The Pharma Innovation Journal 2023; 12(3): 1556-1559

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(3): 1556-1559

www.thepharmajournal.com
Received: 05-12-2021
Accepted: 16-01-2023

Sharmishtha Thakur
Department of Entomology, CSKHPKV, Palampur, Himachal Pradesh, India

Priyanka Duggal
Department of Genetics and Plant Breeding, CCSHAU, Hisar, Haryana, India

Sardul Singh Mann
Department of Nematology, CCSHAU, Hisar, Haryana, India

Corresponding Author:
Sharmishtha Thakur
Department of Entomology, CSKHPKV, Palampur, Himachal Pradesh, India

A review: Sustainable approaches for the nematode management in organic farming

Sharmishtha Thakur, Priyanka Duggal and Sardul Singh Mann

Abstract
Nematodes, the most abundant group of multi-cellular animals on earth in terms of numbers of individuals, may be the bacterial-feeders, fungal-feeders, plant parasites, predators, and omnivores. Once they enter the field, cannot be eradicated completely form the soil. Some agronomic practices can be manipulated in such a way to not only reduce the nematode damage in field but also enhance soil properties and increase the yield potential. Plant-parasitic nematodes cause major concerns in organic farming systems worldwide therefore, it is necessary to have an idea about management aspects of plant parasitic nematodes in organic farming.

Keywords: Organic farming, nematodes, crop rotation, resistance, management

Introduction
Nematodes are the members of phylum Nematoda and are thread like worms. Nematodes have been in existence for an estimated one billion years, making them one of the most ancient and diverse types of animals on earth (Wang *et al*., 1999) [26]. Nematodes are most abundant group of multi-cellular animals on earth in terms of numbers of individuals. In agricultural soils, the most common groups of nematodes are the bacterial-feeders, fungal-feeders, plant parasites, predators, and omnivores. Soil nematodes, especially bacterial feeding nematodes, can contribute to organic matter recycling. The other important group is of plant-parasitic nematodes which are equipped with an anteriorly placed stylet through which they cause damage to plants. Plant-parasitic nematodes range from 250 um to 12 mm in length, averaging 1 mm, to about 15-35 um in width. They may be ectoparasites, feeding on plant roots from the outside, or endoparasite, which enter the tissues and then either remain sedentary or migrate through the plant roots. Common above-ground symptoms of PPNs are stunting, yellowing, wilting, and yield losses and belowground root malformation due to direct feeding damage. The economic importance of a plant parasitic nematode is judged by its parasitic or pathogenic potential, geographical distribution and value of the crop. Overall average annual loss of the world's major crops due to damage by plant-parasitic nematodes was estimated to be 12.3%. Organic farming is a farming method that involves cultivation of crops without the use of synthetic based fertilizers and pesticides. Even, genetically modified organisms are not permitted. International Federation of Organic Agriculture Movements (IFOAM) has defined it as "A production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effect. According to FAO (1998) [22] organic farming is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs. Organic farming system in India is not new and is being followed from ancient time. The scope of organic farming in India has been tremendously increasing due to the new researches made in the field of agriculture. New techniques which are being innovative during organic farming are purely related to soil health. One of the challenges is to boost productivity and promote organic farming is reconditioning the soil back to a healthy state. Demand of organic products has been inclined as the primary goal of organic agriculture is to optimize the health and productivity of interdependent communities of soil life, plants, animals and people (National Organic Standard Board, 1997). This opens up opportunities for many new entrepreneurs in India with a huge response from the consumers.

Several studies have revealed that problem of plant-parasitic nematodes is emerging under organic farming (Hallmann *et al*., 2007, Chen *et al*., 2012; Adam *et al*., 2013) [8, 5, 1]. Plant parasitic nematodes are pathogens that cause major concerns in organic farming systems worldwide. Therefore, it is necessary to have an idea about management aspects of plant parasitic nematodes in organic farming.

