USE OF ORGANIC AMENDMENTS FOR THE CONTROL OF ROOT - KNOT NEMATODE IN BRINJAL

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Use of organic amendments for the control of root-knot nematode in brinjal" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

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Vellayani,
23.8.1986.

CERTIFICATE

Certified that this thesis, entitled "Use of organic amendments for the control of root-knot nematode in brinjal" is a record of research work done independently by Smt. P.L. KAMALAKSHI AMMA under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to her.

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INTRODUCTION

INTRODUCTION

Brinjal (Solanum melongena L.) is one of the important vegetables in Kerala. A major constraint in the economic production of this crop is pests and diseases. Among the different pests, root-knot nematode, Meloidogyne incognita has been found to be one of the most commonly occurring and destructive pests. Due to the continuous cultivation of the crop and the polyphagous habit of the pest, the soil usually maintain a very high population of this nematode. The advantage of adopting better crop husbandry practices are generally offset by infestation by the root-knot nematode. Plants infested by the nematode lose their vigour, become stunted with discoloured leaves and suppressed flowering. When such plants are uprooted severe galling on roots is observed. Plants infested yield less and die early.

Among the studies made by different workers on the control of root-knot nematode one approach was the use of organic amendments. These include application of materials like oil cakes, saw dust and green leaves (Singh and Sitaramiah, 1969 and 1971; Sharma et al., 1971; Prem Kumar and Nair, 1976 and Zaiyd, 1977). Investigation on the control of root-knot nematode, Meloidogyne incognita infesting brinjal plants using organic amendments was not done in the State.

The present study therefore envisaged the evaluation of different oil cakes and organic wastes for their efficacy in controlling root-knot nematode M. incognita infesting brinjal.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Soil organic constituents are found to influence the life and activities of soil nematodes to a significant extent. Much work has been done in this field and the more important contributions are reviewed here.

Nattrase (1944) found that chopped napier grass applied in trenches in soil heavily infested by root-knot nematodes enabled him to grow a normal crop of potatoes.

Watson (1944) reported that mulching with any decayable vegetable material controlled root-knot infestation and this benefit lasted for a long period.

Gill (1952) indicated that application of tung nut meal for controlling the root-knot nematodes was of no use as a soil treatment.

Reduction in population of the beet eelworm, Heterodera schachtii was reported by Duddington et al. (1956) as a result of microplot application of organic matter. The fungus, Dactylaria thaumasia has no effect on the final cyst formation. But neither treatment affected the 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 increasing the microflora and

fauna thus leading to increased competition for exygen resulting in reduced egg hatch and larval activity of the eelworms.

Microplot experiment conducted by Duddington et al. (1956a) to test the effect of a predaceous fungus, Dactylaria thaumasia Dreschlor and 3 types of organic matter viz. leaf mould, compost and chopped cabbage upon potato eelworm, Heterodera rostochiensis Woll. showed that the population of the eelworm was low with treatments. The treatments showed no effect on the yield of potato.

Significant numerical differences of eelworm population were observed in 22 day old potato plants treated with farm yard manure, compost and fertilizers (Van Der Laan, 1956). In the case of organic matter the population was much lower. The organic matter in soil appeared to hamper the growth of nematodes in plants. In the organic manured soils the second and third stage larvae were lowest.

While studying the effect of green manuring on the cereal root eelworm, Heterodera major Duddington and Duthoit (1960) observed that application of chopped cabbage leaves reduced the infestation of the spring oats variety eagle by nematodes. Plants in the control plots showed the eelworm damage as indicated by reduction in height and change in

colouration. The ears in the treated plots were big and those in control small. Soil samples collected showed the presence of predaceous fungi, Arthrobotrys oligospora Fores and Dactylaria thaumasia Dreschlor.

Application of the mycelium of Dactylaria thaumasia at 4 oz/2 sq inches and incorporation of grass mowings were effective in reducing the nematode population, Heterodera avenae infested soils (Duddington et al., 1961). Cabbage leaves and Dactylaria thaumasia reduced the cereal root eelworm infestation. Green manuring without fungal inoculation failed to reduce eelworm invasion.

Hams and Wilkin (1961) stated that the use of farm yard manure gave better crops in eelworm infested soils irrespective of whether predaceous fungi were naturally present or added.

Johnson (1962) reported that mature crop residues (oat straw and lespodeza hay) when mixed with soil infested with Meloidogyne incognita gave good control of the nematode. Residues were chopped and added to soil at the rate of one per cent by weight. Amended and unamended soils were incubated for two weeks under various environmental conditions and tomato seedlings grown in them under green house conditions. Control of the nematodes was obtained in soils to which residues were added and incubated at 5 - 30°C.

By adding dung (steer manure), green manure (alfalfa) rotten wood shavings and oat hay, Mankau (1962) obtained large increase in the number of microphagus nematodes. The population of the predaceous Dorylaimus sp. was not influenced by the organic materials. Dung and green manured soil had shown greatest activity of predaceous fungi.

It was observed by Mankau and Minteer (1962) that out of the different organic matter added to soil infested with Tylenchulus semipenetrans only steer manure failed to cause substantial reduction in number of larvae in 84 days. It was also observed that castor pomace eliminated all citrus nematode larvae from the soil though apparently it did not contain substances toxic to nematodes. 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.

Miller and Edgington (1962) obtained very good control of Pratylenchus penetrans when paper and white pine saw dust were added to soil infested with nematodes atleast for 154 days.

Johnson (1963) found that addition of mature dried oat straw in root-knot infested soil gave good control of

the nematode at 73° - 76°F of night temperature and 81° - 84°F of day temperature in green house conditions. Less control was obtained when average daily temperature was 85°F or higher.

Laboratory, green house and field studies conducted by Mankau (1963) showed that fluctuations in nematode population in soil during periods of over 300 days were greatly influenced by the addition of different organic fertilizers. In slightly alkaline soils decomposable nitrogenous materials enhanced microbial activity resulting in the decrease of Tylenchulus semipenetrans and root-knot nematode larvae and stimulated microbivorous and fungivorous nematodes. Decomposition of cellulose in soils slightly reduced citrus nematode survival but enhanced microbivorous and fungivorous sp.

Decomposition products derived from plants were found to have nematicidal activity as reported by Sayre et al., 1964. When rye was allowed to decompose under appropriate conditions in soil substances capable of inhibiting the growth of roots of tobacco and lettuce seedlings were obtained. These substances were purified and tested in vitro as nematicides against plant parasitic nematodes Meloidogyne incognita and Pratylenchus penetrans and saprophytic nematodes.

Oteifa *et al.* (1964) studying the nematode fauna in fields regularly treated with organic manure found build up of predaceous nematodes belonging to the genera *Tripyla*, *Monohystria*, *Diplogastor*, *Aphelenchoides*, *Dorylaimus* and *Mononchids*. Mononchid nematodes found were *Mononchus* and *Mylonchus* and were confined to soils manured with goat dung. Dorylaimid nematodes occurred in stable manured soils. Soils manured with sugarcane begasse encouraged the rapid growth of predaceous fungi. Pigeon droppings was the richest of all local organic additives that favoured development of nematophagous fungi.

Presence of predaceous fungi *Arthrobotrys*, *Dactylaria*, *Dactyella* and *Trichothecium* was reported by Pramer (1964) in soil amended with organic soil conditioners and the nematodes which were attacked struggled for a time and then appeared dead or moribund. The body wall of the nematode was penetrated and the fungus ramified throughout the carcass, digesting and absorbing its content. Fungi by means of hyphal loops trapped a large number of nematodes. The death was due to the production of toxin by fungi.

Patrick *et al.* (1965) stated that naturally occurring decomposition products of plants and specific nematicidal activity. The decomposition products tried were obtained from rye residues decomposing in soil for 10 - 15 days.

The aqueous extracts were purified and the end product was an yellowish liquid. There was considerable difference between parasitic and saprophytic nematodes in their susceptibility to the toxic products.

Volatile fatty acids were produced abundantly during the decompositon of rye and timothy plant residues under laboratory conditions and that they were also present in lesser amounts when similar plant residues were decomposing in the field. These conclusions were drawn by Sayre et al. (1965). Butyric acid was found to be one of the major component of the fatty acids thus produced.

Hollis and Kabana (1966) showed that rapid kill of nematodes took place in soils of low pH and with large amounts of rapidly decomposing organic matter. When rice soil was supplemented with corn meal there was decline of nematode population. n-butyric acid and lesser amounts of propionic acid were quickly formed in treated plots 4 days after flooding. Hydrogen ion concentration increased and number of anaerobic spore bearing bacteria increased in treated plots. They also showed that butyric acid at concentrations found in treated plots killed 100% of the nematodes in few hours and propionic acid exerted an additional effect on total acids.

Invasion of brinjal roots by Heterodera tabacum as reported by Miller and Wihrheim (1966) was reduced after incubation of infested soil with amendments of cellulolytic materials. After one year larval invasion of soil containing 1 per cent paper, white pine saw dust or tobacco stem was only 5 per cent of its initial value while in control it was 35 per cent. In soils stored for six weeks with 0.1 per cent cotton seed manure or 1 per cent saw dust and 0.1 per cent of 23:19:17 (N:P:K) fertilizer, invasion was 20 per cent of the original. After 6 weeks larval invasion was 85 per cent of the original in soils containing paper alone, 50 per cent in soils with paper and fertilizer and 97 per cent in fertilised soils. Fertilizer prevented the root penetration by hatched larvae. Reduced invasion was reported to be due to high NH_3 content.

Singh and Sitaramiah (1966) obtained very significant results when the soil infested with nematodes were amended with oil cakes of margosa, castor and peanut three weeks before planting. The root galls were significantly reduced. They also found that plot experiments with 1600 lb/acre of any of these cakes resulted in better plant growth and reduction in root-knot incidence. Residual effect of these amendments check root-knot of tomato without any further amendments. Roots of plants in amended soils contained

fewer number of eggs, larvae and mature females than roots of plants raised in unamended soil. Water extracts of soil amended with oil cakes at the rate of 2 per cent inhibited liberation of egg masses and hatching of larvae.

Johnson et al. (1967) found that root-knot infestation was reduced when alfalfa hay, oats straw, lespedeza hay and flax hay were chopped and incorporated in soil infested with Meloidogyne incognita. Better reduction was obtained when amended with 10 tonnes/acre instead 5 tonnes and 8 months before than before shorter periods.

Singh and Sitaramiah (1967) stated that green leaves of Azadiracta indica, Melia azadirach, Cassia fistula, C. occidentalis, Crotolaria juncea, Sesbania aculeata and saw dust to soil infested with Meloidogyne javanica significantly reduced the incidence of root-knot in okra and tomato in pot experiments. They stated that field experiments in which a green leaf Cassia occidentalis at 200 mds/acre, saw dust at 20 mds/acre or urea at 400 lb N/acre caused increased growth of okra and tomato and reduced incidence of root-knot. They also reported that the residual effect of one amendment was sufficient to reduce the root-knot in a succeeding crop in the same field.

Singh et al. (1967) found that gall formation on roots of tomato and okra caused by Meloidogyne javanica was appreciably reduced if saw dust at the rate of 2000 lb/acre was mixed with soil 3 weeks before planting. The nitrogen deficiency was counteracted by balanced NPK fertilizers. Saw dust and fertilizer amendments to infested soil reduced the number of galls to ½ to ¼ of that found in untreated plots and also increased okra yield by 70% and tomato yield by 12% over the check.

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

It was found that Meloidogyne population on tomato in India was diminished more by the preplanting application of mustard cake to the soil than by the application of other oil cakes (Hameed, 1968).

Healf and Burton (1968) reported that inactivated sewage sludge reduced the number of Belanolaimus longicaudatus on turf green and bermuda grass more than inorganic nitrogen. Average plant weights of turf that received organic nitrogen were greater than those received inorganic nitrogen.

Miller et al. (1968) reported that decomposing organic matter reduced both larval emergence and root invasion by tobacco cyst nematode. Larval invasion of egg plant roots was suppressed by materials like saw dust and paper. Cotton seed meal suppressed root invasion during early stages of decomposition both in laboratory and field and was more effective than castor pomace and lineeed meal.

Tenssown et al. (1968) found that production of water soluble phytotoxins during decomposition of barley residues in soil in the laboratory was unaffected by temperature between 16 - 24°C but required soil moisture content above 30% of the soil and residue dry weight. Phytotoxin activity reached a maximum in 3 weeks and then declined after 6 - 7 weeks. The phytotoxins were found tc be benzoic acid, phenylacetic acid, 3-phenyl propionic acid and 4-phenyl butyric acid but benzoic acid and phenyl acetic acid were found to be the major component.

The effect of the application of oil cakes of neem, mahua, groundnut and castor on the control of the population of Tylenchorhynchus sp., Haplolaimus sp., Holicotylenchus sp., Rotylenchulus reniformis and Meloidogyne incognita was studied by Khan et al. (1969). None of the oil cakes except those of mahua suppressed the population of saprozoic form.

Desai et al. (1969) stated that the use of nematophagous fungi generally found in almost all soils controlled the plant parasitic nematodes. The nematophagous fungus Dactylaria sp. became effective when applied along with organic matter like FYM.

Addition of mustard cake at the rate of 32 mds/acre and chopped neem leaves in soil gave significantly reduced root galling of plants and increased their growth. The organic fertilizers changed the soil consistency and increased the water holding capacity which helped the growth of various predatory fungi and nematodes. Crop rotation and summer ploughing was also found to reduce loss due to nematodes (Lass and Hameed, 1969).

In vitro studies on the effect of water extracts of whole and deoiled cakes of Ricinus communis, Arachis hypogea, Eruca sativa, Carthamus tinctorius, mustard and Sesamum indicus showed that the hatching of the eggs of Rotylenchulus reniformis was significantly suppressed (Rao and Prasad, 1969).

