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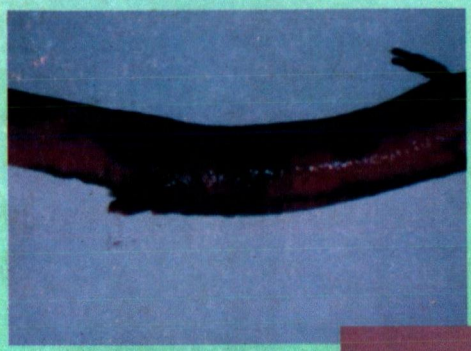
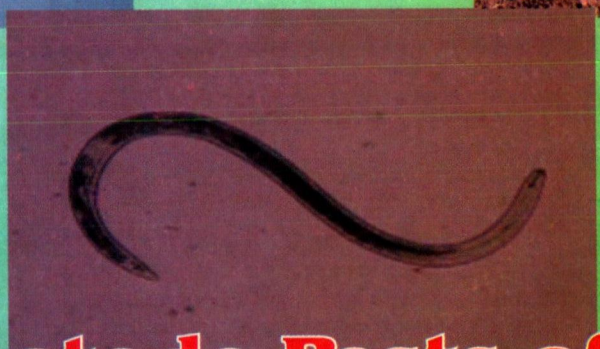
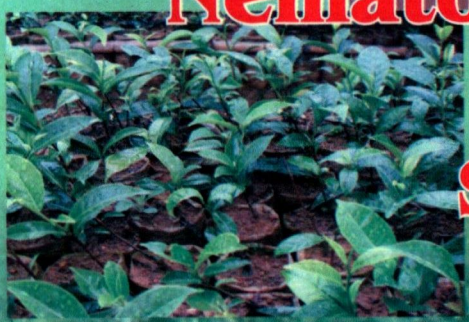




Nematode Pests of Tea in Sri Lanka



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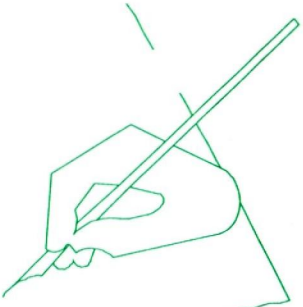

Nematode Pests of Tea in Sri Lanka

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The Tea Research Institute of Sri Lanka
Talawakelle
Sri Lanka
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The objectives of this Monograph

- To introduce phytophagous nematodes of tea lands
- To briefly describe the damage caused by nematodes to the tea plant
- To introduce the different methods of nematode control feasible in tea lands and present a forward to the new control methods which have been described in four other monographs individually and would form the foundation to a future publication on the integrated management of Tea Nematodes.

Contents

Nematode Pests of Tea in Sri Lanka

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1.0 Introduction

Nematodes (Phylum: Nematoda) are the invertebrate organisms that are commonly referred to as round worms. They differ from earthworms (Phylum: Annelida) mainly by not having the segmentation in the body. However, their skin may be annulated. The nematodes inhabit each and every ecological niche in the world. Some live in the soil feeding on organic debris or on living organisms; some in the water and some others as parasites or predators of both animal and plant organisms. Those nematodes that are parasitic on tea are microscopic organisms. It is only the symptoms of their feeding that can be seen with the naked eye.

It was in 1928 that nematode attack on tea was first reported, and the species was identified as *Heterodera marionii* Goodey (Stuart Light, 1928). Later, it was classified under the genus *Meloidogyne* by Chitwood (1949).

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2.0 Nematode Species inhabiting Tea Lands

Among the nematodes that feed on tea are external as well as internal parasites of plants.

2.1 Species that are Endoparasitic on tea

Pratylenchus loosi Loof (Meadow eelworm or Root lesion nematode. This is also an important pest of tea in Japan)

Pratylenchus spp.
P. coffeae
Radopholus similis Cobb (Burrowing nematode; also, a serious pest of tea in Java, but not so elsewhere)
Meloidogyne brevicauda(Chitwood) (Root-knot nematode; only reported from Sri Lanka and South India).

Meloidogyne spp.
Meloidogyne javanica
Meloidogyne incognita
Meloidogyne arenaria

2.2 Species that are Ectoparasitic on tea

The species that is ectoparasitic or semi-ectoparasitic on tea is:
Paratylenchus macrophallus (is armed with a spear).

