EFFECT OF OIL CAKES ON SOIL NEMATODES OF BHINDI IN RELATION TO FUNGAL AND BACTERIAL FLORA AND pH OF SOIL

BY

J. JOSEPH, B.Sc. (Ag.)

THESIS

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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 bonafide research work carried out by Shri J.Joseph, under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

24.11.72

(J.Sam Raj),
D E A N
Faculty of Agriculture,
Kerala Agricultural
University.

22.9.72

(M.R.Gopalakrishnan Nair),
Director of Research.
Kerala Agricultural University,
Mannuthy, Trichur.

Agricultural College &
Research Institute,
Vellayani/Trivandrum,
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J. JOSEPH

C O N T E N T S

INTRODUCTION

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Recent studies have revealed that plant parasitic nematodes play an important role in limiting agricultural production. On account of their microscopic size they remained undetected and insidious. When proper methods of research were perfected more objective studies on these agricultural pests became possible and at present they have been recognized as a significant factor in scientific agriculture. In Kerala, for instance, studies undertaken so far have brought to light the presence of several destructive parasitic nematode species in soil. These include the burrowing-nematode, Radopholus similis, citrus nematode Tylenchulus semipenetrans, the rice root nematode Hirschemanniella oryzae, the root-knot nematode Meloidogyne incognita and the sugarcane nematode Helicotylenchus carebensis and Pratylenchus sp.

Soil nematodes are difficult to be controlled effectively. However there are two main methods for

controlling nematodes. They are cultural method of control and the chemical method of control.

Among the various methods proposed for the cultural control, modification of the soil environment occupies an important position. This method is designed in full accordance with the ecological principle that the soil population at any time will be determined by habitat conditions, and that the populations can, therefore be changed in any desired direction by making an appropriate change in the soil conditions. Major attention to bring about such changes has been given to exploration of the effects of various kinds of organic amendments especially those of green manures, dry crop residues, oil cakes and saw dust. Such materials can be made available by ploughing into the soil during normal farming practices.

The beneficial effects of plant residues and other organic amendments in reducing the parasitic nematode population were first demonstrated by Linford and his associates during 1936-38. Since then

a number of reports have been published showing that addition of a variety of organic substances to soil results in definite reduction of the population of plant parasitic nematodes.

The control of plant parasitic nematodes can be achieved by chemical fumigation. This method of control, however, has several limitations. The control obtained is of a temporary nature, the toxic materials get accumulated in soil, certain fumigants are ineffective in some types of soil, the chemical treatments are highly expensive and the chemicals are not easily available. Non-chemical methods of control through modified management practices such as use of organic and/or inorganic soil amendments causing changes in micro and macro-environment of the soil, though not as effective and quick as chemical methods, are expected to help in keeping nematode populations in soil at an innocuous level and also help in building up soil fertility. Such methods can be especially suitable for tropical and sub-tropical regions and for crops like vegetables.

The present studies were hence undertaken with the idea of exploring the possibilities of some of the locally available oil cakes being used as soil amendments for bringing about suppression of nematodes with special reference to the changes in fungal and bacterial populations and the soil reaction. An effort has also been made to understand how the changes caused to the bacterial and fungal populations and to soil reaction by the oil cakes are correlated with the soil nematode populations. In these studies eight oil cakes were used as soil amendments to determine their effect on the soil nematodes associated with bhindi crop.

REVIEW OF LITERATURE

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Soil nematode population is profoundly influenced by a number of factors, chemical as well as biological such as organic matter content of soil, pH of the soil, fungal flora of soil and bacterial flora of soil. Soil reaction, fungal flora and bacterial flora are in their turn influenced by the type and quantity of organic matter incorporated in the soil. Following is a review of literature pertaining to the above factors.

Peters (1926) could find little correlation between soil pH and cyst concentration of Heterodera rostochiensis in various districts of South Lincolnshire, England.

Godfrey et al (1933) found that pine apple raised in soils having pH ranging from 4.0 to 8.5 in Hawaii showed no difference in the infestation of Meloidogyne sp.

Linford et al (1938) observed reduction of galls on pine apple roots by the additions of chopped green

pine apple plants, coarse grass and cane sugar. Additions of pine apple plants approximately equivalent to 50, 100 and 150 tons per acre foot of soil gave progressively greater reductions in numbers of galls. The decomposition of these organic materials was found to result in the build up of nematode capturing fungi, non-trapping fungal parasites of nematodes, predacious nematodes and predacious mites.

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 potato root diffusate for hatching. Larval emergence decreased as pH fell from 6.7 to 4.0 and at pH levels of 3.4 and below there was no emergence at all.

Gill (1952) reported that application of tung-nut meal for controlling the root-knot nematodes was of no use as a soil treatment. But parathion when thoroughly mixed with soil gave very good control of root-knot nematodes.

Duddington et al (1956) observed that in microplot application of organic matter reduced the final population of the beet eelworm Heterodera schachtii. The fungus Dactylaria thaumasia had no effect on the final cyst population. But neither treatment affected final egg population. It was not known whether the organic matter lowered the cyst population by enhancing the effect of predaceous fungi in soil or by increase in the microflora and fauna, thus leading to increased competition for oxygen resulting in reduced egg hatching and larval activity of the eelworm.

Oostenbrink (1958) observed 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 sugar beet growth

to increase in pH caused by these treatments rather than to nematode control.

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.

Duddington and Duthoit (1960) found application of chopped cabbage leaves reduced infection of Hirschmanniella major on oats. Two nematode trapping fungi were identified, Arthrobotrys oligospora Fres. and Dactylaria haumaria Drechler. The plants in the control plots showed nematode injury.

Mankau (1960) found that many species of predaceous fungi captured and consumed root-knot larvae on agar in petri dishes. Arthrobotrys arthrobotyoides and Dactylaria thaumasia were very effective in petri dish cultures. When the fungi were added to root-knot infested soil without an organic amendment, treated pots indicated some nematode control with better control in amended soil.

In another test the species Dactylaria trochophaga, Arthrobotrys dactyloides, A. conoides and D. ellipsospora were inoculated into sterile soil in which tomato seedlings and root-knot larvae were added. None of the fungi gave adequate nematode control but plant survival was better than control in soils amended with sugar beet pulp and inoculated with Arthrobotrys conoides and Dactylaria ellipsospora.

Tarjan (1960) in his study of predaceous activity and growth of nematophagous fungi on various organic substances found that the nematophagous fungus, Dactylaria thaumasia growed and sporulated best on either sugarcane filtre press mud, combran, shreded peanut hulls or oat hulls. This fungus proved most effective in reducing populations of the nematode Panagrellus redivious in Erlenmeyer flasks, when the source of organic matter was either sugarcane bagasse, soybean mill feed, ground oat hulls, corn bran or stock yard manure.

Duddington et al (1961) inoculated Dactylaria thaumasia Drechler. into the soil infested with

Hirschmanniella avenae and then oat seeds of variety S.147 was sown. After the crop, the plants were lifted without root injury. The number of invading H.avenae were counted. Fungus and green manure separately and combined differed significantly from the untreated plots and fungus alone and combined differed significantly from green manure alone.

In 1958 a similar trial was made in spring oats in a field at Pathenghem Sharpshire heavily infested with cereal root eelworm. Six replicates of four treatments were applied, 1 oz of wet Dactylaria thaumasia mycelium with 0.5 lb of chopped cabbage leaves, fungus without chopped cabbage, and autoclaved mycelium alone. The first 3 treatments significantly and first two treatments differed from fourth.

In the two trials the effect of fungus in reducing the invasion of oat seedlings by eelworm larvae was obtained and the effect of the fungus with or without green manuring was significantly greater

than that of green manuring alone. In second trial green manuring without fungal inoculation failed to reduce eelworm invasion. It may have been due to the deficiency in the natural predaceous fungi at Pathenghem.

Hama and Wilkin (1961), while studying the control of Heterodera sp. by use of predaceous fungi under manured and unmanured conditions observed that in nematode infested soil, use of farm yard manure and green manure considered, gave better crops than in unmanured conditions irrespective of whether predaceous fungi were natured or artificially added.

Mankau (1962) while studying the effect of various organic additives, such as dung, (Steer manure) green manure, (alfalfa), rotted wood shavings, oat hay and chicken manure on nematode fauna found that there was a large increase in the number of microphagus nematodes in easily decomposible amendments. The population of predaceous Dorylaimus sp. was not influenced greatly by organic matter.

Mankau and Minteer (1962) observed that out of eight 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 eliminated 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.

Katznelson and Henderson (1962) studied the influence of actinomycetes and fungi isolated from soil and from plant roots on Rhabditis (Cephaloboides) oxycerca, a bacteria feeding nematode was studied. A striking accumulation of nematodes occurred in the vicinity of isolates, with little evidence of repulsion of the nematodes. Shake culture filters of a large percentage of actinomycetes tested strongly attracted the worms and non repelled or was toxic to them. It is suggested

that the commonly observed attraction of nematodes to plant roots may be due to not only to root diffusates but also to the abundance and activity of the soil micro-organisms in the vicinity of the roots.

Johnson (1962) studied the effect of some mature, dried crop residues (oat straw, and lespedeza hay) chopped to about 1/8 in particle size and mixed with soil infested with Meloidogyne incognita. The residues were added to soil at the rate of 1 per cent by weight. Residue amended and unamended soils were incubated for ten weeks under various environmental conditions, then tomato seedlings were transplanted and the soils were subjected to green house conditions. Significant control of root-knot was obtained in soils to which residues had been added and incubated at temperatures of 5-30°C. More control, however, was obtained in soils previously incubated below 20°C than that at 20°C or higher. Less root-knot occurred in unamended soils incubated under high moisture levels (80-100% MHC) than in soils incubated under lower ones. Significant control of root-knot was obtained under low

and medium moisture levels, by adding crop residues. In unamended soils, there was less root-knot at soil pH levels about 7.0 than at neutrality or below. Significant control of root-knot by adding oat-straw to soil was obtained at pH levels 4.6-7.0, with slightly more control at the lower pH levels (4.6-5.5). Survival of root-knot nematodes in soils incubated for 10 weeks under flooding conditions and at pH levels above 7.0 was comparable to the control obtained with crop residues under more normal, environmental conditions.

Mankau (1963) reported that the survival of nematode population could be correlated with high nitrate levels and decrease in pH. In vitro studies under pH concentrations on 7.7-8.0 plant parasitic nematode larvae were adversely affected by high NH_4^+ concentration.

Pramer (1964) reported the fungi Arthrobotrys, Dactylla and Trichothecium were found in soil amended with organic soil conditioners and the nematodes attacked struggled for a time and then appeared dead

or moribund. The body wall of nematode was penetrated and the fungus ramified throughout the carcasses, digesting and absorbing its contents. Fungi by means of hyphal loops trapped a large number of nematodes. The death was due to the production of a toxin by fungi.

Katznelson and Henderson (1964) in their studies on relationships between nematodes and other soil microorganisms tested the influence of actinomycetes, bacteria and fungi on Aphelenchoides parietinus (Bastain 1865) Steiner (1932) a fungus feeding nematode was studied. Thirty per cent of the actinomycete cultures tested showed some attraction for this nematode on agar plates. The filtrates from a number of these actinomycete cultures favoured accumulation of nematodes on areas of agar on which the fluids were spotted. In some instances the nematodes were repelled from these areas. Of the 60 bacterial isolates from the rhizosphere soil only one "attracted" the nematode most of the others repelled it. The filterates from most of these bacterial cultures were similarly unfavourable. The nematode aggregated strongly around

43 of 54 cultures of fungi and propagated on 32 of these. The results suggest that the microflora of the root zone may exert a marked effect on the accumulation of this nematode there in.

Katznelson et al (1964) studied the lytic action of soil myxobacters on certain species of nematodes. Three species of bacterium feeding nematodes, Caenorhabditis briggsae, Rhabditis oxycera and Panagrellus sp. were lysed by two out of three soil isolates of myxobacters in liquid and agar medium. Aphelenchus avenae a fungus feeding nematode and Heterodera trifolii a cyst forming plant parasite, was unaffected by the myxobacters. Lysis of the nematodes was also shown spectrometrically by the decrease in optical density of a nematode homogenate following addition of an enzyme concentrate from a cell free fluid culture of one of the myxobacters and by the increase in trichloracetic acid, soluble tyrosine residues in the mixture after 15-20 minutes incubation. The enzyme concentrate could be separated into a lytic fraction that dissolved the nematodes and a "proteolitic" fraction that did not lyse.