Mobin and Khan (1969) studied the effect of certain organic amendments in the rhizosphere fungi and nematode fauna of guava (Psidium guajava), phalsa (Grewia asiatica) and

Citrus sp. and that combination of oil cakes of neem and mahua, groundnut and mahua, groundnut and mustard were effective in reducing the population of fungi and stylet bearing nematodes around the roots of guava, phalsa and citrus.

Singh and Sitaramiah (1969) found that amendment of root-knot (M. javanica) infested soil with oil cakes of margosa, castor, peanut, mustard and linseed as well as with saw dust at the rate of 25 quintals per hectare gave effective reduction in the intensity of root galls on okra and tomato. The yield was also increased. Highest degree of control was given by peanut and margosa cakes.

Hameed (1970) studied the effects of incorporating organic materials with soil in a ratio of 1 : 3 on the incidence of Meloidogyne spp. in tomato. It was found that the addition of organic matter generally reduced the incidence of Meloidogyne spp. and that the addition of Chrysanthemum coronarium, Melia azadirachta and Tagetes patula had reduced nematodes substantially and increased plant growth.

Gour and Prasad (1970) found that when alluvial soil amended with wheat straw, neem cake and F.Y.M. 6 weeks prior to sowing and amended with dhaincha 4 weeks prior to planting

along with fertilizer N.P.K. enhanced the saprozoic population of nematodes in all the plots amended with the organic matter alone. The increase in the plant parasitic nematode population was comparatively low. They found that the application of N.P.K. in the absence of organic matter amendment increased the plant parasitic nematodes.

Johnson (1971) carried out pot experiments to test the influence of oat straw and mineral fertilizer soil amendments on severity of tomato root-knot nematode. A complete mineral fertilizer at 2000 to 8000 lb per acre reduced the severity of root-knot infection. Oat straw induced a nutrient deficiency and reduced the infestation, the target dose of mineral fertilizer overcame the deficiency and increased the effectiveness of the oat straw in reducing galling.

Singh and Sitaramiah (1971) stated that the effective control of Meloidogyne javanica can be achieved if the soil is amended with 25 quintals/ha of saw dust 3 weeks before planting and then inorganic nitrogenous fertilizers are added along with P and K at the time of planting. The control increased with increase in the amount of nitrogen following saw dust amendment. Urea was found to be the most effective nitrogen source. At 120 lb N/ha galling was reduced and yield increased.

Economic returns were obtained from bhindi and tomato grown in Meloidogyne spp. infested soil by application of mustard, mahua and margosa cakes. Root-knot incidence was much reduced by both margosa cakes and saw dust with urea (Sharma et al., 1971).

Johnson (1972) reported that galling of tomato roots by M. incognita was reduced by 75 to 99 per cent on plants grown in soil mulched with flax, lucerne or orchard grass residues.

Goswami and Swarup (1972) tested oil cakes of linseed, margosa, groundnut and karanj for their efficacy against M. incognita on tomato seedlings. Soil amended with karanj and groundnut cakes showed considerable decrease in population of nematodes.

Joseph and Nair (1972) reported that oil cakes of maroti, neem and groundnut were effective in increasing soil fungi, bacteria and non-parasitic nematodes and in reducing the population of plant parasitic forms especially species of Meloidogyne and Helicotylenchus.

Addition of oil cakes like groundnut, longe, neem, castor, niger and lonne and farm yard manure improved growth of tomato in terms of height, fresh weight of shoot and roots, groundnut, niger and castor being particularly good (Gowda and Shetty, 1973).

Rice husk (3000 and 6000 kg/ha) and sugarcane begasse (2000 and 4000 kg/ha) without predecomposition were added to plots 5 weeks before planting tomato. Rice husk had no effect on percentage of root galled by M. javanica and it decreased tomato yield. Sugarcane begasse at 2000 kg/ha had no effect on root galling but increased yield; at 4000 kg/ha there was 22 per cent reduction in galling but no increase in yield. Fifty days after amendments there was more than 70 per cent reduction in larvae in amended plots. Sugarcane begasse caused a greater reduction in M. larvae (Sikora et al., 1973).

Sukan et al. (1974) reported that aqueous extracts of leaves of Tagetia involucrata and Polygonum hydropiper reduced both galling and the population of M. incognita on ladies finger without phytotoxicity.

Habicht (1975) found that raw sewage sludge at 2, 4 and 8 per cent dry weight and composit sewage sludge at 4, 8 and 16 per cent dry weight were incorporated into soil infested with M. incognita acrita (1,400 larvae per 100 g of soil) and planted with tomato; both significantly reduced galling. Raw sludge and higher levels of the amendments were the more effective.

It was observed by Hackney and Dickerson (1975) that root population of Meloidogyne in tomato simultaneously cultivated with marigold and chrysanthemum were significantly lower than in tomato cultivated alone.

From their experiments Castillo et al. (1975) noted that three successive crops of maize, Tagetes erecta, tomato with T. erecta or Crotalaria juncea as inter crop tomato with preplant soil application of chicken dung or rice straw compost and fallow for 3 growing seasons suppressed field populations of Meloidogyne incognita to varying degrees but failed to eliminate the nematode.

Alam and Khan (1975) studied the efficacy of certain oilcakes for the control of local population of nematodes in spinach field. Greatest reduction in the population of stylet bearing nematodes took place with neem cake and nemagon followed by mahua cake and D-D, mustard cake, groundnut cake and castor cake. Except for the last two mentioned oilcakes the other oilcakes were as effective as D-D and nemagon.

A report of Sitaramiah et al. (1976) indicated that carbofuran, fensulfothion and saw dust plus N.P.K. all significantly reduced Meloidogyne javanica parasitism on Pusa sawani and that the sawdust treatment gave the greatest yield. Mocap and sawdust + urea were less effective.

Desai et al. (1976) observed that tomato plots which were left unirrigated during summer had higher plant stand, fruit yield and shoot weight, with lower root-knot incidence than irrigated plots. Deep ploughing during summer and spot application of farmyard manure also resulted in high plant stand, fruit yield and shoot weight while spot application of manure showed the lowest disease index and gave reasonable root-knot control and better yield than with D-D soil fumigation.

The nematicides D-D, Nemagon, Thimet 10 G, Dasanit and oilcakes of castor, mustard, margosa and groundnut gave excellent control of plant parasitic nematodes in nurseries of the perennial plants. It was found that the efficacy of a particular nematicide or oilcake depended largely on the crop and on the species of nematode involved (Khan et al., 1976).

Pot experiments conducted by Reddy et al. (1976) revealed that amino acids DL-methionine and DL-valine gave greatest reduction in root galling of tomato.

Prasad et al. (1976) observed in pot experiments, soil drenches of DL-alamine, DL-serine and DL-threomine applied at concentrations equal to their mg molecular weight to tomato plants one week after innoculation with M. incognita resulted in significantly lower reproduction of nematodes.

Studies conducted by Kumar and Nair (1976) to determine the effect of certain organic soil conditioners viz., sawdust, coconut husk powder, paddy husk, mango leaves, cashew leaves, calotropis leaves, eupatorium leaves, lemongrass leaves, paddy straw, cashew shell powder, press mud, coconut oilcake and farm yard manure when applied 3 weeks prior to sowing on the population of plant parasitic and nonparasitic nematodes associated with bhindi and on the growth and yield of the plants revealed that all the organic substances suppressed root galling caused by Meloidogyne sp. increased plant growth and yield of fruits. The population of Meloidogyne sp. and Helicotylenchus sp. was significantly reduced by the use of all the organic substances. The population of the non-parasitic species, however, showed a significant increase with the application of organic substances.

In experiments using amendments, sawdust, margosa cake and sawdust with urea enhanced larval hatch was noticed in amended soil but the larvae had poor ability to invade roots (Sitaramiah and Singh, 1977).

Meloidogyne javanica gall number was reduced and plant top weight increased by addition of mustard cake, groundnut cake, linseed cake and castor cake to okra plants in pot trials conducted by Zaiyd (1977).

Sundaresh *et al.* (1977) carried out an integrated control experiment of root-knot nematode. *Zea mays* var. *seneca* resistant to *M. incognita* when rotated with tomato and chilli caused a significant reduction in nematode population. Carbofuran and oilcake together caused the greatest reduction.

Mashkoor Alam *et al.* (1978) analysed different oilcakes for formaldehyde and acetone. The amount of formaldehyde was 0.966, 0.088, 0.316, 0.258 and 0.478 mg respectively and that acetone 0.9, 0.110, 0.220, 0.280 and 0.180 mg respectively per 100 mg of sample. Formaldehyde was found more toxic to nematode than acetone. The high content of formaldehyde in oilcakes is likely to be an important mechanism of control of nematode.

Inderjit Singh *et al.* (1979) placed egg masses of *M. incognita* for 3 days in oilcake extracts of mustard, taramira, sesame and cotton and then transferred to tap water. All extracts prevented hatching of eggs during the first 3 days and in water the eggs revived. All treatments did suppress hatching, notably mustard and cotton.

Trials on the use of organic amendments have shown that sawdust and paddy husk at the rate of 500 g per plant and neem leaves and Eupatorium leaves at the rate of 250 g per plant reduced root-knot infestation and increased yield in bhindi (Anonymous, 1980).

Cayrol and Frankowski (1980) showed that all five organic amendments applied except for undecomposed city waste, were equally good for the development of the nematophagous fungus Arthrobotrys used for Meloidogyne control.

The addition of dried poultry faeces, dried poultry manure, oilcake, composted municipal refuse and partially composted poultry manure to tomatoes in the field, significantly reduced infestation by Meloidogyne incognita. Undecomposed or partially decomposed organic matter had the greatest effect (D'Errico and D'Maio, 1980).

Kaliram and Gupta (1980) conducted an experiment to test the efficacy of neem leaf extract. It was seen that best plant growth was obtained at the highest level (leaf extract prepared from 40 g neem leaves per kg of soil) which was also comparable with the next lower level (30 g neem leaves per kg of soil). There existed a positive correlation between the treatments and reduction in the number of galls.

In an experiment conducted to determine the efficacy of integrated control of root-knot nematode in brinjal it was found that application of aldicarb at the rate of 3 kg a.i. per hectare and deep ploughing increased the yield and reduced root-knot nematode population in soil (Hebsi Bai, 1981).

The effect of soil amendments with cotton seed oilcake and chicken litter on M. arenaria was studied in glass-house experiments with Cucurbita pepo. The amendments reduced root galling and stimulated plant growth. The degree of nematode control was dependent on the amount of material added. The use of oilcakes at rates of 0.4 per cent or higher caused significant phytotoxicity. All treatments with chicken litter were nonphytotoxic (Mian and Kabana, 1982).

In glass-house experiments Mian and Kabana (1982a) applied spent coffee grinds, holly leaves, pecan shells or tannic acid at 0.4 per cent w/w to soil heavily infested with M. arenaria. After three weeks the soil was planted with Cucurbita pepo. All materials but pecan shells reduced nematode numbers. The most effective were those with tannic acid; however, these amendments caused severe phytotoxicity. Coffee grinds at 0.4 per cent reduced galling but caused phytotoxicity.

MATERIALS AND METHODS

MATERIALS AND METHODS

Two field experiments were conducted - one for evaluating oilcakes and another for evaluating organic wastes for the control of the root-knot nematodes affecting brinjal.

These experiments were carried out in the Instructional Farm, College of Agriculture, Vellayani, in an area infested by root-knot nematodes.

Design and layout:

The field experiment was laid out in randomised block design with 3 replications.

Plot size	:	2.4 m x 2.4 m
spacing	:	60 cm x 60 cm
No. of plants in each plot	:	16

Experiment I

In this experiment different oilcakes were used to assess their effect on the nematodes. There were ten treatments including control as detailed below:-

Groundnut cake	:	Pit application @ 15 g/pit
Castor cake	:	Pit application @ 15 g/pit
Neem cake	:	Pit application @ 15 g/pit
Mustard cake	:	Pit application @ 15 g/pit

Groundnut cake	:	Broadcasting @ 240 g/plot
Castor cake	:	Broadcasting @ 240 g/plot
Neem cake	:	Broadcasting @ 240 g/plot
Mustard cake	:	Broadcasting @ 240 g/plot
Control	:	Fertilizer as per package of practices recommendation of KAU and extra fertilizer to compensate the NPK in oilcake dose of 15 g per plant.
Control	:	Fertilizer as per package of practices recommendation of KAU (43 g N, 23 g P and 14 g K per plot)

Experiment II

Under this experiment the effect of different organic wastes was studied using the treatments given below:-

Saw dust	: Pit application @ 2500 kg/hectare
Coconut husk powder	: Pit application @ 2500 kg/hectare
Paddy husk	: Pit application @ 2500 kg/hectare
Lemongrass waste	: Pit application @ 2500 kg/hectare
Cashew shell powder	: Pit application @ 2500 kg/hectare

Sawdust	: Broadcasted in the plot @ 2500 kg/hectare
Coconut husk powder	: Broadcasted in the plot @ 2500 kg/hectare
Paddy husk	: Broadcasted in the plot @ 2500 kg/hectare
Lemongrass waste	: Broadcasted in the plot @ 2500 kg/hectare
Cashew shell powder	: Broadcasted in the plot @ 2500 kg/hectare
Control	: No application of organic wastes.

Application of organic amendments

The required quantities of organic amendments were applied and raked to a depth of 25 cm. Watering was done for 21 days for the proper decomposition of the organic amendments.

Transplanting

Three weeks old brinjal seedlings raised in nematode-free soil were planted in the main field 21 days after the application of the organic amendments.

Application of fertilizers

The entire quantities of superphosphate and muriate of potash and half of urea were given as basal dressing before transplanting the seedlings. The balance quantity of urea was top dressed 30 days after transplanting.

