CONTROL OF ROOT-KNOT NEMATODES IN BRINJAL

BY

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DECLARATION

I hereby declare that this thesis entitled "Control of root-knot nematodes 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,
November 5, 1980.

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Certified that this thesis, entitled "Control of root-knot nematodes in Brinjal" is a record of research work done independently by Smt. Susannamma Kurien, 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 popular vegetables grown extensively in almost all the states in India. In Kerala, it is cultivated throughout the year, although the area under the crop is much more during monsoon season.

Root-knot nematodes, Meloidogyne spp., had been reported as a serious pest attacking almost all the important crops in different parts of India. (Sitaramaiah et al., 1971). Reports from Kerala include those of Venkitesan (1972), Raveendran and Nadakal (1976), Jacob and Kuriyan (1979) and Charles and Kuriyan (1980 a) Brinjal is highly susceptible to the root-knot nematode Meloidogyne spp. Root-knot nematodes are the most important pests of vegetables causing severe damage. Nearly all vegetables have been reported as hosts for root-knot nematodes and some crops may be invaded by more than one species.

There are many methods for controlling nematodes in vegetables but recommendation procedures vary depending on climate, crop, cultural or production practices, economics, environmental restrictions etc. The basic problem in practical nematode control is to prevent the nematodes from feeding on crop plants with the object of improving plant growth. It is possible to prevent their feeding on plants in a variety of ways.

Though complete eradication of these nematodes from soil is impossible, an effective control can often be achieved by the complete elimination of nematodes from transplants. Hence the present study was undertaken with a view to find out the efficacy of nursery treatment with nematicides in control of the root-knot nematode *Meloidogyne incognita* in brinjal.

REVIEW OF LITERATURE

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Root-knot nematodes are the most important and cosmopolitan of nematode pests of vegetables. The principal symptoms of their attack is root galls or knots. Control of these nematodes is difficult to accomplish by such cultural methods as crop rotation, trap cropping etc. The most common and effective methods used are soil fumigation with nematicides or by use of resistant varieties.

Chemical control of root-knot nematodes

Seiff (1959) reported that soil treatment with edictol and DBCP helped to produce root-knot free tomato seedlings in the nursery and with 15 per cent v/v solution of ethylene dibromide effectively controlled root-knot of tomato. Smart et al. (1967) reported that 10 per cent granular formulation of Zinophos applied at 4.5 kg a.i/ha provided good control of the root-knot nematode on strawberry.

Nemagon at 6 to 7 l/ha was significantly superior to Hexanema, vapam and Nemaphos in reducing the root-knot nematode population and increasing the yield of Solanum melongena four times (Srivastava et al., 1969). Birat (1969) reported that Nemagon (DBCP) at 10 l/acre, D-D or EDB at 100 l/acre reduced the number of root galls and increased fruit yield of tomato.

According to Johnson (1969) control of *Meloidogyne incognita* on *Buxus microphylla japonica* was obtained for five months by three, one monthly drenches of SD 1897 at 10 and 15 gallons/acre, Dasanit at 10 lb a.i/acre and B 68138 G at 5 lb a.i/acre. Experiment conducted by Tu and Cheng (1969) showed that Fumazone, Nemamort and Nemamort G effectively controlled *M. incognita* on tomato and increased plant growth and yields.

Angeliev (1970) reported that of several organophosphorous pesticides applied to the roots of Gerberas, methyl parathion at 0.5 per cent gave the best results. According to Nelmes and Keerweewan (1970) roots of tomato plants dipped in aldicarb were protected from invasion by *M. incognita* larvae.

The average yield increase of muskmelon (*Cucumis melo*) over an eight year period was 89 per cent with row application at 6.5 lb/acre of 1, 2 - dibromo - 3 - chloropropane (DBCP) (Bergeson, 1971). Reddy and Seshadri (1971) showed that thionazin and aldicarb at 4 to 8 kg a.i/ha in pre-inoculation and post-inoculation treatment gave high degree of control of root-knot infection on tomato.

Gupta et al. (1971) revealed that application of D-D at 300 l/ha and DBCP at 4 l/ha reduced the number of primary galls caused by *M. javanica* larvae and increased tomato yields.

Effective control of root-knot nematode of tomato was obtained by Bindra and Kaushal (1971) with root dip treatments of tomato seedlings with parathion, dimethoate and diazinon; dimethoate being the cheapest. Raj and Nirula (1971) reported that application of D-D at 800 l/ha was significantly more effective in reducing the population of M. incognita larvae in potato fields than at 200 l/ha.

Johnson and Cairns (1971) showed that furadan gave the best control of root-knot nematodes and increased the yield of sweet potatoes. On Gardenia, for the control of M. incognita Miller (1971) found that Zinophos, Nemacur and D-1410 were equally effective as bare-root dips, soil drenches or soil mixes. Keerweewan (1972) showed that in pot experiments Du Pont 1410 applied as a soil drench at 1, 2, 4 or 8 ppm reduced invasion of tomato roots by M. incognita larvae. Foliar treatment with this nematicide were better when applied 2 or 3 times rather than once.

Gomez Tovar (1972) obtained good control of root-knot nematode M.exigua in the nursery bed of Coffea arabica with phenamiphos, carbofuran and DBCP. Colon Ferrer et al. (1972) reported that greatest yields of tomato were obtained on the plots with Dasanit 30 lb a.i/acre; but root-knot infestation was least in the nemacur treated plots.

Thomason and Mckinney (1972) recommended telone combined with VC 9-104 (prophos) against M.incognita on squash (Cucurbita sp.) and telone with aldicarb or carbofuran against M.javanica on sugarbeet. Reddy and Seshadri (1972) suggested that tomato seedlings grown in thionazin and aldicarb treated sand were free of root galls even 15 days after inoculation. In a field trial aldicarb granules at 4 lb a.i/acre and D-D at 20 gallons/acre significantly reduced galling of tomato by M.incognita (McLeod, 1972).

Alam et al. (1973) obtained a reduction in the development of root-knot on tomato and egg plant with VC-13 and Basamid bare root dips. Dale (1973) obtained good control when the roots of dormant rose plants infested with M.hapla were dipped for 30 minutes in 0.1 per cent solution of prophos or phenamiphos. Banana suckers (var. Lacaatan) dipped in aldicarb 10 G, ethoprophos 10G and DBCP 20G at 1 g/gallon of water for 15 minutes resulted in slight to moderate galling from M.incognita in pot experiments and gave 54 to 66 per cent increase in growth (Davide, 1973).

Roots of root-knot infected peach seedlings were dipped in fensulfothion, thionazin, DBCP, prophos, oxamyl and methomyl at 500, 1000, 2500 and 5000 ppm and total control was obtained with fensulfothion and thionazin (Ponchillia, 1973). DBCP 75 EC, aldicarb 10G, ethoprop and methomyl each applied at 600, 1200 or 1800 ppm to tomatoes in pots 0, 24, 48 or 72 hours after inoculation with *M.incognita* larvae affected the penetration, development and sex differentiation of nematodes. Infection was drastically reduced by all 3 dosages of DBCP, the higher dosages being increasingly most effective in reducing infection followed by methomyl, ethoprop and aldicarb (Chongrusko and Davide, 1973).

Application of D-D 40 l/1000 m^2, DD-MENCS 40 l/1000 m^2 greatly increased tomato yields and controlled *M.incognita* (Kyrou, 1973). Studies conducted by Franco and Oshita (1973) showed that significant increase in good quality potato tuber yield was obtained with Basamid F-10 per cent at 30 g/m 30 days before sowing.

Sivakumar et al. (1973) showed that seed treatment with carbofuran 3 or 6 per cent a.i can be effectively employed to reduce the severity of root-knot nematode infestation in okra. Brodie and Good (1973) reported that aldicarb at 3.4 kg a.i/ha and Dasanit at 10.0 kg/ha resulted in better root-knot nematode control and tobacco yields in plots infested with *M.incognita*; carbofuran at 4.2 kg/ha also performed better when applied in the seed furrow.

There was an increase of 60 per cent in yield when strawberry transplants were treated with 800 ppm of carbofuran, 400 ppm of ethoprophos or 1200 ppm of Oxamyl (Overman, 1974). Sivakumar et al. (1974) obtained economic control of the root-knot nematodes of tomato when aldicarb

10 per cent G at 1.4 kg a.i/ha, fensulfothion 5 per cent G at 1.0 kg a.i/ha and carbofuran at 0.6 kg a.i/ha were applied to the plants 10 days after planting.

According to Reddy and Seshadri (1974) there was slight or no mortality of M.incognita larvae in sand treated with 4 kg/ha of thionazin or aldicarb, although the nematicides prevented the nematodes from entering the roots of tomato seedlings. A comparison of untreated and nematicide treated soil for soybean production revealed that M.incognita hastened crop maturity, reduced plant height, seed weight and yield. DBCP was more consistent in increasing crop performance than organophosphates or oxime carbamate nematicides (Kinloch, 1974). Bindra and Soodan (1974) obtained best control of M.incognita on brinjal and tomato with D-D at 280.82 l a.i/ha and with DBCP at 26.92 l a.i/ha followed by phorate at 4.94 kg a.i/ha, than D-D at 224.06 l a.i/ha and DBCP at 20.19 l a.i/ha.

Potato plants inoculated with 1000 M.incognita larvae per pot and treated simultaneously or 5 days later with aldicarb granules at concentration 0.10 g/pot prevented the nematode invasion into roots and also affected the nematodes already present in the roots (Abdul Rahman and Eissa, 1975). Radewald et al. (1975) reported that Furadan, Dasanit, Geigy 12223, Temik and Nellite reduced root-knot nematode infestation in potato to 10 per cent or less and Mocap and Nemacur reduced it to 12 to 16 per cent.

Alam et al. (1975) observed that there is complete control following root dip of 3 weeks old tomato seedlings at 1,200 ppm of 'vydate' oxamyl for 30 minutes and 5 sprays, less control with fewer sprays and poor control with foliar sprays alone. Orion (1975) observed that phosfon D had an inhibitory effect on maturation of M.javanica within the gall tissue of tomato.

Singh (1975) reported that in green house experiments, single foliar applications of oxamyl 600 ppm significantly inhibited penetration of roots of tomato and lettuce by M.incognita. In a field trial, 3 foliar applications of oxamyl at 1250 ppm significantly reduced the numbers of M.incognita. Reddy and Rao (1975) reported that when Glycine max cv. Hardie, was sown immediately after treatment with fensulfothion (10 kg a.i/ha), aldicarb (2 kg a.i/ha), Oxamyl (8 kg a.i/ha), methomyl (8 kg a.i/ha), carbofuran (2 kg a.i/ha) and benomyl (2 kg a.i/ha), Meloidogyne was significantly controlled.

According to Reddy (1976) oxamyl applied in the transplant water at 0.5, 1.0 or 2 kg a.i/ha gave very good control (at all 3 doses) of M.incognita and M.javanica on tobacco and increased cured tobacco yields by 53.4 to 56.7 per cent.

Sivakumar et al. (1976) concluded that application of carbofuran 0.18 and 0.36 kg a.i/ha 10 days after transplanting gave significantly higher yields of tomato in M.incognita infested fields. Reduced infestation and increased yield of carrots were achieved with Furadon 75 PM at 3.75 and 4.5 kg a.i/ha and Nemagon at 20 kg a.i/ha by Ikutta et al. (1976).

Sitaramaiah et al. (1976) found that carbofuran, fensulfothion and sawdust + NPK significantly reduced M.javanica infestation on Pusa Sawani and the sawdust treatment gave the greatest yield. Rodriguez-kabana and King (1976) indicated that phorate is a good nematicidal deterrent for M.incognita on cotton and tomato but is only moderately effective against M.arenaria.

Vovlas and Lamberti (1976) studied the systemic action of some chemicals in the control of root-knot nematodes of tomato and revealed that oxamyl at 10 kg a.i/ha prevented larval invasion of the roots for about 25 days, aldicarb at 10 kg a.i/ha and thionazin at 10 kg a.i/ha for 18 to 20 days and carbofuran at 10 kg a.i/ha for about 12 days.

Khair and Ralph (1976) conducted tests to compare the efficiency of methyl bromide and ethylene oxide fumigation for elimination of root-knot nematodes from bare roots of tomato plants. Methyl bromide reduced but did not eliminate infection, whereas ethylene oxide at relatively low concentration was lethal.

Pillai (1976) reported that damages to tubers of Coleus parviflorus by M.incognita was reduced from 21 per cent in the control to 4 per cent with Nemagon treatment at 0.5 ml/30 cm^2, 5.7 per cent with fensulfothion at 2 g/30 cm^2, 11 per cent with D-D at 0.5 ml/30 cm^2 and to a lesser extent with parathion and phosphamidon. Yields were increased by 53 per cent with Nemagon and 47 per cent with fensulfothion.

Prasad et al. (1977) suggested that soil drenches of oxamyl, fensulfothion or carbofuran at 4 or 8 kg/ha can effectively control M.incognita on tomato. The nematode could be controlled by application of carbofuran at 25 kg/ha every 3 weeks (Mazumdar et al., 1977). Mahajan and Mayee (1977) obtained significant fruit yield increases and decreased root-knot nematode population with phorate, fensulfothion and aldicarb applications.

