Sustainability, organics, biodynamics – new scientific perspectives on viticulture

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‘Vineyards are the worst monoculture in the world’
Josh Bergström, Oregon winegrower

I should begin by saying that although I’m scientifically trained (a PhD and 15 years working as a science editor), I’m not a scientific fundamentalist. Reductionist science is an incredibly powerful lens for helping us understand how the world works, but it has limits. There are very real limits to our scientific understanding of life in all its marvellous complexity. In effect, science is one language for understanding the world around us; but other approaches have their place, too. With this in mind, in this short presentation I’m going to attempt to look at the science behind sustainable wine growing in its various forms, and argue for the development of a new approach to viticulture.

Why sustainability?

There are two reasons for adopting sustainable winegrowing. Firstly, it’s a moral imperative: we shouldn’t expect next generation to pick up our tab. There’s no justification for farming systems that degrade the quality of the soil, either by leaving agrochemical residues, exhausting nutrients, or allowing erosion. Equally importantly, though, and less commonly discussed is the possibility that better grape quality can be achieved through a more holistic and deeper understanding of the vineyard agroecosystem. That is,

sustainable farming, when taken far enough, can result in more complex and interesting wines. And the world needs more of these.

Bad old viticulture

The old approach to viticulture, usually referred to as conventional viticulture, is problematic on many levels. First, there is too much focus on the vine alone, with the soils seen merely as inert medium providing support and nutrients to the vine. There is also an emphasis on dealing with problems (fungal, insect, poor nutrition) using simplistic chemical solutions. This leads to a vicious circle: simplistic solutions making problems worse. More significantly, this form of viticulture is unsustainable.

The new viticulture

The new approach to viticulture sees the vine as part of a complex vineyard system (agroecosystem) with many organisms co-existing and interacting with each other. In particular, it recognizes the importance of microorganisms: we can't see them, so we tend to ignore them. New viticulture concentrates on soil and vine health, rather than disease, and uses intelligent, elegant solutions for any problems that remain. Most importantly, it recognizes the true complexity of nature and the limits of our knowledge.

Biology is more complex and awe-inspiring than we realize

One of the main take-home points from this presentation is that we should recognize that biology is much more wonderfully complex than we have realized in the past. Let's look at a few examples.

First of all, semiochemicals. These are herbivore-induced volatile compounds released by plants in response to attack. They recruit the natural enemies of the herbivores, thus acting as an airborne SOS signal from the plant to its insect allies. This reponse can be remarkably specific. For example, a particular caterpillar can cause the plant it is munching on to release a specific volatile (in response to the caterpillar saliva) that then signals to a parasitic wasp that preys solely on this species of caterpillar that lunch is ready.

Another example of nature's wonderful complexity is a paired pattern of plant responses called systemic acquired resistance and induced systemic resistance. Plants are rooted to the spot and thus are unable to move away from problems or unfavourable growth conditions. They therefore need to act as powerful environmental computers, sensing the environment around them and then responding appropriately. These two signalling pathways are the means by which plants detect biotic and abiotic stresses (such as fungal or bacterial infection and herbivory or damage) and then coordinate their response. Signals such as salicylic acid and jasmonates turn on defence pathways in parts of the plant that are not under attack or stress. It's a bit like the plant equivalent of the human immune system.

What does this biological complexity tell us? First, that the systems we are dealing with in vineyards are more intricate than we'd realized. For example, microbes in the root and foliar environment may well be communicating with plants and altering their growth patterns. If we are to make chemical interventions in the vineyard, these could be having knock-on effects that are unpredictable. Second, it tells us that we really do have to see vineyards as entire agroecosystems – it is not useful to focus on vine biology alone.

Sustainable winegrowing

So let's switch gears to looking at the various notions of sustainable winegrowing that have arisen over recent years. If 'sustainable' is to mean anything, it must be certified. Certification is vital if the word is to avoid being used as a form of 'greenwashing'. But such certification must have teeth, and this represents something of a dilemma. Setting the bar of certification programs at the right height is important. Set it too high, and not enough vineyards will participate; set it too low and while everyone will get onboard, it won't make much of a difference to what actually goes on in the vineyard. There needs to be a balance struck between maximum participation versus meaningful difference in vineyard practice.

