PLANT PARASITIC NEMATODES - THE INVISIBLE ENEMY OF CULTIVATED CROPS

N.C. GNANAPRAGASAM

Research Officer, Tea Research Institute of Sri Lanka

Nematodes, commonly referred to as eelworms, round worms and thread worms, because of their characteristic shape, are widely distributed throughout the world and are found inhabiting varying diverse habitats. There is hardly any soil or plant which could be said to be free of some form of nematode species or other. The majority of the species of nematodes are translucent and colourless, microscopic, bilaterally symmetrical worm like animals, ranging in size from 0.2 mm - 10 mm, with an average length of about 1 mm, and could easily pass through the eye of a needle.

Because of their transluscent appearance they are hardly visible to the naked eye and have to be examined through a microscope. As such, severe damage to plants induced by nematodes as pests of economic importance is still not known in several parts of the world, and very often damage caused by nematodes are attributed to other causes like poor soil conditions, waterlogged condition and to nutrient deficiency symptoms.

As is the case with plant diseases and insect pest damage, estimated crop losses by plant parasitic nematodes vary widely. Generally an average of 15-20% loss has been reported, although individually they may cause a crop decline of as much as even 60% or more.

At present when all countries are concentrating on increasing productivity of cultivated crops, increases in nematode population that go unchecked may act as serious

constraints to productivity. Thus the importance of nematodes as pests of economic importance should be brought to the notice of all cultivators and proper remedial measures should be adopted to minimize, if not prevent such losses.

Nematodes could be classified as (1) saprophytic species that derive their food from decaying organic matter or feed on micro-organisms associated with decay; (2) predacious species that feed on small animals including other nematodes; (3) plant parasitic nematodes that feed on plants and (4) animal parasitic species which exists parasitically in man and his domesticated animals, including the intestinal roundworms and the filarial worms.

There are hundreds of species of plant parasitic nematodes that have been recognized and these may be either above ground feeders (those that feed on buds, stems and leaves) and below ground feeders (those that feed on roots and other structures growing below ground). Depending on their feeding habits they can be further classified as (a) ectoparasitic - those that feed mostly from outside and (b) endoparasites - those that feed internally.

Nematodes are entirely dependent on water for their activities and in the absence of water they cease movement, feeding and laying eggs, *etc.* Also under extreme adverse conditions they enter into a state of 'anabiosis' and in this state they can remain quiescent and alive for 2-3 years, without the presence of host plants. Cyst nematodes like the Golden Cyst nematode of potatoes, can remain viable in the soil for as long as 25 years.

In most nematodes the sexes are alike or sometimes the males are slightly small and they differ from the females only in the possession of a pair of spicules at the posterior end and also by the presence of a special corpulatory organ, the bursa. However, pronounced sexual dimorphism is often encountered among the sedentary parasites such as the root-knot nematodes, *etc*, where females are large and either globular or pear shaped.

All parasitic nematodes possess protrusible stylets with which they are able to pierce plant cells and withdraw their proplasmic contents. At the time of feeding they

eject digestive enzymes through the stylet into the plant tissues and thus initial digestion takes place extracorporally. In the case of sedentary nematodes these secretions helps to modify the development and maturation of the surrounding cells to form nurse cells on which the nematode feeds and this results in the swelling of roots producing characteristic 'galls'.

In general the life cycle of all nematodes consist of a egg stage, followed by three juvenile stages and lastly the egg laying adult stage.

Symptoms of damage:

Damage caused by plant parasitic nematode could be mechanical, chemical or physiological or a varying combination of the three. Mechanical injury is induced when the nematode feeds and moves through the plant tissues thus damaging the latter in the process. This mechanical injury could be quite substantial in the case of endoparasites like the lesion nematodes and the burrowing nematodes whereas in the case of external feeders this form of damage is only moderate or light.

Chemical injury is caused during the process of feeding due to the secretion of salivary juices which cause the tissues to react in various ways. In most cases the secretions injected by the nematodes cause death of the surrounding host tissues resulting in the formation of lesions as is seen in the case with the damage caused by the root-lesion nematode of tea, *Pratylenchus loosi*.

In addition nematodes are also known to predispose the plants to invasion by bacteria, fungi, virus, *etc*, thus resulting in disease complexes. Nematodes are also known to cause the breakdown of resistance of plant varieties that have been selected for resistance to other diseases caused by the above pathogens.

The damage caused by nematodes is often encountered in the feeder root system and thus interfering in the uptake of water and soil nutrients. The infested plants therefore appear unthrifty with a tendency to wilt fast on warm days, show typical nutrient deficiency symptoms

despite the presence of adequate nutrients increase susceptibility to foliage disease, lose resistance to pathogens *etc.* In heavily infested plants the main root system gets severely affected and such a condition leads to a sharp decline in the productivity of the cultivated crop.