On both granitic soil and alluvial sandy loam aldicarb, oxamyl, phenamiphos, and ethoprop proved effective against M.javanica and M.incognita on tobacco (McLeod and Mead, 1977). Among granular nematicides compared against Meloidogyne on tomatoes, by McLeod (1977) the best results were obtained with aldicarb, ethoprop and oxamyl, applied in a 1 m wide strip along the planting row.

Hemeng (1977) reported that in field experiments, D-D, Nemagon and Vapam gave better control of *M. incognita* on tomato than the burning of a layer of dry grass or a straw mulch but the last two practices resulted in greater yield increases.

Application of 20 per cent granules of Nemagon at 150 to 250 kg/ha reduced *Meloidogyne* infestation of glasshouse cucumbers to commercially acceptable levels and increased yields (Guschin et al., 1977). Panayis (1977) reported that despite some degree of root galling DBCP, D-D, telone, Di-trapex and methyl bromide gave very good control of *Meloidogyne* on tomato as judged by fruit yield.

Nematicide trials on tomato grown in glasshouse soil infested with *M. incognita* showed D-D at 300 l/ha to be the most effective as it directly acts on the eggs of *M. incognita*, whereas phenamiphos and oxamyl attack the infective stage (Dandria et al., 1977). Overman (1977) suggested that introduction of methyl bromide at 488 kg/ha into irrigation water through a bi-wall tube burried 10 cm deep in a plastic mulched bed significantly reduced the incidence of *Meloidogyne* on tomato and increased yield by 20 per cent.

The development of *M.incognita* in tomato roots was reduced when larvae were inoculated one week after application of DL-methionine but not when inoculated 14 or more days after. The greater nematode control was obtained 7 days after amino acid application rather then later (Reddy et al., 1977).

In nematicide trials against *M.incognita* on sugarbeet, Di Vito and Lamberti (1977) found that the best yields were obtained with Di-Trapex, MDB or D-D. Phenamiphos was the most efficient nematicide.

Reddy and Seshadri (1977) reported that root-knot nematode infested tomato seedlings planted in soil in which granular formulations of thionazin and aldicarb had been mixed at rates of 4 and 8 kg a.i/ha, no nematode multiplication had occurred upto 6 weeks.

Brown and Turner (1978) reported that plots infested with *M.javanica*, when treated with liquid phenamiphos at 8 kg a.i/ha before planting tomato, greatest reduction in root-knot index and highest yields were obtained. Aldicarb and Oxamyl increased yields nearly as much as phenamiphos and ethoprophos was not very effective.

Cotton seed treatments with UC-21865 75 per cent WP at rates of 5, 10 and 20 g/kg seed suppressed penetration and maturation of *M.incognita* in plants grown in the glass house at 2, 4 and 6 weeks after inoculation. Nematode populations in the roots of treated plants were suppressed from 57 to 93 per cent and 87 to 95 per cent at 2 and 4 weeks respectively. Coating seeds with UC-21865 appears to be an effective and inexpensive method providing at least 4 weeks control of root-knot disease of cotton (Hussey, 1978).

Johnson (1978) achieved an increase of 50 per cent and 33 per cent respectively in the yields of tomatoes compared with yields from non-treated plots, when phenamiphos and carbofuran applied at 11.2 kg a.i/ha through water in a sprinkler irrigation system. Winoto Suatmadji (1978) suggested chemical dip treatment of roots of grapevine rootlings with 1000 ppm solution of phenamiphos for complete control of M.javanica.

Among the various nematicides incorporated into soil infested with M.incognita, 20 days before planting seeds of watermelon phenamiphos at 50 kg/ha, Di-Trapex at 500 l/ha, EDB at 83 l/ha, and D-D at 500 l/ha increased the yield. Roots of plants grown in soil treated with EDB, D-D, Di-Trapex or phenamiphos (30, 40 or 50 kg/ha) were completely immune to attack by the nematode (Vito and Lamberti, 1978).

Ahuja (1978) studied the effect of root dip treatment on infestation of brinjal by M.incognita. Oxamyl at 5000 ppm for 60 minutes and Dimethoate at 7,500 ppm reduced galling. In a fuquay loamy sand, injection of ethylene dibromide at 4.67 to 56.04 1 a.i/ha, D-D at 18.68 to 74.72 1 a.i/ha or 1, 3-D at 18.68 to 37.36 1 a.i/ha to a depth of 20 cm increased soybean yields and reduced population level of M.incognita (Minton and Parker, 1979). Kinloch (1979) reported that application of dibromomethane at 18.7 or 37.4 1/ha reduced M.incognita numbers in a field of soybean.

Oryzalin (250 μ m/pot) reduced root-knot counts when applied 1 or 2 weeks before inoculation, at inoculation or 1 week after inoculation with 2000 larvae/pot. Incubation with 10,000 ppm BAS 083 for 24 h reduced the ability of larvae to infest roots (Orum et al., 1979).

Of several nematicides tested as granular soil application and as foliar application for the control of M.javanica by Nandal and Bhatti (1980) significant reduction in root-knot galls was obtained only with pre-inoculation treatment of fensulfothion at 30 and 60 kg/ha and ethoprop at 30 and 60 kg/ha. In foliar application, none of the chemicals as pre and post-inoculation treatment was effective.

Specific damage by root-knot nematodes to plants

Chattopadhyay and Sen Gupta (1955) noticed mottling of the leaves as a symptom in jute plants infected by M.incognita. Blackening and dropping off of the growing tips of betelvine was observed as the primary symptoms infected with M.incognita followed by wilting (Dhande and Sulaiman, 1961).

Studies on pathogenicity of M.incognita on egg plant, chilli and tomato by Chidambaranathan and Rangaswami (1965) revealed considerable reduction in shoot, root and plant weight. Pathogenicity of five banana varieties ie. Bungulan, Dward cavendish, Lacatan, Latundan and Saba was studied by Claudio and Davide (1968) and found them to produce stunted growth, bunching of petioles and narrow and pale leaves. Birat (1969) observed galled roots, marked shortening of tap roots, and significant loss in root, shoot and fruit weight of okra (Abelmoschus esculentus) when inoculated with M.javanica. Coconut palms when inoculated with root-knot nematodes was found to produce stunted growth and galling of root tips (Pizarro, 1969).

Pathogenicity of M.incognita on Polianthes tuberosa was studied by Johnson (1970) and found to cause reduction in top and root weights. Root-knot nematodes artificially inoculated on potato and coleus stems induced galls on the latter (Huang and Lin, 1971). Mukherji and Sharma (1973) studied the symptoms of young and older plants of Trichosanthes dioia caused by M.incognita. Infection on young plants resulted in stunting, occasional chlorosis and reduced stands whereas on older plants made the stem thin, weak and pale coloured. Root system was reduced, knots on the tap roots were large and confluent.

Pathogenicity tests made on Celery (Apium graveolens) seedlings by Castillo and Bulag (1974) showed significant reduction in top weight, root weight and higher gall ratings. Mammen (1974) reported severe wilt symptoms of betelvine associated with M.incognita.

Reddy (1975) reported in glass house experiments Cicer arietinum inoculated with M.incognita markedly reduced growth, drying and shedding of leaves and poor pod formation. Waseem Ismail and Mashkoor Alam (1975) observed reduction in root weight and in root surface of brinjal by M.incognita.

Pot experiments have shown that the growth pattern of brinjal (Solanum melongena var. Pusa Purple long) was, in general, correlated with the level of infestation with M.incognita (Prasad and Gaur, 1975).

Jayaraman et al. (1976) reported that Polianthes tuberosa were severly damaged by M.incognita and M.javanica. The galls on the roots were irregular and conspicuous and the infested plants showed yellowing, drying up of leaves and retarded growth. When the infestation was heavy the bulbs rotted. Seedlings of Manihot esculenta inoculated with M.incognita showed reduction in tuber weight at all inoculum levels. At lowest inoculum levels (500 and 1000 larvae/plant) height was increased, galling increased root weights at inoculum levels of 500, 1000 and 2000 larvae (Caveness, 1977).

Rajendran et al. (1978) observed that inoculation of M.incognita on Crossandra unduleofolia retarded the growth, leaves became chlorotic and roots heavily galled.

Crop loss by root-knot nematodes

Huang (1966) reported M.incognita to infect rhizomes as well as fibrous and fleshy roots of Zingiber officinale in Hawai and major crop losses were due to rhizome infection. Tomato plants inoculated with 6000 larvae of M.incognita caused 75 per cent reduction in weight of the foliage and 48 per cent in root weight. Under aseptic conditions the same number of foliage and increased root weight by 50 per cent (Mayol and Bergeson, 1970).

Ducusin and Davide (1971/1972) reported that inoculation of tomato (rainy season var. 2029) with M.incognita egg masses at planting gave 85.3 per cent yield loss and 39.9 per cent if inoculated at the flowering stage.

Rice inoculated with M.incognita caused loss in grain yield and weight. The reduction in grain yield was related to the level of larval inoculum irrespective of the age of the plant at inoculation (Rao and Biswas, 1973).

The pathogenicity of the root-knot nematode, M.incognita to cacao (Theobroma cacao L.) var. "Catongo" was studied by

Sharma and Maia (1976) at three inoculum levels. Comparing the inoculated plants with controls at 37 weeks after inoculation it was found that dry plant weight, stem diameter and plant height had decreased 31.2 to 47.9 per cent, 10.6 to 17.4 per cent and 20.6 to 28.4 per cent respectively.

The marketable yield of seven tomato cultivars was considerably reduced at all the inoculum levels (741, 2222, 6666 and 20,000 larvae of M.incognita/1 of soil). Pre-plant soil population levels likely to cause economic loss (10 per cent yield loss) were between 2222 and 6666 nematodes/1 for Cv. Rossol and 741 nematodes/1 for the other varieties (Ogunfowora, 1977).

Threshold Inoculum

Swarup and Sharma (1965) observed that tomato was more susceptible to M.javanica than to M.incognita acrita. When incoulum of 1, 10, 100, 1000 and 10,000 larvae/400 g of soil was added to seedlings in pots, shoot growth was affected significantly by 100 M. javanica and 1000 M.incognita. Root growth was also affected by 1000 larvae/400 g soil of either spp. Birat (1960) reported that growth of the Abelmoschus esculentus was significantly affected only by an inoculum levels of 1000 and 10,000 M.javanica larvae per pot although there was some indication of damage with inoculum of 100 larvae per pot.

Rajagopalan et al. (1969) inoculated 1000 *M.incognita* larvae into 45 days old chilli seedlings and found perceptible reduction in observations made on shoot length, shoot weight, root length, root weight, percentage of infested roots and the galls per root. Inoculation of lettuce seedlings with 0, 260, 520, 1300 or 2600 larvae of *M.incognita* per plant in 1000 cm^3 of soil by *Schilt* et al. (1973) observed heavy root galling, 24 days after planting and at a constant temperature of 22°C. At six weeks, the weight of the above-ground parts of infested plants showed a linear decline with the level of the inoculum upto a maximum of 9.2 per cent.

Sharma and Maia (1975) inoculated *M.incognita* at 2500, 5000 or 10,000 larvae per 2.5 kg steam-sterilized soil and found to cause reduced growth and root galling on cocoa (*Theobroma cacao*) cv. catongo grown in the glass houses. Acosta and Ayala (1975) studied pathogenicity of *M.incognita* on *Dioscorea rotundata* on the basis of top weight, root weight, number and weight of the tubers three months after inoculation. Inocula of 200 *M.incognita* per plant stimulated plant growth but 600 or 1000 caused root galling and necrosis.

In glasshouse experiments, *Cicer arietinum* var. Annegeri-1, inoculated with 1000 or 10,000 *M.incognita* per plant, exhibited markedly reduced growth, drying and shedding of leaflets and poor pod formation compared with plants inoculated with 0, 10 or 100 *M.incognita* (Reddy, 1975).

Cowpea seedlings var. Pusa Barsati grown in sterilized soil in pots were inoculated with 10, 100, 1000 or 10,000 larvae of *M.incognita* or *Heterodera cajani* or with a combined inoculum of 5000 larvae of each species. The threshold level for producing measurable effects on the growth of the plants was 100 larvae/500 g soil of either nematodes (Sharma and Sethi, 1977).

Dhawan and Sethi (1978) inoculated seedlings of *Solanum melongena* with 10, 100, 1000 or 10,000 larvae of *M.incognita* per kg sterilized soil and examined after 90 days. It was found that lengths of shoots, roots and shoot weight were significantly less with inocula of 1000 larvae or more than when uninoculated, root weight was significantly less than controls with an inocula of 10 larvae/kg soil. Highest gall number and nematode multiplication rate were with 100 larvae per kg soil.

Vaishnav and Sethi (1978) showed that a population level of 1000 larvae of *M.incognita* or adults and larvae of *Tylenchorhynchus vulgaris* per 500 g soil was the marginal threshold level for damaging the plant growth of bajra in terms of shoot length, shoot weight and root length.