Oregon

Many countries/wine regions are now introducing certified sustainable programs. A good example is that of Oregon Certified Sustainable Wine (OCSW). This has brought together various certifying bodies under one banner (LIVE [low-input viticulture and enology], Oregon Tilth Certified Organic, Demeter Certified Biodynamic and Salmon Safe) to form a single sustainability brand that can clearly be communicated to consumers. OCSW doesn't certify; instead, it acts to publicise this single brand, because unless consumers can get their heads around what certified sustainable means, they won't be prepared to pay a little more for it. Currently, consumers recognize organics and are willing to pay more for organic produce. But if growers are to increase their viticultural costs to go sustainable, it makes this journey a lot more attractive if the effort is recognized by consumers.

Oregon LIVE is a good example of a certification program for winegrowers that is scientifically credible and has some 'teeth'. Ted Casteel, one of the founders, highlighted some of the goals of the program.

(1) Reduction and elimination of out-of-farm inputs

(2) Biodiversity: avoiding monoculture

(3) The whole farm seen as an ecosystem that interacts with itself

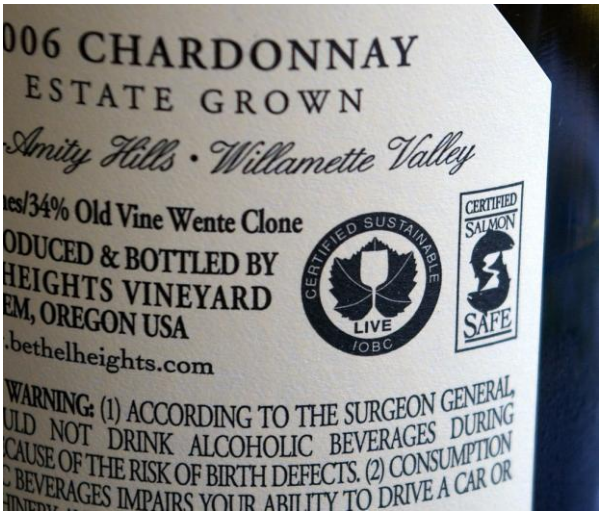
(4) Trying to certify the whole industry

'Certification is an important part of sustainability: it gives growers a sense of rigour and discipline, and encourages record keeping and monitoring for pests,' says Casteel.

Certification requires two years farming under LIVE guidelines, and third party inspections are used. It costs US$100 for an application, then US$175 a year for up to 20 acres and then an extra $2 per acre. Inspection fee is US$300; yearly for the first two years and then every third year on a random basis.

Under LIVE there is a 'Yellow list' of approved chemicals. Growers who need to use a non-approved chemical can apply for a variant: the application goes to a technical committee, and LIVE will work with the grower to try to find a sustainable solution to the problem. Growers can only apply for a variant once in a 3 year process; use of non-approved chemical results in loss of certification for a year.

Currently 7224 acres of vineyards are certified by LIVE, which is an impressive half of the Oregon wine industry.



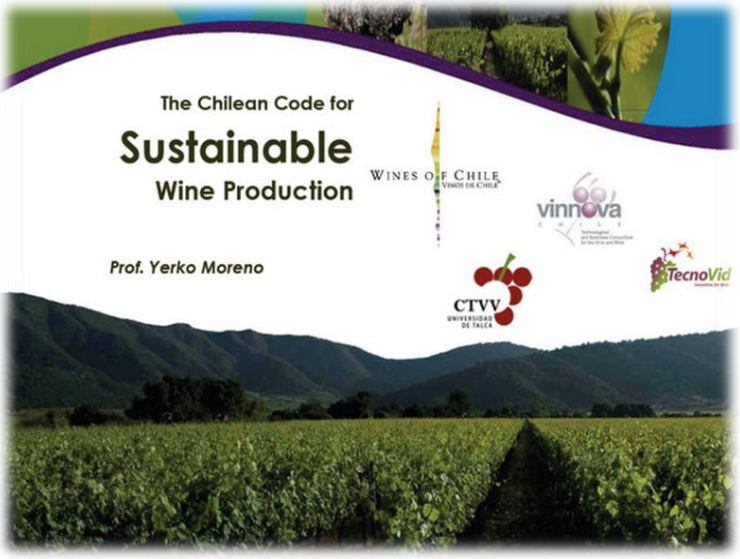
South Africa

Since 2000, South African wine producers have been able to verify their sustainability by being certified by an organization called Integrated Production of Wine (IPW). This is a voluntary environmental sustainability scheme consisting of a set of guidelines detailing good agricultural practices related to grape production as well as guidelines covering winemaking and bottling. Compliance with these guidelines is assessed through a self-evaluation questionnaire, and this is then independently audited through spot checks. Certification is overseen by the Wine and Spirit Board.

