PLANT AND SOIL NEMATODES

ENHANCING THE NEMATODE-SUPPRESSIVE CAPACITY OF SOILS USED FOR VEGETABLE PRODUCTION

One of the reasons vegetable growers experience nematode problems is that the practices used to grow the crop have destroyed the natural enemies that should be keeping plant-parasitic nematodes under control. This fact sheet explains the management practices required to restore the biological health of vegetable-growing soils and enhance their capacity to reduce populations of nematode pests.

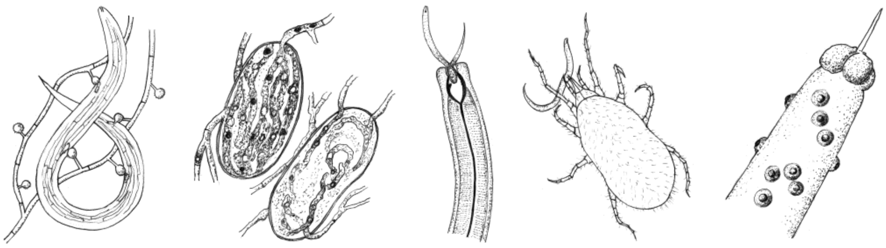
Why are nematodes a widespread problem on vegetable crops?

There are several reasons why plant-parasitic nematodes (but particularly root-knot nematode) are an insidious problem on vegetable crops. First, most widely grown crops (e.g. tomato, capsicum, carrot, cucurbits, potato, eggplant, sweetpotato) are very susceptible to root-knot nematode. Second, fields are cropped frequently and so there is insufficient time between crops for the nematode population to decline. Third, the nematode is carried over from crop to crop on weeds and volunteers.

A fourth reason is discussed in this fact sheet. Natural enemies should be helping to keep the pest under control but they have been destroyed by the management practices used in the vegetable industry.

What are the main natural enemies of nematodes?

- **Nematode-trapping fungi**: These fungi produce a range of trapping devices that are used to capture nematodes
- **Egg-parasitic fungi**: These fungi proliferate in root-knot nematode egg masses and then parasitise the eggs
- **Predatory nematodes**: These relatively large nematodes have an open mouth armed with teeth which is used to feed on other nematodes
- **Microarthropods**: These small animals have a range of food sources. Some mites eat only nematodes while others consume nematodes and other soil organisms
- **Bacteria in the genus *Pasteuria***: Spores of this bacterium attach to nematodes as they move through soil. The nematode is then parasitised by the bacterium and does not reproduce



Natural enemies of nematodes (from left to right). Nematode captured by a fungus with adhesive knobs. Fungus parasitising nematode eggs. Nematode consumed by a predatory nematode. Predatory mite eating a nematode. *Pasteuria* spores adhering to a nematode

Why have we lost natural enemies from vegetable-growing soils?

In natural soils, plant-parasitic nematodes do not cause problems because their populations are regulated by their natural enemies. There are several reasons why many of these regulatory agents have been lost, or their populations have declined to low levels, in soils used for vegetable production.

- Tillage disrupts the fungal networks that should be radiating through soil; it disperses spores of *Pasteuria* so they are less likely to come into contact with nematodes; and it kills predatory nematodes and microarthropods because being relatively large, they are particularly vulnerable to damage caused by tillage equipment such as rotary hoes.

- Vegetable-growing soils generally have low levels of organic matter, the energy source that sustains the soil biological community. Consequently, they do not have an active and diverse food web that cycles nutrients and prevents pests from multiplying to high levels.
- Soil is often compacted by farm machinery and this causes it to become anaerobic in wet conditions and an unsuitable habitat for many soil organisms. Compaction also eliminates the pore spaces inhabited by predatory animals such as microarthropods.
- The fertilisers and pesticides used to produce vegetables have side-effects that are detrimental to beneficial soil organisms.

The fix

There are no silver bullet solutions to soil health problems. Farm managers need to have a broad understanding of soil biological processes and recognise that soil organisms provide many important ecosystem services: maintenance of soil structure, storage and release of nutrients, detoxification of pollutants and suppression of soilborne pests and diseases. They must then attempt to integrate the following crop and soil management practices into their farming system.