The sustainable approaches for the management of plant parasitic nematode in organic farming

As organic farming is totally based on natural remedies to manage the insect pest and pathogen including nematodes so there are certain agronomic practices including cultural practices, use of bio-control agents, host resistance and addition of organic amendments which can be modified in such a way to not only decrease the cost of cultivation but also to increase the productivity by managing various disease causing pests.

Crop Rotation

Crop rotation attempts to keep nematode populations to a level at which crop damage is reduced to minimum. By growing non-host crops number of plant nematodes is reduced, the number of years for this to occur depends on the initial nematodes population and the rate of population decrease (LaMondia, 1999) [12]. Cereal cyst nematode, *Heterodera avenae* can be managed by following crop rotation with carrot, fenugreek and gram. Cowpea or black-eyed peas, which can be used as a rotation crop to reduce nematode numbers, has several cultivars that are quite different in their ability to support reproduction of the root-knot nematode, *Meloidogyne incognita.* A greater population of plant-parasitic nematodes was recorded from plots with wheat-wheat than the wheat-lupin rotation (Rahman *et al*., 2007) [19]. Plant-parasitic nematodes were comparatively low in the rotated sequence suggesting biological control mechanisms (e.g. improvement of soil quality and conditions, abundance of free-living nematodes and other microbes in the rhizosphere areas etc.) may have occurred.

Green Manure/Cover Crops/Cash Crops

Cover crops or green manuring crops are grown between main crops which are valuable tool for managing nematodes. The warm season legume cover crops are effective in reducing populations of certain plant parasitic nematodes by breaking their life cycles (Potter *et al*., 1998, Vargas-Ayala *et al*., 2000) [18, 24] The populations of sting nematode, *Belonolaimus longicaudatus* and root-knot nematode, *Meloidogyne incognita* were effectively reduced in cash crops by hairy indigo and joint vetch cover crops combined with mulching of cowpea clippings (Rhoades and Forbes, 1986). *Crotalaria* is a poor host to many plant-parasitic nematodes including *Meloidogyne* spp., *Rotylenchulus reniformis*, *Radopholus similis*, *Belonolaimus longicaudatus* and *Heterodera glycines* (Wang *et al*., 2002) [27]. Green manuring with rapeseed (*Brassica napus*) has given good results in suppression of nematodes under field conditions (Johnson *et al*., 1967; Mojtahedi *et al*., 1993) [11, 16].

Nematode-suppressive Plants

Many species of marigold, resistant to a number of nematode species, can effectively control nematodes on agricultural crops when they are grown in rotation, interplanted with the crop, or used as soil amendments (Akhtar and Alam, 1992; Akhtar, 1998) [3, 2]. French marigolds (varieties include Nemagold, Petite Blanc, Queen Sophia, and Tangerine) are most effective. Avoid signet marigolds, *T. signata* or *T. tenuifolia*, because nematodes will feed and reproduce on these. To prevent marigold seed from getting in the soil, cut or mow the plants before the flowers open.

Addition of Organic Amendments

Organic amendments can be divided into two broad categories:(a) amendments that are cultivated in situ and are incorporated into the soil such as green manure, cover crops, or trap crops and (b) the amendments transported from elsewhere into the field such as composted animal manure and composted yard material or animal waste. Many plant residues and other amendments can release nitrogen compounds, organic acids or other compounds that may have adverse effects on nematodes. Organic amendments such as composted animal manure may release nematicidal compounds such as ammonia that is directly lethal to nematodes (Rodríguez-Kábana and Ivey, 1986; Oka, 2010; Thoden *et al*., 2011) [21, 17, 23]. Chicken manures reduced the numbers of cyst and citrus nematodes and resulted in increased yields of potato and citrus (Gonzalez and Canto-Saenz, 1993) [7]. Neem (*Azadirachta indica*) is the best known example that acts by releasing pre-formed nematicidal constituents into soil. Neem products, including leaf, seed kernel, seed powder, seed extracts, oil, sawdust, and particularly oilcake, have been reported as effective for the control of several nematode species (Akhtar and Alam, 1992) [4].