Gaur and Prasad (1980) showed that a population density above 1000 second stage juveniles per plant hastened maturity of the crop resulting in shortened duration of fruiting.

MATERIALS AND METHODS

MATERIALS AND METHODS

I. Efficacy of nursery treatment on control of root-knot nematode, *Meloidogyne incognita*

The effect of nursery treatments on the brinjal seedlings and their subsequent performances in the main field, infested with root-knot nematode was studied with the following chemicals.

1. DBCP (Nemagon 60 EC)
2. Metham sodium (Vapam)
3. Carbofuran (Furadan 3G) and
4. Aldicarb (Temik 10G)

The experiment was laid out in the Instructional Farm of the College of Agriculture, Vellayani, using a local brinjal variety. Randomised block design was followed, with 4 replications and the following 11 treatments.

1. T_1 - DBCP at 3 ml ai/m^2
2. T_2 - metham sodium at 15 ml/m^2
3. T_3 - metham sodium at 20 ml/m^2
4. T_4 - metham sodium at 25 ml/m^2
5. T_5 - Carbofuran at 0.2 g/m^2
6. T_6 - Carbofuran at 0.3 g/m^2
7. T_7 - Carbofuran at 0.4 g/m^2
8. T_8 - Aldicarb at 0.2 g/m^2

9. T_9 - Aldicarb at 0.3 g/m^2

10. T_{10} - Aldicarb at 0.4 g/m^2

11. T_{11} - untreated (check)

<u>Nursery</u>

Forty four raised beds of 1 m^2 were prepared in a root-knot nematode infested area. DBCP and metham sodium were applied at the respective doses 15 days before sowing the seeds by stagnating 5 cm of water in the beds, adding the chemicals and allowing them to percolate. The other chemicals were applied one day prior to sowing seeds, uniformly on prepared beds and the soil was raked up. Two grams of brinjal seeds were sown in each bed in lines. The nursery was maintained by giving all agronomic practices (Package of practices, KAU, 1978). The germination and stand of the seedlings at 1, 2, 3 and 4 weeks of sowing were recorded.

After 4 weeks of sowing the seedlings were uprooted and the following observations were taken on 10 plants at random.

1. Number of leaves
2. Height of seedlings and
3. Number of root-knots.

The weight of 25 seedlings transplanted to the main field was also recorded.

Mainfield

Forty four plots of 4 m^2 were prepared in an already root-knot nematode infested field, with randomised block design lay out and the soil population of root-knot nematode was estimated. Twenty five brinjal seedlings 4 weeks after sowing, were transplanted from each treatment in the nursery to the corresponding treatment in the main field at a spacing of 55 x 60 cm and properly labelled. The plants were maintained giving all the recommended practices (Package of practices, KAU, 1978).

Yield of brinjal was recorded plant wise. When no more fruits were available, the plants were uprooted and the following observations were taken on 10 plants at random from each treatment.

1. Shoot weight
2. Number of leaves
3. Root weight
4. Number of root-knots
5. Root-knots per 10 cm of roots at random
6. Root-knot nematode population per 100 ml of soil from each treatment
7. Total yield per 10 plants in each treatment.

Estimation of nematodes in soil

A composite sample of 100 ml soil was collected from each treatment in the mainfield and the nematodes were extracted by the modified method of Cobb's decanting and sieving technique (Christie and Perry, 1951). The nematode suspension was examined under binocular microscope and the root-knot nematode population was counted.

II. Pathogenicity Studies.

The extent of damage at different inoculum level and the threshold of infection of root-knot nematode, *Meloidogyne incognita* in brinjal was studied by conducting pot culture experiment under green house conditions.

Preparation and sterilisation of pot mixture

Pot mixture was prepared by mixing sieved field soil (red loam), sieved sand and well decomposed farm yard manure in the ratio of 2:1:1. The pot mixture was denematized by applying DBCP (Nemagon) at the rate of 3 ml/m^2 of pot mixture in beds of 15 cm thickness.

Raising of pure culture of *Meloidogyne incognita*

Pure culture of *Meloidogyne incognita* was raised from single egg mass collected from brinjal roots, after identifying the species by observing the perineal pattern, and maintained on brinjal plants in sterile soil. Egg mass collected from the above culture were used for the experiment. Subculturing was done periodically.

For obtaining one day old larvae of *Meloidogyne incognita*, a large number of egg masses from the culture plants maintained was hand picked and kept in a cavity block containing sterile water. Care was taken to see that the egg masses were in contact with water. Every 24 hours, the suspension in the cavity block was collected into a measuring cylinder. The average number of larvae per ml of suspension was determined with the help of Peters one ml eelworm counting slide from five aliquots. The larval concentration was adjusted to the required number per ml of suspension by dilution with a suitable quantity of sterile water.

Raising of brinjal seedlings

Brinjal seedlings were raised by sowing the brinjal local seeds in pots containing the sterilized soil. Four weeks after sowing, seedlings of uniform size and growth were transplanted singly in 30 cm diameter pots filled with denematized soil.

Twelve days after transplanting, one day old larvae of *Meloidogyne incognita* were inoculated at the following rates to each plant.

T_0 - No nematodes

T_1 - 10 nematodes per plant

T_2 - 100 nematodes per plant

T_3 - 500 nematodes per plant

T_4 - 1000 nematodes per plant

T_5 - 5000 nematodes per plant

T_6 - 10,000 nematodes per plant

The experiment was replicated six times with completely Randomised Design lay out.

Inoculation was done by boring five holes in the soil about 4 cm deep with a glass rod, 1.5 cm away from the base of the stem. The required suspension was pipetted out equally into five holes which were closed immediately. The inoculation of all six replicates in each treatment was completed on the same day. Pots were irrigated to keep the soil just moist. The pots were kept in the green house benches. The plants were maintained giving all the recommended agronomic practices. (Package of practices, KAU, 1978).

Yield was recorded during the experiment. When no more fruits were available, the plants were uprooted and the following observations were taken.

1. Number of leaves per plant
2. Height of the plant

3. Shoot weight per plant

4. Root weight per plant

5. Number of root-knots

6. Root-knots per 10 cm of roots at random

7. Nematode population per 100 g of soil.

RESULTS

RESULTS

I. "Efficacy of nursery treatment on control of root-knot nematode".

An experiment was laid out in Randomised Block Design with 11 treatments and 4 replications as mentioned in materials and methods, to study the effect of nursery treatment of 4 nematicides namely carbofuran, aldicarb and metham sodium at 3 levels each and DBCP at 1 level in controlling *Meloidogyne* sp. in brinjal. Plant characters like number of leaves, height of the plants, galls per plant, weight of 25 seedlings etc. were compared to study the effect of the treatment in the nursery. In the main field, 5 plant characters and 4 on *Meloidogyne incognita* were compared to study the effect of nursery treatment on the performance of the crop. Results are presented in Tables 1, 2 and 3 and Appendices I, II and III.

A. Nursery

The germination and stand of the crop was observed 1, 2, 3 and 4 weeks after germination. Seeds were found to germinate on 4th day and almost 100 per cent germination was noted by 7th day. During the second, third and fourth week, stand of the seedlings was uniform in all the plots except in check plots. When the seedlings were uprooted, all of them except in check plots were free of root-knots.

a. Number of leaves

The number of leaves, 4 weeks after sowing ie, at the time of transplanting were taken and the average number of leaves from 10 plants are presented in Table 1 and Appendix I. Seedlings from carbofuran treatments 0.4 g/m^2 (T_7), 0.3 g/m^2 (T_6) and 0.2 g/m^2 (T_5) recorded an average of 4.55, 4.68 and 4.56 leaves whereas aldicarb at 0.4 g/m^2 (T_{10}), 0.3 g/m^2 (T_9) and 0.2 g/m^2 (T_8) produced an average of 4.69, 4.59 and 4.71 leaves. The minimum number of leaves 3.05 was recorded in check plots (T_{11}). Metham sodium at 25 ml/m^2 (T_4), 20 ml/m^2 (T_3) and 15 ml/m^2 (T_2) had 4.71, 4.66 and 4.56 leaves respectively. DBCP at 3 ml a.i/m^2 (T_1) produced an average of 4.61 leaves.

b. Height of the seedlings

The height of the seedlings under various treatments were taken 4 weeks after sowing ie, at the time of transplanting and the data are presented in Table 1 and Appendix I. Carbofuran treatment at 0.2 g/m^2 (T_5) 0.3 g/m^2 (T_6) and 0.4 g/m^2 (T_7) recorded an average height of 5.54 cm, 5.34 cm, and 5.53 cm respectively. Aldicarb at 0.2 g/m^2 (T_8), 0.3 g/m^2 (T_9) and 0.4 g/m^2 (T_{10}) had produced an average height of 5.31 cm, 5.50 cm and 5.27 cm.

Table 1. Effect of nursery treatment on brinjal seedlings (Average of 25 plants)

Treatments	Number of leaves		Height of the plants (cm)		Weight of 25 seedlings (gm)	
	Mean leaves	% increase over check	Mean height	% increase over check	Mean weight	% increase over check
T_1	4.61	51.10	5.33	11.97	86.30	38.23
T_2	4.56	49.50	5.48	15.13	85.14	36.38
T_3	4.66	52.80	5.37	12.80	86.07	37.87
T_4	4.71	54.40	5.50	15.50	86.20	38.07
T_5	4.56	49.50	5.54	16.40	86.30	38.23
T_6	4.68	53.40	5.34	12.20	85.20	36.47
T_7	4.55	49.20	5.53	16.20	87.00	39.36
T_8	4.71	54.40	5.31	11.60	85.20	36.47
T_9	4.59	50.10	5.50	15.50	86.15	37.94
T_{10}	4.69	53.80	5.27	10.70	87.03	39.40
T_{11}	3.05	--	4.76	--	62.43	--
CD at 5% level	0.50	--	1.06	--	36.39	--

Metham sodium at 15 ml/m^2 (T_2) recorded an average height of 5.48 cm, 20 ml/m^2 (T_3) with 5.37 cm and 25 ml/m^2 (T_4) with 5.50 cm respectively. The treatment T_1 (DBCP at 3 ml a.i/m^2) was only 5.33 cm height followed by 4.76 cm in check plots.

c. Weight of 25 seedlings

The weight of 25 seedlings were taken at the time of transplanting and the data are presented in Table 1 and Appendix I. Weight of 25 seedlings under carbofuran treatment at 0.4 g/m^2 (T_7) was 87.00 g, at 0.3 g/m^2 (T_6) was 85.20 g and at 0.2 g/m^2 (T_5) was 86.30 g respectively. Treatments T_{10}, T_9 and T_8 (aldicarb at 0.4 g/m^2, 0.3 g/m^2 and 0.2 g/m^2) had an average weight of 87.03 g, 86.15 g, and 85.20 g and treatments T_4, T_3 and T_2 (metham sodium at 25 ml/m^2, 20ml/m^2 and 15 ml/m^2) had 86.20 g, 86.07 g and 85.14 g respectively. The treatment T_1 (DBCP at 3 ml a.i/m^2) had 86.30 g and T_{11} (check) had only 62.43 g.

d. Root-knots per plant

The total number of root-knots in each plant were recorded at the time of transplanting. Galls were found only in plants in the control plots. All the plants in the various treatments by the nematicides were free of any root-knots and thus had no symptom of root-knot nematode infestation.

