

Cultural practice of nematode management: An overview

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ABSTRACT

Nematodes are microscopic organisms which are also called as thread worms, eelworms or round worms. They inhabit the region around the roots in the soil. A few species also feed on the aerial parts of the plants like the stem, leaves, ear-heads, grains etc. Unlike insects, viruses, fungi or bacteria, nematode populations increase rather slowly and the diseases caused by them are generally not of sudden epidemic type resulting in obvious destruction of crop and yield but cause a rather slow decline in yields. Symptoms of nematode diseases are often not clear cut and easy to pinpoint. The damage due to nematodes is many a time a result of interaction between nematodes or bacteria, viruses or fungi. Plant parasitic nematodes are so wide spread and universal in distribution that no living plant is likely to be free from their attack. All cultivated crops are usually attacked by one or more species of nematodes. There are various methods available for nematode management. The aim of this review to highlights the cultural methods of the nematode management.

INTRODUCTION

Plant-parasitic nematodes are usually microscopic generally ranging from 0.5 to 1 mm in length (Wallace, H. R, 1963). They are cylindrical, the body tapering towards the head and tail ends. Mature females of some nematodes however assume swollen pouch like, lemon pear kidney or irregular shapes while males remain slender. The most important diagnostic feature of PPN is that they have a stylet or spear at the mouth end. It is a long sharp pointed tube like doctor's hypodermic needle. The stylet is worked back and forth into the plant tissue. A nematode sucks up the plant sap and at the same time injects a small quantity of its gland secretion into the tissue (Jain, R. K *et al.*, 2007). The reaction of the plant and the expression of various disease symptoms are attributable to some toxic substances injected and depletion of plant nutrients. Due to their large population, Nematodes have a short life span, so their population levels change in large numbers, weekly. Nematodes are dioecious, with separate male and female genders. There are four stages of a nematodes life: egg stage, four larval or juvenile stages, and an adult stage. During each juvenile stage, a molt happens where the cuticle is shed, allowing the nematode to increase in size. Plant-parasitic nematodes pass through the juvenile molt, without hatching from the egg. Mild to warm temperatures, 55-65°F are optimal developing temperatures. Soil moisture and food availability also affect a nematodes development time (Goodey, T, 1933). The male is smaller than the female, and using its bent tail to hold the female, injects sperm into the female ovary, to fertilize an egg. Eggs are protected with an outer shell, and after some development, hatch into larvae. Eggs can hatch in a variety of ways such as: the nematode-bacterium complex cycle or the egg being held in the uterus until hatching, which can sometimes result in the juvenile nematode eating its parent nematode after hatching, or sometimes the egg will develop in another organism or plant (Jones, J. T *et al.*, 2013).

NEMATODE INTERACTION WITH HOSTS

Plant-parasitic nematodes are obligate parasites. During feeding they penetrate the plant cells causing mechanical injury. This is evident in case of a large number of nematodes infecting the plant. Nematodes also inject digestive juices in the plant cells causing hydrolysis of the host components altering the host metabolism (Luc *et al.*, 1990). Feeding nematodes deprive the host off nutrients and water necessary for plant growth. The conductive tissues are also blocked leading to impairment of organ functioning. Root knot nematodes may directly be responsible for poor germination and thin seedling stand due to pre and post emergence damage. Root knot nematode and reniform nematode may also interfere with rhizobial nodulation in legumes leading to decrease in nodule number, size and therefore nitrogen fixation. Most

important are the secondary infections caused by avenues caused due to penetration. The infections of other plant pathogens like bacteria, viruses and fungi are on the rise and further weaken the plant. Nematodes make the plant vulnerable to damage from pathogens which are otherwise weak. Some nematodes are vectors of soil borne pathogenic viruses.

