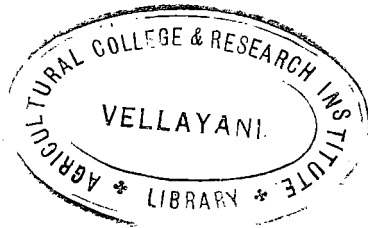


STUDIES ON
THE NEMATODES ASSOCIATED WITH BANANA
IN KERALA



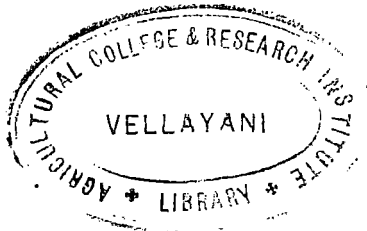
BY
K. C VARGHESE, B. Sc. (Ag.)

THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURE
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DIVISION OF ENTOMOLOGY
AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE
VELLAYANI, TRIVANDRUM

1967



CERTIFICATE

This is to certify that the thesis herewith submitted contains the results of bona fide research work carried out by Sri Varghese, K.C., under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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August, 1967.

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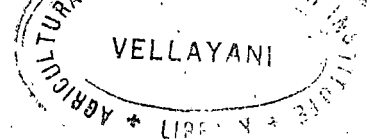
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CONTENTS

	Page
✓ INTRODUCTION	1
✓ REVIEW OF LITERATURE	3
✓ MATERIALS AND METHODS	15
✓ DETAILS OF STUDIES AND RESULTS	22
✓ DISCUSSION	53
✓ SUMMARY AND CONCLUSIONS	60
REFERENCES	1 - vi
PLATES	1 - 111

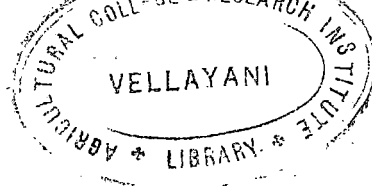
LIST OF ILLUSTRATIONS



- FIGURE I Map of Kerala showing the distribution of the parasitic genera of nematodes found in association with banana.
- II Population of parasitic nematodes in the soil of banana in relation to climate, soil type and condition of the plant.
- III Population of non-parasitic nematodes in the soil of banana in relation to climate, soil type and condition of the plant.
- IV Population of parasitic nematodes in the roots of banana in relation to climate, soil type and condition of the plant.
- V Population of parasitic nematodes in the soil of banana in relation to climate and condition of the plant observed at various localities.
- VI Population of non-parasitic nematodes in the soil of banana in relation to climate and condition of the plant observed at various localities.
- VII Population of nematodes in the roots of banana in relation to climate and condition of plant observed at various localities.
- PLATE I Radopholus similis, full grown within the tissues of banana root.
- II Radopholus similis larva within a single cell of banana root tissue.
- III & IV Radopholus similis adult female with eggs within banana root tissues.
- V Retziolenchus sp. adults within banana root tissues.

INTRODUCTION

INTRODUCTION



Plant parasitic nematodes constitute a major limiting factor of agricultural production. Till recently, these exceedingly small worm like organisms remained as a little known group because of the difficulties involved in isolating them from the soil and plant tissues and preparing them for detailed studies on their identification and their relationship with plants.

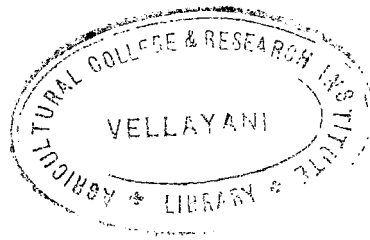
Nematology is still in its infancy in India and research in this field has already been initiated at various centres in the country. A perusal of literature (loc.cit) will show that information available on the plant parasitic nematodes and the role they play on the agricultural economy in India is meagre.

So far as Kerala is concerned, practically no work has been done in this virgin and important field. There are however indications that the plant parasitic nematodes play a vital role as enemies of cultivated crops in this state also. Thus, nematodes known to be highly destructive such as the burrowing nematode Radopholus similis a potential enemy of banana, and the citrus nematode Tylenchulus semi-penetrans have already been recorded to be present in Kerala (Nair et al 1966 and Nair 1965). Root knot nematodes are already known as serious enemies of vegetables and other

crops such as Coleus parviflorus in this region (Sathya Rajan et al 1966). Many other nematode problems affecting agriculture in Kerala still remain undetected and unstudied.

The present studies were hence undertaken with a view to initiate research in the field of plant parasitic nematodes, and to invite the interest of workers to this field. In the present studies, an effort has been made to survey the types of nematodes found in association with banana and to understand their abundance in relation to various environmental factors.

The literature on the work done in India on plant parasitic nematodes have been reviewed.



REVIEW OF LITERATURE

REVIEW OF LITERATURE

A review of literature relating to the plant parasitic nematode fauna in India is presented in the following pages. The information available is classified under the various genera of nematodes.

1. Genus: Aphelenchoides

Dastur (1936) reported a disease of rice from Central Province caused by a species of Aphelenchoides. The infested plants produced white earheads. Tips of the developing leaves get twisted and wrinkled with their apical portions turning yellow for an inch or two. The panicles were reduced in length and the kernels became small and deformed. The nematodes were found inside the white glumes of the sterile spikelets and between the floral parts of the under developed flower buds.

Nao et al (1961) reported Aphelenchoides parietinus Bastian and Steiver, in association with Sugarcane in Madras.

2. Genus: Anguina

Pradhan (1963) studied the infestation by the grain gall nematode Anguina tritici on wheat. The infestation led to stunted growth and wrinkled and twisted leaves of young plants. The earheads were reduced in size with galled

grains - ear cockles - on them. The infested seeds could be separated from the rest by putting the grains in 16% brine water.

3. Genus: Ditylenchus

Butler (1912) reported Ditylenchus angustus Filipjev under the name Tylenchus angustus But; as a parasite on rice in Nokhali and Tippera, causing a disease called "Ufra", over an area of six million acres. The infestation caused conspicuous stunting of the plant, withering of leaves, formation of brownish nodal patches and shrivelling of grains. Burning of stubbles and providing a break between two successive crops were recommended as preventive measures against the disease. Birat (1965) made further studies on the infestation of this nematode. He reported that the symptoms of the disease were shown by the plants three weeks after transplanting. Initially, there was slight discolouration at the collar region of the plants which later spread to the leaves which finally led to a withered appearance of the plants.

4. Genus: Hoplolaimus

An undescribed species of Hoplolaimus was reported by Sen (1958) on the roots of bhindi and potato. The infested plants showed drooping of the lower leaves. The root system was found bunched in appearance. The affected plants did not wither unless associated with other diseases like bacterial

wilt. Hoplolaimus indicus was recorded on sugarcane, paddy, and brinjal by Banerji et al (1966) from West Bengal. The nematode was found to be more numerous in and around the root zone. The infested plants showed stunting of the internodes, drooping of the foliar system and curling of the new leaves. Affected paddy plants were characterized by stunted growth and suppression of earhead formation.

Rao et al (1961) reported Hoplolaimus cornatus Cobb in association with sugarcane in Madras State.

5. Genus: Helicotylenchus

Infestation of rice by Helicotylenchus sp. was reported by Birat (1965). Infested plants showed discolouration of the collar region followed by the discolouration of the leaves. The disease symptoms appeared twenty one days after transplanting. Ultimately the plants developed a withered appearance. The presence of Helicotylenchus erythrinae Zimmerman in the soil around the roots of sugarcane in Madras was reported by Rao et al (1961).

6. Genus: Heterodera

Ayyar (1925) reported Heterodera radiculicola Muller on sugarcane from South India. Parasitisation of the roots by this nematode caused severe gall formation, the size of the galls found ranging from one inch to one and a half

inches in diameter. Ayyar (1926) observed that the attacked plants initially presented a dwarfed appearance and subsequently showed wilting. The leaves turned yellow and the roots were malformed with variously shaped swellings on them. Partial sterilisation, trap cropping and soil drenching with formalin or Carbon bi sulphide were effective, in controlling the nematode. Cholam, redgram and maize were moderately resistant to the attack of this nematode and hence these were recommended for crop rotation programmes (Ayyar, 1932). Under conditions obtaining in South India, this nematode thrived well during August to February. It was abundant in sandy porous soils of loose texture provided there was sufficient moisture. Heavy clayey soils and water logged or dry soils were relatively not favoured by H. radiculicola (Ayyar, 1933).

It was found that the damage caused by the nematode was considerably reduced by sterilising the soil with sulphuric acid, carbolic acid, Banicide or potassium cyanide. Partial sterilisation accompanied by trap cropping were more effective than any of the above treatments alone. Soil drenching with formalin gave satisfactory control of the parasite. A double treatment with potassium cyanide and ammonium sulphate was found to be the most effective treatment against H. radiculicola. Musa paradisiaca (plantain) was recorded as a susceptible host (Ayyar 1933).

Ayyar (1933) observed that the population of

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Heterodera marioni Cornu, was maximum at depths between twelve inches to eighteen inches while below a depth of thirty inches the population was minimum. The nematodes were extremely rare beyond a depth of thirty inches. He (Ayyar, 1934) observed that Andropogon sorghum (cholan), Zea mays (maize) and Oryza sativa (paddy) were resistant to attack by this parasite. Dutt (1960) showed that when grown in soil infested with H. marioni jute plants took infection within a week after germination. During the last part of growth Canularia types showed higher infestation than Olitorius types of jute. Maximum population of the nematodes was observed at a depth of six to seven inches in the soil. Nematode population was higher in samples collected during the months of May and June.

Heterodera rostochiensis the golden nematode of potato was recorded in India for the first time from Nilgiris by Jones (1961).

It may be pointed out that the species described as Heterodera radiculicola and Heterodera marioni have now been recognised as species of the root-knot nematode Meloidogyne. These species have however been inadequately defined (Goodey 1962).

7. Genus: Hirschmanniella

Pradhan (1962) observed that in Bihar the rice root nematode Hirschmanniella oryzae was associated with the

8

"Mentek" disease of rice. The symptoms of the disease represented the combined effect of the reduction in root function along with the development of new roots consequent on nematode infestation. The exact relationship between the nematodes and the disease was not clearly established. Birat (1965) observed that the symptoms of the disease appeared three weeks after transplanting. Initially there was a slight discoloration at the collar region of the plant which later spread to the leaves. Ultimately the plants developed a withered appearance.

This nematode was found in association with Tylenchus angustus But. in all cases of infection on rice (Birat 1965).

8. Genus: Longidorella

A new species of Longidorella was reported by Khan et al (1963) from Almorah in North India, occurring around the roots of apricots. The nematode infestation led to the wilting of leaves, general sickly appearance and retarded growth of the plants. The yield was also considerably reduced.

9. Genus: Meloidogyne

Chathopadhyay et al (1955) observed Meloidogyne incognita infesting jute plants Corchorus capsularis in West Bengal. Ahamed et al (1960) found that majority of the varieties S20, T17 and NP60 and Nicotiana rustica varieties

NPS₂₁₉ and Motihari showed more or less neutral effect on the infestation by the nematode larvae. The Nicotiana tabacum varieties G6, K20 and K49 attracted the larvae while N. tabacum variety NP70 and N. rustica variety T238 had a repellent effect on them. It was also observed that in tests using excised roots, the larval penetration was the highest in the roots of pumpkin and Chinese cabbage. Roots of pea, raddish and Indian flat beans had a repellent effect on the larvae.

