Soil, Plant & Ecological Sciences Division

Lincoln University

GRAPE PHYLLOXERA RESOURCE FOR CENTRAL OTAGO GRAPE GROWERS

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GRAPE PHYLLOXERA RESOURCE

FOR

CENTRAL OTAGO GRAPE GROWERS

Compiled by

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Biology of Grape Phylloxera

Name

The insect is variously called by the scientific names *Phylloxera vitifoliae* and *Daktulosphaira vitifoliae.* American and Australian authorities prefer the latter but British authorities the former. Similarly, it is known by the common names of grape phylloxera, phylloxera or grapevine louse. The first is the approved common name in New Zealand and the last should not be used since the insect is an aphid and not a louse.

General Comments

This aphid is a native of North America that has been spread into nearly every significant grape-growing region in the world. It has been present in New Zealand since the latter part of the 19th century and is known to affect grapes in Gisborne, Hawke's Bay and Marlborough.

Life History

Grape phylloxera in New Zealand over-winters in the mature nymph stage in cracks and crevices in the bark of older roots (other modes of over-wintering, e.g., eggs, are known). In spring, after bud burst, these nymphs moult and become adults (see Fig. 1). All adults in the soil are females and reproduce asexually laying up to 200 oval yellow eggs (see Fig. 2). The eggs hatch after varying times, depending on temperature, and the active first stage nymphs (crawlers) may take up residence on a root close by (see Fig. 3) or else they may move to the surface to disperse. Dispersal may be by crawling, wind, or surface or sub-surface water. These crawlers may survive out of soil up to 3 days. Once having taken up residence on a root, the nymphs feed from the roots and grow through three more moults. The final instar nymph, under New Zealand conditions, then generally moults to become a mature adult female. The cycle then repeats 4-9 times depending on prevailing temperatures. On North American *Vitis* species, the final instar nymph may give rise to a winged adult. This insect lays eggs that lead to a single sexual reproductive generation which lays eggs that overwinter on the bark. In the following spring these eggs hatch and the nymphs induce galls that are apparent on the lower surface of the leaf. As in the soil, this aerial phase may pass through 4-9 generations during a season. Eventually, some nymphs return to the soil, establish on roots and begin the asexual life cycle again.