2.3 Species that are parasitic on other plants

The following species infest roots of other plants on tea lands, such as shade trees, cover crops and weeds. They may live in the vicinity of tea roots but, they do not infest the tea roots, here in Sri Lanka.

Rotylenchulus reniformis (Reniform nematode; reported as a pest of tea else where)
Helicotylenchus namus (Spiral nematode; *Erythrina lithosperma*, *Gliricidia sepium* and *Albizzia* are good hosts.)
Helicotylenchus dihystrea (spiral nematode)
Pratylenchus curvitatus (Pin nematode)
Hemicycliophora longicaudata (a Sheath nematode)
H. typica, (a Sheath nematode)
Xiphinema americanum (a Dagger nematode)
X. radiciola, (a Dagger nematode)
Hoplolaimus spp. (Lance nematode)
Scutellonema brachyurus (Spiral nematode)
Boleodorus sp.

3.0 Nematodes of Importance to Tea

Among the many species of nematodes that live in tea lands there are only a few that cause considerable damage to either tea or other plants like shade trees that are grown with a purpose. They are the following:

3.1 Meadow eelworm / Root Lesion nematode

Zoological nomenclature of this nematode has undergone revision several times over the years. It was first known as *Anguillulina pratensis* (Gadd, 1939). A 1940 revision of taxonomy of one group of nematodes resulted in the species *Anguillulina pratensis* (de Man) Goffart being transferred to the genus *Pratylenchus*, so that its name became *Pratylenchus pratensis* (deMan) Filipjev (Gadd, 1945). It was later referred to as *P. coffeae* (Loos,1953a; Gadd, 1939). However, *P.coffeae* was later found to be a different species and *P.pratensis* was named as *Pratylenchus loosi* Loof (Hutchinson,1961). *P. loosi* (plate 01) is by far the most injurious of the tea nematodes in Sri Lanka. *P. Loosi* is more in abundance in Upcountry Uva and Deniyaya areas.

The males and females of this species are eel shaped and both have strong stylets, the skeletal structure found in the mouth of all the phyto-parasitic species (plate 05). This species attacks and breeds within the roots of Tephrosia (*Tephrosia vogelli*) as readily as it does in tea. It breeds very fast.The life cycle from egg to egg could be as short as 46 to 48 days (Gadd, 1940).

3.2 Burrowing nematode

The Burrowing nematode, *Radopholus similis* (Cobb) has assumed serious proportions in Sri Lanka. It is known to be a pest of tea in Indonesia as well. Even though the species was present in Sri Lanka infesting other plants, it is only in 1968 that the species was recognized as a potential limiting factor in tea lands (Sivapalan, 1968 and Campos, 1990). It is only since 1982, that the species has been referred to as one injurious to tea (Gnanapragasam, 1988). It is particularly active in the estates in Nawalapitiya, Gampola, Udapussellawa (Gnanapragasam, 1983). *R. similis* (plate 01)occurs in association with *P. loosi* in some of the Uva plantations and in Deniyaya-Morawak Korale areas. Morphologically, the main difference between the Burrowing nematode and the Root lesion nematode is that the former has two ovaries. The symptoms brought about by these two species also are similar (Plate 02).

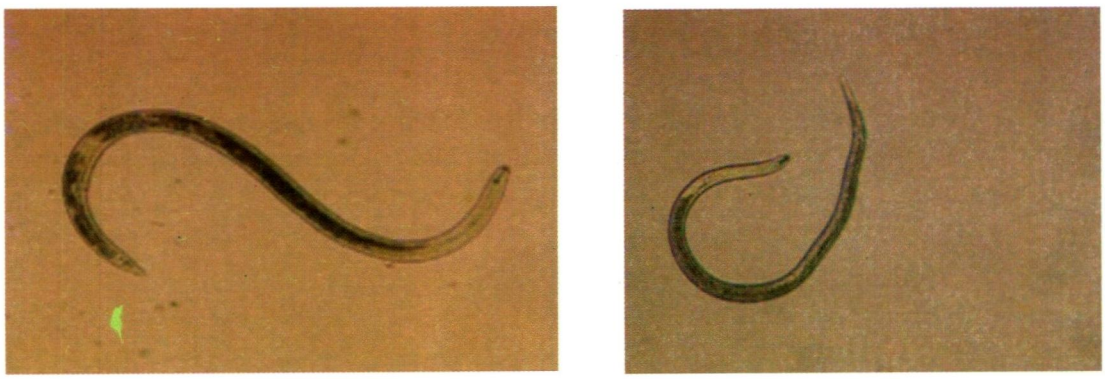

Plate 01 - *Pratylenchus loosi* Loof (a) and *Radopholus similis* Cobb (b)

