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Executive Summary

The status of soil health in the viticulture and wine industry

A review

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Note: The Table of Contents is included in this Executive Summary so that readers can access the specific details of topics in the body of the review.

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Executive summary

What is soil health? 'Soil health' is a relatively recent term that in popular parlance has replaced the more rigorously defined concept of 'soil quality'. Whereas soil quality describes a soil's fitness for purpose, taking account of a range of inherent and dynamic soil properties, soil health emphasizes soil biology and the concept of a soil supplying ecosystem services.

This review examined Australian and international literature on soil health in a holistic sense, that is, soil health equals soil quality. The focus was on the interaction of physical, chemical and biological properties that drives important soil processes, and how these processes influence the soil's function in promoting healthy vines, producing quality wine grapes. National and international experts on soil quality were consulted and a selection of growers and industry personnel were surveyed on a range of soil quality issues and their management.

Common issues. The most common issues of concern to growers and industry personnel were salinity, sodicity, structure (including compaction), organic matter, biological tests and water stress (including irrigation water availability). The issues with biological tests were - of what value were the tests and how to interpret them.

Soil organic matter. The most striking result was the changes in management practice that have been implemented to increase soil organic matter (SOM), using less cultivation, cover crops, manures and composts. The main concern about SOM was to know what was a satisfactory level (a benchmark). Most growers (and the larger companies) were moving towards organic practices (less chemical fertilizer, more organic inputs, reduced herbicide use). However, scientific results showed that (a) SOM had decreased in nearly all Australian soils from their virgin state, (b) large inputs of organic materials were required to significantly increase SOM, especially in sandy soils in warmer climates, and (c) the effect of increased SOM on available water was relatively small, especially in clay soils, and confined to the topsoil. Cover crops of cereals, grasses and broad-leaf species were more effective in building up SOM than those based on legumes, which were better in supplying nitrogen. Overall, the effect of organic inputs was beneficial.

Water and salinity. With severely reduced water allocations during the drought years and increased water salinities in some regions, soil salinity levels have increased and were of concern in McLaren Vale, Langhorne Creek, the Coonawarra and parts of the Barossa Valley. Furthermore, as subsoil salinity levels rise, increasing sodicity becomes a problem. Where possible, control of this problem requires the blending of poor and good quality input waters and restoration of a leaching fraction. The use of salt-tolerant rootstocks should also be considered.

Vine nutrition. About half the survey respondents found plant and soil tests were useful for guiding decisions on vine nutrition, but some would like more information (e.g. updating and benchmarking) and better interpretation of the tests for deciding on a fertilizer recommendation. Some respondents were unhappy about 'snake oil merchants' pushing particular products. Several respondents found soil survey data to be useful, although in some cases the small scale of the maps limited their value. Scientifically, much is known about the chemistry of essential plant nutrients in soil and their uptake by vines. However, some soil testing laboratories promoted the concept of a 'basic cation saturation ratio' in soil, which is not supported by mainstream soil science. Furthermore, the idea that vines can obtain a supply of nutrients through the direct uptake of organic compounds, as promoted by some 'organic practitioners', is not consistent with scientific knowledge.

Soil sampling. Soil sampling in vineyards is complex, especially under drip irrigation and where cover crops are grown. Plant analysis is most useful for on-going monitoring of vine nutrient status because the vine integrates short-range soil variability in the vineyard; but the identification of critical values for the essential nutrients could be improved by the updating of current databases, with reference to the most popular cultivars now grown. Interpretation of plant and soil analyses could be much improved by taking account of the longer range soil variability that occurs in vineyard blocks, as delineated by soil survey and proximal sensing techniques.

Soil biological tests. Apart from the variability inherent in soil sampling, much variation exists between laboratories carrying out tests for the same soil property, a situation that is especially true of soil biological tests. For example, values reported for microbial biomass carbon (MB-C), regarded as the current 'gold standard' for biological tests, ranged from 50 to 1480 kg C/ha to 15 cm depth for vineyard soils in Australia, New Zealand and France. Not surprisingly, growers find interpreting test results difficult because the test methods used by different laboratories are not well defined and results vary with the season and from year to year. Thus, any soil or plant testing should be carried out over a period of years to reveal trends and the same laboratory should be used. New soil biological tests based on gene identification and DNA profiling of the microbial community are being developed, but as yet little connection has been made between the results of such tests and processes in the soil that influence its function as a medium for vine growth. This is an area of current research investment, particularly by the Grains R and D Corporation (GRDC).

Viticultural systems. The merits of conventional, organic and biodynamic (BD) systems were compared. Most well-executed research has found that a number of soil properties are improved when sufficient time is allowed for the larger organic inputs of an organic/BD system to have an effect. An example is given in Table ES.1.

Table ES.1 Mean values of soil properties for seven biodynamic (BD) farms compared with one or two adjacent conventional farms of mixed enterprises on the same soil type in New Zealand. Data originally from Reganold *et al.* (1993).

Soil property	BD farms	Conventional farms
pH	6.10	6.29*
Bulk density (Mg/m^3)	1.07	1.15*
Penetration resistance 0-20 cm (MPa)	2.84	3.18*
Soil structure index	7.4	5.7*
Organic C (%)	4.84	4.27*
Respiration rate (µL/g/hr)	73.7	55.4*
Mineral N (mg/kg)	140	105.9*
CEC (cmol charge/kg)	21.5	19.6*
Total N (mg/kg)	4840	4260*
Extractable P (mg/kg)	45.7	66.2*

*Indicates a significant difference at the 1 percent probability level.