Collection of soil samples for nematode counts

Soil samples from all the plots were collected before application of the organic amendments for assessing the pretreatment nematode population. Soil samples were collected at transplanting, on the 45th day and 60th day of transplanting and on the day of final harvest. Soil to a depth of 30 cm was collected from 5 places in each plot from the root zone to make a bulk of 500 g/plot. The soil was thoroughly mixed and taken in polythene bags.

Extraction of nematodes from soil samples

Nematodes were extracted from soil samples following the modified method of Cobb's decanting and sieving technique (Christie and Perry, 1951).

The soil weighing 100 g was transferred to a plastic basin and mixed thoroughly with three times water. Coarse particles and foreign materials were allowed to settle for a few seconds. The suspension was then decanted through a twentyfive 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 seconds and then passed through a hundred mesh sieve and the catch in the sieve was collected. The sediments in the basin after

three washings were discarded. The filtrate was again allowed to stand for a few seconds and then decanted and passed through two hundred mesh sieve and then through three hundred and twentyfive mesh sieve. The fine silt and nematodes collected in these sieves were washed down into a beaker using minimum quantity of water.

Isolation of nematodes by Baerman's funnel

Nematode suspension obtained from the soil samples was poured gently into a tissue paper kept in position in the Baerman's funnel with the help of a wire gauze. The funnel was filled with water up to a level just touching the tissue paper. The funnel was kept undisturbed for twentyfour hours. Then about 10 ml of the water was drawn out into a specimen tuber by loosening the pinch cock.

Fixing and preservation of nematodes

The nematode suspension obtained from the water drawn out from the Baerman's funnel was allowed to settle and the volume was reduced to 5 ml by pipetting out water from the top. An equal quantity of boiling formalin 10 per cent was added to this to kill the nematodes. A drop of this suspension was examined under a stereo microscope to ascertain whether the nematodes were properly killed.

Counting the nematodes

The preserved suspension of nematodes was shaken well and one ml was taken and transferred to a counting slide by means of a pipette. Then the population of Meloidogyne incognita was counted and recorded.

Assessment of results

The effect of the different treatments was assessed in terms of yield, formation of galls on roots, plant height, number of leaves, number of branches, shoot weight and root weight of the plants and build up of nematode population in soil under different treatments.

Yield

In order to compare the yield in the different treatment plots, weight of fruits obtained from 4 plants from each plot was recorded.

Gall formation on roots

Gall counts were taken in the uprooted plants from the different treatments at the end of the experiment. All the roots of a plant were carefully cut out and the galls on each rootlet were counted and recorded. The gall population was expressed as number of galls per 10 cm of root. For

estimating the weight of galls, all the galls from the root system of a plant were cut out and weighed. The total weight of the root system was found out before cutting out the galls. Percentage weight of galls in terms of root-knot index was calculated from these values.

Height of plants

The height of plants in the observational plot was taken at the end of the experiment. The plant height was taken from the first node to the base of the terminal bud. Average height was calculated.

No. of leaves

Total number of leaves produced on every plant in the observational plot was recorded at the end of the experiment.

No. of branches

Total number of branches produced per plant was recorded at the end of the experiment and average calculated.

Weight of roots

To find out the weight of root system, at the time of harvest the below-ground part of each plant was weighed after proper washing and drying.

Shoot weight

Shoot weight of the plants at the time of harvest was assessed by cutting off the root system and weighing the shoots separately for each plant.

Nematode population.

Observations on the soil population of nematode were made before application of amendments, at the time of transplanting and at 45th, 60th and 90th days after planting.

RESULTS

RESULTS

Experiment I

Control of Meloidogyne incognita on brinjal using oilcakes

Effect of treatments on root galls

Table 1 gives the number of galls on the roots of brinjal at harvest. It may be observed that all the treatments reduced gall formation on the roots significantly as compared to control. As against 14.430 and 15.830 galls per 10 cm of root under control 1 and control 2 respectively, the number of galls ranged from 0.342 to 1.690 in different treatments. Statistically there was no significant difference among the different treatments and also between the two methods of application. However, the maximum reduction in the number of galls was shown under pit applications of mustard cake (0.342 galls per 10 cm root) and neem cake (0.363 galls per 10 cm root). This was followed by broadcast (0.761 galls per 10 cm root) and pit application (1.022 galls per 10 cm root) of groundnut cake, broadcast application of mustard cake (1.100 galls per 10 cm root), pit application of castor cake (1.132 galls per 10 cm root) and broadcast applications of neem cake (1.150 gall per 10 cm root) and castor cake (1.690 galls per 10 cm root).

Formation of root galls with egg mass

It can be seen from Table 1 that all the treatments reduced significantly the number of root galls with egg mass as compared to the control. While the number of galls with egg mass per 10 cm of root was 2.06 under control 1 and 2.73 under control 2, it ranged between 0.03 and 0.24 in the different treatments. Reduction in the number of galls with egg mass was the highest in the pit applications of mustard cake (0.03 gall with egg mass per 10 cm root) and neem cake (0.07 galls with egg mass per 10 cm root). This was followed by broadcast application (0.08 galls with egg per 10 cm root) and pit application of groundnut cake (0.11 galls with egg mass per 10 cm root), broadcast applications of neem cake (0.12 galls with egg mass per 10 cm root) and mustard cake (0.14 galls with egg mass per 10 cm root), pit application of castor cake (0.17 galls with egg mass per 10 cm root) and broadcast application of castor cake (0.24 galls per 10 cm root).

Root-knot index

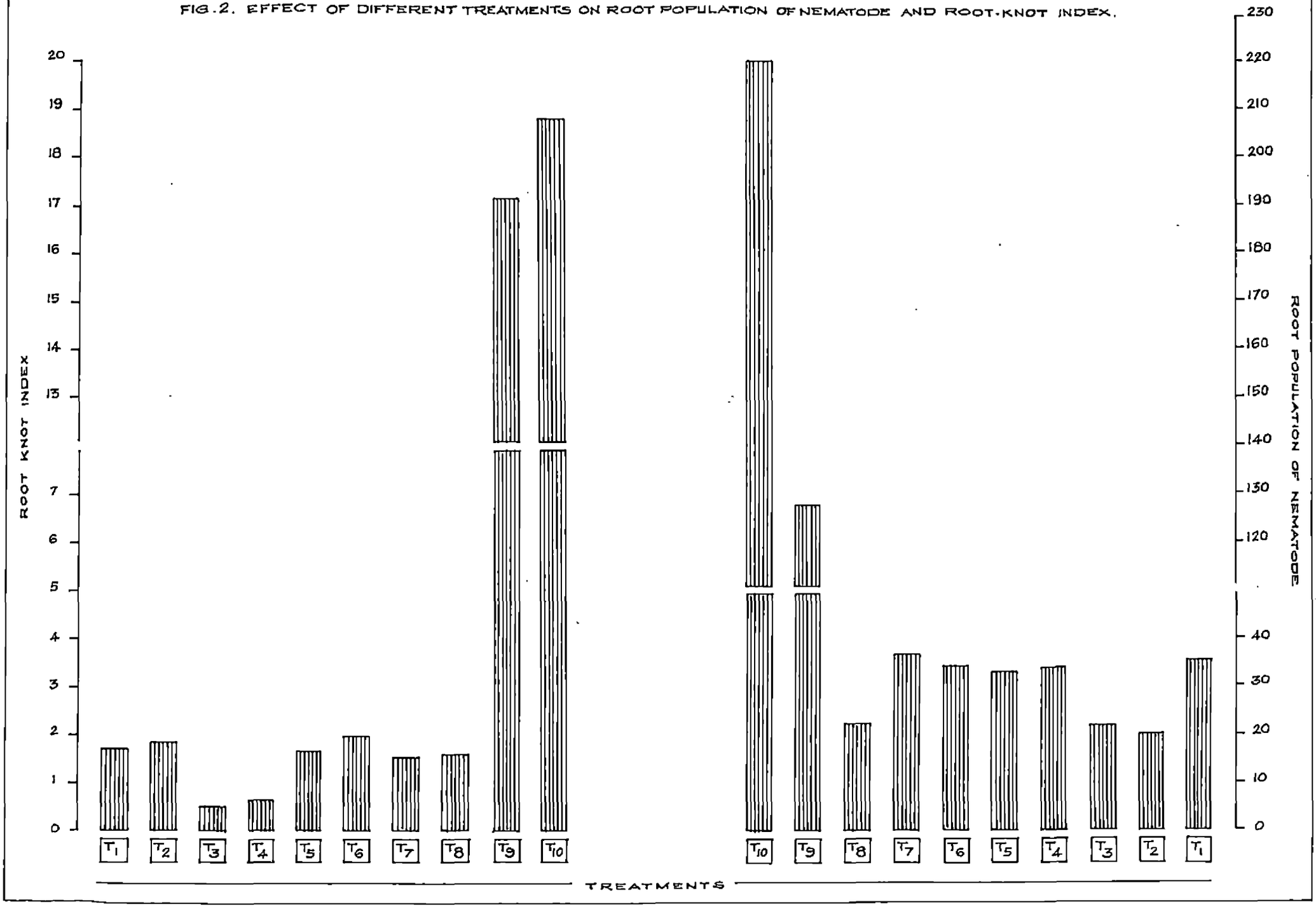
Data on root-knot index (Table 1 and Fig. 2) showed that the index (which gives an overall picture of root infestation by the nematode) was significantly low in all the treatments. Mean root-knot index ranged between 0.51 and 1.98 in different treatments as compared to 17.19 and

Table 1. Gall formation on roots of brinjal plants treated with different oilcakes. (Average of three replications)

Treatments	Mean number of galls per 10cm of roots	Mean number of galls with egg mass per 10cm of root	Root-knot index
Pit application			
Groundnut cake	1.022 (1.422)	0.11 (1.05)	1.75 (1.32)
Castor cake	1.132 (1.460)	0.17 (1.08)	1.92 (1.38)
Neem cake	0.363 (1.164)	0.07 (1.03)	0.51 (0.71)
Mustard cake	0.342 (1.157)	0.03 (1.01)	0.65 (0.80)
Broadcast application			
Groundnut cake	0.761 (1.322)	0.08 (1.04)	1.71 (1.31)
Castor cake	1.690 (1.640)	0.24 (1.11)	1.96 (1.40)
Neem cake	1.150 (1.466)	0.12 (1.06)	1.58 (1.25)
Mustard cake	1.100 (1.449)	0.14 (1.07)	1.64 (1.28)
Control 1 - Fertilizers at package of practices plus extra NPK equivalent to oilcake dose	14.430 (3.925)	2.06 (1.74)	17.19 (4.14)
Control 2 - Fertilizer at package of practice	15.830 (4.062)	2.73 (1.93)	18.89 (4.34)
C.D.	0.60	0.23	0.11

(Figures in parentheses are values $\sqrt{x + 1}$ transformation)

FIG. 2. EFFECT OF DIFFERENT TREATMENTS ON ROOT POPULATION OF NEMATODE AND ROOT-KNOT INDEX.



18.89 under control 1 and 2 respectively. Pit application of neem cake was found to be the most effective with a mean root-knot index of 0.51 followed by pit application of mustard cake with 0.63 as mean root-knot index. Broadcast application of neem cake (1.58 as mean root-knot index) was the next effective treatment followed by broadcast applications of mustard cake (1.64 as mean root-knot index) and groundnut cake (1.71), pit applications of groundnut cake (1.75) and castor cake (1.92) and then by broadcast application of castor cake (1.96 mean root-knot index).

Population of Meloidogyne incognita in roots at harvest

Table 2 and Fig. 2 give the number of root-knot nematodes in roots at harvest. It may be seen that the number of nematodes in roots of plants receiving the oilcakes was considerably low when compared to those of plants in the control. The effect of the treatments was statistically significant. While the mean population in the control ranged from 128 to 221 in 10 g of root, it ranged between 20.33 and 36.67 in different treatments. The mean population of nematode in root was the lowest in pit application of castor cake (20.33 per 10 g of root) followed by pit application of neem cake (22 per 10 g of root), broadcast applications of mustard cake (22.67 per 10 g of root) and groundnut cake (33 per 10 g of root), pit application of mustard cake (34 per 10 g of root),

broadcast application of castor cake (34.65 per 10 g of root), pit application of groundnut cake (35.67 per 10 g of root) and broadcast application of neem cake (36.67 per 10 g of root).