B. Main field

When the fruit setting was over and when no more fruits were available, the experimental plants were uprooted and the following observations were taken.

a. Number of leaves

Average number of leaves from 10 plants are presented in Table 2 and Appendix II. Plants treated by carbofuran at 0.4g, 0.3g and 0.2g/m^2 had an average of 171.58, 133.20 and 117.70 leaves. Treatments T_{10}, T_9 and T_8 (aldicarb at 0.4 g/m^2, 0.3 g/m^2 and 0.2 g/m^2) and T_4, T_3 and T_2 (metham sodium at 25 ml/m^2, 20 ml/m^2, and 15 ml/m^2) produced an average of 143.94, 122.80, 110.65, 143.28, 120.01 and 99.90 leaves respectively. But the treatment T_1 (DBCP at 3 ml a.i/m^2) had 94.51 leaves and T_{11} (check) had only 85.03 leaves.

b. Shoot weight

The average shoot weight of 10 brinjal plants under various treatments are presented in Table 2 and Appendix II. Maximum shoot weight of 236.05 g was recorded in treatment T_7 (carbofuran at 0.4 g/m^2) followed by aldicarb 0.4 g/m^2 (T_{10}) with 222.45 g, metham sodium 25 ml/m^2 (T_4) with 217.58 g, carbofuran 0.3 g/m^2 (T_6) with 197.08 g, aldicarb 0.3 g/m^2 (T_9) with 194.08 g, metham sodium 20 ml/m^2 (T_3) with 188.43 g, carbofuran 0.2 g/m^2 (T_5) with 184.75 g, aldicarb 0.2 g/m^2 (T_8) with 174.40 g, metham sodium 15 ml/m^2 (T_2) with 169.18 g and DBCP 3 ml a.i/m^2 (T_1) with 165.45 g. The check (T_{11}) plants had only a shoot weight of 147.20 g.

c. Root weight

The average root weight of 10 plants under the various treatments are presented in Table 2 and Appendix II. The maximum root weight of 58.60 g was observed under carbofuran, 0.4 g/m^2(T_7) treatment. Root weight in the other treatments are in the following order; Aldicarb 0.4 g/m^2(T_{10}) with 57.28g, metham sodium 25 ml/m^2(T_4) with 55.98 g, carbofuran 0.3 g/m^2 (T_6) with 53.55 g, aldicarb 0.3 g/m^2(T_9) with 51.40 g, metham sodium 20 ml/m^2(T_3) with 50.64 g, carbofuran 0.2 g/m^2(T_5) with 48.40 g, aldicarb 0.2 g/m^2(T_8) 47.43 g, metham sodium 15 ml/m^2 (T_2) with 44.50 g, DBCP 3 ml a.i/m^2(T_1) with 40.30 g and in the check (T_{11}) 40.75 g respectively.

d. Total number of galls per plant

The average number of galls per plant under various treatments was recorded at the time of final harvest and are presented in Table 2 and Appendix II. The treatments T_5, T_6 and T_7 (carbofuran 0.2 g/m^2, 0.3 g/m^2 and 0.4 g/m^2) had an average of 517.98, 401.70 and 225.18 galls per plant. Treatments T_8, T_9 and T_{10} (aldicarb 0.2 g/m^2, 0.3 g/m^2 and 0.4 g/m^2) had an average of 520.95, 442.90 and 247.23 galls per plant. Treatments T_2, T_3 and T_4 (metham sodium 15 ml/m^2, 20 ml/m^2 and 25 ml/m^2) had an average of 531.85, 482.30 and 332.88 galls. Treatment

Table 2. Effect of nursery treatment on brinjal plants in the main field (Average of 10 plants)

Treatments	Number of leaves		Shoot weight (g)		Root weight (g)		Number of fruits per plant		Weight of fruits per plant (g)		Total number of galls per plant		Galls per 10 cm roots at random	
	Mean leaves	% increase over check	Mean weight	% increase over check	Mean root weight	% increase over check	Mean number fruits	% increase over check	Mean weight	% increase over check	Mean of total galls	% decrease over check	Mean of total galls	% decrease over check
T_1	94.51	11.2	165.45	12.4	40.30	1.2	7.30	8.9	289.05	14.8	579.75	25.9	33.39	3.6
T_2	99.90	17.5	169.18	14.9	44.50	9.1	7.58	13.1	301.63	19.8	531.85	31.9	29.87	13.8
T_3	120.01	41.2	188.43	28.0	50.64	24.0	8.98	34.0	354.50	40.8	482.30	38.3	25.45	26.6
T_4	143.28	68.5	217.58	47.8	55.98	37.4	10.98	63.9	424.80	68.7	332.80	57.4	22.19	35.9
T_5	117.70	38.4	184.75	25.5	48.40	18.8	7.98	19.1	309.75	22.9	517.98	33.8	27.30	21.2
T_6	133.20	56.7	197.08	33.9	53.55	31.4	9.38	40.0	366.60	45.6	401.70	48.6	24.08	30.5
T_7	171.58	101.8	236.05	60.4	58.60	43.8	12.33	84.0	496.65	97.2	225.18	71.2	17.04	68.5
T_8	110.65	30.1	174.40	18.5	47.43	16.4	7.95	18.7	302.13	19.9	520.95	33.4	27.72	20.0
T_9	122.80	44.4	194.08	31.8	51.40	26.1	9.15	36.6	365.21	45.0	442.90	43.4	25.09	27.6
T_{10}	143.94	69.3	222.45	51.1	57.28	40.4	11.18	66.9	426.98	69.5	247.23	68.4	20.29	41.4
T_{11}	85.03	—	147.20	—	40.75	—	6.70	—	251.85	—	782.00	—	34.65	—
CD at 5% level	37.46	—	54.75	—	15.07	—	0.42	—	83.43	—	5.13	—	1.26	—

with DBCP 3 ml/m^2 (T_1) had 579.75 galls and in the check(T_{11}) there were 782.0 galls also.

e. Number of galls per 10 cm of roots

The number of galls per 10 cm of roots taken at random from plants under various treatments are presented in Table 2 and Appendix II. Treatments T_5, T_6 and T_7 (carbofuran at 0.2 g/m^2, 0.3 g/m^2 and 0.4 g/m^2) had only 27.30, 24.08 and 17.84 galls per 10 cm of roots. Treatments T_{10}, T_9 and T_8 (aldicarb 0.4 g/m^2, 0.3 g/m^2, and 0.2 g/m^2), T_4, T_3 and T_2 (metham sodium 25 ml/m^2, 20 ml/m^2 and 15 ml/m^2) had 20.29, 25.09, 27.72, 22.19, 25.45 and 29.87 galls whereas in T_1 (DBCP at 3 ml/m^2) and check (T_{11}) there were 33.39 and 34.65 galls per 10 cm of roots.

f. Number of fruits

The total number of fruits harvested from various treatments are presented in Table 2 and Appendix II. Maximum number of 12.33 fruits per plant was obtained from the treatment T_7 (carbofuran 0.4 g/m^2) and the next best treatment was T_{10} (aldicarb 0.4 g/m^2) with a value of 11.18. From the treatments T_6 and T_5 (carbofuran 0.3 g/m^2 and 0.2 g/m^2) the number of fruits obtained were 9.38 and 7.98. In the treatments T_9, T_8, T_4, T_3, T_2 and T_1 (aldicarb 0.3 g/m^2, 0.2 g/m^2, metham sodium 25 ml/m^2, 20 ml/m^2, 15 ml/m^2 and DBCP 3 ml/m^2) the number of fruits produced were 9.15, 7.95, 10.98, 8.98, 7.58 and 7.30 respectively. Minimum number of fruits 6.70 was produced by plants in check plots (T_{11}).

g. Weight of the fruits

The average of the total weight of the fruits from 10 plants under various treatments were taken and are presented in Table 2 and Appendix II. The treatment T_7 (carbofuran 0.4 g/m^2) was found to produce maximum weight of 496.65 g per plant. The treatment T_{10} (aldicarb 0.4 g/m^2) is the next best with a fruit weight of 426.98 g followed by T_4 (metham sodium 25 ml/m^2) with 424.80 g, T_6 (carbofuran 0.3 g/m^2) with 366.60 g, T_9 (aldicarb 0.3 g/m^2) with 365.21 g, T_3 (metham sodium 20 ml/m^2 with 345.50 g, T_5 (Carbofuran 0.2 g/m^2) with 309.75 g, T_8 (aldicarb 0.2 g/m^2) with 302.13 g, T_2 (metham sodium 15 ml/m^2) with 301.63 g, T_1 (DBCP 3 ml/m^2) with 289.05 g and in T_{11} (check) 251.85 g.

h. Soil population of plant parasitic nematodes

The total number of plant parasitic nematodes including M.incognita present in 100 ml soil before planting the treated seedlings and at close of the experiment were taken and are presented in Table 3 and Fig.3. It may be seen from the table that the nematode population was considerably reduced in the experimental plots where nematicide treated seedlings were planted. In the plots of T_5, T_6 and T_7 with carbofuran 0.2 g/m^2, 0.3 g/m^2 and 0.4 g/m^2 the initial and final populations were 575.00 and 373.75; 578.00 and 328.25; 575.00 and 286.75 respectively. In T_8, T_9 and T_{10} with aldicarb (0.2 g/m^2, 0.3 g/m^2 and 0.4 g/m^2)

Table 3. Population of plant parasitic nematodes in the main field.

Treatments	Total plant parasitic nematodes in 100 ml soil			Population of *Meloidogyne incognita* in 100 ml soil		
	Pre-planting	At conclusion	% reduction/ increase	Pre-planting	At conclusion	% increase/ reduction
T_1	577.00	461.50	-20.0	190.25	148.49	-21.9
T_2	578.00	416.25	-27.9	194.25	135.74	-30.1
T_3	576.00	351.25	-39.0	193.25	112.24	-41.9
T_4	579.00	318.50	-44.9	192.25	99.74	-48.1
T_5	575.00	373.75	-35.0	195.25	117.24	-39.9
T_6	578.00	328.25	-43.2	194.00	102.74	-47.0
T_7	575.00	286.75	-50.1	194.50	87.74	-54.9
T_8	576.00	403.25	-29.9	192.25	124.75	-35.1
T_9	574.00	344.25	-40.0	193.25	108.25	-43.9
T_{10}	580.00	313.25	-45.9	192.0	96.00	-50.0
T_{11}	574.25	923.00	+60.7	195.25	294.24	+50.7

treatments the initial and final populations were 576.00 and 403.25; 574.00 and 344.25; 580.00 and 313.25 respectively. In T_2, T_3 and T_4 (metham sodium 15 ml/m^2, 20 ml/m^2 and 25 ml/m^2) treatments the initial and final populations were 578.00 and 416.25; 576.00 and 351.25; 579.00 and 318.50 respectively. In T_1 (DBCP 3 ml a.i/m^2) the initial and final populations were 577.00 and 461.50. But in T_{11} with no nematicides the initial population of 574.25 was increased to 923.00.

i. Soil population of root-knot nematodes

The initial and final population of root-knot nematodes in 100 ml soil from the experimental plots are presented in Table 3. and Fig. 3. In T_5, T_6 and T_7 with carbofuran treatments (0.2 g/m^2, 0.3 g/m^2, 0.4 g/m^2) the initial root-knot nematode population of 195.25, 194.00 and 194.50 was reduced to 117.24, 102.74 and 87.74. In T_8, T_9 and T_{10} with aldicarb treatments (0.2 g/m^2, 0.3 g/m^2 and 0.4 g/m^2) the initial root-knot nematode population of 192.25, 193.25 and 192.00 was reduced to 124.75, 108.25 and 96.00. In T_2, T_3 and T_4 (metham sodium 15 ml/m^2, 20 ml/m^2 and 25ml/m^2) the initial root-knot nematode population of 194.25, 193.25 and 192.25 was reduced to 135.74, 112.24 and 99.74 respectively. In T_1 (DBCP 3 ml a.i/m^2) the initial root-knot nematode population of 190.25 was reduced to 148.49. But in T_{11} with no nematicide treatment, the initial root-knot nematode population of 195.25 was increased to 294.24.

II. Pathogenicity studies.

The extent of damage caused by *Meloidogyne* sp. on bringal was studied in pot culture experiments as described.

The most conspicuous effect of this nematode on the underground portion of the host plant is the formation of root-knots or galls on the roots. The general reduction in growth characters of both above and below ground parts of the plant at different levels of inoculum of 10, 100, 500, 1000, 5000 and 10,000 larvae per plant are brought out in Tables 4 and 5. The fact that the brinjal plant is a very suitable host for this root-knot nematode is also evident from the observations taken.

Characters like number of leaves, height of the plant, weight of the shoot, weight of the roots, total number of root-knots in 10 cm roots at random per plant, yield of the plant (both number and weight of the fruits) of inoculated and uninoculated plants were compared. Population of the nematodes from 100 ml soil was also estimated.

The observations were taken when no more fruits were available in the experimental plants and are presented in Tables 4 and 5.

a. Number of leaves

The average number of leaves from 6 experimental plants are presented in Table 4 and Appendix III. Maximum number of leaves (63.00) are produced in the check plants where no larvae was inoculated. The average number of leaves produced from plants inoculated with 10, 100, 500, 1000, 5000 and 10,000 larvae per plant are 53.67, 41.83, 34.00, 29.17, 26.67 and 22.33 respectively.

b. Height of the plants

The average height of 6 plants under various treatments are presented in Table 4 and Appendix III. Maximum height of 68.92 cm was recorded in T_0 ie check plants and from the table it can be seen that the height gradually decreases at various inoculum levels. The average height of the plants at 10, 100, 500, 1000, 5000 and 10,000 larvae per plant are 65.50, 62.32, 61.33, 61.32, 57.43 and 46.45 cm respectively.

c. Number of fruits

The total number of fruits harvested from various treatments are presented in Table 4 and Appendix III. The average number of fruits produced from plants inoculated with 10,000 and 5000 larvae per plant are only 1.20 and 2.30.