Root diffusates from host plants like bottle gourd and tomato stimulated the hatching of the eggs of the nematode, whereas diffusates from sorghum and wheat had no influence on hatching. Leachings obtained from soils where susceptible plants were grown, distinctly stimulated hatching while those prepared from soils where non-host plants were grown had no hatching stimulus (Ahamed et al 1960).

Dutt (1960) reported the incidence of Meloidogyne incognita (Kofoid and white) on bitter jute Corchorus capsularis and non-bitter jute Corchorus olitorius from West Bengal. It was observed that, eventhough the roots of infected plants showed galling, they grew normally without malformation of the leaves and stem. Dhande et al (1961) reported Meloidogyne incognita Var: acrita as a causal agent for the root galls of betel vine from Nasik.

Investigations by Birat (1963) showed that accumulation of nitrogen favoured root knot development, while accumulation of phosphorous did not have any effect on nemic activity. Khanna et al (1964) observed that a potato variety HC194 resisted infection by this nematode.

The incidence of Meloidogyne javanica was reported by Sen (1958) on the roots of bhindi and potato. He also reported it as a parasite of gram and tomato.

He observed that the infested plants showed a sickly appearance with the dropping of lower leaves along with the bunched nature of the root system. On tubers it produced wart like eruptions.

Lal et al (1959) reported that Meloidogyne javanica Var. acrita Chitwood, infested vegetables belonging to Solanaceae, Leguminosae, and Malvaceae. This nematode was found surviving in the soil for about three months without any host. Addition of muriate of potash in the soil reduced the nematode injury to the hosts.

David (1959) reported the occurrence of Meloidogyne sp. on sugarcane roots in Nellikuppem and surrounding areas in Madras State.

The influence of temperature and hydrogen ion concentration on the hatching of the eggs of Meloidogyne javanica

was studied by Ahamed et al (1960). The maximum hatching occurred at 25°C. A sharp decline in hatching percentage was observed at 35°C and hatching was completely arrested at 40°C. Hatching was very poor at lower temperatures ranging from 10°C to 15°C. The hatching percentage was found to be the highest at a pH of 7. There was sharp decline in hatching percentage at pH 8 and hatching was completely arrested at pH 2 to 3.

Nirula (1961) studied the relative efficiency of DD, EDB and Nemagon in controlling the root-knot nematode Meloidogyne javanica which occurred as a pest of potato in Patna. DD at 400 lbs per acre gave best results in two consecutive years as only 10% of the tubers were infected as against plots treated with EDB at 200 lbs per acre which showed an infestation of 12.5% in the second year. Nemagon at 20 lbs per acre showed 17.5% infestation in the first year and 12.5% infestation in the second year.

Vijayalakshmi et al (1961) observed that susceptible sugarcane cuttings when planted in sand beds and inoculated with equal numbers of root knot nematode M. javanica showed terminal swellings within a fortnight. But in the case of resistant varieties such terminal swellings were not observed.

Chandy et al (1963) recorded Eleusine coracana, Cleome sp. and Ageratum sp. as hosts of Meloidogyne javanica.

Birat (1966) carried out field experiments to

ascertain the relative efficiency of Nelliite and Nemagon on the control of Meloidogyne javanica infesting tomato. Nelliite when applied at the rate of 2 lbs of the technical material per acre reduced the number of nematodes from 136 to 12 in 10 ml of the soil. Nelliite was found superior to Nemagon in view of easier field application, economy and nematicidal efficiency.

10. Genus: Panagrolaimus

Nadakkal (1965) observed a species of the saprophagous nematode Panagrolaimus on the leaves of coconut which were necrotic or semi-necrotic. He however reported that the association of these nematodes with diseased leaves might be of little pathological significance and that the parasite must have facilitated the entry of secondary invaders.

11. Genus: Radopholus

Radopholus similis Cobb. was found associated with the roots of sugarcane which showed chlorotic symptoms (Swarup et al 1961).

Nair et al (1966) reported for the first time from India, the presence of Radopholus similis as a pest of banana. The first symptoms of infestation observed were the yellowing of the outer whorls of leaves which extended to the inner whorls in 7 to 10 days. This followed the withering and drooping of the leaves which resulted in the falling down of the plants.

13

Roots of the attacked plants were rotten with little or no side roots. The rotting extended into the pseudostem also, in advanced stages of infestation.

12. Genus: Rotylenchulus

The reniform nematode Rotylenchulus reniformis Linford and Oliveria, was reported as a parasite on the roots of Mangifera indica, Citrus lemon, Citrus sinensis, and Citrus reticulata by Siddiqi (1960).

13. Genus: Tylenchulus

Occurrence of the Citrus nematode Tylenchulus semi-penetrans Cobb. was reported from Aligarh by Siddiqi (1960). About 80% of the citrus plants found in the area were infested with this nematode. The citrus nematode was found infesting Citrus lemon, Citrus sinensis and Citrus reticulata.

Hair (1965) reported from Kerala State for the first time, the presence of Tylenchulus semipenetrans Cobb infesting the roots of citrus at Helliampathy. He reported that the trees infested by this root parasite appeared stunted with typical decline symptoms. Detailed examination of the infested roots after staining revealed the presence of this nematode inside the root tissues.

14. Genus: Xiphinema

The presence of Xiphinema opisthohystercum Loos

in soil collected from around the roots of Cerissa sp. and Artocarpus integrifolia was reported by Siddiqi (1961) from Aligarh.

Birat (1965) reported Xiphinema indicus Sher as a parasite on rice in Bihar. The nematode produced disease symptoms three weeks after transplanting. The slight discoloration initially noted at the collar region of the plants spread to the leaves and finally the plants showed a withered appearance. This nematode was generally found together with Hirschmanniella oryzae.

MATERIALS AND METHODS

MATERIALS AND METHODS

Materials

(a) Equipment: The following equipment were used for the present studies:-

Nematode sieves:

Five U.S. standard sieves of meshes 20, 60, 100, 200 and 325 per square inch made by Daul Mfg. Co., Chicago, were used for sieving out the nematodes in the soil suspension.

Baermann funnel:

An ordinary glass funnel of 10 cm diameter, fitted with a 15 cm long rubber tube having a pinch cock controlling system at its tail end was used for filtering the nematodes present in the soil suspension.

Tissue paper:

'Sateena' white facial tissue paper of size 21 cm x 16 cm was used for separating the nematodes present in the soil suspension.

Wire gauze:

20 mesh galvanised iron wire gauze of size 15 cm x 15 cm was used as a support for the tissue paper while filtering

the nematodes. The wire gauze was made into a circular flat bottomed tray just fitting into the funnel.

Other equipment:

Other equipment used for the studies included the following:-

- 1) Two numbers of enameled basins each of 30 cm diameter and 8 cm height for washing the soil.
- 2) Funnel stands to support the funnels when set up for filtration.
- 3) Six numbers of Pyrex beakers of 250 cc capacity.
- 4) One ordinary wash bottle to wash down the nematodes with a slow stream of water from the sieves to the beakers.
- 5) One square counting dish (Perspex) of size 7 cm x 7 cm having 1 cm x 1 cm square markings on it for counting the number of nematodes present in the soil and root extracts.
- 6) Glass wool for supporting the coverslips while making permanent mounts of the nematodes.
- 7) Four numbers of very fine needles to tease the plant tissues.
- 8) Specimen tubes 8 cm long and 2 cm in diameter to preserve the soil extract and roots for further examination and counting.
- 9) One spirit lamp to heat the specimens before preservation.
- 10) Cavity blocks of size 4 cm x 4 cm and 8 cm x 8 cm for taking the root bits for teasing.
- 11) Microscopes
- 12) Pipettes

(b) Chemicals

Formaline: 10% formaline was prepared from 40% solution for preserving the soil extracts containing nematodes. A little CaCO₃ was also added to the final solution to neutralize the free formic acid to prevent granulation within the body of the preserved nematodes (Baker 1945).

Lactophenol: Clear lactophenol solution was used to preserve the infected roots and to make permanent mounts of the nematodes. The solution was prepared according to the formula adopted by Asann (1896) which was as follows:-

Phenol (Pure crystals)	20 gm
Lactic acid (S.G.I. 21)	20 gm
Glycerine	40 gm
Distilled water	20 gm

The ingredients were mixed well by thorough shaking and kept in glass stoppered bottles.

Methylene blue: For staining the nematodes within root tissues Methylene blue was used. A 0.1 percent of the stain dissolved in lactophenol was prepared and used for this purpose.

Methods

Collection of soil and root samples: Samples of soil and

and roots were collected from the base of healthy banana plants and from the base of banana plants infected with bunchy top disease. For drawing these samples, about 500 gm of the soil and 50 gm of the roots each were collected from the bases of four plants at depths of 4 - 7 inches. The soil collected from the four plants were mixed up together and a quantity of 500 gm was drawn out of it to form the sample to be analysed in the studies. The roots collected from the four plants also were pooled together, chopped and mixed up and 20 gm drawn out of it to form the sample for further studies. Both soil and root samples were collected in polythene bags to prevent any loss of moisture.

Processing of soil samples:

The soil samples were washed to isolate the nematodes in them by adopting the method of Christie and Perry (1951) and the nematodes were recovered from the washings by the modified Baermann funnel technique. The technique was as follows:

About 500 gm of the soil was weighed out and taken in a basin and it was thoroughly mixed with thrice the quantity of water. After removing the roots and very rough particles, this soil suspension was passed through a series of sieves of 20, 60, 100, 200 and 325 meshes per square inch. The fine silt and nematodes collected in 100, 200 and 325 mesh sieves, after repeated washing with clean water, were washed down into

a beaker using a minimum quantity of water. The beaker was kept undisturbed for half an hour and the supernatant water, if any, was pipetted out without disturbing the settled silt and nematodes. The concentrated suspension thus obtained was gently poured over a layer of facial tissue paper kept on the flat bottomed circular wire gauze tray in the Baermann's funnel. The funnel was filled with its base just touching the water surface. The setting was left undisturbed and at the end of 24 and 48 hours, 30 cc of water each was drawn out from the tail end of the funnel by loosening the pinch cock. These contained the nematodes which had wriggled down from above the tissue paper. The funnel was again filled to the original level as done earlier after every draw.

Processing of roots:

A homogenizer method was adopted for extracting the nematodes from the root samples collected. The roots were gently cleaned of any soil adhering to them by holding them in a stream of water under a tap. The cleaned roots weighing 20 gm were then sliced into small bits of less than 3 mm in length. They were then put into the homogenizer along with 5 cc of water. The homogenizer was switched on and worked first for 60 seconds and then for another 60 seconds with a break of 30 seconds in between. The contents were then washed down into a beaker using the minimum quantity of water from a wash bottle. A few drops of 10% formaline was added to

20
the nematode suspension. The nematodes present in the whole of the suspension were counted under a stereo microscope.

Fixation and preservation of nematodes:

The nematode suspension drawn from the Baermann funnel was taken in a specimen tube. It was kept undisturbed for 15 to 30 minutes. When the nematodes had settled to the bottom, part of the water from the top was pipetted out. The tube was gently heated for about 60 seconds over a spirit lamp flame. The nematodes were killed and relaxed in this process. To this suspension, an equal quantity of 10% formaline neutralized with a little CaCO_3 (Baker 1945) was added. The formaline poured into the nematode suspension got diluted by the water in it and thus the nematodes came to be preserved in 5% solution of the preservative.

Counting of nematodes:

The suspension of nematodes collected and preserved in 5% formaline was taken in a counting dish and all the nematodes present in the extract were counted. The nematodes were counted under two main categories, viz., parasitic and non-parasitic. The different genera of the parasitic forms were counted separately. Counting of the nematodes in the root suspension also was done in the similar way.



