Creating a Healthy Soil

By BART DAVIDSON

As David has covered in earlier articles the need to have a “balanced” pot (see GFV July 2003), we have returned to the need to constantly examine our practices with respect to soil health.

To successfully develop soil health, and maintain it, demands that it be measurable. Should we measure the components of soil health or its outcomes? The former is often cause for disagreement in soil science and hence the latter is more useful and effective a method. What soil health gives us as managers in a tangible sense is better Return On Assets (ROA) by means of increased yield and/or lowered production costs over a rolling time average of at least three to five years.

So how do we create a healthy soil? And do we know how? My answer to that is categorically that we must, because the alternative leaves an unacceptable legacy for future generations of land managers and consumers of its produce.

Definitions of soil health are inherently difficult because the threshold level of fertility needed within a farm to be labelled ‘healthy’ will vary between climates, soil derivation and land use. Healthy soil will be quite a different physical, biological and chemical entity for a vegetable irrigation farm to the same level of health required within a pasture soil for a grazier, or dryland wheat paddock. Soil health is relative to the system of production and even enterprise.

Soil health could be defined as the resistance and resilience of a farming system to change and the capacity to maintain water, nutrient and biological cycles within the boundaries of the production system.

From a growers perspective, rather than soil scientists’ jargon, we need to be able to assess soil health from year to year, as a trend, because while it is often very difficult (and the cause of much political argument) to define whether we have actual soil health, or a sustainable system, at a given point in time, it is a very straight forward process to identify if we are going backwards, holding our own or in fact improving the resource against some two or three very basic indicators.

Measuring sustainability

To recap on the three measures of sustainability outlined in my July 2003 article, we can boil sustainability and soil health down into three very basic units of measure, to monitor each year and benchmark performance. The importance of each will vary in scale from the enterprise, to farm and climatic region.
There is increase in soil health where there is:

- Increased water use efficiency—i.e., the water input per unit output is reduced and the $/ML returned is maximised (or effective rainfall in the case of dryland farming);
- Increased nutrient use efficiency—i.e., where output per unit input fertiliser is increased with increased nutrient cycling efficiency; and
- Reduced $/ha spent on energy, whether in the form of fuel, chemical or labour to maintain weeds and pests within economic thresholds.

These parameters can be measured from year to year, down to a per enterprise level within a farm, but are only valid over consecutive years due to interdependent relationships within the soil-plant system. For example, an improvement in biological fertility, which translates into increased phosphate cycling, will take longer than a single season to become evident in output, as compared to a water-soluble phosphate fertiliser application.

Given we can monitor the outcomes of soil health, good or bad, in the parameters above and in the landscape itself, it would be a logical conclusion that we should want to know what it looks like and develop it as quickly as possible.

What does healthy soil look like for high value irrigation crops?

Everyone will draw from his or her own experience and RCS is no different. We can draw upon our benchmarking experience across a statistically large area of production in Australia, comprising some 5000 years of business performance and an area representing $1.5 billion of assets across many industries. In our experience, healthy soils, as measured by return on assets in irrigation farming, can be identified as having the following common traits.

Soil chemistry. This is one of the most important areas. It is also one of the most controversial areas in moving towards sustainability.

1. An adequate and timely supply of macro and micro nutrients through the critical stages of the plant life cycle, with emphasis on different nutrients at different stages of the growth. For example calcium and nitrate in the vegetative growth stages and boron going into flower set;
2. Aside from and contributing to the above is an ordered balance within the major nutrients held on the clay colloid. This balance is known as the Albrecht ratios, after American soil scientist William Albrecht, and is universally accepted now as a desirable range for the majority of soils. To view this balance only requires an analysis of a soil growing Grange or other premium grapes. The clay of such soils will comprise 65-70% calcium, 15-20% magnesium, 5-7% potassium, less than 3% sodium and approximately 5% of the trace elements combined. These values are known as percentage base saturation; and
3. Soil with an absence of significant excesses in nutrients, which in horticulture and grapes can tend to occur as high phosphorous, potassium and copper, which in turn have inhibitive effects on other nutrients, namely zinc and magnesium respectively and beneficial soil fungi in the case of copper. This process of antagonistic interaction occurs even where there appears to be adequate levels of these secondary nutrients within a soil analysis.

Soil physical properties. The essence of soil physical health is the capacity to buffer the extremes of moisture which management or climate produce in soils. Healthy soils are able to receive quick rainfall events, storing and releasing this moisture back to the active rootzone over a longer period. There is also physical resilience in the capacity of healthy soils to respond to mechanical force, such as tillage or simply tractor traffic, which in the case of a horticulture, for example, will commonly be 40-50 passes up each row per year.

While there are many factors contributing to the physical properties of soil, including clay content and bulk density, there are only two within the *sphere of influence* of land managers. They are humus, or organic matter, and the base saturation percentages described above. These two components more than any other, give a soil its spring and capacity to maintain structure and adequate aeration, drainage and biology in the face of modern machinery and irrigation.