Nematode pests of tea:

The most commonly encountered plant parasitic nematodes in the tea growing areas of Sri Lanka are species of the root-knot nematodes, *Meloidogyne* spp. These species of nematodes have a very wide host range and are found in diverse habitats. In the case of tea, these species are known to attack both clonal and seedling young tea. With increasing maturity (8-15 months), tea plants are known to develop resistance to this nematode, except in the case of *Meloidogyne brevicauda*, which is the only known species that is capable of attacking mature and old tea.

Meloidogyne brevicauda is the only species of nematode found attacking mature tea and as far as our present knowledge goes, it is unique to Sri Lanka and found only at very high altitudes (1,500 m). The spread of attack of this species is very slow and so far this has been located only in three estates bordering the same jungle. No alternate hosts other than tea have so far been found and tea plants of all ages are found to be susceptible.

The males of root-knot nematodes are eel-shaped and remain sedentary only during the larval stage whilst the females are larger and globular and remain sedentary throughout their life. The eggs are laid into a gellatinous matrix that protrudes from the posterior end of the female and this is commonly referred to as the egg-sac. In a favourable host several hundreds of eggs are laid, the maximum recorded being 2,880.

Plants infested with *Meloidogyne* spp. are easily recognized due to their characteristic gall formation of the infested roots. These galls, as mentioned above are formed during feeding activity.

The attack caused by *Meloidogyne brevicauda* is similar to those caused by the other parasitic nematodes of tea. The effect of infestation is most noticeable at the time of recovery from prune and during periods of stress, such as drought.

The most widespread and serious nematode pest of tea is the root-lesion nematode, *Pratylenchus loosi*, which is found prevalent within the elevation range of 750-1,800 m. The damage caused by this nematode is most serious within the elevation range of 1,000-1,500 m. This nematode attacks both young and mature tea plants and is a serious problem in tea nurseries, new clearings and mature tea fields.

The males and females of root-lesion nematodes are eel-shaped throughout their life. They are provided with a very prominent stylet which aids in the feeding activity. *P. loosi* attack both feeder roots as well as mature roots and major proportion of these nematodes often remain within the roots. Due to their movement within the roots, tunnels are formed within which the females deposit their eggs at the rate of two per day per female.

The digestive enzymes secreted during feeding activity cause the host plant tissue to die and thus leading to the formation of brown necrotic areas or lesions. With time such necrotic areas or lesions enlarge and girdle the root thus cutting off all food supply to the distal ends and ultimately leading to the death of the entire root. Large numbers of nematodes can remain alive beneath the lesions of large storage roots in a state of 'anabiosis' (dormant inactive state) for a long period, as much as 2 to 3 years.

The largest soil population is found at a depth of 10-15 cm, in the region of rhyzosphere. Rapid increase in population and the greatest damage to tea occurs in clayey soil whilst the damage is less in sandy and gravelly soil. Soil moisture and rainfall is known to have a definite influence on the population of nematodes.

The typical symptoms of injury caused by *P. loosi* is the appearance of patches of stunted unthrifty tea that goes into flowering and fruiting prematurely. The leaves

of the attacked plants appear pale and the storage roots bear the common sign of lesions or necrotic areas.

Radopholus similis the burrowing nematode, is another nematode that closely resembles *P. loosi*, and causes economic loss of crop between the elevation range of 500-1,000 m.

Morphologically this species of nematode is very similar to *P. loosi* except for the fact that they possess two ovaries instead of one. The type of damage induced by *Radopholus similis* is also similar. Some of the common hosts of this species are *Panicum maximum*, Banana *(Musca)*, Pepper *(Piper nigrum)*, Sugar-cane *(Saccharum officinarum)*. *Citrus* spp. Anthuriam, *etc.*

The spiral nematode *Helicotylenchus* spp. and the pin nematode *Pratylenchus curvitatus* are ectoparasites of tea. Although large numbers of these species are found in tea soil they have not found to be pathogenic to tea.

Some of the other species of nematodes that are encountered in tea soils are: *Hemicycliophora longicaudata* and *H. typica* (sheath nematodes), *Xiphenema americanum* and *X. radicola* (Dagger nematodes), *Hoplolaimus* (lance nematodes). None of these are found pathogenic to tea.

Nematode control:

Any particular method of control of pest would be able to keep the latter under check only for a limited period of time and any changes in the environment would cause a shift in the pest population dynamics and new recommendations of control will have to be made from time to time. Therefore, an integrated approach to pest management, making use of all available methods of control (*eg.* chemical, biological, use of resistant varieties and cultural control), would be the best possible way to manage pest species on a long-term basis.

