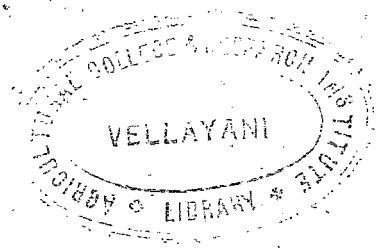
STUDIES ON THE POPULATION OF SOIL NEMATODES IN RELATION TO CERTAIN CHEMICAL AND BIOTIC FACTORS OF SOIL



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C E R T I F I C A T E

This is to certify that the thesis herewith submitted contains the results of bonafied research work carried out by Sri K.K. Ravindran Nair, 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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C O N T E N T S

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INTRODUCTION

I N T R O D U C T I O N

It is an established fact that various micro-organisms, inhabit the soil, the study of which is difficult because of their life in complicated environment. The living phase of the soil is dynamic and responsible for numerous biological activities. Some organism will decompose organic matter thus improving the soil fertility. But a majority of them is capable of causing enormous economic losses by damaging many crop plants.

Nematodes are minute thread-like animals commonly called threadworms, roundworms, eelworms or nemas. They may be plant parasitic or may be free living in soil, fresh water or sea water. A plant parasitic nematode can generally be differentiated from the rest, by the presence of a needle-like feeding organ called the mouth Spear at the anterior end of the body. Eventhough great majority of the members of this phyllum are microscopic, according to Jones & Jones (1964) they rank next to insects as pests of cultivated crops.

Earlier studies have shown that the Kerala soils abound in various types of nematodes. Some of these have already been recognised as potential pests of important crops. These include the burrowing nematode, Radopholus similis (Nair et al 1966), the Citrus Nematode Tylenchulus semipenitrans (Nair 1965), the root knot nematode Meloidogyne incognita (Sathya Rajan et al 1966) and the spiral nematode, Helicotylenchus caribensis. Various unidentified species of Helicotylenchus, Rotylenchus and Criconemoids have been observed to occur in association with banana (Vargheese and Nair 1968). Much remains to be done in understanding the various parasitic nematodes infesting the various crops of Kerala especially with reference to their ecological factors.

The only work on the ecology of soil nematodes in Kerala is that of Vargheese and Nair (1968). This work has given definite indication that the type of soil plays an important role in deciding the population of the soil abiding nematodes. Nothing, however, is known about the different properties of the soil which govern the population build up of the nematodes. Hence an attempt is made in the present work to study the effect of the chemical and biotic properties of soils on the nematode population. The chemical

properties studied include p^H, conductivity and organic matter content and the biotic properties include the population of bacteria and fungus.

The literature on the ecological factors of soil nematodes have been reviewed.

REVIEW OF LITERATURE

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Following is a review of the literature available on the influence of the different soil factors on the population of soil nematodes.

p^H

Peters (1926) made the first attempt to correlate p^H levels and nematode population in soils. He found little correlation between soil p^H and cyst concentration of Heterodera rostochiensis in various districts of South Lincohnshire, England.

Godfrey and Hagan (1933) found that pineapple raised in soils having p^H ranging from 4.0 to 8.5 in Hawaii, showed no difference in the infestation of Meloidogyne Sp.

Petherbridge and Jones (1944) observed that Heterodera schachtii was absent in the highly acidic soils of the Fen district of England.

Ellenby (1946) Soaked cysts of Heterodera rostochiensis for 24 hours in a series of acetate buffers,

washed and soaked them in distilled water for another 24 hours and then placed in potato root diffusate for hatching. Larval emergence decreased as p^H fell from 6.7 to 4 and at p^H levels of 3.4 and below there was no emergence at all.

Fenwick (1951) Studied larval emergence from cysts of Heterodera rostochiensis in root diffusates containing different proportions of N/10 Sodium Carbonate and N/10 hydrochloric acid. There was no difference in total emergence or rate of emergence over a p^H range of 3.0 to 8.0.

Ahlberg (1951) observed that there was no difference in the rates of reproduction of Heterodera rostochiensis in the acid and alkaline soils in Sweeden.

Stockli (1952) believed that the ordinary variations found in the soil p^H have little direct effect on Soil nematode.

Simon (1955) reported that there was a positive correlation between soil p^H and the level of Heterodera schachtii infestation in Belgium. He observed that Sugar beet grew best on alkaline soils, so nematode infestation

might be correlated with host plant growth rather than p^H.

Robinson and Neal (1956) studied the influence of p^H on larval emergence from a Heterodera rostochiensis cyst in distilled water containing hydrochloric acid. Emergence reached a maximum at p^H 2.5 in a range 1 to 6.5. Similar results were obtained with citric and formic acids.

Oostenbrink (1958) also found that some cases of poor sugar beet growth could be cured by treating the soil with chalk, heat or with Nematicide D.D. He attributed the subsequent improvement in sugarbeet growth to increase p^H caused by these treatment rather than to nematode control.

Harrison (1959) reported that in the range in which the potatoes were normally grown, p^H had little influence on the succeptibility of potato to attack by Heterodera rostochiensis.

Bird (1959) observed in his studies on the attraction of Meloidogyne javanica to the roots of the host that p^H played only a secondary role although larvae were repelled at p^H3 and 10.6 at either end of the range.

Loewenberg et al (1960) reported that the hatch of Meloidogyne incognita incognita and larval survival reached the maximum in p^H 6.5 in Heller's nutrient solution.

Lownsbery (1961) found no difference between population levels of Criconemoids xenoplax on peach soil at $p^H 5$ and $p^H 7$.

Jimmenezmillian (1962) studied the influence of p^H on Rehabditis terricola from Central Spain Soils. Invitro culturers were made in a mixture of boiled root extracts of Vicia faba.L and Hordium vulgare -L. in sterile soil buffered at different p^{Hs}. Known numbers of living nematodes were placed in petridishes and the population that developed was counted every 12 hours upto the 14th day, the living eelworm being recorded as a percentage of number introduced. Inspite of being collected from an acid soil maximum reproduction occurred at p^H 8; the largest numbers being recorded in the p^H range 7.7 to 8.6. At p^H 4 or less all nematodes died, between p^H 4 and 6 different percentages of mortalities were recorded. Nematode numbers fell sharply above p^H 9.3.