Population of root-knot nematode in soil

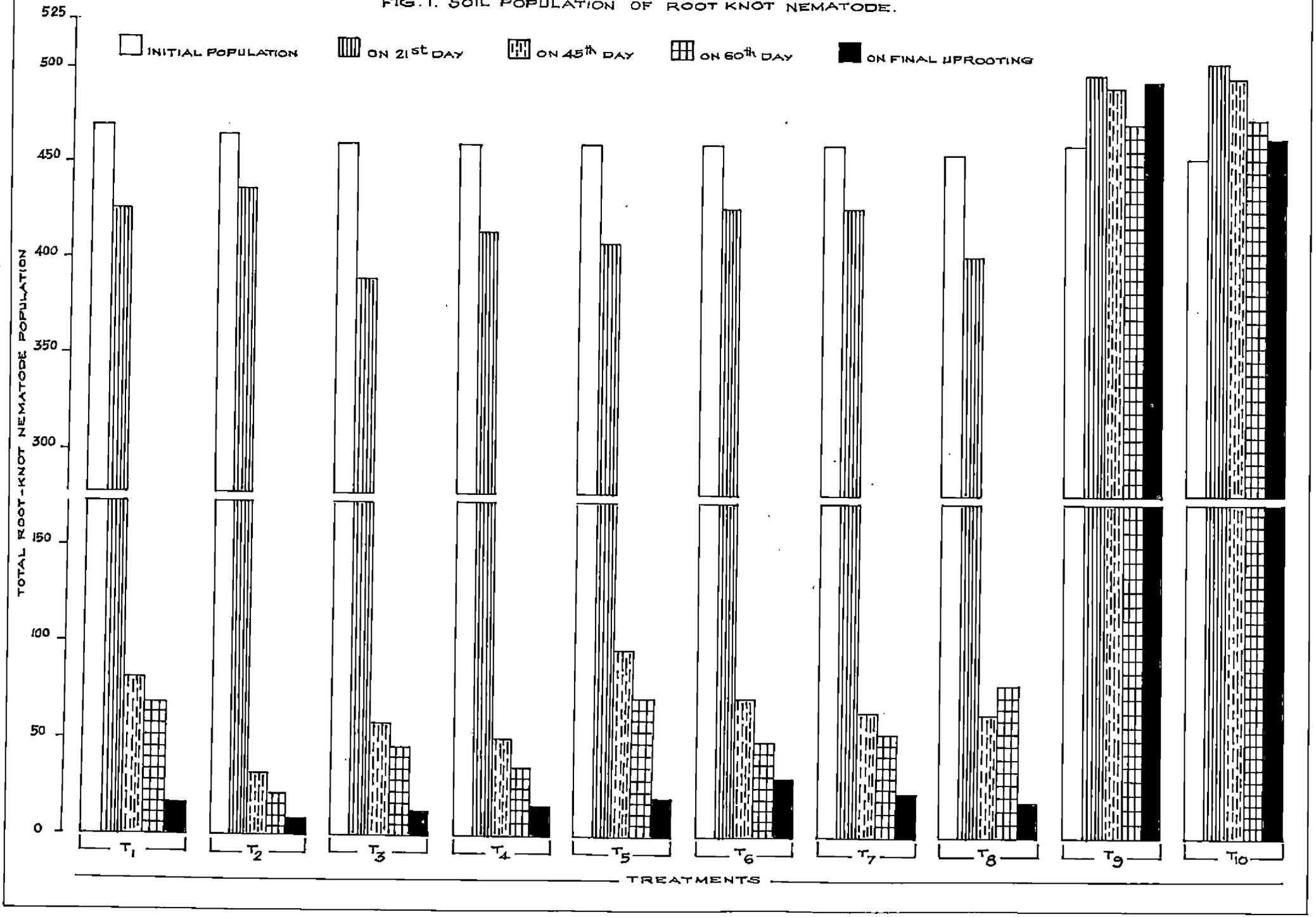
Before application of oilcakes

Table 2 and Fig. 1 show the nematode population status in soil before amendment with oilcakes. The different plots showed no significant variation in nematode population which ranged between 455 and 471 per 100 g of soil.

Twentyone days after application of oilcakes

Nematode population in soil just before transplanting and 21 days after application of oilcakes is given in Table 2 and Fig. 1. The decrease in population level in the treated plots as evident from the table is statistically significant when compared to the population before application of the oilcakes. Mean population was the lowest in pit application of neem cake (390.7 per 100 g of soil) followed by broadcast applications of mustard cake (400.7 per 100 g of soil) and groundnut cake (408.7 per 100 g of soil), pit applications of mustard cake (413.7 per 100 g of soil) and groundnut cake (426 per 100 g of soil), broadcast applications of neem cake (427 per 100 g of soil) and castor cake (427.3 per 100 g of

FIG. 1. SOIL POPULATION OF ROOT KNOT NEMATODE.



soil) and pit application of castor cake (432 per 100 g of soil).

Fortyfive days after transplanting

Table 2 and Fig. 1 present the population of root-knot nematode in soil 45 days after transplanting and 66 days after application of oilcakes. There was significant reduction in the population due to treatments. Mean population of the nematode per 100 g of soil varied between 31.7 and 98.7 in different treatments as against 491.3 and 496.7 in control 1 and 2 respectively. The reduction in population was the highest in pit application of castor cake (31.7 per 100 g of soil). Next to this came pit application of mustard cake (50.7 per 100 g of soil) and neem cake (57 per 100 g of soil). This was followed by broadcast applications of mustard cake (64.3 per 100 g of soil), neem cake (66.7 per 100 g of soil) and castor cake (73 per 100 g of soil), pit application (82.7 per 100 g of soil) and broadcast application (98.7 per 100 g of soil) of groundnut cake.

Sixty days after transplanting

Soil population of the nematode 60 days after transplanting and 81 days after application of oilcakes as presented in Table 2 and Fig. 1 showed that the population was maintained on significantly lower levels due to different treatments.

The mean population in treatments varied between 24.3 and 78.3 (per 100 g of soil) as against 473 to 474.3 (per 100 g of soil) in control. Pit application of castor cake (24.3 per 100 g of soil) ranked first in effectiveness. This was followed by pit applications of mustard cake (35 per 100 g of soil) and neem cake (43.3 per 100 g of soil), broadcast applications of castor cake (48.7 per 100 g of soil) and neem cake (53.3 per 100 g of soil), pit application of groundnut cake (70.33 per 100 g of soil) and broadcast applications of groundnut cake (73 per 100 g of soil) and mustard cake (78.3 per 100 g of soil).

At harvest

Data on soil population of nematode 111 days after application of oilcakes presented in Table 2 and Fig. 1 reveal the effectiveness of the different treatments over control 1 and control 2 in bringing down the nematode population in soil. The reduction in the population obtained by the treatments was highly significant over the control. The lowest population level was recorded in the case of pit application of castor cake (8.7 per 100 g of soil). This was followed in the descending order of effectiveness by pit applications of neem cake (11.7 per 100 g of soil), mustard cake (16 per 100 g of soil) and groundnut cake (16.3 per 100 g of soil) and broadcast applications of mustard cake

(17 per 100 g of soil), groundnut cake (20.7 per 100 g of soil), neem cake (21.3 per 100 g of soil) and castor cake (29.6 per 100 g of soil).

Yield

The yield data are presented in Table 3 and Fig. 4. Against the mean yield of 118.33 g and 113.02 g of fruits per plant in control 1 and control 2, the mean yield varied from 153.75 to 221.46 g per plant in different treatments. The highest yield was recorded in the case of pit application of mustard cake (221.46 g per plant). This was closely followed by pit applications of castor cake (209.17 g per plant) and groundnut cake (202.92 g per plant). Broadcast applications of mustard cake (194.59 g per plant) and castor cake (180 g per plant), pit application of neem cake (177.19 g per plant) and broadcast applications of neem cake (161.98 g per plant) and groundnut cake (153.75 g per plant) ranked next in effectiveness.

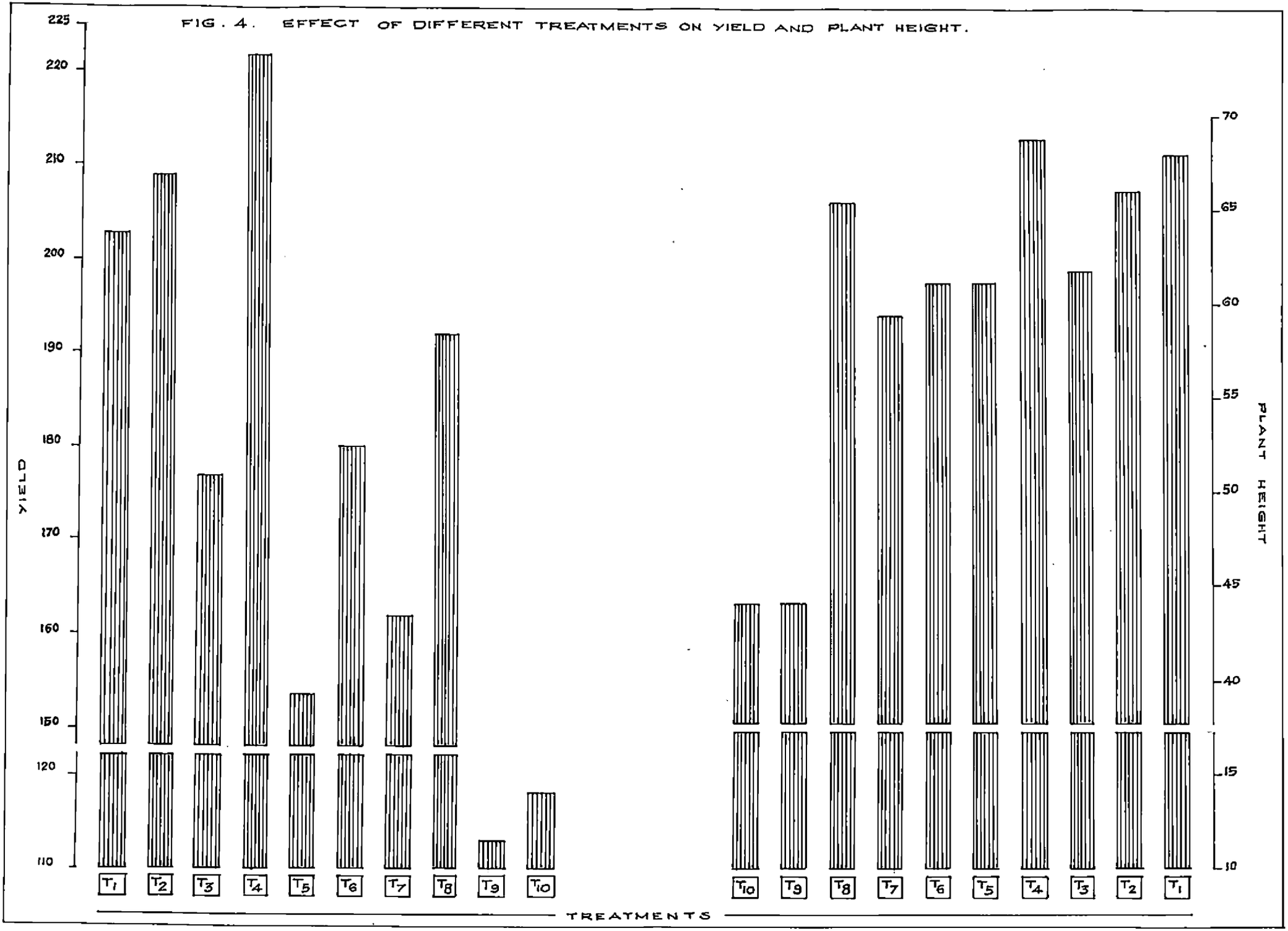
Plant height

Data presented in Table 3, Fig. 4 show that the mean height of the plants was 44.17 cm and 44.16 cm in control 1 and control 2 respectively, while the height ranged between 59.42 cm and 68.82 cm in treated plots. Pit application of

Table 3. Biometrical observation of brinjal plants treated with different oilcakes. (Average of three replications)

	Mean height of plant (cm)	Number of branches	Number of leaves	Root weight (g)	Shoot weight (g)	Yield (g)
Pit application						
Groundnut cake	68.17	13.83	68.83	33.17	172.4	202.92
Castor cake	66.00	12.58	64.33	34.87	160.3	209.17
Neem cake	61.92	12.75	52.33	31.10	145.1	177.19
Mustard cake	68.82	12.83	75.08	31.85	158.9	221.46
Broadcast application						
Groundnut cake	61.67	12.50	67.83	33.27	187.1	153.75
Castor cake	61.17	13.66	84.08	32.83	202.6	180.00
Neem cake	59.42	12.08	67.17	36.27	180.6	161.98
Mistard cake	65.50	13.33	70.92	32.90	196.3	194.59
Control 1 - Fertilizers at package of practices plus extra NPK equivalent to oil-cakes dose	44.17	9.83	43.83	22.07	107.1	113.02
Control 2 - Fertilizers at package of practices	44.16	8.75	42.58	18.70	101.9	118.33
C.D.	16.71	2.28	21.15	7.48	44.33	47.54

FIG. 4. EFFECT OF DIFFERENT TREATMENTS ON YIELD AND PLANT HEIGHT.