Table 4. Effect of different inoculum levels of root-knot nematode *M.incognita* on brinjal (Average of 6 plants)

	T_0	T_1 10 larvae per plant		T_2 100 larvae per plant		T_3 500 larvae per plant		T_4 1000 larvae per plant		T_5 5000 larvae per plant		T_6 10,000 larvae per plant		
	No nematode (check)	Nematode infected	% reduction over check	Nematode infected	% reduction over check	Nematode infected	% reduction over check	Nematode infected	% reduction over check	Nematode infected	% reduction over check	Nematode infected	% reduction over check	CD at 5% level
1. Number of leaves	63.00	53.67	14.8	41.83	33.6	34.00	46.0	29.17	53.7	26.67	57.7	22.33	64.6	1.52
2. Height of the plants	68.92	65.50	4.9	62.32	9;6	61.33	11.0	61.32	11.0	57.43	16.7	46.45	32.6	19.41
3. Number of fruits per plant	6.70	5.30	20.9	4.20	37.3	3.50	47.8	3.30	50.8	2.30	65.7	1.20	82.1	0.38
4. Weight of fruits per plant	318.67	251.50	21.1	165.33	48.1	129.00	59.5	112.50	64.7	94.00	70.5	34.67	89.1	51.92
5. Weight of shoot in gms.	97.50	91.67	5.9	59.00	39.5	58.83	39.7	54.17	44.4	41.33	57.6	37.85	61.2	31.17
6. Weight of root in gms.	27.83	26.37	5.2	25.48	8.4	23.10	16.9	20.65	25.8	19.37	30.4	18.10	34.9	10.99

Maximum number of fruits was obtained from T_0 (check) with 6.70 and there was a gradual decrease as 5.30, 4.20, 3.50 and 3.30 from plants inoculated with 10, 100, 500 and 1000 larvae per plant.

d. Weight of the fruits

Average total weight of the fruits from 6 plants at various inoculum levels were taken and presented in Table 4 and Appendix III. The check plants (T_0) was found to produce the maximum weight of 318.67 g. The weight of the fruits from plants at various inoculum levels are in the following order: 251.50 g at 10 larvae/plant, 165.33 g at 100 larvae/plant, 129.00 g at 500 larvae/plant, 112.50 g at 1000 larvae/plant, 94.00 g at 5000 larvae/plant and 34.67 g at 10,000 larvae/plant.

e. Shoot weight

The average weight of shoot at the time of uprooting are presented in Table 4 and Appendix III. Minimum shoot weight of 37.85 g was recorded in T_6 ie plants inoculated with 10,000 larvae and maximum of 97.50 g in T_0 ie in check. The treatments T_1, T_2, T_3, T_4, and T_5 had an average shoot weight of 91.67 g, 59.00 g, 58.83 g, 54.17 g and 41.33 g respectively.

f. Root weight

The average root weight of plants under the various treatments are presented in Table 4 and Appendix III. The root weight was found to be in a decreasing order as the inoculum level increases. The average root weight at 10, 100, 500, 1000, 5000 and 10,000 inoculum levels are 26.37 g, 25.48g, 23.10 g, 20.65 g, 19.37 g, 18.10 g respectively. Maximum root weight of 27.83 g was recorded in T_0 (check).

g. Total root-knots per plant

The average number of root-knots per plant under various treatments are presented in Table 5 and Appendix III. There were no root-knots in the control plants. Maximum number of 410.00 and 412.33 root-knots were produced in T_5 and T_6 ie plants inoculated with 5000 and 10,000 larvae per plant. The treatment T_1, T_2, T_3 and T_4 had an average of 148.50, 186.83, 244.17 and 344.33 galls.

h. Number of root-knots per 10 cm of roots

The number of root-knots per 10 cm of roots at random from plants at various inoculum levels were taken and presented in table 5 and Appendix III. In this also, maximum number of root-knots was recorded in T_6 23.9 and no root-knots in T_0. The number of root-knots per 10 cm roots

Table 5. Effect of initial inoculum levels of root-knot nematode (M. incognita) on Root-knot production and Root-knot nematode population.

Treatments	Total root-knots per plant (Average of 6 plants)	Galls per 10 cm roots at random (Average of 6 plants)	Population of *Meloidogyne incognita* in 100 ml soil (Average of 6 samples)
T_0 - (Check)	0.0	0.0	0.0
T_1 - (10 larvae per plant)	148.50	13.70	28.0
T_2 - (100 larvae per plant)	186.83	15.23	37.0
T_3 - (500 larvae per plant)	244.17	17.27	45.0
T_4 - (1000 larvae per plant)	344.33	22.50	53.0
T_5 - (5000 larvae per plant)	410.00	22.97	155.0
T_6 - (10,000 larvae per plant)	412.33	23.90	243.0
CD at 5% level	76.96	6.02	8.89

obtained from T_1, T_2, T_3, T_4 and T_5 are 13.70, 15.23, 17.27, 22.50 and 22.97 respectively.

i. Soil population - *Meloidogyne incognita*

Meloidogyne incognita population per 100 ml soil are presented in Table 5 and Appendix III. Control plants were found to be completely free of any nematodes. The *Meloidogyne incognita* population per 100 ml soil at various inoculum levels was found to be 28.0 at 10 larvae per plant, 37.0 at 100 larvae per plant, 45.0 at 500 larvae per plant, 53.0 at 1000 larvae per plant, 155.0 at 5000 larvae per plant, and 243.0 at 10,000 larvae per plant respectively.

DISCUSSION

DISCUSSION

In the present investigations efficacy of nursery treatment with nematicides in control of the root-knot nematode *Meloidogyne incognita* in brinjal and the extent of damage caused by root-knot nematode *M. incognita* on brinjal, at different inoculum levels, were studied.

The observations taken from the nursery showed that the overall growth of the seedlings was quite satisfactory except those in untreated plots.

The number of leaves, 4 weeks after sowing in the treated plots (Table 1 and Fig. 1) ranged from 4.55 to 4.71 whereas in check plots the number was only 3.05. Thus there was significant increase of 49.20 to 54.40 per cent in number of leaves in seedlings over check by nursery treatments. But there was no significant difference among the treatments.

Increase in height of the seedlings caused by the application of nematicides in the nursery was statistically significant over the control. There was an increase of 10.7 to 16.4 per cent in height by nematicidal treatment over control. (Table 1 and Fig.1) But among treatments there was no significant differences.

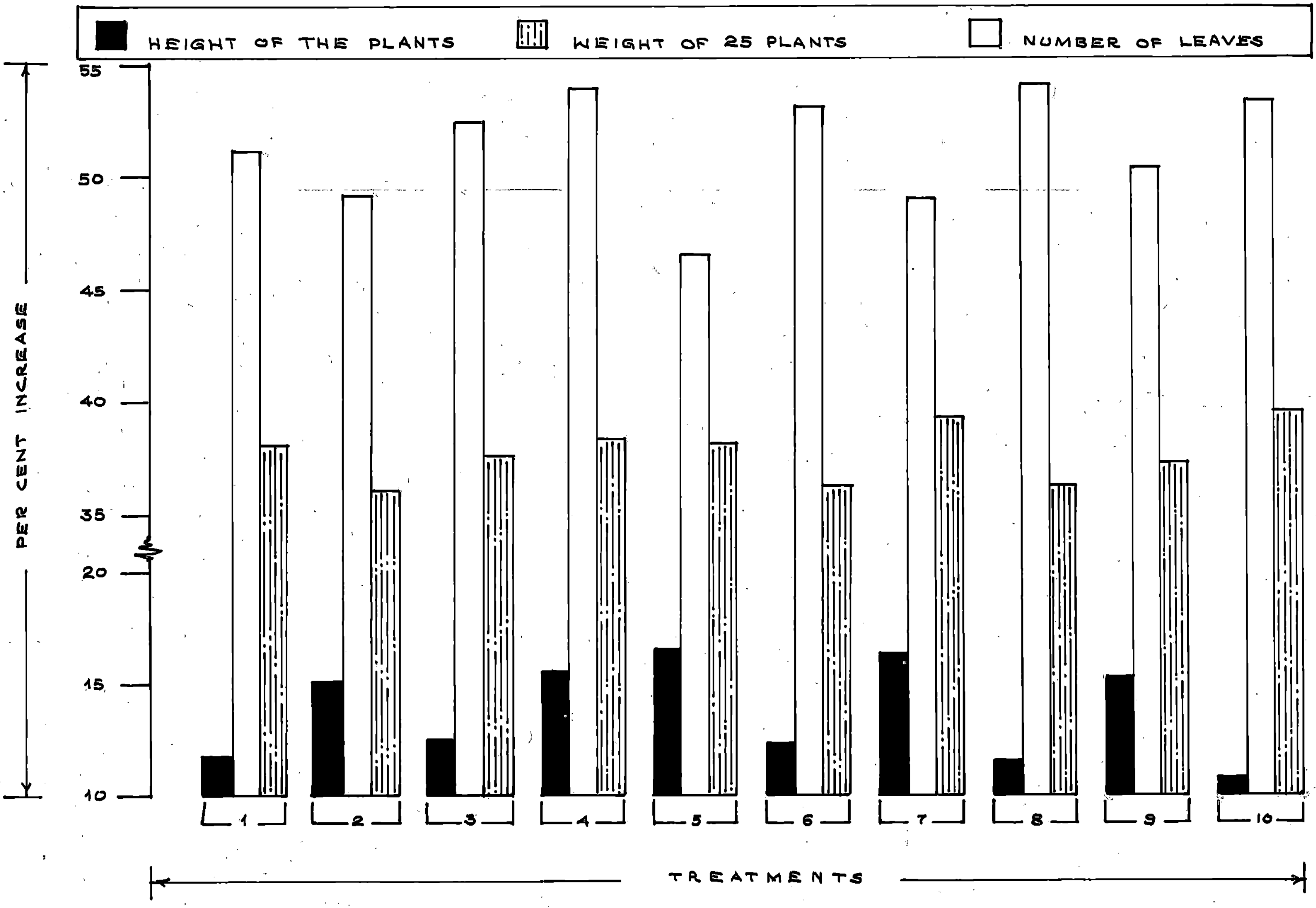

FIG: 1 EFFECT OF NURSERY TREATMENT BY NEMATICIDES ON CONTROL OF ROOT-KNOT NEMATODES IN BRINJAL (NURSERY OBSERVATIONS)

Application of nematicides in the nursery gave significant increase in average weight of 25 seedlings over the control. (Table 1 and Fig. 1) The weight increased by 36.38 to 39.4 per cent over control. But the weight of seedlings between treated plots were not significant.

There were no root-knots at the time of transplanting in any of the seedlings raised in nematicide treated plots. But the seedlings in the check plots had 8.0 root-knots. This shows that the nursery treatment with the nematicides tried, could produce brinjal seedlings free of root-knots, thereby indicating that the seedlings are free of root-knot nematode infection.

Reddy and Seshadri (1974) also found tomato seedlings grown in thionazin and aldicarb treated sand (4 kg a.i/ha) to be free of root galls 15 days after inoculation with 500 larvae of M.incognita. Anderson and Griffin (1972) also showed that onions sown in soil treated with chlorthal dimethyl at 0, 8 or 12 lb per acre had less than one gall per plant even after 4 weeks of sowing.

Generally, reduction in root-knot disease severity (root gall number and root gall index), improvement in plant growth characters and increase in yield were used as parameters to measure the efficiency of nematicides.

Plant growth response in plots treated with carbofuran, aldicarb, metham sodium and DBCP in brinjal was similar to that reported by Gomes Tovar (1972). They obtained good control of the coffee root-knot nematode M. exigua in the nursery bed of *Coffea arabica* with phenamiphos, carbofuran and DBCP. Similar studies were conducted by Birat (1969) who showed that fewest root galls and greatest shoot weight were obtained when insecticides like diazinon 2.4 kg per acre, chlordane or heptachlor both at 12 kg per acre were applied to the soil before transplanting. Reddy and Seshadri (1971) revealed that thionazin and aldicarb at 4 to 8 kg a.i/ha in pre-inoculation treatment completely eliminated the root-knot infection in tomato. Thus the present finding of producing root-knot nematode free brinjal seedlings by nematicidal treatment of nursery is in agreement with the earlier reports.

The performance of the seedlings raised above were compared in the mainfield after transplanting, based on 5 plant characters and 4 of the root-knot nematode themselves.

The average number of leaves of the different treatments presented in Table 2 and Fig. 2 showed that increase in number of leaves produced by the use of carbofuran 0.4 g/m^2, aldicarb 0.4 g/m^2, metham sodium 25 ml/m^2, carbofuran 0.3 g/m^2 and aldicarb 0.3 g/m^2 are statistically significant over the control. There was an increase of 101.8 per cent by applying carbofuran 0.4 g/m^2; 69.3 per cent by applying aldicarb 0.4 g/m^2; 68.5 per cent in the case of metham sodium 25 ml/m^2; 56.7 per cent in carbofuran 0.3 g/m^2 and 44.4 per cent in the case of aldicarb 0.3 g/m^2 over the control plants. The increase in number of leaves produced by metham sodium at 20 ml/m^2, carbofuran at 0.2 g/m^2 and aldicarb at 0.2 g/m^2 are 41.2 per cent, 38.4 per cent and 30.1 per cent respectively. The least increase of 11.2 per cent in number of leaves was produced by DBCP at 3 ml a.i/m^2. Similar nematicidal trials were conducted by Kueh and Teo (1978) on Piper nigrum and aerial growth, branch and leaf numbers were enhanced by methomyl, phenamiphos, carbofuran and oxamyl each at 0.15 per cent, applied 9 times at monthly intervals.

