New Zealand update on black foot disease

Dr Roderick Bonfiglioli
Technical director
Linnaeus
Gisborne, New Zealand

Many winegrowers throughout New Zealand, California and South Africa are unfortunately already familiar with a destructive root-rotting disease of grapevines commonly known as "black foot." Thought to be caused by the aptly named fungus *Cylindrocarpon destructans,* black foot may also be associated with other species of the genus *Cylindrocarpon*.

Although we in the wine industry recognise it as an important pathogen of grapevines, *Cylindrocarpon destructans* also wreaks havoc on various other hosts, including forestry trees (especially Silver firs), apples, pears, stone fruits, and walnuts, as well as a number of agriculturally significant plants, such as peas, strawberries, and bulbs.

The causative agent

While research on *Cylindrocarpon destructans* is now international in scope, our knowledge of the disease remains sketchy. To date, the most significant contribution regarding black foot has been made by Professor Pedro Crous, Dr Paul Fourie and PhD student Francois Halleen, a South African research team originating from the University of Stellenbosch. From his investigations, Francois Halleen and his colleagues have reclassified the genus, resulting in several new species of *Cylindrocarpon* being added as well as a division of the genus *Cylindrocarpon* into *Cylindrocarpon* and *Campylocarpon*.

The situation in New Zealand

Black foot can be found in low incidences in just about every viticultural region of the country – often, with little noticeable spread. In other regions, particularly Marlborough, the disease is widespread and has apparently been there for quite some time.

The reasons for this are not clear, although the higher incidence of the disease in Marlborough could be related to the region's earlier history of high-density apple orchards. Over time, of course, many orchards have been transformed into vineyards. In addition, some of the newer vineyard developments in and around the Marlborough region have utilised sub-optimal sites, which have heavy soils and are often poorly drained. Heavy and poorly drained soils are high risk factors for many root diseases, especially black foot.

The development of sub-optimal sites is not exclusive to Marlborough; rather, it is a general trend in many countries where new plantings are made in attempts to extend the boundaries of already established and successful viticultural regions.

Disease progress and symptoms

The progression of the disease within a single vine can be either sudden or gradual. If progression is sudden, the grapevine may collapse and die in mid-summer with a full load of fruit on it. Conversely, the vine may decline gradually and die over a two- to three-year period, during which the shoots will be visibly stunted, the vine will be paler in colour than the other healthy vines around it, and vigour will obviously be failing. In the latter instance, affected vines will probably carry very little fruit. Typically, an affected grapevine will show symptoms in the first few years following establishment.

The disease may initially be seen in a single patch or area, most likely in a lower-lying or poorly drained part of the vineyard. Over time, however, infection may radiate well beyond those first dips and hollows, spreading into other previously healthy areas of the vineyard.

Pathology

Examination of a longitudinal cross section of the lower portion of the vine trunk will typically show the very base of the rootstock section of the vine to be filled with a dark brown-black staining (see Figure 1). This staining extends upwards in the xylem tissue: once staining has progressed about 6 to 8 inches up from the very base of the rootstock, the vine usually dies. A deeply planted vine may develop a second-tier root system above the infection, but it is still just a matter of time before the infection progresses upwards and kills the vine. Examination of the interior of the roots may show various levels of the dark staining. This may indicate that the fungus invaded the vine through a particular root and worked its way upwards from there into the trunk.

The mechanism that produces the disease symptoms is thought to be a direct blockage and degradation of the xylem in the base of the rootstock. The fungal mycelium grows up the inside of the xylem in the trunk of the vine, effectively blocking the xylem and degrading the wood of the lower part of the rootstock. With most of the xylem blocked, the vine cannot transport sufficient water upwards. This results in the sudden

Fig. 1. Examination of a longitudinal cross section of vine trunk shows black staining extending upwards from the very base of the vine (left side), clearing towards the point where the trunk emerges above the soil line (right side). The black staining can also be seen in a major root, coming off the base of the trunk on the left side.

Fig. 2. With most of the xylem blocked, the plant cannot transport sufficient water upwards, as shown here in a vine that suddenly collapsed in late spring.

collapse seen in mid-summer when the transpirational demands on the vine exceed its compromised capacity to conduct water from the roots to the aerial parts of the vine (see Figure 2). It is not known if a fungal toxin is involved in producing any of the symptoms, as is seen in some other serious systemic fungal diseases of vines, such as Eutypa.