Guidelines operate on a scoresheet basis, where producers score more points where they adopt environmentally friendly practices. They need to reach a certain threshold score to be certified. Below are some examples of the guidelines issued to producers (these are available in full from the IPW website, www.ipw.co.za).

One person from the farm or cellar must attend an IPW training course. Each farm should have a conservation plan for natural areas, and an environment management plan for cultivated areas (information about how to do this is provided on the website). There is also an exhaustive list of environmental guidelines. For example, new vineyard blocks are to have wildlife corridors in them, and producers are encouraged to think of implementing these in existing vineyards where possible. The use of cover crops is encouraged to reduce the use of herbicides and to lessen the risk of erosion. If pre-emergence herbicides are used, a record has to be kept together with sufficient justification for their use. If fertilizers are used, it is only with a view to replacing what has been taken out during the growing season: records of plant and soil analyses need to be kept to show that this was the case. For disease control, IPM tactics must be applied. Only registered chemicals are permitted, if indeed chemical use is found to be necessary at all. Growers are given guidelines on how to monitor for various vineyard pests, including the use of pheromone traps, and for the appropriate control measures depending on the pest population level. In the winery, waste management is a strong focus, but the guidelines also cover greenhouse gas emissions and steps to reduce these.

Along with the IPW certification, South Africa also has the Biodiversity and Wine Initiative (BWI; website: www.bwi.co.za), which is a partnership between the wine industry and the conservation sector. The BWI aims to prevent further loss of native habitat in critical sites, to increase the total area set aside as natural habitat in contractual protected areas, and to promote changes in farming practices that enhance the suitability of vineyards as habitat for biodiversity, while reducing farming practices that have negative impacts on biodiversity, both in the vineyards and in surrounding natural habitat. Producers who want to join need to commit to managing areas of native habitat in certain ways compatible with promoting biodiversity. As of September 2009, 155 members were managing 113 127 hectares, which is slightly more than the actual vineyard area in the Cape winelands. The BWI works in partnership with IWP



Chile: developing a sustainable protocol for the wine industry

Caliterra is a winery in Chile's Colchagua Valley that was founded as a joint venture between Eduardo Chadwick and Robert Mondavi in 1996. In 2004 Eduardo Chadwick brought Mondavi's share back when Mondavi was sold to Constellation, and decided to change strategy. 'We thought about organics,' explains

chief winemaker Sergio Cuadra, 'but we wanted a broader approach to winegrowing and winemaking. We thought that sustainability as a concept was the best option we had.' There was a problem, though: the sustainable approach wasn't certifiable. As a result, Caliterra contacted Professor Yerko Moreno of University of Talca, with a view to creating a protocol for sustainability in Chile.

Moreno lived in Oregon for five years, and so has taken a keen interest in the development of the LIVE certification for sustainability in Oregon. He thinks the situation in Chile is very similar to what happened in Oregon several years ago as growers began to think about ways of working sustainably, but where they weren't satisfied with organics and biodynamics. In Oregon, the growers approached a researcher for help establishing the scheme, Carmo Candolfi-Vasconcelos; this approached has been mirrored with Caliterra approaching Moreno. Moreno outlined how Caliterra and the University of Talca were devising the sustainable protocol, which they hope will be adopted by much of the Chilean wine industry.

'We have used many ideas from the LIVE system,' Moreno explained, 'which is based on the IOBC guidelines and the key aspects covered by the OIV sustainability guidelines.' While these guidelines are useful, they don't give the details, and so Moreno and his colleagues need to consider the particular growing conditions in the different Chilean wine regions. Other information is gathered from guidelines for social responsibility, which is a unique feature of this Chilean protocol. Not only does it cover the environment, but it also deals with social issues. 'This is very important,' says Moreno, 'but it is not considered in organics and biodynamics.' Moreno also stresses that the system must be profitable. 'If you go broke, there is one less environmental warrior in the system.' He also adds that, 'If you do it because of marketing, it is going to be a mess.'