All the treatments gave increase in shoot weight of the plants over check (Table 2 and Fig.2). Carbofuran 0.4 g/m^2, aldicarb 0.4 g/m^2 and metham sodium 25 ml/m^2 treated plants gave statistically significant increase in the weight of the shoot over check. There was an increase of 60.4 per cent weight with carbofuran 0.4 g/m^2; 51.1 per cent with aldicarb 0.4 g/m^2 and 47.8 per cent with metham sodium 25 ml/m^2 over check. Though the shoot weight increase of 33.9 per cent in the case of carbofuran 0.3 g/m^2 and 31.8 per cent in the case of aldicarb 0.3 g/m^2 are not statistically significant, it may be seen that

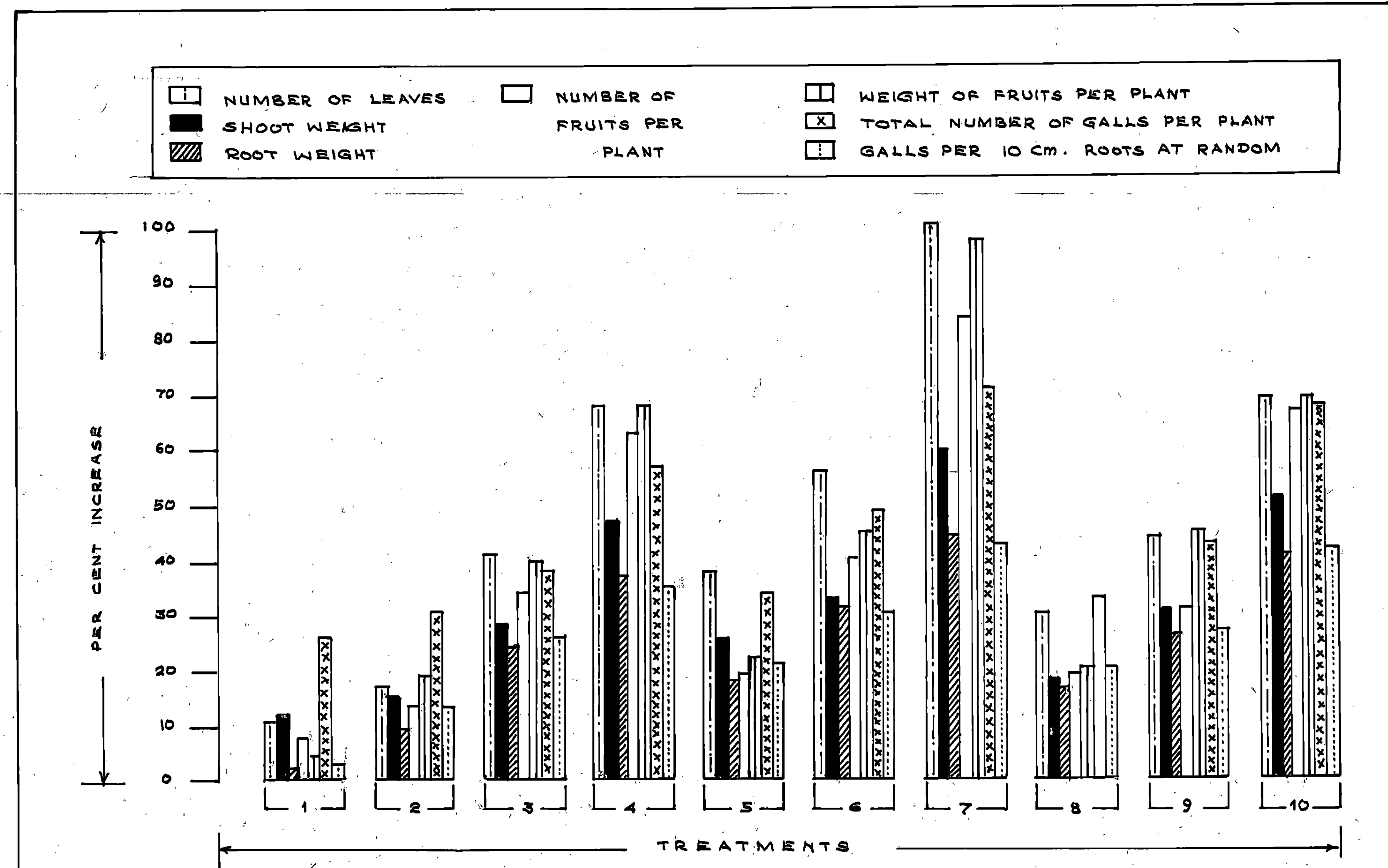

FIG: 2 EFFECT OF NURSERY TREATMENT BY NEMATICIDES ON CONTROL there is a definite improvement in weight of the shoot when compared to check. Such an increase in number of leaves and weight of the shoot might be due to the resistance developed by the plant to infection by M.incognita due to nursery treatment. Birat (1969) showed that application of diazinon at 2.4 kg per acre to soil before transplanting, resulted in few root galls and greatest shoot weight. Acosta, (1976) showed that in glasshouse experiments, average top weight and number of twigs of Coleus blumei planted in pots of soil infested by M.incognita were considerably increased by drench application of fensulfothion at 20 lb a.i/acre.

The fresh root weight also increased by the various treatments as against the check plants (Table 2 and Fig.2). Carbofuran 0.4 g/m^2, aldicarb 0.4 g/m^2 and metham sodium 25 ml/m^2 gave significant increase in root weight over the check. The root weight increased by 43.8 per cent in carbofuran 0.4 g/m^2, 40.4 per cent in aldicarb 0.4 g/m^2 and 37.4 per cent in metham sodium 25 ml/m^2 over the root weight of the check plants. But between the treatments there was no significant difference. Carbofuran 0.3 g/m^2 and aldicarb 0.3 g/m^2 also gave increased root weight of 31.4 per cent and 26.1 per cent respectively. The lowest increase in root weight was obtained with DBCP treatment.

In an experiment, Pillai (1976) had showed that damage to tubers of *Coleus parviflorus* by *M. incognita* was reduced from 21 per cent in control to 4 per cent with Nemagon treatment at 0.5 ml/30 cm^2 and yield increase of 53 per cent. Kuoh and Teo (1978) also reported enhanced root weight of *Piper nigrum* by methomyl and carbofuran treatment in the field before transplanting.

Plants raised on treated nursery also had more number of fruits than check plants (Table 2 and Fig. 2). Maximum number of fruits was obtained from plants treated with carbofuran 0.4 g/m^2. All the treatments gave statistically significant increase in number of fruits. Carbofuran 0.4 g/m^2 increased the number of fruits by 84.0 per cent, carbofuran 0.3 g/m^2 increased by 40.0 per cent, aldicarb 0.4 g/m^2 increased by 66.9 per cent and metham sodium 25 ml/m^2 increased by 63.9 per cent. DBCP at 3 ml a.i/m^2 gave an increase of only 8.9 per cent over the check. The increase in number of fruits brought about by the nematicides treated plants could be attributed to the control of *M. incognita*, since the population was reduced in all nematicide treated plots as evidenced in Table 3. The results obtained on yield increase is in agreement with Johnson and Cairns (1971) who showed that carbofuran gave the best control of nematodes of sweet potato *M. incognita* and significantly increased the yield. Similarly Sivakumar et al. (1976) reported that application of carbofuran 0.18 and 0.3 kg a.i/ha 10 days after transplanting, gave significantly higher yields of tomato in *M.incognita* infested fields. Mahajan and Mayee (1977) reported significant yield increase of tomato with phorate, fensulfothion and aldicarb applications. Similar results of increased yield of tomato in aldicarb (10 kg a.i/ha) treated soil was reported by Chhabra and Mahajan (1974).

The weight of fruits on the plants raised from nematicide treated nursery also was more than on check plants (Table 2 and Fig. 2). Carbofuran at 0.4 g/m^2 and 0.3 g/m^2, aldicarb 0.4 g/m^2 and 0.3 g/m^2 and metham sodium 25 ml/m^2 and 20 ml/m^2 produced 97.2 per cent, 45.6 per cent, 69.5 per cent, 45.0 per cent, 68.7 per cent and 40.8 per cent increase in weight of fruits over the check plants. The increase in weight of fruits produced is also statistically significant. Though not significant there was increase in weight of fruits in other treatments also. In this also, the least production was in the case of DBCP at 3 ml $a.i/m^2$. Charles and Kuriyan reported (1980 b) increased rhizome weight of 66.8 to 212.4 g over control with different nematicidal treatments.

Root-knot nematode infestation as represented by total gall formation and total multiplication (Soil + root population) was rather affected by the nursery treatment. Reduction in number of root-knots and increase in yield are factors which proves the efficiency of nematicides under field conditions. The intensity of root-knot nematode attack on plants in plots treated with carbofuran, aldicarb and metham sodium at the 3 doses tried was considerably lower than the plants from untreated plots. However, the reduction in root-knot intensity was not proportional to the dosage of nematicides applied, since at higher dosages the plants were not completely free from infection.

From the Table 2 and Fig. 2 it may be seen that the number of root-knots were as high as 782.00 per plant under check plots. But the application of carbofuran 0.4 g/m^2, 0.3 g/m^2, 0.2 g/m^2, aldicarb 0.4 g/m^2, 0.3 g/m^2 and 0.2 g/m^2, metham sodium 25 ml/m^2, 20 ml/m^2 and 15 ml/m^2 reduced the number of root-knots by 71.2 per cent, 48.6 per cent, 33.8 per cent, 68.4 per cent, 43.4 per cent, 33.4 per cent, 57.4 per cent, 38.3 per cent and 31.9 per cent respectively. DBCP at 3 ml a.i/m^2 was found to be the least effective with only 25.9 per cent reduction in number of root-knots. This reduction in all the treatments is statistically significant. Srivastava et al. (1969) reported that among the 4 nematicides tested, Nemagon at 6 to 7 l/ha was significantly superior to others and greatly reduced the nematode population and root-knot severity.

The total number of galls per 10 cm of roots was significantly reduced (Table 2 and Fig.2) by the application of carbofuran 0.4 g/m^2, aldicarb 0.4 g/m^2 and metham sodium 25 ml/m^2 over the check. This again is in agreement with the findings of Brown and Turner (1978); Prasad et al. (1977); Reddy (1975); Johnson and Harmon (1974). McLeod (1972) reported that in a field trial, aldicarb granules at 4 lb/acre and D-D at 20 gallon/acre significantly reduced galling of tomato by *M.incognita*. Rajendran and Naganathan (1978) also reported that in a vineyard infested with *M.incognita*, treatment with aldicarb (2 g a.i/vine), DBCP (1.2 ml/m^2) or carbofuran (0.6 g a.i/vine) decreased the number of galls per g of root by approximately 25 per cent. Yield increased by 96.4 per cent, 72.6 per cent and 70.8 per cent respectively. Thus the marked reduction in galling in carbofuran and aldicarb treated plots and the large increase in yield observed in the present studies demonstrate the effectiveness of these chemicals for control of root-knot nematodes in brinjal.

There was also a consequent decrease in nematode population in the soil as seen in Table 3 and Fig.3. In the case of total plant parasitic nematodes in the soil there was an increase of 60.7 per cent in control plants whereas the planting of seedlings treated with carbofuran, aldicarb, metham sodium and DBCP reduced the population by