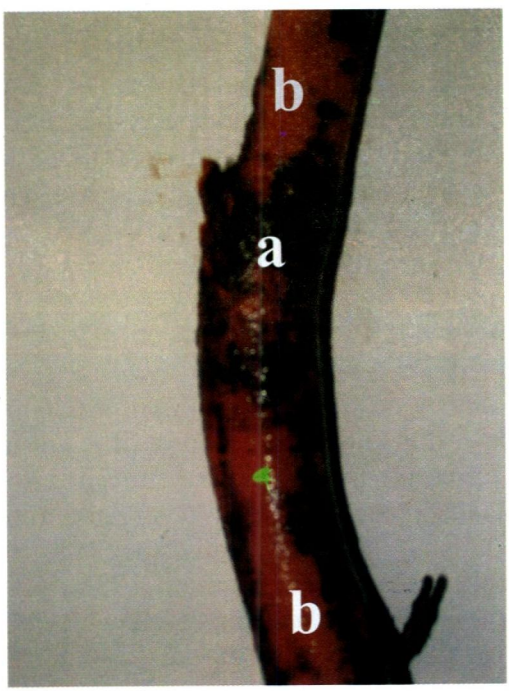

Plate 02 - Appearance of the injury inflicted upon the root tissue by *Pratylenchus loosi* or *Radopholus similis* as seen after removal of the bark.
(A) Necrotic tissue; (b) healthy cortex

3.3 Root knot nematodes

The Root knot nematodes, other than *Meloidogyne brevicauda* (Chitwood) are associated with nursery plants. As the plants age the degree of resistance increases (Loos,1953, 1953a and Gnanapragasam, 1989). Four of such species, *M.incognita, M.arenaria, M.hapla* and . *M. javanica* are predominantly found in other cultivated crops such as vegetables.

Meloidogyne brevicauda(Plate 03), the Root knot nematode of young and mature tea, has been reported only from Sri Lanka and South India. The species was encountered in both countries about the same time. In 1951, C.A. Loos the then pathologist of the TRI found *M.brevicauda* occurring only on three estates, namely Mooloya in Hewaheta, Oliphant in Nuwara Eliya and Kabaragala Estate in Elamulla, all of which are situated bordering the same jungle. In mid 1960s when it was encountered in one other estate in Hewaheta district, fears were expressed that it was present in many other estates. However, since 1995 the nematode has not been detected in the soil samples received from Mooloya and Oliphant Estates. Perhaps, *M. brevicauda* is now confined to Kabaragala Estate at an elevation of about 2000m a m s l. The species can attack young tea as well. It was believed that tea was hypersensitive to the attack of *M. brevicauda.*

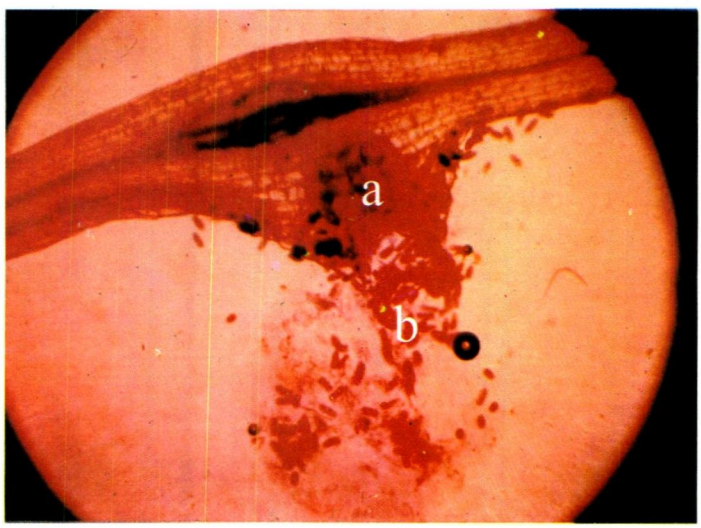

Plate 03 - Mature female of Root-knot nematode *Meloidogyne spp*
(a) Gravid Female (b)Egg sac is projecting out

