NEMATODES AND TEA

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Nematodes constitute one of the most important and abundant groups among soil-inhabiting organisms. A large majority of the soil-inhabiting nematodes are known to live saprophytically, while the plant-parasitic species constitute a smaller percentage, feeding on the roots of plants, either as ecto-parasites or as endo-parasites. Besides attacking roots, certain plant-parasitic nematodes are known to attack aerial parts of plants, including stems, leaves and flowers. There are probably around 500 species of plant-parasitic nematodes, a large majority of them known to be of world-wide distribution. The majority however, are most persistently destructive in sub-tropical, tropical and mild temperate climates because of the longer growing seasons and continuous growth of the host crops. Rarely is any crop free from nematode attack, and as a result of their microscopic size and protected position within the soil, the grower is usually unaware of their presence.

As a result of the technical difficulties encountered in their isolation and subsequent preparation for detailed microscopic examination, nematodes have been a little known group in the field of agriculture, through the years. It was only within the last three decades that they have come to be recognized as economically important among the factors restricting agricultural productivity.

Decline in crops caused by nematodes has been, and still is, in many instances, being ascribed to environmental factors. Discolourations in plant parts have often been ascribed to mineral deficiencies, although nematodes are sometimes the primary cause of such disorders. There is much evidence to show that nematodes cause mineral deficiency symptoms which can be corrected by the subsequent application of the deficient minerals. Nematode infected roots are less capable of fully utilizing soil fertility, resulting in the loss of efficacy of added fertilizer.

The nature of nematode interference could be mechanical, chemical or physiological, solely or combined. Besides causing direct injury to plants, nematodes have now come to be recognized as being associated with numerous plant diseases, where they have teamed up with other plant pathogens such as bacteria and fungi, creating disease complexes. Nematodes are known to be involved in predisposing the host for an invasion by other plant pathogens by altering the normal physiological state of the host. Furthermore, they are also known to be involved in the direct introduction of bacteria and viruses into plant tissues, thus serving as convenient vectors for harmful plant pathogens.

A frank evaluation of the taxonomy, host range, habitat and life history of plant-parasitic nematodes, would lead one to the inevitable conclusion that *we must learn to live with these nematodes* ! The chances of complete eradication of these pests is exceedingly remote, except perhaps in certain isolated instances. In general, there are five broad approaches to control plant-parasitic nematodes. These control measures include, 1— crop rotation ; 2 — cultural practices, including leaving land fallow, mulching and composting and the cultivation of nematocidal plants ; 3 — therapeutics, involving the use of hot water treatment, the use of systemic nematocides and the application of steam ; 4 — soil fumigation and 5 — the selection of resistant and tolerant plants. The types of control selected depend on the species of nematode involved and on the host plant concerned.

