PLANT AND SOIL NEMATODES

NON-SUSTAINABLE METHODS OF NEMATODE CONTROL: INTENSIVE TILLAGE, SOLARISATION, BARE FALLOWING, AND SOIL FUMIGATION

A wide range of tactics are used to reduce the damage caused by plant-parasitic nematodes but some are detrimental to the health of the soil. This fact sheet discusses why tactics such intensive tillage, solarisation, bare fallowing, and soil fumigation should be phased from use and replaced with more sustainable tactics that will not only reduce nematode populations but also improve soil health.

Why do plant-parasitic nematodes multiply to high levels on agricultural crops?

Plant-parasitic nematodes never reach high population densities or cause damage in natural ecosystems. However, these pests multiply readily in agricultural soils because the regulatory mechanisms that should be suppressing their populations are no longer operating effectively. There are several reasons why this has occurred

- The fungi, bacteria, microarthropods, and other organisms that parasitise or prey on nematodes and keep them under control are sustained by carbon inputs from plants. However, levels of soil organic matter in most agricultural soils have declined by 50-80%, and so the activity and diversity of the community of organisms that regulate nematode populations has declined.
- Rippers, discs, tined implements, and rotary hoes are often used in agriculture (particularly in the vegetable industry). However, tillage is detrimental to fungi, the most important biocontrol agents of nematodes. Mesofauna that survive by preying on nematodes (e.g. omnivorous and predatory nematodes, and predatory microarthropods) are also affected by tillage.
- Nutrients and pesticides are commonly applied to agricultural soils, and they are detrimental to many of the natural enemies of nematodes

The key components of conservation agriculture (minimum or zero till, crop rotation and stubble retention) have improved the situation to some extent in broadacre agriculture. However, the vegetable industry still has a long way to go. Most soils used for vegetable production are cultivated intensively, land is sometimes bare fallowed for several months, cover crops are not always a component of the production system, crop residues are rarely retained on the soil surface, polyethylene (plastic) film rather than organic mulch is used to cover the beds, soil is often fumigated prior to planting, inorganic fertilisers are often applied at rates in excess of the crop's requirements, and fungicides and insecticides are applied routinely. The end result is that key soil functions are lost and vegetable-growing soils begin to resemble a 'biological desert'. Few nutrients are mineralised from organic matter, soilborne pathogens have no competitors, and the soil is little more than an inert medium which supports the crop.

The 'biological desert' philosophy of vegetable production. Soil is routinely bare fallowed and aggressively tilled (left), and then it is fumigated (middle) and covered with plastic (right).

Nematode control practices detrimental to soil health

Although the poor health of many agricultural soils is the collective effect of many components of the farming system, four control measures that are often used to reduce nematode populations are making the situation worse.

Intensive tillage

Tillage reduces populations of plant-parasitic nematodes in upper soil horizons because some nematodes will be damaged by the tillage implements or crushed by soil particles that are disturbed during the tillage process. Also, some nematodes will be brought to the soil surface when soil is tilled and they will desiccate in hot, dry conditions or be killed by heat from the sun. However, tillage is also disrupts the hyphae of nematode-trapping fungi and other fungal antagonists of nematodes, and reduces populations of omnivorous and predatory nematodes that have a regulatory role in the soil food web.

Solarisation

The process of soil solarisation involves laying transparent polyethylene sheeting over moist soil for 6-12 weeks, thereby heating the soil to temperatures that are lethal to nematodes and other soilborne pathogens. However, the level of nematode control obtained depends on the depth of the soil that is effectively solarised. Some nematode control is usually obtained in the upper 20 cm of the soil profile, but nematodes in deeper soil layers may not be affected. As solarisation also kills the beneficial organisms that help keep pest nematodes under control, solarisation sometimes increases the amount of damage caused by these pests. Unaffected nematodes from depths of 20-40 cm move upwards into the solarised zone and because their natural enemies have been killed, they multiply to high densities and cause severe damage.

Bare fallowing

As plant-parasitic nematodes are obligate parasites of plants, nematode populations will decline when host plants are not present. Thus, a bare fallow (a soil that is free of weeds and other plants that might host the nematode) is a useful control measure. Studies in the tropics and subtropics have shown that provided the soil is warm and moist, a bare fallow will reduce root-knot nematode populations by 95-99% in about three months. The reason it is so effective is that juveniles hatch from eggs and move through the soil in search of a host plant. As no food source is available, the nematodes deplete their food reserves and eventually die. The disadvantage of bare fallowing is that soil carbon levels decline, and this has flow-on effects to the soil biological community. The absence of plant cover also means that the soil is exposed to the risk of wind and water erosion.

Soil fumigation

Soil fumigation is perhaps the most biologically disruptive practice used in agriculture. All soil fumigants have a broad spectrum of activity, and so they not only kill nematodes and other pathogens but also a huge range of beneficial organisms. When soil is fumigated, a biological vacuum is created and if the pest is reintroduced, it will multiply to very high levels because its natural enemies have been eliminated.

What is the impact of nematicides?

The first generation of non-volatile nematicides (the organophosphates and carbamates) were detrimental to non-target organisms, particularly free-living nematodes and microarthropods. However, they have been phased from use and a new generation of chemicals are now registered in Australia or are undergoing the registration process (see Fact sheet PSN 007). At this stage, it is not clear whether they are detrimental to the organisms that parasitise or prey on nematodes, and so research to address this issue is required.

Conclusion

When a decision is being made on whether a particular nematode control practice should be used, the level of nematode control that is likely to be obtained is not the only factor that should be considered. It is also important to consider whether the practice is detrimental to the many beneficial organisms that maintain the health of the soil and help keep plant-parasitic nematodes under control.

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