Singh (1965) while studying the effect of organic soil amendments and fertilizers on incidence of root-knot and yield of okra in nematode infested soil, observed that silt loam soils infested with Meloidogyne javanica showed that among organic soil amendments (Farm yard manure, saw dust and castor cake) and fertilizers used, saw dust (24 Q/ha) mixed with soil one month before sowing reduced the intensity of root galls on okra. Sawdust and high level K treatments reduced the number of galls than plants in untreated plots. Saw dust and NPK fertilizers gave 60 per cent more yield than untreated plants. The use of simple organic amendments such as saw dust in combination with fertilizers can be taken up as a practice to have a good crop from root-knot infested soil.

Singh (1965) reported that in pot-culture experiments karanj cake (Pongamia glabra) could reduce root-knot by about 50 per cent at low field dosages and by 100 per cent at high dosages.

Sayre et al (1965) studied the nematocidal components in extracts of plant residues decomposing

in soil. Extracts obtained from rye (Secale cereale) and timothy (Phleum pratens) plant residues decomposing in soil under laboratory and field conditions were tested and found to be selectively nematocidal to two species of plant parasitic nematodes, Meloidogyne incognita and Pratylenchus penetrans. They were non toxic to saprophytic nematode species when used at similar concentrations. By means of chromatographic and nematode bioassay techniques some of the nematocidal components in the extracts were isolated. One of these was identified as butyric acid. Chemical behaviour and nematocidal activity of chemically pure butyric acid and that isolated from the decomposing plant residues were compared and found to be identical. Butyric acid and residue extracts were nematocidal only in the pH range of 4.0 to 5.3.

Banage and Visser (1965) studied the effect of some fatty acids and pH on a soil nematode. Observations are presented on the effect of fatty acid solutions on a Dorylaimid nematode, Dorylaimus sp. Formic, acetic, propionic, butyric and veleric acids in distilled water at nine concentrations ranging from

1/μ to 0.001 μ were exceptionally toxic to the nematode which however, was not affected by a 0.0001 u solution and considerably less so by sodium salts of the acids. Evidence was obtained that the undissociated acid molecule was the chief toxic factor. Formic acid was less toxic at any value while at all other acids were similar to each other in their effects.

Singh and Sitaramaiah (1966) reported that oil cakes of margosa, castor and pea nut when applied to infested soil in pots at rates of 0.2 p.c.(w/w) and higher, 3 weeks before planting significantly reduced the intensity of root galls of okra and tomato caused by Meloidogyne javanica.

In field experiment a dosage of 1600 lb/acre of anyone of these cakes resulted in better plant growth and significant reduction in the incidence of root-knot in okra. Roots of plants grown in amended soil contained a fewer numbers of eggs larvae and mature females than the roots of plants raised in unamended soil. Water extracts of soil amended with oil cakes at the rate of 2 p.c. inhibited liberation of egg masses and hatching of larvae for at least 6 days.

Johnson et al (1967) reported that when mature crop residues chopped to about 1/8" particle size were incorporated into soils in field plots infested with Meloidogne incognita root-knot infestation was reduced by alfalfa hay, oats straw, lespedeza hay and flax hay amendments. Better reduction was obtained when amended with 10 tons/acre instead of 5 tons and 8 months before than before shorter periods.

Walker et al (1967) reported that soyabean meal and certain plant derived oil reduced the population of Pratylenchus penetrans. The nematocidal effect was apparent at 16°C and 25°C incubation and independent of the time that the soyabean meal was present in the soil.

Hameed (1968) studied the efficacy of the oil cakes, karanj cake, castor cake, linseed cake, and safflower cake on the incidence of root-know nematodes. The effect of decomposition of these oil cakes was tested by planting two weeks old tomato seedlings at three different periods of intervals viz. (1) planting

just after inoculation, (2) 15 days after inoculation, (3) 30 days after inoculation. The dose used was 5 gm per 1800 g of soil.

Planting 15 days after inoculation had a distinct effect on decreasing the nematode incidence in all treatments, but later it increases. This shows that at a particular stage of decomposition the nematodes are controlled. The number of galls per plant were found to be minimum in mustard oil cake (19.90 galls). The others found in the order of efficacy were karanj (54.67 galls/plant) and linseed (86.43 galls/plant) followed by groundnut (92.81 galls/plant). The toxic effect of mustard may be due to the presence of allyl isothyiocyanate in the mustard cake as observed by Ellenby (1945).

Desai et al (1969) observed that nematophagous fungi Dactylaria sp. could become effective in controlling nematodes of tobacco if given along with organic manure such as farm yard manure.

Desai et al (1969)(a) stated that the use of nematophagous fungi generally found in almost all soils

controlled the parasitic nematodes. The nematophagous fungus Dactylaria sp. become effective when applied along with organic matter such as farm yard manure.

Khan et al (1969) while studying the effect of organic amendments on the population of nematodes and fungi in the rhizophere of egg plant found that as a result of the application of oil cakes of neem, mahua, groundnut and castor the population of Tylenchorhynchus sp., Hoplolaimus sp., Helicotylenchus sp., Rotylenchus reniformis, Meloidogyne incognita was considerably suppressed. All the oil cakes failed to suppress the population of saprozoic form except mahua cake. Similarly the application of oil cakes adversely affected the population of Colletotrichum sp., Rhizoctonia sp., Fusarium sp. and not Trichoderma lignorum.

Mobin and Khan (1969) studied the effect of certain organic amendments on the rhizosphere fungi and nematode fauna of guava, (Psidium guajava), Phalsa, (G.asiatica) and Citrus sp. Oil cakes of neem, mahua,

ground nut and mustard were effective in reducing the population of fungi and stylet bearing nematodes around the roots of guava, phalsa and citrus.

Sitaramaiah et al (1969) reported that weak molar solutions of butyric and propionic acids increase egg liberation and hatching of Meloidogyne javanica.

Nair and Mohandas (1969) reported that the total population of soil nematodes and the population of non parasitic forms show a positive correlation with pH of the soil within a range of 4.5-7.4. The parasitic population is not correlated with pH of the soil. They also found that there exists no correlation between the soil nematode population on the one hand and organic matter content, total soluble salts, fungus and bacterial population of the soil on the other.

Gour and Prasad (1970) found that when alluvial soil amended with wheat straw (0.45% C) neem cake (0.05% C) and Farm yard manure (0.5% C) 6 weeks prior to sowing and amended with daincha four weeks prior

to planting along with fertilizers NPK, enhanced the saprozoic population of nematodes tremendously in all the plots amended with the organic matter alone. The increase in the plant parasitic nematode population was comparatively low. They found that application of NPK in the absence of any organic matter amendment increased the plant parasitic nematodes. Neem cake appreciably decreased the population of plant parasitic nematode over the control. It is worthy to note that although NPK increased the plant parasitic population as compared to NPK alone and neem cake was the most effective in lowering their numbers and it was comparable to control. It is concluded that organic matter particularly neem cake has essentially components for controlling the proliferations of plant parasitic nematodes.

Singh and Sitaramaiah (1971) reported that amendment of root-knot (Meloidogyne javanica) infested soil with saw dust and oil cakes of margosa, castor, peanuts, mustard, mahua and linseed at the rate of 25 quintals per hectare gave effective reduction in the intensity of root galls on okra and tomato. This also

gave increased yields. Nitrogen deficiency by saw dust application was eliminated when oil cakes and saw dust were mixed. Highest degree of control was given by peanut and margosa cakes. The treatments not only reduced disease intensity but also the number of eggs, larvae, and adult females in root tissues of plants growing in the amended soil. The increase in yield was related to decrease in root galls.

Singh and Sitaramaiah (1971) reported that effective control of Meloidogyne javanica can be achieved if the soil is amended with 25 Q/ha (2200 lb/ acre) saw dust 3 weeks before planting followed by inorganic nitrogenous fertilizers along with P and K applied at the time of planting. Urea is the most effective source of nitrogen and the degree of control increases with increase in the amount of nitrogen applied after saw dust amendment. Not only is the intensity of root galls reduced but several fold increase in yield has also been obtained by this treatment. Best results were observed with 120 kg nitrogen per hectare.

Premkumar and Nair (1971) reported that the population of the parasitic nematodes viz. Meloidogyne sp.

and Helicotylenchus sp. was significantly reduced by the use of all the different soil conditioners used in infested soil. The soil conditioners tested were saw dust, coconut husk powder, paddy husk, mango leaves, cashew leaves, calotropis leaves, Eupatorium leaves, lemon grass leaves, paddy straw, cashew shell powder, press mud, coconut oil cake and farm yard manure. They found that there was a tremendous multiplication of saprophytic nematodes. All the treatments were found to increase the growth and yield of plants over the control.

MATERIAL AND METHODS

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MATERIALS

Oil cakes used

Coconut oil cake	-	*Cocos nucifera*
Castor oil cake	-	*Ricinus communis*
Gingelly oil cake	-	*Sesamum indicum*
Ground nut oil cake	-	*Arachis hypogea*
Mahua oil cake	-	*Bassia latifolia*
Maroti oil cake	-	*Hydnocarpus wightiana*
Neem oil cake	-	*Azadirachta indica*
Undi cake	-	*Calophyllum inophyllum*

Nematicides used

D, D-mixture

Nemagon

The experimental site

The experiment was conducted in the dry land of the Agricultural College Farm, Vellayani. The soil was of the red loam type. Analysis showed that the soil contained 0.049 per cent nitrogen, 0.0024 per cent available P_2O_5 and 0.0230 per cent available K_2O.

The area selected was ascertained to be infested with root-knot nematode and also other forms of parasitic nematodes.

Seeds used

Bhindi seeds used were of variety "Pusa sawani" supplied by Pestonjee Pocha's vegetable and fruit nurseries, Poona.

Media used for plating.

Fungus

Peptone-dextrose agar with rose bengal and streptomycin (Martin, 1950).

Dextrose	-	10 g
Peptone	-	5 g
KH_2PO_4	-	1 g
$MgSo_4$	-	0.5 g
Agar agar	-	15 g
Rose bengal	-	1 part in 30000 parts of the medium

Bacteria

Soil extract agar (Taylor and Loch-head 1938)

Soil extract	-	1000 ml
K_2HPO_4	-	0.2 g
Agar agar	-	15 g

Other materials used

They included nematode sieves, plastic basins, Baermanns' funnel, tissue papers, wire gauze, polythene bags, formalin, wash bottles, beakers, pH meter, conical flasks, petri dishes etc.

METHOD

Design and layout

The experiment was laid out in randomised block design with 3 replications. The blocks and plots were demarkated by bunds formed by soil taken from outside the site of the experimental field.

The details of the layout were as follows:-

Gross plot size	- 2.30 x 1.30 M
Net plot size	- 1.50 x 0.90 M
Spacing	- 0.75 x 0.45 M
Net area of each plot	- 1.35 sq.M
Total area	- 88.20 sq.M

Treatments

There were altogether 10 treatments and 2 control as detailed below:

T_1	Coconut oil cake	- 2500 kg/hectare
T_2	Castor oil cake	- 2500 kg/hectare
T_3	D,D - mixture	- 200 kg/hectare
T_4	Gingelly oil cake	- 2500 kg/hectare
T_5	Ground nut oil cake	- 2500 kg/hectare
T_6	Mahua oil cake	- 2500 kg/hectare
T_7	Maroti oil cake	- 2500 kg/hectare
T_8	Nemagon	- 11 litres/hectare a.i.
T_9	Neem oil cake	- 2500 kg/hectare
T_{10}	Undi oil cake	- 2500 kg/hectare
T_{11}	Control	- No treatments
T_{12}	Control	- No treatments

Field culture

The experimental area was initially dug and then lay out of the field was carried out. Bunds were taken with soil outside the site of the experimental field. Each plot was dug upto a depth of 60 cm, clods broken and soil pulverised to a fine tilth.

Application of treatments

(a) Oil cakes

The required quantity of powdered oil cakes were

applied to each plot and then thoroughly mixed with the soil. Watering was done daily for 21 days for the proper decomposition of the oil cakes.

(b) Application of nematicides

D,D-mixture was injected into the loose soil at the rate of 2 cc per injection at a distance of 1 foot. Immediately after injection the plot surface was compacted to avoid loss of the fumigant.

Nemagon was injected into the loose soil at the rate of 0.17 cc per injection at a distance of 1 foot. Immediately after injection the plot surface was compacted. No irrigation was done to the plots treated with nematicides.

Sowing

Four shallow pits of 30 cm diameter were taken at a spacing of 75 x 45 cm in each plot and 4 seeds were dibbled in each pit. Twenty days after germination all plants excepting one were removed from each pit.

Application of fertilizers

Fertilizers were applied at the rate of 75 kg N, 100 kg P_2O_5 and 50 kg K_2O per hectare. The entire

quantity of super phosphate and muriate of potash and one third of ammonium sulphate were given as basal dressing. The balance quantity of ammonium sulphate was top dressed 20 and 30 days after the first application in two doses.