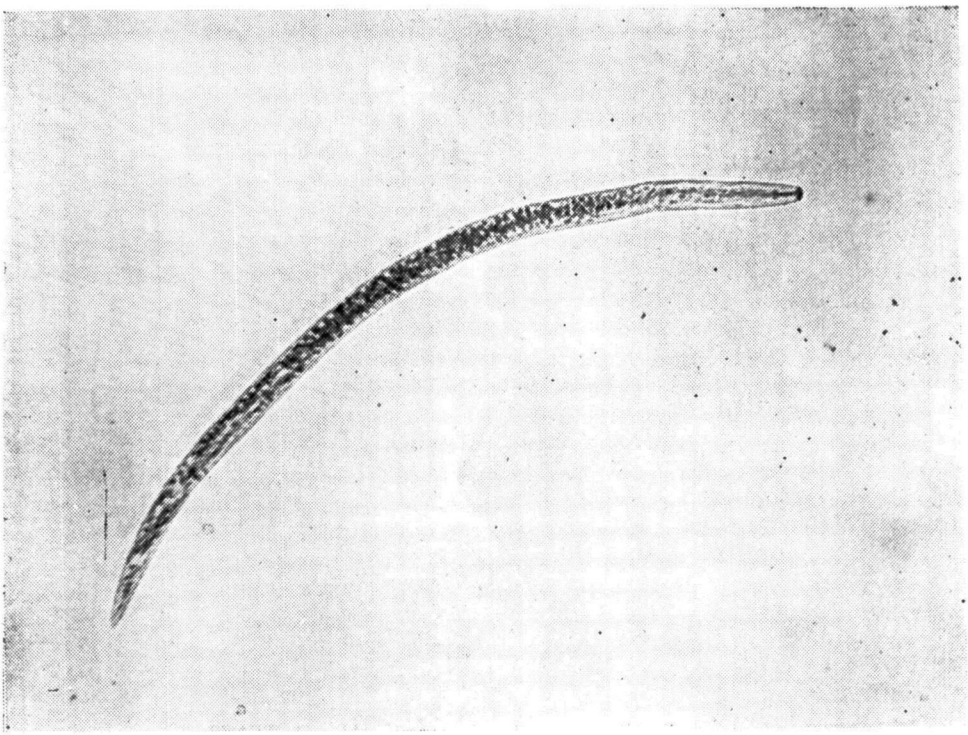

PLATE 1 — The Root-Lesion Eelworm, *Pratylenchus loosi*

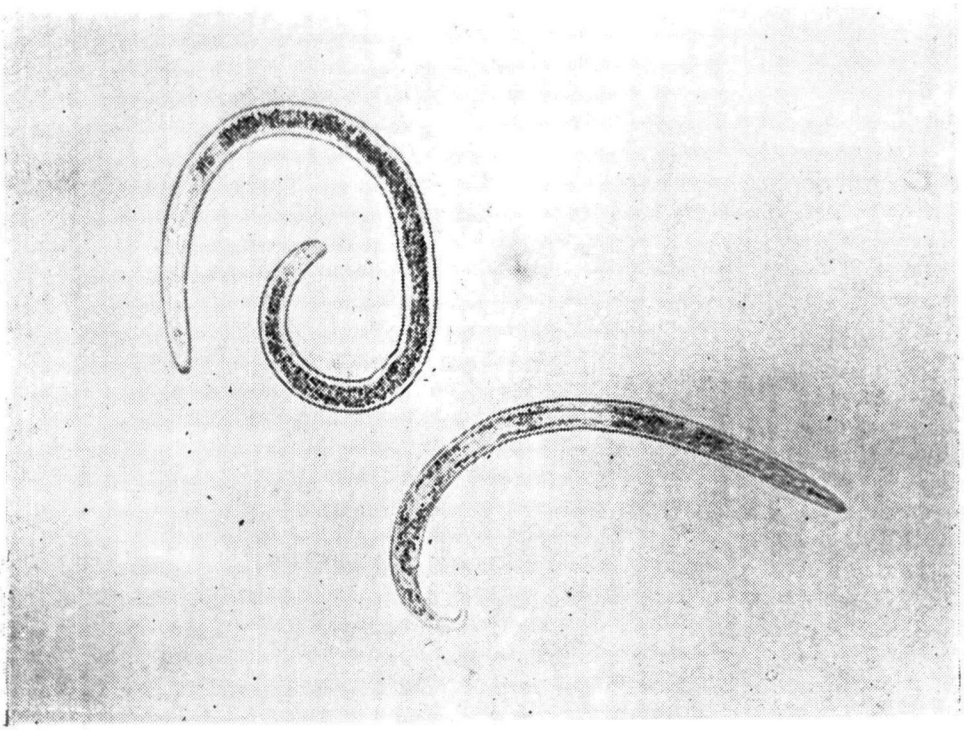

PLATE 2 — *left* — The Spiral Nematode, *Helichotylenchus dihystera*
right — The Pin Nematode, *Pratylenchus curvitatus*