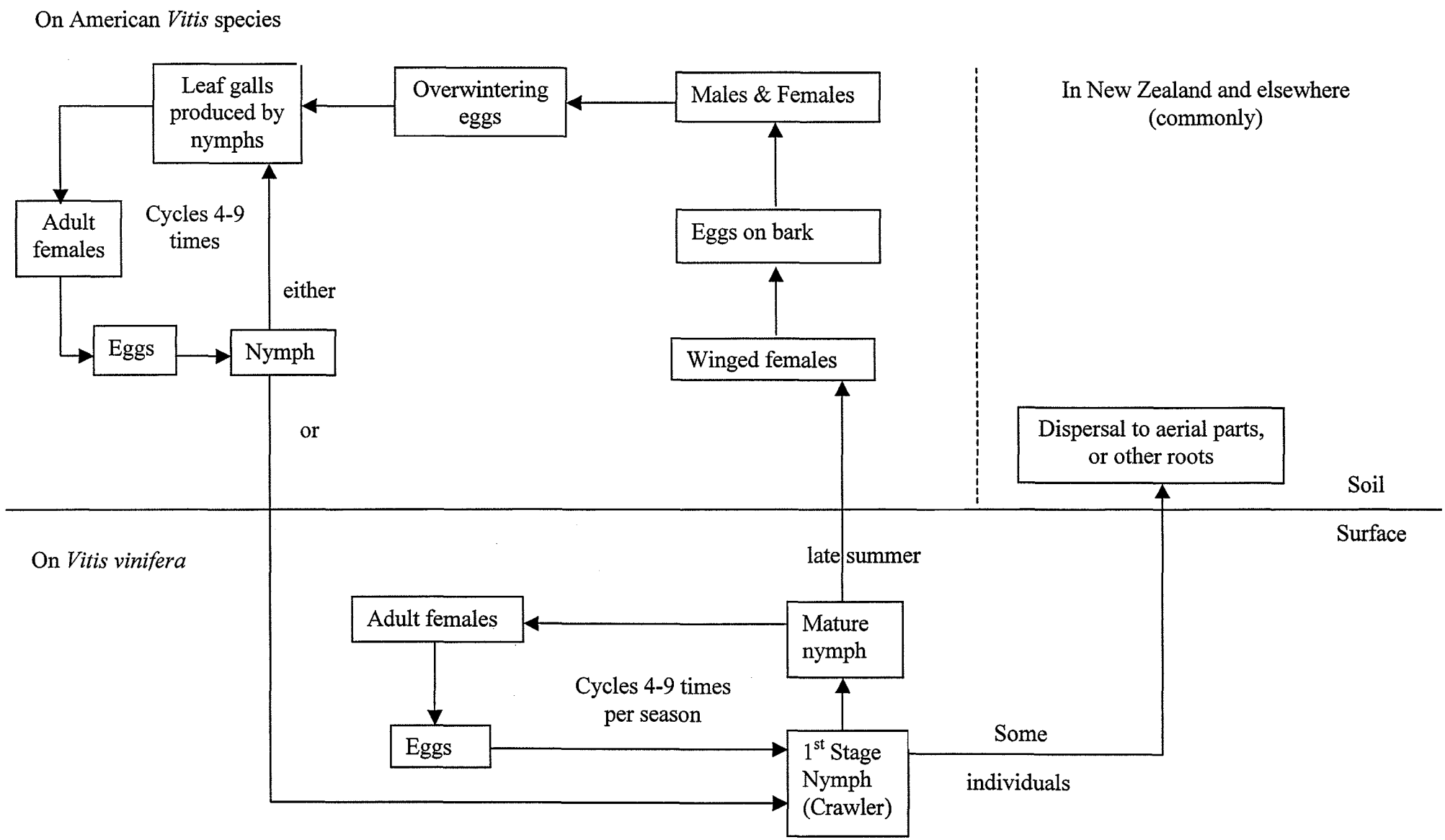

Figure 1 – The typical life cycles of grape phylloxera on *Vitis vinifera* and North American *Vitis* species

Figure 2: Grape phylloxera eggs on a grape root (Photo: M.H. Bowie)