Epidemiology

Black foot is considered to be primarily a soil-borne disease. It is thought that the disease thrives in poorly drained and heavy soils, especially on sites where there may be standing water or the ground is sodden for significant periods of time. It is considered likely that mobile water tables and other forms of water moving through the soil may assist in the spread of the disease through a vineyard. Previous land use is also thought to be important, and old orchard ground is considered to be a prime risk, as *Cylindrocarpon destructans* is known to be a major pathogen of apple trees. Planting vines in sites previously used to grow pears or stone fruit – or used as a forestry nursery – also carries a risk, since all these sites are likely to contain residual infection.

As Francois Halleen has shown in his PhD study, *Cylindrocarpon destructans* can be transmitted from the nursery to the vineyard through nursery vines with infected roots. Yet even a high level of infection in nursery vines does not seem to result in a correspondingly high level of disease in the vineyard. This has been attributed to the stress "predisposition" required for the pathogens to cause disease.

Cylindrocarpon destructans is not known to have an aerial phase in its lifecycle. There is no evidence to show that spore dispersal ever occurs aboveground, and pruning wounds higher up the vine are therefore not considered to be potential sites of entry for this fungus, although de-suckering wounds close to or beneath the ground level might be. No insect vector has ever been implicated in assisting the spread of the disease, although it has been speculated that nematode wounds on roots might provide infection portals for the pathogens.

Control

Without a more detailed understanding of the epidemiology of the disease, recommendations for control are somewhat speculative. Some degree of control can probably be exerted at various stages, including site selection, site preparation, nursery propagation and planting. Control over the disease once it is in the vineyard remains an unknown for the time being. Currently there are no proven methods to control or eradicate the disease from infected vineyards, although some applications may be worth trying.

Control at the site selection stage

It would be sensible to make sure the site is well drained and not prone to significant periods of wetness. Any drainage issues should be addressed and fixed before planting. If the site is poorly drained and has a heavy soil, then it is strongly recommended to assess these risks properly before development. If the site was previously used as an apple, pear or stone-fruit orchard, or as a nursery site for forestry trees, or for growing strawberries, then expert advice should be sought before development continues. Soil sterilisation may be an option, but there is no research available to say how effective this practice may be for control of *Cylindrocarpon destructans.*

Control at the site preparation stage

If there is any question as to the risk involved in the site, then the ground could be treated with Trichoderma fungi when it is worked up before planting. Trichoderma species are naturally occurring fungi; they are natural enemies of a range of pathogenic fungi, including *Cylindrocarpon destructans,* against which they have a proven antagonistic activity. The method of application is important and the Trichoderma must be in the soil before planting in order to achieve the best result. Trichoderma in some preparations can be applied through drippers, but this method is probably not as good as direct addition into the soil. Several commercial preparations of Trichoderma fungal species are available as bio-control agents, and any such preparation should be useful.

Mycorrhizae fungi are also naturally occurring symbiotic fungi that inhabit the roots of many different plants and are known to assist in the uptake of nutrition. Mycorrhizae are considered to be a potentially useful treatment against soil-borne fungal diseases, probably by simply improving the overall health of the plants. Preliminary results of work on Mycorrhizae fungi in Dr Doug Gubler's laboratory at the University of California at Davis show that these symbiotic fungi do appear to have potential value against attack from root-rotting fungi.

Soil sterilisation is another option, but again, there is no research to verify that it will work. Many people are in fact extremely wary of this practice, as it results in soils with little or no biological activity. Indeed, sterile soils may actually be vulnerable to rapid re-colonisation by pathogenic fungi. While this option may appear to work well in the short term, it may actually worsen the situation in the long term.

In a related note, it is becoming increasingly apparent that soil health is a primary and vital factor in the prevention of soil-borne root diseases. Application of good compost and careful maintenance of soil health in a way that sustains a wide range of microbial activity and good levels of organic matter is likely to be beneficial. Research groups in different countries have focused on soil health and are now in the process of releasing their findings. Soil Foodweb, Inc. based in Corvallis, Oregon and headed by Dr Elaine Ingham, has done some interesting work in this area (for more information, go to the website, www.soilfoodweb.com). The group has affiliate laboratories in many countries, including New Zealand, and provides a listing of certified advisers who are available for consultation.