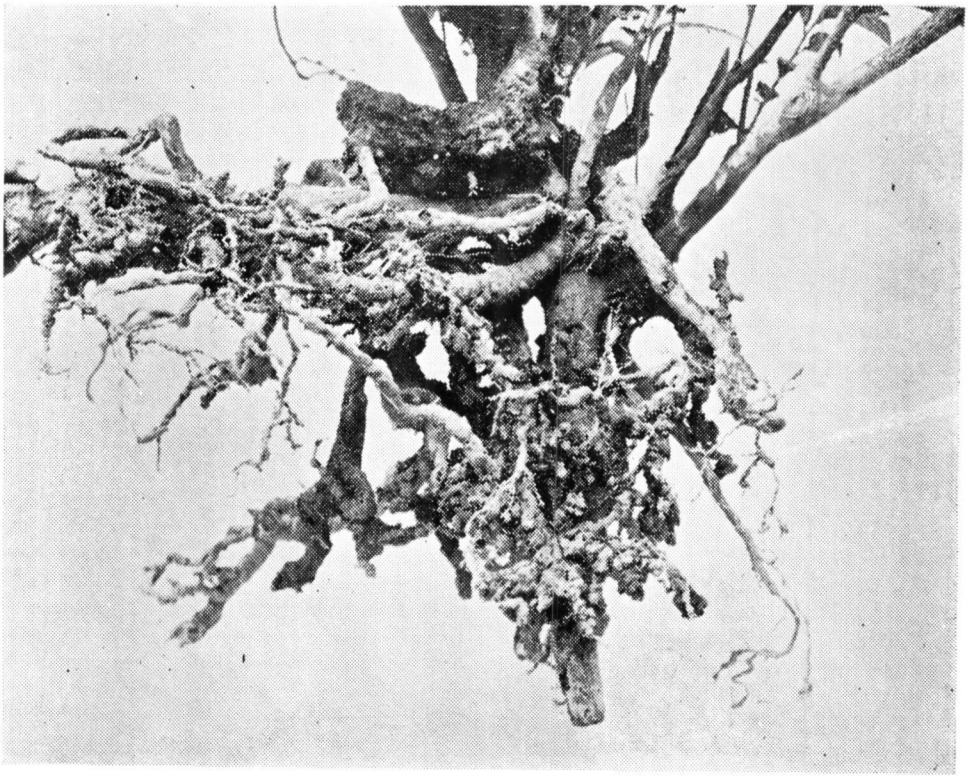

PLATE 3 — Roots of a mature tea plant showing knots caused by the Root-Knot Nematode *Meloidogyne brevicauda*

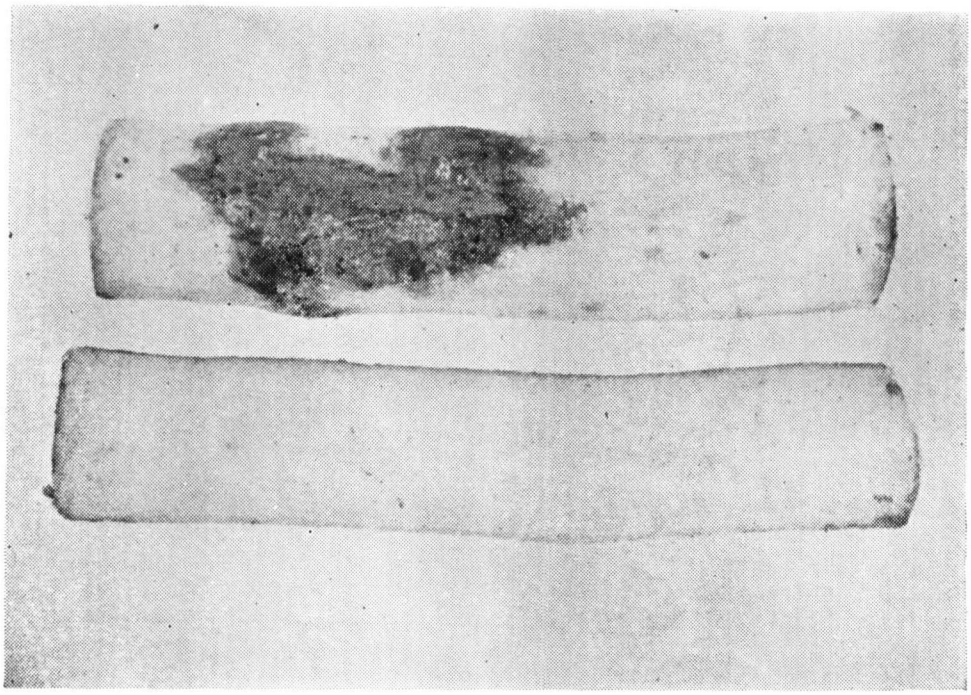

PLATE 4 — Top — A tea root showing a lesion caused by *P.loosi*
Bottom — A healthy tea root

Nematode parasites of tea

The Root-Knot Nematodes

Nematode parasitization of tea came to be recognized in Ceylon in 1928, when Stuart Light, the then Entomologist of the TRI observed the importance of the root knot nematode infestations of young tea seedlings and recognized the potential destructive ability of these pests among the tea nurseries of Ceylon. Root-knot nematode infestation was easily recognizable from the characteristic tumour-like galls or knots present on the roots of infested plants. Around the same time, Gadd recognized root-knot nematode infestations on shade trees such as *Erythrina lithosperma* (dadaps) and on *Tephrosia vogelii*. These root-knot forming species were then called *Heterodera marionii*, the generic name *Heterodera* being given to all members of the family Heteroderidea, irrespective of whether they were cyst formers, such as the golden nematodes of potatoes, or non-cyst formers, such as the ordinary root-knot nematodes. Later, the genus *Meloidogyne* was erected for those species that were non-cyst formers and as a result, the root-knot nematode of tea came to be classified under this generic name and is now referred to as *Meloidogyne arenaria*.