Staining of nematodes within roots:

Fresh roots collected from the field were stained with Methylene blue in lactophenol (0.1% Methylene blue-lactophenol) for studying the position of parasitic nematodes within the root tissues. The roots were cut into small bits of 5 mm size and immersed in the boiling stain. The boiling was continued for another three minutes. When cooled, the stained roots were transferred to clear lactophenol. At the end of 24 hours, the nematodes could be easily located within the root tissues, since the roots were destained in clear lactophenol while the nematodes retained the stain.

Mounting of nematodes:

The nematodes were mounted in clear lactophenol with glass wool supports. Nematodes of approximately the same size were chosen and four or five of them were arranged at the centre of a drop of lactophenol taken on a clean glass slide. Three bits of glass wool which were of the same thickness as that of the specimens were placed around the nematodes as support for the cover glass. After placing the cover glass, it was ringed with wax.

**DETAILS OF STUDIES
AND
RESULTS**

DETAILS OF STUDIES AND RESULTS

Nematode population in the soil and roots of Banana collected from different parts of Kerala

Studies have been made of the nematode fauna found in association with banana in their roots and soils collected from the different parts of Kerala from Vellayani in the South to Trichur and Kannara in the North. Details of the samples collected from the various localities and of the nematode populations found in each sample are given in the following pages.

LOCALITY 1 - TRIVANDRUM

Details of collection

Place of collection:	Kowdiyar, Trivandrum.
Type of soil:	Loamy
Collection of samples:	Samples of soil and roots of healthy banana plants and banana plants infected with bunchy top disease were collected. Collection of samples was made during two seasons viz., rainy and summer seasons.
Analysis of nematodes in the soil:	Samples were processed by Christie and Perry method and recovered by Baermann funnel technique.
Analysis of roots:	By homogeniser method

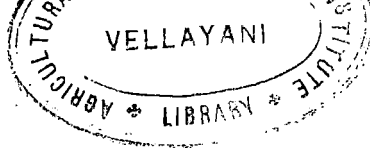
For details of collection of samples and analysis of nematodes in the soil and roots of banana see under "Methods".

TABLE I - Analysis of nematodes in soil and roots of banana at Trivandrum

Season and date of collection	Condition of the plant	No. of nematodes in 500 gm soil			No. of different genera of parasitic forms				
		Para-sitic	Non-para-sitic	Total	In soil (500 gm)		In roots (20 gm)		Total
					HE	CR	HE	CR	
Rainy 28-11-56	Bunchy-top	(1) 432	329	761	412	10	93	5	98
-do-	-do-	(2) 437	342	773	431	6	84	-	84
-do-	Healthy	(1) 294	361	655	294	-	59	10	69
-do-	-do-	(2) 307	310	617	307	-	61	-	61
Summer 28-3-57	Bunchy-top	(1) 111	160	271	111	-	121	-	121
-do-	-do-	(2) 137	210	347	137	-	118	-	118
-do-	Healthy	(1) 66	181	247	66	-	72	-	72
-do-	-do-	(2) 60	168	228	60	-	70	-	70

HE - Genus Helicotylanehus

CR - Genus Criconemoides



Results:

Results are furnished in Table 1. It may be seen that during rainy season the total population of the nematodes in the soil is 751 to 773 per 500 gm in the soil of bunchy top affected banana plants as against 617 to 655 in the soil of healthy plants. During summer, the populations are 271 to 347 and 228 to 247 respectively in diseased and healthy plants. In the case of nematodes in the roots, the population is 84 to 98 and 61 to 69 per 20 gm of roots of diseased and healthy plants respectively in rainy season and 118 to 121 and 70 to 72 in summer season. The parasitic forms observed are Helicotylenchus sp. and Criconemoides sp. of which the former is more abundant than the latter. Criconemoides sp. is not seen during summer season.

LOCALITY 2 - PALODE

Details of collection

Place of collection: Farm of the Central Arecanut Research Station, Palode, Trivendrum District.

Type of soil: Loamy

(Other details as under locality 1)

TABLE 2 Analysis of nematodes in soil and roots of banana at Palode

Season and date of collection	Condition of the plant	No. of nematodes in 500 gm soil			No. of different genera of parasitic forms					
		Para-sitic	Non-para-sitic	Total	In soil (500 gm)		In roots (20 gm)		Total	
					RO	HE	RO	HE		
Rainy 25-11-66	Bunchy-top	(1)	3	49	51	1	2	17	11	28
-do-	-do-	(2)	4	37	41	2	2	14	8	22
-do-	Healthy	(1)	4	23	27	-	4	5	7	12
-do-	-do-	(2)	2	41	43	1	1	3	5	8
Summer 5-3-67	Bunchy-top	(1)	1	31	32	-	1	22	28	50
-do-	-do-	(2)	2	33	35	-	2	29	16	45
-do-	Healthy	(1)	1	18	19	-	1	10	14	24
-do-	-do-	(2)	-	40	40	-	-	21	15	36

RO - Genus Rotylenchus

HE - Genus Helicotylenchus

Results:

Results are tabulated in Table 2. It is seen that during rainy season, the total population of nematodes in 500 gm of soil is 41 to 51 in the case of bunchy top affected banana plants and 27 to 43 in the case of healthy plants. During summer the populations are 32 to 35 and 19 to 40 respectively. With regard to the population of nematodes in 20 gm of the roots, 22 to 28 nematodes are observed in the case of bunchy top infected plants, and 8 to 12 for healthy plants during rainy season, as against 45 to 50 and 24 to 36 during summer season. The parasitic forms observed are Rotylenchus sp. and Helicotylenchus sp. The population of these parasitic forms in the soil is very low.

LOCALITY 3 - VELLAYANI

Details of collection

Place of collection: Agricultural College Farm,
Vellayani, Trivandrum District.

Type of soil: Loamy

(Other details as under locality 1)

TABLE 3 Analysis of nematodes in soil and roots of banana at Vellayani

Season and date of collection	Condition of the plant	No. of nematodes in 500 gm soil			No. of different genera of parasitic forms			
		Para-sitic	Non-para-sitic	Total	In soil (500 gm) HS	In roots(20 gm) HS	Total	
Rainy 24-11-66	Bunchy-top	(1)	27	104	131	27	14	14
-do-	-do-	(2)	18	86	104	18	12	12
-do-	Healthy	(1)	16	91	107	16	11	11
-do-	-do-	(2)	11	97	108	11	8	8
Summer 15-2-67	Bunchy-top	(1)	11	51	62	11	24	24
-do-	-do-	(2)	9	60	69	9	23	23
-do-	Healthy	(1)	5	43	48	5	16	16
-do-	-do-	(2)	9	48	57	9	18	18

HS - Genus Helicotylenchus

Results:

Results are recorded in Table 3. It is observed that the total population of nematodes in 500 gm of the soil is 104 to 131 in the case of bunchy top affected banana plants and 107 to 108 in the soil of healthy plants during rainy season as against respective populations of 62 to 69 and 48 to 57 during summer. With regard to roots, the population is 12 to 14 and 8 to 11 per 20 gm of roots in diseased and healthy plants respectively in rainy season and 23 to 24 and 16 to 18 in summer season. The population of parasitic forms is seen to be considerably less than that of non-parasitic forms. The parasitic form observed is Helicotylenchus sp. and it is present both in the soil and in the roots.

LOCALITY 4 - CHAVARADetails of collection

Place of collection: Shankaramangalam,
Chavara, Quilon District.

Type of soil: Sandy

(Other details as under locality 1)

TABLE 4 Analysis of nematodes in soil and roots of banana at Chavara

Season and date of collection	Condition of the plant	No. of nematodes in 500 gm soil			No. of different genera of parasitic forms					
		Para-sitic	Non-para-sitic	Total	In soil (500 gm) RO	HE	In roots (20 gm) RO	HE	Total	
Rainy 8-10-66	Bunchy-top	(1)	207	240	447	142	65	53	27	80
-do-	-do-	(2)	163	216	379	112	51	43	31	74
-do-	Healthy	(1)	54	192	246	38	16	33	23	61
-do-	-do-	(2)	62	172	234	41	21	19	24	43
Summer 5-2-67	Bunchy-top	(1)	85	100	185	58	27	67	43	117
-do-	-do-	(2)	84	93	177	61	23	71	38	109
-do-	Healthy	(1)	35	81	116	18	17	51	30	61
-do-	-do-	(2)	18	61	79	11	7	49	40	89

RO - Genus Rotylenchus

HE - Genus Helicotylenchus

Results:

Results are furnished in Table 4. The total population of nematodes in soil collected from bunchy top affected banana plants is 379 to 447 per 500 gm and that found in the soil collected from healthy banana plants is 234 to 246 during rainy season as against a total population of 177 to 185 and 79 to 116 in summer season. The population of parasitic forms in 20 gm of the roots of bunchy top infected banana plants is 74 to 80 and that in the roots of healthy plants is 43 to 61 during rainy season. The corresponding population for summer season are 109 to 117 and 81 to 89. The parasitic forms observed are Rotylenchus sp. and Helicotylenchus sp. and these are present both in the roots and in the soil.

LOCALITY 5 - KAYAMKULAMDetails of collection

Place of collection: Krishnapuram,
Kayamkulam, Alleppey District.

Type of soil: Sandy

(Other details as under locality 1)

TABLE 5 Analysis of nematodes in soil and roots of banana at Kayamkulam

Season and date of collection	Condition of the plant		No. of nematodes in 500 gm soil			No. of different genera of parasitic forms				
			Parasitic	Non-parasitic	Total	In soil (500 gm)		In roots (20 gm)		Total
						RO	HB	RO	HB	
Rainy 20-11-66	Bunchy-top	(1)	143	176	319	103	40	56	38	94
-do-	-do-	(2)	114	153	267	91	23	40	33	73
-do-	Healthy	(1)	83	137	220	61	22	38	33	71
-do-	-do-	(2)	55	111	166	40	15	29	28	57
Summer 11-2-67	Bunchy-top	(1)	68	93	161	51	17	93	44	137
-do-	-do-	(2)	68	97	165	57	11	72	48	120
-do-	Healthy	(1)	31	80	111	22	9	51	50	111
-do-	-do-	(2)	23	71	94	12	11	65	46	111

RO - Genus *Rotylenchus*

HB - Genus *Helicotylenchus*

Results:

Results are given in Table 5. During rainy season, the total nematode population per 500 gm of the soil is 267 to 319 in the case of bunchy top infected banana plants and 166 to 220 for healthy plants. During summer season, the corresponding populations are 165 to 161 and 94 to 111. The population of parasitic forms present in 20 gm of the roots of the bunchy top infected banana plants is 73 to 94 and that present in the roots of healthy plants is 57 to 71, during rainy season as against 120 to 137 and 111 respectively in summer season. The parasitic forms observed are Rotylenchus sp. and Helicotylenchus sp. The root population of Helicotylenchus sp. is low when compared to the other.

LOCALITY 6 - MAVELIKARADetails of collection

Place of collection: Thattarambalam,
Mavelikara, Alleppey District.