Irrigation

Watering was done twice daily for the first month and once a day subsequently. This ensured high moisture content in the soil which was essential for the decomposition of the previously applied soil conditioners and for proper survival of nematodes.

Collection of samples for nematode counts

For the assessment of pretreatment nematode population, soil samples from all the plots were collected prior to the application of treatments. From each plot soil was taken from 4 places, from the root zones of the plants and upto a depth of 25 cm. Samples thus collected were mixed thoroughly and 500 g of it was taken and packed in a polythene bag. Thus 36 samples were collected for each observation. Then the samples taken from the plots in which the same treatment was given was again mixed together and a composite

sample of 500 cc was taken in polythene bags for further processing.

Washing the soil samples for nematode separation

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

The soil sample was transferred to a plastic basin and mixed thoroughly with 1500 cc of water, coarse particles, foreign materials etc. were allowed to settle. Then the supernatent liquid was passed through 60 mesh sieve and the materials collected in the sieve and the sediments in the basin were discarded. The filtrate was allowed to stand for a few minutes and then decanted and passed through 325 mesh sieve. The fine silt and nematodes collected in these sieves were washed down into a beaker, using a wash bottle with the minimum quantity of water.

Isolation of nematodes by Baermann funnel

The nematode suspension obtained after washing through sieves was poured gently into a tissue paper kept in position in the Baermann funnel with the help of a wire gauge. The funnel was filled with water upto

a level just touching the tissue paper. The funnel was kept undisturbed and at the end of 24 hours about 10 cc of water was drawn out into a specimen tube by loosening the pinch cock.

Fixing and preservation of nematodes

The nematode suspension obtained from the drawings from the Baermann funnel were allowed to settle and the volume was reduced to 5 cc by pipetting out water from the top. To this an equal quantity of boiling 10 per cent formalin was added to kill the nematodes. To ascertain whether the nematodes were properly killed a drop was examined under a binocular microscope.

Counting the nematodes

The preserved suspension of nematodes was reduced to 10 cc by pipetting out liquid from the top. Then it was shaken well and 1 cc was taken and transferred to a counting slide by means of a 1 ml pipette. Meloidogyne sp., Helicotylenchus sp. and saprophytic forms were counted separately and recordings were done. Ten times of this count gave the population in 500 cc soil processed.

Determination of total fungi and bacteria

The method adopted in the present studies was the soil dilution and plate counts Timonin (1940) for assessing the total fungal and bacterial populations. 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 were the details of the procedures adopted.

One gram of soil 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 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 of solution was pipetted to 99 cc of sterile water. Thus the dilution was made to one in 100 x 100 x 100 ie. 1 in 1000000. All the transfers were done under aseptic conditions using sterile pipettes, sterilised previously with one end plugged with cotton wool.

One ml each of this final dilution was plated in sterile petri dishes along with 15 ml of melted and cooled medium. Different media were used for getting colony counts of the two groups of microorganisms. Soil extract agar was used for bacteria and peptone dextrose agar with rose bengal and streptomycin for fungi.

Plating was done using the method suggested by Timonin (1940). One ml of the final dilution was transferred to sterile petri dish using a sterile 1 ml pipette.

The plate was rotated gently so as to get a uniform spread of the soil dilution in the plate. Medium melted and cooled to 48°C was then poured over the dilution and the petri dish was again rotated in a swirling movement so as to get an even spread of the soil dilution in the medium.

Soil dilutions were plated in triplicate for each group of microorganisms. The plates were then incubated at room temperature ie., about 28°C to 30°C for about 14 days. Counts for the fungal colonies were

taken after 5-7 days after plating, as soon as the colonies began to appear.

The dishes were examined daily and fast growing colonies were taken out aseptically after recording the counts, in order to prevent the deasimination of spores from these colonies. For bacteria an incubation period of 10-14 days was given before final counts were taken. For taking colony counts Spencer's Dark Field Quebec Colony Counter was used. The average number per treatment is multiplied by the dilution factors to obtain the number per gram in the original soil sample. The counts are expressed in millions per gram of the soil on dry weight basis.

Determination of dry weight of soil

The soil sample used for dilution was made free of excess water by keeping in between sterile blotting papers. Two samples of the dried soil were weighed separately. One sample was put in a previously weighed clean china dish and dried for 6 hours in a hot air oven, at a temperature of 105^{0}-110^{0}C till the entire moisture got evaporated. The dish was allowed to cool inside the oven itself over night and weighed

to obtain the dry weight of the soil used. The other sample was used for preparing soil dilution.

Determination of pH

pH was measured potentiometrically in 1:2.5 water suspension. Ten grams of air dry soil was taken in a beaker and 25 cc of distilled water added to it. This was kept for half an hour with intermittent stirring. The pH was measured directly using glass electrode after the final stirring.

Calendar of operations

23-12-1971 - Digging the site of experiment

24-12-1971 - Lay out of the field

25-12-1971 - Taking bunds

26-12-1971 - Digging the plots collection of pretreatment soil samples

27-12-1971 - Application of treatments

18-1--1972 - Taking pits in plots for sowing. Collection of second soil sample, Basal dressing with fertilizers, Dibbling.

7--2--1972 - Top dressing and thinning

18-2-1972 - Top dressing

4--3-1972 - Taking soil samples (Third time)

18-4-1972 - Uprooting plants.
Taking soil samples at the end of the crop.

Yield of fruits was recorded at two days interval from 47th day of sowing.

RESULTS

RESULTS

Effect of oil cakes on soil reaction

In table-1 is given the data on the pH recorded before the application of the oil cakes to soil and at different intervals thereafter. It may be seen that the pH recorded an initial increase in plots receiving the oil cakes excepting neem oil cake; a decrease in pH was evidenced in plots receiving neem cake. The initial increase in pH recorded in the plots was temporary only as subsequently it decreased and went back to the pretreatment level. In plots treated with the nematicides, D,D-mixture and nemagon, the pH was found to have decreased from the original pretreatment level (Fig.1).

Effect of oil cakes on fungal population in soil

Table-2 gives the recordings of fungal population done at different occasions. The fungal population in the case of oil cake treated plots after decomposition was found to have increased in all cases over the control and over the pretreatment population; the greatest increase in population was

TABLE-I

pH readings of soil at different occasions and under different treatments

Treatment	Occasions			
	Pre-treatment.	21 days after application of oil cakes	45 days after application of oil cakes	90 days after application of oil cakes
Coconut oil cake	5.0	5.3	5.0	5.0
Castor oil cake	5.0	5.5	5.0	5.0
D,D-mixture	5.3	5.2	5.1	5.1
Gingelly oil cake	5.1	5.3	5.0	5.1
Groundnut oil cake	5.3	5.6	4.9	5.0
Mahua oil cake	5.2	5.3	5.1	5.1
Maroti oil cake	5.1	5.5	5.1	5.1
Nemagom	5.2	5.1	5.2	5.2
Neem oil cake	5.3	5.2	5.1	5.1
Undi cake	5.2	5.3	5.2	5.2
Control-I	5.1	5.1	5.1	5.1
Control-II	5.2	5.2	5.2	5.2

TABLE-2

Fungal population in soil at different occasions and under different treatments expressed in million per g of dry soil

Treatment	Occasions			
	Pre-treatment	21 days after application of oil cakes	45 days after application of oil cakes	90 days after application of oil cakes
Coconut oil cake	1.5	7.0	7.3	4.9
Castor oil cake	1.5	2.4	5.2	0.9
D,D-mixture	1.5	3.0	4.0	0.9
Gingelly oil cake	1.8	2.1	5.5	1.5
Groundnut oil cake	1.5	6.4	3.0	1.5
Mahua oil cake	2.1	0.6	12.2	0.9
Maroti oil cake	2.1	4.9	3.7	1.8
Nemagon	1.5	0.0	3.0	1.5
Neem oil cake	0.6	5.8	6.4	0.9
Undi oil cake	0.9	6.1	5.5	0.6
Control-I	1.5	3.0	6.4	2.4
Control-II	1.5	1.2	4.0	0.9

observed (7.0 million/gm dry soil) in plots receiving coconut oil cake followed by groundnut cake and neem cake.

In plots treated with nemagon the fungal population was nil when plated 21 days after treatment.

The fungal population except in a few treatments tended to remain steady or to come down and attain the pre-treatment value as time elapsed (Fig.2).

Effect of oil cakes on bacterial population in soil

The data on the bacterial population is given in table-3. It may be seen that at all the occasions following application of oil cakes the bacterial population has increased over the control as well as over pre-treatment population in all the treatments. The bacterial population attained its zenith in the middle of the crop beyond which it decreased (Fig.3).

Effect of oil cakes on the nematode population in soil

Pre-treatment population

The populations of the two commonly occurring parasitic forms viz., Meloidogyne sp. and Helicotylenchus sp. and that of the non-parasitic forms present in

TABLE-3

Population of bacteria in soil at different occasions and under different treatments expressed in million per g of dry soil

Treatment	Occasions			
	Pre-treatment	21 days after application of oil cakes	45 days after application of oil cakes	90 days after application of oil cakes
Coconut oil cake	4.3	16.4	13.7	9.4
Castor oil cake	4.0	10.0	21.0	7.6
D,D-mixture	4.0	8.2	28.0	8.2
Gingelly oil cake	4.0	19.5	25.3	10.5
Groundnut oil cake	4.0	8.0	19.2	7.0
Mahua oil cake	3.3	11.3	19.5	7.3
Maroti oil cake	4.0	14.6	20.1	10.0
Nemagon	3.3	14.3	20.4	10.3
Neem oil cake	4.0	7.6	13.7	6.0
Undi oil cake	3.0	10.6	18.3	8.5
Control-I	3.0	8.8	10.0	4.6
Control-II	3.3	7.3	18.6	5.2

the soil before the application of oil cakes are given in tables 4,5 and 6.

Nematode population 21 days after oil cake application

The counts of nematodes in 500 g sample of soil made 21 days after the application of the treatments are given in tables 4,5 and 6. It may be seen that the population of Meloidogyne sp. decreased in all the treatments. The population of Helicotylinchus sp. was found to remain more or less constant. There was a tremendous increase in the number of non-parasitic nematodes in all the oil cakes treated plots.

In the case of nematicidal treatments D,D-mixture and nemagon, the population of non-parasitic nematodes had decreased over the pretreatment count. There was also a decrease in the number of parasitic forms.

Nematode population 45 days after oil cake application

Tables 4, 5 and 6 gives the results of nematode count at this occasion. It may be seen that the Meloidogyne sp. had decreased to the minimum in this stage. Similar was the results of counts of

TABLE-4

Population of Meloidogyne sp. in 500 g soil at different occasions and under different treatments

Treatment	Occasions			
	Pre-treatment	21 days after application of oil cakes	45 days after application of oil cakes	90 days after application of oil cakes
Coconut oil cake	270	230	30	50
Castor oil cake	270	140	20	60
D,D-mixture	210	30	20	70
Gingelly oil cake	240	210	30	20
Groundnut oil cake	160	80	180	40
Mahua oil cake	140	30	30	20
Maroti oil cake	280	170	40	70
Nemagon	510	40	30	80
Neem oil cake	360	220	30	60
Undi oil cake	250	240	20	70
Control-I	260	260	90	140
Control-II	250	160	140	160

TABLE-5

Population of *Helicotylenchus* sp. in 500 g soil at different occasions and under different treatments

Treatment	Occasions			
	Pre-treatment	21 days after application of oil cakes	45 days after application of oil cakes	90 days after application of oil cakes
Coconut oil cake	400	400	70	140
Castor oil cake	520	280	50	80
D,D-mixture	330	90	70	30
Gingelly oil cake	370	550	60	90
Groundnut oil cake	300	200	180	70
Mahua oil cake	290	80	130	30
Maroti oil cake	470	290	90	120
Nemagon	700	600	50	110
Neem oil cake	570	310	50	80
Undi oil cake	390	400	40	150
Control-I	340	770	40	150
Control-II	350	390	90	120

TABLE-6

Population of saprophytic nematodes in 500 g soil at different occasions and under different treatments

Treatment	Occasions			
	Pre-treatment.	21 days after application of oil cakes	45 days after application of oil cakes	90 days after application of oil cakes
Coconut oil cake	530	1700	910	740
Castor oil cake	850	1760	390	580
D,D-mixture	510	390	920	600
Gingelly oil cake	518	2470	990	430
Groundnut oil cake	480	1530	2170	1000
Mahua oil cake	460	490	1190	390
Maroti oil cake	580	1880	1010	550
Nemagon	850	800	1160	510
Neem oil cake	740	2750	1080	860
Undi oil cake	490	2980	530	630
Control-I	470	1170	390	340
Control-II	450	440	610	380

Helicotylenchus sp. Here the non parasitic forms in most cases decreased from the previous observation but was far higher than the control plots.