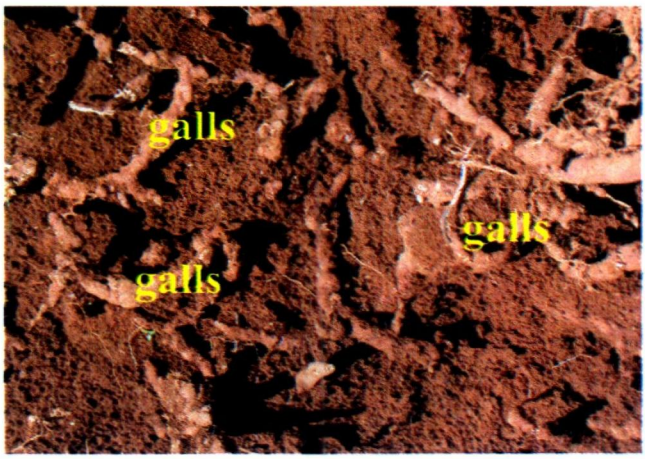

Plate 04 -Root-knot nematode infestation (*Meloidogyne brevicauda*)
Note - Galled roots scattered in the soil

3.4 Pin nematodes

The pin nematode commonly found around roots of tea, had been identified by Dr. A.C. Tarjan of the Citrus Experiment Station in Florida as, *Pratylenchus curvitatus.*

3.5 Spiral nematodes

There are two species of spiral nematodes commonly present around tea roots. Dr. S.A. Sher of the University of California had identified them as *Helicotylenchus namus* and *Scutellonema brachyurus* (Hutchinson, 1960). *Erythrina lithosperma, Gliricidia sepium* and *Albizzia* are good hosts to *H. namus.*

4.0 Nematode Damage in Tea

P. loosi and *R. similis* cause similar injury to tea roots leaving behind tell-tale signs in the form of scar tissues(necrotic tissues) in the root cortex referred to as root-lesions (Plate 02) . Death of tissues is caused by mechanical injury as well as by the effect of the toxic saliva that the nematodes inject into the injury while feeding. Feeding activity of *M. brevicauda* induces gall formation which are much more easy to detect. The pest is involuntarily disseminated into adjoining tea areas, by run off water and by movement of people and animals, and other means.

Damage caused by *P. loosi t*o young tea plants is highest in clayey soils and least in sandy soils. This pattern of population behaviour and consequent damage to host plants are as a result of interactions of soil moisture with specific soil types. Where the moisture tension is favourable to nematode population the growth of the host would be affected. Grow of the host differs in the different soil types (Sivapalan, 1971).

4.1 Mechanisms involved in infestation and injury

Nematodes are attracted to root exudates of susceptible hosts (Loos, 1951). Before entry, the nematodes explore the root surface for a suitable entry point. On encountering such a point, the nematode proceeds to pierce the root epidermis. It makes use of a skeletal structure called the stylet to pierce the outer cover or the epidermis of the root (Plate 05). The stylet protrudes out through the mouth, and resembles a hypodermic needle. Once the root is pierced the nematode sucks up the cell sap that oozes out. With repeated stylet action it makes the puncture large enough to enter into the epidermal cells. Once inside the root, the nematode moves in the intercellular spaces and also, pierces through the cell walls causing further injury.

