PLANT AND SOIL NEMATODES

THE ROLE OF NEMATODES IN REPLANT DISEASES OF TREE FRUIT AND NUT CROPS

Replant disease (sometimes referred to as 'soil sickness', 'soil exhaustion' or 'replant disorder') is a worldwide problem on fruit and nut trees, but is most commonly observed on apples. When a field is repeatedly planted with the same or a closely related crop, newly planted trees exhibit severe growth reduction. Symptoms are consistently observed 1-3 months after planting and include uneven growth throughout the orchard, reduced shoot growth, discoloured roots, root tip necrosis and a general reduction in root biomass. Plant pathologists have been trying to determine the cause of replant disease for many years but the causative agents remain unknown. However, plant growth usually improves significantly following soil pasteurisation or fumigation, which suggests that the disease is primarily caused by biotic factors (Mazzola and Manici 2012).

Multiple strategies and methods have been employed to improve our understanding of the causal agents. In some cases, fungi and bacteria that are normally considered non-pathogenic (e.g. *Trichoderma*, *Penicillium*, *Mortierella* and *Bacillus subtilis)* have been associated with the disease. However, the pathogens considered to be the primary causal agents are multiple fungal species in the genera *Rhizoctonia*, *Phytophthora* and *Cylindrocarpon*, several *Pythium* species, and one root-lesion nematode species (*Pratylenchus penetrans*). However, the relative contribution of these organisms to the disease complex seems to vary from site to site and from one geographic region to another. Thus, there is general agreement that replant disease is caused by a myriad of biotic factors and that it is exacerbated to some extent by abiotic factors such as unbalanced nutrition, low pH, poor soil structure and drainage, cold or drought stress, and decomposition products from decaying roots.

The remainder of this fact sheet focuses on the contribution of nematodes to the replant disease complex.

Root-lesion nematodes

Root-lesion nematodes are known as migratory endoparasites, which means they enter the roots of a host plant and move freely through root tissue, feeding on root cells as they go. Dark-coloured lesions form where the cells are damaged and these lesions often coalesce so that the whole root becomes discoloured and eventually dies. The damage caused during the feeding process provides entry points for other soilborne pathogens, and also allows fungi and bacteria that are normally not pathogenic to enter roots and cause damage. Thus, it is difficult to determine whether root-lesion nematodes are causing the disease, as they are always interacting with other organisms in the soil biological community.

***Pratylenchus* species associated with apple replant disease**

One root-lesion nematode species (*Pratylenchus penetrans*) has long been recognised as an important component of the apple replant problem. It is considered one of the predominant causal agents in many countries, but a limited number of studies suggest that it plays a limited role at some locations. *P. penetrans* is certainly contributing to apple replant problems in Australia, as it is widespread on apples and occurs in all states. It is also likely to be damaging other tree fruit and nut crops such as peach, apricot, plum, walnut and almond.

Although *P. penetrans* is the dominant root-lesion nematode species on apples in Australia, another species (*P. jordanensis*, now considered a junior synonym of *P. zeae*) also occurs on some properties in the Granite Belt, an important apple-growing area in Queensland. This species is also pathogenic to apple, as it reduced shoot dry weight in a pot experiment by almost 50%, and also reduced root dry weight. However, *Fusarium tricinctum*, *Cylindrocarpon destructions* were also implicated in the replant problem because they were consistently isolated from discoloured roots and reduced the dry weight of apple roots in pots (Dullahide et al. 1994).

Management of root-lesion nematode in replanted apple orchards

Replant disease in apples is commonly overcome by fumigating the soil with a broad-spectrum soil fumigant. Although soil fumigants consistently provide effective disease control, they are expensive, difficult to apply, hazardous to human health, and have disastrous effects on the soil biological community. Also, it is not clear

whether they will continue to be available in future, and so research in the last few decades has focused on developing non-chemical methods of overcoming the problem. The practices that have received the most attention are rootstocks that perform well in replant situations, cover crops to reduce populations of *P. penetrans*, and organic amendments to enhance general disease suppression.

Management of root-lesion nematode on apple replants in Queensland

Field trials in a Queensland apple orchard infested with *P. jordanensis* showed that trees fumigated with methyl bromide performed well for the first two years, but after five years, trees mulched with sawdust, or sawdust + feedlot manure, produced yields that were as good as, or better than, fumigated trees. Lesion nematode populations were also reduced by the mulch treatments, but other benefits (reduced soil temperatures during summer; improved water infiltration; increased root density near the soil surface; and improved water holding capacity) also contributed to the growth and yield response. Thus, in contrast to the short-term effects of the soil fumigant, mulching provided multiple benefits that were likely to have continued for the life of the crop (Stirling et al. 1995).

Although a thick layer of mulch provided many benefits, the above study showed that the following practices should also be included in the replant program.

- Removal of the previous crop at least 12 months prior to replanting
- Growth of a green manure crop, or the addition of an animal manure amendment, during the period before the new crop is planted
- Choice of a vigorous rootstock that can tolerate attack by the root pathogens associated with replant disease

Free-living nematodes and apple replant disease

In a recent greenhouse study with apple replant disease soils from Germany that did not contain *P. penetrans*, nematodes and microbes were extracted from these soils and added to an autoclaved perlite/sand mix. Although free-living nematodes are normally considered beneficial (see Fact sheet PSN 023), the results showed that disease symptoms were enhanced when these nematodes were added with the microbes. *Acrobeloides*, a relatively common bacterial-feeding nematode and *Cephalenchus*, a plant associate that feeds on roots but does not cause damage, were the nematodes found in high numbers in replant disease soils (Kanfra et al. 2018). Although interactions between these free-living nematodes and microbes in the apple rhizosphere seemed to be essential for disease development, the mechanisms involved were not clear. One possibility is that high populations of *Acrobeloides* were reducing populations of bacteria that normally promote plant growth. Another possibility is that the labile carbon exuded when *Cephalenchus* was feeding on roots was predominantly being utilised by microbes that are detrimental to plant growth.

Conclusion

Replant diseases in tree fruit and nut crops have a complex etiology. Consequently, there is still a lot to learn about the pathogens/parasites/microbes associated with the disease, and the practices that can be used to modify the soil biology so that orchard soils are suppressive to the primary casual agents.

Literature cited

Dullahide SR, Stirling GR, Nikulin A, Stirling AM (1994) The role of nematodes, fungi, bacteria and ability factors in the etiology of apple replant problems in the Granite Belt of Queensland. *Australian Journal of Experimental Agriculture* 34, 1177-1182.

Kanfra X, Beerhues L, Sorensen SJ, Heuer K (2018) Free-living nematodes together with associated microbes play an essential role in apple replant disease. *Frontiers in Plant Science* 9, Article 1666. doi: 10.3389/fpls.2018.01666

Mazzola M, Manici LM (2012) Apple replant disease: Role of microbial ecology in cause and control. *Annual Review of Phytopathology* 50, 45-65

Stirling GR, Dullahide SR, Nikulin A (1995) Management of lesion nematodes (*Pratylenchus jordanensis*) on replanted apples. *Australian Journal of Experimental Agriculture* 35, 47-258.

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