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Nematodes in Western Australian vineyards

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Nematodes in Western Australian Vineyards

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Department of Agriculture Western Australia, South Perth
Contents

Introduction .......................................................................................................................... Page 3
Identification of a nematode problem .................................................................................. Page 5
When and how to take root and soil samples ..................................................................... Page 7
Nematodes in Western Australian vineyards ...................................................................... Page 8
Other nematode species associated with grapevine ......................................................... Page 10
How are nematodes spread? ............................................................................................... Page 10
Control in the vineyard ........................................................................................................ Page 10
Biofumigation ...................................................................................................................... Page 11
Nursery hygiene .................................................................................................................. Page 11
Biosecurity .......................................................................................................................... Page 11
Recommendations ............................................................................................................... Page 12
References ......................................................................................................................... Page 12
Acknowledgements ............................................................................................................. Page 12
Nematodes are worm-like microscopic animals that live in the soil. There are numerous soil-inhabiting nematode species, but not all are harmful to plants. Some nematodes are plant-parasitic, feeding on and damaging roots, including those of grapevine. Feeding activities of these nematodes reduce the vine’s ability to take up water and nutrients from the soil, leading to lack of vigour, symptoms of nutrient deficiency, wilting, lower yield, vine decline and, in severe cases, vine death. Nematode feeding sites can also lead to entry of other disease-causing organisms (e.g. fungi or bacteria), resulting in rapid vine decline.

Nematodes can survive in the soil for many years, so are difficult to eradicate. It is therefore important to prevent introduction of damaging nematodes to the vineyard, particularly as their control or management in established vineyards is difficult to achieve.

Table 1 lists the common and scientific names of nematodes that are known to attack grapevine in Australia, the symptoms they cause on the roots, and their importance to commercial viticulture.

### Table 1. Nematodes that attack grapevine in Australia (adapted from Stirling et al 1999)

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Root symptoms</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root Knot Nematode</td>
<td><em>Meloidogyne incognita</em></td>
<td>Stunting, galling and knotting of roots (Figure 1)</td>
<td>Widespread, can be a serious problem to own-rooted vines and susceptible rootstocks; most frequent and economically important nematode pest of grapevine</td>
</tr>
<tr>
<td>Root Lesion Nematode</td>
<td><em>Pratylenchus species</em></td>
<td>Lesions and discoulouration of roots, destruction of feeder roots</td>
<td>High populations can cause economic loss</td>
</tr>
<tr>
<td>Dagger Nematode</td>
<td><em>Xiphinema species</em></td>
<td>Stunting, galling, swelling and malfunction of root tips (Figure 2)</td>
<td>Common, but importance often masked by infection caused by other nematodes; one species can transmit fan leaf virus</td>
</tr>
<tr>
<td>Citrus Nematode</td>
<td><em>Tylenchulus semipenetrans</em></td>
<td>Stunting and general deterioration of roots (Figure 3)</td>
<td>Common and damaging in medium-textured soils where vines are grown in association with citrus; has caused problems in the Swan Valley on vineyards not associated with citrus crops</td>
</tr>
<tr>
<td>Ring Nematode</td>
<td><em>Criconemella xenoplast</em></td>
<td>General debilitation and loss of feeder roots (Figure 4)</td>
<td></td>
</tr>
<tr>
<td>Pin Nematode</td>
<td><em>Paratylenchus species</em></td>
<td>General debilitation and loss of feeder roots</td>
<td></td>
</tr>
<tr>
<td>Stubby Root Nematode</td>
<td><em>Paratrichodorus species</em></td>
<td>Stunting, debilitation and swelling of root tips</td>
<td></td>
</tr>
<tr>
<td>Stunt Nematode</td>
<td><em>Tylenchorchus species</em></td>
<td>General debilitation and loss of feeder roots</td>
<td></td>
</tr>
</tbody>
</table>
The presence of nematodes that feed on grapevine roots does not necessarily mean that the vine is suffering economic damage. The extent of vine damage is influenced by a number of factors: the rootstock used, number and species of nematodes in the soil, climate, soil type, grape variety and management factors such as the degree of moisture stress. Infected vines often appear healthy if growing in moist, fertile soil, or if a low number of nematodes are present. However, as nematode numbers increase, vine damage can increase.

Nematodes are microscopic (transparent and less than 1 mm in length), so cannot be seen with the naked eye (Figure 5). However, some species can be identified from the appearance of root symptoms: galling or knotting of the root system (RKN); lesions on the roots and destruction of feeder roots (RLN); short stunted and/or swollen roots (Dagger Nematode). Soil and root samples need to be analysed in a laboratory for definitive diagnosis of the species and levels of nematodes present.