Soil biology. The biological composition of healthy soil is simply a wonder beyond our current linear methods of reductionist science. We can label and measure the presence of various bacteria, fungi, protozoa and nematodes, which comprise the soil foodweb, yet we are constantly reminded that the whole is more than the sum of its parts when it comes to soil biology. In my experience, looking at analyses of the soil foodweb from all major crops in all states except the Northern Territory there is almost universally the development within our farming systems of *bacterial* dominant soils, with low *fungal* diversity and presence.

In perennial soil-crop systems, such as tree crops, the soil biota have evolved with high levels of soil fungi performing a variety of roles, from efficiently completing the recycling of carbon residues to living in mutually beneficial association with plants, providing available nutrients from the soil in exchange for sugars/carbohydrates from the plant. Our conventional management systems have favoured low diversity within the soil foodweb and whether Organic or not, the goal of sustainable management must be to actively promote the reverse, as it is in diversity that the true benefits of soil biology are evident, as disease suppression, nutrient cycling, soil aggregation and more.

In annual cropping systems, however, the natural balance is typically a bacterial dominant soil, though one with beneficial fungal populations present, although proportionally lower than within perennial systems.

So now, after considering what it looks and smells like, we finally in a position to ask ourselves if we can '*create* healthy soil', as against being in the fortunate position of inheriting it from geologically fortuitous circumstances or previous management. The answer is, in my experience, yes but only if we attend to the limiting factor impeding soil health, which will typically be a combination of chemistry imbalance, low biological diversity and physical soil compaction.

How to create soil health

Irrespective of the crop, it would, it would be wise to start by finding the best examples of profitable sustainable production we can find *and replicate it* to the greatest extent possible. From the Barossa Valley to the lower quality area of Griffith and up into quality cool country vineyards of Cowra and Mudgee and even the Hunter, there will be a common trait to the soils beneath the best producing grapes.

Step one for creating soil health will be in the approach, and essentially a shift in paradigm. We will focus not on feeding the plant alone, but on applying a proportion of all fertility inputs that feed also the soil itself, via improved balance in the base saturation percentages and the biology within it. As such, the goal is feeding the plant (vine), soil and biology with a structured program of inputs to achieve a desired return in production.

In terms of process, this comes down to feeding the vine/plant nutrients in forms and at rates that contribute to the overall soil fertility, not imbalance. Can this be achieved with organic inputs? With absolutely no problems except for nitrogen. If yield objectives cannot be met via the use of organic, non-synthetic materials, then it will in my experience only be as a function of time. Time being the limiting factor most commonly in building threshold levels of phosphorous and calcium.

Healthy soil will result in the production of excellent sugars in the plant, and ultimately the berry, no different to if it were producing corn or wheat. Yet few growers measure the dynamic sugar production of their crops while there is still time to react with management to poor sugars, the majority use yield at harvest, which is too late for change. Along with good carbohydrate production, these healthy soils will supply luxury quantities of calcium to the fruit or new cell tissue, evident in grapes as thick skins less susceptible to disease and weathering.
Along with calcium, all nutrients will be available at non-limiting levels to the vine. In our experience, this more often than not means avoiding excess of one nutrient at the expense of another, such as is commonly the case with phosphorous and zinc, being evident as chicken and hen sized fruit. More than any other issue, the oversupply of some nutrients and the associated tie-up in others is the cause of poor plant performance in horticulture. We are effectively seeing growers paying for nutrients twice, first with application and then with making up the shortfall caused in another nutrient.

In terms of feeding the soil, the issue is typically one of pushing base saturation values into shape, usually by raising calcium to reach the desired benchmark, via lime, dolomite or gypsum depending on circumstance to improve calcium levels and/or lower magnesium or sodium concentration. Where potassium has been overused it is at times magnesium alone that must be raised via bulk application or fertigation. Both can be achieved within organic certification if required and the correct forms used.

Biologically, there are an ever-expanding number of products and brews available to growers now to achieve enhanced populations of soil microbes. In the context of grapes, my experience is simply that the goal is to actively manage for what we want, that is, high diversity and concentration of soil fungi to fill out the foodweb. This demands first that we consider the impact of high (and growing) copper levels on soil fungi by assessing alternative above ground pathogen control and secondly, actually feeding stimulatory inputs to enhance the presence of beneficial soil fungi. This is achieved with the use of inputs high in soluble carbon and organic acids.

Good examples of these are humic acid and fish hydrolysates, both of which are acceptable within organic production systems. The use of compost teas and potential for both pathogen control they provide is another area receiving too little investigation by either Organic or conventional growers at present.

Finally it is perhaps cheeky, but nevertheless important, to ask the question, will healthy soil be created by our farming systems? The essential question I ask of you is whether you are confident your existing management will improve the future water, nutrient and energy requirements of growing your grapes and hence be improving soil health. If not, will you commit to finding ways forward to improvement?

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