

PRACTICAL ASPECTS OF THE EELWORM PROBLEM IN TEA

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Introduction

Infestation of tea by parasitic eelworms has been investigated by the Institute for many years and has been referred to in numerous articles (reviewed by Visser, 1959); but the eelworm problem is still with us and, because subsidised replanting of eelworm-infested fields is being undertaken, we draw attention once more to some features of practical importance.

Among the eelworms which attack both young and mature tea, the meadow eelworm (*Pratylenchus coffeae* Sher & Allen) is the most damaging. Root-knot eelworm (*Meloidogyne javanica* Chitwood) infests young tea plants (in India: *M. incognita* Chitwood), but does not appear to attack mature tea. Another species of the same genus (*M. breviscauda* Loos) has been reported to do severe damage to mature bushes, but so far in only a few isolated cases. How far other eelworms infest and harm tea in Ceylon is not yet known, but Dr Hutchinson is investigating this.

It is not surprising that parasitic eelworms have appeared as a pest, for this is a common occurrence in any crop, whether annual or perennial, if it is grown continuously in the same place. Under such conditions, a slow increase in the eelworm population is to be expected, though adverse effects on the crop vary in severity.

The information available indicates that meadow-eelworm infestation is fairly widespread in the Dimbula district, that it is prevalent in certain areas of other districts as well, and that it has become a serious and acute pest on only a few estates. It cannot be said for certain whether infestation at present latent is going to become apparent and increasingly severe with increasing age of the tea or whether it can be kept in check indefinitely. Presumably, there are factors which decide whether or not eelworm infestation will become serious, for one can find fields or estates, side by side, of which the one is much less infested than the other, judging by the appearance of the bushes and by their yield.

There is no doubt that estates where meadow-eelworm infestation is acute have a serious problem. Losses in yield of heavily infested fields may be about 250 lb. of made tea per acre per year, as compared with fields with little or no infestation.

Bush and Soil Management

There is something to be said for the school of thought which claims that the eelworm problem in Ceylon is partly an agricultural problem related to the condition of both bush and soil. It is evident that weak bushes are more easily affected by adverse conditions than healthy ones, though it must be remembered that it is the best-manured and most productive tea bush that tends to contain most shot-hole-borer beetles.

In general, however, all factors like erosion, hard plucking, hard pruning and insufficient manuring, which tend to weaken the bush, are also liable to aggravate

the effects of eelworm attack. This is confirmed by observations in the field and the weaker bush succumbs sooner than the stronger.

Since the eelworm destroys the feeding roots, the speed with which the roots can be replaced affects the chances of survival of the bush. For instance, when any bush is pruned, many of its feeding roots normally die. New ones will subsequently be formed, the capacity for growth largely depending on the condition of the bush before pruning. If the reserves are low, subsequent recovery will be slow. Consequently, eelworm attack on the few, slowly forming, feeding roots at this time may lead to the degeneration or death of the bush. It is possible, moreover, that roots of weakened bushes are more readily attacked by eelworms than those of vigorous ones.

The health of the bush is naturally affected not only by the treatment given to it as regards plucking and pruning, but also by the condition and fertility of the soil in which it grows. Bushes in soils with maintained or augmented organic matter content are likely to grow more vigorously and thus will be less prone to eelworm damage than bushes whose growth is impeded by low soil fertility.

In addition to this, there are indications that the application of organic material to the soil may have a direct depressing effect on the parasitic eelworm population, in so far as it probably increases the resistance of the roots to eelworm attack. It may well be that the gradual destruction of the organic matter and disappearance of the top soil caused by erosion and exposure as a result of bad agricultural practices have increased the severity of eelworm infestation on certain old tea plantations.

The application of organic material, in the form of thatch, compost, stable manure or loppings, is therefore sound agricultural practice, not only for improving soil conditions but also for keeping eelworm infestation in check. In short, all measures normally aimed at increasing the yield and the maintenance of soil fertility should also help to check or slow down the degeneration of old tea through eelworm infestation. The emphasis must be on prevention, for the bushes cannot be cured once they begin to show symptoms of eelworm attack.

Green Manures and Shade Trees

The growing of green manures (cover crops) in the tea is obviously of benefit to the soil. They sometimes serve a double purpose; for example, *dadaps* (*Erithrina lithosperma*) and *Gliricidias* provide both shade and loppings. The same is true of shade trees proper like *Gravillea* or *Albizia* where leaf-fall adds to the organic matter supply. Naturally both the organic matter provided by their roots and the competition of those roots should also be taken into account.