The Talca team consists of five people in the University and five people from Caliterra (two winemakers, two viticulturalists and an agronomist), and the project has now been going for 18 months. The first goal is to develop version 1.0, which has three chapters: a green chapter (viticulture), a red chapter (in the winery), and an orange chapter (social). When this version 1.0 is complete, it will be opened up to companies who specialize in certification, with a view to giving one of them a contract for the third-party certification of sustainability in Chile.

One example of the sort of approach the sustainable protocol will take is with regards to irrigation. Many vineyard managers irrigate whenever they want; others will do monitoring of water status of vines and soils. 'We promote and give a better score if you have three monitoring methods and use them,' says Moreno. 'You have to justify everything you do, and record keeping is a key aspect of our system.'

Another is the use of herbicides. 'For years and years people have been using residual herbicides,' says Moreno. 'We tell people that if you stop using them you will see the benefit in one season. Already the winery owners have realized that they have to be looser in managing their vineyards. They used to look neat with vines only, but now we start to see different plant species and biodiversity.' Growers get points for biodiversity in their vineyards.

Cover crops are also encouraged, but Moreno pointed out that there were some pitfalls for the unwary. 'You seed them and think that all this biodiversity is great, but you can find that they are hosting pests,' he warned. 'Nature is not easy to understand. We need to find out which cover crops work best for each vineyard.'

Moreno and his colleagues have been working on using precision viticulture approaches to manage vineyards more effectively. These use aerial imagery to identify differences in vigour in the vineyard. Using software, this sort of imagery can identify separate management blocks, which can then be managed differentially to increase quality. For example, some parts of the vineyard might be ripening later than others, perhaps because there were differences in soils in those particular blocks. Rather than

wait for these blocks to catch up, they could be picked separately, while the earlier ripening blocks could be picked at peak ripeness. Another example would be particular sections of the vineyard that are susceptible to disease or certain pests. Action could be taken just on these blocks, rather than on the whole vineyard level.

Biological control approaches for pests are one of the cornerstones of sustainable viticulture. Moreno cites the ladybird *Cryptolaemus montrouzieri* as a promising biological control agent for mealy bug. Mealy bug can be a big problem for vineyards because it is a vector for leaf roll virus. However, this form of biological control hasn't been tried yet because it will only work when there is a big enough infestation of mealy bug to support the ladybird predator. Red spider mites are a problem, and these can be controlled biologically, by predatory mites such as *Phytoseiulus persimilis*. Alternatively, they can be controlled by spraying oil. For nematode problems, biological nematicides exist, as well as rootstocks that are resistant to nematodes. 'We have learned to monitor things and determine thresholds for taking action,' says Moreno. He stresses the importance of information. 'If you don't have information you are blind, and you just have to use the calendar,' he says, referring to the old-style practice of calendar spraying.

The hope is that the protocol produced by Moreno and his colleagues will be taken up by wineries across Chile and provide a solid certified sustainable basis for the whole industry.

Sustainable viticulture in the Douro: the Fladgate Partnership's initiatives

The Douro Valley in northern Portugal is one of the world's most spectacular wine regions. Around two-thirds of its vineyards (28 000 hectares out of a total of 39 000) are planted on hillsides with a gradient of over 30%. The main block of these vineyards, on the banks of the river Douro, have been designated as a UNESCO World Heritage site.

In 2009, the prestigious Banco Espírito Santo Biodiversity Prize was awarded to The Fladgate Partnership for its project 'A New Model for Viticulture in the Douro Region'. This annual prize is sponsored by BES in partnership with CIBIO, the Centre for Research in Biodiversity and Genetic Resources, and recognizes innovative projects in the fields of research, conservation and management of biodiversity in Portugal.

The Fladgate Partnership owns over 500 hectares of vineyards in the Douro, from which it produces Port from three historic Port houses: Taylor, Fonseca and Croft. Over the last 10 years they have invested 27 million Euros in the Douro valley, and recent work has been focused on replanting the steeply sloped vineyards in a more sustainable way.

In the past, the only way to plant these slopes was to construct walled terraces. The walls, built of stone, were necessary to support the earth and prevent erosion. In the 1970s and 1980s, a new method of planting became more popular: using bulldozers to carve out reasonably wide terraces from the schist on which two rows of vines are planted. These are called patamares.

There are two problems with these patamares. First of all, the earth banks are unsupported, and so winter rains are liable to cause erosion. Secondly, the only way of controlling weed growth is by the use of herbicides, because the proximity of the inner row of vines to the earth bank means that mechanical cultivation isn't possible.