However, increasingly for Australian viticulture, one concludes that the terms 'conventional' and 'organic' are now of little relevance because many growers are attempting to apply the best practices from both systems. For some vineyards, an organic certification may confer a marketing advantage. Provided adequate inputs to the vineyard are maintained, 'biodynamic' viticulture need be no different from 'organic', since the effect of BD preparations 500 to 508 *per se* on soil quality is insignificant.

Benchmarking. Approaches to benchmarking soil quality using soil and vine properties or alternatively, on the basis of cultural practices in the vineyard, were compared. The advantages and disadvantages of each were identified using the experience of other benchmarking systems such as the Cornell Soil Health Assessment Training Manual (see Table ES.2), examples of systems used in New Zealand and California, and the EntWine and Vitis programs developed in Australia. A modification of the Cornell Soil Heath Assessment program would be useful for benchmarking soil quality in Australian vineyards and enabling growers to assess their progress towards improving soil quality, and their overall vineyard performance goals. Such a program would also enable growers to evaluate which management practices were best suited to their attaining those goals.

Soil quality and resilience. A few growers were interested in the concepts of sustainability, enterprise diversity (not specifically biodiversity) and to a lesser extent, environmental impacts and ecosystem services. In some of the inland regions, and with managers in some of the larger companies, the emphasis was on survival and the short-term viability of the business. However, most felt that by improving soil quality, the resilience of their vineyards would be improved.

Knowledge gaps. Although much information about soil quality is available for other rural sectors, some survey respondents believed that growers in their region would take little notice of this information. Others believed there were gaps in knowledge for their region, as well as shortcomings in the transfer of existing knowledge (both from other sectors and other regions) to growers in a form they could assimilate. The latter was considered to be an issue of high priority for the industry. There was considerable interest in grower involvement in research and the dissemination of knowledge (through better extension packages and more field days).

Recognition of these deficiencies leads to the main questions to be resolved in any future R and D program:

- How should soil quality in vineyards be assessed and maintained? Is it feasible to establish a system of benchmarks, along the lines of the Cornell Soil Health Assessment program for example, and, given the areal extent of the industry, how regionally specific should those benchmarks be?
- How good is the information about management practices available to growers to enable them to attain the benchmarks appropriate to their production system, and how can they judge the merits of different systems for the maintenance of soil quality?

Recommendations. To address these issues, the following recommendations for R and D investment, in order of priority, are made.

1. A team of experts should review the existing data on soil quality in Australian vineyards and shortlist a suite of soil properties that can be benchmarked for growers in the main viticultural regions. Management practices that move a vineyard towards these benchmark

Table ES.2 Cornell Soil Health Test Report for a silt loam soil under continuous maize with conventional tillage

Factor	Indicators	Value	Rating	Constraint
Physical	Aggregate stability (%)	22	25	Aeration, infiltration, rooting
	AWC (mm/m)	180	63	
	Surface hardness (psi)	107	78	
	Subsurface hardness (psi)	400	13	Subsurface pan, compaction
Biological	Organic matter (%)	2.1	14	Energy storage, C sequestration, water retention
	Active C (ppm)	462	21	Soil biological activity
	Potentially mineralizable N (µg N/g soil/week)	2.0	0	N supply
	Root health (1-9)	2.3	88	
Chemical	pH	8.3	0	Toxicity, nutrient availability
	Extractable P (ppm)	9.5	100	
	Extractable K (ppm)	20	11	Plant K availability
	Minor elements		56	
Overall quality score out of 100			39.1	Very low

From the Cornell Soil Health Assessment Training Manual (Gugino *et al*. 2009). Note the confusing mixture of units for the soil property values, which should be avoided.

values should be identified; so too practices deleterious to soil quality. This will require a review of data from longer-term trials in Australia and relevant trials overseas. Databases such as Treasury Wine Estates' Footprint Reporting on 25 company vineyards could be valuable for this purpose, and other growers could be involved in their vineyards. The values for key soil properties should be linked wherever possible to petiole analyses (with a review of critical values for individual nutrients), yields and fruit composition.

2. Research should be commissioned as soon as possible on the relevance of soil biological tests – what are the key indicators of soil quality and how can these best be measured and used in a benchmarking system? GWRDC should cooperate closely with GRDC in this exercise because they have invested, and continue to invest, strongly in this kind of research.

3. Concurrently with recommendation 1, a team consisting of scientists, extension specialists and growers should take the best research information and 'package' it for transmission to growers and winemakers in the main regions. It is important for growers to contribute to this process because information transfer is a 'two-way street': growers must be proactive in telling researchers and advisers what information they need.

4. Candidate soil properties for recommendation 1 will vary greatly in their ease of measurement, partly because of soil variability and partly because of analytical difficulty. However, mapping soil variability using existing rapid techniques and the development of new 'on-the-go' proximal soil sensors will help to overcome some of these difficulties. Physical properties may be amenable to a pedotransfer function approach that utilizes data from routinely measured soil variables, such as bulk density, particle size analysis and organic C. The values for key soil properties should be linked wherever possible to petiole analysis (with a review of critical values for individual nutrients), yields and fruit composition. This could be an output from the investigation initiated under recommendation 1, and could be phased in over time.

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