Nematode population 90 days after oil cake application

Tables 4, 5 and 6 gives the results of nematode counts at this occasion. Here it is observed that both the parasitic forms tended to increase in number over that in the previous occasion. At the same time the nonparasitic forms showed a decrease in population.

Effect of oil cake treatments on the yield of Bhindi fruits

The yields were recorded in terms of number of fruits and weight of fruits. Total yield upto 90th day was taken together. The results are presented in tables 7 and 8. It is observed that the yield both in respect of numbers and weight showed significant effects due to different treatments on the yield over the control plots. In plots receiving 'maroti' cake the yield was the maximum both fruit number basis and weight basis followed by D,D and nemagon.

TABLE-7

Mean yield of Bhindi fruits in grams under different treatments

Treatment No.	Treatment	Mean yield
T_7	Maroti oil cake	1644.33
T_3	D,D-mixture	1147.66
T_8	Nemagon	1108.33
T_6	Mahua oil cake	1036.33
T_2	Castor oil cake	880.66
T_4	Gingelly oil cake	833.66
T_5	Groundnut oil cake	754.66
T_{10}	Undi oil cake	747.00
T_1	Coconut oil cake	598.66
T_0	Control	476.00
T_9	Neem oil cake	385.33
C.D. for comparison between treatments		444.21
C.D. for comparison of treatment vs. control		385.87

T7 T3 T8 T6 T2 T4 T5 T10 T1 T0 T9

TABLE-8

Mean number of Bhindi fruits under different treatments

Treatment No.	Treatment	Mean yield
T_7	Maroti oil cake	67.33
T_3	D,D-mixture	54.00
T_8	Nemagon	44.33
T_5	Groundnut oil cake	43.00
T_2	Castor oil cake	42.33
T_6	Mahua oil cake	36.33
T_{10}	Undi oil cake	33.66
T_4	Gingelly oil cake	33.00
T_1	Coconut oil cake	25.00
T_0	Control	21.66
T_9	Neem oil cake	19.33
C.D. for comparison between treatments		19.45
C.D. for comparison of treatment vs control		16.97

T7 T3 T8 T5 T2 T6 T10 T4 T1 T0 T9

Correlations studied

All possible correlations between nematode population on the one hand and pH, fungal population and bacterial population on the other were calculated. The results were presented in table 9.

It may be seen that the correlation between pH and nematode population was in general positive. With total nematodes the correlation was not significant (+ 0.186).

The correlation between pH and population of parasitic nematodes (+ 0.350) was significant at 5 per cent level.

The correlation between pH and population of saprophytic nematodes (+0.473) was significant at both the levels indicating a strong positive correlation between the two factors.

The correlation between fungal population and total nematodes was positive (+0.091) but not significant.

The correlation coefficient between fungal population and population of parasitic nematodes (-0.289) was negative but not significant.

TABLE-9

Correlation between the soil factors and nematode population in soil

Sl. no.	Factors	Correlation coefficient(r)
1	pH vs. total nematode population in soil	+ 0.186
2	pH vs. parasitic nematode population of soil	+ 0.350
3	pH vs. saprophytic nematode population of soil	+ 0.473
4	Population of fungus vs. total nematode population of the soil	+ 0.091
5	Population of fungus vs. parasitic nematode population of the soil	- 0.289
6	Population of fungus vs. saprophytic nematode population of the soil	+ 0.459
7	Population of bacteria vs. total nematode population of the soil	+ 0.031
8	Population of bacteria vs. parasitic nematode population of the soil	- 0.507
9	Population of bacteria vs. saprophytic nematode population of soil	+ 0.275

The correlation between fungal population and population of saprophytic nematodes (+0.459) was significant at both levels indicating a strong positive correlation between the two factors.

The correlation between bacterial population and total nematodes was (+0.031) not significant.

The correlation between bacterial population and population of parasitic nematodes (-0.507) was significant at both levels indicating a strong negative correlation between the two factors.

The correlation between bacterial population and population of saprophytic nematodes (+0.275) was not significant.

DISCUSSION

DISCUSSION

A perusal of the review presented will show that use of organic soil amendments are highly effective in minimising the damage caused to crop by parasitic nematodes. This has been attributed to various factors such as nematicidal activity of the decomposition products (Sayre et al 1965; Sing and Sitaramaiah 1966; Hameed 1968; Ellenby 1945), production of nematophagous fungi (Linford et al 1938; Dudington et al 1956; Mankau 1962, Pramer 1964) and increase in population of predacious nematodes (Mankau 1962; Gour and Prasad 1970). In the present studies an effort has been made to understand the effect of oil cakes applied as amendments in soil on the fungal and bacterial population and on soil reactions and how these effects are correlated with the soil nematode populations.

The results presented will show that in general there exists a positive correlation between soil pH and nematode population. This correlation has been found to be highly significant in the case of

saprophytic forms. This result is in general agreement with the observations of previous workers. The data presented on the variations in pH consequent on the addition of soil amendments will show that there is a tendency for the soil pH to increase in the beginning though ultimately it goes back to the original level. On the other hand the addition of the amendments are highly effective in reducing the population of the parasitic forms. These are apparently conflicting. This may be due to the interference or operation of other factors associated with the application of the soil amendments.

The data presented on the effect of oil cakes on the fungal population have shown that the addition of the oil cakes has considerably increased the soil population of fungal organisms. As far as correlation between fungal population and nematode population is concerned it has been in evidence that while the correlation between fungal and parasitic nematode populations is negative (Fig. 2,3) the correlation between fungal and nonparasitic nematode populations is

FIG.I

Graph showing pH readings under different treatments.

1. Coconut oil cake
2. Castor oil cake
3. D,D-mixture
4. Gingelly oil cake
5. Groundnut oil cake
6. Mahua oil cake
7. Meroti oil cake
8. Nemagon
9. Neem oil cake
10. Undi oil cake
11. Control-II
12. Control-II

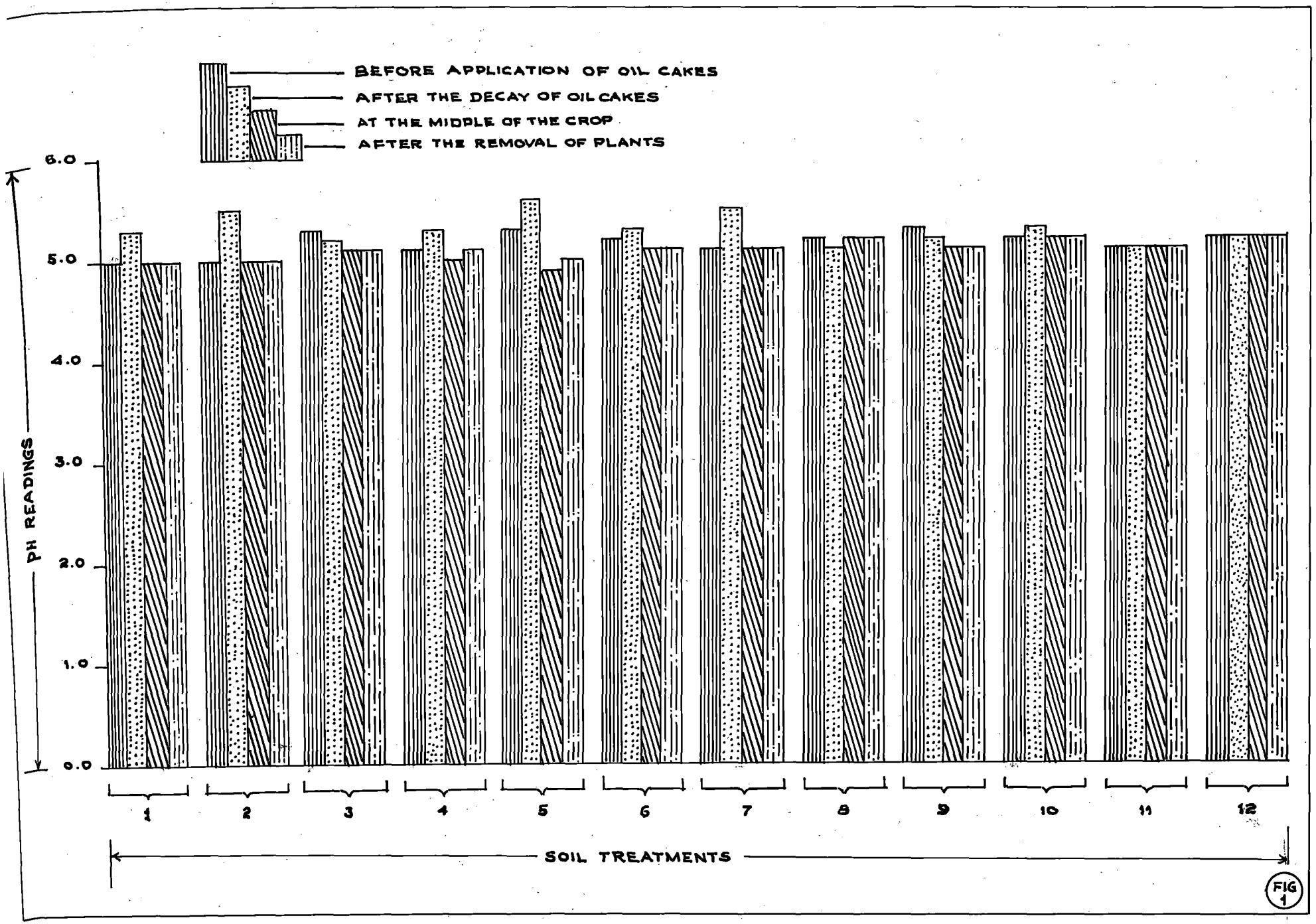

BEFORE APPLICATION OF OIL CAKES
AFTER THE DECAY OF OIL CAKES
AT THE MIDDLE OF THE CROP
AFTER THE REMOVAL OF PLANTS
6.0
5.0
4.0
3.0
2.0
1.0
0.0
PH READINGS
1
2
3
4
5
6
7
8
9
10
11
12
SOIL TREATMENTS
FIG 1

FIG. II

Graph showing *Meloidogyne* sp. and fungal population

1. Coconut oil cake
2. Castor oil cake
3. D, D-mixture
4. Gingelly oil cake
5. Groundnut oil cake
6. Mahua oil cake
7. Maroti oil cake
8. Nemagon
9. Neem oil cake
10. Undi oil cake
11. Control-I
12. Control-II

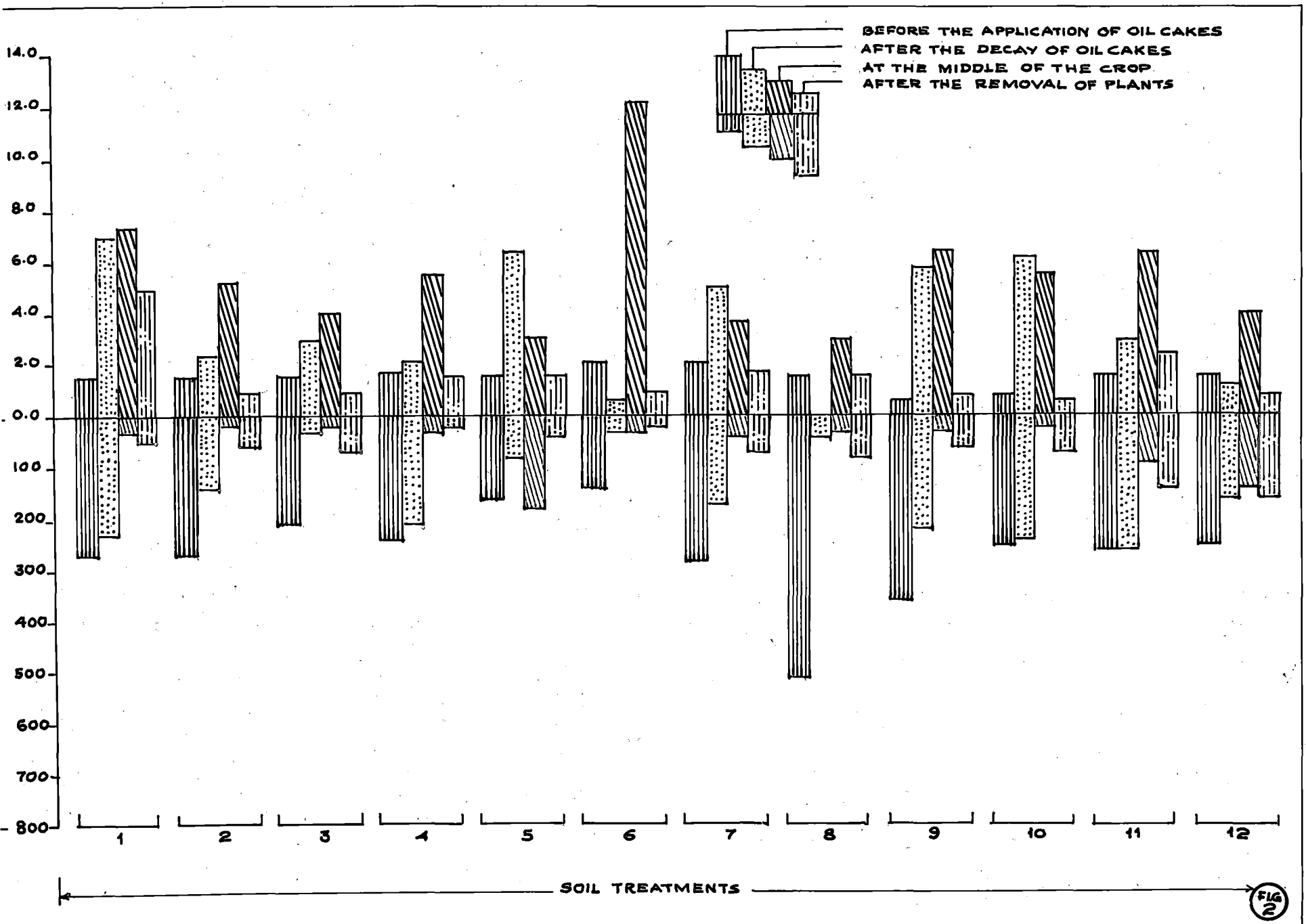

BEFORE THE APPLICATION OF OIL CAKES
AFTER THE DECAY OF OIL CAKES
AT THE MIDDLE OF THE CROP
AFTER THE REMOVAL OF PLANTS
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
100
200
300
400
500
600
700
800
1
2
3
4
5
6
7
8
9
10
11
12
SOIL TREATMENTS
FIG 2