Koen (1967) determined the influence of p^H on Pratylenchus brachyurus. The parasites were placed in water

acidified at different levels with Hcl, and the percentage of larvae which survived one week after was noted. There were no significant differences in the Survival of larvae in pH values 5, 7, and 7.3. At a pH of one all the worm were dead; and at a pH3 only 39.2% of the eelworms were alive.

Organic matter contents of Soil

Linford et al (1938) reported that decomposition of organic matter in soil reduced the number of Heterodera marioni galls in roots of cowpeas. They also found that the varying of the fineness of plant materials added to soil or the frequency of their application had little influence on nematode population. There was a simultaneous increase in the population of Saprophagus and microphagus free living nematodes and of predaceous nematodes (Dorylaimids).

Duddington, et al (1956) found that organic matter reduced the cyst population of eelworm Heterodera schachtii.

Oostenbrink (1960) reported that organic manures such as stable dung, green manure compost and other organic materials promoted the Saprozoic nematodes which resulted in an increase in the total nematode population.

Mankav and Minteer (1962) found that out of 8 organic materials added to soil, infested with Tylenchulus semipenetrans, only steer manure failed to cause substantial reduction in numbers of larvae in 84 days. They observed that castor pomace eleminated all citrus nematode larvae from the soil, though apparently it did not contain substances toxic to nematode. Environmental factors associated with increased microbial activity following organic amendments was presumed to produce conditions unfavourable for the survival of Citrus nematode larvae in fallow soil.

Mankav (1962) studied the effect of several organic additives viz dung (steer manure) green manure (alfafa) rotted wood shavings, oat,hay, and chicken manure on the nematode fauna, and found that there was a large increase in number of microphagus nematodes in easily decomposable amendments. The population of predaceous Dorylaimus Sp. was not influenced greatly by organic matter.

Fungal Flora of Soil

Holdeman and Graham (1952) found that varieties of cotton, resistant to fusarium wilt, succumbled to wilt only when the sting nematode Belonolaimus gracilis, was present in the soil.

Smith (1954) showed that the effect of Fusarium wilt in cotton increased, when the plants were attacked by the nematodes. He suggested that in addition to providing openings in the root for the fungus, Meloidogyne also increased the susceptibility of the host in the later stages of development.

Sasser et al (1955) grew two varieties of black shank resistant tobacco in Steam sterilised soil to which Phytopthora parasitica var nicotianae and Meloidogyne Sp. were added alone and in combination. When the inoculum contained fungus and nematodes together the black Shank symptoms developed earlier and more severely than in soils with fungus alone. The nematodes appeared to do more than simply wound the tissues, because the plant roots cut artificially and inoculated with fungus showed no increased symptoms. They observed that the nematode altered the host cells biochemically thereby providing a more congenial substratum for the fungus.

Moree et al (1956) reported that an increased resistance to black shank was achieved by crossing varieties known to be tolerent to infestations of Meloidogyne, Pratylenchus and Tylenchorhynchus claytoni with resistant varieties.

Holdeman (1956) found that wilt symptoms in tobacco caused by Fusarium oxysporum var nicotianae were greater when Tylenchorhynchus claytoni was present in the soil. But the fungus was not dependent on the nematode for invasion of the host.

Bendict and Mountain (1956) found that the Fungus Rhizoctonia solani and the nematode Pratylenchus minyus were closely and consistently associated with naturally occurring infection of winter wheat. In greenhouse and field experiments the combined effect of the Fungus and nematode on the growth of wheat was almost twice that of either pathogen alone. Pure culture techniques did not reveal the dependence of the fungus on the nematode for host penetiation although they were closely associated in the disease.

Reynolds and Hanson (1957) found that 'post emergence damping off' of Cotton by the fungus Rhizoctonia solani was higher in the presence of Meloidogyne incognita acrita.

Jenkins and Courseen (1957) found that the incidence of Fusarium wilt in Tomato was increased by root knot nematodes.

They concluded that nematodes lowered the natural resistance in some varieties in addition to providing a means of entry for the fungus, since artifidal wounding did not affect succesptibility.

Binder and Hutchinson (1959) repeated some of the work of Jenkins and Coursen and found that although the wilt resistant tomato 'Chesapeake' was heavily galled by Meloidogyne incognita acrita the resistance to fusarium was not impaired. They concluded that the breaking of resistence in tomato was influenced by the race of nematode used in the experiments and by the number of nematode in the inoculam.

Labruye're et al (1959) observed the combined incidence of the nematode Hoplolaimus uniformis and the fungus Fusarium oxysporum caused extensive decay of root cortex and early yellowing of peas. The nematode and the fungus did not produce symptoms when inoculated separately.

Mckeen and Mountain (1960) reported that plant nematodes provided an entry for the fungus in to host plants by mechanical damage and the enzymes secreted during feeding, provided a substrate for fungal growth.

Later work by Mountain and Mckeen (1962) showed that *verticillium dahliae* added to a filed soil infested with *Pratylenchus penetrans* increased the rate of reproduction of the nematode in the roots of brinjal and tomato, but not in Pepper. The rate of reproduction of *Tylenchorhynchus capitatus* in tomato roots also increased with the fungus added. They pointed out that there was a direct association between the incidence of wilt and the suitability of the plant as a host for *Pratylenchus penitrans.*

Bacterial flora of soil.

Cheo (1946) claimed that bacterial disease of wheat was the result of an obligate relationship between a bacteriam *Bacterium tritici* and the nematode *Anguina tritici.*

Crosse and pitcher (1952) found that symptoms of Cauliflower disease of Strawberries appeared only if the two Pathogens involved *Corynebacterium flaccum facious* and *Aphelenchoides ritzemabois* are inoculated in Combination.

Lucas *et al* (1955) reported that Symptoms of bacterial wilt caused by *Psuedomonas solenacearum* in tobacco increased while associated with *Meloidogyne incognita acrita.*

Stewart and Schindler (1956) studied wilting of Carnation cuttings infested with bacterium *Psuedomonas*

Garyophylli in association with different Phytoparasitic nematodes. Cuttings were inoculated with either Meloidogyne sp. Helicotylenchus nannus, Xiphinema diversicaudatum or Ditylenchus Sp. followed by inoculation with bacterium. Treatments with and without root woulds and parallel treatments without bacteria were also included. The results of the experiments indicated that wounding Meloidogyne Sp. and Helicotylenchus nannus increased the rate of wilting in the presence of bacteria. Xiphinema diversicaudatum showed no effect with or without bacteria, and with the Dity lenchus inoculam the rate of wilting even decreased. It was concluded that endoparasitic and ectoparasitic nematodes aggravate the bacterial wilt in carnations by wounding the roots and allowing the bacteria to enter the plant.