The Fladgate Partnership have pioneered a new model for planting, which is based on a single narrow terrace that supports just one row of vines. These terraces are constructed using laser-guided earth-moving equipment which allows the terraces to be inclined at precisely 3° to the horizontal. This 3°

inclination strikes a balance between rainwater run-off and its penetration in the soil, avoiding topsoil erosion.

The single row of vines allows mechanical control of weed growth, which means that herbicide use in the vineyard can be eliminated. Cover cropping is also used on the surface of the terrace, with vegetation remaining between November and late spring, which is then mown as the vines grow to prevent competition for water and nutrients, and to act as a natural mulch. This also adds organic material back to the soil.

Other components of the model include planting olive trees along the vineyard boundaries and the conservation of indigenous vegetation on slopes too steep to cultivate. In addition, care is taken to plant the right vine varieties in the right place, which helps in terms of disease prevention and pest avoidance. The Fladgate initiative is not part of any certification program, but initiatives such as this, if applied more widely, have great promise to ensure the sustainability of the spectacular Douro vineyards.

Tools for the new viticulture

IPM: using information

Scientifically based sustainable viticulture goes under a range of names. Integrated pest management (IPM) is the most widely used term, along with the broader term integrated farm management (IFM), which encompasses not just pest and disease control but also soil health and plant nutrition. In France, which is leading the way with the application of these in viticulture, *lutte raisonée* (which translates best as the 'rational fight') and *viticulture raisonée* are the corresponding terms.

IPM itself represents a paradigm change in agriculture: previously the prevailing attitude was one of blitzing all pests with a chemical arsenal, leaving just the crop species, perfect and unblemished. Farmers intervened to prevent any crop loss to disease or pests. This was based on a simplistic understanding of nature, and a failure to recognize the complex network of relationships that exist in most ecosystems. Thus science wasn't the problem: it was bad science that led agriculture in this direction.

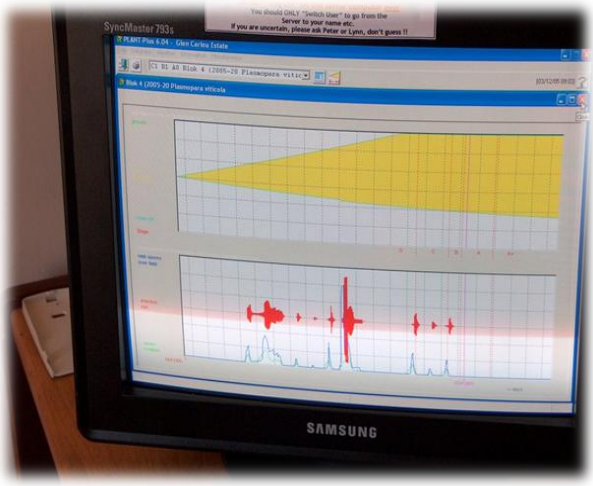
However, there has recently been a sea change in attitudes, partly because such practices simply don't work due to the problem of resistance, and also because farmers are increasingly realizing that the only morally acceptable way of farming is to do so in a sustainable way that doesn't involve the next generations picking up the tab for our bad practices.

Natural ecosystems have evolved with checks and balances to produce a stable system, a bit like a ceasefire arrangement. Biology is incredibly rich and complex, and consists of numerous interactions among the various players in the system. Farming creates an artificial ecosystem, where just one species is grown at high density, creating the ideal conditions for suitably equipped insect, fungal and nematode pests, as well as the problem of weed species. The simplistic, 20th century response was for chemists to develop an arsenal of sprays targeting these problem species, but this served to create a more serious problem of pests with resistance to the fungicides and pesticides employed by farmers, as well as having killed the natural enemies of these pest species that before will have kept their population numbers under a degree of control. In addition, the widespread use of agrochemicals has in some cases led to degradation of soil quality.

IPM rests on a thorough scientific knowledge of the biology of pest, weed and disease organisms, in the context of the larger ecosystem. Practitioners use this knowledge to monitor populations of potential problem organisms and then anticipate when they will reach damaging levels. In essence, it is about reconciling rather disparate aims: farmers want to reduce crop losses while at the same time reducing environmental degradation and avoiding pest resistance build-up. Farmers using IPM are making choices based on a broad-perspective outlook that takes into account the whole ecosystem rather than just a part of it.