Type of soil: Sandy

(Other details as under locality 1)

TABLE 6 Analysis of nematodes in soil and roots of banana at Mavelikara

Season and date of collection	Condition of the plant		No. of nematodes in 500 gm soil			No. of different genera of parasitic forms				
			Para-sitic	Non-para-sitic	Total	In soil (500 gm) RO	RE	In roots(20 gm) RO	RE	Total
Rainy 11-10-66	Bunchy-top	(1)	188	202	390	127	61	48	34	82
-do-	-do-	(2)	239	241	480	163	76	58	23	81
-do-	Healthy	(1)	63	270	333	40	23	27	38	65
-do-	-do-	(2)	86	238	323	48	37	23	14	37
Summer 11-2-67	Bunchy-top	(1)	117	91	208	73	44	71	60	131
-do-	-do-	(2)	103	87	190	70	33	66	41	127
-do-	Healthy	(1)	26	82	108	18	8	39	47	86
-do-	-do-	(2)	28	74	102	16	12	45	28	73

RO - Genus Rotylenchus

RE - Genus Helicotylenchus

Results:

Results are furnished in Table 6. The total nematode population in the soil of bunchy top affected banana plants is 390 to 480 per 500 gm and of healthy plants is 328 to 330 in rainy season, and 190 to 208 and 102 to 108 respectively in summer season. The population of parasitic forms in the roots of bunchy top affected banana plants is 81 to 82 per 20 gm and in healthy plants 37 to 65 during rainy season. The respective population during summer season are 127 to 131 and 79 to 86. The parasitic forms observed are Rotylenchus sp. and Helicotylenchus sp. of which Rotylenchus sp. is found in more numbers than that of the other. Both these are present in soil and roots.

LOCALITY 7 - CHENGANNUR

Details of collection

Place of collection: Keezcherimel,
Chengannur, Alleppey District.

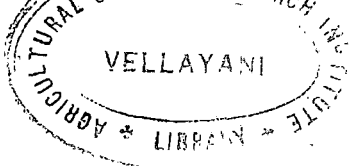
Type of soil: Laterite

(Other details as under locality 1)

TABLE 7. Analysis of nematodes in soil and roots of banana at Chengannur

Season and date of collection	Condition of the plant	No. of nematodes in 500 gm soil			No. of different genera of parasitic forms							
		Para-sitic	Non-para-sitic	Total	In soil (500 gm)			(In roots (20 gm)			Total	
					RA	RO	HE	RA	RO	HE		
Rainy 24-10-66	Bunchy-top	(1)	114	266	380	4	78	32	58	23	14	95
-do-	-do-	(2)	61	198	259	3	48	10	49	18	23	90
-do-	Healthy	(1)	47	207	254	1	26	20	24	18	15	57
-do-	-do-	(2)	20	153	173	-	13	7	38	27	18	83
Summer 12-2-1967	Bunchy-top	(1)	23	159	182	1	10	12	66	30	18	114
-do-	-do-	(2)	20	158	178	-	9	11	57	29	19	105
-do-	Healthy	(1)	16	148	164	-	7	9	33	24	21	88
-do-	-do-	(2)	19	152	171	-	9	10	44	31	16	91

RA - Genus Radopholus
 RO - Genus Rotylenchus
 HE - Genus Helicotylenchus



Results:

Results are recorded in Table 7. During rainy season, the population of nematodes in 500 gm of soil collected from bunchy top infected banana plants is 259 to 380 and that seen in the soil collected from healthy plants is 173 to 254 as against respective populations of 178 to 182 and 164 to 171 in summer season. The population of nematodes present in 20 gm of the roots collected from bunchy top infected plants is 90 to 95 and that in the roots of the healthy plants is 57 to 83 during rainy season. The respective population data for summer season is 105 to 114 and 88 to 91. The parasitic forms seen are Radopholus sp., Rotylenchus sp. and Helicotylenchus sp. The population of Radopholus sp. in the soil is very low; while that in the roots is high.

LOCALITY 8 - THIRUVALLA

Details of collection

Place of collection: Kavumbhagam,
Thiruvalla, Alleppey District.

✓ Type of soil: Laterite

(Other details as under locality 1)

TABLE 8 Analysis of nematodes in soil and roots of banana at Thiruvalla

Season and date of collection	Condition of the plant	No. of nematodes in 500 gm soil			No. of different genera of parasitic forms						
		Para-sitic	Non-pa-sitic	To-tal	In soil (500 gm)			In roots(20 gm)			Total
					RA	RO	RE	RA	RO	RE	
Rainy 31-10-66	Bunchy-top (1)	31	109	140	1	18	12	84	27	13	124
-do-	-do- (2)	72	270	342	1	84	17	68	19	18	105
-do-	Healthy (1)	14	111	125	-	11	3	37	30	5	70
-do-	-do- (2)	44	274	318	-	32	12	35	13	12	60
Summer 12-2-67	Bunchy-top (1)	41	62	103	3	17	21	72	31	15	118
-do-	-do- (2)	19	152	171	-	11	8	51	23	27	101
-do-	Healthy (1)	12	149	161	-	5	7	39	40	8	87
-do-	-do- (2)	17	150	167	-	6	11	27	16	18	61

RA - Genus Radopholus

RO - Genus Rotylenchus

RE - Genus Helicotylenchus

Results:

Results are furnished in Table 8. A range of 140 to 342 and 126 to 318 per 500 gm is seen in soil collected during rainy season from Bunchy-top infected banana plants and healthy banana plants respectively. The respective populations during summer season is 103 to 171 and 161 to 167. The population of parasitic forms per 20 gm of the roots of the bunchy-top infected plants is 105 to 124 and that in the roots of the healthy plants 60 to 70 during rainy season. The respective population figures for summer season are 101 to 118 and 61 to 87. The parasitic forms observed are Rhizoglyphus sp., Botrylenchus sp. and Helicotylenchus sp. The population of the former two are distributed in the soil and the roots while that of Rhizoglyphus sp. is mostly confined to the roots.

LOCALITY 9 - VALLAMBULAMDetails of collection

Place of collection: Kaviyoor, Vallambulam,
Alleppey District.

Type of soil: Laterite

(Other details as under locality - 1)

TABLE 9 Analysis of nematodes in soil and roots of banana at Vallankulam

Season and date of collection	Condition of the plant		No. of nematodes in 500 gm soil			No. of different genera of parasitic forms						
			Para-sitic	Non-para-sitic	Total	In soil (500 gm)			In roots (20 gm)			Total
						RA	RC	RE	RA	RC	RE	
Rainy 31-10-66	Bunchy-top	(1)	109	311	420	9	73	27	48	23	14	85
-do-	-do-	(2)	118	279	397	8	81	29	34	22	8	64
-do-	Healthy	(1)	84	342	376	-	23	11	23	18	17	58
-do-	-do-	(2)	87	326	413	-	71	16	34	18	8	60
Summer 19-2-67	Bunchy-top	(1)	31	83	114	2	18	11	37	33	28	104
-do-	-do-	(2)	24	89	113	-	14	10	41	37	30	108
-do-	Healthy	(1)	22	86	108	-	9	13	21	23	27	71
-do-	-do-	(2)	22	76	98	-	10	12	29	38	21	88

RA - Genus Radopholus

RC - Genus Rotylenchus

RE - Genus Helicotylenchus

Results

Results are given in Table 9. It may be seen that the total population of nematodes per 500 gm of the soil collected from the base of bunchy-top infected banana plants is 397 to 420 during rainy season and that in the soil collected from the base of healthy plants is 376 to 413. The population data of parasitic forms per 20 gm of the roots is 64 to 85 in the case of bunchy-top infected plants and 58 to 60 in the case of healthy plants during rainy season. In summer the populations in soil are 113 to 114 and 78 to 108 on bunchy top affected and healthy banana plants respectively while those in roots are 104 to 108 and 71 to 82 respectively. The parasitic forms are Nedophilus sp., Rotylenchus sp. and Helicotylenchus sp. The population of Nedophilus sp. is mostly confined to roots.

LOCALITY 10 - ALLEPPEY

Details of collection

Place of collection: Nedumudi, Alleppey District.

Type of soil: Clayey

(Other details as under locality - 1)

TABLE 10 Analysis of nematodes in soil and roots of banana at Alleppey

Season and date of collection	Condition of the plant		No. of nematodes in 500 gm soil			No. of different genera of parasitic forms						
			Para-sitic	Non-pars-itic	Total	In soil (500 gm)			In roots (20 gm)			Total
						RA	RO	RE	RA	RO	RE	
Hainy 28-11-66	Lunchy-top	(1)	83	96	184	8	23	27	36	23	27	66
		(2)	87	123	180	11	20	17	39	28	31	98
	Healthy	(1)	32	107	149	3	18	11	21	14	12	57
		(2)	43	104	147	5	22	13	23	30	24	77
Summer 27-2-67	Lunchy-top	(1)	23	51	74	3	11	9	49	45	54	148
		(2)	29	76	105	5	14	10	41	47	44	132
	Healthy	(1)	19	49	68	-	12	7	32	29	31	92
		(2)	19	76	95	1	9	9	33	40	35	109

RA - Genus Radopholus

RO - Genus Rotylenchus

RE - Genus Helicotylenchus

Results

Results are recorded in Table 10. A total nematode population of 154 to 180 and 147 to 149 per 500 gm is observed in the soil of bunchy-top affected and healthy banana plants respectively during the rainy season and 74 to 105 and 68 to 95 respectively in summer. The population of the parasitic forms per 20 gm of the roots is 86 to 98 in diseased plants and 57 to 77 in healthy plants during rainy season and 132 to 148 and 92 to 109 respectively in summer season.

Radopholus sp., Rotylenchus sp. and Helicotylenchus sp. are the parasitic forms present in the samples. Radopholus sp. is present more in the roots than in the soil.

LOCALITY 11 - MONKOMPU

Details of collection

Place of collection: Monkompu, Alleppey District

Type of soil: Clayey

(Other details as under locality - 1)

TABLE 11 analysis of nematodes in soil and roots of banana at Nonkompu

Season and date of collection	Condition of the plant	No. of nematodes in 500 gm soil			No. of different genera of parasitic forms							
		Para-sitic	Non-para-sitic	Total	In soil (100 gm)			In roots (20 gm)			Total	
					RA	RO	RI	RA	RO	RI		
Rainy 27-11-66	Bunchy-top	(1)	37	107	144	2	20	15	21	16	20	57
-do-	-do-	(2)	47	123	170	-	29	18	18	14	18	50
-do-	Healthy	(1)	22	119	141	-	13	9	7	13	13	38
-do-	-do-	(2)	37	109	146	1	16	20	12	10	9	31
Summer 26-2-67	Bunchy-top	(1)	19	52	71	-	12	7	33	27	29	89
-do-	-do-	(2)	26	59	85	-	18	8	39	29	32	100
-do-	Healthy	(1)	18	40	58	-	9	4	7	34	20	61
-do-	-do-	(2)	22	38	60	-	12	10	18	17	15	50

RA - Genus Radopholus
 RO - Genus Rotylenchus
 RI - Genus Helicotylenchus

Results

Results are furnished in Table 11. A total nematode population of 144 to 170, and 141 to 146 per samples of 500 gm of the soil is seen in the case of diseased banana plants and healthy banana plants respectively during rainy season. The respective population rates for the summer season are 71 to 85 and 52 to 60. The population of nematodes in 20 gm of the roots of bunchy top infected plants is 50 to 57 during rainy season and 29 to 100 during summer season. The respective populations in healthy roots are 31 to 38 during rainy season and 50 to 61 during summer season. The parasitic forms observed are Radopholus sp., Rotylenchus sp. and Helicotylenchus sp. Population of Radopholus sp. in the soil is found very low. All the three parasitic forms are seen both in the soil and in the roots.

LOCALITY 12 - AMBALAPUZHA

Details of collection

✓ Place of collection: Ambalapuzha, Alleppey District.