The movement of nematodes in soil is very slow and the maximum recorded rate is about 30 cm/month. Thus the, movement or spread of nematodes over long distances is through irrigation water or by transport of infested soil

or plant material. Control of nematodes should, therefore, begin at the nursery stage.

Nematode control in tea nurseries:

Since vegetatively propagated plants are used in nurseries, it is often possible to eliminate nematodes by selecting uninfested parts of the plant and rooting them in nematode-free soil.

The soil used for nurseries situated between the elevation range of 500-1,800 m should be routinely fumigated with either Methyl Bromide or Dazomet 98% G at the rate of 0.5 kg/2.83 cu.m.

Despite proper soil fumigation subsequent infestations have often been encountered in tea nurseries. Such infestations have been suspected to have originated from the use of infested water that courses through fields infested with plant parasitic nematodes. If nurseries have to depend on such water for irrigating the plants, it is essential that they build sedimentation tanks and allow the nematodes to sediment for 48 h. Special wells could also be dug in the nurseries as a source of water. Care should be taken to discard any infested plants in the nurseries.

Control of nematodes in newly planted tea fields:

In order to prevent infestation of newly planted fields, precautions should be taken prior to planting young tea.

In the case of old fields to be replanted, if known to be infested with nematodes, the uprooting of old tea should be carried out very carefully and thoroughly. The old tea bushes should be removed, preferably with the aid of winches, followed by deep forking to a depth of 75 cm to remove root fragments. Any root fragments left behind in the soil may harbour nematodes which continue to remain in a state of 'anabiosis'. These nematodes can remain viable for as long as 2-3 years and serve as a source of infestation in the newly planted field. In order to

prevent this, all roots up to pencil thickness should be removed at the time of uprooting.

Following uprooting of the old tea, the area should be planted with a suitable soil reconditioning grass cover crop like guatemala or mana grass for a minimum period of two years. Such cover crops, in addition to reducing nematode populations in the soil provides adequate mulch and add large amount of organic matter, improves soil structure and consequently water permeability and soil aeration and also provide large quantities of thatching material for use in newly planted fields.

It is not possible to completely eradicate soil populations of nematodes, even after a period of rehabilitation under the above species of grass cover crops. Therefore, all fields that have had a history of nematode infestation should be planted with only nematode resistant or tolerant clones. Although samples of soil collected from areas rehabilitated under the above cover crops indicate negative results, it does not mean that the soil is free of nematodes. Therefore, in order to prevent the newly planted tea from being infested at the time of establishment in the field, it is important to incorporate suitable nematicides in the planting hole at the time of planting. The recommended nematicides are: Carbofuran (Furadan, Curaterr 3% G), Fenamiphos (Nemacur 5% G) and Fensulfothion (Terracur 5% G) at the rate of 7 g/plant.

Control of nematodes in old fields:

Most nematicides are effective only for a few months. As such, if nematicides are to be used in mature tea repeated applications would be warranted and this would be most uneconomical. Therefore the use of nematicides in mature tea is discouraged.

As long as the tea bush is able to keep producing adequate new feeder roots to replenish those damaged by the nematodes, the plant will be able to tolerate nematode attack. Severity of nematode damage to mature tea could be minimized by the adoption of proper cultural methods that would promote healthy growth of the root system.

Very good control of nematodes could be achieved by forking the field once if not twice a cycle. This would expose the nematodes to desiccation and in addition, forking also helps to break the hard pan improving soil aeration, which in turn would result in an improved root growth.

The incorporation of compost and organic matter have also shown an indirect advantage in nematode infested fields. This could be either because (a) the plants treated with such organic manure show a better growth of feeder roots and thereby enabling the plant to better tolerate nematode attack (b) they may increase the population of saprophytic nematodes which in turn would increase the various species of predators, nematode-trapping fungi and other enemies of nematodes, all of which could keep the population of plant parasitic nematodes under control (c) during the process of decomposition they may release certain organic acids which may be toxic to the nematode larvae or (d) they may alter the soil micro environment making it unsuitable for the build-up of nematodes. However, in order to bring about a significant decline in nematode population, large quantities of compost would have to be used.

Another method of checking infestations in mature fields is by avoiding the cultivation of cover crops that are susceptible to nematodes. *Tephrosia vogelli* is very susceptible to *P. loosi* and as such the cultivation of this green manure crop in tea fields prone to nematode attack is discouraged.

Interplanting vacant patches with the different species of marigold is also a useful practice to reduce nematode populations. Marigold serves as a trap crop attracting the nematodes towards its own root system. On entry into the marigold roots, the nematodes are killed by certain highly toxic chemicals present within the feeder roots of this plant.