*PASTEURIA PENETR*ANS, A BENEFICIAL BACTERIUM THAT REDUCES ROOT-KNOT NEMATODE POPULATIONS IN PERENNIAL CROPS

Bacteria in the genus *Pasteuria* are specialised parasites of nematodes. Endospores of the bacterium attach to the nematode as it moves through soil and after they germinate, the parasite proliferates through the body of the nematode and prevents it from reproducing.

There are hundreds of nematode-attacking strains of *Pasteuria* but each strain is host specific, as it will only parasitise a limited number of nematode genera and species. Nevertheless, there are species and strains of *Pasteuria* that infect all major nematode pests, which means that the bacterium is a very useful biological control agent. Another key feature of *Pasteuria* is that its endospores are resistant to environmental stresses such as heat and dryness, which means they survive well in the Australian environment.

Root-knot nematode and *Pasteuria penetrans*

Root-knot nematode (*Meloidogyne* spp.) is by far the most damaging nematode pest in Australia, as it reduces the productivity of many widely grown food and fibre crops. The final stage in the nematode's life cycle is shown in Fig. 1a. The nematode has set up a feeding site within a root, become an obese female about 1 mm in diameter, and then produced about 1000 eggs on the surface of the root gall which formed around the nematode. The important point to recognise is that the nematode produces huge numbers of eggs, and so it has the capacity to multiply quickly to damaging levels.

The *Pasteuria* species which attacks root-knot nematode is known as *Pasteuria penetrans*, and the way it interacts with its host is shown below. The wormlike juvenile nematode has hatched from an egg and moved through the soil, and during the process, spores of the parasite have adhered to the surface of the nematode (Fig. 1b). The juvenile then entered the root and became an obese female but was unable to reproduce because the bacterium multiplied within her body and destroyed her ovaries. Thus, when the female developed to maturity, she was unable to produce any eggs. Instead, her body was filled with millions of bacterial spores (Fig 1c).

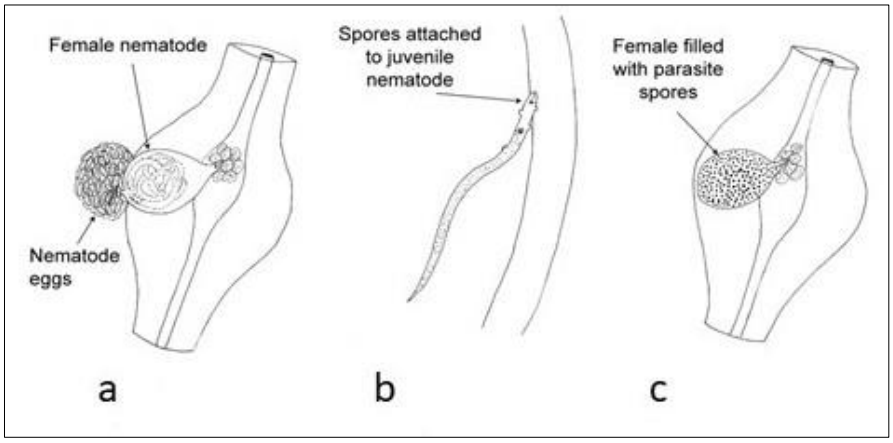

Fig. 1. (a) A healthy, egg-producing female of root-knot nematode. (b) A juvenile encumbered with spores of *Pasteuria penetrans* just prior to entering a root. (c) A parasitised female showing that rather than producing eggs, the body is filled with millions of *P. penetrans* spores.

Root-knot nematode is by far the most important nematode pest of perennial crops in Australia, causing yield losses on many crops, including grapevine, almond, peach, pineapple, passionfruit, papaya, kiwi fruit and sugarcane. However, two Australian studies have shown that there are situations where naturally occurring populations of *P. penetrans* can build up to high levels on such crops and keep the nematode under control.

Natural control of root-knot nematode on grapevine

Surveys of grapevines in South Australia during the 1970s and 80s showed that root-knot nematode often reached very high population densities in the sandy soils along the river Murray. Nematode numbers were very high in young

vineyards, particularly those that were less than 10 years old, but numbers were much lower in vineyards that were 50-70 years old. *P. penetrans* parasitised a large proportion of the nematodes in old vineyards and was found to be partly responsible for suppressing the pest. In contrast, it was rarely seen in young vineyards. The reason this naturally occurring bacterium was effective in old vineyards is that in a perennial crop such as grapevine, the soil is never disturbed by tillage. Consequently, endospores produced in infected females remain in the root zone and gradually accumulate over many years. Eventually, the spore concentration reaches a point where there are so many endospores that at least one of them will almost always attach to a juvenile before it enters a root. Thus, most of the females that develop will be parasitised and unable to reproduce.

Natural control of root-knot nematode on sugarcane

Root-knot nematode is one of the most important nematode pests of sugarcane in Queensland, and in a survey undertaken in 2015 and 2016 it was detected in 26% of the fields sampled. The bacterial parasite *P. penetrans* was found in about a third of these fields but in most cases infestation levels were relatively low. However, there were exceptions, one being a field near Bundaberg where susceptible sugarcane varieties had been grown for about 40 years and a susceptible rotation crop (lablab, *Dolichos purpureus*) had always been planted at the end of the sugarcane cycle. Soil collected from this field was used in a greenhouse experiment and the results showed that the *P. penetrans* was having a major impact on root-knot nematode populations. The nematode was inoculated into *Pasteuria*-infested and *Pasteuria*-free soil and when nematode populations were checked 37 weeks later, 99% fewer root-knot nematodes were recovered from the naturally infested field soil than from a nearby soil that did not have *P. penetrans*.

Conclusions and comments

Both these studies showed that when root-knot nematode is present on a perennial crop for many years, a naturally occurring biocontrol agent (*P. penetrans*) increases to levels which markedly reduce its population density. Nevertheless, there are several points that should be kept in mind when considering this result.

- When female nematodes are parasitised and are not producing eggs, they are still feeding on the root system. Consequently, the host plant will be suffering some nematode damage as the *Pasteuria* population increases
- Once the endospore concentration reaches about 10^5 endospores/g soil, most of the second-stage juveniles will be encumbered with large numbers of spores. This affects their motility and so they are no longer able to move to and enter a root. Thus, in situations where *P. penetrans* and its nematode host interact for many years, the endospore concentration may reach the point where damage to the plant is reduced
- *P. penetrans* does not control root-knot nematode in most sugarcane fields because growers usually cultivate their fields when replanting a crop. Most *Pasteuria* endospores are found within or near roots and when roots and rhizosphere soil are mixed with soil that contains few endospores, the endospore concentration will be reduced. Thus, endospore concentrations capable of suppressing root-knot nematode will only be obtained if a minimum till farming system is adopted.

Further reading

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