This species was found to infest only young tea plants up to the age of 12–14 months ; older plants were found to be completely immune to their attack. This happens to be one of the rare instances of a plant acquiring complete immunity with age towards nematode infestations. Through proper nursery hygiene, it was possible to supply fairly clean material into the field without any fear of further attack. At that time, however, it was thought that because this species survived on shade trees growing in between mature tea, a strain could possibly develop that would eventually infest mature tea. Fortunately no such strain has yet been found.

In 1951, Loos, the, then Pathologist of the TRI found another distinct species of *Meloidogyne* attacking mature tea, which did not appear to be a strain of the species which attacked young tea. This species was later confirmed as *Meloidogyne brevicauda*. This Root-Knot Nematode of mature tea was at that time found to be present on only three estates — Oliphant Estate in Nuwara Eliya, Kabaragala Estate in Elamulla and Mooloya Estate in Hewaheta. No other estates were known to harbour it until very recently when one more estate in the Hewaheta district was found to be infested. There is, however, a strong possibility of it being present in many other estates as well, perhaps in fields that have escaped survey. It may be possible that tea is not a very suitable host to it and that tea is hypersensitive to its attack. Tea bushes have been found to suffer very badly even when the surrounding soil population was low. Figure 1 shows the root system of a mature tea bush that had been badly attacked by *M. brevicauda*.

The female Root-Knot Nematodes are the ones that induce gall formation. As the potential female larvae mature within the root tissue, they change shape from the typical eel form to a sausage-shaped form and then finally into the sexually matured pear-shaped form that remains sedentary within the root tissue. As they commence to feed, they secrete enzymes that bring about biochemical changes that result in the characteristic gall formation. When the female deposits her eggs, she ceases to feed and the galled tissue gradually dries up and dies. With increasing numbers of knots being formed, the entire root gradually dies. The males remain eel-like throughout their life, and do not induce gall formation.

The Root-Lesion Nematodes

The nematode problem of mature tea came to be recognized in 1930, when Gadd observed a species of the Root-Lesion Nematode (Meadow Nematode) then referred

to as *Anguillulina pratensis*, attacking both nursery plants and mature tea. It was considered to be of serious economic importance even at that time, when only a few estates in the up-country districts were known to be infested.

By 1951, Loos estimated at least 50 estates in the up-country districts to be afflicted. The extent of damage was estimated to range from a few acres to more than 100 acres on various estates. Intensive sampling showed that more and more estates were affected : the careless transport of infested material from place to place, had in fact contributed to the large increase of infestation. By 1963, it was estimated that about 270 estates, mainly in the up-country districts, were infested. It was estimated, however, that on the average, only ten per cent of the total acreage of any given estate was actually infested : yet, the Institute warned of the possible increase of the infested acreage, if immediate and adequate attention is not given.

With the ever-improving knowledge of the taxonomy of nematodes, the name of this nematode has changed several times since 1939. From its earlier name of *Anguillulina pratensis* it changed to *Pratylenchus pratensis* and then to *Pratylenchus coffeae* and is now referred to as *Pratylenchus loosi* Loof (1960).

The typical symptoms of injury caused by *P.loosi* are small to large patches of unthrifty tea, with the bushes having suffered a considerable loss of maintenance foliage and many of the remaining leaves turning pale green to yellow. The bushes have a pronounced tendency to produce flowers and fruits precociously. The feeder-root system of severely-attacked bushes are either decorticated or dried up ; while the larger storage roots bear lesions of varying sizes that are revealed by scraping off the bark. Unthrifty bushes finally die during periods of drought or fail to recover from pruning.

According to a survey conducted by the Institute in 1963, the lesion nematodes occur in greater numbers at elevations of 3500 ft and above and in the zone receiving the South-West Monsoon rather than in the zone receiving the North-East Monsoon. Only low levels of infestation were noted below this elevation, and that too only rarely.