FIG.III

Graph showing *Helicotylenchus* sp. and fungal population

1. Coconut oil cake
2. Castor oil cake
3. D, D-mixture
4. Gingelly oil cake
5. Groundnut oil cake
6. Mahua oil cake
7. Maroti oil cake
8. Nemagon
9. Neem oil cake
10. Undi oil cake
11. Control-I
12. Control-II

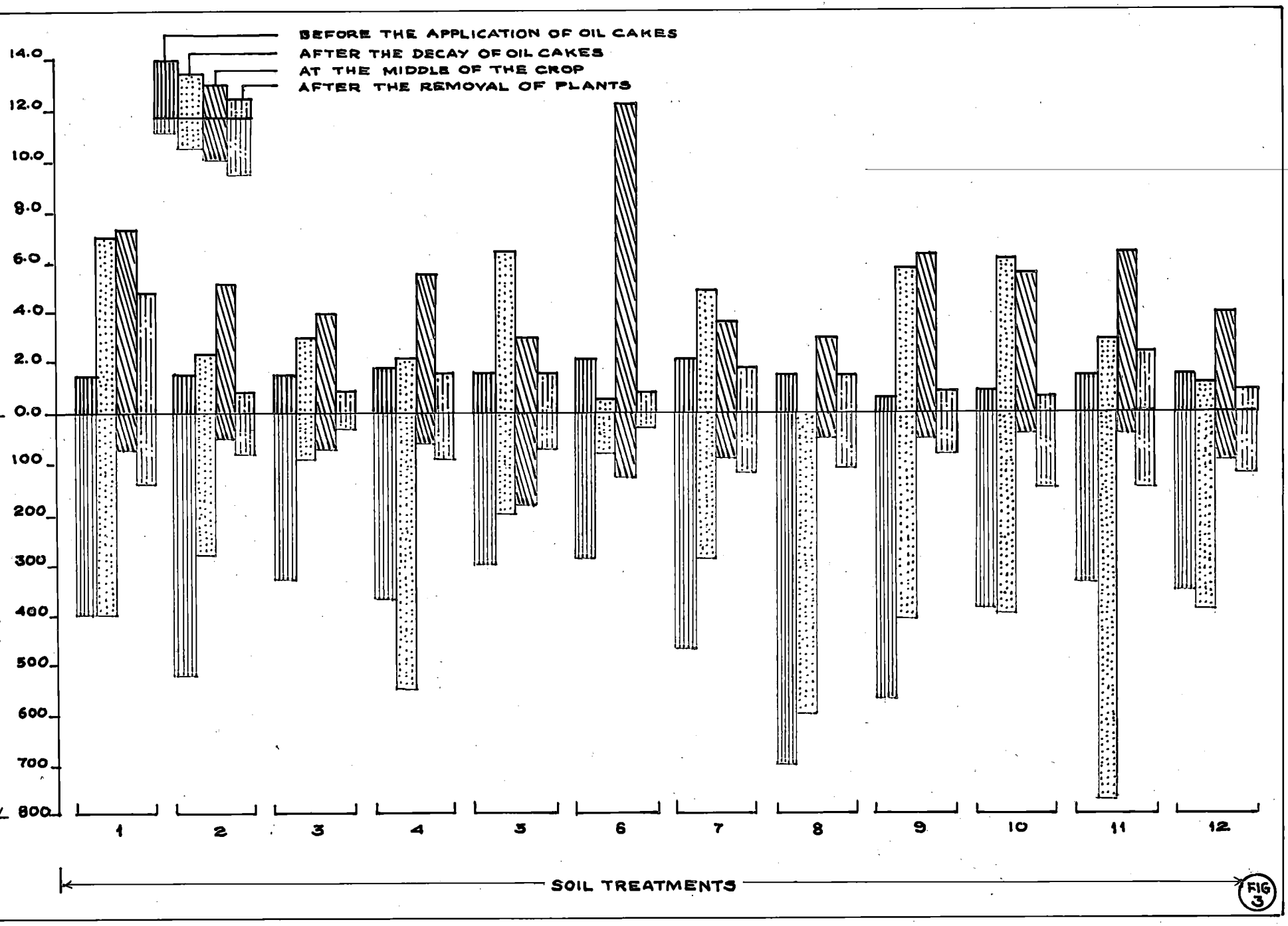

BEFORE THE APPLICATION OF OIL CAKES
AFTER THE DECAY OF OIL CAKES
AT THE MIDDLE OF THE CROP
AFTER THE REMOVAL OF PLANTS
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
100
200
300
400
500
600
700
800
1
2
3
4
5
6
7
8
9
10
11
12
SOIL TREATMENTS

FIG 3

significantly positive (Fig. 4). This observation indicates that the fungal population is not involved in nematophagous activities; probably the nematophagous forms were absent in the soil. Similar observations have been recorded earlier by Linford et al (1938), Oostenbrink (1960) and others.

As regards the bacterial population of the soil it is seen to have increased considerably as a result of the addition of oil cakes. Correlation studies have shown that there exists a highly significant negative correlation between the bacterial population and the population of parasitic nematodes (Fig.5,6). This is a highly significant observation. This effect may be attributed to as mentioned by Katznelson et al (1964) to the repellent properties of bacteria on nematodes. The saprophytic nematodes are however, not found to be significantly affected by the bacterial populations (Fig.7). This differential effect is again a significant factor in the utilisation of bacterial organisms for the suppression of plant parasitic nematodes in soil.

Considering the effect of different oil cakes on the soil nematode populations the results presented will

FIG. IV

Graph showing Saprophytic nematodes and fungal population

1. Coconut oil cake
2. Castor oil cake
3. D,D-mixture
4. Gingelly oil cake
5. Groundnut oil cake
6. Mahua oil cake
7. Maroti oil cake
8. Nemagon
9. Neem oil cake
10. Undi oil cake
11. Control-I
12. Control-II

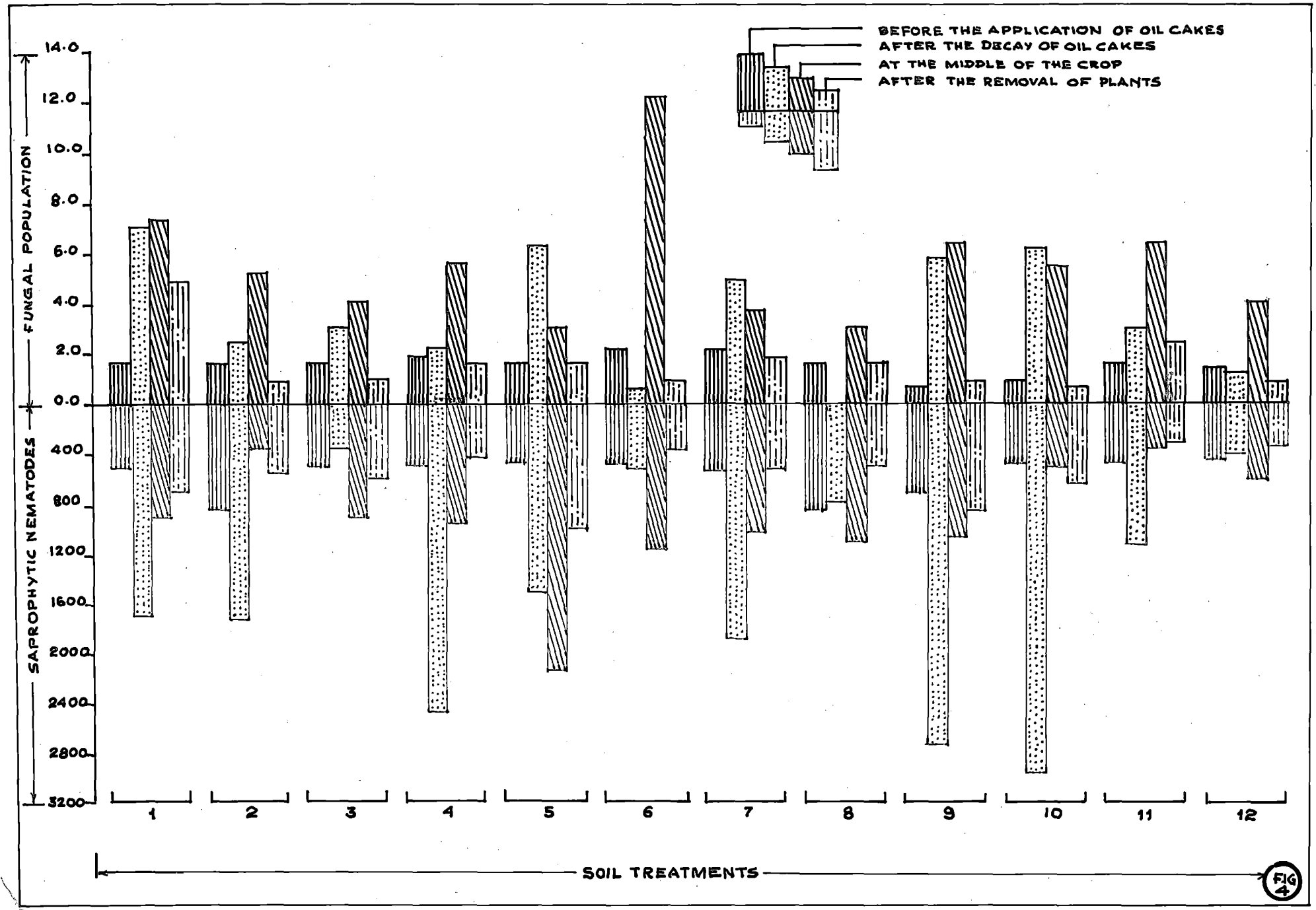

BEFORE THE APPLICATION OF OIL CAKES
AFTER THE DECAY OF OIL CAKES
AT THE MIDDLE OF THE CROP
AFTER THE REMOVAL OF PLANTS
FUNGAL POPULATION
SAPROPHYTIC NEMATODES
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
400
800
1200
1600
2000
2400
2800
3200
1
2
3
4
5
6
7
8
9
10
11
12
SOIL TREATMENTS
FIG 4

FIG. V

Graph showing *Meloidogyne* sp. and bacterial population

1. Coconut oil cake
2. Castor oil cake
3. D,D-mixture
4. Gingelly oil cake
5. Groundnut oil cake
6. Mahua oil cake
7. Maroti oil cake
8. Nemagon
9. Neem oil cake
10. Undi oil cake
11. Control-I
12. Control-II