Type of soil: Clayey

(Other details as under locality - 1)

TABLE 12 Analysis of nematodes in soil and roots of banana at Ambalapuzha

Season and date of collection	Condition of the plant		No. of nematodes in 500 gm soil			No. of different genera of parasitic forms						
			Para-sitic	Non-para-sitic	Total	In soil (500 gm)			In root (20 gm)			Total
						RA	RO	HE	RA	RO	HE	
Rainy 20-11-66	Bunchy-top	(1)	36	98	134	4	18	14	38	28	15	82
-do-	-do-	(2)	40	91	131	3	21	16	33	12	23	74
-do-	Healthy	(1)	26	92	118	2	13	11	23	19	18	60
-do-	-do-	(2)	29	83	112	3	16	10	28	23	15	69
Summer 26-2-67	Bunchy-top	(1)	29	158	187	2	12	15	45	39	27	112
-do-	-do-	(2)	33	163	196	1	13	18	34	37	29	100
-do-	Healthy	(1)	24	151	175	-	8	19	43	29	19	91
-do-	-do-	(2)	22	163	185	-	5	17	40	26	16	82

RA - Genus *Racopholus*
 RO - Genus *Rotylonchus*
 HE - Genus *Helicotylonchus*

Results

Results are furnished in Table 12. It may be seen that during rainy season, the total population of nematodes is 131 to 134 per 500 gm in the soil of diseased banana plants and 112 to 118 in that of healthy plants. During summer the populations are 187 to 196 and 175 to 185 respectively. In the case of nematodes in the roots, the population is 74 to 82 and 60 to 69 per 20 gm in diseased and healthy plants respectively in rainy season and 100 to 112 and 82 to 91 respectively in summer season. The parasitic forms observed are Radopholus sp. Rotylenchus sp. and Helicotylenchus sp. The population of Radopholus sp. is seen very low in the soil during summer season.

LOCALITY 13 - ALWAYS

Details of collection

Place of collection: Always town, Ernakulam District.
 Type of soil: Clayey loam
 (Other details as under locality - 1)

TABLE 13 Analysis of nematodes in soil and roots of banana at Always

Season and date of collection	Condition of the plant		No. of nematodes in 500 gm soil			No. of different genera of parasitic forms						
			Para-sitic	Non-para-sitic	Total	In soil (500 gm)			In roots (20 gm)			Total
						RA	RO	RE	RA	RO	RE	
Rainy 11-11-66	Bunchy-top	(1)	61	143	204	23	17	21	41	18	22	81
-do-	-do-	(2)	52	182	234	16	22	14	44	23	16	83
-do-	Healthy	(1)	32	113	145	11	9	12	27	21	11	69
-do-	-do-	(2)	41	203	244	9	13	19	26	16	17	58
Summer 11-3-67	Bunchy-top	(1)	28	85	113	11	5	12	54	26	33	113
-do-	-do-	(2)	23	83	106	8	10	5	60	31	22	123
-do-	Healthy	(1)	16	67	83	6	3	7	34	28	20	62
-do-	-do-	(2)	19	91	110	-	9	10	45	27	21	93

RA - Genus Radopholus

RO - Genus Rotylenchus

RE - Genus Helicotylenchus

Results

Results are given in Table 13. The total nematode population in 500 gm of the soil collected from bunchy top affected banana plants is 204 to 234 and that seen in the soil collected from healthy plants is 145 to 244 during rainy season. The corresponding population levels during summer season are 106 to 113 and 83 to 110 respectively. The population of parasitic forms present in 20 gm of the roots collected from bunchy top infected banana plants is 81 to 83 and of that collected from healthy plants is 58 to 59 during rainy season; the respective population rates during summer season are 113 to 123 and 82 to 93 respectively. The parasitic forms observed both in the soil as well as in the roots are Radopholus sp., Rotylenchus sp. and Helicotylenchus sp. Population of Radopholus sp. is seen very low in the soil during summer season when compared to rainy season.

LOCALITY 14 - TRICHUR

Details of collection

Place of collection: Trichur Town, Trichur District.

Type of soil: Clayey loam

(Other details as under locality - 1)

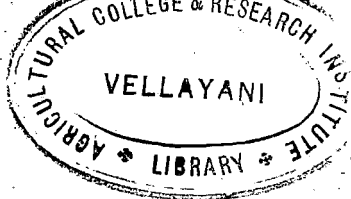
TABLE 14 Analysis of nematodes in soil and roots of banana at Trichur

Season and date of collection	Condition of the plant		No. of nematodes in 500 gm soil			No. of different genera of parasitic forms						
			Para-sitic	Non-para-sitic	Total	In soil (500 gm)			In roots (20 gm)			Total
						RA	RO	HE	RA	RO	HE	
Rainy 21-12-66	Bunchy-top	(1)	41	198	239	8	18	15	74	25	18	117
-do-	-do-	(2)	50	207	257	11	21	19	67	34	21	122
-do-	Healthy	(1)	32	216	254	4	18	16	43	18	19	80
-do-	-do-	(2)	46	189	235	7	19	20	33	22	14	79
Summer 9-3-67	Bunchy-top	(1)	18	105	113	-	11	7	86	40	28	154
-do-	-do-	(2)	26	110	136	1	12	13	79	42	29	150
-do-	Healthy	(1)	12	91	103	-	7	5	50	21	19	90
-do-	-do-	(2)	22	65	87	-	12	10	40	27	23	90

RA - Genus Radopholus

RO - Genus Rotylenchus

HE - Genus Helicotylenchus



Results

Results are furnished in Table 14. The sample of soil collected from bunchy top infected banana plants during rainy season shows a total nematode population of 239 to 257 per 500 gm and the population in the soil collected from healthy plants for the same season is 225 to 264. The corresponding population data for summer season is 113 to 136 and 87 to 103. The parasitic forms present in 20 gm of the bunchy top infected roots is 117 to 122 and in healthy roots is 79 to 80 during rainy season and 150 to 154 and 90 respectively during summer season. The parasitic forms observed are Radopholus sp., Rotylenchus sp. and Helicotylenchus sp. The population of Radopholus sp. in the soil during summer season is negligible when compared to that of rainy season.

LOCALITY 15 - KANNARA

Details of collection

Place of collection: Banana Research Station Farm,
Kannara, Trichur District.

Type of soil: Clayey loam

(Other details as under locality - 1)

TABLE 15 Analysis of nematodes in soil and roots of banana at Kannara

Season and date of collection	Condition of the plant		No. of nematodes in 500 gm soil			No. of different genera of parasitic forms						
			Para-sitic	Non-para-sitic	Total	In soil (500 gm)			In roots(20 gm)			Total
						RA	RO	RE	RA	RO	RE	
Rainy	Kokkan	(1)	58	243	301	20	20	18	28	20	17	125
-do-	-do-	(2)	68	173	241	18	29	21	22	28	22	132
-do-	Healthy	(1)	37	210	247	9	17	11	48	19	20	87
-do-	-do-	(2)	50	162	210	11	23	16	53	22	12	87
Summer	Kokkan	(1)	14	107	121	3	5	6	102	30	26	157
-do-	-do-	(2)	22	65	87	3	9	10	110	40	31	181
-do-	Healthy	(1)	14	110	124	-	7	7	53	28	36	117
-do-	-do-	(2)	15	51	67	1	7	8	61	29	20	110

RA - Genus Radopholus

RO - Genus Rotylenchus

RE - ^{Genus} Helicotylenchus

Results

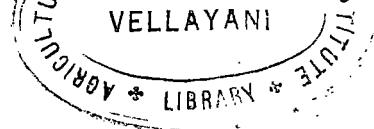
Results are furnished in Table 15. It is seen that the total nematode population per 500 gm of soil collected from Kokkan infected banana plants is 241 to 301 and the population present in the soil collected from healthy banana plants is 210 to 247 during rainy season as against respective populations of 87 to 121 and 67 to 124 during summer season. The parasitic population present per 20 gm of the roots show a range of 125 to 132 in the case of diseased plants and 87 in the case of healthy plants; during rainy season and 157 to 181 and 110 to 117 respectively during the summer season. The parasitic forms observed are Radopholus sp., Rotylenchus sp. and Helicotylenchus sp. of which the population of Radopholus sp. in the roots are seen very high when compared to the other two.

Damage caused to banana roots by the nematodes

The roots of banana plants infested by the nematodes showed the presence of rotten and discoloured patches or lesions on them. On examination, it was found that Radopholus, Rotylenchus and Helicotylenchus invaded the roots and were present within the root tissues mostly confined to the tissues surrounding the rotten patches (Plates 1, 2 & 5). In the case of Radopholus eggs also could be seen within the root tissues (Plates 3 & 4).

DISCUSSION

DISCUSSION

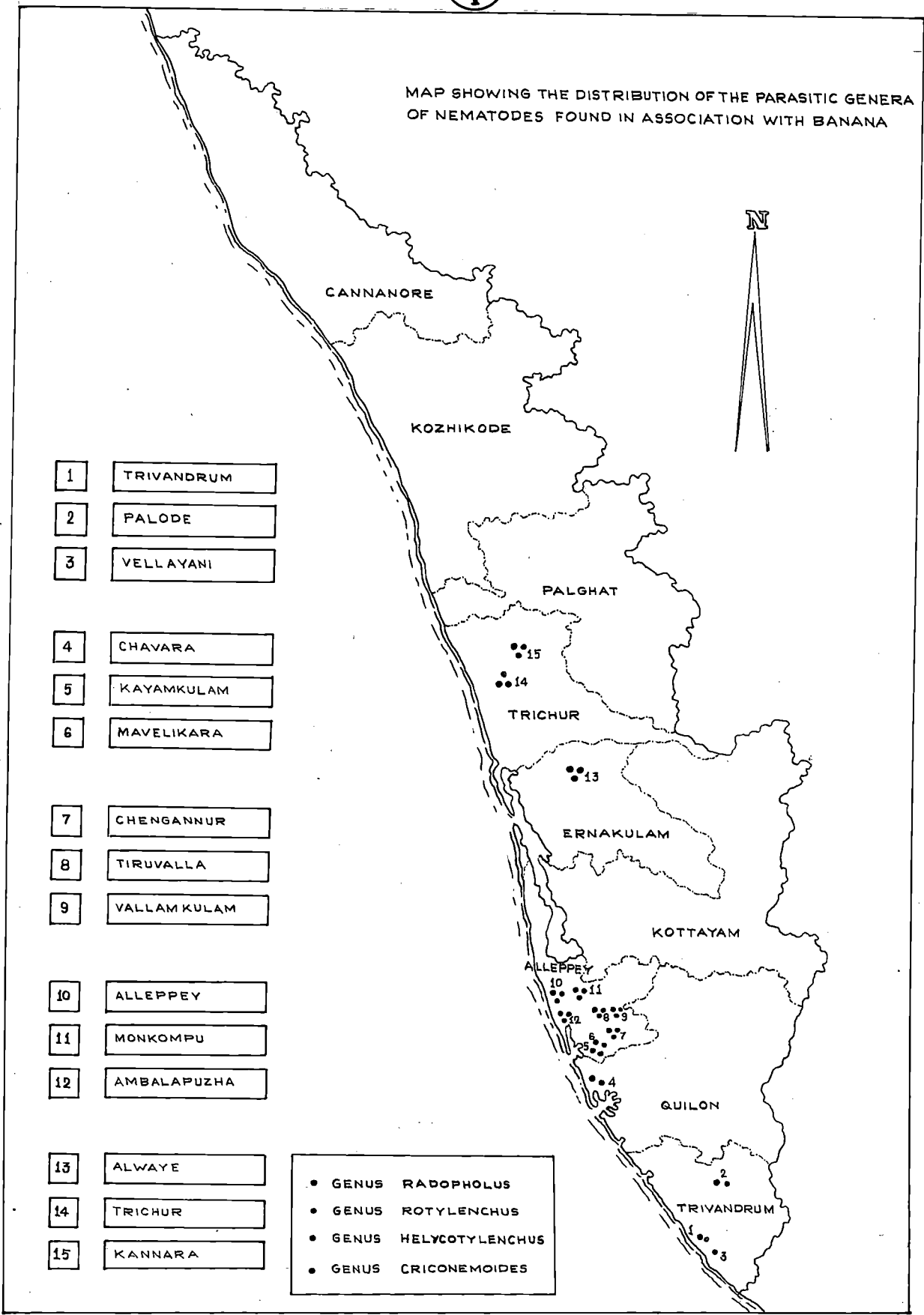


Results of the survey of nematodes found in association with banana in Kerala show that the parasitic forms among them belong to four genera, viz., Helicotylenchus, Rotylenchus, Radopholus and Cricconemoides. The distribution of the different genera is depicted in Fig. 1.

