

THE EFFECTS OF INFECTION BY *PRATYLENCHUS LOOSI*, AND OF FUMIGATION, ON THE GROWTH OF YOUNG TEA PLANTS IN DIFFERENT SOIL TYPES

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The growth of young tea plants of Clone TRI 2024 in gravelly and clayey soils was significantly superior to the growth in soils rehabilitated with Guatemala Grass (*Tripsacum laxum*), and in sandy soils. Injury caused by *Pratylenchus loosi* to these plants was most severe in clayey soil and least in sandy soil. The best growth of infected plants was in gravelly soil and this was comparable to the growth of plants in nematode-free guatemala and sandy soils. Soil type also influenced the population growth of *P. loosi*, both in plant roots and in soil. The highest build up of the population was in clayey soil and this was significantly higher than that in other three soil types. Pre-planting soil fumigation with methyl bromide was injurious to young tea plants in soils rich in organic matter and was harmless to those in soils having a relatively high composition of clay. On the other hand, soil fumigation appeared to benefit growth of young tea plants in sandy soils with relatively low organic matter and clay contents.

The growth response of plants in fumigated soils is variable and claims have been made for improved growth in such soils (Pitcher 1957; Firman & James 1963; Ruehle & Sasser 1964). Young tea plants grown in soils fumigated with methyl bromide, DD (a mixture of 1,3 dichloropropene and 1,2 dichloropropane) and Di-Trapex (methyl isothiocyanate and DD, 20:80) were found to grow significantly better than in untreated soils (Sivapalan 1969a) and this effect was found in the case of methyl bromide, to be related with the dose of fumigant used (Sivapalan 1969b).

In some locations, however, the growth of young tea plants was found to be adversely affected when planted in areas pretreated with methyl bromide. In such instances, the set-back in growth was found to be even greater than that caused by nematode infection. These observations were found to vary with soil types. An experiment was, therefore, designed to test the effect of nematode infection and of soil fumigation on the growth of young tea plants in different soil types.

MATERIALS AND METHODS

The soils used in this experiment were collected from three distinct sources: a) gravel soil from the top 30 cm of an area that had been under Mana Grass (*Cymbopogon confertiflorus*) for over ten years; b) Guatemala soil, from the top 30 cm from old tea land that was uprooted and rehabilitated under Guatemala Grass for two years; and c) clayey soil from a 45 to 60 cm deep layer of a gum (*Eucalyptus* spp.) and fern forest, an area that served as the source of soil for the nursery. The fourth type, 'sandy soil' was made up by mixing equal portions of guatemala soil and river sand.

The aluminium content in the soil was determined by the method of Chenery (1948); organic matter was determined by the dry-combustion method of Ball (1964) and textural analysis was carried out by the hydrometer method (Piper 1942).

Each different soil was mixed very thoroughly to make it consistent and divided into three equal portions. One portion of each soil type was separately fumigated (bulk fumigation) with methyl bromide at the rate of 1 kg/6 m³ of soil, under tight polythene covers. The polythene covers were removed at the end of 48 hr and each

fumigated lot of soil was turned over and raked thoroughly to permit the excess fumes to escape and the soil heaps were left to stand in a dry state for a further period of one week.

The 3 lots of soils (one fumigated and two untreated lots) from each of the four types were then separately filled into large square cement pots (0.45 m high and 0.3 x 0.3 m square). Each individual lot was replicated six times, providing a total of 72 pots. They were arranged on stone terraces at random. Uniform plants of Clone TRI 2024 six-month-old were planted in the pots. One lot (6 replicates) of the untreated soil of each soil type was inoculated with 3,000 active *P.loosi* per pot, two weeks after planting.

Fertilizer (T 65 mixture—6 g/l) was applied to all pots at monthly intervals, at the rate of 50 ml/pot/month. All the pots were watered uniformly and regularly, preventing the soil from drying out. The plants were removed at the end of 12 months for assessments of shoot and root weights. Duplicate samples of 10 g of roots from each of the inoculated plants were processed separately for nematode estimation. Duplicate samples of 100 g of soil was also collected from each inoculated pot and processed separately for nematode estimation in the soil. Nematodes were recovered from root samples according to the modified method of Hutchinson & Vythilingam (1963) and from soil samples according to the modified method of Sivapalan (1967).