Resistant Plants

Host plant resistance achieved by traditional breeding programs can be a valuable protection against some nematodes. Two terms that are often used when talking about host plant resistance to nematodes are “tolerance” and “resistance.” Tolerance means that the plant can withstand some damage caused by nematodes without experiencing significant yield reduction. In contrast, resistance means that nematode reproduction is very low or non-existent on the plant. Both provide protection for the crop plant, but the next crop following a tolerant plant can be damaged by the nematodes that survived on the tolerant plant. Different plant species or even cultivars of the same plant species can exhibit varying degrees of resistance or tolerance. According to the University of Missouri-Columbia extension service, the following vegetable plants are recommended as reasonably resistant to root-knot nematodes: broccoli, brussel sprouts, mustard, chives, cress, garlic, leek, ground cherry and rutabaga (Donald, 1998) [6]. In contrast, Globe artichokes, Jerusalem artichoke, asparagus, sweet corn, and horse radish, some lima bean varieties, onion and rhubarb are considered to be tolerant.

Sanitation

Nematodes usually are introduced into new areas with infested soil or plants. Prevent nematodes from entering your field by using only nematode-free plants purchased from reliable nurseries. To prevent the spread of nematodes, avoid moving plants and soil from infested parts of the field. Don’t allow irrigation water from infested field to run off, as this also spreads nematodes. Nematodes can be present in soil

attached to tools and equipment used elsewhere, so clean tools thoroughly before using them in your field.

Soil Solarization

Soil solarization is one of the effective ways of suppressing root-knot nematode populations. The technique consists of covering moist soil with a plastic film during periods of intense sunshine and heat, thereby capturing radiant heat energy from the sun, causing physical, chemical and biological changes in the soil. Soil solarization is effective as a pre-plant and post-plant treatment and has been compatible with chemical soil treatments and also biological soil amendments after solarization. Soil solarization is a significant advancement in the non-chemical control of many pathogens and pests (Stapeleton *et al*., 1998) [22]. The recommended thicknesses of plastic film between 25 to 30 µm. Temperatures can rise anywhere between 35°C and 60°C (95°F-140°F) during the summer months when air temperatures are close to 32 °C (89.6 F) or higher. Soil temperatures only rise to detrimental levels in the first 10 to 30 cm of soil and even in this range temperatures drop off as depth increases. The plastic has to be sealed to prevent air movement underneath the plastic, which would prevent temperatures from rising sufficiently. The soil should remain covered for a minimum of four weeks, and increasing solarization time improves effectiveness. This helps to heat the soil at a greater depth, which means that more nematodes will be affected by it (McGovern and McSorley, 1997) [13].

Tillage

Tillage and the practice of fallowing fields may appear as alternatives to cover crops for nematode management. Tillage inverts and mixes soil and exposes deeper soil layers to the sun. This practice is meant to kill nematodes by desiccation, since nematodes depend on moisture for survival. This practice may kill some of the nematodes that are in the upper soil layers, however it will not reach to the nematodes that have retreated into moderate or deeper soil layers. Once a field has been fallowed, nematodes will move into deeper soil layers to avoid drying and may enter an inactive stage that enables them to survive periods without food and in addition protects them from desiccation. McSorley and Gallaher (1993) [14] compared the effects of tillage versus crop rotation on nematode densities in tropical corn (*Zea mays*) cultivar Pioneer X304C in North Florida. Tillage did not have significant effects on nematode densities, while a rotation crop of sorghum cultivar DeKalb BR64 reduced population levels of root-knot nematodes (*M. incognita*). These results demonstrated that tillage alone is not a reliable method for nematode management. Though, use of tillage with crop rotation and biological control in an integrated approach gave reliable results in nematode management.