Lucas and Krusberg (1956) found that Tylen chorhynchus claytoni did not increase the severity of bacterial wilt by xanthomonas solanacearum in wilt resistant tobacco plants.

They suggested that weakening of the tobacco roots by the nematodes provided a less suitable environment for the bacterium which developed best in vigorous and actively growing plants. They also pointed out that Tylenchorhynchus claytoni did not penetrate to the xylem tissues of the tobacco

root during feeding and hence the symptoms did not aggravate in their presence.

Soil Type

Petherbridge and Jones (1944) found Heterodera schachtii in most soil types, but not in heavy soils where beet was grown less frequently.

Seinhorst (1950) observed that infestation of Ditylenchus dipsaci were more frequent on clay soils in Holland and he suggested that the high moisture content in such soils favoured infestation and movement. Seinhorst also showed that there was some factor in the sandy soils which inhibited activity.

Ahlberg (1951) reported that reproduction of Heterodera rostochiensis was low in sandy soils because of the high permiability which caused dry conditions.

Christie (1952) reported that the population of Dolichodorus heterocephalus was more in heavy soils.

Sasser (1954) stated that infestation of Meloidogyne incognita, Meloidogyne incognita acrita and Meloidogyne hapla were more severe in sandy loam soils than in

heavy clay soils of Eastern Maryland.

Oosteubrink (1954) examined the roots of several crops of Maize and beet in a heterogenous agricultural area in Holland. He found that Pratylenchus pratensis and Pratylenchus penetrans were more abundant in sand and sandy peat soils, whereas pratylenchus minyus occurred chiefly in clay soils.

Sleeth and Reynolds (1955) conducted experiments in five soil mixtures, mixing loamysand and clay loam in different porportions, The level of infestation of Sesbania exaltata by Meloidogyne javanica was assessed in each soil mixture. Infestation increased in proportion to the loamy sand in the mixture.

Seinhorst (1956) showed a very close correlation between high population levels of Ditylenchus dipsaci in clay soils in the island of Geeree-flakkee.

Minton (1957) reported that root knot nematodes were found in soils ranging from light sand to heavy clay.

Hollis and Fielding (1958) found that in Louisiana the distribution of Commonly occurring species in the general pratylenchus, Trichodorus, Tylenchorhynchus

xiphinima, Hopololaimus, and Helicotylenchus was independent of soil type.

Brown (1958) found that root knot nematode occurred on both heavy and light soils.

Caveness (1958) suggested that the dense population of Heterodera schachtii in clay soils in U.S.A. may be related the soil structure.

Mountain and Boyee (1958) reported that the course soils contained larger population of Pratylenchus penitrans than the finer soils.

Thomson and Lear (1959) found that Meloidogyne incognita acrita occurred in the course textured soils, and they were less common in the fine textured loams and the clay loams.

Endo (1959) grew straw berry and Cotton plants in four soil types: Sandy, Sandy loam, loam, and clayloam. A suspension of about 500 adults and larvae of Pratylenchus brachyurus were added to the different soil types, and after three months the infestation levels were determined by counting the nematodes in the roots. Infestations were greatest in the sandy loam and least in the sand, and clay loam.

Sol and Seinhorst (1961) stated that Trichodorus pachydermus occurred most commonly on sandy soils in Holland whether in arable, pasture, wood land or in soil not under cultivation. It was rare in clay soils.

O'Bannon and Reynolds (1961) reported that the infestation of Meloidogyne incognita acrita was heaver in course textured soils in Arizona.

Vangundy and Rackham (1961) found that the population increase of Hemicycliophora arenaria on tomatoes was greater in sandy soil than in a loam soil, or a mixture of the equal parts of the two.

Wallace (1962) reported that the mobility of Ditylenchus dipsaci was higher in sandy soils than in clay soils. But Seinhorst found that this nematode was more abundant and destructive in clay soil.

Vargheese (1967) reported that the genus Helicotylenchus and Rotylenchus Sp. were distributed in all types of soils in Kerala. The genus Radopholus was absent in Sandy and loamy soils.

Nair (1968) reported that there was variation in the population of the different types of nematodes in

relation to types of soils. He found that the total parasitic population as well as the population of the non parasitic forms was highest in loamy soils followed closely by lateritic soils. This again was followed in the descending order by the sandy soil, clayey soil, and the black soil. The black soil inspite of its high humus and organic matter contents showed the lowest nematode population.

MATERIAL AND METHODS

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Material

Nematode Sieves

Five Sieves of meshes 20, 60, 100, 200 and 325 square inch made by Duel Mfg. Co., Chicago were used for sieving out the nematodes from the soil.

Baermann funnel

Glass funnels of 10cm diameter with 9" long rubber tube and a pinch cock fitted at its tail end constituted the Baermann funnel. A dozen of such funnels were used for filtering the nematodes from the soil washings.

Tissue paper

'Sateena' white facial tissue paper of size 21 x 16cm were used for filtering the nematode.

Wire Gauze

Wire gauze of 20 mesh having a size of 15 cm x 15cm were used as supports for the tissue paper in Baermann funnels. The gauze pieces were made into dish like shape, with flat bottoms to fit into the funnels.

Basins

Plastic basins of each 32cm diameter were used for washing the soil samples.

Other equipments

They included funnel stands, wash bottles, beakers, specimen tubes, spirit lamp, cavity blocks, counting slide, counting dish, fine needles, glass slides, cover slips, glass wool, cavity slide, nematode picks, made by bamboo, pipettes, reagent bottles, microscopes, tally counter, polythene bags, specimen tube stands etc.

METHODS

Collection of soil samples

Different localities were selected at random covering the different soils types. Soil samples were collected from cultivated lands. A thorough representative sample of 1000 cc of soil was taken for studies from a depth of 4-6". The samples were kept in polythene bags to prevent drying. Care was taken to ensure that the samples were taken of soils which were sufficiently moist ie. neither too wet nor dry.

Washing the soil samples

The soil samples were processed by the method by Christie and Perry (1951).

