INTERNAL BIOSECURITY – A REALISTIC OBJECTIVE FOR PLANT NEMATODES?

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ABSTRACT

Nematodes and insects share common features of taxonomic and ecological biodiversity, with different species exploiting a wide range of environmental niches. However, plant-feeding nematodes are usually very small, and require a moisture phase for activity. This allows very limited active dispersal in soil, but survival mechanisms allow the ability for passive dispersal in transported soil, plant material, flowing water and sometimes wind-blown soil. The range of plant hosts differs widely among nematode species. The indigenous New Zealand fauna has not adapted to exotic agricultural plants. Agricultural crops are exposed to a limited biodiversity of introduced pest nematodes, with many of the nematodes having only a limited distribution within New Zealand. This reduced nematode diversity compared with comparable habitats in the northern hemisphere contributes to competitive advantages for plant-based industries. As many crops are strongly regionalised, deliberate grower application of biosecurity practices could sustain unique advantages. The possibilities in New Zealand are illustrated using a variety of crop examples.

Keywords: plant nematodes, restricted biodiversity, biosecurity, grower opportunity.

INTRODUCTION

Nematodes are very diverse organisms found in nearly every terrestrial habitat where life is supported. Plant feeding species have evolved specialisations to feed on all plant forms. Most live in the soil environment and feed on or within plant roots. They cause root dysfunction in water and nutrient uptake efficiency and enhanced secondary microbial root infections, leading to potential loss of yield and product quality. These species are often less than 1 mm, and rarely more than 2 mm, in length and all require a free water film for activity. This makes them vulnerable to environmental extremes, for which they have evolved a variety of survival strategies. This may include having a wide host range, a cyst form for enduring adversity (e.g. climatic extremes or host absence up to several years), and many are able to undergo a process of anhydrobiosis. In this state the nematode loses most of its water and adopts an inanimate state enabling it to survive extremes of temperatures and low moisture for extended periods. The longest known survival period was 39 years in dried herbarium plant specimens (McSorley 2003).

Nematodes had relatively free entry into New Zealand until recent times. In a survey of dust and dirt taken from shipping container surfaces at New Zealand ports, live nematodes were recorded from 81% of samples from 347 containers, although only 4% were of plant feeding species (Gadgill et al. 2000). This was still equivalent to the potential arrival of plant nematodes on some 10,000 containers entering New Zealand annually. MAF presently ensures that containers are washed inside and out before transshipment within New Zealand.

Once established, onward distribution is largely through movement in plant material or nematode contaminated soil on plants, vehicles, machinery, tools and other equipment.

Given adequate awareness about nematodes and their survival and dispersal attributes, primary producers could directly contribute to maintaining the enviable advantage they share. The overall diversity of nematode species in traditional horticultural areas is greater than in pastoral areas (e.g. Knight 2001). This is partly due to greater diversity of plant species, sources and contamination of the plant material introduced.

AVOIDANCE OF NEMATODE DISPERSAL

Active dispersal and new establishment by nematodes is minimal and limited by their size and specific range of host plants. Once established they are difficult to eradicate, depending on host availability and survival mechanisms. Thus by managing passive dispersal it is possible to play a meaningful contribution towards maintaining the existing low diversity of plant parasitic nematodes at any site. Although nematode species differ widely in their overall pathogen potential, the combined effects of plant feeding species can be additive. In most cases, simple biosecurity precautions that avoid the transfer of nematodes can indefinitely delay their spread into new territory. A number of scenarios in New Zealand provide an insight into where opportunities have been lost and where, with adequate awareness and desire, existing advantages for and by growers can largely be preserved.