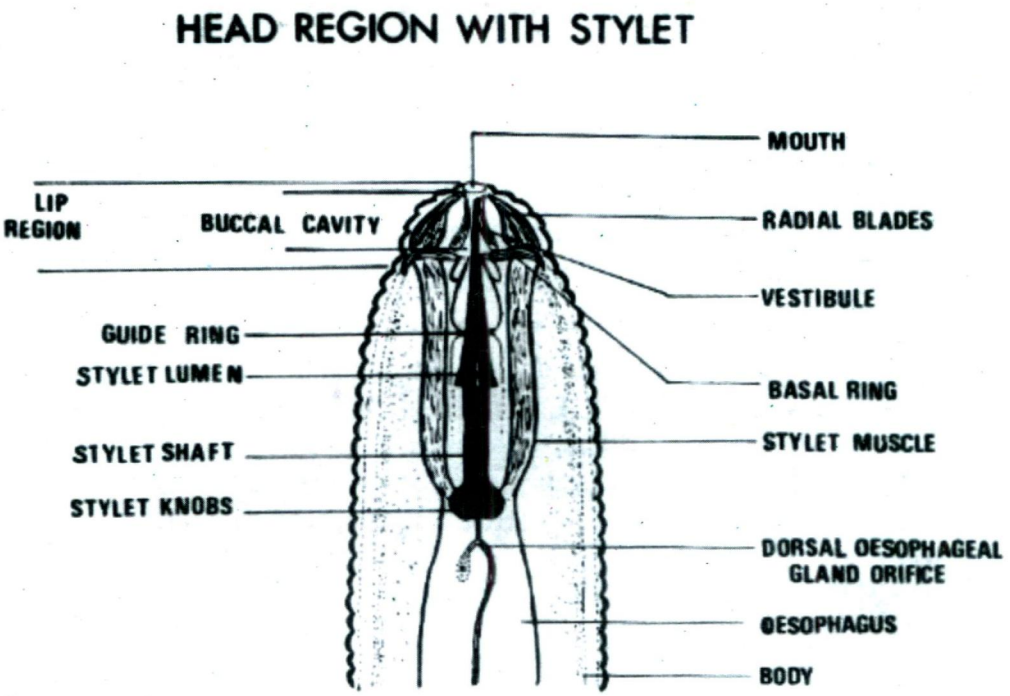

Plate 05 - Anterior end of phytophagous nematode, exhibiting the Stylet

4.2 Manifestations of Nematode attack

The typical symptoms of injury caused by these nematodes are small to large patches of unthrifty tea in the field. Heavy infestation in the field produces stress symptoms. In mature tea, the condition of the affected bushes was earlier referred to as "Witches broom" in which the foliage starts yellowing, branches develop short internodes and tufts of dwarfed leaves at their terminals (Hutchinson, 1960a).

The affected bushes enter the reproductive phase prematurely and exhibit flowering and fruit set if the infesteation is not checked (Plate 06).

Plate 06 - Under heavy nematode activity bushes have entered the reproductive phase prematurely
Note - Flowering and fruit set

The affected bushes have reduced root system. In the case of *P. loosi* and *R. similis* the roots have dark necrotic patches or lesions of varying size in large roots as well (Plate 02). This condition results in premature death of bushes. Nursery plants become stunted, yellowed and may bear flowers and fruit. The feeder roots are either decorticated or dried up, while the larger storage roots bear lesions of varying sizes that are revealed by scraping off the bark.

Plate 07 - Plants in a nematode infested nursery
Note - yellowed and stunted nature of plants

5.0 Economic Losses caused by nematodes

Over 20 % of the annual yield losses of major crops in the world is reported to be caused by plant-parasitic nematodes. Financial losses due to nematodes are estimated to be US$100 billion worldwide. The size of the nematicide market is estimated to be US$500 billion (Oka *et al*, 2000). Gadd (1939) reported that the yield of an infested tea planting can be halved in 10 years.

Gnanapragasam (1988) attributed 4 to 40% crop loss to plant parasitic nematodes of tea in Sri lanka. The yield loss had been earlier estimated to be in the range of 225 - 350 kg made tea per ha per year (Sivapalan, 1972; Visser, 1959).

As far as root feeding nematode pests are concerned, even a very low population level cannot be tolerated in tea lands because, the populations do build up with time.

Plate 08 -Tea Field exhibiting heavy casualties resulting from Nematode damage

5.1 Assessment of Damage

The degree of damage caused by nematodes is relative to the population levels found in the roots and the soil. The method of population assessment has been revised from time to time (Gadd, 1940; Loos, 1951; Oostenbrink, 1960; Sivapalan, 1967).

The currently employed method uses a modified Baerman Funnel Technique the original of which was first introduced in 1917 (Southey, 1970).

In the case of tea nematodes the population counts have been categorized by Hutchinson and Foster-Bahram (1963) to describe the degree of infestation as given below:

Light infestation	-	1 - 5 nematodes recovered per 100 g soil
Moderate infestation	-	6 - 25 " " " "
Heavy infestation	-	26 - 69 " " " "
Very Heavy infestation	-	70 or more " " " "

The categorization has been revised subsequently as given below, and is being adopted to-date (samples are taken at a depth of 20-25 cm).