Five hundred milli liters of the soil was measured out from the sample using a beaker in to a basin and it was mixed well with three times of water by volume. Coarse particles like stem pieces and roots were allowed to settle. Then it was passed through a series of sieves of 20, 60, 100, 200 and 325 meshes per square inch. The fine silt and Nematode collected in 200 and 325 mesh seives were washed down into a beaker with minimum quantity of water by using a wash bottle.

Isolating the nematode by the Baermann funnel

The nematode suspension sieved out from the soil samples was poured gently into tissue paper tray kept in position in the Baermann funnel with the help of a flat bottomed wire gauze. The funnel was filled with water till the level just touched the tissue paper. It was kept undisturbed, and at the end of 24 hours about 30 cc of water was drawn out into a specimen tube by loosening the Pinch Cock. Then the water level in the funnel was restored as before for the second drawing at the end of 48 hours.

Killing and preserving the nematode

The nematode collected from the Baermann funnel together with the water in which they were suspended were kept still for about 30 minutes, allowing the nematodes to settle down and the volume was reduced to half by pipetting out the water from the top. The remaining suspension was taken to mix up the nematodes in water. The tube was gently heated over a flame. At frequent intervals drops of the nematodes suspension were taken in a cavity slide and examined under a binocular microscope to ascertain whether the nematodes have relaxed to their characteristic shape. When it was done the suspension was made up by the addition of an equal quantity of 10% formaline, neutralized with a little caco3 (Baker 1945), thus getting the nematodes preserved in 5% formaline.

The preserved suspension of nematodes was made up to 50 cc by adding water. It was stirred well and the counting slide was filled with 1cc of this suspension using a pipette and the nematode present in it was counted under a binocular microscope. From these the nematodes present in 500 cc soil were calculated.

Fungus and Bacterial Counts

The soil dilution and plate method

The soil dilution and plate count method was used for counting the micro organisms (Fungus and Bacteria) from the soil. An estimate of the total population of fungi and bacteria in numbers per gram was calculated. The estimate referred to the number of visible cells or mycelial fragments in the sample capable of growing on the agar medium: Following are the details of the procedures adopted:-

One gram of soil (on oven dry basis) was transferred to a conical flask containing 99 ml of sterile water. The mixture was shaken thoroughly in a Mechanical shaker for 30 minutes and one ml of suspension was drawn out by means of a sterile pipette, while in motion and transferred to another conical flask containing 99 ml. of sterile water thus making the total volume upto 100 ml. This suspension was shaken well by hand for a few seconds and again 1 ml. solution pipetted to 99 cc of sterile water. Thus the dilution was made to in 100 x 100 x 100 ie.i in, 1,000,000.

Fifteen milliliters of the desired medium (Soil extract for Bacteria, and Rose Bengal for Fungus) contained in the

test tubes were melted and cooled to just above the solidifying temperature and transferred to 10 cm petridishes. One Ml. of the desired final soil dilution also was transfer aseptically into the medium by sterile pipettes before the agar got solidified and the petridishes were rotated so as to get a uniform dispension of the solution in the medium. The dishes were labelled and incubated at 25°c for 7-14 days and the resulting colonies were counted under a colony counter. For counting purposes dishes containing fungal or bacterial spreaders or large clean zones of antagonisms were discarded. The average number per dish is multiplied by the dilution factors to obtain the number per gram in the original soil sample.

Determination of the p^H, conductivity and organic matter of the soil samples:

p^H

p^H was measured potentiometrically in a 1:2 water suspension. Ten grams of air dry soil was taken in a breaker and 20 cc of distilled water added to it. This was kept for half an hour with intermittent stirring. The p^H was measured directly using glass electrode after the final stirring.

Organic Matter

One gram of the soil passed through a 0.5 mm Sieve, was transferred to a 250 ml. conical flask. Ten milli litres 'N' Potassium dichromate was added to it. The contents were mixed well followed by an addition of 2 ml. of concentrated sulphuric acid. After shaking for a few minutes the flask was kept undisturbed for ½ an hour. The solution was diluted with 100 ml. of distilled water and shaken thoroughly. Ten cc of 80% phosphoric acid was added to make the 'end point clear. One Ml. of indicator diphenylamine was added and titrated against standard ferrous sulphate. 1 cc of 1 normal dichromate = 0.003 gm of carbon.

Conductivity (Total Soluble Salts)

The suspension made for finding out the p^H was kept for 1 hour and the conductivity was measured by the 'Conductivity Bridge' in the supernatent liquid.

DETAILS OF STUDIES AND OBSERVATIONS

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The variations in the population of plant parasitic and non parasitic soil nematodes with reference to the chemical and biotic environments existing in soil were studied under these investigations. The samples were collected from the different types of soils of the state viz. sandy, sandy loam, Red soil, Laterite soil, Forest soil and Black soil etc. As for as possible the samples were collected only from the cultivated areas under each soil types.

The nematodes were extracted, fixed, preserved and counted as detailed under 'Methods'.

The chemical environment was determined in terms of pH, total soluble salts, and organic matter content; while the biotic environment was determined in terms of Bacterial and Fungal populations.

RESULTS

Table 1 gives the counts of the parasitic and non parasitic soil nematodes of the different samples collected with the details of the samples. Results of the studies on the chemical and biological characters of the different soils

also are given in the table. The data were analysed for the possible correlations, between the nematode population and the different chemical and biological characters of the soil. The results of these analyses are given in Table 2.

TABLE 1

Population of soil nematodes in relation to various soil Factors

Sl. No.	Locality	Crop	No. of nematodes (in 500 cc soil)			pH	Organic matter percent	TSS	Bacteria in Million/ gram of dry soil	Fungus (in Million/ gram of dry soil	Parasitic Nematodes (Genera)
			Parasites	Non parasites	Total						
1	2	3	4	5	6	7	8	9	10	11	12
					SANDY SOIL						
1	Kazhakuttam	Vegetables	760	1166	1926	5.6	0.68	0.0	6.0	2.3	Helicotylenchus Meloidogyne
2	"	Coconut Seedlings	80	113	193	5.5	2.18	0.0	5.0	8.3	Helicotylenchus
3	Palkulangara	Coconut	20	120	140	6.9	0.54	0.0	27.0	3.3	Helicotylenchus
4	Trivandrum	Vegetables	316	889	1205	7.2	0.87	0.0	16.0	5.3	Hoplolaimus, Nothotylenchus, Helicotylenchus

Contd...