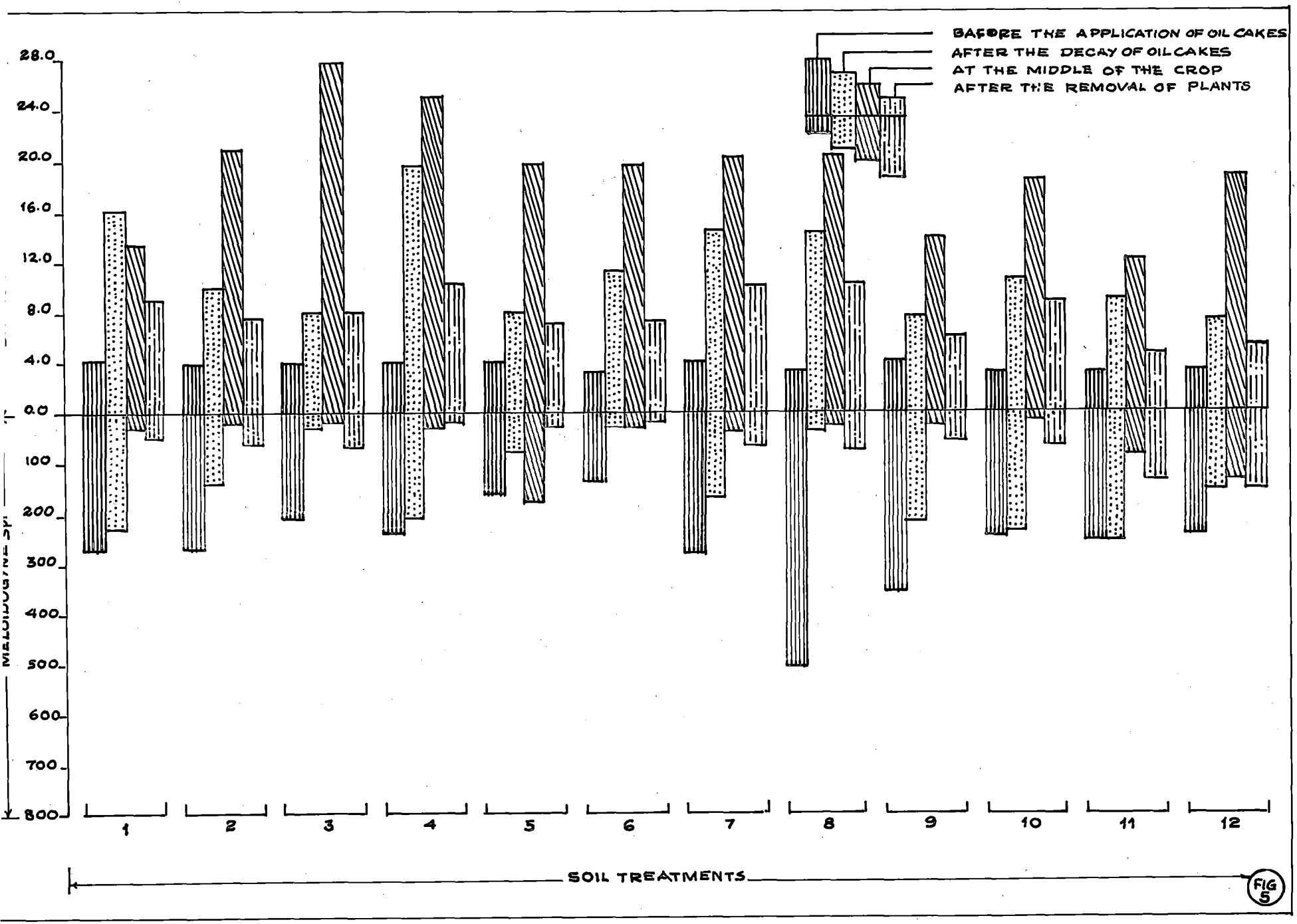

BAFORE THE APPLICATION OF OIL CAKES
AFTER THE DECAY OF OIL CAKES
AT THE MIDDLE OF THE CROP
AFTER THE REMOVAL OF PLANTS
28.0
24.0
20.0
16.0
12.0
8.0
4.0
0.0
100
200
300
400
500
600
700
800
1
2
3
4
5
6
7
8
9
10
11
12
SOIL TREATMENTS

FIG 5

FIG. VI

Graph showing Helicotylenchus sp. and bacterial population

1. Coconut oil cake
2. Castor oil cake
3. D,D-mixture
4. Gingelly oil cake
5. Ground nut oil cake
6. Mahua oil cake
7. Mavoti oil cake
8. Nemagon
9. Neem oil cake
10. Undi oil cake
11. Control-I
12. Control-II

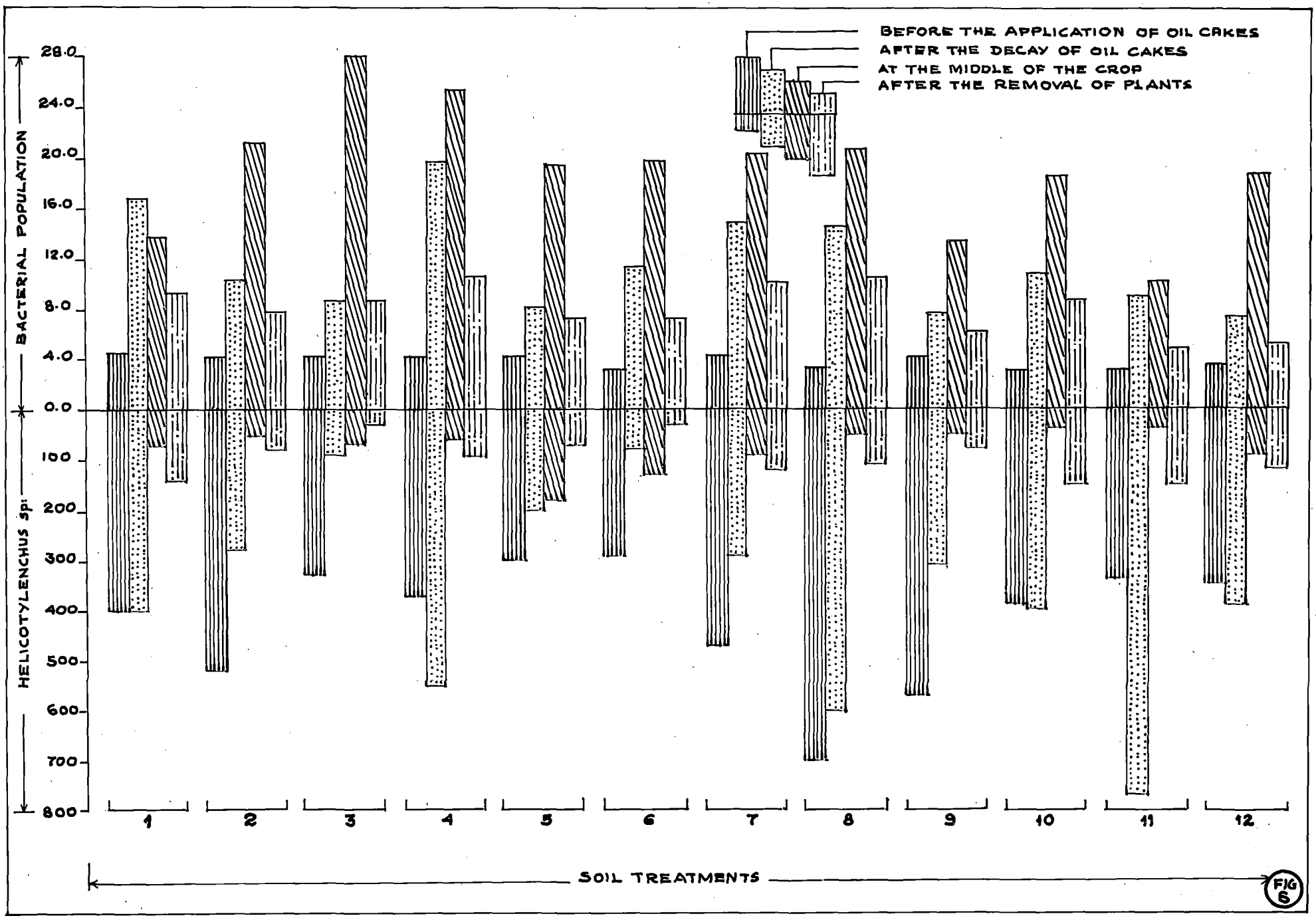
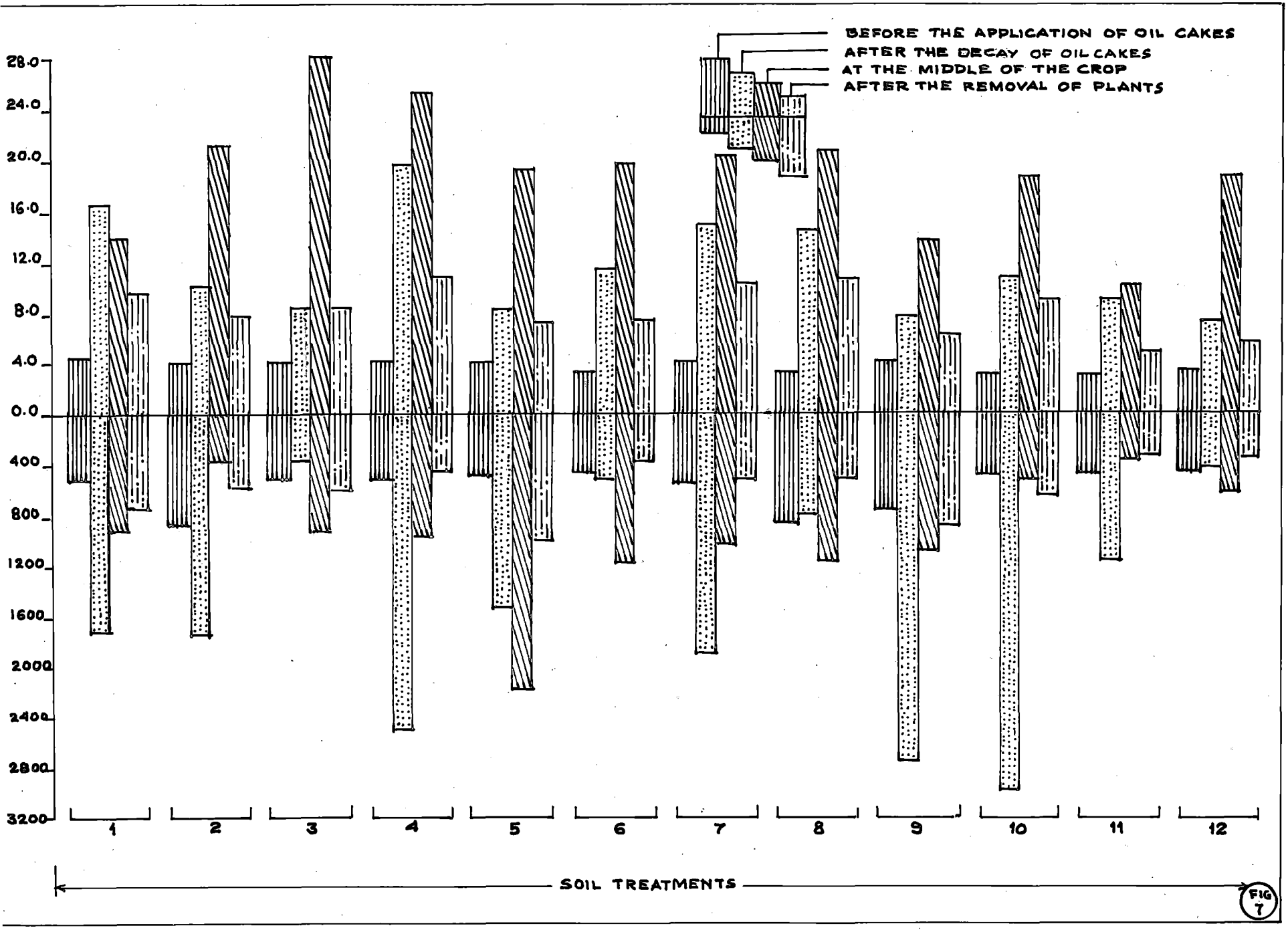

BEFORE THE APPLICATION OF OIL CAKES
AFTER THE DECAY OF OIL CAKES
AT THE MIDDLE OF THE CROP
AFTER THE REMOVAL OF PLANTS
BACTERIAL POPULATION
HELICOTYLENCHUS SP.
28.0
24.0
20.0
16.0
12.0
8.0
4.0
0.0
100
200
300
400
500
600
700
800
1
2
3
4
5
6
7
8
9
10
11
12
SOIL TREATMENTS
FIG 6

FIG. VII

Graph showing Saprophytic nematodes and bacterial population

1. Coconut oil cake
2. Castor oil cake
3. D,D-mixture
4. Gingelly oil cake
5. Groundnut oil cake
6. Mahua oil cake
7. Meroti oil cake
8. Nemagon
9. Neem oil cake
10. Undi oil cake
11. Control-I
12. Control-II


BEFORE THE APPLICATION OF OIL CAKES
AFTER THE DECAY OF OIL CAKES
AT THE MIDDLE OF THE CROP
AFTER THE REMOVAL OF PLANTS
28·0
24·0
20·0
16·0
12·0
8·0
4·0
0·0
400
800
1200
1600
2000
2400
2800
3200
1
2
3
4
5
6
7
8
9
10
11
12
SOIL TREATMENTS
FIG 7

show that the oil cakes increase the non parasitic nematode population while they decrease the parasitic nematode populations. These observations are in general agreement with those of previous workers. In the present case the parasitic forms of nematodes involved are Meloidogyne sp. and Helicotylenchus sp. In the case of Meloidogyne sp. drastic reduction of population is seen with groundnut cake, mahua cake and castor cake (Fig.8). In the case of Helicotylenchus sp. castor cake, mahua cake and maroti cake are seen to be effective in suppressing the population (Fig.9). In both these cases the suppression of the nematodes by the oil cakes was comparable with suppression caused by the two chemical nematicides. As regards the population of the nonparasitic forms the data presented show a very high increase in the population with all the oil cakes (Fig.10). There is however a tailing-off the population towards the end of the crop. This may be due to the rapid decomposition of the organic matter added.