Figure 6 shows vines suffering from the severe effects of RKN infestation. The above-ground symptoms of this nematode damage appear similar to and could be confused with, other problems such as: moisture stress, nutrient deficiency, poor soil structure or the effects of other soil-borne pests or diseases.
Identification of a nematode problem

To determine if established vines are being attacked by nematodes, the root system should be examined. Holes should be dug and soil removed close to the trunk of the vine. The hole should be deep enough to collect a handful of the vine feeder roots. The soil should be carefully washed from the roots to enable proper root examination and observations taken of any galling or knotting on the roots, lesions, root discolouration or darkening and short, stunted roots. The root systems of low-vigour vines should be compared with vines from well-performing areas in the vineyard.

To positively identify the nematodes present in the soil, root and/or soil samples should be taken and sent to a diagnostic laboratory. Sampling is best done during the period from late Spring to mid-Autumn, when both the nematodes and the plant roots are more active. This ensures that the nematodes can be more reliably detected if present. Samples should be taken when soil is moist, as this prevents unnecessary damage to the nematodes during sampling and transport.

The more nematodes in the soil, the greater the likelihood of root damage and loss of yield. Table 2 provides guidelines on the potential for levels of different nematode species to adversely affect grapevines. These figures should be used as a guide only, as the actual damage to the vine is influenced not only by nematode level, but also by factors such as the climate, soil type, management and grape variety.
Table 2. Relationship between nematode level detected in roots or soil and estimated damage potential to grapevine (from Nicol et al. 1999)

<table>
<thead>
<tr>
<th>Nematode species</th>
<th>Damage potential</th>
<th>In roots Nematodes/g</th>
<th>In soil Nematodes/200 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root Knot Nematode (RKN)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meloidogyne spp.</td>
<td>Low</td>
<td>40 – 80</td>
<td>&lt;15</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>150</td>
<td>15 - 100</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>300 – 500</td>
<td>&gt;100</td>
</tr>
<tr>
<td></td>
<td>Very high</td>
<td>&gt;500</td>
<td>Not available</td>
</tr>
<tr>
<td>Root Lesion Nematode (RLN)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pratylenchus spp.</td>
<td>Low</td>
<td>10</td>
<td>&lt;5</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>20 – 30</td>
<td>5 – 20</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>60 - 80</td>
<td>&gt;20</td>
</tr>
<tr>
<td>Dagger Nematode</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xiphinema index</td>
<td>Low</td>
<td></td>
<td>&lt;5</td>
</tr>
<tr>
<td>X. americanum</td>
<td>Medium</td>
<td></td>
<td>5 – 40</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td></td>
<td>&gt;40</td>
</tr>
<tr>
<td>Citrus Nematode</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tylenchulus semipenetrans</td>
<td>Low</td>
<td>20 – 40</td>
<td>&lt;10</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td></td>
<td>10 – 100</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>60 - 70</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Ring Nematode</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Criconemella xenoplax</td>
<td>Low</td>
<td></td>
<td>&lt;5</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td></td>
<td>5 – 50</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td></td>
<td>&gt;50</td>
</tr>
<tr>
<td>Pin Nematode</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paratylenchus spp.</td>
<td>Low</td>
<td></td>
<td>&lt;20</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td></td>
<td>20 – 200</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td></td>
<td>&gt;200</td>
</tr>
<tr>
<td>Stubby Root Nematode</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paratrichodorus spp.</td>
<td>Low</td>
<td></td>
<td>&lt;5</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td></td>
<td>5 – 40</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td></td>
<td>&gt;40</td>
</tr>
</tbody>
</table>
When and how to take root and soil samples

AGWEST Plant Laboratories can analyse soil and roots for nematodes. To obtain submission forms and full sampling instructions contact:

AGWEST Plant Laboratories
Department of Agriculture Western Australia
3 Baron-Hay Court
South Perth 6151
Phone (08) 9368 3721 or (08) 9368 3333

Existing vineyard

Remove surface debris from around the base of the vine. Use a soil corer (‘pogo stick’) or narrow spade to sample soil to a depth of at least 20 cm. Collect a total of 500 g of soil from the root zone of vines suspected to show nematode damage, by sampling (as described above) from several vines. Only sample soil where vine roots are clearly present.