Citrus: opportunity gone

Citrus (*Citrus* spp.) have been grown in warmer areas of New Zealand since early European times, when the first exotic nematodes are presumed to have arrived (Yeates 2004). The citrus nematode (*Tylenchulus semipenetrans*) is the major nematode pathogen of citrus worldwide. While initial establishment could not have been avoided, later dispersal, probably through transplanted rootstocks, has resulted in infestations in all major commercial citrus growing regions. Sufficient grower awareness of this nematode could have avoided its establishment in most plantings over recent decades. The nematode is estimated to cause crop losses of 7% in Australia, but nematicide application to young orange trees increased yields in a replant soil by >100% (Walker & Morey 2001). This nematode is also a pest of grapevines (*Vitis vinifera*) and other crops in New Zealand. Thus vine planting in former citrus growing sites is more risky.

Grapes: opportunity available

Viticulture in New Zealand has a similar long history, with early planting material being brought in with minimum phytosanitary concerns. A worldwide literature survey of nematode pests in vineyards showed that some 154 species in 9 main genera are potential grape pathogens (Watson 2004). Some 27 species of these are established within New Zealand including representatives of all main pest genera (Table 1). This compares with 47 species that have been associated directly with vineyards in Australia, which has a similar viticulture history. Since viticulture is largely found in cold-warm climate zones in New Zealand, some of the more pathogenic species adapted to hot climate regions in Australia are precluded, e.g. *Meloidogyne arenaria*, *M. javanica* and *Pratylenchus zeae*.

Recent viticulture expansion in New Zealand has seen the development of large, widely separated, growing regions in areas with no history of commercial grape production and a largely pastoral immediate history. Modern growers have been cognisant of the opportunities to establish disease free vineyards by using reliable rootstocks and phytosanitary awareness. Some widely distributed nematodes commonly present in pastures also survive on grapes, e.g. root knot (*Meloidogyne hapla*), lesion (*Pratylenchus penetrans*, *P. crenatus*), stubby root (*Paratrichodorus minor*), spiral (*Helicotylenchus pseudorobustus*, *H. vulgaris* and *H. labiatus*) and pin (*Paratylenchus projectus*) nematodes, but only some of these occur in each site or region.

TABLE 1: Numbers of nematode species established within New Zealand that are pests of viticulture in Australia and worldwide.

GENUS	New Zealand	Australia	Worldwide
<i>Meloidogyne</i>	4 ²	7	9
<i>Xiphinema</i>	3	8	42
<i>Longidorus</i>	1	3	20
<i>Trichodorus</i>	1	0	4
<i>Paratrichodorus</i>	2	3	4
<i>Pratylenchus</i>	4	12	12
<i>Tylenchulus</i>	1	1	1
<i>Macroposthonia</i> ¹	1	1	8
<i>Helicotylenchus</i>	6	3	15
Other minor genera	4	8	39
Total species	27	46	154

¹Includes related genera.

²Includes two hot climate species restricted to northern North Island.

Distributions of potentially more pathogenic species, including dagger (*Xiphinema americanum*, *X. diversicaudatum* and possibly *X. brevicolle*), needle (*Longidorus elongatus*), stubby root (*Paratrichodorus minor*) and lesion (*Pratylenchus vulnus* and *P. thornei*) nematodes, are generally more restricted, but infestations of some species may occur in several widely separated geographic locations within New Zealand (Sturhan et al. 1997). The potentially serious nematode-transmitted fan leaf virus occurs in New Zealand, although the main vector nematode (*Xiphinema index*) does not. By comparison, European viticulture alone has 23 of some 40 species of *Xiphinema* associated with vineyards. Nematodes are estimated to cause 7 and 20% losses in wine production in Australia and the United States respectively (Nicol et al. 1999).

While nematodes are a minor issue in most vineyards in New Zealand at present, problems may evolve, e.g. when re-planting occurs and established pest populations are drawn onto young rootstocks or if potentially more serious species are spread. With sufficient grower awareness and continued application of sound biosecurity practices throughout New Zealand, the grape industry is in a position to protect its competitive advantages.