Very light	-	1-10 nems. 100 g soil or 01g root material
Light infestation	-	11-20 " " " "
Moderate infestation	-	21 - 40 " " " "
Heavy infestation	-	41 - 100 " " " "
Very Heavy infestation.	-	100 or more " " "

These designations represent a broad classification of infestation and a rough way to indicate the extent of the problem. Heavy infestation indicates that the nematodes were responsible for serious injury to the tea. Very light infestation indicates that the problem is not due to nematodes. Light infestation in visibly affected tea indicates that there ought to be other contributory stress factors. These other stress factors may include slab rock, poor drainage, infrequent manuring, Shot-hole Borer infestation, an attack of scarlet mite or severe attack of Red Spider mite.

6.0 Control of Nematodes

Tea nematodes can cause heavy casualties in tea nurseries and young tea and severely debilitate the older tea. The different situations where nematode eradication is needed are:

(i) nursery at preparation,
(ii) infested nursery at planting of tea in a new area,
(iii) infested young tea field and infested mature tea fields.

The recent studies have investigated the efficacy of chemical nematicides by themselves and in combination with other nematode control methods.
The novel methods that have been recently investigated into included Soil Solarization and Soil Substitutes. There has not been much emphasis on steam sterilization or heat treatment of nursery soils in the light of the fact that nematode active areas have large volumes of soil to handle and the two methods need careful attention to detail and very precise application. However, they are being evaluated for the benefit of the organic tea sector.

6.1. Resistant Clones

There is significant variation between tea clones in their susceptibility to the different nematodes. Since 1955, the Institute has been screening clones and classifying them according to their degree of susceptibility (Loos, 1955). In the TRI Advisory Circulars the clones have been broadly classified into three categories: Resistant, Susceptible and Tolerant. Resistance at root penetration is offered by 4 factors:

(i) absence of attractants (kairomones)
(ii) mechanical hardness of the cell wall of the epidermal layer
(iii) presence of repellents (allomones)
(iv) toxins (antibiotics)

The physiological health of the plant too can influence the resistance of a plant to nematode attack. A nematode can attack with greater ease, a plant that has already been weakened by other conditions. Also, a plant or a clone that is resistant to a nematode species in one area may not necessarily be so in another area. This is due to the occurrence of different nematode populations or pathotypes, in different areas. Thus, it is necessary to test the clones under different soil conditions and in different areas. This is why the Institute collects infested soils from different estates to prepare the growing medium used in testing tanks.

There is hardly any tea clone that is immune to tea nematodes. Webster, (1956) categorically stated that TRI 2135 was immune to *P. loosi*. Subsequently, Kerr & Vythilingam (1967a) and also, the TRI Circular No. C8 (Anon, 1991) categorized the same clone as susceptible. This difference in performance of this clone cannot be easily explained. However there is the possibility that different pathotypes were responsible. What is clear from this is that one cannot depend on clonal immunity as far as nematodes are concerned.

6.2 Chemical Fumigants for Soil Disinfestation

In the Nursery: Methyl bromide and dazomet have been recommended for nursery soil fumigation (Kerr & Vithylingam,1967; Sivapalan, 1969). Dazomet is more effective in up country, whereas, methyl bromide is more beneficial in lower elevations (mid country and Deniyaya areas). Studies have been conducted to find alternatives for methyl bromide which is an ozone depleting agent. Metham sodium (Metam) has been shown to be comparable to methyl bromide in nematicidal activity and more beneficial in mid country in terms of enhancement of plant growth.

Plate 09 - At termination of a chemical nematicide trial. (Hauteville Estate, 2001)

6.3 Soil Substitutes

In the case of tea the influence of organic matter on populations of Root-lesion nematode and the Burrowing nematode had been studied as far back as in 1964 when raw cattle manure and composted cattle manure were tested as nursery media and the study had mixed results. In recent studies local agricultural wastes such as coir dust, paddy husk and refuse tea have been tested for their nematicidal activity and growth boosting effect on nursery plants. All three materials were found to be equally good as nematicidal agents. They can be used as partial or total soil substitutes in tea nurseries.

The best methods of using soil substitutes are:

a. Tea waste and soil in two layers in the bag, with tea waste being placed at the bottom.

b. Paddy husk mixed with soil in defferent proportions.

c. Coir dust can be used by itself, or mixed with soil or packing it at the bottom of the nursery bag with the top half filled with untreated soil.

