic type substances. He believes that **FF50** is better as a soil carbon builder than grape mark. Brian has found since using FF50 he can cut back on N application, probably because it is helping to unlock N stored in the soil. He uses 2.5 T/Ha of FF50 and is about to make the 3rd application in 3 years. Brian also uses twin N to boost nitrogen. In 2013 his rates for Humic acid have been substantially increased from about 1Kg/Ha to about 8Kg/Ha. See ATTACHMENT 2 for Brian's fertilizer applications from 1994 – 2011 (does not include FF50)

Soil microbes are used to assist nutrient cycling and bio-availability. Brian makes a suspension of soil microbes brewed for 18hrs and strained through a silk stocking. He then 'fertigates' them with some Molasses as food through the drippers. He has added them several times since 2003. He is not conducting any testing of microbial levels, but believes they are helping to unlock nutrients and improve soil structure.

The value of Soil and Petiole Testing

From about 1992 Brian's petiole testing was primarily for tracking salinity, but since about 2009 he began also checking for trace elements. Occasional soil testing from about 1992 looked at salinity only, but since 2003 Brian began checking for trace elements and identified that he had abundant fertilisers locked up in his soil. Since 2007 Brian began looking at soil tests in conjunction with petiole tests on an annual basis to checks nutrients, TEC, trace elements, salinity etc. As a result of thorough testing Brian has now completely abandoned 'feel good' fertilizer applications and replaced them with very specific fertigations based on his soil and petiole tests. As a result there is much less fertiliser locked up in his soils and leaching away, saving money and reducing the overall EC levels.

Brian's nutrient results are constantly monitored (both soil and plant) and have stayed on track in spite of the major changes he has made. See fig 3 below for a graph of the macronutrients over time



Since using Humic, Fulvic and FF50 (in 2006 & 2008) Brian's TEC readings have steadily improved to double the desired level according to his last soil report, meaning that there is a very free exchange of cations in the soil. This also means the salts are easier to leach out. Brian's soil is now holding and releasing water and nutrients much more efficiently, in particular because of using Humic and Fulvic acid and FF50 which have raised his cation exchange capacity.

'Brian is confident that if he gets everything right with irrigation, fertilisers, microbes etc., in terms of rates and timing, then conservative inputs will do the job much more cost-effectively and make his farm more sustainable'.

Summary of the monitoring and recording tools Brian uses:

All of the outcomes that have been achieved have relied on sound knowledge of how plants, water, soil and nutrients interact with each other, and being able to monitor and control what is going on in the soil and in his plants.

For primary data gathering

- Eyes on plants, looking for signs of stress and improvement at the earliest possible stage
- Dig stick/auger to look at moisture levels and assess soil types
- Annual soil testing is more valuable now he knows he can unlock most nutrients so they become available to his plants
- Petiole analysis for nutrient and chloride monitoring
- SARDI soil water extractors for salinity monitoring and fertiliser penetration assessment
- Soil moisture probes providing digital data form for computer upload.

Digital collation and analysis

- The CIT irrigation meter records his daily and total water uptake
- Enviroscan software receives data from soil moisture probes and can be checked from remote long distances away
- IRES software enables him to prepare detailed irrigation reports for all blocks (does not always agree with the CIT meter!)
- Chemical desktop filing and reporting of nutrients, and pesticides and 'biologicals' with dates, rates and costs
- Internet weather sites provide forecasts and histories that are useful for assessing his irrigation applications and crop performance against rainfall.

Brian uses all of these in combination to get a complete picture. Realistically to get full value from being competent with these tools requires a good training program, or a long term on farm learning project with expert support!

'While interviewing Brian, he emphasized the importance of some key experiences and ways of thinking that enabled him to realize what his real needs were and succeed in addressing them'.

There are a number of simple sayings he lives and works by including:

- *Make the plant happy in the top 30cm – don't waste any more, only give them what they need*
- *Its all about timing – make sure its there when the plant needs it*
- *Instead of big hits every now and then a little but often is better*
- *Know your targets. Get your tools. Stay on track by checking moisture readings, soil and petiole tests, irrigation meter flow rate and good maintenance of filters, drip lines etc.*
- *You need to put some research and physical effort into it and be patient. The results will come*
- *I'm a sponge myself. If I lack knowledge on a problem I don't hesitate to seek out expert help*
- *It purely comes back to economics*
- *During the tough times water management separated the sheep from the goats.*

Brian hasn't finished learning and is convinced that there is much more to learn including:

- What is going on with nutrient uptake late in the season and other aspects of plant nutrition
- Is doing a leaf analysis at the beginning of the year the right time, or is it better just prior to harvest? (he now knows that the fruit cells are produced in Nov-Dec for the next season)
- He wants to continue improving his management of water and salinity
- He wants to know more about the optimal use of humate's (Humic and Fulvic acid, FF50)
- He feels there is more to learn about how soil microbes respond to management actions and what effect their activity has on nutrients, soil and plants.

Project Summary

Project Organisation: Hortex Alliance
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Grower Support Officer: Mr. Noel Johnston

Acknowledgements

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- Noel Johnston for quality industry training – More people should do such courses!
- Dr. Tapas Biswas for developing the SARDI "Solu-Sampler" to check salinity and fertiliser's in the soil profile
- Central Irrigation Trust for efficient water supply & technology to track water usage
- Tony Adams (PIRSA) for irrigation management support including using the IRES (Irrigation recording efficiency system).
- The Barmera Ag Bureau grower group for guest speakers and a valuable exchange of ideas.