Collect soil from at least three unthrifty vines and from at least three healthy vines. Place the soil and roots from the unthrifty and healthy vines separately in sealed plastic bags. Label each bag clearly, using a permanent marker, so that samples can be easily identified by the laboratory. Roots must be provided within the bags of soil. This allows for observation of symptoms on the roots, as well as additional investigation of the nematodes occurring within the roots if necessary. Leave roots in the soil, as this will protect them during transport.

New vineyard sites

Analysis of soil pre-planting is advisable to determine the risk of nematode damage to new vines, and to decide if resistant rootstocks or a pre-plant soil treatment for nematodes is required.

Remove surface debris in the area to be sampled. Sample soil when moist.

Use a soil corer (‘pogo stick’) or narrow spade to sample soil to a depth of at least 20 cm. Sample soil in a grid pattern, taking 20 samples per hectare, 500 g per sample. Mix all soil samples thoroughly, BUT GENTLY, by hand in a bucket. Take a 500 g sub-sample from the mix. Seal the sample in a plastic bag and label.

Where possible, sample near weed species known to be susceptible to nematodes (e.g. deadly nightshade, Solanum nigrum, is susceptible to RKN).

Sample handling, storage and transport

Despatch samples to AGWEST Plant Laboratories as soon as possible after sampling. Keep samples cool and out of direct sunlight. Samples can be refrigerated for storage prior to transport, but do not allow freezing.

Note, however, that samples from tropical and sub-tropical areas should not be refrigerated prior to testing for nematodes.

If possible, ensure that the temperature of the samples does not rise above 25°C during transit. Avoid sending samples on a Thursday or Friday.

Include a completed Plant Disease Diagnosis Submission Form with the samples.
Nematodes in Western Australian Vineyards

Root Knot Nematode (*Meloidogyne* spp.)

Root Knot Nematode (RKN) occurs in all major vine-growing areas of Australia, and is the most serious nematode pest of grapevine in Western Australia. A combination of factors predispose Western Australian vineyards to RKN: sandy soils, warm climate, use of ‘own-rooted’ vines, and use of land previously planted to vegetable or fruit crops. Since the 1970s, nearly all new plantings of vines in the Swan Valley have been made using grafted vines and RKN-resistant rootstocks. A series of rootstock trials clearly established that viable yields could not be achieved in the Swan Valley if vines were planted on their own roots. However, newer viticulture areas are almost exclusively planted to own-rooted vines that may be susceptible to RKN.

Large areas of vines have, in recent times, been planted on sandier soils (e.g. Jindong, Swan Coastal Plain, Gingin) or on old horticultural land (e.g. Manjimup, Mt Barker) where significant levels of damaging nematodes may occur. Many of the gravelly soils in the south-west of Western Australia have loamy sand topsoils which are less prone to build-up of nematodes.

A comprehensive survey of 71 vineyard sites across the wine grape growing regions of the State was conducted in 2003. RKN (*Meloidogyne javanica* or *M. arenaria*) was detected in 31 per cent of the vineyards sampled. Fourteen of these vineyards showed obvious symptoms of decline, and these were all infested with RKN. On adjacent areas where vine decline was not apparent, RKN was not detected or was present at only low levels. In many vineyards where RKN was detected it is likely that levels were not yet high enough to cause economic damage. However, once present, these nematodes can not only increase in number with time, but also spread within a vineyard.

Vine growth in infested vineyards is patchy, with vines showing stunting, shorter internodes, reduced canopy and early senescence.

Root galls typical of RKN infection can be observed along the roots, combined with abnormal growth of feeder roots. Distorted and swollen roots show small, dark galls from which mature female nematodes and their associated egg masses can be observed microscopically (Figure 7).

Figure 7. Root galls showing protruding Root Knot Nematode females (f) and egg masses (e). (Professor Franco Lamberti, Visiting Scientist, DAWA, 2003).
**Effect of soil type**

RKN infestation is more likely to occur on sandy soils, and nematode reproduction is greater under these growing conditions. In addition, the lower water and nutrient holding capabilities of sands exacerbate the water and nutrient stresses experienced by nematode-infected vines.

RKN has also caused economic damage to vines planted on gravelly duplex soils in the Margaret River and Great Southern. This is of considerable concern because the vast majority of vines planted in the south-west of Western Australia are planted on their own roots.

Vines growing on loams and clays, as compared to sands, are better able to tolerate higher nematode infestations without loss of vine performance. These soils have higher water and nutrient holding capacities which can more readily supply the vine if its root function is impaired by nematode attack.

