PLANT AND SOIL NEMATODES

A NEW GENERATION OF NON-VOLATILE NEMATICIDES: THEIR SAFETY AND EFFICACY

Two groups of chemicals are used to control plant-parasitic nematodes in Australia. The non-volatile nematicides are covered here and an accompanying fact sheet (PSN 006) provides information on the soil fumigants.

Historical background

Non-volatile nematicides (sometimes referred to as non-fumigant nematicides) are liquid or granular products with an active ingredient that must be distributed through the upper soil profile by mechanical incorporation or percolation of water. These chemicals were discovered in the 1960s and 70s in programs primarily designed to find insecticides and four were widely used against nematodes in Australia.

- Organophosphates: Fenamiphos (Nemacur®); Ethoprophos (Mocap®); Oxamyl (Vydate®)
- Carbamates: Aldicarb (Temik®)

Organophosphate and carbamate nematicides have a highly toxic active ingredient which acts on the nervous system of nematodes. When applied at the recommended rate, egg hatch is inhibited and motility is affected, and so the target nematode cannot move towards a root, enter it, and establish a feeding site. However, the concentration of the active ingredient declines quite quickly, and 2-6 weeks after application it reaches the point where some of the nematodes recover and begin to multiply. Consequently, these chemicals are often considered to be nematostatic rather than nematicidal. Nevertheless, they provide good nematode control in annual crops because only short-term control is required.

The organophosphate and carbamate nematicides were registered on many fruit and vegetable crops, but were highly toxic to humans and other animals and also contaminated the environment. Consequently, most were removed from the market between 2002 and 2014. In January 2023, oxamyl was still registered in Australia and fenamiphos had a very limited registration.

A new generation of nematicides

Following the phaseout of the organophosphates and carbamates, a new generation of nematicides was developed. They were quite different to previous products, as they were much safer to use, less likely to contaminate the environment and had much less impact on beneficial organisms. Three of these nematicides are now registered in Australia or are going through the registration process, and they are listed in the table below. As all have a trifluoro (3-F) group in their chemical structure, they are often referred to as the 3-F nematicides. However, as the table shows, they are quite different in terms of their properties and mode of action.

Chemical name	Trade name	Company	Water solubility	Half-life in soil (days)	Mode of action
Fluensulphone	Nimitz®	Adama	545 ppm	Short (7-17)	Beta oxidation inhibitor
Fluopyram	Indemnify®	Bayer	10 ppm	Long (>200 days)	Succinate dehydrogenase inhibition
Fluazaindolizine	Salibro®	Corteva	2000 ppm	Medium (30 days)	Unknown

A review by Desaeger et al. (2020) provides an overview of what has been learnt about these nematicides in the period since they were developed. Results of later studies have also been published and so we are gradually beginning to understand when and how they should be used. Some of the key findings are summarised below.

- Most studies in the greenhouse and field have focused on root-knot nematode and they have shown that the 3-F nematicides generally reduce egg production, numbers of second-stage

juveniles, and the level of galling. However, products sometimes differ in efficacy and this is probably due to differences in the solubility of the three chemicals and their half-life in soil.

- Fewer trials have been done on other plant-parasitic nematodes, but fluopyram seems to affect a relatively broad spectrum of nematodes whereas fluazaindolizine and fluensulphone have little impact on some plant parasites.
- Soil temperature may affect efficacy. Fluopyram and fluensulphone were more effective against root-knot nematode when applied at 25°C rather than 15°C, whereas the efficacy of fluazaindolizine was not affected by temperature.
- The biological status of the soil appears to affect efficacy, as a greenhouse study showed that the three nematicides were more effective in sterilised soil than natural soil.
- The results of some studies suggest the 3-F nematicides have little impact on free-living nematodes and other soil fauna whereas detrimental effects were observed in other studies.

Other formulations and technologies

The detrimental effects of **abamectin** on soil nematodes have been recognised for decades. However, abamectin has never been widely used as a nematicide because its water solubility is very low, its soil adsorption value is extremely high, and it binds rapidly to organic matter and clay minerals. Consequently, it does not move well in soil. Syngenta have recently produced new formulations that allow the active ingredient to move down the soil profile and one of them (**Tervigo™**) is registered for use on some vegetable crops in Australia. However, there is little published evidence to indicate that the new formulation is effective. The same applies to **(Tymirium®)**, a novel nematicide and fungicide that was launched globally by Syngenta in 2022.

Research requirements

As the 3-F nematicides are relatively new, it will take years of research to fully understand their mode of action, evaluate their capacity to control different plant-parasitic nematodes, determine the best application methods and timings on various crops, assess their efficacy under different environmental and soil conditions, and quantify the economic benefits they provide. If these nematicides are to play a role in sustainable integrated nematode management programs, research will also have to be undertaken to answer the following questions.

- How often can these nematicides be applied before they become ineffective due to enhanced microbial degradation?
- The 3-F nematicides have very specific modes of action and will probably be used more frequently than the old nematicides, so will the target nematodes develop resistance to these chemicals?
- What is the impact of these nematicides on the beneficial organisms that provide nematode-suppressive services when soils are managed in a sustainable manner?

Decision-making on nematicides at a grower level

As very little comparative research on the 3-F nematicides is likely to be undertaken in Australia, growers will have to decide whether any of these nematicides increase yield or provide worthwhile economic benefits in their cropping system. One-way this could be done is to set up trials in which the three nematicides are compared in the same field. Such comparisons are relatively easy to do. Simply apply each of the nematicides to replicated rows and measure nematode populations and yield when the crop is harvested. Another alternative would be to use the nematicides in rotation and assess their effects in a range of situations. One advantage of the latter approach is that the target nematode would be less likely to develop resistance, as the same nematicide would not be used repeatedly at the same site.

Future prospects

It remains to be seen whether any of the new nematicides will play a key role in future nematode management programs. Efficacy and cost will be the main factors that will affect uptake, but the availability of soil fumigants will also play a role. If any widely used fumigants are phased out or regulations are introduced that make them difficult to use, growers who depend on them will turn to non-volatile products.

Literature cited and further reading

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