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Crucifers in Nematode Management

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Introduction

Plant parasitic nematodes (PPN) are minuscule organisms lives in the soil along with plethora of microbes such as bacteria, fungi, protozoa, rotifers, tardigrades, gastrotrichs, kinorhyncha, flatworms, mites and even other beneficial nematodes. The plant parasitic nematodes depend on the plant roots for its food and can be differentiated from the other nematodes by the presence of specialized hypodermal syringe like structure called stylet. Using the stylet, the PPN punctures the plant roots and sucks away the nutrients from the xylem and phloem vessels. This leads to the nutrient shortage in the plant system and the infested plant become weak. The external manifestation of this nematode infestation is visible as stunting, yellowing and day wilting (wilting observed in bright day light even in presence of enough water in the soil). Almost all the cultivated crops are susceptible to plant parasitic nematodes including the crucifers.

The crucifers are flowering plants commonly known as the Brassica or mustard or cabbage family. Crucifers are of great economic importance, as they are cultivated as vegetables, oilseed, condiments, and forages and are also rich source of vitamin C and soluble fibre (Dixon, 2007). They include the cultivated species such as cabbage, Chinese cabbage, cauliflower, broccoli, kale, collards, rapeseed, mustard, turnip, radish, kohlrabi, Brussels sprouts, horseradish, rutabaga, mustard, and daikon.

Crucifers susceptible to nematodes

Among various pests and diseases causing economic damage to crucifers, the nematodes are the crucial one to cause yield loss. Several nematode species such as the sugar beet cyst nematode (SBC) *Heterodera sachati*, Root-knot nematode *Meloidogyne* spp., sting nematode *Belonolaimus* sp, stubby-root nematode *Trichodorus* sp. and awl nematodes *Dolichodorus* sp. are found to be the most damage causing to the crucifers. The sugar beet cyst

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nematode in particular infest the crop belongs to families such as Chenopodiaceae (sugar beets, garden beet, and spinach) and Cruciferae. Within the *Brassica* spp., the *Brassica oleracea* group is found to be more susceptible to cyst nematodes and at higher densities, these cyst nematodes were found to cause 50% yield loss. The rape seeds are the good host for some *Meloidogyne* spp., and at higher (>22^{o}C) temperature, the nematode will proliferate fast. Despite the susceptibility of the crucifers to nematodes, some crucifers such as mustard were found to play a decent role in reducing the plant parasitic nematode population thru natural biofumigation.

Crucifers antagonistic to nematode

Biofumigation is a method of suppressing the soil borne pathogens using the decomposing plant tissues especially of brassica family. Though biofumigation was observed in several *Brassica* spp. including *B. oleracea*, *B. napus* (rapeseed and canola), *B. rapa* ssp. *rapa* (turnip rape), *Raphanus sativus* (radish), *B. rapa* ssp. *oleifera* (oilseed rape), *B. juncea* (Indian mustard), *Sinapis alba* (white/yellow mustard), *B. nigra* (black mustard), *B. carinata* (Ethiopian mustard), *Eruca sativa* (salad rocket), the Indian mustard, *B. juncea* was found to be a potent one for nematode management. In general, the mustard crop was densely grown as a cover crop/green manure crop and was incorporated in to the soil during the flowering stage. Then the soil was irrigated once to accelerate the decomposition and release of nematode antagonistic chemicals (Figure 1). However, in other countries such as Germany and Netherland, the white mustard varieties were rotated with sugar beets to suppress the cyst nematode (*Heterodera schachtii*) (McCann, 1981).

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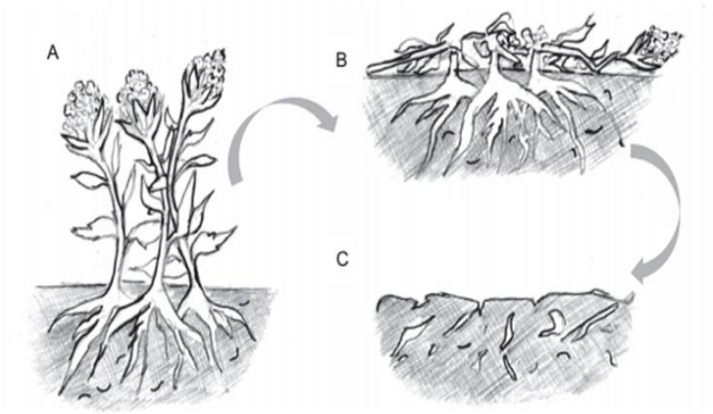

Figure 1: The biofumigant crop is grown to the optimal life stage (A), macerated or chopped (B), tilled under and irrigated to release glucosinolate hydrolysis products, including isothiocyanates-ITCs (C). ***(Brennan et al., 2020)***

In Washington, a commercial mustard variety was available in the name of Mighty Mustard® for nematode management where, the mustard was chopped, incorporated into soil and followed by irrigation to suppress the nematode problems. In Nilgiris a popular vegetable growing belt of Tamil Nadu, the mustard was recommended as mulch crop to control root knot nematode problem in carrot wherein the crop was mulched at 45-60th day after sowing. Some of the other brassica crops deployed against nematodes in abroad are given in Table 1.