**Effect of previous land use history**

RKN is common on land previously used for horticulture (e.g. potato properties at Jindong, fruit properties at Manjimup and Mt Barker). In the Swan Valley, where new plantings occur on old vineyard land, severe infestations of nematodes occur.

RKN has the ability to reproduce on a wide number of plant species. Most leguminous cover crops (e.g. faba bean, field pea, vetch, sub-clover, medic) are highly susceptible to and support populations of RKN, whereas most cereals and grasses will not harbour RKN (Fisher 2003, McLeod and Warren 1993). Solanaceous weeds such as deadly nightshade (*Solanum nigra*) can also act as nematode hosts and allow build-up of RKN populations. The roots of these weeds are effective indicators of nematodes in existing or future vineyards.

**Planting material**

When planting vineyards with own-rooted vines, it is essential that the planting material is free of nematodes. Rootlings that are infected with RKN will not only result in vines yielding poorly, but nematodes can spread to adjacent blocks and also cause these vines to decline.

**Dagger Nematode (Xiphinema spp.)**

These nematodes are common in Australian vineyard soils, but no detailed study of the species or the damage they may cause has been made. Dagger Nematode was identified in 20 per cent of the Western Australian vineyards sampled in 2003, but growth and performance of these vines did not appear to be adversely affected. Unlike other countries where Dagger Nematode occurs, there was a distinct lack of diversity among these nematodes in Western Australian vineyards, and most were *Xiphinema rivesi*.

*X. index*, which is a vector for the devastating Grapevine Fan Leaf Virus (Factsheet 4/2000 *Grapevine fanleaf virus*), has not been detected in Western Australian vineyards.

**Root Lesion Nematode (Pratylenchus spp.)**

Root Lesion Nematode (RLN) usually occurs at low populations on vines, but is widespread and potentially more damaging than RKN if high population levels develop. Several RLN species are associated with vines in Australia.

RLN has been observed in Western Australian vineyard soils, but these nematodes do not seem to be associated with any economic decline. They are often identified at low-medium levels in diagnostic samples, and occasionally at high to very high levels.

Time of sampling is critical for detection of RLN in vineyards (Walker and Morey 2001). Levels in the soil can appear low over most of the season, but increase with flushes of root growth in Spring. This is also the time when vine roots are most vulnerable.
to infection and damage from these nematodes. To make any further conclusions on the role of RLN in Western Australian vineyards it would be necessary to conduct more detailed sampling of both roots and soil throughout the season.

**Other nematode species associated with grapevine**

- **Citrus Nematode** is rarely identified in Western Australian vineyards, and at only low levels. This nematode may cause considerable economic damage if it were to become established in a vineyard.

- **Ring, Pin and Stubby Root Nematodes** are rarely identified in Western Australian vineyards, but can sometimes occur at high levels. These nematodes have not been associated with economic damage to grapevines in Western Australia.

- **Stunt Nematode** is detected rarely and has only been found at low levels in Western Australian vineyards. These nematodes have not been associated with economic damage to grapevines in Western Australia.

**How are nematodes spread?**

Nematodes occur naturally, at low levels, in most soils. Establishment of susceptible plants will lead to an increase in nematode population levels, favouring development of the plant-parasitic nematode species. This is especially true of perennial crops (like vines), where continued growth of the plant allows development of nematode populations over a prolonged period. For vine production, it is not possible to practise an annual crop rotation with non-host plants to reduce nematode levels in the soil. Once nematodes are present, they are almost impossible to eliminate.

Nematodes can move only short distances in the soil, but can spread to previously un-infested areas through introduction on planting material, by movement of soil or water, and in soil adhering to machinery and other equipment.

Distribution of nematode-infested grapevine rootlings is one of the major routes for the introduction and spread of nematodes. It is therefore crucial to ensure that planting material is free of nematodes before it is introduced to the vineyard.

**Control in the vineyard**

Growers planting vines into soil with high nematode levels, on old horticultural land or in sandy soils, should use resistant rootstocks. Nematode-resistant rootstocks offer the most effective, long term control of nematodes in vineyards. Many rootstocks are resistant to RKN, so the nematodes will be slow to multiply, even if they are already present in the vineyard soil. Table 3 lists rootstocks currently in use in Western Australia and their relative resistance to RKN. Resistance to RKN, however, does not necessarily confer resistance to the other nematode species that attack grapevine.