As regards the yield of Bhindi fruits it has been seen that all the substances excepting neem cake

FIG. VIII

Number of *Meloidogyne* sp. in 500 g of soil under different treatments

1. Coconut oil cake
2. Castor oil cake
3. D,D-mixture
4. Gingelly oil cake
5. Ground nut oil cake
6. Mahua oil cake
7. Maroti oil cake
8. Nemagon
9. Neem oil cake
10. Undi oil cake
11. Control-I
12. Control-II

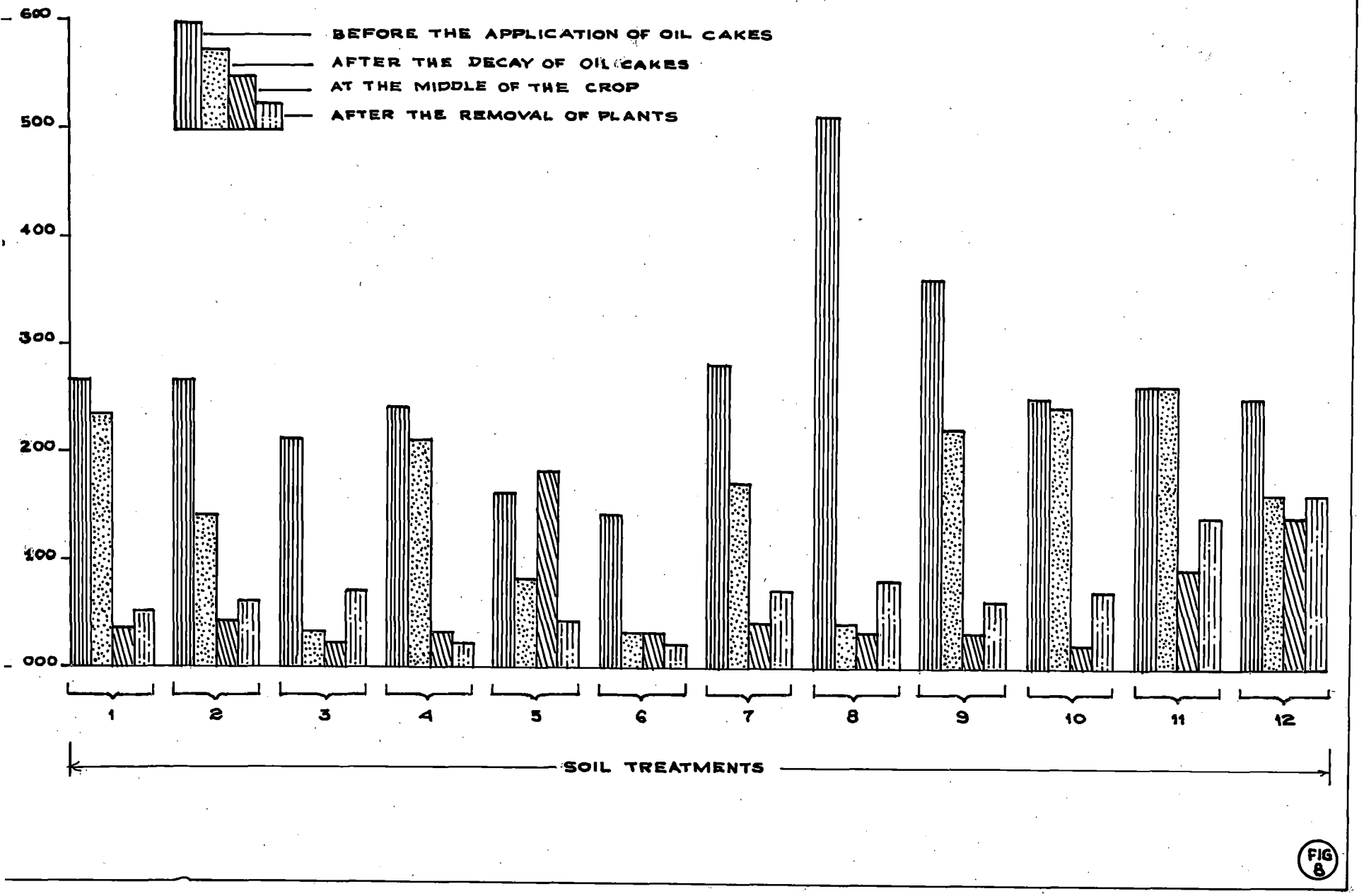

600
500
400
300
200
100
000
BEFORE THE APPLICATION OF OIL CAKES
AFTER THE DECAY OF OIL CAKES
AT THE MIDDLE OF THE CROP
AFTER THE REMOVAL OF PLANTS
1
2
3
4
5
6
7
8
9
10
11
12
SOIL TREATMENTS

FIG 8

FIG. IX

Number of *Helicotylenchus* sp. in 500 g of soil under different treatments

1. Coconut oil cake
2. Castor oil cake
3. D,D-mixture
4. Gingelly oil cake
5. Ground nut oil cake
6. Melma oil cake
7. Maroti oil cake
8. Nemagon
9. Neem oil cake
10. Undi oil cake
11. Control-I
12. Control-II

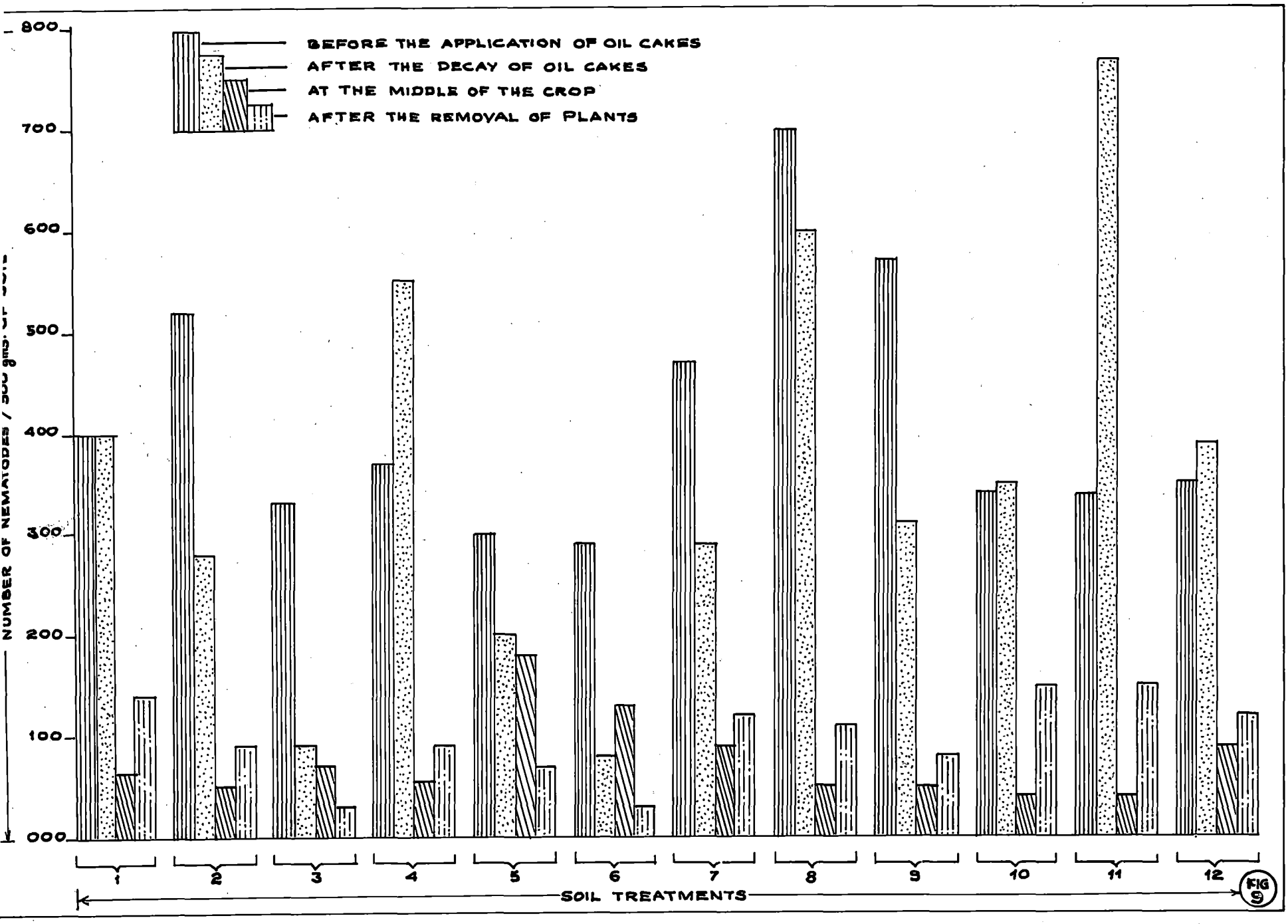
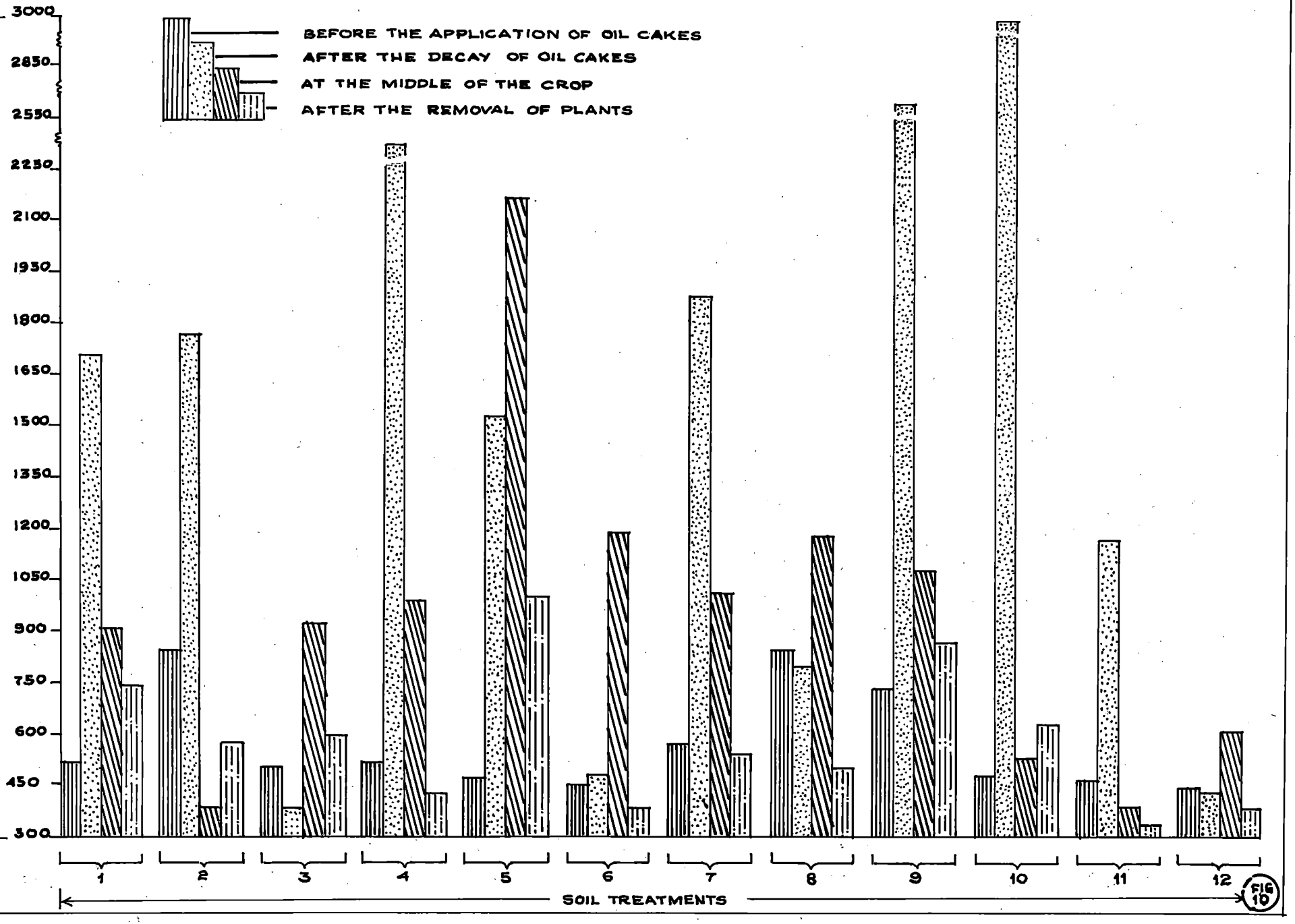