It may be seen that the parasitic nematodes coming under the genus Helicotylenchus are present in all the places i.e. from Vellayani in the south to Trichur and Kannara in the north. The genus Rotylenchus is also common in the soil in all the places except Vellayani and Trivandrum of the loamy tract. The genus Radopholus (the species present appears to be Radopholus similis) is absent at Chevvara, Mavelikara and Kayamkulam of the sandy soil tract and at Palode, Vellayani and Trivandrum of the loamy soil tract. Thus it appears that the genus has not spread to the South beyond Chengannur, and is prevalent in the region between Chengannur in the south and Trichur in the north and probably beyond this place also in the north which was not surveyed under the present studies. Nematodes of this genus are found in lateritic, clayey and clayey loam soils. Hair et al (1966) recorded Radopholus similis on banana at Kizhakkencherry in Palghat District. The present observations show that this injurious nematode has spread to a large area in this State. The genus Cricconemoides

Fig 1

MAP SHOWING THE DISTRIBUTION OF THE PARASITIC GENERA OF NEMATODES FOUND IN ASSOCIATION WITH BANANA



is seen only at Trivandrum in loamy soil and that too during rainy season only.

A perusal of the results will also show that the soil around banana plants harbours a large population of non-parasitic nematodes besides the parasitic forms. The population of the nematode fauna is correlated with the type of soil, climate and condition of the plant. These correlations observed in the present studies are summarised in Tables 16 and 17 and figures 2 to 7 and are discussed below.

1) Variation in the nematode population in relation to the condition of banana plants

The condition of the banana plants considered in these observations is whether the plants are healthy or infected with bunchy top disease. A perusal of the summary representations of the results referred to above will show that the population of the parasitic forms both in the soil and in the roots is invariably more in association with the diseased plants than in association with healthy plants. This difference is considerably high in certain localities like Chavara and Mavelikara where the population of parasitic nematodes is three or more times more in the soil of diseased plants than in the soil of healthy plants.

The population of non-parasitic nematodes in the soil does not show any variation due to the diseased or

healthy condition of the banana plants. It is the parasitic forms only, which derive their nutrition from the host plants as the non-parasitic forms are either saprophytes or predators and not plant feeders. So it is only logical to derive that the increased population of the parasitic forms feeding on the roots of diseased plants is because they are able to get some additional nutritive factors from such plants and which is not available in healthy plants. Definitive conclusions can, however, be drawn only after objective studies on this aspect have been made.

2) Variations in the nematode population in relation to climatic conditions

As the most important factor of the soil which governs the population of soil nematodes is the moisture content of the soil, the population of the nematodes in the soil was observed during the rainy season and during the dry season (rainless season). Irrespective of the type of soil, the nematode population - both parasitic and non-parasitic - in the soil is found significantly high during the rainy season than during the rainless season. This observation holds equally good for both healthy and diseased plants. On the other hand, the population of the parasitic nematodes within the roots, is seen to be lower during the rainy season than during the dry season, irrespective of whether the plants are healthy or diseased and irrespective of the type of soil. This may be

because, the parasitic nematodes seek shelter in larger numbers, within the roots to escape from the adversities of the dry condition existing in the soil during the rainless season. It may also be due to the multiplication of nematodes within the roots and the absence of it in the soil.

3) Variations in the nematode population in relation to the type of soil

Samples of nematodes were studied from loamy, sandy, lateritic, clayey and clayey loam soils. Results (Figs. 2 - 4) will show that the population of the parasitic nematodes is high in the sandy and loamy soils and low in the lateritic, clayey and clayey loam soils. This is the case during both rainy and dry seasons. In the case of non-parasitic nematodes lateritic type of soil supports the maximum population followed in the descending order by sandy, clayey loam, loamy and clayey soils. As regards the population of the parasitic nematodes within the roots of banana, roots of banana growing in the clayey loam soils show the highest nematode infestation followed in the descending order by the plants growing in the lateritic, sandy, clayey and loamy soils.

TABLE 16 - Mean nematode population in relation to climate, condition of the plant and soil types

Type of soil	Condition of the plant	Rainy season		Summer season			
		In soil (500 gm)		In roots (20 gm)		In roots (20 gm)	
		Parasitic	Non-parasitic	Parasitic	Para-sitic	Non-para-sitic	Pana-sitic
Loamy	Diseased	152	158	43	45	74	64
	Healthy	106	154	28	24	83	39
Sandy	Diseased	176	205	81	88	94	124
	Healthy	67	187	56	27	75	82
Laterite	Diseased	84	239	94	26	117	108
	Healthy	41	326	65	18	127	81
Clayey	Diseased	46	106	75	27	93	112
	Healthy	32	102	55	20	85	82
Clayey loam	Diseased	56	191	127	22	93	148
	Healthy	41	182	75	17	79	97

TABLE 17 - Mean nematode population in different localities in relation to climate and condition of the plant.

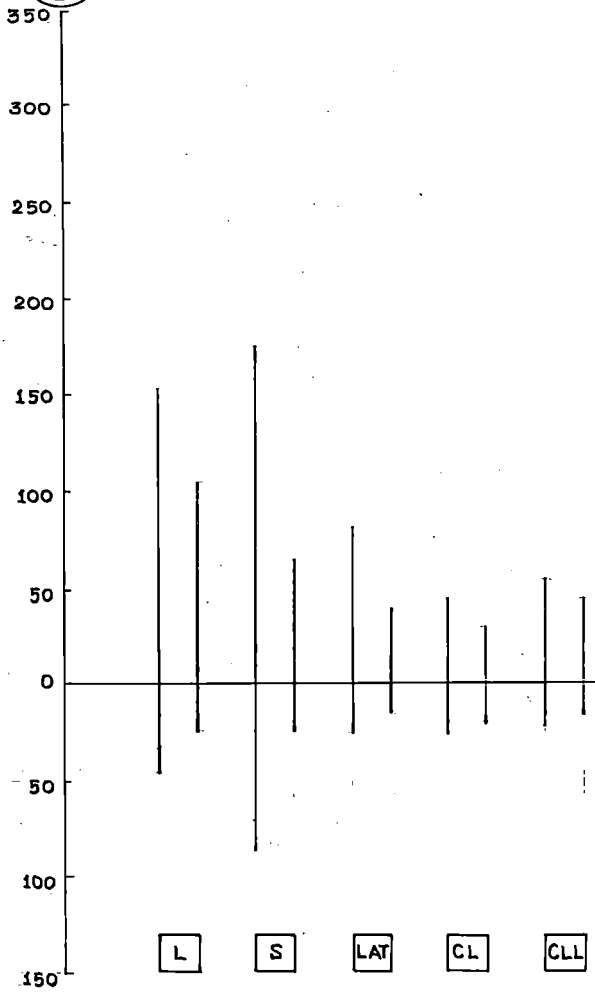
Locality	Condition of the plant	Rainy season		Summer season			
		In soil (500 gm)		In roots (20 gm)			
		Parasi- tic	Non-para- sitic	Para- sitic	Para- sitic	Non-para- sitic	Para- sitic
Trivandrum	Diseased	430	336	91	124	185	120
	Healthy	301	336	65	63	175	71
Palode	Diseased	4	43	25	2	32	48
	Healthy	3	32	10	1	36	30
Vellayani	Diseased	23	95	13	10	56	24
	Healthy	14	94	10	7	46	17
Chavara	Diseased	185	228	77	85	97	114
	Healthy	58	182	52	27	71	85
Kayankulam	Diseased	129	165	84	68	95	129
	Healthy	69	124	64	27	76	111
Mavelikara	Diseased	214	222	82	110	89	149
	Healthy	74	254	51	27	78	80

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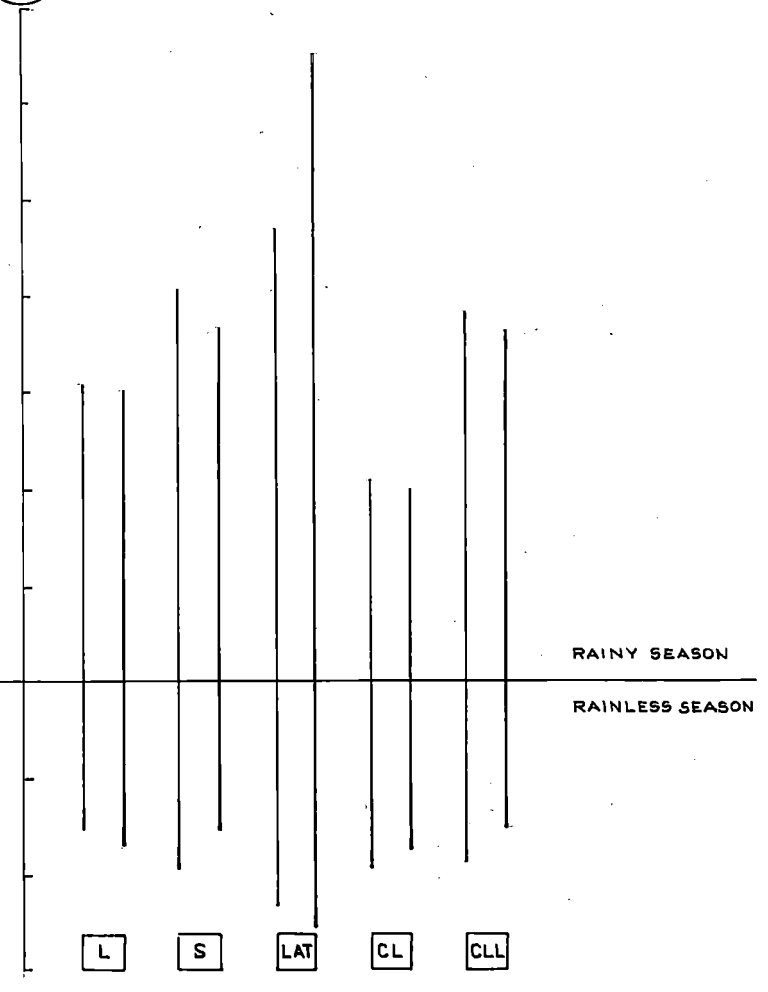
Locality	Condition of the plant	Rainy season		Summer season			
		In soil (500 gm)		In roots (20 gm)			
		Para-sitic	Non-para-sitic	Para-sitic	Para-sitic	Non-para-sitic	Para-sitic
Chengannur	Diseased	88	232	93	22	159	110
	Healthy	34	180	70	18	150	90
Thiruvalla	Diseased	52	140	115	30	107	110
	Healthy	29	193	65	15	150	74
Vallamkulam	Diseased	114	295	76	28	86	106
	Healthy	61	334	59	22	81	80
Alleppey	Diseased	58	110	92	26	64	140
	Healthy	38	106	67	19	63	101
Monkumpu	Diseased	42	115	54	23	66	95
	Healthy	30	114	35	18	39	56
Ambalapuzha	Diseased	38	95	78	31	161	102
	Healthy	28	88	65	23	152	91
Alwaye	Diseased	57	163	82	26	84	118
	Healthy	37	158	59	18	79	88
Trichur	Diseased	46	203	120	22	108	152
	Healthy	42	148	80	17	78	90
Kannara	Diseased	63	208	129	18	86	169
	Healthy	44	186	87	15	81	114