MANAGEMENT OF PLANT-PARASITIC NEMATODES

All the control methods are directed at bring down the population of nematodes in soil, low enough to raise the crop profitably. Usually a combination of the control methods is needed to raise crops economically (Siddiqui, Z. A , 1999). Nematodes are omnipresent and can be transmitted through a variety of methods. Irrigation water is the prime source of transfer followed by use of infected composts, soil, Regulatory methods-

1. Quarantine- The principle involved is of exclusion, which implies excluding the possibility of entry of a pest in a region where it is not known at the time of regulatory operation but is likely to establish in the absence of the same (Lal R, 2006). This is needed as the golden nematode of potato has spread to 40 countries in hundred years. Countries have their vigilance and insist on phyto-sanitary certificate. But in India, domestic quarantine is not carried out. Burrowing nematode has spread from Kerala and Tamil nadu to Maharashtra, Goa, Gujarat, Orissa, Tripura and Lakshadweep Islands too. Some vigilance and cooperative efforts by the farmers and the decision makers are necessary to prevent spread. Cultural methods-

Crop rotation This is one of the important methods of keeping nematode population under check especially when there are distinct host preferences like the cyst nematodes of wheat, potatoes. Susceptible crops should be grown once in few years and rotating them with non-host crops. Vegetables should not be grown repeatedly in the same field but should be rotated with cereals in order to reduce infestation with root knot nematodes. Fallowing and ploughing during summer months.- Hot and dry conditions in India are favorable for controlling the nematodes during the summer months. Nematodes are sensitive to heat and drying action of the sun and the wind. Keeping the land fallow during the summer months and deep ploughing the soil two to three times at intervals of 10 to 15 days is an excellent method to reduce root knot nematodes and others. Use of organic amendments.- Soil amendments with green manure, compost, oil-cakes of neem, mahua, mustard, groundnut, cotton, linseed and karanji, sawdust etc. has been found to reduce the nematode populations. These cakes incorporated at the rate of 1 to 1.5 tons/ ha has been found to give good control of root knot nematodes and should be practiced. These encourage the growth of natural enemies of nematodes and the decomposition products of these amendments are also toxic to nematodes. Use of resistant and tolerant varieties- This is one of the most practical and economical methods of controlling nematodes. Though there are practical difficulties the development of multi-resistant strains of plants to nematodes and fungi is the best choice (Trudgill, D. L, 1991). Though lot of work has been done on developing varieties of tobacco, cotton, soybean, cowpea, capsicum, tomato, sweet potato much more needs to be done. Also the main drawback sometimes is the development of resistant breaking nematodes which make the process futile. Physical Methods-

Heat treatment of soil - This is a general practice for soil sterilization against all organisms harmful or beneficial. Nurseries use autoclaved soil 30 psi for 30 minutes for potting. In greenhouses steam is released through perforated pipes running through the soil. Temperatures go up to 82 °C for 30minutes. Dry heating of soil by burning off the standing crop waste is also practiced in some parts of India. Hot water treatment of planting material - It is mainly used for transplanted crops, bulbs, rhizomes, root stock and tubers. Effective time and temperatures vary with respect to the plant parts 10 to 60 minutes at 43 to 54 °C. Usually dormant bulbs of ornamental plants and root stocks of citrus are given this treatment. Hot water treatment of rice seed at 52 to 55°C for 10 to 15 minutes is a very effective method to control white tip nematode which is transmitted through seed. Solar drying - Nematode eggs and juveniles are killed if exposed to summer ploughing- Soil solarization or pasteurization-Oil - Spraying 15% water soluble hydrogenated fish oil also reduces infestation by nematodes. Corn oil, cotton seed oil, ground nut oil and soybean oil reduce the counts of migratory eco-parasitic nematodes. Flootation of seeds- The control of ear cockle or the 'tundu' disease in wheat is done by removal of nematode galls from seed material and floatation. Besides these, nematodes are also killed by irradiation, osmotic pressure, ultrasonic and electrical heat. But these methods are uneconomical and not practical. Biological Methods-

Nematodes have their natural enemies in soil like predatory nematodes, fungi, protozoa, viruses, arthropods. Use of Bio Control agents like fungi, bacteria, nematodes, mites, arthropods etc. Use of nematophagous fungi -Parasites of vermiform worm like stages-Fungi that form traps- Several species of soil-dwelling fungi produce traps to ensnare nematodes before they infect them. Traps come in many forms: adhesive hyphae, networks, knobs, rings; and constricting rings. Some trapping fungi can proliferate in soil in the absence of nematodes while others are more