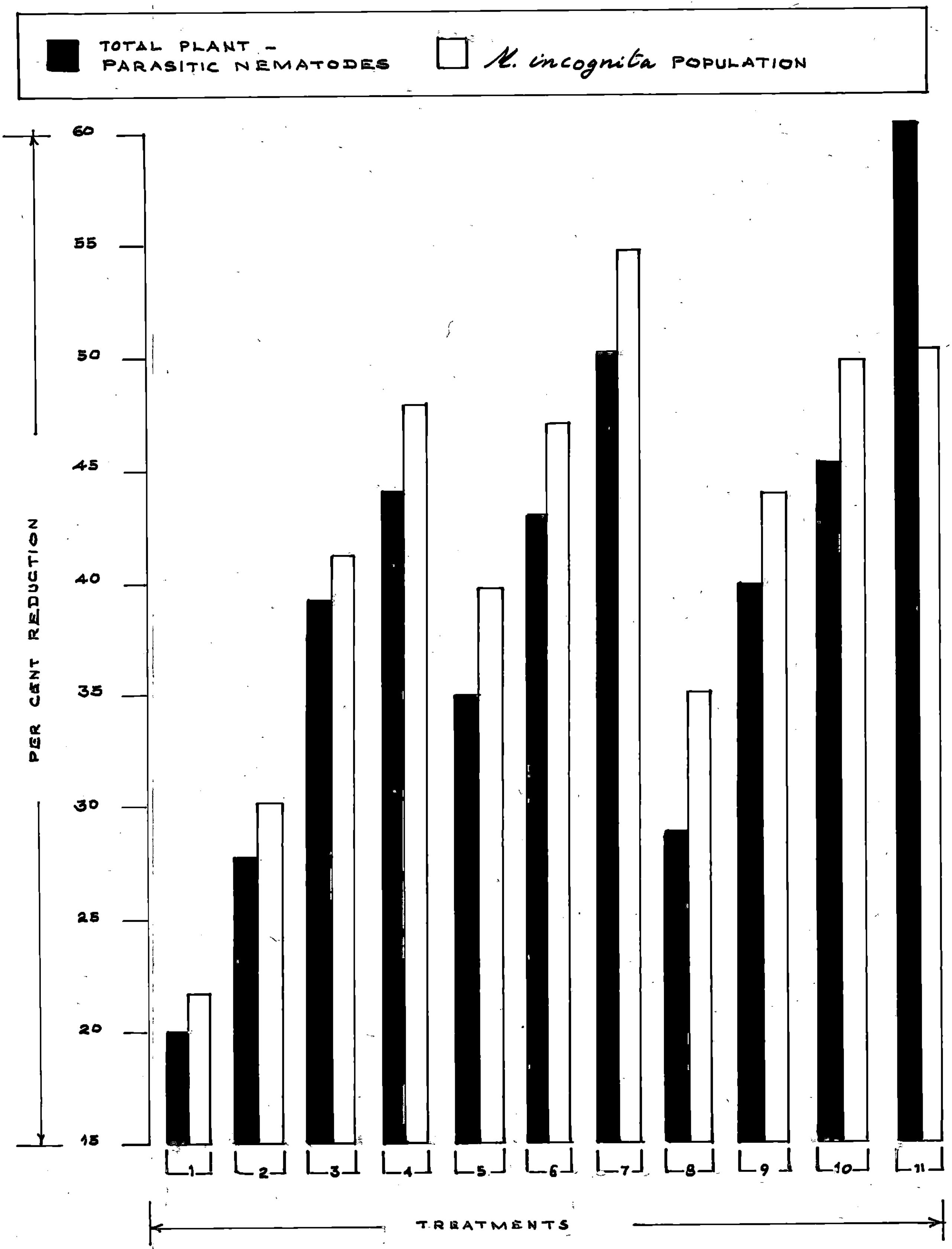

FIG: 3 EFFECT OF NURSERY TREATMENT BY NEMATICIDES ON CONTROL OF ROOT-KNOT NEMATODES IN BRINJAL

(TOTAL PLANT PARASITIC NEMATODES INCLUDING *Meloidogyne incognita* IN 100 ml. SOIL)

35.0 per cent, 43.2 per cent 50.1 per cent, 29.9 per cent, 40.0 per cent, 45.9 per cent, 27.9 per cent, 39.0 per cent, 44.9 per cent and 20 .0 per cent respectively over the initial population. The total _M.incognita_ population was also decreased by the application of DBCP 3 ml/m^2, metham sodium 25 ml/m^2, 20 ml/m^2 and 15 ml/m^2, carbofuran 0.4 g/m^2, 0.3 g/m^2 and 0.2 g/m^2 and aldicarb 0.4 g/m^2, 0.3 g/m^2 and 0.2 g/m^2. The decrease in _M.incognita_ population was 21.9 per cent; 48.1 per cent, 41.9 per cent and 30.1 per cent; 54.9 per cent, 47.0 per cent and 39.9 per cent; 50.0 per cent 43.9 per cent and 35.1 per cent respectively. However, the root-knot nematode population increased by 50.7 per cent in check plants. These observations are also in agreement with Raj and Nirula (1971) who reported that application of D-D at 800 l/ha was significantly more effective in reducing the population of _M.incognita_ larvae in potato fields. Sivakumar et al. (1973) showed that soil application of carbofuran 3 or 6 % a.i gave the most economical control against the root-knot nematode _M.incognita_ and also increased the yield considerably. Hemeng (1977) reported better control of _M.incognita_ in tomato in field experiments by D-D, nemagon and vapam. Therefore, it may be presumed that the low initial root-knot nematode population densities associated with nematicide treatment of soil protect the crop in its early phases of growth and maintain the plants in more healthy conditions during the cropping season.

Thus the results presented above show that root-knot free seedlings of brinjal could be produced by nursery treatments with carbofuran, aldicarb, metham sodium and DBCP. However, when these seedlings were transplanted in untreated main plots, they were found to be invaded by root-knot nematodes, but in varying degrees of intensity of attack and performance of plants. The nursery treatment with carbofuran 0.4 g/m^2 gave consistant and significant control of M.incognita on brinjal.

The experimental studies on the nursery treatments indicated that carbofuran at 0.4 g/sq.m and aldicarb at 0.4 g/sq.m were promising over the other treatments as evidenced by the improvement in plant growth, higher yield and reduction in root-knots. The low doses of these nematicides also were found to give protection against these nematodes and thereby increase the yield. Because the granular systemic pesticides like carbofuran and aldicarb offer control of both insects and nematodes, the grower can expect to receive additional benefits in lowered unit production costs and reduced use of pesticides. Another advantage was that none of these nematicides were phytotoxic to the brinjal plants.

Nematode injury to crops is most commonly evaluated by measuring changes in yield under varying degrees of infection and by actual root examination. The nematode usually causes a distinct reduction in vitality and growth of host plant without being lethal. The effect of infection of top growth is such that the visible symptoms have often been diagnosed as due to various nutrient deficiencies.

In the present investigation, the nature and extent of damage caused by M.incognita to egg plant at 6 different inoculum levels ie.,10(T_1), 100(T_2), 500(T_3), 1000(T_4), 5000(T_5) and 10,000(T_6) larvae per plant were studied. The results (Tables 4 and 5 and Plates 1, 2 and 3) indicate a progressive decrease in plant growth with increasing inoculum density.

There was a significant reduction of 14.8 per cent in number of leaves during a period of 108 days at the inoculum level of 10 larvae per plant, 33.6 per cent at 100 larvae per plant, 46.0 per cent at 500 larvae per plant, 53.7 per cent at 1000 larvae per plant, 57.7 per cent at 5000 larvae per plant and 64.6 per cent at 10,000 larvae per plant (Table 4 and Fig.4).

In the case of shoot length (Table 4 and Fig.5) also there was a significant reduction of 4.9 per cent, 9.6 per cent, 11.0 per cent, 11.0 per cent, 16.7 per cent and 32.6 per cent at the inoculum level of 10, 100, 500, 1000, Plates 1,2 & 3. Effect of different inoculum levels of *M.incognita* on brinjal plants.

T_1 - Uninoculated plant (check)

T_2 - 10 larvae per plant

T_3 - 100 larvae per plant

T_4 - 500 larvae per plant

T_5 - 1000 larvae per plant

T_6 - 5000 larvae per plant

T_7 - 10,000 larvae per plant

PLATE. 1

PLATE. 2

PLATE. 3

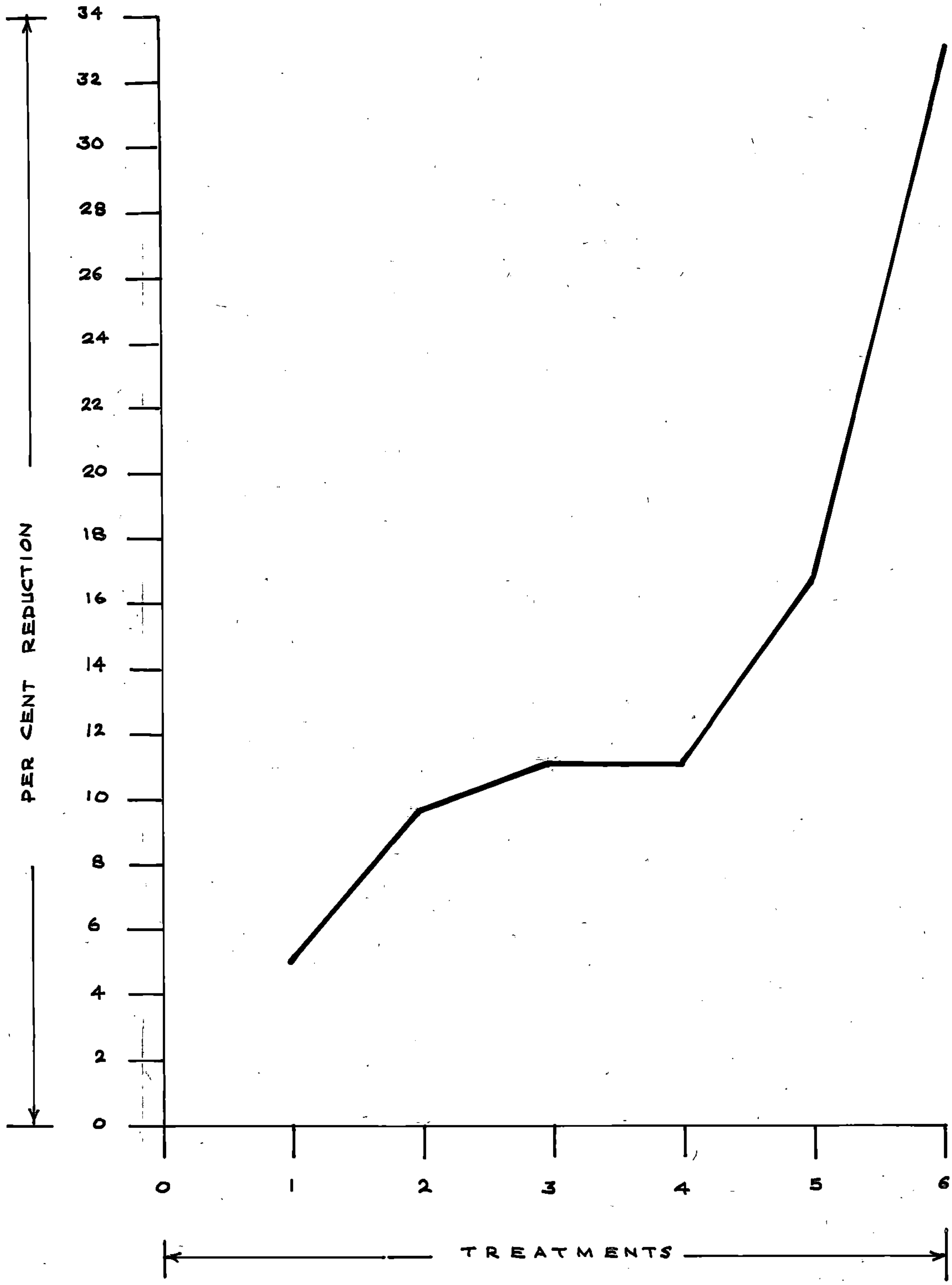

FIG: 5 EFFECT OF DIFFERENT INOCULUM LEVELS OF ROOT-KNOT NEMATODES ON BRINJAL (HEIGHT OF THE PLANTS)

5000 and 10,000 larvae respectively within 108 days. This is in agreement with the observations of Sharma and Maia (1976) who compared the inoculated plants of cocoa (*Theobroma cacao* L) with controls at 37 weeks after inoculation. They found that dry plant weight, stem diameter and plant height had decreased 31.2 to 47.9 per cent, 10.6 to 17.4 per cent and 20.6 to 28.4 per cent respectively. Dhawan and Sethi (1978) also observed significant reduction in length of shoot when seedlings of *Solanum melongena* were inoculated with 1000 and 10,000 larvae of *M.incognita* per kg sterilized soil and examined after 90 days.

Fresh weight of shoot was also significantly reduced after inoculation with root-knot nematode. From the Table 4 and Fig.4 it may be seen that weight of the shoot decreased to 5.9 per cent at 10 larvae per plant, 39.5 per cent 100 larvae per plant, 39.7 per cent at 500 per plant, 44.4 per cent at 1000 larvae per plant, 57.6 per cent at 5000 larvae per plant and 61.2 per cent at 10,000 larvae per plant. Dhawan and Sethi (1978) reported reduction in shoot fresh weight of egg plant at 1000 juveniles. Reduction in root fresh weight was also observed even at 10 juveniles per plant when inoculated just at growing root tips, in 15 cm diameter earthen pots.