1	2	3	4	5	6	7	8	9	10	11	12
5	Quilon	Coconut	373	393	766	6.7	1.28	0.1	5.5.	4.5	Aphelenchus (Mostly) Helicotylenchus
					SANDY LOAM						
6	Vellayani	Banana	653	300	953	5.9	2.61	0.0	5.0	1.3	Pratylenchus (mostly) Helicotylenchus
7	Vellayani	Banana	93	406	499	5.6	2.78	0.3	10.0	3.0	Circonemoids, Nothotylenchus Hoploliamus
8	Vellayani	Mango	480	193	673	6.1	3.01	0.0	12.0	1.0	Helicotylenchus
9	Mavelikara	Coconut	180	464	826	7.4	0.90	0.3	24.0	14.3	Helicotylenchus Anhlenchus

Contd...

1	2	3	4	5	6	7	8	9	10	11	12
10	Mavelikara	Vegetables	73	940	1013	7.2	2.06	0.9	25.0	9.3	Helicotylenchus
11	Peroorkada	Vegetables	2787	4153	6940	7.4	0.90	0.0	18.0	6.6	Helicotylenchus Meloidogyne
12	Peroorkada	Coconut	120	493	613	7.0	0.28	0.0	10.5	4.3	Aphlenchus, Tylenchus
13	Kayamkulam	Paddy	67	220	287	5.5	0.38	0.4	10.5	5.5	Tylenchorhynchus Hirschmanniella oryzae
14	Quilon	Paddy	0	253	253	5.4	1.28	0.4	6.5	2.5	-
15	Ponmudi	Tea	240	507	747	4.7	4.55	0.1	12.0	1.5	Helicotylenchus

Contd...

1	2	3	4	5	6	7	8	9	10	11	12
					RED SOIL						
16	Vellayani	Pappaya	346	313	659	5.6	1.66	0.1	5.0	4.7	Helicoty-lenchus
17	Vellayani	Banana	180	313	493	5.2	0.69	0.0	7.0	7.5	Helicoty-lenchus
18	Vellayani	Coleus	140	106	246	6.3	0.93	0.0	5.0	3.3	Helicoty-lenchus
19	Vellayani	Tomato	213	180	393	5.5	1.44	0.0	5.0	4.3	Meloidogyne. Helicotylenchus
20	Vellayani	Vegetable	2353	1153	3506	5.1	0.76	0.3	11.0	3.5	Helicotylenchus
21	Kazhakuttam	Vegetable	246	60	306	6.2	0.26	0.0	4.0	2.0	Meloidogyne, Helicotylenchus
					LATERITE SOIL						
22	Kawdiar	Tapioca-& Banana	2280	1853	4133	6.9	4.18	0.1	18.0	6.3	Helicotylenchus
23	Vithura	Rubber	767	393	1160	6.1	2.68	0.0	12.5	2.0	Boleodorus (Mostly) Helicotylenchus

Contd...

1	2	3	4	5	6	7	8	9	10	11	12
24	Vithura	Arecanut	253	186	439	6.1	10.44	0.0	31.0	6.0	Helicotylen-chus
25	Vellayani	Yams	413	900	1313	5.5	2.14	0.1	22.0	5.5	Aphlenchus Helicoty-lenchus
26	Palode	Arecanut	160	280	440	5.5	4.65	0.6	13.0	2.5	Pratylenchus Helicotylenchus
27	Palode	Arecanut	0	240	240	4.5	1.29	0.1	10.0	3.5	- -
					FOREST	SOIL					
28	Munnar	Tea	173	1253	1426	6.9	4.78	0.0	7.5	3.0	Helicoty-lenchus
29	Madupetty	Cabbage	80	113	193	5.2	7.21	0.0	19.0	2.6	Helicoty-lenchus
30	Madupetty	Tomato	806	280	1086	6.6	3.98	0.0	19.0	8.3	Helicoty-lennhus

Contd ...

1	2	3	4	5	6	7	8	9	10	11	12
31	Madupetty	Vegetables	246	60	306	5.2	17.61	0.6	25.0	1.0	Helicotylenchus
32	Munnar	Ornamentals	106	220	326	6.1	7.70	0.1	9.0	2.0	Helicotylenchus
33	Madupetty	Cholam	426	346	772	5.2	11.86	0.1	22.5	4.0	Helicotylenchus
34	Madupetty	Banana	413	266	679	5.3	10.44	0.0	11.5	1.0	Helicotylenchus
35	Madupetty	Grass	40	433	473	5.4	3.59	0.0	18.5	4.5	Helicotylenchus
					BLACK	SOIL					
36	Alleppey	Paddy	47	427	474	7.0	2.34	1.4	23.0	30.0	Meloidogyne (young ones)
37	Alleppey	Coconut	140	600	740	6.0	1.60	0.7	6.5	3.0	Tylenchorhynchus
38	Chittoor	Vegetable	1320	1360	2680	7.8	4.37	0.1	18.0	1.0	Helicotylenchus
39	Chittoor	Sugarcane	973	2040	3013	7.2	4.20	0.6	14.0	2.0	Helicotylenchus
40	Chittoor	Cotton	80	453	533	4.7	4.64	0.5	9.0	1.5	Helicotylenchus

TABLE 2

Correlation between the population of Soil Nematodes and the various environmental factors

S.No.	Factors	Correlation (r) coefficient
1	Population of Parasitic nematode Vs p^H of the soil	0.292
2	Population of parasitic nematode Vs organic matter of the soil	-0.080
3	Population of Parasitic nematode Vs. Total soluble salts of the soil	-0.152
4	Population of parasitic nematode Vs Bacterial population of the soil	0.106
5	Population of parasitic nematode Vs Fungus population of the soil	-0.030
6	Population of Non parasitic nematode Vs p^H of the soil	0.511
7	Population of Non parasitic nematode Vs Organic matter of the soil	-0.170
8	Population of non parasitic nematode Vs Total soluble salts of the soil	0.013

Contd..