RESULTS

The results of soil texture analyses, the organic matter contents and the contents of aluminium ions of the different soil types are presented in Table 1. The shoot and root weight analyses of the plants for each treatment are presented in Tables 2 and 3 respectively, and the assessments of nematodes present in the roots and soils in the different treatments are presented in Table 4.

From these results it is evident that soil types, nematode infection and soil fumigation bring about significant effects on the growth of young tea plants. There were also significant interactions between soil type and nematode infection on the one hand and between soil type and fumigation effects on the other.

Effects of soil type

As seen from Tables 2 and 3, shoot and root weight of plants grown in the gravel and clayey soils was significantly superior to that in guatemala and sandy soils. While the shoot growth of plants in the gravel soil was significantly the better than that for all other soil types, no such difference was observed between root growth of plants in gravel and clayey soils.

Effects of nematode infection

Suppression of plant growth was significant in nematode-infested clayey, gravel and guatemala soils, whereas in sandy soil, only root weights were less (Tables 2 & 3). The greatest reduction in growth due to nematode pathogenicity was in the clayey soil, whereas it was least in sandy soil. Growth of plants was significantly superior in nematode infested gravel soil than in other nematode-infested soils and was comparable to the growth of plants in nematode-free guatemala and sandy soils.

As seen from Table 4, the build up of the nematode population was also significantly affected by soil type, the highest population build-up, both in plant roots and in soil, being in clayey soil. No significant difference in population size was observed between plants growing in the other three soil types.

TABLE 1 — Analysis of soils for aluminium, organic matter content, gravel* and texture

Soil Type	Aluminium (m.eg. %)	Organic matter (% w/w)	Gravel (% w/w)	Sand (% w/w)	Texture Silt (% w/w)	Clay (% w/w)
Clay	0.78	12.6	<-3.0	40.7	9.7	49.6
Gravel	0.88	21.9	26.7	60.9	13.5	25.6
Guatemala	5.38	19.3	<-3.0	57.9	13.6	28.5
Sandy	0.89	10.5	<-3.0	75.3	3.0	21.7

* Gravel was sieved on a 2 mm sieve and the sieved soil was used for textural analysis

TABLE 2 — Mean shoot weight

Treatments	Soil types	Mean shoot weight (g)				Treatment means
		Clay	Gravel	Guatemala	Sand	
Control		295.8	393.3	205.0	164.5	264.6
Fumigated		313.3	138.5	121.3	286.2	214.8
Infested		118.8	237.2	71.2	100.9	132.0
LSD ($P=0.05$)	72.3	—	—	—	—	36.1
($P=0.01$)	96.3					48.1
Soil type means		242.6	256.3	132.5	183.9	
LSD ($P=0.05$)		41.7				
($P=0.01$)		55.6				

TABLE 3 — Mean root weight

Treatments	Soil types	Mean root weight (g)				Treatment means
		Clay	Gravel	Guatemala	Sand	
Control		184.3	176.9	130.4	116.5	152.0
Fumigated		158.2	63.5	63.0	134.3	104.7
Infested		64.9	136.8	62.3	64.5	82.1
LSD ($P=0.05$) ($P=0.01$)	40.0 53.4	—	—	—	—	20.0 26.7
Soil type means		135.8	125.7	85.2	105.1	
LSD ($P=0.05$) ($P=0.01$)		23.1 30.8				

TABLE 4 — Nematode assessments in plant roots and soils of different treatments

Soil type	Root count	Soil count
	Nematodes/g root (Log n)	Nematodes/100 g soil (Log n)
Clay	2.82	1.94
Gravel	2.28	1.37
Guatemala	2.48	1.46
Sand	2.38	1.39
LSD ($P=0.05$)	0.04	0.23

Effects of soil fumigation

A significant suppression of plant growth was observed in the gravel and guatemala soils fumigated with methyl bromide (Tables 2 & 3). The toxic effects of fumigation in the gravel soil was more damaging to the plants than even nematode damage. In guatemala soil, these two forms of injury were almost the same. Growth, however, was not affected in fumigated clayey soil and it was almost the same as that in the corresponding untreated soil. Soil fumigation, on the other hand, significantly improved the shoot growth of plants in sandy soil, but there was no corresponding improvement in root growth.