Table 1: Crucifers antagonistic to nematodes

Crops / by-products	How the crops are deployed against nematodes?
Eruca sativa **(Taramira)**	Used as green manure and also as trap crop due to its ability to form ITC when incorporated in to the soil
Sinapis alba **(white mustard)**	Used as mulch crop and the active compound released during the incorporation process 60 to 75 days after planting affects to slow down the nematodes' life cycle in the roots
Brassica juncea **(Indian mustard)**	Included in a crop rotation programme, usually planted during the season just before the main cash crop to suppress

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	certain soil-borne diseases, weeds and nematodes. It is specifically efficient when combined with *E. sativa*
Brassica napus **(Canola)**	Included in crop rotation program to reduce the root-knot nematode population
Volatile oil of Mustard (VOOM)	Mixture of oils from different brassicas was used as pre-planting application which act as an alternative to methyl bromide.
Mustard/canola meal or oil cake or powder	Incorporated in to the soil instead of crop mulch

Mechanism of mustard biofumigation against nematodes

The Indian mustard varieties have high levels of glucosinolates, which makes our mustard spicy. These glucosinolates got released when the mustard was incorporated into the soil. These glucosinolates reacts with the soil water (assisted by myrosinase enzyme) and releases the nematode antagonistic compounds called the isothiocyanates (ITCs). At high concentrations these ITCs behave like commercial nematicides like dazomet and metham sodium (Figure 2). Moreover, the decomposing plant parts also release several other organic sulphides toxic to nematodes. Hence the ITCs along with organic sulphides interrupt the nematode's host finding mechanism and disrupt the movement. Further, these nematicidal compounds were found to penetrate the nematodes' hard cyst and eggs, and affect the functions of several bodily enzymes of nematodes.

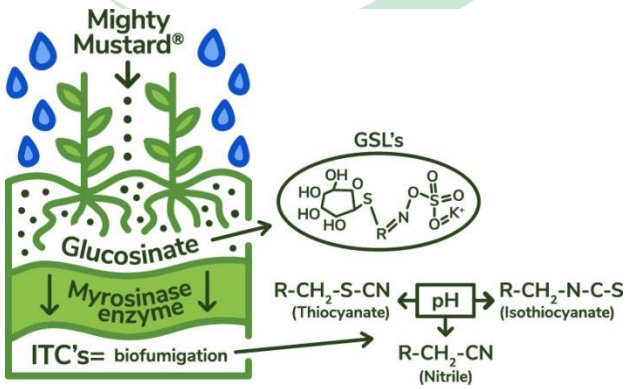

Figure 2: Mechanism involved in mustard biofumigation against nematodes

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The efficacy of the antagonistic compound released from a decomposing plant material varies with the genus, species and cultivars. Further, the efficacy is found to increase with optimum soil moisture, soil type, soil microbial population and decreasing size of the chopped plant material (Bellostas *et al*., 2004; Kruger *et al*., 2013).

Conclusion

The mustard biofumigation mitigate not only the parasitic nematode population but also other soil borne pathogens such as bacteria, fungi and weeds. Moreover, biofumigation can be combined with soil solarisation using 50-micron transparent polysheets to reap the additional benefits of pest control. In the same time, the negative effect of mustard on beneficial organisms (entomopathogenic nematode) should not be ignored, and hence has to be used judiciously in a field to suppress nematode population. In Toto, the mustard biofumigation can be considered as an economically feasible, ecologically sustainable alternative to chemical fumigation in mitigating the plant parasitic nematodes.

References

Bellostas, N., Sorensen, J.C. and Sorensen, H. 2004. Qualitative and quantitative evaluation of glucosinolates in cruciferous plants during their life cycles. Agroindustria, **4:**267-272.

Brennan, R.J.B., Glaze-corcoran, S., Wick, R. and Hashemi, M. 2020. Biofumigation: An alternative strategy for the control of plant parasitic nematodes. Journal of Integrative Agriculture, **19(7):** 1680–1690.

Dixon, G.R. 2007. Vegetable Brassicas and related crucifers. Crop Production Science in Horticulture, 14. CABI, Wallingford, Oxfordshire, pp 327.

Kruger, D.H.M., Fourie, J. and Malan, A. (2013). Cover crops with biofumigation properties for the suppression of plant-parasitic nematodes: A review. South African Journal of Enology and Viticulture, 34, pp. 287-295.

McCann, J. 1981. Threshold populations of *Heterodera cruciferae* and *H. schachtii* causing damage to cabbage seedlings. Plant Disease **65:** 264-266.