S.No.	Factors	Correlation (r) coefficient
9	Population of Non parasitic nematode Vs Bacterial population of the soil	0.160
10	Population of Non parasitic nematode Vs Fungus population of the soil	0.049
11	Population of Total nematode Vs pH of the soil	0.414
12	Population of total nematode Vs organic matter content of the soil	0.130
13	Population of total nematode Vs Total soluble salts of the soil	0.055
14	Population of total nematode Vs Bacterial population of the soil	0.140
15	Population of total nematode Vs Fungus population of the soil	0.002
16	Population of parasitic nematode Vs Non parasitic nematode of the soil.	0.780

It may be seen that the Correlation coefficient between the population of parasitic nematode and pH of the soil is 0.292. It is not significant either at 5% level or at 1% level.

The correlation coefficient between the population of parasitic nematode and the organic matter content of the soil is -0.08. The correlation is negligible and negative.

The correlation coefficient between the population of parasitic nematodes and the total soluble salts of the soil is 0.152. The correlation is not significant at both the levels.

The correlation coefficient between the population of the parasitic nematodes and the bacterial population of the soil is 0.106. The correlation is not significant.

The correlation coefficient between the population of the parasitic nematode and the fungus population of the soil is -0.03. The negative correlation is not significant at any of the levels.

The correlation coefficient between the population

of non parasitic nematode and the pH of the soil is 0.511. The correlation is significant at both the levels. Thus it is observed that when the pH of the soil increases the population also increases with in the range of pH noted viz: 4.5 - 7.4.

The correlation coefficient between the population of non parasitic and organic matter content of the soil is -0.17. The correlation is negative and negligible.

The correlation coefficient between the population of non parasitic nematode and total soluble salts of the soils is 0.013. It is not significant at both the levels.

The correlation coefficient between population of the non parasitic nematode and the bacterial population of the soil is 0.16. It is also not significant at both the levels.

The correlation coefficient between population of non parasitic nematode and the fungus population in soil is 0.049. It is not significant at any of the levels.

The correlation coefficient between the total population of soil nematode and the pH of the soil is 0.414. The correlation is significant at both the levels.

Thus when the soil pH increase the population of the soil nematodes also increases.

The correlation coefficient between the total population of soil nematode and the organic matter content is 0.130. Thus correlation is not significant.

The correlation coefficient between the total population of soil nematode and total soluble salts of the soil is 0.055. The correlation is negligible.

The correlation coefficient between the total population of nematode and the bacterial population is 0.140 which is not significant at any of the levels.

The correlation coefficient between total population of nematode and the fungus population of the soil is 0.0027 and this is very slight.

The correlation coefficient between the population of parasitic nematodes and the non parasitic nematode is 0.78. The correlation is highly significant at both the levels. That is when the population of the parasitic nematode increases population of the non parasite also increases.

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DISCUSSION

DISCUSSION

Results of the studies presented show that there exists a positive correlation between the total population of the nematodes in the soil and the pH of the soil. Thus when pH increases the population of soil nematode also increases within the pH range of 4.5 - 7.4, a range existing in the different soils of Kerala (Table 2). The correlation between the pH of the soil and the population of the non-parasitic soil nematode alone is significantly positive within the above range. The population of the parasitic nematode considered alone on the other hand, is not significantly affected by the changes in the pH of the soil. (Table 2). This observation is in conformity with the previous works. For instance Peters (1926) found little correlation between soil pH and the population of Heterodera rostochiensis. Godfrey and Hagan (1933) observed no difference in the infestation by Meloidogyne Sp to Pineapple raised in soils having different pHs. Ahlberg (1951) reported no difference in the rate of reproduction of Heterodera rostochiensis in the acid and alkaline soils. Lownsbery (1961) also found no difference between the population levels of Criconemoides xenoplax on peach soils at pH 5 and pH 7.

There is no correlation between the organic matter content of the soil and the population of either the parasitic

nematodes or the non-parasitic nematodes, (Table 2). It is only natural to expect that at least the population of the non-parasites will be affected by the amount of organic matter available in soil as the organic matter forms the food of the saprophytic soil nematodes. The lack of any significant correlation in the present studies may be due to the presence in the soils of Kerala an optimum range of organic matter contents, the available organic matter in the soils of Kerala has been seen to range between 0.28 to 17.61.

There is no relation between the conductivity (Total soluble slats) of the soils and the nematode population of the soil. (Table 2). This indicates that the soil nematodes, like the plants, are adapted to the range of salt content present in the soil.

The population of soil nematode does not show any relation with the population of the fungus organisms present in the soil. (Table 2). Fungus organism usually exert two types of influences on the soil nematode fauna. The predatory fungal organisms destroy the nematode, while other fungi serve as food to the nematodes. The variations of the fungal fauna population in the soils under study do not appear to be sufficient enough to affect the nematode population by either of the ways mentioned.

The relation between the population of the soil nematode and the population of the bacteria present in the soil does not show correlation either positive or negative. (Table 2). Bacteria also usually serve as food for the nematodes and the lack of any correlation in this respect may be attributed to the inadequate variation in the bacterial populations of the soils under study.