Plate 10 - Growth of nursery plants in soil substitutes
From left to right
(1) paddy husk mixed with soil at 1:1,
(2) coir dust and soil mixed at 1:1,
(3) soil and coir dust in layers with soil at the top,
(4) 100% coir dust
(5) dazomet (std.)
(6) untreated soil.

6.4 Soil Solarization

Soil Solarization is the solar heating of moist soil under the cover of transparent mulch over a pre-decided period in order to disinfest the soil of harmful nematodes, insects, microbes and weed seeds.

Studies conducted over the last two years have proven that Soil Solarization can be adopted in tea plantations to eradicate phyto-parasitic nematodes. Soil Solarization of urea supplemented soil over a period of 6-weeks was proven to be effective in terms of nematicidal activity as well as growth boosting effect on nursery plants under agro-climatic condition.

Plate 11 - Soil Solarization Experiment site

Note - Solarization of the polythene covered beds is in progress for the high shade nursery. The frame for high shade is in place .Queenstown Estate (2001)

Soil Solarization has been discussed in detail in another volume of this series of monographs.

6.5 Trap crops, Non-hosts and Thatching to control Nematodes

It has been known that some chemicals of aromatic plants have detrimental effects on soil borne nematodes. Marigold (*Tagetes spp.*) and Vetiver also known as Khus Khus (*Vetiveria zizanoides*) are two such plants. *P. loosi* adults have been noted to enter the roots of Marigold, lay a few eggs and die inside the root tissue within 7 to 10 days (Hutchinson 1961). Thus, Marigold functions as a true trap crop. The cell contents seem to be toxic to the nematode.

In other cases they may inhibit development of the nematode by way of not allowing the 3 moults required for development, or else they may make the adults sterile. Probably, this is what happens in the case of wild sun flower *Tithonia diversifolia*. On the other hand, Guatemala (*Tripsacum laxum*) and Mana (*Cymbopogan confertiflorus*) are non hosts and are used to eradicate the nematodes by starving them to death. Marigold plants must be retained in the vegetative stage for about one year for it to serve as a trap crop. This too has been reconfirmed in the recent studies (Vitarana, *et al*- unpublished data)

These four plant species can be used to eradicate certain nematode species in young tea. Even though Visser (1959) reported that Marigold did not have any effect on the Meadow nematode while it reduced the Root- knot nematode populations. In recent studies at Rothschild Estate, Nawalapitiya, it has been shown that the marigold species, *Tagetes palida* was effective in reducing populations of *Radopholus similis*.

Plate 12 -*Vetiveria zizanoides* (Vetiver)

Plate 13 - *Tithonia diversifolia* (Wild sun flower)

Plate 14 - *Tagetes spp* (Marigold)

Plate 15 -*Tripsacum laxum* (Guatemala)

Plate 16 - *Cymbopogan confertiflorus* (Mana)

Wild sun flower has nematicidal properties. By thatching the ground with this plant, menatode populations in the soil can be reduced. This too has been established in the recent studies. However, these nematicidal plants can be used for nematode control only in the case of young tea and not in old tea lands or from those lands, where the tea has been uprooted for replanting.

Thus, there are several methods to bring about reduction of nematode infestation in the soil. Some like chemical fumigants, soil solarization are more applicable to the nursery while other methods are applicable in the tea field.

New methods like soil substitutes and soil solarization are being recommended to tea nurseries for the first time, now. These serve dual purpose of eradicating plant parasitic nematodes and enhancing the growth of the plant.

References

Anon (1991) Advisory circular No. C 8, Susceptibility of tea clones to the Root-Lesion nematode, *Pratylenchus loosi* Tea Research Institute of Sri Lanka.

Campos, V. P., Sivapalan, P and Gnanapragasam, N.C, (1990) Nematode parasites of coffee, cocoa and tea. 387-430, In *Plant Parasitic Nematodesin Subtropical and Tropical Agriculture*, Wd. M. Luc, R.A. Sikora and J. Bridge, CAB International, Wallingford, U.K.

Gadd, C. H. (1939) A destructive root disease of tea caused by the nematode *Anguillulina pratensis*. Tea Q. 12 (3), 131 - 139.

Gadd, C. H. (1940) Annual report, 27-29.

Gadd C. H. (1945) Annual report for the year 1945. 27-29.