- Minimum tillage
- A diverse rotation sequence
- Continuous inputs of organic matter from cover crops and organic amendments
- Maintenance of a permanent cover of plant residue on the soil surface
- Avoidance of compaction through traffic control
- Judicious use of pesticides and fertilisers

It is possible to achieve an active and diverse soil biological community in vegetable-growing soils. However, it is a very challenging process in root and tuber crops such as carrot, potato and sweetpotato because the disturbance involved in the harvest operation cannot be avoided. Consequently, it is vital that other tillage operations are minimised when these crops are grown, and that the practices listed above are also integrated into the farming system.

Development of more sustainable production systems: One example

In the farming system used to grow sweetpotatoes in Australia, the soil is repeatedly tilled to kill weeds and volunteer plants, incorporate cover crop residues, prepare beds for planting, and harvest the crop. Collectively, these practices have disastrous effects on the health of the soil. Trial work undertaken at Cudgen NSW showed that if the farming system was modified in the following way, tillage could be markedly reduced without affecting yield.

- Immediately after harvest, volunteer sweetpotatoes and weeds were killed using tillage and herbicides and then beds were reformed
- Cover crops (forage sorghum and oats) were grown on the beds and the aboveground biomass was retained on the soil surface as mulch
- Sweetpotatoes were planted into undisturbed beds using a strip-till process where a tine was used to form a channel in the middle of the bed and stem cuttings were planted in the channel

In another trial, a V-shaped furrow about 14 cm deep and 9 cm wide was prepared in the centre of the bed and various organic amendments were placed in the furrow. Sweetpotato was then planted in the furrow so that the swollen roots were surrounded by an amendment as they developed. When roots were collected 7 weeks after planting, the number of galls produced by root-knot nematode was much lower where the amendments had been applied than in non-amended plots. Results obtained at harvest were also encouraging, as the sawdust and sawdust/chicken litter amendments both increased marketable yield by 29% and reduced final populations of root-knot nematode by 43% and 39%, respectively. Follow-on work in the greenhouse confirmed that sawdust-based amendments reduce root-knot nematode populations and the severity of nematode damage. The results also suggested that the nematode control obtained with the amendments was mainly due to the effects of a wide range of natural enemies (predatory nematodes, mesostigmatid mites and nematophagous fungi).

How can growers move forward?

The above example shows that it is possible to enhance the nematode-suppressive capacity of a vegetable-growing soil. As the practices known to improve the biological status of a soil are well known, it is up to vegetable growers to assess them in on-farm field trials and integrate those that show promise into their farming system. During this process, the carbon content of the soil, its biological status, and its nematode-suppressive capacity should be monitored, as this will show whether improvements are occurring.

As it may take years to complete a soil improvement program, a safe and effective nematicide will always be required as a backup. Consequently, growers should check the efficacy of potentially useful chemical and biological products, but focus on products known to have little impact on the organisms that regulate nematode populations.

Further reading

Stirling GR (2014). Biological Control of Plant-parasitic Nematodes. 2nd edition. Soil Ecosystem Management in Sustainable Agriculture. CAB International, Wallingford. 536 pp.

Stirling GR, Stirling AM, Prichard M (2020) Sustainable sweetpotato farming systems to improve soil health and reduce losses caused by root-knot nematode. *Australasian Plant Pathology* 49, 591-604.

Stirling GR (2021) Surrounding the swollen roots of sweetpotato with a decomposing band of an organic amendment enhances nematode-suppressive services and reduces damage caused by root-knot nematode. *Australasian Plant Pathology* 50, 151-168.

Stirling GR (2021) Modifying a productive sweetpotato farming system in Australia to improve soil health and reduce losses from root-knot nematode. Sikora et al. (eds.) *Integrated Nematode Management: State-of-the-art and visions for the future* (Eds. RA Sikora et al.) CAB International, Wallingford, Chapter 51, 368-373.

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Author: Graham R Stirling, Plant and Soil Nematodes. **Contact details:** graham.stirling@biolcrop.com.au

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