Optimising eradication strategies for exotic plant pathogen incursions on grapevines

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Abstract

*The current strategy for eradication of exotic grapevine diseases includes complete removal of affected and suspected vines, a method which incurs significant costs to growers and the wine industry as a whole. Alternative strategies need to be developed which optimise the eradication process and minimise the economic cost of returning the crop to its previous quality and production levels. A CRC for National Plant Biosecurity project aims to do this by using a research and development model that facilitates development of an alternative strategy using an endemic pathogen as a model, followed by validation on the target exotic pathogen. A drastic pruning protocol has been proposed to eradicate the exotic disease, black rot (*Guignardia bidwelli*), and is being evaluated in Australia using black spot disease (*Elsinoe ampelina*). It will then be validated on black rot in the USA, where the disease is endemic and there is scientific expertise on the pathogen. This research has potential to save the Australian wine industry over $18 million in the case of an exotic disease incursion.*

Introduction

The current strategy for eradication of an exotic disease incursion is based on the removal of all affected and suspected plants, and burning and/or burial of the plant material. This strategy may incur significant costs to industry and the community when perennial species, such as grapevines, are involved. The time taken to re-establish a vineyard to its previous level of economic production, following removal, can be many years.

In Australia, this strategy has been used to eradicate grapevine leaf rust (*Phakopsora euvitis*) in Northern Territory (West 2005). In other perennial crops, eradication of apple scab (*Venturia inaequalis*) in Western Australia has led to the state being the only apple-producing region of the world free of this disease (McKirdy et al. 2001). An eradication campaign involving tree removal and destruction, has been applied for citrus canker (*Xanthomonas axonopodis*) in Queensland, and providing the disease is not detected again by the end of the surveillance period in December 2008, the eradication will be deemed successful (Telford 2008). However, the time taken to re-establish vineyards or orchards to their previous yield and quality following removal, incurs significant costs to industry and communities.

The challenge is to develop novel alternative strategies that eradicate the exotic pathogen, while minimising negative economic and social impacts. For example, eradication of black sigatoka (*Mycosphaerella fijiensis*) from bananas in Queensland, began with the strategy of complete removal of plants. This strategy was unsustainable and led to use of an alternative, involving partial plant removal and chemical control (Peterson et al. 2005).

Estimating the capacity to eradicate exotic pathogens is difficult because they are not present in Australia. The objective of this study is to use a research and development model system to assess proposed alternative strategies. A drastic pruning strategy for the eradication of black rot disease (*Guignardia bidwelli*) of grapevine is currently being evaluated and is reported in this paper.

Research and development model

The model system is based on the classification of exotic pathogens by plant distribution type; i.e. surface or systemic pathogens. Surface pathogens include mainly fungal and bacterial species that inhabit foliage, fruit and green or non-lignified wood tissue throughout their life cycle. Systemic pathogens include viral, bacterial and fungal species that inhabit most parts of the plant, often travelling through the vascular system (Agrios 1988).

High priority exotic pathogens are listed in Plant Health Australia's National Viticultural Industry Biosecurity Plan (PHA 2008). Grapevine pathogens endemic in Australia, with similar biology and epidemiology to high priority target exotic pathogens have been identified, where possible, for each of the proposed categories (Table 1). These may be used as the basis for the development and evaluation of alternative incursion management strategies. The list has been compiled with input from various industry representatives, but is not exhaustive, and other exotic and endemic model pathogens may be included for future research.

Finally, the strategies can be validated in countries where the target exotic pathogen is endemic; through collaboration with

Table 1. Examples of high priority target exotic grapevine pathogens are categorised along with potential model pathogens, endemic in Australia.

Category	High priority exotic pathogens*	Potential endemic model pathogens
Surface bacteria	none	none
Surface fungi	Black rot (*Guignardia bidwelli*) Grapevine leaf rust (*Phakopsora euvitis*) Angular leaf scorch (*Pseudopezicula tetraspora*) Angular leaf spot (*Mycosphaerella angulata*) Rotbrenner (*Pseudopezicula tracheiphila*)	Black spot (*Elsinoe ampelina*) Phomopsis (*Phomopsis viticola*) Botrytis bunch rot (*Botrytis cinerea*)
Systemic bacteria	Pierce's disease (*Xylella fastidiosa*) Bacterial blight (*Xanthomonas ampelina*)	Crown gall (*Agrobacterium vitus*)
Systemic fungus	none	Eutypa dieback (*Eutypa lata*)
Systemic virus	Corky bark disease (grapevine virus B)	Grapevine leafroll virus

*Source: Plant Health Australia

international research teams recognised with leadership in the management of the respective pathogen.