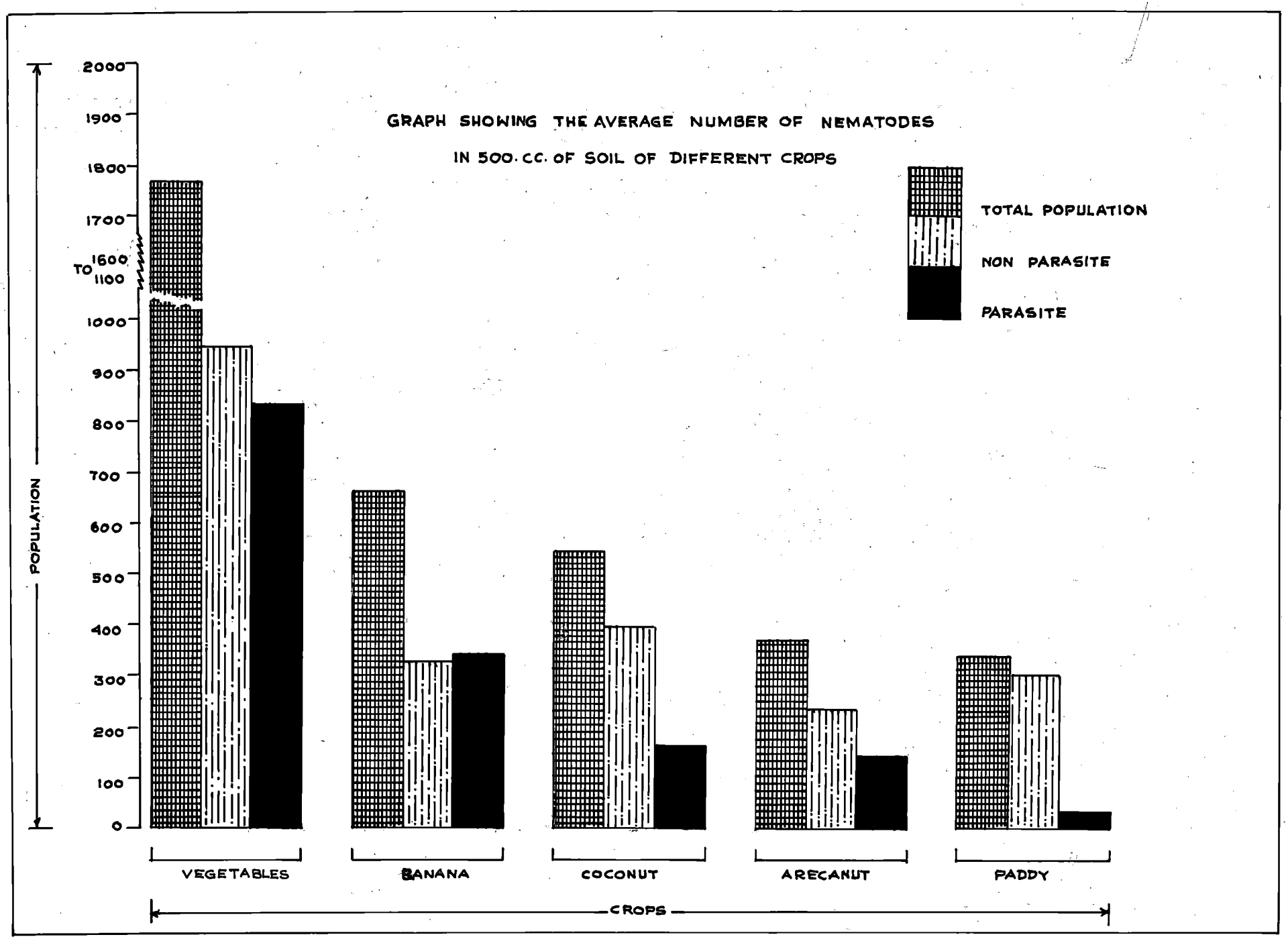
The relation between the population of parasitic and non-parasitic forms of soil nematode shows a high positive correlation. (Table 2). Thus when the population of parasitic forms increases that of the non-parasites also increases. This indicates that the conditions favourable for the parasites are equally favourable for the non-parasites.

Considering the nematode population in relation to the different crops it is seen that in general there is a high population of parasitic and non-parasitic nematodes associated with vegetable crops. (Table 3). Since vegetables are irrigated crops the nematode population is always kept up without suffering any setback caused by dry conditions. The generous manuring with organic materials which is usually practised in raising vegetable crops also appears to have encouraged the sustenance of a very high population of the non-parasitic forms in the soil.

TABLE 3

Average number of Nematodes in 500 cc of Soil of different crops

S No	Crop	Parasite/ 500 cc	Non parasite/ 500 cc	Total population/ 500 cc of soil
1	Vegetables	836.36	941.27	1777.63
2	Banana	334.75	321.25	656.00
3	Coconut	152.16	394.16	546.32
4	Arecanut	137.66	235.34	373.00
5	Paddy	38.00	300.00	338.00


GRAPH SHOWING THE AVERAGE NUMBER OF NEMATODES
IN 500. CC. OF SOIL OF DIFFERENT CROPS
TOTAL POPULATION
NON PARASITE
PARASITE
POPULATION
2000
1900
1800
1700
TO 1600
1100
1000
900
800
700
600
500
400
300
200
100
0
VEGETABLES
BANANA
COCONUT
ARECANUT
PADDY
CROPS

Next to vegetables, banana soil gives the maximum population followed by coconut, Arecanut, and Paddy in the descending order. Paddy soil shows the least number of parasitic nematode (Table 3).

The different genera of parasitic nematodes found in association with the different crops are Helicotylenchus, Meloidogyne, Hoplolaimus Aphelenchus, Nothotylenchus, Pratylenchus, Criconemoids, Tylenchus, Tylenchorhyncus, Boleodorus and Hirschmanniella (Table I).

As regards the distribution of different nematodes, Helicotylenchus is present in almost all types of soils and associated with most of the crops.