Data and knowledge are both keys for IPM. This can help reduce the number of chemical inputs by predicting when certain pests or diseases are likely to be a problem. Any spray programmes can be scheduled intelligently, applied only when they are really needed. This climatic monitoring is inexpensive to implement, and is likely to actually save money—sprays and the labour required to administer them are costly. An example of this in action is the work at Glen Carlou in South Africa's Paarl region. The viticultural team use in-vineyard environmental data gathering, which is linked up to a computer in the winery running a software package called Plant-PLUS. This is a decision support system that is used to predict the incidence of pests and diseases, allowing control only where it is needed. The system uses data collected from the various parts of the vineyard and combines these with weather forecast data, indicating when control might be necessary. Further data on the growth phase of the vines can be added manually by

the viticulturalist. As a result, minimal chemical inputs are used, and this system paid for itself from these savings in just one season.



Biological control is another one of the foundations of IPM. If you have a pest problem, introduce the natural enemies of this pest—be they predators or diseases—and let them control the problem. Many IPM strategies rely on the identification of natural enemies of pest arthropods. These are also known as 'beneficials'. Natural enemies might be predators, who eat the problem species, or parasitoids, which are insect parasites. An example of the latter are parasitic wasps: these might lay eggs in a problem caterpillar which produce larvae that then grow inside the caterpillar, using it as a food source and killing it in the process.

A twist on the biological control theme is to use pheromones to cause sexual confusion in the pest species. This is already widely practiced in vineyards for controlling the serious pest species Eudemis (*Lobesia botrana*) and Cochylis (*Eupoecilia ambiguella*), which are moths whose larvae damage developing grape

clusters. Small brown plastic capsules are hung on wires in the vineyards at regular intervals, releasing pheromones that attract the male moths and thus prevent them finding and mating with females. This biological control is around three times more expensive than chemical control, but is widely practiced.

There is serious science behind biological control, with an organization coordinating efforts worldwide: the IOBC (International Organization for Biological Control of Noxious Animals and Plants; www.unipa.it/iobc/), which is split into six regional groups.

Biopesticides are a new development that may prove important in the future. These are pesticides that use specific microbes as the active agents. One example is that of *Trichoderma harzianum*, a fungal enemy of another fungus, *Botrytis cinerea* that causes bunch rot on grapes, and *Ampelomyces quisqualis*, an antagonist of powdery mildew. Some are already being used in vineyards.

If parasitoids or predators of pests are introduced into a vineyard, they will need somewhere to live, and they might not find vines an ideal home. Added to this, clean-cultivated vineyards are barren places during the dormant season, with nowhere for over-wintering insects to hide. This is where ecological compensation areas or zones (ECAs or ECZs) come in handy. These are patches of ground given over to specific patterns of vegetation, such as scrubland, woods or hedgerows that can act as refuge areas for natural enemies of problem species. This sort of biodiversity can offset some of the negative effects of monoculture. It is likely that the efficacy of these compensation areas will be enhanced by the use of cover crops or allowing some vegetation to grow between vine rows. These compensation zones are not a panacea for all vineyard problems: there is a risk that growing certain types of vegetation near vineyards could encourage the presence of insect species that actually turn out to be a problem, either directly as pests themselves, or indirectly by acting as transmission agents of viral or bacterial diseases. Knowledge and experimentation are needed to fine tune the use of ECAs for specific wine regions, because no broad brush solutions can be applied across all.

A nice example of biological control is the use of flowering buckwheat, *Fagopyrum esculentum*, as a cover crop that acts as a habitat for the wasp *Dolichogenidea tasmanica,* a common parasitoid of leafroller larvae, a serious pest of grapevines.

The biological control of botrytis is also an elegant solution to a problem that otherwise would have required a chemical solution. Two products on the market are Botryzen®, a fungus that competitively colonises plant material also invaded by pathogenic fungi, and Serenade®, a bacterium (*Bacillus subtilis*) producing a diffusable substance that inhibits fungal pathogens. Some people I have spoken to have had excellent results with these; others have had some problems.

One organically approved spray that is now quite widely used is BioAg. This is an Australian product that is an organically approved mixture of nutrients as well as some of the biodynamic preparations. This

could be working both as a microbial inoculum as well as providing trace elements to the vines, and is consists of both foliar treatments as well as soil treatments. Growers I have spoken to give mixed reports. Some have had very positive experiences, while others are less enthusiastic. Some complain that it is a bit like twisting biodynamics to fit the old conventional viticulture mindset, using sprays to defeat problems. It is also quite expensive (one grower quoted a cost of NZ$1000/hectare).

