POTENTIAL RESEARCH PROJECTS ON ORGANIC AMENDMENTS FOR NEMATODE SUPPRESSION

Background

The use of organic matter for control of plant-parasitic nematodes has a long history, as studies in the 1920s (cited by Linford *et al*., 1938) showed that organic mulches minimised root-knot nematode damage to orchard trees; that sugar beet cyst nematode was killed by decomposing green manures; and that molasses, compost and a 'mud press' by-product of the sugar milling industry improved the growth of sugarcane and reduced the number of nematodes in roots. However, it was the seminal papers of Linford and his colleagues in Hawaii (Linford, 1937; Linford *et al*., 1938) that stimulated interest in this area by convincingly demonstrating that root-knot nematode populations declined when the nematode was exposed to decomposing organic matter.

The Hawaiian experiments showed that free-living nematodes multiplied to high levels when organic matter was added to soil and that natural enemies such as nematode-trapping fungi, predatory nematodes and predacious mites were activated in amended soils. Thus, Linford *et al*. (1938) hypothesised that organic amendments greatly increased populations of free-living nematodes and that those populations, in turn, supported an increase in a wide range of parasites and predators of nematodes. Since many of the natural enemies were non-specific, it was assumed that they killed both plant-parasitic nematodes and free-living species.

In the years since the initial studies in Hawaii, there have been hundreds of reports on the use of organic amendments for nematode control (collated by Muller and Gooch, 1982; Stirling, 1991; and Akhtar & Malik, 2000). More recent reviews of the topic (Oka, 2010; Thoden *et al*., 2011; McSorley, 2011b; Renčo, 2013) are testimony to the fact that organic materials are still seen as a potentially valuable tool for managing plant-parasitic nematodes, particularly in high-value annual crops.

A huge range of organic amendments have been tested against nematodes and the results have shown that animal manures and other materials with reasonably high nitrogen contents provide useful levels of nematode control. These amendments are effective because nematicidal concentrations of ammonia are produced during the decomposition process, but one of their limitations is that nematodes are only controlled for a relatively short period.

Results of research in Australia suggest that materials with a high C:N ratio may be more useful because they act through biological mechanisms and control nematodes for a longer period. Sawdust reduced the population of root-knot nematode on tomato to the point where the roots were almost free of galls (Vawdrey and Stirling, 1997), while a subsequent study on sugarcane showed that sugarcane residue, sawdust, and grass hay enhanced suppressiveness to plant-parasitic nematodes in pots (Stirling *et al*., 2003). The beneficial effects of sugarcane residue were then confirmed in the field, as roots growing in amended soil contained 95% fewer *Pratylenchus zeae* than roots in the unamended control (Stirling *et al*., 2005). One of the reasons such amendments are effective is that they stimulate the activity of nematode-trapping fungi, perhaps the most widely distributed natural enemies of nematodes. These fungi are commonly found in nitrogen-limited habitats and obtain the nitrogen they require by capturing nematodes.

Although organic amendments often produce promising results in pot experiments and field trials, they are still not used routinely in mainstream nematode control programs. One of the main reasons is that large quantities must be applied to obtain immediate effects. Based on results from pot experiments, application rates of 20 to 100 t/ha may be required to control nematodes (Stirling, 1991; McSorley, 2011b), and such high rates are a major limitation to the use of organic amendments. Thus, future research should focus on determining the long-term effects amendments that are regularly applied at economically feasible rates.

Given that the composition of specific organic amendments may vary from year to year, and that decomposition rates are affected by environmental conditions, the performance of amendments in field situations will always be difficult to predict. Nevertheless, it is important that we attempt to improve the consistency of results obtained with these materials because in addition to providing nematode control, organic amendments have beneficial effects on many important soil physical, chemical, and biological properties (Stirling *et al*., 2016). Thus, when growers are conserving organic matter or applying amendments to improve soil health, they also need to know whether these practices will have an impact on the nematode pests that are affecting their crops.

Recent work with organic amendments on sweetpotato

One way of reducing the application rate of an organic amendment is to apply it to the area where it is most likely to reduce the number of nematodes trying to invade the newly developing root system. In sweetpotato, this is the zone in the centre of the bed where the swollen roots produced by the next crop will be produced. Consequently, field trials were established to determine whether damage from root-knot nematode could be reduced by planting sweetpotato into V-furrows filled with various types and rates of organic amendments.

An initial field trial showed that sawdust and a mixture of sawdust and chicken litter were the most effective amendments, as they both reduced root-knot nematode populations and the severity of nematode damage, and increased marketable yield by 29% (Stirling et al. 2020). Follow-on studies in the greenhouse showed that sawdust-based amendments enhance the nematode-suppressive services provided by a wide range of predators. The suppressive agents included predatory nematodes, mesostigmatid and acarid mites, nematode-trapping fungi and an unidentified fungus that captures nematodes on bulbous hyphal extensions (Stirling 2021a).

Future research on organic amendments

Organic amendments have the potential to improve soil health, increase yields, reduce nematode damage, and enhance sustainability, but further research is required in the following areas.

- Understand the temporal effects of adding various organic amendments to soil, particularly with regard to their decomposition rates and their capacity to produce a biological community at an optimal time that is capable of limiting the multiplication of key pests such as root-knot nematode
- Determine whether nitrogen drawdown problems can be overcome and nematode-suppressive services maintained when materials with a high C:N ratio (e.g. sawdust and sugarcane trash) are used as amendments
- Develop molecular techniques to quantify nematophagous fungi and other nematode antagonists in soil. Use these techniques to study the population dynamics of these organisms in organically amended soil and to assess their role as nematode-suppressive agents
- Assess the soil health benefits obtained when organic amendments are integrated into sustainable vegetable farming systems in which permanent beds are maintained, tillage is minimised, traffic is controlled, cover crops are always grown, and cover crop residues are retained as mulch

References

Most of the references cited above can be found in the following books.

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

Stirling GR, Hayden HL, Pattison AB, Stirling AM (2016) *Soil Health, Soil Biology, Soilborne Diseases and Sustainable Agriculture. A guide.* CSIRO Publishing, Melbourne, 275 pp.

Three recent references are listed below.

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 (2021a) 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 (2021b) Modifying a productive sweet potato farming system in Australia to improve soil health and reduce losses from root-knot nematode. In: 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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