Project information and soil management factsheets etc. are available on the Hortex Alliance website (http://www.hortexalliance.com.au

ATTACHMENT 1

LIMESTONE RIDGE VINEYARD (Petiole Analysis 1994 – 2011)

Patch 2: Chard on Ramsey 1984. 1.42ha 16 Rows

	Adequate	1994	1995	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Nitrate Nitrogen mg/kg	500-1200	857	1560	1500	1900	2473	820	1550	2150	3800	3900	1500	2400	3100	760	293	519	339
Total Nitrogen %	.80-1.10	1.047	1.2	1.8	1.4	2	1.19	1.38	1.71	1.9	1.6	1.6	1.4	1.5	1.7	0.92	1.05	1.07
Sulfur %		0.259	0.13	0.17	0.17	0.3	0.14	0.18	0.23	0.23	0.21	0.19	0.17	0.18	0.23	0.16	0.17	0.14
Phosphorus %	.2-.46	0.536	0.38	0.42	0.52	0.87	0.31	0.62	0.58	0.76	0.63	0.57	0.42	0.48	0.58	0.42	0.6	0.56
Potassium %	1.5-3.5	2.45	3.17	2.1	3	3.36	2.77	2.99	1.75	4.6	3.7	2.3	4	2.9	2.2	3.08	2.99	3.23
Calcium %	1.2-2.5	1.92	1.41	1.7	1.6	1.56	1.54	1.33	1.7	1.5	1.8	1.5	1.9	1.3	1.5	1.85	1.81	2.1
Magnesium %	>0.3	0.93	0.66	0.52	0.43	0.6	0.36	0.34	0.55	0.44	0.42	0.38	0.51	0.38	0.47	0.46	0.48	0.47
Sodium %	<.30	0.251	0.13	0.09	0.18	0.127	0.07	0.14	0.18	0.15	0.05	0.05	0.04	0.16	0.18	0.1	0.05	0.07
Chloride %	<1.0	0.771	0.62	0.4	0.57	0.34	0.47	0.43	0.37	0.35	0.39	0.27	0.21	0.43	0.45	0.3	0.1	0.07
Copper mg/kg	>6	129.8	220	22	42	165	139	234	289	470	110	120	10	12	9.7	8.24	101.5	128.4
Zinc mg/kg	>35	99.5	45.4	110	50	102	76	66	140	110	72	160	70	84	89	158.8	91.49	71.9
Manganese mg/kg	>25	34.4	19.2	36	16	31	49	32	36	48	41	45	56	52	28	95.48	50.11	23.88
Iron mg/kg	70	50.2	54.4	50	36	32	39	24	104	56	25	23	48	42	37	62.95	22.83	66.39
Boron mg/kg	30-100	53	38.1	39	42	40	40	36	41	48	38	43	43	45	41	48.91	41.02	39.33

Patch 4: Cab Sav own roots 1973. 1.8ha 33 Rows

	Adequate	1994	1995	1996	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Nitrate Nitrogen mg/kg	500-1200	851	440	1000	1680	1390	890	4280	2800	3200	3000	1400	2200	740	1106	1422	858
Total Nitrogen %	.80-1.10	0.874	0.92	1.1	1.3	1.22	0.89	1.94	1.8	1.3	1.5	1.1	1	1.2	1.19	1.14	1.22
Sulfur %		0.223	0.24	0.2	0.3	0.16	0.24	0.19	0.23	0.22	0.21	0.22	0.2	0.17	0.21	0.19	0.15
Phosphorus %	.20-.46	0.204	0.44	0.18	0.46	0.34	0.31	0.6	0.54	0.52	0.44	0.26	0.37	0.4	0.28	0.41	0.33
Potassium %	1.5-3.5	4.70	4.55	4.4	5.1	4.37	4.68	3.37	3.8	4.3	3.7	4.8	3.6	3.3	4.19	4.08	4.45
Calcium %	1.2-2.5	2.458	1.83	1.9	2.4	1.65	2.12	1.8	1.9	1.9	1.6	2.1	1.8	1.7	1.82	1.79	1.81
Magnesium %	>0.3	0.58	0.45	0.45	0.57	0.32	0.43	0.33	0.44	0.55	0.47	0.49	0.33	0.36	0.35	0.38	0.39
Sodium %	<.30	0.118	0.14	0.05	0.08	0.04	0.07	0.05	0.03	0.02	0.02	0.03	0.05	0.03	0.06	0.03	0.04
Chloride %	<1.0	1.179	1.01	0.86	0.68	0.7	1.12	0.39	0.59	0.67	0.6	0.76	0.58	0.65	1.16	0.75	0.76
Copper mg/kg	>6	62.1	114	6.6	110	74	95	90.8	320	140	99	19	104	9.9	9.56	59.73	92.47
Zinc mg/kg	>35	45.1	47.9	85	80	38	43	63	54	71	68	110	87	50	119.5	64.28	42.83
Manganese mg/kg	>25	25.1	53.4	60	55	21	65	25	25	53	21	82	58	32	66.46	35.64	18.13
Iron mg/kg	70	29.2	55.4	50	90	36	42	45	70	15	40	24	47	20	33.72	15.73	36.52
Boron mg/kg	30-100	45.5	22.6	33	47	39	35	46	39	38	37	34	42	43	42.18	38.95	39.54