PLANT AND SOIL NEMATODES

DO NEMATICIDES HAVE A PLACE IN MODERN INTEGRATED NEMATODE MANAGEMENT PROGRAMS?

During the 20th century, nematicides were the predominant means of controlling plant-parasitic nematodes. Effective non-chemical management programs have now been developed for most crops and so this fact sheet looks at whether there will be a need for nematicides in the 21st century.

Nematicides and fumigants

Chloropicrin, a chemical that became known as 'tear gas', is a poisonous gas that was developed in World War 1 to disable enemy soldiers. After the war, large stocks of chloropicrin were available and when it was added to soil in pots, it increased the growth of tomatoes and reduced the number of nematodes and other organisms in the soil. Follow-on work in Hawaii showed that chloropicrin markedly increased pineapple yields and consistently produced plants free of root-knot nematode. Thus, chloropicrin can be credited with alerting the world to the fact that plant-parasitic nematodes reduce the yield of many widely grown crops.

Several other fumigant nematicides were developed following the second World War, and during the period from 1950 to 2000, soil fumigation was the primary nematode control strategy in vegetable crops and many perennial horticultural crops. Several organophosphate and carbamate nematicides were also developed during this period and they were widely used on fruit and vegetable crops.

The health hazards involved in manufacturing, handling, and applying nematicides, and the detrimental effects of 1,2-dibromo-3-chloropropane (DBCP) on the environment were recognised by government regulatory agencies in the 1970s. DBCP was the first fumigant removed from the market and it was followed by ethylene dibromide (EDB), which was found to be carcinogenic and to contaminate groundwater. Methyl bromide, a broad-spectrum fumigant that was also used against nematodes, was phased out in 2005 because it depleted the ozone layer. Several organophosphate and carbamate nematicides were also deregistered at that time because they were toxic to humans and other animals, and found to be detrimental to the environment.

All the above nematicides, together with the fumigants registered for use in many countries today (1, 3 dichloropropene (1,3 D), ethanedinitrile (EDN), chloropicrin, metham sodium, and dazomet) had a huge impact on non-target organisms. The fumigants killed a wide range of bacteria, fungi, protozoa, free-living nematodes, microarthropods and other microscopic organisms that provide many important ecosystem services, while the non-volatile nematicides reduced populations of free-living nematodes and microarthropods. Nevertheless, their use was accepted because yield responses were consistently obtained.

The development of more sustainable farming systems

In the 1980s, there was increasing recognition that the management practices used in modern agriculture were degrading the soil though compaction and loss of organic matter, increasing soil losses due to water and wind erosion, and causing fertilisers and pesticides to move into waterways. Research was undertaken to find ways of increasing productivity while minimising environmental harm and this resulted in many farmers taking steps to improve the health of their soils, revitalise their food production system, and make their farming system more sustainable. Thus, practices such as no-till, routine retention of crop residues, diverse crop rotations, and cover cropping, are now being used in broadacre agriculture; sugarcane growers have taken steps to prevent soils being compacted by harvest machinery; organic amendments are being applied to vegetable-growing soils; and mulches are widely used on tree and vine crops.

Soil health, soil biodiversity and nematode suppressive services

At about the same time as farming systems began to improve, soil biologists were beginning to understand the critical role that soil organisms play in improving the health of a soil. Bacteria, fungi, protozoa, free-living nematodes, microarthropods, and larger soil organisms such as earthworms, have many beneficial effects, as they improve soil physical properties, enhance water infiltration, increase moisture retention, recycle nutrients, provide plants with nutrients, enhance water and nutrient uptake, and degrade pollutants.

Soil biologists also showed that healthy soils contain a diverse community of natural enemies that regulate populations of nematodes and other pests. The natural enemies of nematodes included nematode-trapping fungi, egg-parasitic fungi, bacteria in the genus *Pasteuria*, predatory nematodes, and omnivorous and nematophagous microarthropods. Observations in the field showed that these parasites and predators were more likely to survive when soil organic matter levels were increased, tillage was reduced, and crop residues were retained on the soil surface as mulch. Thus, nematode suppressive services were much stronger when more sustainable farming systems were introduced.

Integrated nematode management

Practices such as minimum and zero tillage, crop rotation, cover cropping, retention of crop residues on the soil surface, mulching, and amending soil with compost or other organic materials are now being used by many Australian growers to improve the health of their soil and enhance the sustainability of their farm business. Once these practices are adopted, growers have the option of developing an integrated management program that will reduce losses from nematode pests. Nematode resistant rotation and cover crops can be used to reduce populations of the key nematode pest, while the collective effects of the other practices listed above will produce an active and diverse community of suppressive agents capable of limiting nematode multiplication.

Once a farming system has been upgraded and an integrated nematode management program is in place, growers who have previously used nematicides need to consider whether they should be applied in future. As off-target effects are commonly observed with pesticides (Sanchez-Mayo, 2011; Bourguet and Guillemaud, 2016), I would argue that nematicides should not be used until there is clear evidence that they do not negate the suppressive services provided by a broad range of natural enemies.

Do the new nematicides have off-target effects?

In the last decade, several new nematicides have been developed, and three (fluensulphone, fluopyram and fluazaindolizine) are either registered in Australia or are undergoing the registration process. Although these nematicides have a more favourable toxicological profile than the organophosphates and carbamates, their effects on non-target organisms have not been determined. Recent studies showed that when vermiform life stages of root-knot nematode and various free-living and entomogenous nematodes were continually exposed to fluazaindolizine, there was an irreversible decrease in the mobility and infectivity of the root-knot nematode juveniles whereas the other nematodes did not show any signs of intoxication or reduced motility (Thoden and Wiles 2019; Thoden et al. 2020). However, this does not justify the authors' claim that fluazaindolizine is a selective nematicide. Its effects on some free-living nematodes may be limited, but what is its impact on omnivorous and predatory nematodes? Also, a huge range of fungi, microarthropods and other organisms contribute nematode suppressive services and play other vital roles in the soil food web, so does the nematicide affect their activity? Until those questions are answered, growers trying to make their farming system more sustainable should think carefully about including these new chemicals in their integrated nematode management program.

Literature cited

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