Males and females are eel-shaped throughout their life both having prominent stylets with which they puncture the root tissues and feed by secreting enzymes. Unlike Root-Knot Nematodes, they do not induce gall formation, instead, as a result of their feeding, brown lesions develop on the root surface. These lesions are in effect necrotic areas, where the tissue is in the process of dying or is already dead. The nematodes move away from such areas to fresh feeding sites. During their movement through the root cortex, they make tunnels in which the females deposit their eggs, each laying at the rate of one to two eggs per day. They attack both the feeder roots and the larger storage roots, but are found to prefer the more succulent feeder roots.

Other nematodes associated with tea

As a result of a survey made for all species of plant parasitic nematodes associated with tea soils it was found that the Spiral Nematode, *Helicotylenchus dihystera*, is by far the most prevalent nematode in each of the three major climatic regions in which tea is grown, and was frequently found in large numbers in tea soils. However, inoculation experiments indicated that tea is an unlikely host and that the shade tree *Erythrina lithosperma* was an excellent host. The common shade tree of the lower elevations, *Gliricidia maculata*, as well as, *Albizia moluccana*, are also suspected to be suitable hosts of this species.

The Pin Nematode *Pratylenchus curvitatas*, was found to be the next in order of frequency followed by the second stage larvae of *Meloidogyne spp.*, the Lesion-Nematode. Although the Pin Nematode occurs in abundance, unlike in the case of the Spiral Nematode, no special host range studies have yet been made.

Other species of plant-parasitic nematodes that have been encountered occasionally among tea soils are :

Sheath Nematodes	—	*Hemicycliophora longicaudata* and *H.typica*
Dagger Nematodes	—	*Xiphinema americanum* and *X.radicicola*
Lance Nematodes	—	*Hoplolaimus* spp
Spiral Nematodes	—	*Helicotylenchus* n.sp, and *Scutellonema* n.sp.

Control measures

As the root-knot nematode (*M.arenaria*) infestation in Ceylon tea nurseries is not a problem in the large majority of estates, and on account of the fact that the tea plant acquires complete immunity towards this nematode with age (over 12 months), this is not considered to be a serious problem. Furthermore, routine fumigation of nurseries keeps in check populations of all nematodes. Careless nursery management may, however, result in losses among young plants, as a result of root-knot nematode attack.

The problem with the other species of Root-Knot Nematode, *M.brevicauda*, is quite different as this could infest both young and mature plants alike. Fortunately, in Ceylon, there are only a few estates that have so far recorded this pest. These estates will have to ensure that their nurseries are absolutely free from infection to prevent its further spread. Nursery plants having root knots should be destroyed immediately. On account of its limited distribution, no intensive control measures have yet been initiated.

Nematode control programmes have been aimed almost exclusively at the Root-Lesion Nematode, *P.Loosi*, both as a result of its wide distribution and its ability to infest both nursery plants and mature tea.

Of the five broad categories of control measures mentioned in the introduction, three have been actively persued in the control of the Root-Lesion Nematode of tea (1) Cultural practices (2) Chemical control (3) The selection of resistant and tolerant varieties of tea.

Cultural practices

Decomposition of organic matter in the soil, has been associated with a reduction in the population of plant-parasitic nematodes. Nematodes have their natural enemies and predators such as nematophagous (trapping) fungi, protozoan parasites, and predaceous nematodes of the genus *Monunchus*. When the organic matter in the soil is increased, the populations of the natural enemies and predators increase, and these in turn help control the populations of plant-parasitic nematodes.

Using this principle, as much as 15—20 tons of green manure per acre, has been applied to nematode-infested tea fields. However, through years of testing, no appreciable reduction in the population was observed, and in order to maintain the population low, large amounts of mulch and compost had to be applied at regular intervals.

As the cultivation of Guatemala Grass assumed importance with the tea replanting scheme, several investigations were made to study the effects of cultivating this grass on the nematode populations in the soil. Guatemala Grass was found to decrease the population by a much greater extent than the reduction achieved by leaving the land fallow. Thus, the practice of cultivating Guatemala Grass became accepted, both for reconditioning the soil, as well as for decreasing nematode populations.

Guatemala Grass certainly does not eradicate the nematode population completely, but it brings about a decline of the population to such low levels, that the currently used techniques of nematode extraction fail to detect their presence. This initial reduction in numbers of plant-parasitic nematodes, however, gives a chance for the young tea to establish itself in the field.