The current understanding of soils is that they are complex ecological communities of bacteria, fungi, other micro-organisms, nematodes, small insects and arthropods. When soil is healthy, it is a balanced ecological community with a complex and inter-dependent food chain. Disruption to the system, such as repeated use of fungicidal chemicals, will push it out of balance by favouring some organisms over others. With depleted numbers and diversity of fungi, for example, as may occur when powerful fungicidal chemicals are repeatedly used, bacteria may start to dominate the soil community. Over time, this could result in an anaerobic soil that's no longer conducive for growing plants.

Control at the nursery propagation stage

Good sanitation and hygiene control in the nursery will most likely prevent the problem from occurring at this stage. In the case of potted vines, all pots, trays, and media should be steam sterilised. Stand-out areas, benches and other surfaces where trays of pots sit should also be cleaned and treated with a disinfectant such as chlorine or quaternary ammonium compounds. Water running beneath (and thereby connecting) the pots in a stand-out area or bench carries the highest risk for transmission. The addition of Trichoderma fungi and Mycorrhizae to the potting media could also be a useful option.

In the field vine nursery, the same focus on soil health should apply. Repeated use of a site for any crop incurs risks that need to be properly managed. Use of good composts and careful maintenance of soil health is an essential element in the production of good-quality vines. Composts and bio-control agents such as Trichoderma could be worked into the soil of the nursery beds before planting and the vines could also be usefully dipped in ▸

Trichoderma (and/or Mycorrhizae) before planting. Further applications of Trichoderma could be applied through a drip irrigation system.

Hot-water treatment of vines requires some research specific to New Zealand. In the warmer viticultural climates of Australia and South Africa, the practice has been shown to be very successful against Cylindrocarpon species, several other fungal pathogens, Agrobacterium infections and grapevine phytoplasmas. Nonetheless, hot-water trials by nurseries in New Zealand have not yet been successful, and the reasons for this are not clear. It is thought that the wood produced on vines in cool-climate New Zealand may not be dense enough (perhaps in carbohydrate reserves) to survive the hot-water treatments.

Control at the planting stage and in the vineyard

Control at planting time is similar in concept to the nursery stage. The ground should be prepared with composts to ensure the soil is healthy before planting begins. Trichodermas can also be added, and it may help to stand the base of the vines in a slurry of Trichoderma spores for an hour or so before planting.

There is some evidence to show that, during the establishment stage of the vines (that is, the first couple of years), foliar applications of phosphorous acid can stimulate an anti-fungal response. These preparations have been shown to sometimes be of benefit with specific fungal diseases such as *Phaeomoniella chlamydospora,* the fungus involved in the disease commonly known as "black goo" – or more correctly now as "Petri vine decline." Trials on the use of phosphorous acid preparations against black foot have not yet been done, and concerns have been raised in Australia about the possible presence of residual chemicals called "phosphonites" in wines made from vines treated with multiple applications of high-dose phosphorous acid preparations.

There is no evidence to show that drenching the soil around the base of the vines with chemical fungicides will be of any use, indeed, it may just be an expensive waste of time. The continued use of powerful chemical anti-fungal compounds may simply further damage the soil ecology and suppress plant growth.

Rootstock sensitivities to black foot

Anecdotal evidence in New Zealand suggests that the rootstock 101-14 may be more sensitive to black foot than other rootstocks, although there are no reports from any overseas researchers to substantiate this. If this observation turns out to be correct, then we still have to determine if this is a factor related to the specific rootstock, or if some of the New Zealand accessions of 101-14 are in some way compromised.

Where to from here?

We do not yet have a lot of hard data about the epidemiology or control of black foot disease in vineyards. We are aware that sites with poor drainage and heavy soils present a higher risk. It is possible that previous land use, as in cropping ground or old orchard ground, may also present greater risk, but more information is needed before we can be sure of these issues.

New Zealand Winegrowers has recently developed a research project with Lincoln University, in conjunction with the University of Stellenbosch in South Africa, to research the epidemiology and control of black foot in New Zealand vineyards, and we look forward to the results of this investigation over the next few years.

Dr Roderick Bonfiglioli is the technical director of Linnaeus, a subsidiary of Riversun Nursery Limited, in Gisborne, New Zealand. He oversees the scientific diagnostics, as well as research and development, for both.