Cover crops in the strict sense are only sporadically grown in tea, partly because they do not grow well under a good cover of tea and partly because their cultivation is not encouraged for fear of competition and the difficulty of their eradication. Nevertheless there are some estates which now practise clean weeding, but might well profit from a cover crop against exposure to soil erosion and other climatic influences, particularly after pruning.

Naturally it is important to know if a plant species is susceptible to the same eelworm species that attack mature tea bushes and it is inadvisable to use susceptible species. The available data concerning the susceptibility of a number of cover crops, bush crops and shade trees have been reviewed previously (Visser, 1959, 1959a), so only a brief summary is given here.

All of the cover crops and weeds investigated appeared to be nearly or completely resistant to meadow-eelworm attack. Of these, four grass species, notably Guatemala grass, are resistant to root-knot eelworm as well. As for bush crops,

the planting of *Tephrosia vogelii* is not recommended because it is susceptible to both meadow eelworm and root-knot eelworm; most *Crotalaria* species, on the other hand, are remarkably immune to both eelworms. Among shade trees commonly grown in tea, only *dadap* shows such a susceptibility to root-knot eelworm that degeneration may often occur; *Albizia sumatrana*, though attacked by the same eelworm, does not seem to suffer from it. Some other shade trees were found to be not susceptible, or only slightly so, to either meadow or root-knot eelworms.

Accordingly, it may be said that most of the plants investigated so far do not appear to be congenial hosts for meadow eelworm and therefore are not likely to contribute to its spread; the exception is *Tephrosia vogelii*, which ought not to be used. The susceptibility of some of them to root-knot eelworm is a handicap only during their own establishment, but this species will not endanger mature tea. It is very important, however, not to grow susceptible plants in nurseries that may be used later for the propagation of tea, because young-tea plants are susceptible to root-knot eelworm.

In this context attention must be drawn to marigolds (*Tagetes patula* and *T. erecta* varieties); these species have been shown to have a very marked suppressing effect on both meadow and root-knot eelworms (Visser & Vythilingam, 1959). In fact the cultivation of marigolds has been found to be as effective as fumigation. In our trials we obtained the best results with two vigorously growing types which were obtained locally. Both, sown in rows 9-12' apart, were found to grow extremely well on fallow tea soil (when liberally manured) and they provided a great amount of organic material, estimated at 15 to 20 tons fresh weight per acre, within 5 to 7 months after sowing. These varieties almost completely covered the soil 2½ months after sowing, while, once fully established, they appeared effectively to suppress weed growth, forming both a dense cover (4-5 ft. high) and a continuous mat of roots.

Marigolds as a cover crop in young tea, sown immediately after the plants were put out, did equally well, but competed rather severely with the young tea plants. In mature tea they grew only moderately well when sown after pruning and then only in fields with many vacancies and when left undisturbed for several months. Although in both cases the meadow-eelworm population was significantly depressed, the cultivation of marigolds, on their own or together with another cover crop, is successful and practical only in the absence of tea.

Fumigation

Fumigation of mature tea can be carried out without phytotoxic effects to the bushes with Nemagon at 10 gallons per acre (Loos, 1953, 1954, 1956; Visser, 1959a). Although reinfestation of the soil is likely to occur after some time, probably on a small scale within a year, the effect on the bushes has been observed to be favourable. Indications are that in the year following fumigation (done after pruning) a 25% increase in yield may be obtainable (Visser, 1959). Yield increases may continue longer than a year. Unfortunately fumigation of old infested tea is not economically worth while at present, costing about Rs. 800/- per acre.

Fumigation of nurseries and soil used for basket plants, on the other hand, is a practice which can be, and should be, a standard procedure when eelworms are present. It costs only a fraction of the value of young plants succumbing to moderate eelworm attack in the nursery or after transfer to the field. It must be remembered, however, that it is of little use to fumigate nurseries that already carry infested young tea plants. Shell D.D. and Nematox are very toxic to young plants, while Nemagon — though not phytotoxic — is not very effective in killing the eelworms living in the roots.

Regarding nursery soils, care should be taken *not* to use a nursery that is already heavily infested or worn out (Visser, 1958; Visser, Kehl and Tillekeratne, 1959). Such a nursery should be abandoned, or its soil should be reconditioned or replaced by new soil. The use of "tea soil" should be avoided for, apart from possible infestation with parasitic eelworms, it is not the best medium for either propagation or basket plants. Moreover, such soil is likely to contain roots which, if infested, are not so easily rendered harmless by fumigation. Instead, soil from Guatemala grass areas, or good *patana*, or jungle soil should be used; the meadow and root-knot eelworm populations in such soils are usually low; rooting and growth are better in grass soils than in tea soil.