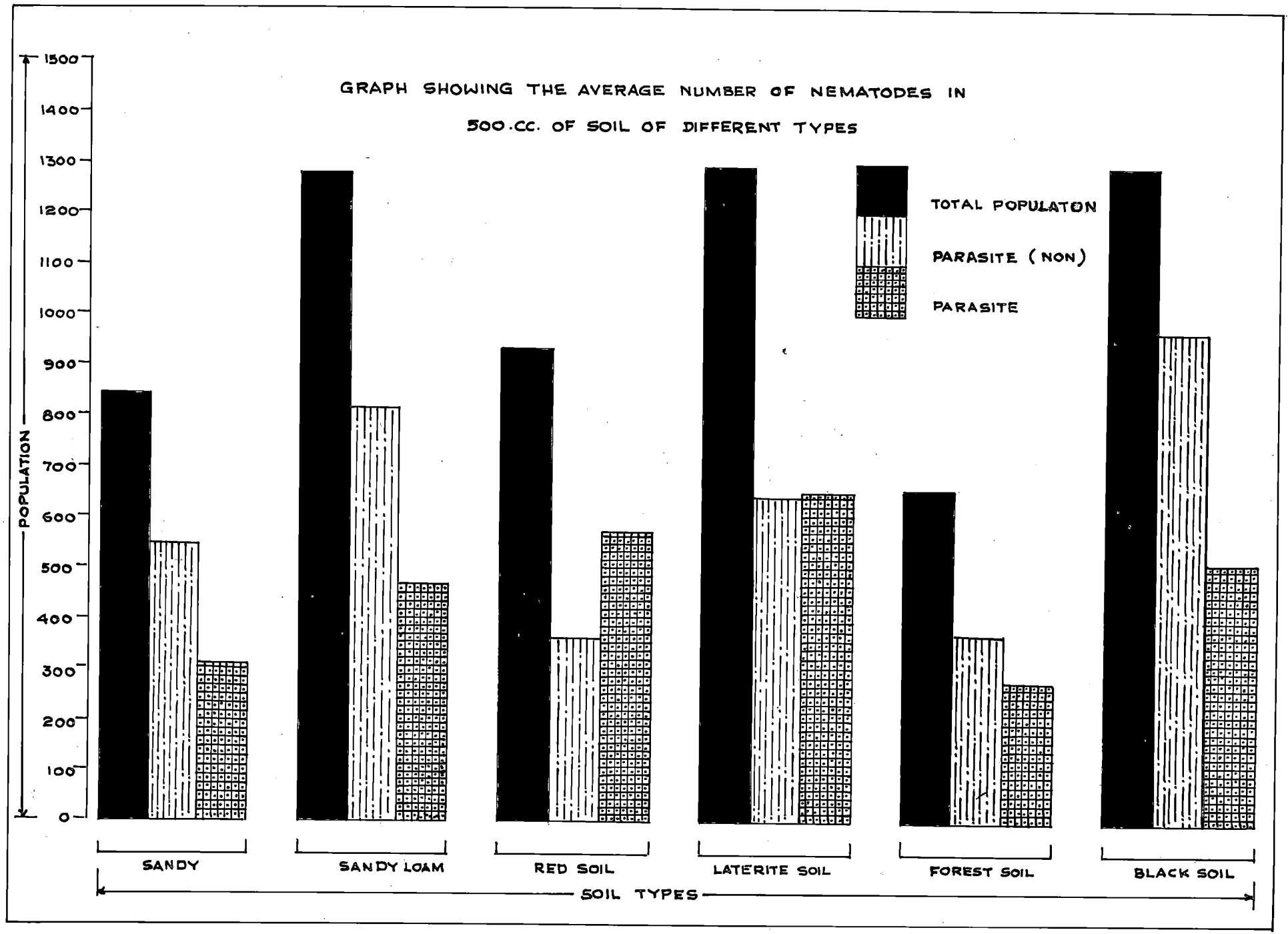
The genera Meloidogyne, Hoplolaimus, Nototylenchus, Aphelenchus, Pratylenchus and Criconemoids are seen in sandy, and sandy loam soils associated with vegetables, coconut and banana.

The genus Boleodorus is seen associated with Rubber in Laterite soil. The genus Tylenchorhynchus is seen in sandy loam associated with paddy. The rice root nematode Hirschmanniella oryzae was also seen associated with paddy in sandy loam soils of Onattukara.

TABLE 4

Average nematode population, pH, Organic matter contents and bacterial and fungal populations in different types of soils

Sl. No.	Type of soil	Nematode/500 cc of soil			pH	Organic matter percent	T.S.S.	Bacteria No/1 gm of soil in (Million)	Fungus No/1 gm of soil (in Million)
		Parasites	Non parasites	Total					
1	Sandy	309.8	536.2	846.0	6.38	1.11	0.02	11.9	4.74
2	Sandy loam	469.3	811.1	1280.4	6.22	1.64	0.24	13.35	4.08
3	Red soil	579.6	354.1	933.7	5.65	0.95	0.66	6.16	4.21
4	Laterite soil	645.5	642.0	1287.5	5.76	4.23	0.15	4.23	17.75
5	Forest soil	286.3	371.3	657.6	5.73	8.39	0.10	16.50	3.30
6	Block soil	512.0	976.0	1288.0	6.54	3.43	0.66	14.10	7.50


GRAPH SHOWING THE AVERAGE NUMBER OF NEMATODES IN
500.CC. OF SOIL OF DIFFERENT TYPES
POPULATION
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
TOTAL POPULATON
PARASITE (NON)
PARASITE
SANDY
SANDY LOAM
RED SOIL
LATERITE SOIL
FOREST SOIL
BLACK SOIL
SOIL TYPES

As regards the parasitic nematodes, whose population in soils has been studied it is observed that the soils collected from the lateritic area shows the maximum population closely followed by black soil, red soil and sandy loam. Sandy soil and Forest soil have the least population (Table 4).

The population of the non-parasitic forms shows a different picture; black soil gives the maximum population followed closely by sandy loam. Red soil and forest soils support the lest populations (Table 4).

The population of the parasitic and non-parasitic forms are comparatively high in laterite soil and are more or less equal in number. In both cases forest soil gives the least population. The forest soils were collected from the cultivated land of Madupetty. Madupetty is situated in the high ranges at attitude 4000-5000 ft., above M.S.L. The organic matter content of the soils is relatively high. As such it is logical to expect that the population of the non-parasitic forms will be high in these soils. The population of the nematode in the forest soils thus appears to be restricted and inhibited by factors other than the organic matter contents. An explanation for the low nematode population in these soils may have to be found in the texture of

the soil, crop, and also in the climatic factors existing in high ranges.

SUMMARY

SUMMARY

A total of 40 soil samples were collected and analysed to study the variations in the population of plant parasitic and non-parasitic soil nematodes with reference to the chemical and biotic environments existing in soil.

The total population of soil nematodes and the population of non-parasitic forms show a positive correlation with the pH of the soil within a range of 4.5-7.4. The parasite population is not correlated with the pH of the soil. There exists no correlation between the soil nematode population on the one hand and organic matter content, total soluble salts, and fungus and bacterial population of the soil on the other.

The populations of both parasitic and non-parasitic forms are high in association with vegetable crops. This is followed in the descending order by soils of banana, coconut arecanut and paddy.

The parasitic forms observed fall under 11 genera, viz. Helicotylenchus, Meloidogyne, Hoplolaimus, Anhelenchus, Nothotylenchus, Pratylenchus, creconemoids Tylenchus,

Tylenchorhyncus, Boleodorus and Hirschimanniella.

The genus Helicotylenchus is distributed in all types of soils in association with most of the crops. Hirschmanniella oryzae was observed on paddy at Kayamkulam.

The population of the parasitic forms is high in laterite soils, followed by black soil, red soil, and sandy loam. Sandy soils and forest soils have the least population.

The population of the non-parasitic forms is maximum in black soil, followed by sandy loam, laterite, red and forest soils.

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