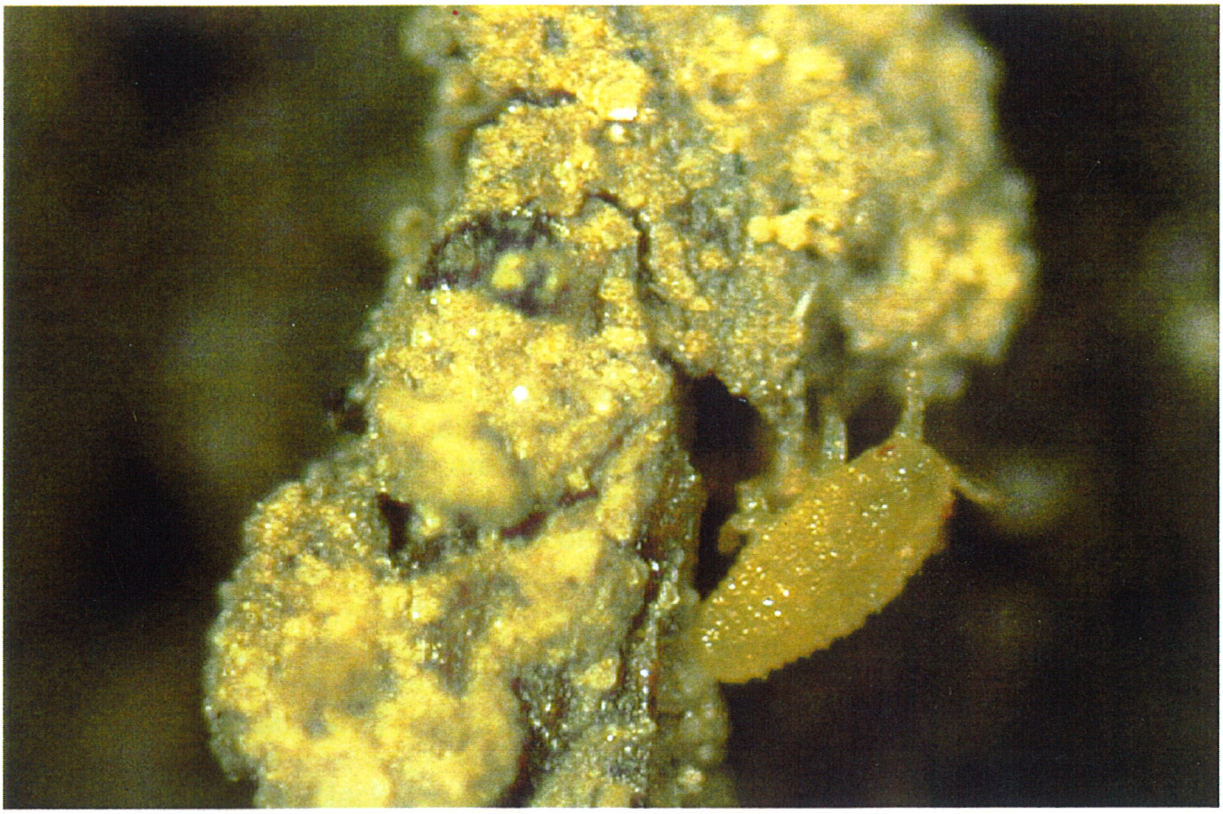

Figure 3: Grape phylloxera nymph on grape root (Photo: M.H. Bowie)

Phylloxera Effects on Grapes

Symptoms

Where leaf galls form, they appear as more or less spherical balls on the lower surface of the leaf that open to the atmosphere through the upper surface. When leaf galls are not found, e.g., on *Vitis vinifera*, the leaves turn yellow early in autumn. Generally, a more or less circular patch of vines will be affected. The symptoms first show up to three years after the vines were infested. Where such an infestation is present the shoots may show weaker than normal growth.

On the roots, symptoms vary depending on the age and size of the root. Fine fibrous roots develop yellow hook-shaped or goose-head galls (nodosities) (see Fig. 4). The aphid causing the malformation is usually near the centre of this gall. In larger roots, warty lesions or scars (tuberosities) are formed and the aphids tend to shelter in these warty areas. In both situations, the affected areas allow the invasion of various pathogens which cause the gall and/or root to rot. A seriously infected vine will have few fine fibrous roots.

In the early stages of an infestation, there may be just a few dead or stunted vines. As the infestation develops, this affected patch increases in size and vines near the centre die. Also, secondary infestation sites may develop as crawlers are spread by the wind or run-off water. A vineyard block with relatively few vines showing symptoms may have aphids present on the majority of vines.

Damage and Losses

Grape phylloxera nymphs and adults suck nutrients from the roots on which they feed. This, plus interference with water absorption because of the galls, means that productivity is lowered and the vine is stressed. The crop yield is consequently reduced. The infestation sites allow other organisms, particularly fungi, to attack the roots, which decreases nutrient uptake and water absorption.

Own-rooted vines decline below economic production levels over varying periods; in heavy clay soils and moderate temperatures it is rapid; in sandy soils and in warmer or colder areas it is slower. The period may vary between three and ten years. Correlations between numbers of aphids present and degree of damage and/or loss are difficult because secondary pathogens such as soil-borne fungi may cause substantial damage. The exact nature of the relationship between the aphid and these pathogens has yet to be confirmed in the field, e.g., the aphid may even be a vector of the pathogens.

Possible Similarity of Symptoms

Infestations of black vine weevil can produce a root structure that might superficially be confused with phylloxera damage in that there may be a similar lack of fine fibrous roots. Two factors permit the exclusion of this other insect as a cause of the damage. The first is that legless, white, crescent-shaped

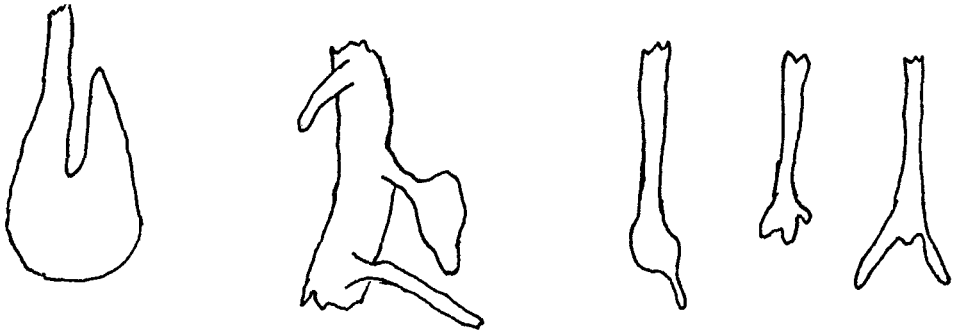

Figure 4: Typical hook, goosehead and other nodosity malformations of fine grape roots due to grape phylloxera infestation.

larvae (grubs) would be present in and around the roots in late autumn, if the weevil is the cause of the damage. Second, there would be no yellow nodosities or tuberosities on the roots if the weevil is the cause of the damage.