A satisfactory substitute, when grass soils are not available, can be made up by mixing sub-soil, peat litter and sand in equal proportions; this mixture has the added advantage that it will be free from eelworms or other harmful pests, if subsequent contamination is prevented. Fumigation of such a mixture is unnecessary.

For all other soils, fumigation is recommended, not only because it kills eelworms, but also because it tends to eliminate other pests such as white grubs (Kehl and Piyasena, 1956). These may sometimes do as much harm to young plants as eelworms. *The use of eelworm-free soil is absolutely essential in order to prevent the spreading of eelworms from the nursery to the field.* Eelworm infestation of the young plants will adversely affect their establishment in the field as well as render useless any measures taken in the field to get rid of the infestation there.

Soil fumigation can be carried out with Nematox 100^g, or Shell D.D. or Nemagon at the recommended rates, applying one injection per square foot (Loos, 1953, 1954). The soil should be well watered and thatched after fumigation.

Although a period of 5-7 weeks after fumigation is ample for the disappearance of possible phytotoxic effects, it is advisable to allow at least 10-14 weeks to elapse before the soil is used for propagation or the filling of baskets. After leaving the soil *fallow* for such a period, it is unlikely that any healthy eelworms would remain, especially after a low initial eelworm population, for the few which survive fumigation would normally die from starvation.

An alternative method of getting rid of parasitic eelworms is to cultivate marigolds in the nursery beds (and paths) for 5-7 months. When sown between rows of Guatemala grass cuttings, a double purpose is achieved, namely, soil improvement and the suppression of parasitic eelworms.

Finally, it is recommended that the *entire* nursery, including paths, is fumigated or reconditioned to prevent contamination from the untreated portions. If that is not possible, the treated area should be separated from the untreated part by a deep drain. Similarly, deep trenches should be dug around the edges of the nursery, to reduce the chances of re-infestation by soil wash and by drain water from surrounding areas.

Eelworms and Replanting

Depending on the condition and yield of an eelworm-infested field, one can either decide to keep infestation within bounds by paying greater attention to agricultural practices, such as thatching, applying heavy dosages (10 to 20 tons/acre) of compost or manure, or one can have the tea uprooted and the area replanted.

If the infestation is moderate and has been discovered before too many casualties have been suffered, and the yield is still satisfactory, thatching and manuring may well be economical. Maintaining or promoting vigorous root growth under such circumstances is important. Re-supplying, if necessary, might be undertaken to increase the stand of the bushes but re-supplying is usually difficult even under normal conditions and can be successful only when carried out with eelworm-

tolerant (or eelworm-resistant) material. Only well-grown basket plants should be used for supplying. Fumigation of the vacancies, or at least of the plant holes, 4-6 weeks in advance and mixing in compost or stable manure at the time of planting will assist the establishment of the plants. If the vacancies are fairly large (to be preferred when re-supplying) reconditioning with marigolds (for 6-7 months), or with Guatemala grass (at least one year), may be feasible, though in the latter case the surrounding tea bushes may suffer from competition.

If the field is already in a bad state and its yield marginal, it is doubtful whether anything more could be achieved by improved bush and soil management than the masking of the detrimental effect of eelworm attack for some time. In such a case it would perhaps be better to replant. Since the Tea Replanting Scheme provides subsidies, it is likely that many estates would decide to take advantage of the scheme. It is compulsory to recondition the soil of such areas properly and advantage can be taken of this to reduce the population of parasitic eelworms, notably meadow-eelworms, to a minimum. If the compulsory reconditioning does not cope with eelworms, replanting is likely to be an economic failure.

An example given in the table below may illustrate this point; it presents the yield data from two fields on an estate in the Dimbula district, which were planted about twenty years ago (with seed) without rehabilitation, after the uneconomic old tea had been uprooted.

Average yield per acre/year	Lightly infested; planted in 1941. 25 acres	Heavily infested; planted in 1938. 43 acres
Since in bearing Over 1951-1957	687 lb. 746 lb.	487 lb. 580 lb.