Cereals: opportunity diminishing

Cereal growing regions in the South Island and southern North Island contain a suite of nematode species that closely match those in temperate cereal growing regions of Australia. These include cereal cyst (*Heterodera avenae*), spiral (*Helicotylenchus vulgaris* and *Scutellonema brachyurus*), cereal root knot (*M. naasi*), lesion (*P. thornei* and *P. vulnus*) and stunt (*Tylenchorhynchus maximus*) nematodes. These nematodes possibly established from imported grain or second hand cropping machinery, possibly from Australia and have subsequently been spread through the cereal growing southern regions of New Zealand. Other graminaceous host plants including pasture grasses can often host these nematodes. Cereal root knot nematode has become widespread in cereal growing districts of the southern North Island and Southland, and the cereal cyst nematode in mid Canterbury. These nematodes are maintained on pasture grasses, but have not hitherto been associated with pasture and major maize growing regions in the North Island. However, isolated locations for *M. naasi* and *S. brachyurus* have been detected in the Waikato/ Auckland regions (Knight 2001). New Zealand maize yields are reputedly the highest in the world, and are associated with good soils, a favourable climate and a low pest burden that includes nematodes. While each nematode species individually may have limited pathogenicity, they can become part of the total pest burden that determines the local potential of a crop and soil.

Potatoes: an opportunity lost?

Potato growing in the northern North Island used to be concentrated in the Pukekohe region, often using continuous rotations for extended periods in market gardening areas. The arrival of two potato cyst nematodes, *Globodera pallida* and *G. rostochiensis*, was first managed by quarantining under MAF control until the nematodes in infected paddocks could no longer be detected. Changes after 1984 meant that this industry became self-managed and the trend for growers to lease pastoral land for extended periods became common. This was practicable because these nematodes have a limited host range among plant species within Solonaceae. Thus the system was compatible with traditional pastoral farming. A new nematode capable of damaging potato crops, *Meloidogyne fallax*, was recently discovered in potatoes (Marshall et al. 2001). As this nematode has a wide host range including pasture species, the practice of rotations with pasture is no longer tenable. All seed potatoes need to be grown in areas free of this nematode and infected sites managed so that further dispersal of the nematode is minimised. Unfortunately the nematode was possibly not detected early in its establishment and its distribution may no longer be manageable. DNA technology, which allows highly sensitive detection of nematode species present in soil samples, could improve nematode eradication prospects and strategies in such situations.

Lucerne: opportunity by containment

Lucerne is a valuable forage species in drier regions but is subject to the foliar feeding stem nematode, *Ditylenchus dipsaci*. This nematode lives in the soil, but at certain times migrates up into the leaf buds. This causes the shoots to become distorted and non-productive. The problem can be largely contained in lucerne by good management practices and the use of resistant cultivars. Harvesting equipment is a means of spreading the nematode. South Island contractors are aware of this and clean their equipment before moving from stem nematode infected properties.

CONCLUSIONS

Nematodes represent huge opportunity costs to the pastoral industry through reduced inputs from atmospheric nitrogen fixation and loss of herbage yield, resilience and forage quality (Watson & Mercer 2000). Considerable yield losses are also sustained across cereal, vegetable, fruit and flower growing industries. In some crops, e.g. export flowers or vegetables, and in crops where cosmetic damage amounts to near zero nematode tolerance standards, e.g. carrots, increased growing costs from nematicide use and lost production can be substantial.

New Zealand remains in an enviable position in that its isolation has meant that relatively few plant parasitic nematode species present major problems in our agricultural industries. Although fortuitous in the past, current quarantine legislation and practice has reduced the likelihood of further new nematode pests establishing. With appropriate awareness, and simple precautions, it is possible that nematodes with limited regional establishment within New Zealand can have their rate of spread delayed to a meaningful degree. Agriculturalists at any level, including those who could directly benefit, largely do not have this awareness. In many cases regional distribution patterns for potential nematode pests for specific crops have not been documented. It is possible, and desirable, for all growers to know what pest nematodes are on their properties and to use biosecurity practices to prevent the arrival of others. Local body legislation already contains clauses regarding the movement of agricultural equipment to prevent the spread of some weeds. Thorough compliance could cover nematode dispersal. Grower organisations are an appropriate means of promoting industry good through biosecurity awareness and practise.

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