PLANT AND SOIL NEMATODES

BIOFUMIGATION: IS IT A USEFUL TACTIC FOR REDUCING LOSSES CAUSED BY PLANT-PARASITIC NEMATODES IN VEGETABLE CROPS?

What is biofumigation?

Biofumigation is a rotation-based approach to crop protection in which *Brassica* cover crops in the family Brassicaceae (also called Cruciferae) are macerated and incorporated into soil prior to planting vegetables. During the leaf maceration process, sulphur-containing compounds known as glucosinolates combine with an enzyme called myrosinase to produce isothiocyanates and other chemical compounds. These broad-spectrum biocides are detrimental to weed seeds and a range of soilborne pests and pathogens, including nematodes.

An example of the biofumigation process. In this case, the flail mower on the rear tractor is mowing and macerating a Nemfix mustard (*Brassica juncea*) cover crop (shown in the background), while the rotary hoe is being used to immediately incorporate the leaves and shoots into the soil. The field was irrigated after cultivation to enhance the biofumigation effect, and cherry tomatoes were planted four weeks later.

Although the term 'biofumigation' implies that the active ingredients are volatile, and act in much the same way as commercial fumigants, some of the most potent chemicals released from decomposing *Brassica* residues are not gaseous at ambient temperatures. Thus, it is important to recognise that these chemicals principally diffuse through soil in the water phase and do not act as true fumigants.

Another point that must be recognised is that the term 'biofumigation' was initially used to describe the production of isothiocyanates from plant residues. However, the term is now commonly used when volatile substances are produced through microbial degradation of animal and plant organic amendments. Thus, plants such as neem, marigold and castor contain compounds that are toxic to nematodes and when they are used as soil amendments and nematode populations are reduced, it is considered a biofumigant effect. Similarly, when microbial fermentation of nutrient rich amendments such as velvet bean, sunn hemp and elephant grass produces toxins that are detrimental to nematodes, the term biofumigation is also used.

Does biofumigation provide consistent control of nematodes and soilborne pathogens?

Although biofumigation is widely promoted as a means of pest and disease control in the vegetable industry, the way it is done will influence efficacy.

- *Brassica* cultivars capable of producing large quantities of glucosinolates must be selected, and because sulphur is an important component of glucosinolates, the brassicas must be grown with optimal nutrition, particularly with regards to sulphur.

- Glucosinolate release from *Brassica* tissue must be maximised by incorporating the cover crop into wet soil at the time of maximum leaf area (i.e. before flowering). During the incorporation process, the leaf tissue must be macerated and disrupted as much as possible.
- To ensure that the volatile chemicals are retained within the soil profile, the field should be irrigated immediately with sprinklers to seal the soil surface, or the soil should be covered with plastic. As this is logistically difficult to do on a large scale, it is a major limitation of biofumigation.

When *Brassica* cultivars with high leaf glucosinolate concentrations are incorporated into soil as described above, nematicidal activity is not always high enough to control the nematode pest being targeted. For example, the damage threshold for root-knot nematode on crops such as carrot, tomato, potato, and sweetpotato is very low, and so biofumigation will often fail to reduce nematode populations to the required level. Also, research has shown that some nematodes (e.g. *Pratylenchus*) are less sensitive to brassicaceous seed meals than others.

Another major drawback of brassicas is that some species and cultivars are good hosts of root-knot nematode, the most important nematode pest of vegetables. Thus, *Brassica* cultivars need to be chosen carefully as there is a danger that the biofumigant crop will increase rather than decrease nematode populations. A paper by Edwards and Ploeg (2014) is worth consulting, as 31 plants in the family Brassicaceae were assessed in the greenhouse for their capacity to host three species of root-knot nematode (*Meloidogyne javanica*, *M. incognita* and *M. hapla*). Indian mustard (*Brassica j*uncea) and turnip (*B. rapa*) were generally good hosts of the two warm-climate species whereas most oil radish cultivars (*Raphanus. sativus* ssp. *oleiferus*) were poor hosts. Some oil radish cultivars were among the best hosts for *M. hapla*, while arugula (*Eruca sativa*) cv. Nemat was a poor host of all three nematode species.

In situations where cyst nematodes cause problems on vegetables, biofumigant crops also need to be chosen carefully because many cruciferous plants are good hosts of species such as *Heterodera schachtii* and *H. cruciferae.*

Given the above, growers should only use biofumigation as a nematode control tactic if appropriate cultivars are selected, practices to maximise glucosinolate release are used, and fields are irrigated or covered with plastic to retain the biocidal isothiocyanates in the soil. Once the biofumigation procedure is optimised, local trials should be undertaken to check that acceptable levels of nematode control are obtained.

Brassicas: a biofumigant crop or a cover crop?

There are many situations where brassicas will prove to be a useful rotation or cover crop. However, one question vegetable growers need to answer is whether they gain additional benefits from macerating the tissue and pulverising wet soils to achieve a biofumigation effect. This process not only destroys soil structure and is detrimental to soil health but also kills or disrupts the larger beneficial soil organisms, many of which are predators. *Brassica* cover crops provide the traditional benefits of a green manure (i.e. a break in the vegetable rotation and inputs of organic matter), but the additional costs of macerating the biomass and incorporating it into soil may not be justified due to the negative effects on soil health.

The benefits obtained from using brassicas as a green manure rather than a biofumigant crop can be determined by establishing strip trials in which the *Brassica* biomass is incorporated aggressively into the soil in some parts of the field and treated as a cover crop in other areas. The costs of the incorporation process, together with data on disease incidence and severity in the following vegetable crop, will indicate whether it is economically worthwhile spending additional time and money trying to achieve a biofumigation effect.

Literature cited

Edwards S, Ploeg A (2014) Evaluation of 31 potential biofumigant brassicaceous plants as hosts for three *Meloidogyne* species. *Journal of Nematology* 46, 287-295.

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