**Table 3 Rootstocks used in Western Australia and resistance to Root Knot Nematode**

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Level of Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own roots</td>
<td>Low</td>
</tr>
<tr>
<td>140 Ruggeri</td>
<td>Low – Moderate</td>
</tr>
<tr>
<td>34EM</td>
<td>Moderate – High</td>
</tr>
<tr>
<td>1103 Paulsen</td>
<td>Moderate – High</td>
</tr>
<tr>
<td>99 Richter</td>
<td>Moderate – High</td>
</tr>
<tr>
<td>Schwarzmann</td>
<td>High</td>
</tr>
<tr>
<td>5BB Kober</td>
<td>High</td>
</tr>
<tr>
<td>Ramsey</td>
<td>High</td>
</tr>
</tbody>
</table>

Nematicides and soil fumigants have been successfully used to control nematodes prior to planting, particularly in nursery situations. Weed species must also be adequately controlled as many can act as alternative hosts for nematodes.
Effective control of nematodes using fumigants is difficult to achieve in established vineyards. The vines make delivery of the chemical to the site of the pest difficult, thus not allowing complete fumigation of the vineyard. Once nematodes (such as RKN) are established within the roots, efficacy of soil fumigation is reduced, particularly on older vines where the nematodes (along with the roots) have penetrated deeply into the soil.

**Biofumigation**

Brassica species (e.g. mustard, canola) have nematicidal properties which potentially can reduce nematode numbers below levels at which significant economic damage is caused. However, to be effective, the brassica crop must be used as a green manure. Plants need to be ploughed in so that the chemicals are released into the soil from the plant material. However, in an established vineyard, control is unlikely to be effective. It is not possible to adequately incorporate the brassica cover crop within the root zone, due to obstruction from the vine trunk and roots. In addition, nematodes may occur at depth on the vine roots away from any nematicidal compounds released from the decomposing brassica plants.

**Nursery hygiene**

Distribution of infested grapevine rootlings is one of the major routes for the spread or introduction of nematodes. Most grapevine nurseries produce rootlings in fumigated soil. Fumigation, however, often does not achieve complete nematode control due to incomplete chemical coverage, or enhanced biodegradation of the chemical by micro-organisms in the soil. Nemacur® is the only chemical registered for use in grapevine nurseries.

Nursery soil should be tested. If nematode numbers build up, the ground should be rotated, thoroughly fumigated and re-tested prior to planting again.

Hot water treatment of rootlings at 52°C for five minutes is recommended for the control of nematodes. However, hot water treatment can cause plant mortality if it is not done properly. The vines must be completely dormant at the time of treatment, the water temperature and timing measured precisely, and hot water treatment should be used only on healthy rootlings. Some varieties, such as Chardonnay and Pinot Noir, are more prone to damage from hot water treatment than other varieties.

**Biosecurity**

Many pests and diseases present in other parts of Australia and overseas do not occur in Western Australia. It is crucial that the high health status of the State is maintained, and this is achieved through the prevention of entry, early detection and prompt response to biological threats to the industry.

The greatest risk of spreading pests and diseases is when propagation material, grapes, juice, must, lees, people, machinery and equipment move between vineyards and from region to region. Grapevine material must be brought into WA through Quarantine, and planting material purchased from within the State should have been grown and prepared with the aim of minimising the spread of pests and diseases.

Movement of machinery and equipment must be monitored to minimise the risk of spreading pests and diseases, particularly through adhering soil and plant material. Second-hand equipment used in vineyards interstate or overseas may not be used in WA. There is an agreed protocol for the introduction of second-hand equipment.

For detailed information refer to the Viticulture Industry Biosecurity Plan which can be located at www.agric.wa.gov.au by searching under ‘HortGuard and viticulture’.
Recommendations

All grapevines planted on sands should be planted with grafted vines on nematode-resistant rootstocks.

All vines planted on old orchard or vegetable sites should be planted with grafted vines on nematode resistant rootstocks.

Old viticultural land should be planted with grafted vines on nematode-resistant rootstocks.

Pre-planting soil tests to determine species and levels of nematodes present are recommended for high risk sites (sands, old horticultural land and previously planted viticultural land).

Confirmation should be made that planting material is not contaminated with nematodes.

Detections of RKN (and other nematodes) in vineyards should be monitored to determine potential for vine damage and nematode spread.

Soil and/or root samples from existing vineyards (particularly if nematode problems are suspected) can be used to monitor nematode levels, determine species present and assess risk of vine damage.

It is critical to maintain vineyard hygiene and biosecurity standards to protect the industry from the introduction of exotic, and spread of endemic, pests and diseases.

Acknowledgements

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References