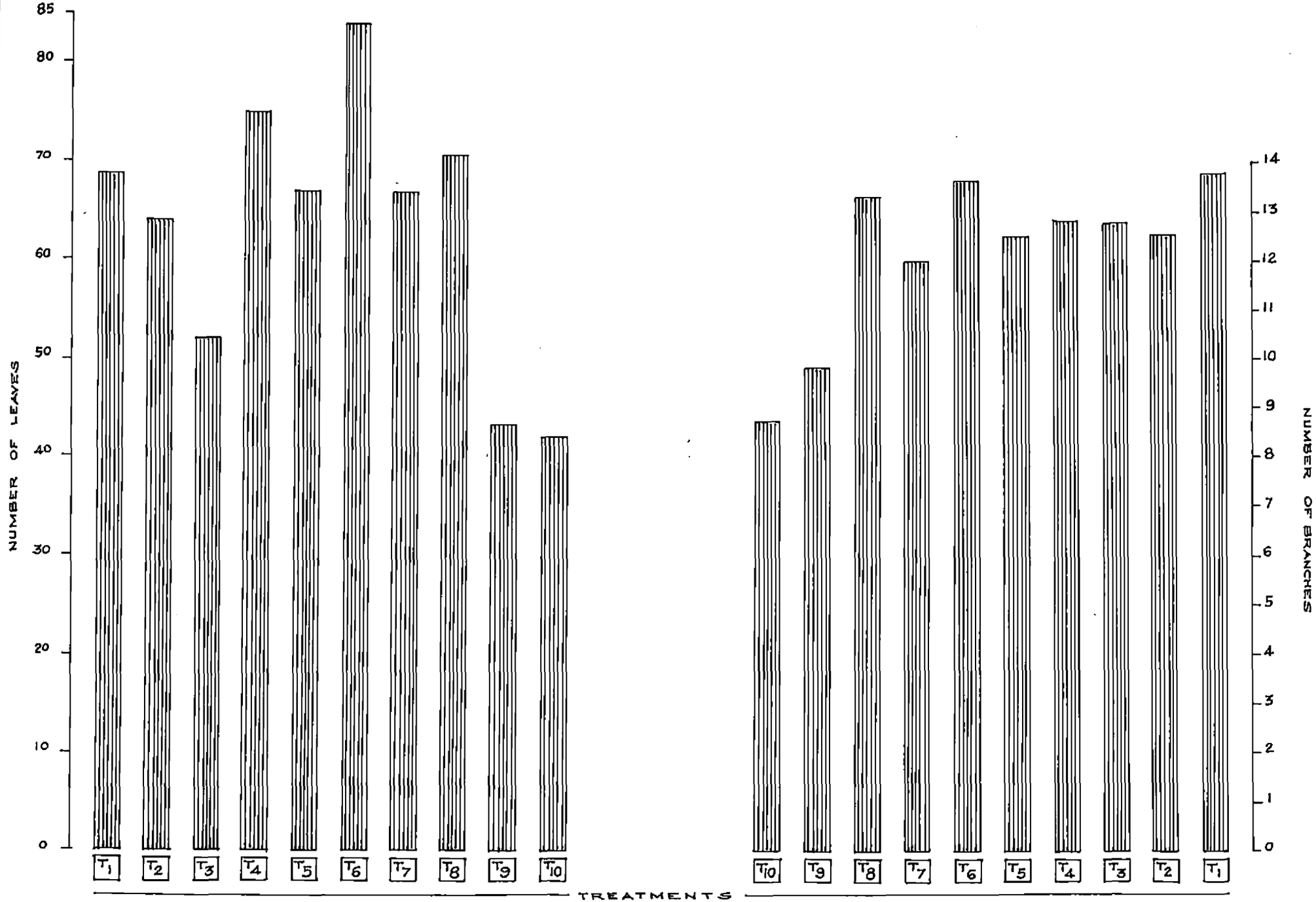


mustard cake produced the tallest plants the mean height being 68.82 cm. This was closely followed by pit applications of groundnut cake (68.17 cm) and castor cake (66 cm). Broadcast application of mustard cake (65.5 om) ranked fourth followed by pit application of neem cake (61.92 cm) and broadcast applications of groundnut cake (61.67 cm), castor cake (61.17 cm and neem cake (59.42 cm).

Number of branches

It is apparent from Table 3 and Fig. 3 that the different treatments had significant impact on the number of branches produced by the plants. The mean number of branches was maximum (13.83) under pit application of groundnut cake which was closely followed by broadcast application of castor cake (13.66). In respect of the remaining treatments mean number of branches produced were 13.33 under broadcast application of mustard cake and 12.83, 12.75 and 12.58 under pit applications of mustard cake, neem cake and castor cake respectively. Under broadcast applications of groundnut cake and neem cake mean number of branches produced were 12.50 and 12.08 respectively. Thus the mean number of branches varied between 12.08 and 13.83 under different treatments while it was only 9.83 and 8.75 under control 1 and 2 respectively.

FIG. 3. EFFECT OF DIFFERENT TREATMENTS ON NUMBER OF BRANCHES AND NUMBER OF LEAVES PER PLANT.



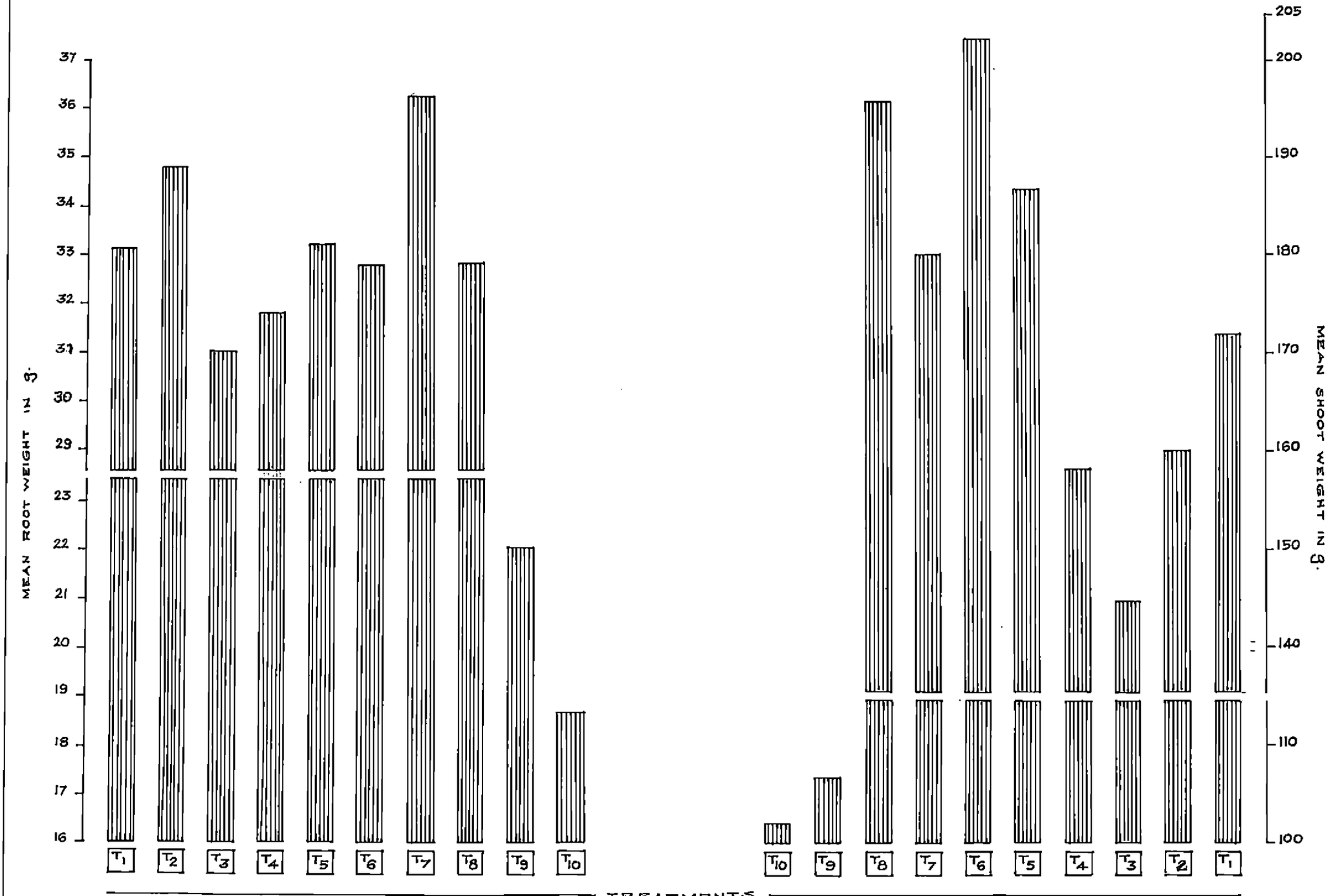
Number of leaves

The different treatments under trial showed significant impact on the number of leaves produced (Table 3 and Fig. 3). The mean number of leaves was within the range 52.33 and 84.08 under different treatments as against 43.83 and 42.58 under control 1 and 2 respectively. Maximum number of leaves produced was under broadcast application of castor cake the mean number of leaves being 84.08. This was followed by pit application (75.08) and broadcast application (70.92) of mustard cake, pit application of groundnut cake (68.83) broadcast applications of groundnut cake (67.83) and neem cake (67.17) and pit applications of castor cake (64.33) and neem cake (52.33).

Root weight

Results presented in Table 3 and Fig. 5 show that the treatments gave significant increase in root weight. While the mean root weight was 22.07 g and 18.70 g under control 1 and 2 respectively it ranged between 31.10 g and 36.27 g under the various treatments. The mean root weight of 36.27 g was under broadcast application of neem cake. Pit application of castor cake (34.87 g) was the next effective, in increasing the root weight. This was followed by broadcast application (33.27 g) and pit application (33.17 g) of groundnut cake,

FIG. 5. EFFECT OF DIFFERENT TREATMENTS ON THE FRESH ROOT WEIGHT AND SHOOT WEIGHT.



broadcast applications of mustard cake (32.90 g) and castor cake (32.83 g) and pit applications of mustard cake (31.83 g) and neem cake (31.10 g).

Shoot weight

Data presented in Table 3 and Fig. 5 show the effect of the different treatments in increasing the fresh shoot weight. The mean shoot weight ranged between 145.1 g and 202.6 g under different treatments while under control 1 and 2 the mean shoot weight was 101.9 g and 107.1 g respectively. The maximum shoot weight obtained was 202.6 g under broadcast application of castor cake. The mean shoot weight was 196.3 g, 187.1 g and 180.6 g under broadcast applications of mustard cake, groundnut cake and neem cake respectively. This was followed by pit applications of groundnut cake (172.4 g), castor cake (160.3 g), mustard cake (158.9 g) and neem cake (145.1 g).

Experiment II

Effect of organic wastes in the control of Meloidogyne incognita on brinjal

Gall formation on the roots

Table 4 shows the mean number of galls on roots at harvest. The treatments were highly effective in reducing

the intensity of gall formation in roots. As against a mean number of 7.85 galls per 10 cm of root in the control the number in the treated plots ranged between 0.28 to 1.85 per 10 cm of root. Broadcast application of sawdust which gave the maximum reduction in gall formation (0.28 per 10 cm of root) was followed in effectiveness by broadcast application of cashew shell powder (0.32 per 10 cm root). Under pit application of lemongrass waste the mean number of galls was 0.48 per 10 cm of root. The other treatments in the order of their effectiveness were broadcast application (0.64 per 10 cm of root) and pit application (0.73 per 10 cm of root) of coconut husk powder, broadcast applications of paddy husk (1.25 per 10 cm of root) and lemongrass waste (1.41 per 10 cm of root) and pit application of cashew shell powder (1.59 per 10 cm of root), sawdust (1.70 per 10 cm of root) and paddy husk (1.85 per 10 cm of root.

Formation of root galls with eggmass

The data presented in Table 4 showed that all the treatments were effective in reducing the number of galls with eggmass. The mean number of root galls with eggmass per 10 cm of root, ranged between 0.04 to 0.42 in the treated plots whereas it was 1.83 in the control. Number of galls with eggmass was the least in broadcast application of cashew shell powder (0.040 per 10 cm of root) followed by broadcast

Table 4. Gall formation on roots of brinjal plants treated with different organic wastes. (Average of three replications)

Treatments	Mean No. of galls per 10 cm of root	Mean No. of galls with egg mass per 10 cm of root	Root-knot index
Pit application			
Saw dust	1.70 (1.01)	0.420 (1.169)	1.90 (1.141)
Coconut husk powder	0.73 (0.85)	0.053 (1.026)	0.87 (0.929)
Paddy husk	1.85 (1.03)	0.410 (1.164)	1.85 (1.086)
Lemongrass waste	0.48 (0.68)	0.073 (1.039)	0.75 (0.591)
Cashew shell powder	1.59 (1.07)	0.080 (1.039)	2.19 (1.312)
Broadcast application			
Saw dust	0.28 (0.53)	0.047 (1.023)	0.39 (0.621)
Coconut husk powder	0.64 (0.78)	0.060 (1.029)	0.86 (0.918)
Paddy husk	1.25 (1.08)	0.300 (1.134)	1.91 (1.340)
Lemongrass waste	1.41 (0.94)	0.230 (1.104)	1.71 (1.196)
Cashew shell powder	0.32 (0.53)	0.040 (1.018)	0.65 (0.750)
Control	7.85 (2.67)	1.830 (1.640)	12.42 (3.460)
C.D.	0.897	0.280	0.969