Drastic pruning strategy

An alternative approach to eradicating surface fungi on grapevines is to drastically prune infected vines by removing all foliage, fruit and cordons. The novelty of this approach is that trunks remain and produce shoots in the following spring, returning the vine to full production and quality within three years, according to anecdotal evidence. This strategy is adapted from a method of remedial surgery which has been adopted for the management of eutypa dieback disease in grapevine (Sosnowski et al. 2005). A similar approach has been trialled for the control of pistachio dieback in Australia (Facelli et al. 2006) and citrus canker in Brazil (Belasque et al. 2005).

For this approach, the fungal disease black rot (*G. bidwelli*) of grapevine has been identified as a high priority exotic pathogen. Black rot occurs in North America, Europe, South America and Asia and the disease causes crop losses of up to 80% (Wilcox 2003; Figure 1). Most cultivars are susceptible to the disease and management of black rot is achieved with the use of a series of fungicide applications at considerable cost. The endemic disease, black spot (*Elsinoe ampelina*) of grapevine, has been chosen as a model pathogen to develop and evaluate the drastic pruning method. Black spot, also known as anthracnose, causes serious yield loss on table grape varieties, has similar epidemiology to black rot and is also managed through application of fungicides (Magarey et al. 1993; Figure 2).

Black spot trial

In 2006, a trial was established in the Sunraysia district of Victoria to develop and assess the drastic pruning protocol. Using a randomised block design, the trial comprises four, commercially grown, table grape cultivars (Red Globe, Christmas Rose, Blush Seedless and Fantasy Seedless) as blocks. Plots are randomly positioned along rows and consist of three vines with standard two-bud spur pruning. Vines in each plot will be either drastically pruned (as described below) or left as controls. Spacing between plots within rows is at least 7.3 m and between rows is 10.5 m.

Vines were inoculated in the spring of 2007 by spraying a suspension of *E. ampelina* conidia spores on new shoots with two to four unfolded leaves. Inoculations were conducted at three different times to cater for differences in phenology between the cultivars. Shoots were covered with a polyethylene bag overnight to provide high humidity to encourage spore germination and infection (Figure 3). Assessment of the vines in December 2007 showed that between 5 and 12 inoculated shoots on each vine were severely infected with leaf lesions and stem cankers.

Drastic pruning protocol

In winter of 2008, infected vines will be drastically pruned using the following protocol. Vines will be cut at the crown using a chainsaw and excised material from above the crown will be removed and placed in an excavated area about 25 m from the trial plots. The vineyard floor around the treated and control vines will be raked and the debris will also be placed in the excavated area. All of the vine material will then be burnt and covered with soil. Soil between vines will be turned by disc cultivation to bury any remaining debris. Finally, remaining trunks of the treated vines will be drenched with a high volume spray of the fungicide ziram.

Overhead irrigation and canopy misters have been installed in the trial block and will be used in the two springs following drastic pruning to provide conditions conducive for disease development. Vines will then be assessed for reoccurrence of disease to determine the success of eradication in treated vines compared to control vines. The latter will continue to be managed using standard pruning practices. Sentinel vines in pots will be placed strategically within and around the trial site during spring to detect any cross-contamination between treatments or external infection.

Figure 1. Berry shrivel symptoms of black rot in New York, USA.

Figure 2. Stem canker caused by black spot in Mildura.

Figure 3. Simulating an incursion by incubating shoots inoculated with *E. ampelina* spores in the trial near Mildura.

Black rot trial

Black rot is endemic in north-eastern USA. A trial will be established in a Cornell University, New York Agricultural Experiment Station vineyard (cv. Concord) that is currently infected with black rot. The distribution of symptoms will be assessed and, if required, will be supplemented with extra inoculation of the pathogen. The drastic pruning protocol described above will be applied to vines and disease development assessed in the following years to determine the success of eradication.

Conclusion

After the described protocol has been assessed and validated, the method will be fine-tuned and developed into a drastic pruning protocol for use by Australian authorities. Plant Health Australia will be consulted to gain an understanding of the possible implications of the new drastic pruning strategy in the context of PLANTPLAN (national emergency response plan for Australian plant industries) and the drastic pruning protocol will be forwarded for inclusion in the Viticulture Industry Biosecurity Plan.

It has been estimated that this research has the potential to save the wine industry over $18 million in lost production and quality, and management costs in the case of an exotic pathogen incursion (R. McLeod, unpublished data). Further research could evaluate this eradication protocol on other high priority exotic diseases that threaten high value grapevines and other perennial crops. Examples of other grape diseases are leaf rust, Rotbrenner, angular leaf scorch and angular leaf spot of grapevines (Table 1).

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