Fig 2

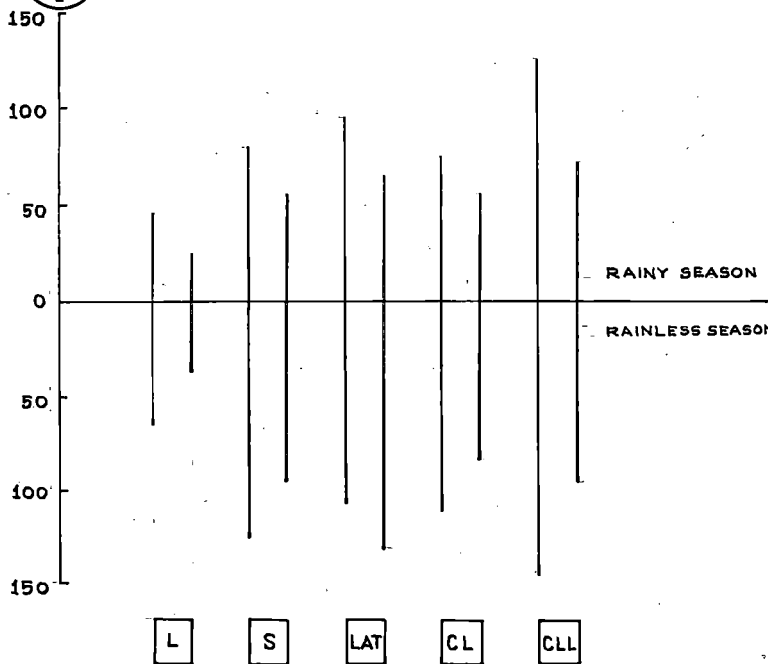
POPULATION OF PARASITIC NEMATODES IN THE ROOTS OF BANANA IN RELATION TO CLIMATE, SOIL TYPE AND CONDITION OF THE PLANT.

**Fig 3**

POPULATION OF PARASITIC NEMATODES IN THE ROOTS OF BANANA IN RELATION TO CLIMATE, SOIL TYPE AND CONDITION OF THE PLANT.

**Fig 4**

POPULATION OF PARASITIC NEMATODES IN THE ROOTS OF BANANA IN RELATION TO CLIMATE, SOIL TYPE AND CONDITION OF THE PLANT.



L	LOAMY SOIL
S	SANDY SOIL
LAT	LATERITIC SOIL
CL	CLAYEY SOIL
CLL	CLAYEY LOAM SOIL

—	DISEASED PLANTS
—	HEALTHY PLANTS

POPULATION OF PARASITIC NEMATODES IN THE SOIL OF BANANA IN RELATION TO CLIMATE AND
CONDITION OF PLANT OBSERVED AT VARIOUS LOCALITIES.

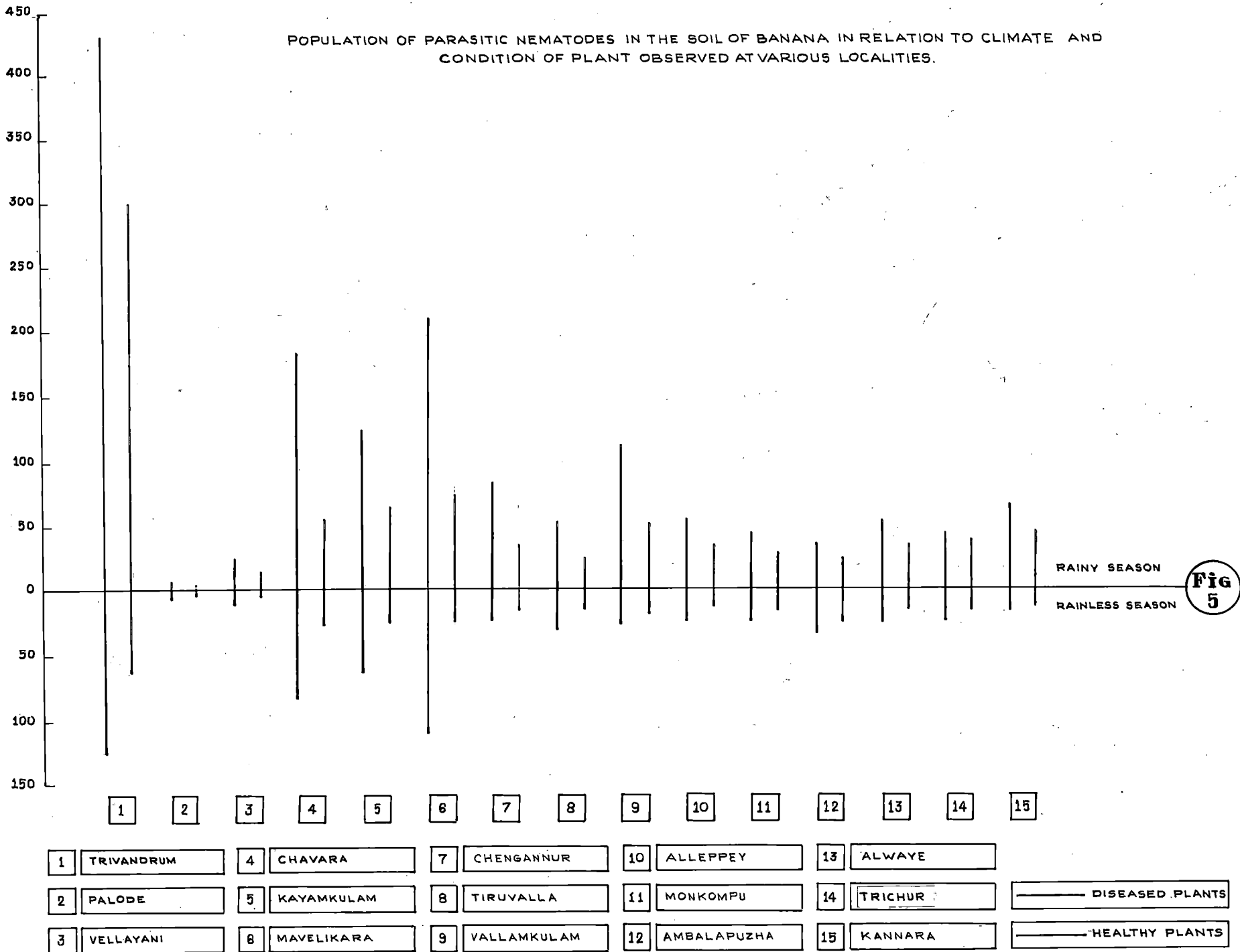


Fig 5

POPULATION OF NON PARASITIC NEMATODES IN THE SOIL OF BANANA IN RELATION TO CLIMATE AND
CONDITION OF PLANT OBSERVED AT VARIOUS LOCALITIES.