Gadd, C. H. (1946) The Problem of nematode control in tea plantations. Tea Q. 18 (1), 3 - 11.

Gnanapragasam, N. C. (1983) Incidence of nematode damage in the mid country caused by the burrowing nematode, *Radopholus similis*. Tea Q. 52, (1) 41.

Gananapragasam, N. C, W. A. M. Dharmasena and D. D. Liyanage, (1989) Development of age resistance in young tea plants to different species of *Meloidogyne*. Int. Nematol. Network Newsl. 6 (4): 45-46.

Gnanapragasam, N. C. (1998) Limitation to growth and productivity of tea by plant parasitic nematodes. Proceeding of the Regional Tea (Scientific) Conference, Session 4, 8.

Hutchinson, M. T. (1960) Fumigating nurseries. Tea Q. 31, pp. 119-120.

Hutchinson, M. T. (1960a) Annual Report of the TRI for the year 1960. 70-74.

Hutchinson, M. T. (1961) Report of the Nematologist for 1960. Rep. Tea Res. Inst. of Ceylon, 70-74.

Hutchinson, M. T and C. B. Foster - Bahram (1963) Soil samples from estates for estimation of meadow nematodes. Tea Q. 34, 34-37.

Hutchinson, M. T. And M. K. Vythilingam (1963) The distribution of *Pratylenchus loosi* Loof among tea estates in Ceylon, with particular reference to altitude. Tea Q. 34, 68-84.

Kerr, A. And Vythilingam, M. K. (1967) The occurrence and control of the root lesion eelworm (*Pratylenchus loosi*). Tea Q. 38, 42-51.

Loos, C. A. (1951) Pathological problems. Tea Q. 22, 27 - 30.

20 References

Loos, C. A. (1953) *Meloidogyne brevicauda*, a cause of root - knot of mature tea in Ceylon. Proc. Helminth, Soc. Was. 20, 83-91.

Loos, C. A. (1953a) Eelworms. Tea Q. 24, 34-38.

Loos, C. A. (1955) Report of the Pathologist for the year 1955. TRI Bulletin No. 37, 51 - 52.

Oka, Y., Koltai, H., Bar-Eyal, M., Mor, M. and Chet, I. (2000) Chemical and non chemical control of phytophagous nematodes. Proc. 5th International Symposium on Chemical and Non-Chemical soil and Substrate Disinfestation. Eds. M. L. Gullino.

Oostenbrink, M. (1960) Estimating nematode populations by some selected methods in Nematology, Ed. By J. B. Sasser and W. R. Jerkins, The University of North Carolina Press, Chapel Hill. 85 - 102.

Sivapalan, P. (1967) Recovery of *Pratylenchus loosi* from soil samples. Tea Q. 38, 29 - 35.

Sivapalan, P. (1968) Association of *Radopholus similis* with decline in young tea fields. Plant Disease Reporter, 52:528.

Sivapalan, P. (1969) Further developments in the control of the root - lesion nematode (*Pratylenchus loosi*) in tea nurseries. Tea Q. 40, 111-113.

Sivapalan, P. (1971) The effects of infection by P*ratylenchus loosi*, and of fumigation, on the growth of young tea plants in different soil types. Tea Q. 42, 131 - 137.

Sivapalan, P. (1972) Nematode pests of tea. In: Economic nematology, ed. Webster. T. M. 563 Academic press N. Y, London, 285-311.

Southey, J. F. (1970) Laboratory methods for work with plant and soil nematodes. Technical Bulletin 2, Ministry of Agriculture, Fisheries and Food, Her Majesty's Stationery Office, London, 5-22.

Stuart Light, S (1928) Pest of nurseries, A warning. Tea Q. 1, 19-22.

Visser, T. (1959) Observations of the prevalence and control of parasitic worms in tea. Tea Q. 30, 96-107.

Visser, T and M. K. Vythilingam (1959) The effect of marigolds and some other crops on the *Pratylenchus loosi and Meloidogyne* populations in tea soils. Tea Q. 30: 30-38.

Webster, B. N. (1956) Report of the Pathologist for the year 1956. TRI, Bulletin No: 38, 49 - 50.

This volume is one in a set of monographs prepared to introduce new techniques to control phytoparasitic nematodes of tea (*Camellia sinensis*, Kuntze). The information contained in this monograph is based on research conducted by the TRI over a period of seventy five years on tea nematodes.

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