It appears that the yields of the two fields, particularly that of the older field, have been unsatisfactory throughout. It is doubtful if they could be improved sufficiently to cover the cost of improvement. Probably both the lack of soil reconditioning and the presence of parasitic eelworms have contributed to the comparatively poor results of replanting in this case.

Reconditioning

It is clear that no effort should be spared to reduce to a minimum the eelworm population of areas which are to be replanted; similarly the soil should be so improved that the young plant has a fair chance of establishing itself.

The method of reconditioning most widely recommended so far is the cultivation of Guatemala grass; this crop, besides being resistant to meadow-eelworm, provides a very considerable bulk of organic matter, both above and below the surface of the ground. For eelworm control, and for soil protection too, *combined cultivation of Guatemala grass and marigolds* is preferable. As Guatemala grass takes, at up-country elevations, at least 6-8 months to become established, planting of this grass alone means that the soil is left exposed for a considerable time.

In recent trials at two up-country estates, marigolds sown between the grass rows almost fully covered the soil within 2½ months after sowing. At that time the grass cuttings had shown little growth. If a vigorous variety is used, it is unlikely that the marigolds will degenerate before the Guatemala grass is fully established and growing vigorously. In the meanwhile they will have effectively suppressed

the parasitic eelworm population, prevented undue soil erosion, and provided additional organic material.

The grass cuttings should be planted at 2 × 2½ ft. and the marigolds sown in between in two or three rows, 9'-12' apart, and in shallow ruts of 1'-2" deep; loosening the soil will favour subsequent growth. It is estimated that at least 5 lb. of (pure) seed will be required per acre; mixing the seed with a bag of tea fluff or paddy chaff will facilitate sowing.

Marigolds respond markedly to manuring; it would therefore seem worthwhile to broadcast at the time of sowing, a dressing of e.g. 1 cwt. of a balanced animal meal per acre mixed with some bags of tea fluff. Thereafter, depending on growth, manuring may be repeated with the standard mixture recommended for Guatemala grass (Tolhurst and Portsmouth, 1956; Tolhurst, 1958).

The large varieties of marigold used in our trials were found to stand up well to lopping at about 2 ft., provided this was not done too early but before flowering. It is likely that with generous manuring they can be lopped several times before the grass is ready to be cut.

As imported seed is expensive and often less suitable than the semi-wild varieties growing locally, planters are advised to produce their own seed from these varieties. The large bushy type is preferable. There should be no difficulty in obtaining sufficient seed eventually, for marigolds are prolific seed-producers. The correct time for sowing would appear to be in the latter half of the wet season; seed must be collected during the dry season, or the viability of the seed tends to be poor.

Thus, in my opinion, soil reconditioning with Guatemala grass and marigolds together is well worth trying. One is likely to find that, on not too poor soils and with liberal manuring, soil reconditioning with both crops will be much more effective in suppressing eelworms and more efficient as regards soil protection, while requiring a shorter period, than with Guatemala grass alone.

Other cover crops may also be used in combination with Guatemala grass. It is possible that, at low- and mid-country elevations, other fast-growing plants may be applicable. None of these is known to be as valuable as marigolds in suppressing eelworms and, at least at up-country elevations, marigolds have been found to grow more quickly than alternative cover crops.

Summary

Eelworms are to be expected in any mono-crop. Mature tea suffers from meadow eelworm, which cannot be eradicated from the tea. The trouble is likely to increase steadily as the time under one species of crop increases. It is therefore vitally important to take advantage of replanting for clearing eelworms out of the replanted area. This can be done by normal reconditioning of the land with Guatemala grass; it can be helped and accelerated by interplanting the grass with marigolds.

Once mature tea is infested with meadow eelworm, the only thing to be done, apart from replanting, is to keep the bushes as vigorous as possible by cultural and manuring methods that ought to be used in any case.

Young plants are susceptible to attack by another species, root-knot eelworm. It is essential to ensure that nurseries, especially for tea and for *dadap* and *Albizia sumatrana*, should be completely cleared of this species and kept clear. It is also important not to introduce meadow eelworm into the fields from the nurseries, either in tea or in shade, cover, and green manure plants. *Tephrosia vogelii* is susceptible to both kinds of eelworm and should not be used because it encourages their multiplication and spread.

For nurseries, a fresh mixture of peat, sub-soil and sand is good because it works well and is free from eelworms; all other soils should be fumigated, whether

known to contain eelworms or not; old tea soil should never be used. Fumigation should extend to the immediate surroundings of the nurseries (paths) and trenches should be dug around them to prevent eelworms migrating into the nurseries.

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