800
700
600
500
400
300
200
100
000
NUMBER OF NEMATODES / 300 gms. OF SOIL
BEFORE THE APPLICATION OF OIL CAKES
AFTER THE DECAY OF OIL CAKES
AT THE MIDDLE OF THE CROP
AFTER THE REMOVAL OF PLANTS
1
2
3
4
5
6
7
8
9
10
11
12
SOIL TREATMENTS
FIG 9

FIG. X

Number of saprophytic nematodes in 500 g of soil under different treatments

1. Coconut oil cake
2. Castor oil cake
3. D,D-mixture
4. Gingelly oil cake
5. Ground nut oil cake
6. Mahua oil cake
7. Maroti oil cake
8. Nemagon
9. Neem oil cake
10. Undi oil cake
11. Control-I
12. Control-II


BEFORE THE APPLICATION OF OIL CAKES
AFTER THE DECAY OF OIL CAKES
AT THE MIDDLE OF THE CROP
AFTER THE REMOVAL OF PLANTS
3000
2850
2550
2250
2100
1950
1800
1650
1500
1350
1200
1050
900
750
600
450
300
1
2
3
4
5
6
7
8
9
10
11
12
SOIL TREATMENTS
FIG 10

were effective in increasing the yield of fruits. Maroti cake ranked the foremost with an yield nearly three times more than that of the control plants. This was followed by D,D-mixture, nemagon and mahua oil cake in that descending order. Between maroti cake and mahua cake the latter was found to be more effective in controlling the parasitic nematodes than the former. The increased yield given by maroti cake may be due to its superiority as a soil amendment.

From the above discussion the following observations appear to be worth high lighting.

1. Though there is an increase in the fungal population consequent on the addition of oil cakes this does not appear to have an impact on the nematode population. This may be because the native fungal population does not contain any nematophagous forms. It is hence worthwhile to inoculate the soil with known nematophagous fungi such as Dactilaria sp., Arthrobotrys sp., Dactvella sp., Trichotheoium sp., etc. and study their effect on the nematode population.

2. There is a significant correlation between the bacterial population of the soil and the population

of the parasitic nematodes, there being a significant reduction of the latter with an increase of the former. The population of the nonparasitic forms is however not seen to be adversely affected by the bacterial population. This is a field requiring objective studies to find out the possibilities of utilising some specific soil abiding bacteria for the suppression of plant parasitic nematodes.

3. Oil cakes have in general proved to be highly effective in encouraging the growth of fungal and bacterial populations and that of nonparasitic nematodes while they suppress the population of the parasitic nematodes. These properties of the oil cakes will be helpful in building up a healthy soil. The role of oil cakes as soil conditioners is well known. Much however remains to be done in fixing up the suitable oil cakes for use as soil amendments in the different types of soils and for different crops.

4. Another significant observation in the present studies is that organic substances such as maroti cake and mahua cake are as effective as the two well known nematicides D,D-mixture and nemagon in controlling the nematodes of Bhindi and enhancing its yield.

SUMMARY

SUMMARY

Field studies were undertaken to ascertain the effect of eight oil cakes and two nematicides on the fungal and bacterial flora of soil, soil reaction and on the population of the parasitic and nonparasitic nematodes of Bhindi.

The oil cakes encouraged the growth of fungal and bacterial populations as well as the population of nonparasitic nematodes. The oil cakes suppressed the population of *Meloidogyne* sp. and *Helicotylenchus* sp. and maroti, mahua, ground nut and castor cakes were more effective than the rest in this respect.

There was significant positive correlation between the fungal population and the population of saprophytic nematodes while the correlation between fungal population and parasitic nematode population was negative though not significant.

pH of the soil was significantly and positively correlated with the parasitic and non-parasitic forms of nematodes within the range of 4.9-5.6.

The population of the parasitic nematodes in soil was negatively correlated with that of the bacterial population, the correlation being highly significant. On the other hand the correlation between bacterial population and saprophytic nematode population was positive though not significant.

Maroti cake and mahua cake were highly effective in increasing the yield of Bhindi this effect being equal to that of D,D-mixture and nemagon.

REFERENCES

REFERENCES

Banage, W.B. and Visser, S.A.	1965	The effect of some fatty acids and pH on a soil nematode. Nematologica, 11: 252-62.
Chandrasekharan, P.	1965	Studies on the effect of NPK in combination with spartin on the growth yield and quality of bhindi (Abelmoschus esculentus Moench.) M.Sc.(Ag.) Thesis submitted to the University of Kerala.
Desai, M.V., Shah, H.M. and Patel, G.J.	1969	Feasibility of the use of Dactylaria sp. as nematode control measure under field condition. First All India Nematology Symposium, 1969. New Delhi, 1969.
Desai, M.V., Patel, G.J., Shah, H.M. and Naphade, S.D.	1969a	Effect of some agronomic practices in the control of root-knot nematodes on tomato. First All India Nematology Symposium, 1969 New Delhi-1969.
Duddington, C.L., Jones, F.G.W. and Moriarty, F.	1956	The effect of predacious fungus and organic matter upon the soil population of beet eelworm Heterodera schachtii. Nematologica 1: 344-48.
Duddington, C.L. and Duthoit, C.M.G.	1960	Green manuring and cereal root eelworm. Pl.Path., 10: 103-109.
Duddington, C.L., Everard, C.O.R. and Duthoit, C.M.G.	1961	Effect of green manuring and a predacious fungus on cereal root eelworm in oats. Pl.Path., 10: 108-109.

Ellenby, C.	1946	Ecology of eelworm Cyst. Nature Lond., 157: 451.
Gill, D.L.	1952	Effect of tung-nut meal and parathion on root-knot nematode infection. Pl.Dis.Rept., 36: 18-21.
Godfrey, G.H. and Hagan, H.R.	1933	Influence of hydrogen ion concentration on infection by Heterodera radicicola (Greeff) Muller. Soil Science, 35: 175-184.
Gour, A.C. and Prasad, S.K.	1970	Effect of organic matter and inorganic fertilizer on soil and plant nematodes. Ind.J.Ent., 32(2): 186.
Hameed, S.F.	1968	Relative efficacy of different oil cakes on the incidence of root-knot nematodes. Mad.Agri.J., 55(4): 168.
Hams, A.F. and Wilkin, G.D.	1961	Observations on the use of predacious fungi for the control of Heterodera sp. Ann.appl.Biol., 49: 515-523.
Johnson, L.F.	1962	Effect of addition of organic amendments to soil on root-knot of tomatoes II. Relation of soil temperature, moisture and pH. Phytopathology, 52: 410-413.
Johnson, L.F., Chambers, A.Y. and Reed, H.E.	1967	Reduction of root-knot of tomato with crop residue amendments in field experiments. Pl.Dis.Reptr., 51: 219-222.

Katznelson, H. and Henderson, V.E.	1962	Studies on the relationships between nematodes and other soil microorganisms.I. The influence of actinomycetes and fungi on Rhabditis (Cephaloboides) Oxycera de Man. Can.J.Microbiol.8(6):875-882.
Katznelson, H. and Henderson, V.E.	1964	Studies on relationships between nematodes and other soil microorganisms.II. Interaction of Aphelenchoides parientinus (Bastian 1865) Steiner 1932 with actinomycetes, bacteria and fungi. Can.J.microbiol.,10: 37-41.
Katznelson, H., Gillespie,D.C. and Cook,F.D.	1964	Studies on the relationships between nematodes and other soil microorganisms III.Lytic action of soil myxobacters on certain species of nematodes. Can.J.microbiol.,10: 699-704.
Khan, A.M., Khan, W. and Saxena, S.K.	1969	Effect of organic amendments on the population of nematodes and fungi in the rhizosphere of egg plant Solanum melongena. First All India Nematology Symposium, 1969,New Delhi-1969.
Linford, M.B., Yap, F. and Oliveira, J.M.	1938	Reduction of soil populations of the root-knot nematode during decomposition of organic matter. Soil Sci.45: 127-140.
Mankau, R.	1960	The use of nematode trapping fungi to control root-knot nematodes. Phytopathology, 50: 645.
Mankau, R.	1962	The effect of some organic additives upon a soil nematode population and associated natural enemies. Nematologica, 7: 64-73.

Mankau, R. and Minteer, R.J.	1962	Reduction of soil populations of citrus nematode by the addition of organic materials. Pl.Dis.Reptr., 46: 375-78.
Mankau, R.	1963	Effect of organic soil amendments on nematode populations. (Abst.) Phytopathology, 53: 881-82.
Martin, J.P.	1950	Use of acid, rose bengal and streptomycin in the plate method for estimating soil fungi. Soil Sci. 69: 215-232
Mobin, M. and Khan, A.M.	1969	Effect of organic amendments on the population of rhizosphere fungi and nematodes around the roots of some fruit trees. First All India Nematology Symposium, 1969. New Delhi-1969.
Oostenbrink,M.	1958	Grandontamelling en pH Meded.Landh Hoogesch.Gent.23: (3/4) 628-635.
Peters, B.G.	1926	Heterodera schachti and soil acidity. J.Helminth.,4(3): 87-114.
Petherbridge,F.R,and Jones, F.W,G.	1944	Beet eelworm (Heterodera schachtii schm.) in East Anglia, 1934-1943. Ann.appl.Biol. 31(4): 320-332.
Pramer, D.	1964	Nematode trapping fungi. Science N.Y.144: 382-388.
Premkumar,T. and Nair, M.R.G.K.	1971	Effect of some organic soil conditioners on the control of nematodes infesting bhindi. M.Sc.Thesis,University of Kerala (unpublished)

Ravindran Nair, K.K. and Mohandas, N.	1969	Studies on the population of nematodes in relation to certain chemical and biotic factors of soil. M.Sc. Thesis, University of Kerala. (Unpublished).
Sayre, R.M., Patrick, Z.A. and Thorpe, H.J.	1965	Identification of selective nematicidal components in extracts of plant residues decomposing in soil. Nematologica 11: 263-268.
Singh, B.	1965	Observations on the effect of organic soil amendment, and fertilizers on incidence of root-knot and yield of okra in nematode infested soil. First All India Nematology Symposium, 1969. New Delhi, 1969.
Singh, R.S.	1965	Control of root-knot of tomato with organic soil amendments. FAO Plant. Prot. Bull., 13: 35-37.
Singh, R.S. and Sitaramaiah, K.	1966	Incidence of root-knot of okra and tomato in oil cake amended soil. Pl. Dis. Reptr. 50: 668-672.
Singh, R.S. and Sitaramaiah, K.	1971	Control of root-knot through organic and in organic amendments of soil. I. Effect of oil cakes and saw dust. First All India Nematology Symposium 1969. Indian J. Mycl. and Pl. Pathol. 1: 20-29.

Singh, R.S. and Sitaramaiah, K.	1971	Control of root-knot through organic and inorganic amendments of soil. III. Effect of saw dust and inorganic nitrogen. Indian J. Nematology 1: 80-84.
Sitaramaiah, K., Singh, R.S. and Singh, K.P.	1969	Induction of oviparity in Meloidogyne javanica by fatty acids. Nematologica, 15: 163.
Tarjan, A.C.	1960	Predacious activity and growth of nematophagus fungi on various organic substances. Phytopathology, 50: 577.
Taylor, C.B. and Lockhead, A.G.	1938	A survey of the bacterial flora of soils differing in fertility. Canad. J. Research C, 16: 1938.
Timonin, M.I.	1940	The interaction of higher plants and soil microorganisms. 1. Microbial population of rhizosphere of seedlings of certain cultivated plants. Can. J. Res. C, 18: 307-317.
Walker, J.T., Specht, C.H. and Mavrodineau, S.	1967	Reduction of lesion nematodes in Soybean meal and oil amended soils. Pl. Dis. Reptr. 51: 1021-1024.