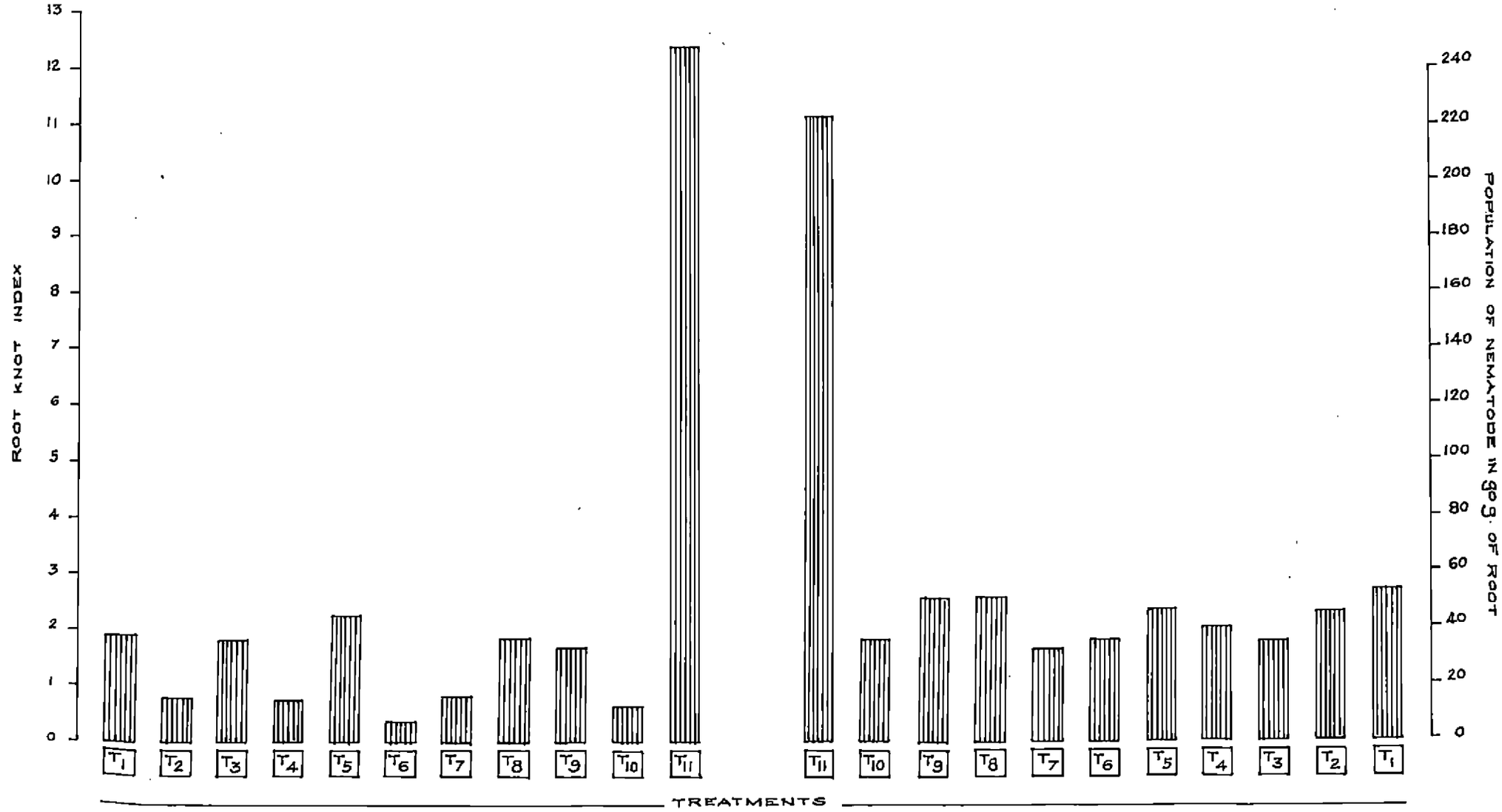
(Figures in parentheses are values after $\sqrt{x}$ transformation)

application of sawdust (0.047 per 10 cm of root). Pit application (0.053 per 10 cm of root) and broadcast application (0.06 per 10 cm of root) of coconut husk powder were the next effective treatments. Remaining treatments in the order of effectiveness were pit application of lemongrass waste (0.073 per 10 cm of root) and cashew shell powder (0.08 per 10 cm of root), broadcast applications of lemongrass waste (0.23 per 10 cm of root) and paddy husk (0.3 per 10 cm of root) and finally pit applications of paddy husk (0.41 per 10 cm of root) and sawdust (0.42 per 10 cm of root).

Root-knot index

Data on root-knot index (Table 4 and Fig. 7) showed the effectiveness of the treatments in reducing the root-knot index which ranged from 0.39 to 2.19 in the treated plots as against 12.42 in the control. Root-knot index was the lowest (0.39) in broadcast application of sawdust. This was followed by broadcast application of cashew shell powder (0.63), pit application of lemongrass waste (0.75), broadcast application of coconut husk powder (0.86), pit application of coconut husk powder (0.87), broadcast application of lemongrass waste (1.71), pit applications of paddy husk (1.85) and sawdust (1.90), broadcast application of paddy husk (1.91) and finally pit application of cashew shell powder (2.19).

FIG. 7 . EFFECT OF DIFFERENT TREATMENTS ON THE ROOT POPULATION OF NEMATODE AND ROOT-KNOT INDEX.



Population of Meloidogyne incognita in roots at harvest

The mean population of nematode in root at harvest (Table 5 and Fig. 7) was appreciably low in plants receiving the treatments. The population ranged between 34.3 and 54.7 per 10 g of root in the treated plots against 221.7 in the control. The lowest population was observed in the plot where coconut husk powder was broadcasted (34.3); population recorded under different treatments were 36.3 in pit application of paddy husk, 36.7 in both the broadcast applications of sawdust and cashew shell powder, 41.7 in pit application of lemongrass waste, 47.3 in pit application of cashew shell powder, 47.7 in pit application of coconut husk powder, 50.3 in broadcast application of lemongrass waste, 51 in broadcast application of paddy husk and 54.7 in pit application of sawdust.

Population of Meloidogyne incognita in soil

Before application of organic wastes

Nematode population in soil before amendment with the organic wastes (Table 5 and Fig. 6) showed no significant difference between the different plots.

Twentyone days after the application

Though there was some reduction in the population of nematode in soil (Table 5 and Fig. 6) it was not statistically

significant. The population ranged between 373.3 and 448.3 per 100 g of soil in the different plots at the time of transplanting and 21 days after application of organic wastes.

Fortyfive days after transplanting

Sixtysix days after amending and fortyfive days after transplanting there was considerable reduction in the population of nematode (Table 5 and Fig. 6) in all the treated plots. The lowest mean population (29.3) was under broadcast application of coconut husk powder. This was followed by broadcast application of cashew shell powder (52) and then by pit application of sawdust (59.3). The population was 61.7 in broadcast application of lemongrass waste, 76.7 in pit application of coconut husk powder, 85.3, 88 and 91.0 in pit applications of cashew shell powder, paddy husk and lemongrass waste respectively, 147 in broadcast application of sawdust and 147.7 in broadcast application of paddy husk. In control the population was 442.3.

Sixty days after transplanting

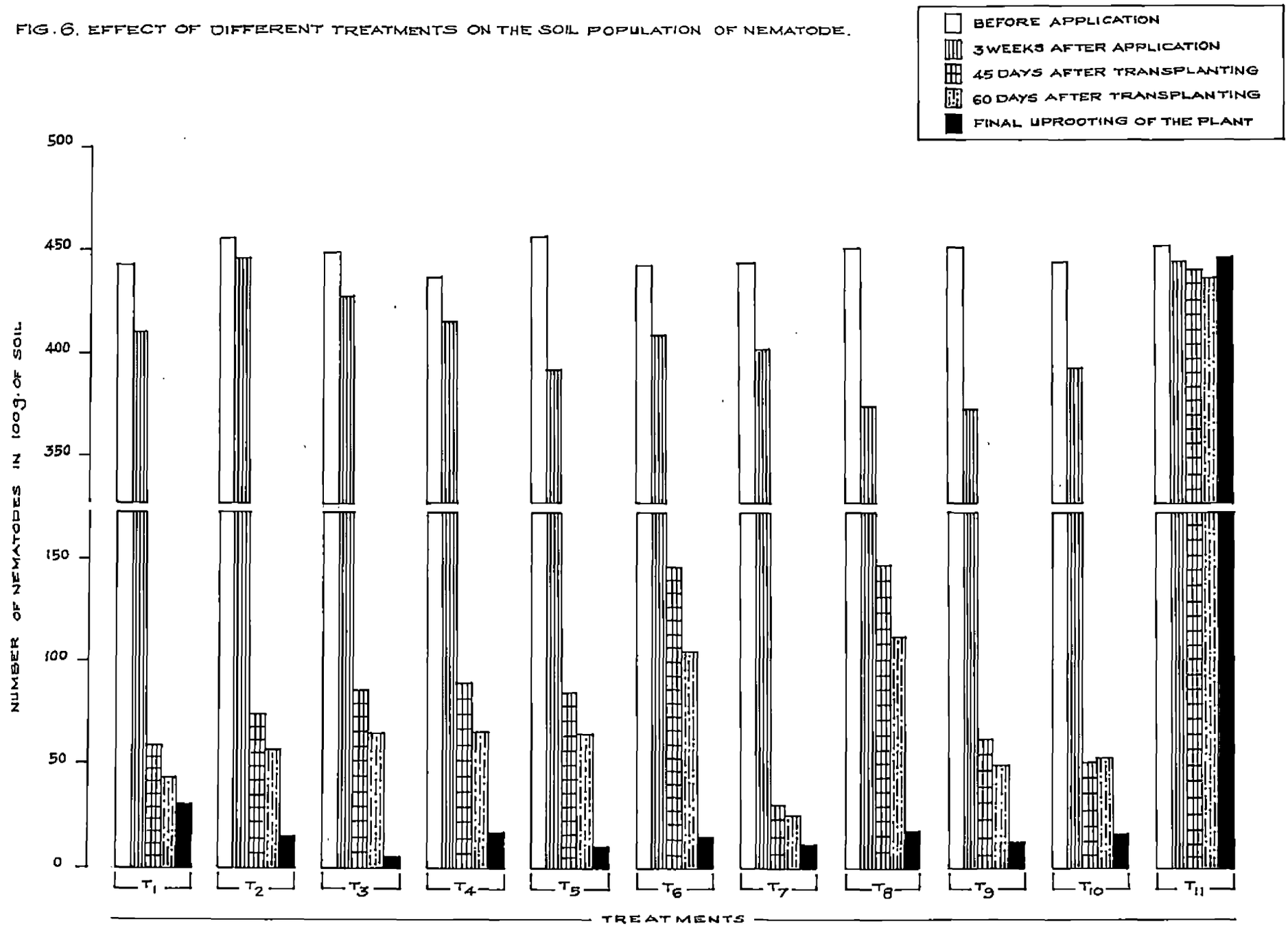
In the different treated plots the population per 100 g of soil 60 days after transplanting and eightyone days after amending the soil, ranged between 26 and 112 (Table 5 and Fig. 6) as against 436 in the control; population was the

lowest (26) in broadcast application of coconut husk powder. This was followed by pit application of sawdust (44.7). In broad cast applications of lemongrass waste and cashew shell powder the population levels were 48.7 and 53.3 respectively. Under pit applications of coconut husk powder, paddy husk, cashew shell powder and lemongrass waste the population was 58, 65.3, 65.35 and 66.7 respectively and under broadcast applications of sawdust and paddy husk it was 107.0 and 112 respectively.

At harvest

Data on population of the nematode in the soil at the final uprooting of the crop, 90 days after transplanting and 111 days after applying the amendments (Table 5 and Fig. 6) show that the mean population per 100 g of soil was very low ranging from 8.7 to 30.7 in the treated plots whereas it was as high as 447.3 in the control. Population level was the lowest (8.7) under pit application of cashew shell powder and this was closely followed by pit application of paddy husk (9) and broadcast application of coconut husk powder (10). Under broadcast applications of lemongrass waste and sawdust the mean population was 12 and 15 respectively. Both under pit application of coconut husk powder and broadcast application of paddy husk the mean population was 15.7. This was followed by broadcast application of cashew shell powder (16.3),

FIG. 6. EFFECT OF DIFFERENT TREATMENTS ON THE SOIL POPULATION OF NEMATODE.



pit application of lemongrass waste (16.7) and finally by pit application of sawdust (30.7).

Yield

The plants which received the organic waste treatments gave significantly higher yield over the control (Table 6 and Fig. 9). Mean yield ranged between 108.96 g and 169.7 g per plant in treated plots against 75.52 g in the control. Among the different treatments broadcast application of lemongrass waste recorded the highest yield (169.7 g). This was followed by broadcast applications of sawdust (158.44 g) and paddy husk (153.79 g). The yield obtained from plot receiving pit application of coconut husk powder was 150.84 g. The yield in respect of the remaining treatments were 147.61 g in broadcast application of coconut husk powder, 146.56 g, 135.42 g, 115.42 g and 114.38 g in pit applications of cashew shell powder, sawdust, lemongrass waste and paddy husk respectively and 108.96 g in broadcast application of cashew shell powder.

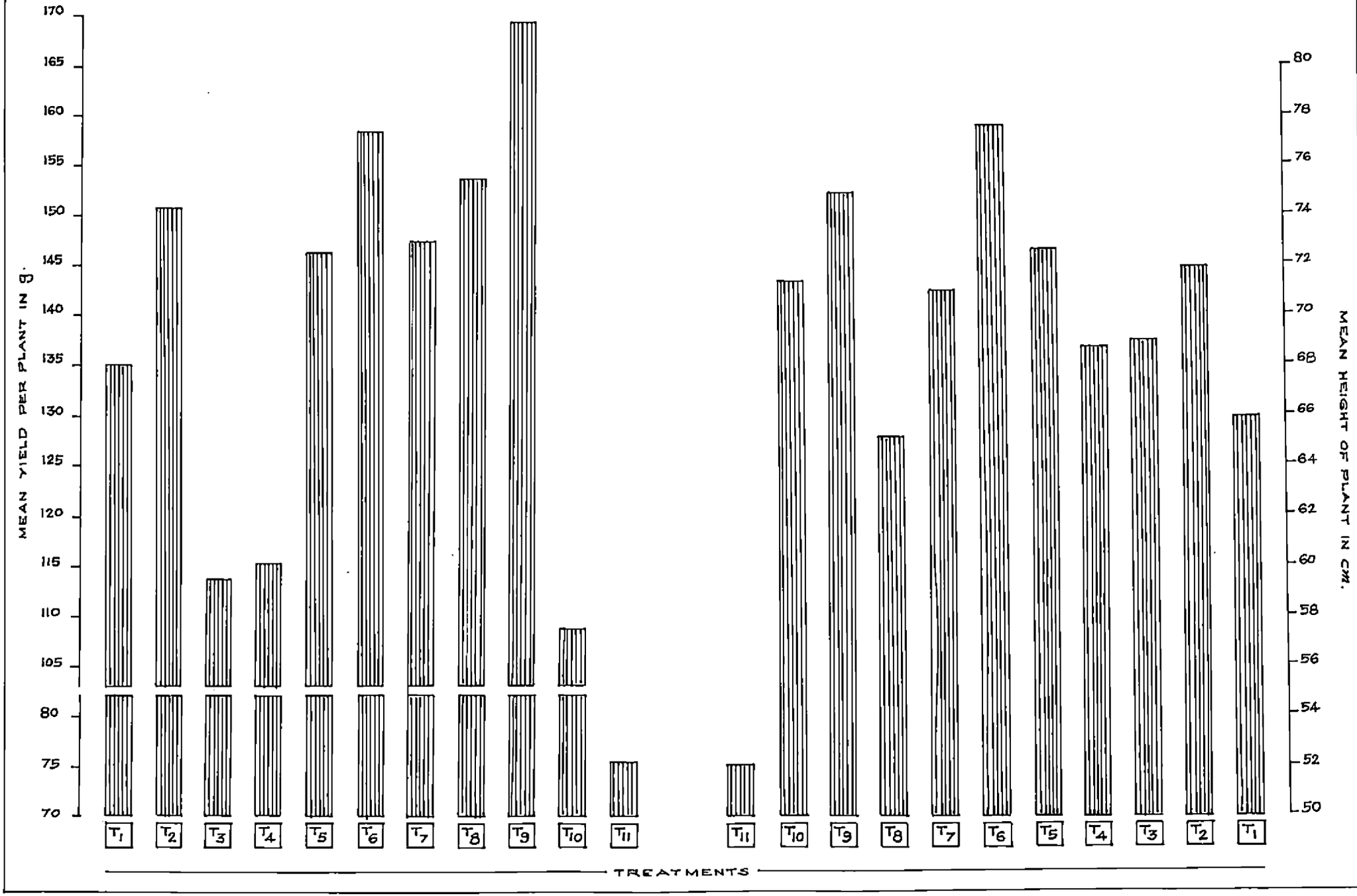
Height of plants

Data presented (Table 6 and Fig. 9) show that the mean height of the control plants was 52.01 cm while the height ranged between 65.5 cm and 77.83 cm under the different treatments. The mean height of plants in respect of the