Conditions Favouring Infestation

Phylloxera is most abundant on own-rooted *Vitis vinifera* and less common on various commercial rootstocks. Other factors that increase the probability of damaging infestation include:

- proximity of other infested vines;
- vigour and age of the vines;
- stress factors affecting vines during the growing season; and
- soil type.

In many ways these factors are inter-related and also interact. For example, if there is little stress on the vines, vigour will be high and the effects of phylloxera, if present, much less obvious and damaging. Similarly, with soil type; deep well drained soils, i.e., less likely to produce stress in the vines, result in more vigorous vines and less apparent damage than vines on shallow, poorly drained soils. In clay soils, vines can be infested for up to three years before own rooted vines show damage symptoms.

Management of Phylloxera

Rootstock Selection

The single most successful tactic to counter the effects of grape phylloxera is the use of so-called resistant rootstocks. These rootstocks are described as 'so-called resistant' because a variety of mechanisms is involved from tolerance (vigorous root growth compensates for the losses due to phylloxera) through to antibiosis (reduction of phylloxera's biological fitness). In all of them, the aphids are present on the roots.

Rootstocks listed in the Australian viticulture integrated pest management handbook are:

Ramsey	5C Teleki	140 Rugerri
Freedom	3309 Couderc	1103 Paulsen
Riparia Gloire	3306 Couderc	SO4
Schwarzmann	99 Richter	5BB Kober
101-14 Mgt	110 Richter	5A Teleki

Rootstocks from this list that have been used successfully in Central Otago are: Riparia Gloire, Schwarzmann, 3309 Couderc and 101-14 Mgt. Another two, 5C Teleki and SO4, have been used only on very low vigour sites.

Rootstocks with *V. vinifera* in the parentage should be avoided. Such rootstocks seem to have been the cause of resistance 'failure' in California. In effect what happened was that selection of a more virulent strain of phylloxera occurred.

Given the aphid response on different species of *Vitis* (see Fig. 1), when resistant rootstocks are used, it is important to remove any aerial sucker shoots from the roots. If not removed, these could provide opportunities for the sexual phase of the life cycle, which currently is extremely rare in New Zealand.

Monitoring for Grape Phylloxera

The obvious area to sample is the patches exhibiting stress symptoms described above. The sampling should be done round the perimeter of the suspect area since the vines here are likely to harbour higher populations of phylloxera. Working about 0.5 m from the vine, roots from a number of locations (say five) round the vine to a depth of 20 cm or so should be removed and examined. Any fibrous roots showing nodosities (see Fig. 4) should be examined with a 10x hand lens for aphids. Any suspected aphids can be removed and placed in a little 70% alcohol in a plastic tube. For confirmation of identity, these suspect samples may be sent to:

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Control Options

Vineyard Establishment

When planting a new vineyard or extending a current one, careful consideration and evaluation of the use of resistant rootstocks is necessary. First consideration here might even be whether to plant at all in a known phylloxera infested area.

All planting material whether own rooted or on resistant rootstock should be free of phylloxera. This may be achieved by purchasing only from nurseries in phylloxera-free districts. However, even then, and certainly where planting material comes from known infested areas, the plants should all receive the hot water treatment (see later). Another alternative is dipping in the 1% malathion (Note: this is **not** a label-approved treatment in New Zealand). Finally, during the establishment of a new vineyard do not use equipment or machinery in the new area that has been used in a known infested area. If this is unavoidable, all equipment and machinery should be thoroughly washed, stripped and steam cleaned before being brought on to the new site.

Normal Operations

If a vineyard is already established, various practices can lower the risk of infestation and slow the spread of phylloxera if a vineyard is infested.

Quarantine Approach

The first and most obvious action, which may not be practical, is to limit human access to the vineyard.

Protocols such as that which the Central Otago growers have in place is one logical step. Elsewhere in the world, e.g., South Australia, quarantine regulations are very strict and go well beyond a voluntary protocol. For example, no equipment used in an infested district may be taken out of the district without being disinfested and inspected by relevant inspectors.