dependent on nematodes as a nutrient source for growth. Fungi that form adhesive spores (or conidia) - As they move through soil pores, nematodes may encounter these conidia. Some of the fungi are host specific and their conidia will adhere to and infect only a few species of nematode. Although they can be cultured on media, in the soil these fungi are obligate parasites of nematodes and other invertebrates. Fungi that form zoospores- Zoospores are motile spores that are propelled by one or two flagella. When zoospores locate a host, they attach to the nematode cuticle, often near a body opening (mouth, anus, vulva), shed their flagellum, and become sedentary (i.e., encyst). The encysted zoospores infect the nematode cuticle by forming a penetration tube that enters through an orifice or directly penetrates the nematode cuticle. (Spiegel, Y.,1998). When the resources within the infected nematode are exhausted, the hyphae differentiate to form sporangia. Zoospores are produced within the sporangia and enter the soil via an exit or discharge tube which is formed when the spores are mature. Zoospore-forming fungi are believed to be opportunistic parasites of vermiform nematodes, attacking or colonizing weakened or dead nematodes. A further limitation of zoospore-forming fungi as biological control agents of nematodes is their requirement for wet soils. Zoospore movement is favored in large, water-filled soil pores.

Parasites of Sedentary Stages - There are a large number of fungi that parasitize nematode eggs, and the sedentary juveniles and females of cyst and root-knot nematodes. These fungi are grouped into two categories: obligate parasites are those that can grow only in nematodes; and facultative parasites are those that can grow to some extent in nematodes as well as on organic matter in the soil.

Obligate Parasite- Zoospores of both fungi encyst on the cuticles of young female cyst nematodes, penetrate, and consume the internal contents, including the eggs. Within the nematode body, zoospores develop within sporangia and are released through exit tubes into the soil.

Bacteria- *Pasteuria* spp. are endospore-forming actinomycetes that are parasites of invertebrates, including nematodes. The bacterium is an obligate parasite and cannot be cultured outside the body of the invertebrate host. Spores of nematophagous species adhere to the cuticle of host nematodes that encounter them while moving through soil. The spores form a germ tube and penetrate the cuticle of the nematode. The germ tube then forms vegetative microcolonies of lobed, septate mycelium. As the infection progress, the microcolonies break up into daughter colonies that contain fewer, but larger vegetative cells. These large-celled colonies are referred to as quartets and doublets. Doublets separate and form single sporangia which give rise to single endospores. *Pasteuria* species are very host specific. Generally, populations of this bacterium are only efficient parasites of the nematode species from which they originated. There are four described species of *Pasteuria* and several undescribed species.

nematophagous fungi- The addition of organic matter to soils is known to improve soil structure, aid in water retention, and provide nutrients. Improving soil conditions reduces plant stress which in turn can make the stress caused by plant parasitic nematodes less severe or apparent. As some plant based products (e.g. marigolds, brassicas, sesame) decompose in the soil, they release chemicals thought to be nematicidal. Brassicas, for example, have been shown to release a compound similar to the active ingredient in metam-sodium containing products. There is abundant evidence in the literature that this group of substances loosely classified as soil amendments, natural products, or organic amendments, can have an affect on nematode populations or stimulate plant growth in spite of the presence of plant parasitic nematodes. There is less evidence that they perform as consistently as traditional chemical nematicides or provide the same degree of nematode control when tested side by side in replicated field trials. In spite of this, there are probably abundant situations in which such products could be utilized in agricultural situations. Because of the variability in agricultural soils, and the suspected mode of action of many soil amendments, it is likely that growers will need to develop different programs for particular crops and sites.

Suppressive soils: A suppressive soil can be loosely defined as one which should have a nematode problem but doesn't. It is thought that one or more biological organisms in the soil are suppressing nematode populations (Westphal, A., 2005).

CONCLUSION

Rotating crops is a good way to control nematodes. The type of root-knot nematodes that damage tomatoes does not colonize the roots of grasses. Doing so in the field of grasses, is basically creating an environment where the root-knot nematode no longer has a host; the population will decrease in the field. This is the opposite of mono cropping, in which the same crop over and over again, allowing the population of nematodes to become progressively more problematic year after year. Crop rotation is a cultural way of controlling nematodes, and it can work quite well. There are even cover crops which produce chemicals that are toxic to nematodes. Mechanical methods, such as repeated tilling of fallow soil, may also be useful, but may be difficult to implement on a large scale.

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