Table 6. Biometric characters of brinjal plants treated with different organic wastes. (Average of three replications)

Treatments	Mean yield per plant (g)	Mean height (cm)	Mean No. of branches.	Mean No. of leaves	Mean shoot weight (g)	Mean root weight (g)
Pit application						
Saw dust	135.42	66.00	13.00	70.50	192.44	25.58
Coconut husk powder	150.84	72.08	12.50	68.67	179.54	29.32
Paddy husk	114.38	69.08	11.67	66.75	158.65	25.97
Lemongrass waste	115.42	68.83	11.50	68.58	152.55	26.71
Cashew shell powder	146.56	72.75	12.42	71.50	176.97	25.99
Broadcast application						
Saw dust	158.44	77.83	13.33	79.17	186.90	25.95
Coconut husk powder	147.61	71.00	12.92	79.33	181.86	27.55
Paddy husk	153.79	65.50	12.08	73.75	202.54	30.90
Lemongrass waste	169.70	74.95	14.17	77.33	165.76	25.85
Cashew shell powder	108.96	71.25	13.83	81.75	162.86	26.26
Control	75.52	52.01	8.83	47.33	102.05	19.73
C.D.	42.1	2.61	2.6	5.46	56.41	3.06

FIG. 9. EFFECT OF DIFFERENT TREATMENTS ON MEAN YIELD AND HEIGHT OF PLANTS.

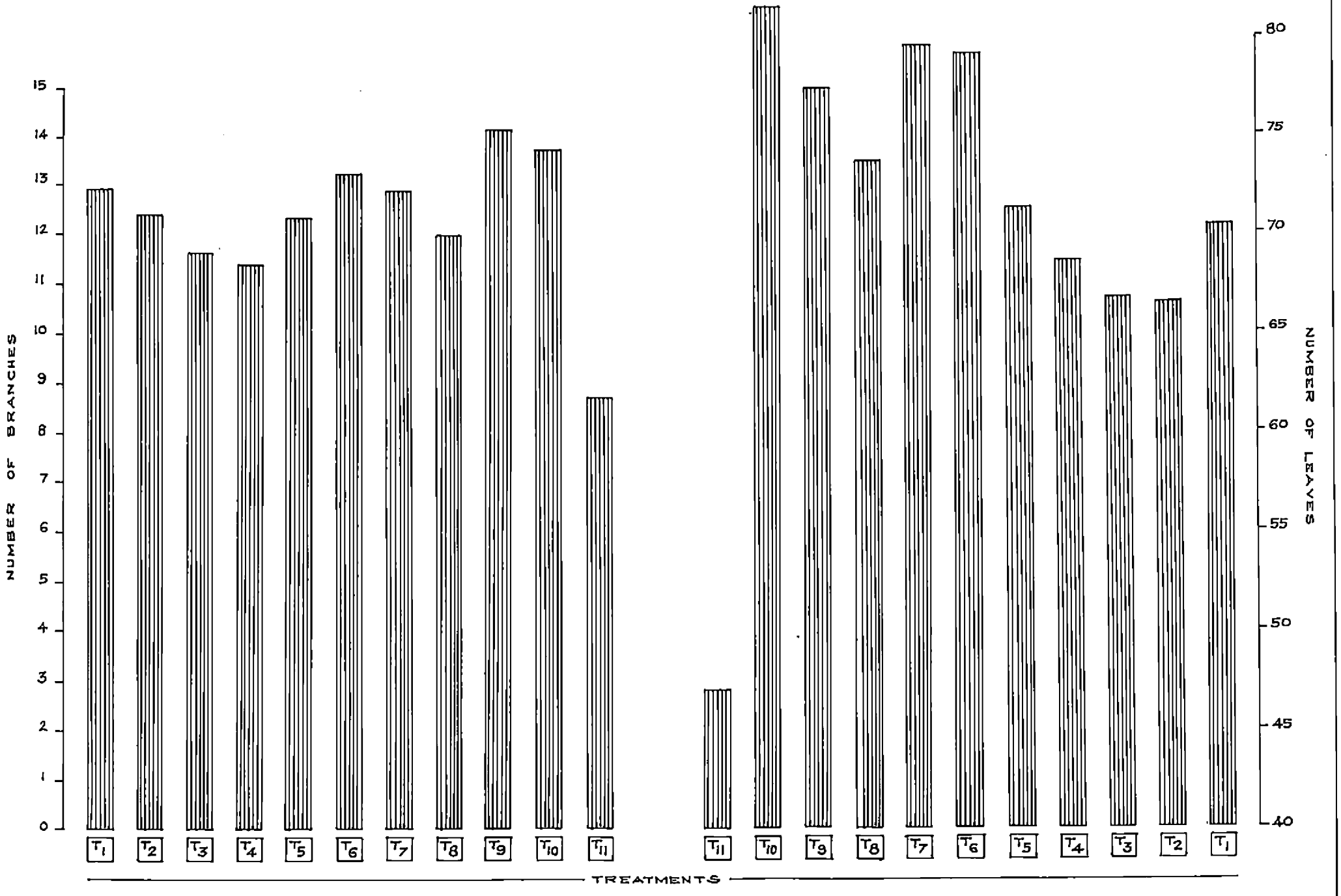


different treatments were 77.83 cm in broadcast application of sawdust, 74.95 cm in broadcast application of lemongrass waste, 72.75 cm and 72.08 cm in pit applications of cashew shell powder and coconut husk powder respectively, 71.25 cm and 71 cm in broadcast applications of cashew shell powder and coconut husk powder respectively, 69.08 cm, 68,83 cm and 66 cm under pit applications of paddy husk, lemongrass waste and saw dust and 65.5 cm under broadcast application of paddy husk.

Number of branches

As against a mean number of 8.83 branches per plant in the control the number of branches under the different treatments varied from 11.5 to 14.17 (Table 6 and Fig. 8). Maximum number of branches (14.17) was produced under broadcast application of lemongrass waste. This was closely followed by broadcast applications of cashew shell powder (13.83) and sawdust (13.33). Under pit application of sawdust the number of branches produced was 13 and under broadcast application of coconut husk powder and pit applications of coconut husk powder and cashew shell powder the mean number of branches were 12.92, 12.5 and 12.42 respectively. In treatments with paddy husk the mean number of branches was 12.08 under broadcast application and 11.67 under pit application and with lemongrass waste it was 11.5 under pit application.

FIG. 8. EFFECT OF DIFFERENT TREATMENTS ON THE NUMBER OF BRANCHES AND NUMBER OF LEAVES PER PLANT.



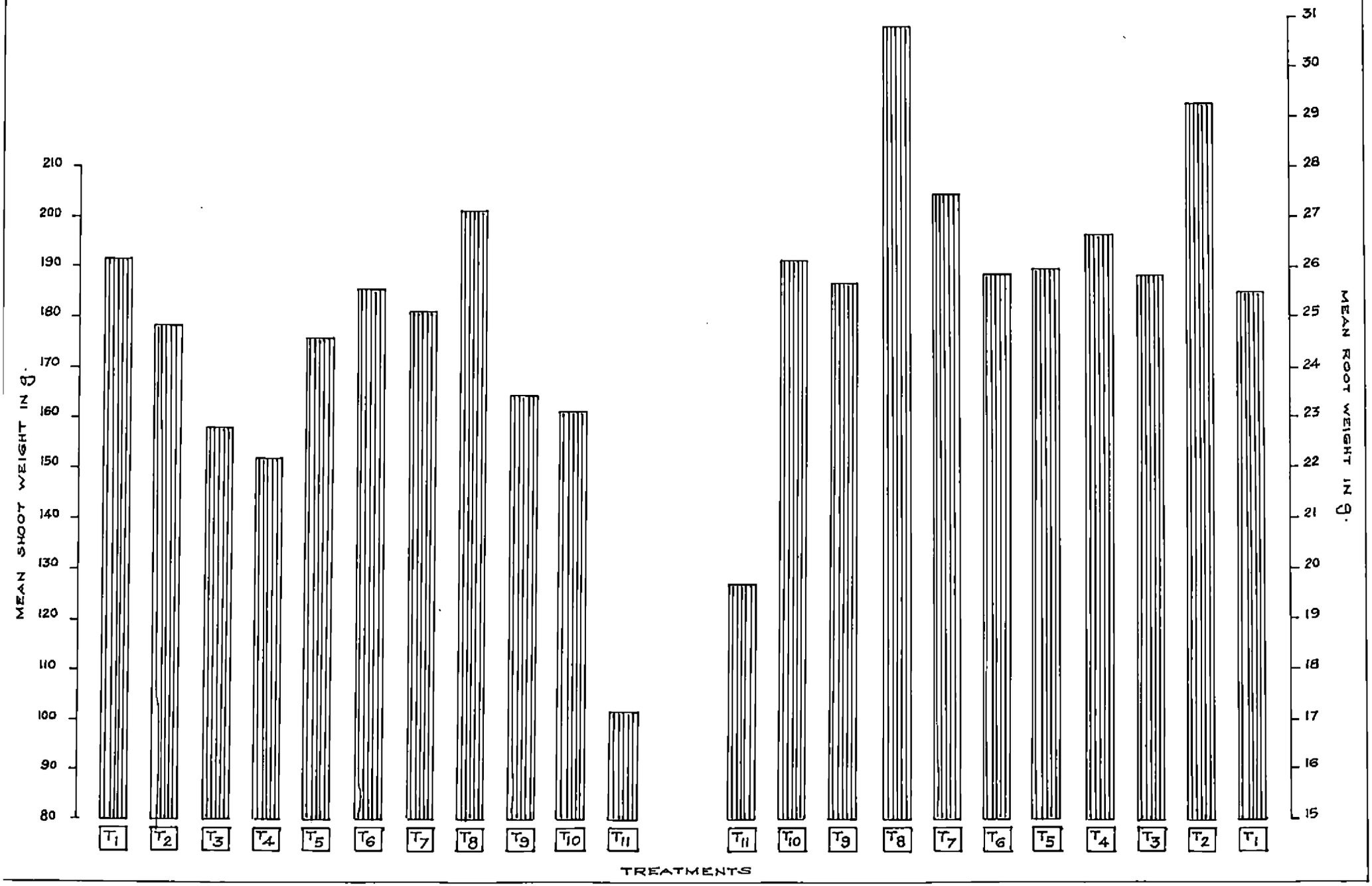
Number of leaves

The different treatments under trial were found to have significant impact on the number of leaves produced (Table 6 and Fig. 8). While the control plants produced a mean number of 47.33 leaves, the number varied between 66.75 and 81.75 in the plants under different treatments. The mean number of leaves under the broadcast applications were 81.75, 79.33, 79.17, 77.33 and 73.75 with cashew shell powder, coconut husk powder, sawdust, lemongrass waste and paddy husk respectively. Under pit application the number of leaves were 71.5, 70.5, 68.67, 68.58 and 66.75 with cashew shell powder, sawdust, coconut husk powder, lemongrass waste and paddy husk respectively.

Shoot weight

The shoot weight of the plants was also seen influenced by the treatments (Table 6 and Fig. 10). The mean shoot weight in the control was only 102.05 g. Under broadcast application of paddy husk the mean shoot weight was 202.54 g. This was followed by pit application (192.44 g) and broadcast application (186.90 g) of sawdust. In treatments with coconut husk powder the mean shoot weight was 181.86 g when broadcasted and 179.54 g when applied in the pit. Cashew shell powder when applied in pits the mean shoot weight observed

FIG. 10. EFFECT OF DIFFERENT TREATMENTS ON THE FRESH ROOT WEIGHT AND SHOOT WEIGHT OF PLANTS.



was 176.97 g. Under broadcast application with lemongrass waste and cashew shell powder it was 165.76 g and 162,86 g respectively. The mean shoot weight observed was 158.65 g and 152.55 g under pit applications of paddy husk and lemongrass waste respectively.