DISCUSSION

The consideration of three soil factors, aeration, organic matter content and clay content appear to be relevant to the discussion of the results of this experiment. The general growth of young tea plants of Clone TRI 2024 was best in soils having about 25% gravel that contributed to good soil aeration, which in turn helped good growth (de Silva 1967). On the other hand, the growth in the relatively, poorly-aerated clayey soil (ca. 50% clay) was also equally good and in this instance, it is possible that the high clay content may have contributed to a better and more efficient cation exchange capacity (CEC) that helped plant growth. Nutrients added to soils with an efficient CEC are retained better and are readily available to the plants. Likewise, apart from the benefits of good soil aeration, the high organic matter content in gravel soil (21.9%) would have complemented the function of the relatively low clay content (25.6%) in contributing to an efficient CEC. The combination may have benefited growth.

On the other hand, the growth performance of plants in guatemala and sandy soils was relatively poor. Although the organic matter content of guatemala soil was relatively high (19.3%), it was rich in aluminium (5.38 m.eq.%, as against 0.78 to 0.89 m.eq.% in the other soils) and as a consequence, many of the retention sites that may normally have been available for binding other essential cations may already be occupied by aluminium ions. In this condition, a fair proportion of the useful basic cations may not have been retained by the soil matrix and might, therefore, have been leached out. The relatively poor performance of plants in sandy soil may have been due to the relatively low organic matter (10.5%) and/or clay (21.7%) contents in this soil. As the pots were watered regularly, the moisture-holding capacity of the different soils would not have had any significant influence on growth.

Nematode infection

Population of *Pratylenchus* spp. are known to be abundant and most damaging to host plants in sandy soils (Young & Ruehle 1955; Parker & Mai 1956; Stover & Fielding 1958; Endo 1959). Instances are also known where damage caused by *Pratylenchus* spp. was highest in relatively heavy soils (Riggs, Slack & Fulton 1956.) In the current experiment, damage caused by *P. loosi* to young tea plants was 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 favourable to nematode population growth differs for the different soil types (Kable & Mai 1968). With the method of watering adopted in this experiment, the optimal moisture tension may perhaps have been better in the heavy clayey soil resulting in the highest population build up and consequent damage whereas in more porous soils, this condition may not have been optimal. Although the final population count in the plant roots and soils in guatemala, gravel and sandy soils were not significantly different from each other, the nematode damage to the young tea plants was less in sandy soil. This may have been due to unfavourable soil moisture tension in sandy soil which impedes root penetration by nematodes (Kable & Mai 1968).

Although there was positive nematode pathogenicity in the gravel soil compared with the growth of plants in uninfested soil this damage was not very evident because of the superior growth of plants in this soil type. Young tea plants growing in soils similar to the gravel type used in this experiment are evidently more tolerant to attacks by *P. loosi*.

Soil fumigation

A significant interaction of soil type and effects of fumigation was observed in this experiment. The earlier generalization of 'stimulated growth' of young tea plants in soils fumigated with methyl bromide, therefore, needs modification (Sivapalan 1969a). The highly significant suppression of growth of young tea plants in gravel and guatemala soils fumigated with methyl bromide may be the result of phytotoxic effects caused either by the lingering methyl bromide or, as a result of bromine toxicity. These two soils differed from the other two types chiefly in respect of their high organic matter content (21.9 and 19.3%, respectively). In soils rich in organic matter, there are many reaction sites available for the attachment of bromide ions or for the attachment of weakly-charged methyl bromide dipolar ions and as a consequence, a greater proportion of methyl bromide or bromide ions could be retained by such soils than in those relatively poor in organic matter. On account of such toxic effects, the growth of young tea plants was significantly suppressed more than that caused by nematodes. In clayey soil (a large proportion of which is in the form of kaolinite) the number of reaction sites available for possible attachment of bromide ions is relatively low. Further, although a relatively large proportion of the methyl bromide is initially entrapped between the compact clay particles, the subsequent raking and turning over of the soil would have permitted such entrapped gas to escape. This may account for the unaffected growth of plants in fumigated clayey soil. Despite this being relatively low, the partial toxic effects of the few lingering bromide ions may yet have masked any possible enhancement of growth. The growth of plants in fumigated clayey soil was, however, significantly superior to that of the corresponding nematode-infected plants. On account of the relatively low organic matter and clay contents in sandy soil, bromide ion toxicity would virtually be small if not absent in such soils. Any beneficial effects that may have accrued to this soil as a result of fumigation, would have been better reflected in terms of growth. The significant improvement of shoot growth and the partial improvement of root growth in fumigated sandy soil substantiates this.

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Accepted for publication: 10th June 1970.