Biological Management

It is the management of plant-parasitic nematodes by living organisms such as bacteria, fungi, predatory nematodes, or other invertebrates. *Pasteuria* spp., which is bacterial parasites of various plant-parasitic nematodes occurring naturally in soils, may be a promising biological control agent. In a 7-year experiment with tobacco, Weibelzahl-Fulton *et al*. (1996) [29] showed that *M. incognita* and *M. javanica* were suppressed exclusively by *P. penetrans*. A large number of fungi are known to trap or prey on nematodes but the most important genera include *Verticillium*, *Hirsutella*, *Nematophthora*, *Arthrobotrys*, *Drechmeria*, *Fusarium* and *Monacrosporium*. Nematode-trapping fungi are also potential candidates for biological management (Wang and McSorley 2003) [28]. Their adhesive knobs, rings, or net structures trap nematodes and kill them. The fungus *Purpureocillium lilacinum*, a nematode egg parasite successfully controlled the nematode *M. incognita* on potato (Jatala *et al*., 1980) [10] and on tomato (Villanueva and Davide, 1984; Hano and Khan, 2016) [25, 9] in field conditions.

Conclusions

Indiscriminate application of chemicals has degraded the quality of soil and lead to residue accumulation in plant products and environmental pollution along with toxicity to living organisms including human beings also. These are the major reasons of adoption of organic farming. Innumerable weeds, use of legumes to get nitrogen in organic farms and continuous cropping to avoid leaching of nutrients provide persistent hosts for many potentially damaging plant-parasitic nematodes. Unfortunately, in many cases, nematodes remain unrecognized as a major factor causing yield losses since nematode problems are often overlooked, misidentified or ignored, thus allowing for a steady increase in nematode populations. Therefore, awareness about nematodes problem in organic farming is the main concern at present in addition to focus on various ecologically sound techniques to keep the nematode population below pathogenic level. Development of resistant varieties and innovation of other sustainable practices is the requirement for safe environment. To achieve promising results in management of plant-parasitic nematodes under organic farming various sustainable techniques should be incorporated together and used as integrated nematode management approach.

References

1. Adam M, Heuer H, Ramadan EM, Hussein MA, Hallmann J. Occurrence of plant-parasitic nematodes in organic farming. International Journal of Nematology. 2013;23:82-90.
2. Akhtar M. Effect of two Compositae plant species and two types of fertilizer on nematodes in an alluvial soil of India. Applied Soil Ecology. 1998;10:21-25.
3. Akhtar M, Alam MM. Integrated control of plant-parasitic nematodes on potato with organic amendments, nematicide and mixed cropping with mustard. Nematology Mediterranean. 1991;19:169-171.
4. Akhtar M, Alam MM. Effect of crop residues amendments to soil for the control of plant-parasitic nematodes. Bioresources Technology. 1992;41:81-83.
5. Chen SY, Sheaffer CC, Wyse DL, Nickel P, Kandel H. Plant-parasitic nematode communities and their associations with soil factors in organically farmed fields in Minnesota. Journal of Nematology. 2012;44:361-369.
6. Donald P. Managing Nematodes in Gardens, Horticultural MU Guide-Vegetables, Outreach & Extension University of Missouri-Columbia G 6204m http://extensionmissouriedu/explorepdf/agguides/hort/g06204pdf accessed. 1998;08-30-2007.
7. Gonzalez A, Canto-Sanenz. Comparison of five organic amendments for the control of *Globodera pallida* in microplots in Peru. Nematropica. 1993;23:133-139.
8. Hallmann JA, Frankenberg A, Paffrath A, Schmidt H.