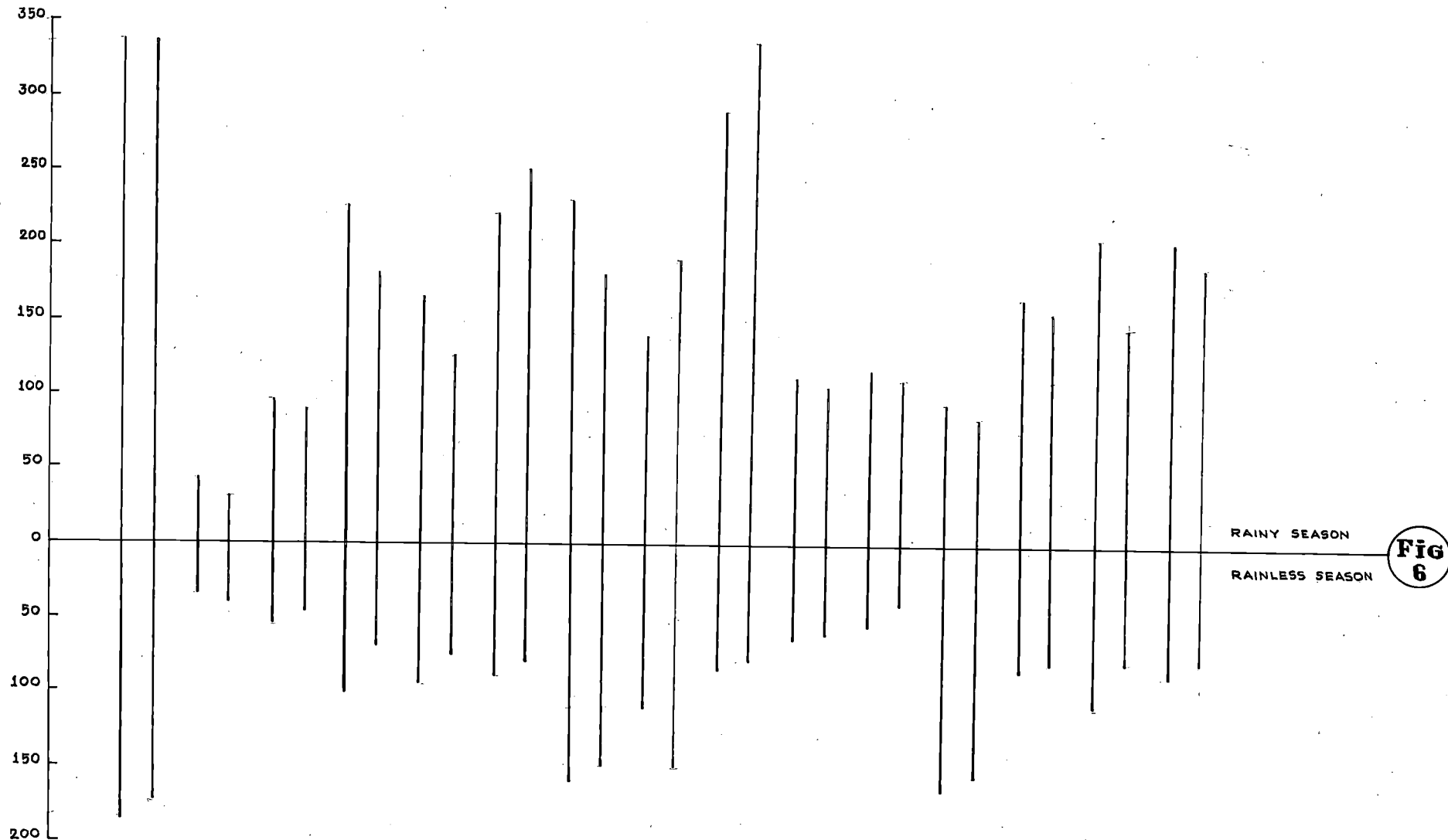


Fig 6

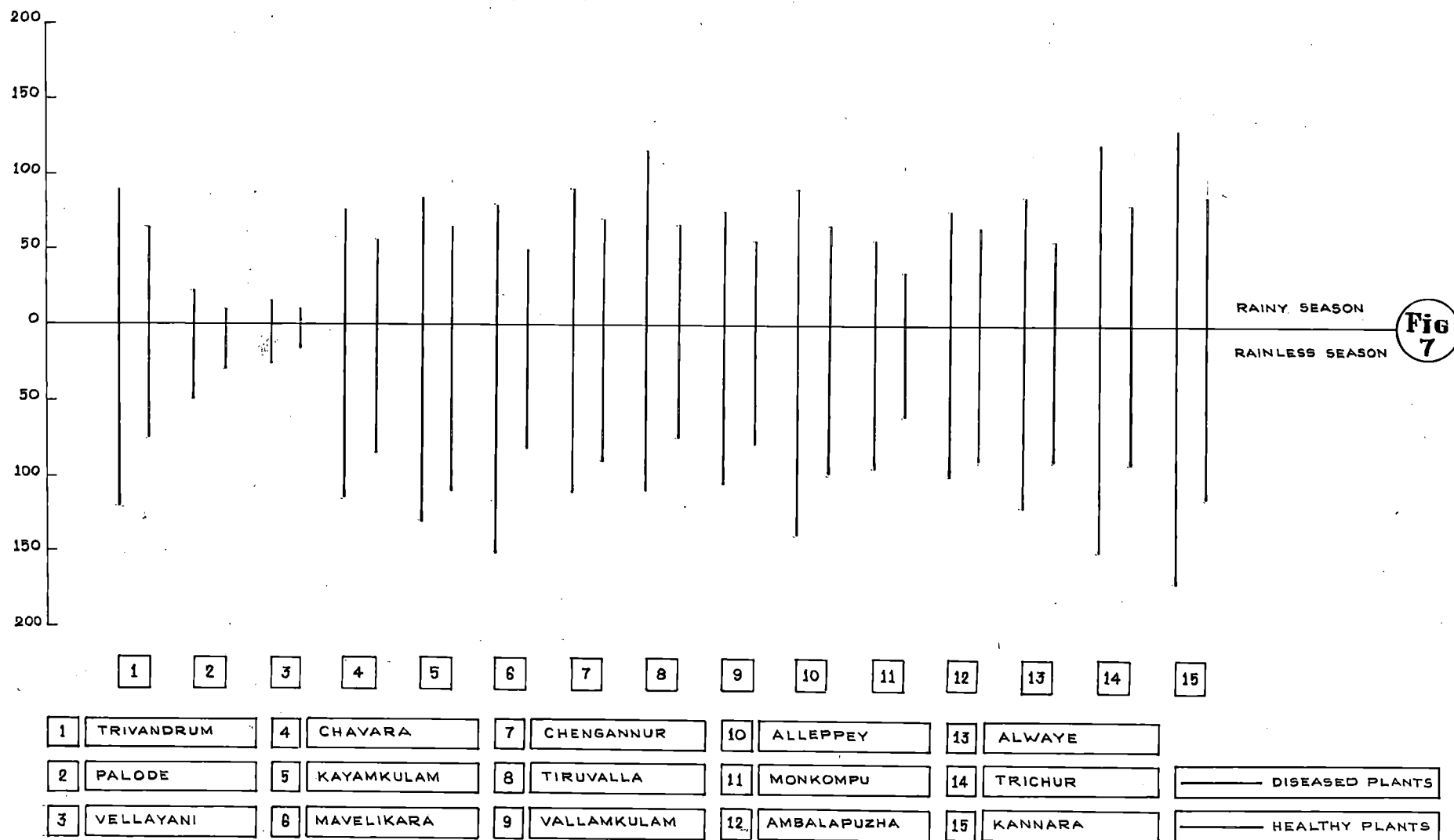
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1	TRIVANDRUM	4	CHAVARA	7	CHENGANNUR	10	ALLEPPEY	13	ALWAYS
2	PALODE	5	KAYAMKULAM	8	TIRUVALLA	11	MONKOMPU	14	TRICHUR
3	VELLAYANI	6	MAVELIKARA	9	VALLAMKULAM	12	AMBALAPUZHA	15	KANNARA

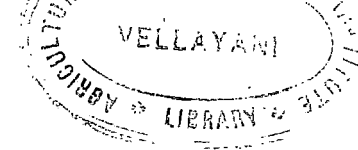
— DISEASED PLANTS

— HEALTHY PLANTS

POPULATION OF PARASITIC NEMATODES IN THE ROOTS OF BANANA IN RELATION TO CLIMATE AND
CONDITION OF PLANT OBSERVED AT VARIOUS LOCALITIES.



**SUMMARY
AND
CONCLUSIONS**



SUMMARY AND CONCLUSIONS

A total of 120 samples of soil and 120 samples of roots of banana were collected from 15 localities between Vellayani in the south and Trichur in the north and their nematode fauna extracted and examined to ascertain:-

- a) The genera of parasitic nematodes associated with banana and their distribution.
- b) Population of the nematodes (parasitic and non-parasitic) in the roots and soil of banana in relation to whether the plant is healthy or diseased, the type of soil and rainy or rainless seasons.

The population of both parasitic and non-parasitic forms present in the soil is high during rainy season than during rainless season, irrespective of the soil type and whether the plant is diseased or healthy. The soil population of parasitic forms is high in association with diseased plants in both the seasons and in all the five soil tracts surveyed. The population of non-parasitic fauna in the soil does not show much variation with respect to the condition of the plant.

The population of parasitic forms within the roots

of banana is much higher in diseased plants than in healthy plants irrespective of the type of soil in which they grow. The nematode population within the roots is far more higher during the summer season than during the rainy season.

The parasitic forms observed fall under four genera viz., Nacobolus, Rotylenchus, Helicotylenchus and Criconeleoides. Of these, Criconeleoides is seen only at Trivandrum which is a place in the loamy soil tract, and that too in the rainy season only. The genus Helicotylenchus is distributed in all the soil tracts, and in all the localities studied. Same is the case with Rotylenchus also, but its population is very low in the loamy soil. The genus Nacobolus is present in the lateritic, clayey and clayey loam soils and is distributed from Chengannur in the south to Trichur in the north. It has not spread to south of lateritic soil tract and is absent in the sandy and loamy soils.

The damage caused by the nematodes to the roots of banana is indicated.

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PLATES

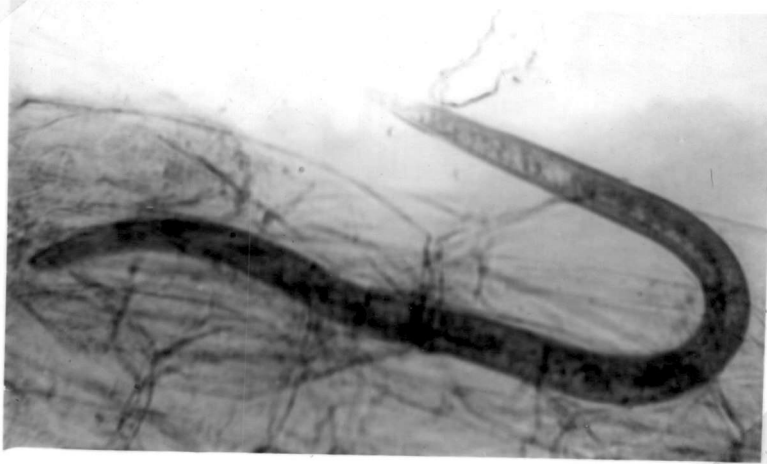


PLATE I Radopholus similis, full grown
within tissues of banana root

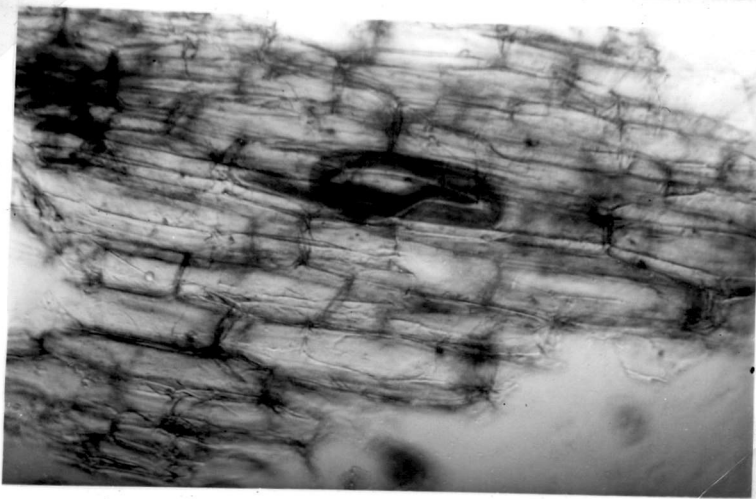


PLATE II Radopholus similis, larva
within a single cell of banana
root tissue.

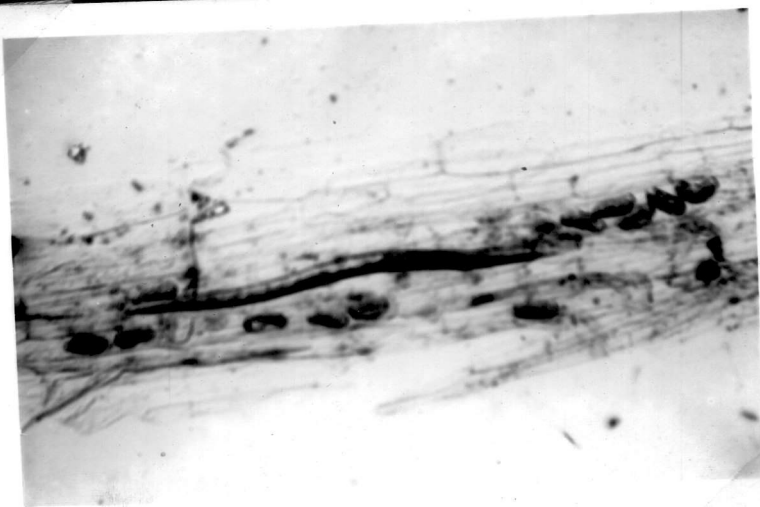


PLATE III & IV Radopholus similis adult female with eggs within banana root tissues.

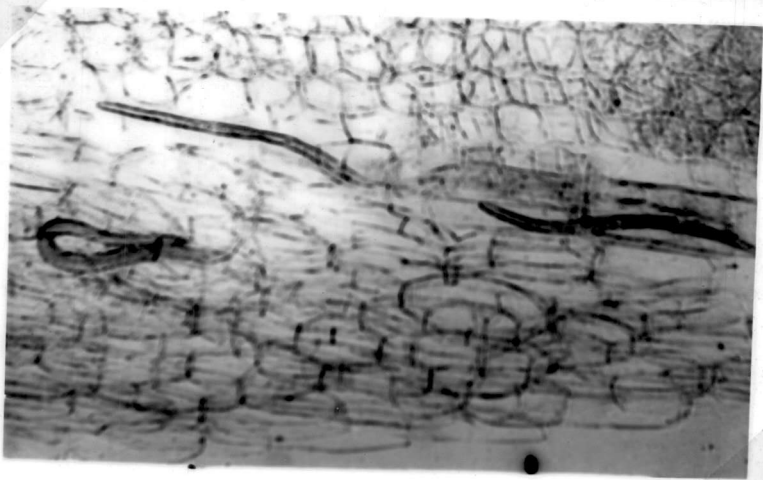


PLATE V

Rotylenchus sp. adults within
banana root tissues.