Marigolds bring about the maximum reduction in the soil population of *P.loosi* followed closely by Guatemala Grass, then fallow soil and finally soil under tea. In relation to the relatively high survial of nematodes in fallow soil, both Guatemala Grass and Marigolds appear to exert an active influence on the decline of nematode populations.

The practice of cultivating Guatemala Grass in new clearings and uprooted fields, is still carried out. Although Guatemala Grass is superior, Mana Grass may also be used, the latter however should be allowed to remain for a longer period in the field – at least two or three years, whereas the rehabilitation time under Guatemala Grass could range from one to two years. With respect to the cultivation of Marigolds, it is now suggested that the practice of inter-planting Marigold among tea fields be restricted to old seedling fields having vacancies, and not to newly planted tea, as the Marigold would compete with the young tea.

Chemical control

Fumigation of tea nurseries and nursery soil has been found to be helpful in reducing not only nematode populations, but also other harmful pests, such as, Wire Worms, White Grubs and Cut Worms. Methyl bromide is now being recommended for fumigating tea nurseries. This chemical has the distinct advantage that it can be used on bagged soil, and at the same time it fumigates the nursery beds. No further handling of the soil is required following fumigation, the cuttings could be planted directly into the bags after only three to four days after treatment. At present, the recommended dosage is two pounds per 100 sq ft.

Several chemicals have been screened to test their efficacy in eradicating nematodes *within* tea roots. Different organophosphorus compounds, including Dimecron, Nemaphos (Zinophos), Thimet and Phosdrin were tested along with different dosages of Nemagon, all of them being applied as soil drench. Nemaphos apparent to be the most promising of this series, reducing the root populations by more than 95 per cent. In another test series, Disyston gave more than 96 per cent control. No chemical, however, has yet been found that would achieve a 100 per cent control of nematodes within the roots. Unless a 100 per cent kill is obtained, any residual. population even one per cent of the original level, could multiply rapidly within a relatively short period. The two promising chemicals, Nemaphos and Disyston, cannot, therefore, be recommended. The search for an ideal nematocide is being still continued.

Rehabilitating new clearings and uprooted areas under Guatemala Grass is done mainly to recondition the soil and at the same time to minimize soil populations of the Root-Lesion Nematode. Guatemala Grass does not fully eradicate the entire nematode population, but brings about an appreciable decline in

the population level. In order to achieve this end, the land has to be left under grass for one or two years. The same level of control, possibly to a better extent, can be achieved by soil fumigation, the waiting period for which is only four to five weeks. An experiment is now being carried out to investigate to what extent Guatemala Grass improves the soil in the up-country districts.

To work out the economics of fumigating new clearings, different chemicals are now being tried out at various levels of application, to investigate efficacy and phytotoxicity.

Selection of resistant and tolerant varieties of tea to P.loosi

Resistance of plants to nematodes results from the presence of certain defence mechanisms within the host tissue, which either restrict penetration, or inhibit reproduction of the parasite. Tolerance could be characterized as a congenial and well-balanced relation that permits normal or near-normal growth, although the host plant may harbour a high population of the parasite.

The selection of resistant and tolerant varieties is one of the best means to combat the nematode problem, especially in the case of perennial plants, such as tea. On the other hand, tea being a crop that has to remain in the field for many years the possible development of biological strains that could 'break' the resistance cannot be ruled out. In order to minimize the chances of the prospective breakdown of resistant varieties to such strains, the current programmes of selection are carried out by testing the different clones against mixed populations of different strains of nematodes.

As a result of screening programmes over the past four years, and also from field observations, the clones that have been under study have now been tentatively categorized on the basis of the degree of resistance and susceptibility.

With the intensive replanting programmes that are being carried out at present, all efforts must be taken to curtail any further spread of this dangerous pest. The strictest measures must be adopted with respect to nursery hygiene, and no chances should be taken with even the lightly-infested plants. Fumigation is a must, especially for those estates situated at an altitude of 2500 ft and above, where both the nursery beds and bag soils should be thoroughly fumigated.

Whenever a field is reported to have had a history of nematode (*P.loosi*), infestation no chances should ever be taken in planting nematode-susceptible clones. Soil sampling may indicate a negative result, yet this does not mean that the soil is free from nematodes. Susceptible clones would offer a chance for the rapid build-up of even the lowest soil population, that is beyond detection by the current techniques of nematode extraction. The TRI should be consulted from time to time for nematode resistant clones and it is with such approved clones that planting should be done.