Root weight

The various treatments under trial affected the root weight of plants (Table 6 and Fig. 10). While the mean root weight was 19.73 g in the control it was 30.90 g under broadcast application of paddy husk, 29.32 g and 27.55 g respectively under pit application and broadcast application of coconut husk powder, 26.71 g under pit application of lemongrass waste and 26.26 g under broadcast application of cashew shell powder. Under pit applications of cashew shell powder and paddy husk the mean root weight was 25.99 g and 25.97 g respectively. The mean root weight observed under broadcast applications of sawdust and lemongrass waste was 25.95 g and 25.85 g respectively and under pit application of sawdust 25.58 g.

DISCUSSION

DISCUSSION

In the present study four oilcakes and five organic wastes were tested for their comparative efficacy in suppressing root-knot nematodes infestating brinjal. Oilcakes of groundnut, neem, castor and mustard and organic wastes viz. sawdust, cocomut husk powder, paddy husk, lemon-grass waste and cashew shell powder were tested individually by applying in planting pits and by broadcasting in the plots three weeks prior to planting. The results were assessed in terms of the growth characters of the plants, infestation of roots, soil population of nematodes and yield. Observations on the growth characters were taken on the 90th day of planting. Observations on the soil population of nematode were made before application of amendments, at the time of transplanting and at 45th, 60th and 90th days after planting.

The nematode population in soil and in roots showed that the oilcakes affected the same significantly and that in turn reflected on the root gall formation, the growth characters of the plant and on the yield (Table 2). Average population of root-knot nematode in 10 g of the root at harvest of the crop ranged between 20.33 and 36.67 against 128 and 221 under control. The soil population before amending with the oilcakes was almost the same in all the

plots ranging between 455 and 471 per 100 g of soil sample. Very slight reduction in soil population could be observed in the treated plots at the time of planting 21 days after application of oilcakes. The population continued to diminish in these plots and on the 46th day of planting the soil population was reduced to 7 to 20 per cent of the initial level, while in the control plots the population showed an increasing trend. Observations 60 days after planting and 90 days after planting showed that the soil population got still reduced and it was less than 6 per cent of the initial population.

Beneficial effects of preplanting application of oilcakes in soil in controlling nematode infestation in vegetables had already been reported. Singh and Sitaramiah (1966) found that soil application of margosa, castor and peanut oilcakes reduced root population of nematode and root gall formation and gave better plant growth in tomato. Hameed (1968) found that Meloidogyne population on tomato got diminished by mustard cake application. Khan et al. (1969) reported that preplanting application of neem cake, mahua cake, groundnut cake and castor cake suppressed parasitic nematodes but not saprozoic forms. Effectiveness of oilcakes in suppressing nematode population in the soil as well as in the roots of crops had been reported by Lass and Hameed (1969), Singh and Sitaramiah (1969), Sharma et al.(1971), Goswami and Swarup (1972), Alam and Khan (1975) and Khan et al. (1976).

Growth and yield of plants in treated plots were significantly better when compared to control (Table 3). The mean heights of plants were 44.17 cm and 44.16 cm in control whereas it ranged between 59.42 and 68.82 cm in the treated plots showing an increase of 34.5 to 55.8 per cent over control. Gowda and Shetty (1973) had also observed that soil amendments with oilcakes helped in increasing plant height.

It is evident from the results that all the treatments were significantly superior to the control improving the stand of the crop. The treated plots showed 22.89 to 40.89 per cent increase over the control in production of branches. The different oilcake treatments except pit application of neem cake showed significant increase ranging from 46.77 to 91.8 per cent over the control in respect of the number of leaves produced. Pit application of neem cake recorded 19.4% increase over the control. The root weight and shoot weight of plants showed considerable increase in the treated plots as compared to the control. While the average root weight under different treatments ranged between 31.1 g and 36.27 g it was below 23 g in the control. The root weight recorded in the treated plots showed 40.9 to 64.3 per cent increase over the control. The increase was highly significant over the control. The shoot weight also showed an appreciable

increase of 35.5 to 89.2 per cent over the control. These observations showed that the oilcakes favoured the growth of the plants. This finding is in conformity with the earlier reports of Singh and Sitaramiah (1966) and Lass and Hameed (1969). Gowda and Shetty (1973) had also observed an increase in the fresh root weight and shoot weight of tomato as a result of soil application of oilcakes. Zaiyd (1977) had reported that as a result of oilcake application gall number was reduced and plant top weight increased in okra plants.

The treatments enhanced the yield also as compared to the control. The increase recorded in this respect ranged between 29.9 and 87.1 per cent over control. Effectiveness of oilcakes in increasing the yield has already been reported by Singh and Sitaramiah (1969) and Sharma *et al.* (1971). The reduction in nematode population, as evident from the data presented, caused by the application of oilcakes resulted in producing a good crop with higher yield. However the different oilcakes did not differ much in efficacy, as also the methods of application.

The nematode population in the soil and in the roots of brinjal plants showed considerable reduction by the addition of organic wastes (Table 5). The average population of

root-knot nematode in 10 g of root, at the time of harvest, ranged between 34.3 and 54.7 in the treated plots while it was as high as 221.7 in control. The initial soil population which ranged between 436.7 and 458.7 was brought down gradually in the treated plots and at harvest, 111 days after application of the amendments, it was reduced to 3.6 per cent of the initial population.

The results of the present study clearly demonstrate that preplanting application of organic wastes suppressed root-knot nematode infestation both in the soil and in the roots. The usefulness of organic wastes in the control of root-knot nematode was already reported by Johnson et al. (1967) and Singh et al. (1967). Miller et al. (1968) reported that larval invasion of brinjal root was suppressed by sawdust and paper. Hameed (1970) and Singh and Sitaramiah (1971) roported suppression of Meloidogyne spp. by the application of organic materials in tomato and okra. Kumar and Nair (1976) had reported that application of organic wastes in soil could effectively control root-knot nematode population in soil and in plants with reduced gall formation on roots of bhindi plants. Sikora et al. (1973) had observed that pre-planting application of paddy husk in tomato caused reduction in larval population of Meloidogyne javanica.

Growth characters of plants were also greatly influenced by the treatments (Table 6). Regarding the mean height of the plants, as against 52.01 cm in the control it was between 65.5 and 74.95 cm in the treated plots. Thus the treated plots recorded 25.9 to 44.1 per cent increase in the height over the control. The mean number of branches as recorded in the treated plots showed 30.2 to 66.5 per cent increase over the control. The mean number of leaves, the mean shoot weight and the mean root weight also showed significant increase in the treated plots. The increase recorded over the control was 41.3 to 72.7 per cent in the case of mean number of leaves, 49.48 to 98.5 per cent with regard to the mean shoot weight and 28 to 56.6 per cent in the case of mean root weight. Thus the organic substances favourably influenced the different growth characters such as plant height, mean number of leaves and branches, shoot weight and root weight of brinjal plants. The increase in growth characters and yield over the control could be attributed to the effect of the organic substances in reducing the nematode population in the root zone and preventing root infestation. However the different methods of application did not show any significant variations in effect.

In the present study treatments with extra fertilizers to compensate the N, P and K content in the oilcake did not

show any significant improvement in plant growth or in yield. These results showed that the increase in yield produced by the oilcakes and organic wastes can be attributed to the suppression of the nematode population by these soil amendments and not due to the additional nutrition provided by them. Many workers have tried to explain the adverse effect of oilcakes and organic amendments on nematode population. One view was that decomposing organic materials produced fatty acids which had nematicidal properties. It appeared that many of these products were toxic to the parasitic forms at low concentrations while relatively very high concentrations were required for them to become toxic to nonparasitic forms (Patrick et al., 1965; Sayre et al., 1964, 1965; Banage and Visser, 1965; Hollis and Kabana, 1966). Another view was that the organic substances encouraged the growth of nematophagous fungi in the soil (Duddington et al., 1956; Duddington and Duthoit, 1960; Duddington et al., 1961; Ham and Wilkin, 1961; Pramer, 1964).

Mankau (1962) observed that the addition of organic amendments enhanced the population of predaceous nematodes which in turn suppressed the parasitic forms. Change in pH, soil temperature, oxygen and nitrogen status in the soil (Duddington et al., 1956; Johnson, 1962, 1963; Mankau, 1963; Hollis and Kabana, 1956; Singh and Sitaramiah, 1969a)

and physiological alteration in the host etc., are also attributed as factors adversely affecting the nematodes. The high content of formaldehyde in oilcakes as a likely mechanism of control was also put forward by Alam et al. (1978).

It is evident from the results of the present investigations that oilcakes and organic wastes give effective control of root-knot nematodes in brinjal when applied as soil conditioners atleast three weeks prior to sowing or transplanting. The studies indicated that the pit application and broadcast application of the materials were equally effective in controlling the pest.

SUMMARY

SUMMARY

Two field experiments were conducted, one for determining the effect of the oilcakes, groundnut cake, castor cake, neem cake and mustard cake and another for determining the effect of certain easily available organic wastes such as sawdust, coconut husk powder, paddy husk, lemongrass waste and cashew shell powder when applied in the planting pits and broadcasted in the plots, three weeks prior to planting on the control of root-knot nematode Meloidogyne incognita infesting brinjal. The results were assessed in terms of yield, growth of plants, gall formation on roots and nematode population in soil and roots.

In pit application as well as in broadcast application all the oilcakes suppressed the formation of root-galls significantly over control. There was no significant difference among the different oilcakes in this respect.

The populations of the root-knot nematode in roots and in soil were significantly reduced by the oilcakes and both the methods of application were equally effective.

All the oilcakes had significant favourable effect on the plant as shown by the number of branches, number of leaves, shoot weight and root weight and plant height.

The yield was also significantly more in treated plots than in control.

As regards the different organic wastes both in pit application and broadcast application all the treatments were significantly superior to the control in suppressing gall formation on roots and nematode population in soil and in roots. Crop stand was also improved by the treatments. Yield also showed significant increase over the control.

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* Original not seen

APPENDICES

APPENDIX - I

Summary of analysis of variance table relating to the data collected on soil population of nematode in the experiment using oilcakes

Date of observation	Mean squares		
	Block df = 2	Treatment df = 9	Error dr=18
Before amending oilcakes	7.44	0.40	0.79
Twentyone days after amending	10.52	2.58	0.32
Sixtysix days after amending	10.95	112.40*	1.26
Eightyone days after amending	8.68	118.44*	2.20
Hundred and eleven days after amending	1.54	170.37*	0.70

* Significant at five per cent level.

APPENDIX - II

Summary of analysis of variance table relating to the data on biometric characters in the experiment using oilcakes

Characters	Mean squares		
	Block df=2	Treatment df=9	Error df=18
Yield per plant (weight of fruits)	18241.59	4053.7*	768.10
Plant height	26.57	247 *	94.89
Number of branches per plant	18.24	8.9*	1.77
Number of leaves per plant	95.44	509.3*	151.98

* Significant at 5 per cent level

APPENDIX - III

Summary of analysis of variance table relating to the data gall formation and population of nematode in roots in the experiment using oilcakes

Gall formation/Population	Mean squares		
	Block df=2	Treatment df=9	Error df=18
Number of galls per 10cm of root	0.200	3.740*	0.123
Number of galls with eggmass per cm of root	0.004	0.310*	0.018
Root-knot index	0.015	5.150*	0.004
Root population of nematode in 10 g of root	0.930	34.240*	0.943

*Significant at 5 per cent level

APPENDIX -IV

Summary of analysis of variance table relating to the data on soil population of nematode in the experiment using organic wastes

Date of observation	Mean squares		
	Block df=2	Treatment df=10	Error df=20
Before amending	0.044	0.069	0.550
Twentyone days after amending	0.140	1.020	0.690
Sixtysix days after amending	0.049	52.600*	2.730
Eightyone days after amending	0.240	54.050*	2.940
One hundred and eleven days after amending	0.730	83.510*	0.460

*Significant at 5 per cent level.

APPENDIX - V

Summary of analysis of variance table relating to the data on biometric characters in the experiment using organic wastes

Characters	Mean squares		
	Block df=2	Treatment df=10	Error df=20
Yield per plant (weight of fruits)	3638.84	2300.34*	610.98
Plant height	1192.01	136.63*	74.96
Number of branches per plant	8.74	6.24*	2.35
Number of leaves per plant	1468.72	266.04*	205.88

*Significant at 5 per cent level

APPENDIX - VI

Summary of analysis of variance table relating to the data on gall formation and population of nematode in roots in the experiment using organic wastes

Gall formation / Population	Mean squares		
	Block df=2	Treatment df=10	Error df=20
Number of galls per 10cm root	2.22	1.02*	0.28
Number of galls with egg mass	0.14	0.96*	0.03
Root-knot index	1.38	1.86*	0.32
Population of nematode in root	0.18	19.70*	0.47

*Significant at 5 per cent level.

USE OF ORGANIC AMENDMENTS FOR THE CONTROL OF ROOT - KNOT NEMATODE IN BRINJAL

BY

P. L. KAMALAKSHI AMMA

ABSTRACT OF A THESIS

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ABSTRACT

Two field experiments were conducted - one for evaluating oilcakes and another for evaluating organic wastes for the control of the root-knot nematode Meloidogyne incognita infesting brinjal. These experiments were carried out in the Instructional Farm, College of Agriculture, Vellayani, in an area already infested by root-knot nematode. The experiments were laid out in randomised block design with three replications. In the first experiment there were ten treatments including the control and in the second experiment there were eleven treatments including the control. Organic amendments were applied to the soil three weeks prior to planting and watering was done during this period for the proper decomposition of these materials.

Results were assessed in terms of yield, growth parameters, gall formation and population of nematode. Results indicated that the nematode population in roots as well as in soil was significantly reduced by the application of oilcakes and organic wastes. It was also observed that the intensity of gall formation on roots was considerably reduced as a result of application of organic amendments. Reduction in the population of the nematode and in the intensity of gall formation in turn resulted in better crop stand and increase in yield. Different methods of application viz. application in the planting pit and broadcasting in the plot did not vary in efficacy.