Occurrence and importance of plant-parasitic nematodes in organic farming in Germany. Nematology. 2007;9:869-879.
9. Hano P, Khan MR. Evaluation of fungal (*Paecilomyces lilacinus*) formulations against root-knot nematode infecting tomato. Bangladesh Journal of Botany. 2016;45:1003-1013.
10. Jatala P, Kaltenback R, Bocangel M, Devaus AJ, Campos R. Field application of *Paecilomyces lilacinus* for controlling *Meloidogyne incognita* on potatoes. Journal of Nematology. 1980;12:226-227
11. Johnson LF, Chambers AY, Reed HE. Reduction of root-knot of tomatoes with crop residues amendment in field experiments. Plant Disease. 1967 51:219-222.
12. LaMondia JA. Influence of rotation crops on the strawberry *pathogens Pratylenchus penetrans*, *Meloidogyne hapla*, and *Rhizoctonia fragariae*. Journal of Nematology. 1999;31:650-655.
13. McGovern RJ, McSorley R. Physical methods of soil sterilization for disease management including soil solarization Ch 12, In: Environmentally Safe Approaches to Crop Disease Control, Eds Rechcigl, N, A and Rechcigl, J E, , CRC Lewis Publishers, Boca Raton, FL; 1997
14. McSorley R, Gallaher RN. Effect of crop rotation and tillage on nematode densities in tropical corn Journal of Nematology. 1993;25:814-819.
15. McSorley R, Gallaher RN. Cultural practices improve crop tolerance to nematodes. Nematropica. 1995;25:53-60.
16. Mojtahedi H, Santo GS, Wilson JH, Hang AN. Managing *Meloidogyne chitwoodi* on potato with rapeseed as green manure. Plant Disease. 1993;77:42-46.
17. Oka, Y. Mechanisms of nematode suppression by organic soil amendments- a review. Applied Soil Ecology. 2010;44:101-115.
18. Potter MJ, Davies K, Rathjen AJ. Suppressive impact of glucosinolates in brassica vegetative tissues on root lesion nematode *Pratylenchus neglectus*. Journal of Chemical Ecology. 1998;24:67-80.
19. Rahman L, Chan KY, Heenan DP. Impact of tillage, stubble management and crop rotation on nematode populations in a long-term field experiment. Soil Tillage Research. 2007;95:110-119.
20. Rhoades HL, Forbes RB. Effects of fallow, cover crops, organic mulches and fenamiphos on nematode populations, soil nutrients and cash crop growth. Nematropica. 1986;16:141-151.
21. Rodríguez-Kábana R, Ivey H. Crop rotation systems for the management of *Meloidogyne arenaria* in peanuts. Nematropica. 1986;16:53-63.
22. Stapeleton JJ, DeVay JE, Elmore CL. Modes of action of solarization and biofumigation In: Soil Solarization and Integrated Management of Soil-borne Pests Plant Production and Protection Paper 147 FAO/Un 1998, Rome. 1998, 78-88.
23. Thoden TC, Korthals GW, Termorshuizen AJ. Organic amendments and their influence on plant-parasitic and free-living nematodes: a promising method for nematode management. Nematology. 2011;13:133-153.
24. Vargas-Ayala R, Rodriguez-Kabana R, Morgan-Jones G, McInory JA, Kloepper JW. Shifts in soil micro flora induced by Velvet bean (*Mucuna deeringiana*) in cropping systems to control root-knot nematodes. Biological Control. 2000;17:11-22.
25. Villanueva LM, Davide RG. Evaluation of several isolates of soil fungi for biological control of root-knot nematodes. Philippine Agricultural Science. 1984;67:361-37.
26. Wang DYC, Kumar S, Hedges BS. Divergence time estimates for the early history of animal phyla and the origin of plants, animals and fungi Proceedings of the Royal Society of London B. 1999;266:163-171.
27. Wang K, Sipes BS, Schmit DP. Crotalaria as a cover crop for nematode management: review. Nematropica. 2002;32:35-57.
28. Wang KH, McSorley R. Nematophagous fungi Dept of Entomology and Nematology, University of Florida, Gainesville, FL http://agroecologyifasufledu/nematophagous%20fungi/Beneficial%20Soil%20fungihtm accessed 09-19-2007.
29. Weibelzahl-Fulton E, Dickson DW, Whitty EB. Suppression of *Meloidogyne incognita* and *M javanica* by *Pasteuria penetrans* in field soil. Journal of Nematology. 1996;28:43-49.