Undervine weed control is a key issue for those wanting to work more sustainably. In regions such as Central Otago, with low disease pressure, this is the last thing that keeps some growers from working organically. Typically, the undervine weeds are managed by glyphosate (aka Roundup, a relatively soft herbicide). However, it is possible to use manual tillage: some tractors have specialized undervine weeders which just take out the weeds, and sense where the vines are. Mulching is another approach to dealing with undervine weeds. For example, it is possible to use a deflector to send mown cover crops/grasses under the vines, and straw is also sometimes used, although this is more expensive.

Composting needs little introduction here: it is increasingly being employed by growers of all persuasions, not just those employing biodynamics and organics. It is a great way of introducing organic material into the soil, resulting in better structure and improved retention of nutrients and moisture.

What about biodynamics? There isn't time to discuss this properly, but it has been a tremendously influential movement, even if worldwide relatively few hectares are actually farmed this way. It has made people think about seeing the vineyard more holistically, and has focused peoples' attention on the life of

the soil. For many scientists, however, the language of biodynamics has been a problem. There have also been very few serious attempts to try to understand biodynamics from a scientific perspective. (Jennifer Reeve and collaborators published the only serious study comparing organic and biodynamic farming a few years back, but the results were inconclusive.) I think this is a shame, because many of the preparations used could potentially have some effect, either as microbial inocula or inducing systemic acquired resistance in the vines, for example. The lack of proper controlled scientific studies is not a problem for proponents of biodynamics, who are convinced by the results they see in their vineyards. But such studies might make elements of the biodynamic toolkit feasible for larger growers or large wine companies who have sufficient acreage to manage. I have visited enough growers around the world now who are making incredible wines from vineyards that are managed biodynamically for me to think that there must be something in what they are doing. Is it just increased time spent in the vineyard? Is there efficacy of biodynamics beyong that of organics? These are important questions.

I wanted briefly to mention the powdery mildew paradox. This disease, caused by the fungus *Uncinula necator*, was introduced to Europe in the 1840s from the USA. *Vitis vinifera* has no resistance to U. necator, and so chemical solutions (sulfur or systemic fungicides) are therefore essential in almost all regions worldwide to protect the grapes, even when biodynamic farming is employed. From American vine species CSIRO/INRA scientists have identified *Run1*, which is a single gene that can confer resistance to this disease. This scientific insight could only be applied if vines were genetically modified. This is possible, but the paradox is that while such genetic modification would reduce chemical use in the vineyards of the world, it is not acceptable to consumers. Personally, I think GM vines would be a disaster. I don't think there are any health issues; rather, it would likely reduce the diversity of vine varieties that are planted, and wine would become much less interesting as a result. There is also the issue of agency. Natural breeding is more acceptable to many because nature is making the genetic modification, not scientists in a laboratory.

Key questions

So, to finish with, some key questions that it would be great to be able to answer.

(1) Does 'sustainability' go far enough? While I think certified sustainable is an important direction for the world's vineyards, I don't think that all the current certification schemes have enough teeth.

(2) What are the effects of systemic fungicides on vineyard microbial populations? I have a sneaking suspicion that we are messing up more than we realize when we use systemic fungicides in vineyards. It would be nice to know more about this.

(3) What effect does glyphosate have on soils? OK, it is a 'soft' herbicide, but what effect is it having on soil biology?

(4) Can we understand biodynamics better using scientific approaches, and will this be helpful? I think yes and yes.

(5) How does work in the vineyard impact on wine quality? This is a big question. It would be great to turn sustainable growing into a win-win scenario (to use this horrid but useful term).

So, in a nutshell, this is my vision for the new viticulture, which we are already starting to see appear. It is an empirical science, based on observation and careful thought, with plenty of room for art and inspiration as well as hard science. It regards the vineyard is a whole. It employs a low-impact viticultural tool kit, embracing elegant biological solutions to any problems, and focusing more on vineyard health than diseases and pests. There is less room for scientific fundamentalism, and it attempts to integrate biodynamics/organics with good science. Also, there is no set prescription for all vineyards. The new viticulture is one that is adapted to each site, aiming to listen to each terroir, allow each site to speak in its own unique way through the wines it produces.

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