Wherever possible, it is desirable to avoid moving machinery and equipment from infested vineyards, or blocks within vineyards, to uninfested areas. This includes footwear. Dipping footwear, shovels, secateurs and the like in undiluted commercial bleach can help but phylloxera eggs have survived seven minute dips in bleach. Boots and clothing should be heat treated at 45°C for 2 hours to kill any phylloxera present. Steam cleaning at the infested site is the preferred option for equipment and that may need to be accompanied by some stripping or dismantling of the equipment – if plant debris can lodge in a remote ledge, nook or cranny then phylloxera crawlers, for example, can be there too.

At harvest, grapes from infested vineyards should be crushed in an on-site crusher or at a winery **within** the infested area to avoid cross-contamination at the winery. The residue from crushing should be disposed of away from vineyards.

Heat treatment
Planting stock being brought into a vineyard should receive the following treatment:

- wash the roots clean of soil (the washings may contain nymphs or adults so should be disposed of in such a way that infestation cannot occur);
- plunge the roots into an initial bath at 44°C for 5 minutes;
- transfer the roots to a hot water bath at 54°C for 3-5 minutes;
- plunge the roots into cold water immediately the above time is up; and
- heel the plants into sand, damp sawdust or sphagnum moss to prevent dessication.

Pesticide treatments
From the first appearance of phylloxera in France, insecticide treatments have proved inefficient or ineffective. The success of the use of rootstocks has largely worked against research in this area. The exception has been where infested blocks were treated before replanting.

Various factors contribute to the difficulty in using insecticides. First, there is poor penetration by insecticides into heavier soils and phylloxera nymphs and adults may be on roots as deep as metres into the soil. Secondly, systemic insecticides generally translocate upwards, which is fine for the leaf-galling stage but not for the root forms, the predominant stage in New Zealand. There is under investigation a compound that is downwardly mobile in plants and this may offer an option in future. Thirdly, the insecticides that have proved effective may have difficulty being re-registered by the Environmental Protection Authority (EPA) in the United States and that would spell the end of their use in New Zealand because of our reliance on wine exporting. In Central Otago and elsewhere, toxicants with a fumigant action like Enzone have been used. They have relatively short-lived action so repeat applications are necessary. Current recommendations target the time of highest phylloxera population levels.

Another potential avenue, because of the involvement of pathogens in the decline of phylloxera infested vines is the use of fungicide treatments. According to recent literature, there is no published information on this approach.

Organic methods
Surveys in California comparing organic and conventionally managed vineyards showed that both had similar, variable levels of phylloxera. However, there were lower levels of root necrosis by the secondary pathogens in the organic vineyards.

Biological control
Though generalist natural enemies of the leaf-galling forms are known they do not seem to exercise any significant control over population levels. Even less is known about natural predators of the root-galling form but, because pathogens are also involved, predation or parasitism of root-infesting stages of phylloxera may simply slow vine decline rather than preventing it.

Cultural control
Selection of vineyard site might be considered a cultural tactic since vines in sandy soils have been found in France and California to not be so susceptible to damage by grape phylloxera. Location considerations might also include ability to flood vineyards – flooding for 40-50 days in winter has been shown to limit populations.

Minimising Phylloxera Impact

As mentioned earlier, vine stress is one of the universal features of grape phylloxera infestations. Therefore, any management actions that minimise stress will reduce the production effects of phylloxera infestation. Such actions could include:

- applications of foliar nutrients to compensate for the reduced absorptive capability of the root system;
- application of frequent light irrigation (while being careful to avoid over-watering); and
- reducing cultivation round vines which means less root disturbance.

These are ways, though involving some cost, to extend the productive life of infested vines while the vineyard is replanted to resistant rootstocks over an extended period.

Replanting

Once a vineyard is infested, the only current long-term solution is to replant own-rooted vines with ones on resistant rootstocks. In order to maintain as much production as possible, this needs to be done in a staged manner. Each vineyard has its own peculiar set of conditions – including financial position – that have to be considered but it would be reasonable to try to replant at least 10% of the vineyard each year. Some prefer to rip out the old vines whereas others have simply cut them off at ground level. There is some anecdotal evidence that the latter approach leads to higher infestation levels in the new plants of the disease called black foot that is caused by *Cylindrocarpon* spp. fungi. It is also possible to treat soil to lower phylloxera population levels between removal of the own-rooted vines and replanting with resistant rootstocks. Various soil insecticides or fumigants may be used.

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