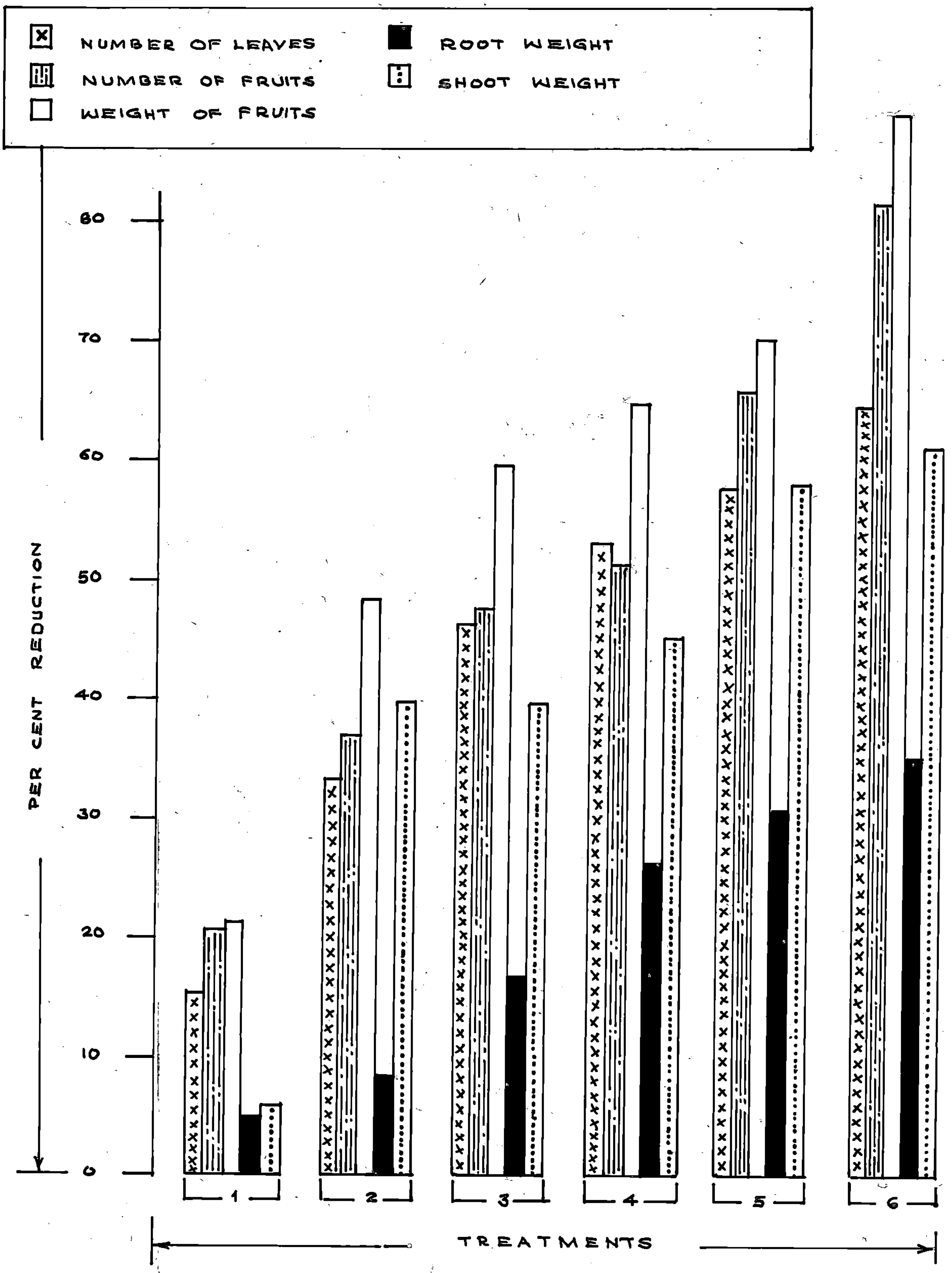

FIG: 4 EFFECT OF DIFFERENT INOCULUM LEVELS OF ROOT-KNOT NEMATODES IN BRINJAL

Reduction in weight of root was observed even at the lowest level of inoculum, 10 larvae per 12 kg soil. (Table 4 and Fig.4) The root weight decreased significantly by 5.2 per cent, 8.4 per cent, 16.9 per cent, 25.8 per cent, 30.4 per cent and 34.9 per cent at T_1, T_2, T_3, T_4, T_5 and T_6 respectively after 108 days of inoculation. Chidambaranathan and Rangaswami (1965) also reported a reduction in shoot, root and plant weight of the egg plant, chilli and tomato. Winto (1972) reported a reduction in plant weight of pepper seedlings by 37.4 per cent and 10.2 per cent due to M.incognita and M.javanica over control, 10 months after inoculation. Reduction in root weight and root surface was also reported by Ismail and Alam (1975).

The yield decreased as the inoculum level increased. (Table 4 and Fig. 4). There was a significant reduction of 20.9 per cent at inoculum level of 10; 37.3 per cent at inoculum level of 100; 47.8 per cent at inoculum level of 500; 50.8 per cent at inoculum level of 1000; 65.7 per cent at inoculum level of 5000 and 82.1 per cent at inoculum level of 10,000 in yield within 108 days of inoculation. At higher inoculum levels the proportion of the total number of fruits picked was less, while lower inoculum levels yielded more fruits. The production of fruits at higher inoculum levels practically stopped after the second picking. This indicated some effect of hastened maturity and shortening in the period of bearing fruit.

Mean weight of fruit per plant was also significantly decreased as the inoculum level was increased. Weight of fruits was reduced by 21.1 per cent, 48.1 per cent, 59.5 per cent, 64.7 per cent, 70.5 per cent and 89.1 per cent at 10, 100, 500, 1000, 5000 and 10,000 larvae inoculum levels within 108 days (Table 4 and Fig.4). Tuber weight of Manihot esculenta were reduced at all inoculum levels where the seedlings were inoculated with M.incognita (Caveness, 1977). Charles and Kuriyan (1980 c) reported a reduction of 9.4 to 46.4 per cent in weight of rhizome of ginger at inoculum levels of 10, 100, 500, 1000 and 5000 larvae of M.incognita.

The total number of root-knots present in each plant and total root-knots per 10 cm of roots at random from each plant also increased gradually as the inoculum level increased from 10 to 10,000 larvae per plant (Table 5). Root-knots were not present in the roots of check plants. The average of total rot-knots was 148.50 in the case of plants inoculated with 10 larvae per plant; 186.83 at 100 larvae per plant; 244.17 at 500 larvae per plant, 344.33 at 1000 larvae per plant, 410.0 at 5000 larvae per plant and 412.33 at 10,000 larvae per plant. The total number of root-knots per 10 cm of roots at random from each plant, was also increased from 13.7 to 23.9 as the inoculum level increased from 10 to 10,000 larvae. Irrespective of the weight of the root tissues, as compared to healthy plants, the absorption by galled roots is appreciably reduced thereby resulting in reduced top growth, as observed in the present investigation and also by Gaur (1973). It is therefore presumed that top weight is a better parameter for studying the pathological effects of root-knot nematodes rather than the root weight.

M.incognita population per 100 ml soil was also increased in the experimental pots (Table 5). Nematode population was absent in check pots (T_0). The population observed in T_1, T_2, T_3, T_4, T_5 and T_6 were (28.0, 37.0, 45.0, 53.0, 155.0 and 243.0 respectively). Gaur (1973) also recorded similar results with *M.incognita* in egg plant.

Thus it can be concluded that *M.incognita* is positively involved in the unthrifty growth of the egg plants wherever nematode infestation is present. Inoculation experiments in greenhouse or growth chambers are useful in studying host suitability for nematode reproduction and host-parasite interaction. Increase in the nematode population and subsequent reduction in yield of crops or other pathogenic effects are directly influenced by the initial density of nematodes in soil. However, the population density at which the yields start declining and the relationships between nematode population, development and growth and yield of the crop are varying. A measurable damage occurs only when population density exceeds a certain limit. A change in growth characteristics of egg plant and a shift in the period of maximum growth have been reported by Prasad and Gaur (1974).

Thus the results presented above show that the growth and yield of brinjal plants were significantly affected at 1000 root-knot nematode larvae per plant and above, but even lower levels caused actual reductions of growth and yield.

The striking decrease in the growth characters of Solanum melongena at high inoculum level indicated the destructive potential of the nematode. Apart from reduction in shoot length and fresh root weight, the studies also indicated clear association between high population of the nematode and yield decline.

SUMMARY

SUMMARY

The effect of nursery treatments on brinjal seedlings and their subsequent performance in the mainfield, infested with root-knot nematode was studied with four chemicals viz. DBCP (Nemagon 60 EC), Metham sodium (Vapam), Carbofuran (Furadan) and aldicarb (Temik).

The experiment was laid out in Randomised Block Design with 4 replications and 11 treatments both in the nursery and in the mainfield. Seeds of brinjal local was sown in nematicide treated nursery beds. Seedlings were uprooted on 30th day after sowing and all of them except in check plots were free of root-knots. Plant characters like number of leaves, height of the plants, weight of 25 seedlings, galls per plant etc. were also studied and found to be significantly superior over the check.

These seedlings were transplanted in the corresponding plots for each treatment and maintained giving the usual agronomic practices. Yield was recorded plant-wise. When the fruit setting was over and when no more fruits were available, the plants were uprooted for final observations like number of leaves, shoot weight, root weight, number and weight of fruits, total root-knots per plant, root-knots per 10 cm roots at random from each plant and soil

population of plant parasitic nematodes including *Meloidogyne incognita*.

In the mainfield plants raised from seedlings treated with carbofuran at 0.4 g/m^2, aldicarb at 0.4 g/m^2 and metham sodium at 25 ml/m^2 gave significantly superior results of characters studied. The number of leaves was increased over check by 101.8 per cent in the case of carbofuran 0.4 g/m^2 and 69.3 per cent with aldicarb 0.4 g/m^2 and 68.5 per cent with metham sodium 25 ml/m^2. There was an increase of 60.4 per cent shoot weight with carbofuran 0.4 g/m^2, 51.1 per cent with aldicarb 0.4 g/m^2 and 47.8 per cent with metham sodium 25 ml/m^2 over check. The root weight also significantly increased by 43.8 per cent with carbofuran 0.4 g/m^2, 40.4 per cent with aldicarb 0.4 g/m^2 and 37.4 per cent with metham sodium 25 ml/m^2 over the root weight of the check plants. Yield of fruits also increased in the plants raised from treated seedlings. The number of fruits and weight of fruits was increased by 84.0 per cent and 66.9 per cent with carbofuran 0.4 g/m^2; 63.9 per cent 97.2 per cent with aldicarb 0.4 g/m^2; 69.5 per cent and 68.7 per cent with metham sodium 25 ml/m^2.

The total number of galls present in each plant was reduced by 71.2 per cent in the case of carbofuran 0.4 g/m^2, 68.4 per cent with aldicarb 0.4 g/m^2 and 57.4 per cent with metham sodium 25 ml/m^2. Soil population of plant parasitic nematodes including *M.incognita* was also found to be reduced (20.0 per cent to 50.1 per cent) in nematicide treated plots over the check.

Thus the results presented show that root-knot nematode free seedlings of brinjal could be produced by nursery treatments with carbofuran, aldicarb, metham sodium and DBCP. Maximum control with increased yield was obtained by the use of carbofuran 0.4 g/m^2 followed by aldicarb 0.4 g/m^2 and metham sodium 25 ml/m^2 in the mainfield.

The extent of damage on brinjal at different inoculum levels was studied in pot cultures under green house conditions. The treatments included the inoculation of one day old larvae of *M.incognita* at the rate of 0, 10, 100, 500, 1000, 5000 and 10,000 numbers per pots of size 30 cm diameter containing 12 kg of sterilized pot mixture. The experiment was replicated six times. The yield was recorded during the experiment and when the fruit setting was over the plants were uprooted for final observations. It was found that the extent of damage caused to the crop progressively increased with the increased inoculum levels. The plant characteristics such as number of leaves, height of the plant, shoot weight, root weight, number and weight of fruits etc. showed reduction of 14.8 to 64.6 per cent, 4.9 to 32.6 per cent, 5.9 to 61.2 per cent, 5.2 to 34.9 per cent, 20.9 to 82.1 per cent and 21.1 to 89.1 per cent respectively.

In check pots, the total number of root-knots and population of _M.incognita_ in 100 ml soil was completely absent. From the results obtained it can be seen that there is a steady increase of total number of root-knots and _M.incognita_ population per 100 ml soil as the inoculum level increases from 10 to 10,000 larvae per plant.

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* Originals not seen.

APPENDICES

APPENDIX I

Analysis of Varience Table related to the data presented in Table 1.

Characters	Total S.S	Block df = 3		Treatment df = 10		Error df = 30		
		S.S.	M.S.	S.S.	M.S.	S.S.	M.S.	F
1. Number of leaves	13.80	0.87	0.29	9.27	0.93	3.66	0.12	7.59 **
2. Height of the plant	41.34	23.06	7.69	1.99	0.19	16.29	0.54	0.37 N.S.
3. Weight of 25 seedlings	29769.21	7246.08	2415.36	3150.81	315.08	19282.32	642.74	0.49 N.S.

** Significant at 5 and 1 per cent levels.

N.S. Not significant.

APPENDIX II

Analysis of Variance Table related to the data presented in Table 2

Characters	Total S.S	Block df = 3 S.S.	Block df = 3 M.S.	Treatment df = 10 S.S.	Treatment df = 10 M.S.	Error df = 30 S.S.	Error df = 30 M.S.	F
Number of leaves	53430.56	8083.31	2694.44	25119.16	2511.92	20228.09	674.27	3.72 **
Shoot weight	97426.27	25651.26	8550.42	28553.13	2855.31	43221.88	1440.73	1.98 N.S.
Root weight	7446.32	2617.89	872.63	1551.08	155.11	3277.35	109.24	1.42 N.S.
Number of fruits per plant	7.16	1.29	4.31	3.28	0.33	2.58	0.09	3.81 **
Weight of fruits per plant	340783.59	28361.74	9453.91	212059.05	21205.91	100362.79	3345.43	6.34 **
Total number of galls per plant	1451.71	396.68	132.23	672.59	67.26	382.44	12.75	5.28 **
Galls per 10 cm roots at random	49.16	13.75	4.58	12.24	1.22	23.17	0.77	1.58 N.S.

** Significant at 5 and 1 per cent level.

APPENDIX III

Analysis of Variance Table related to the data presented in Table 4 and 5

Characters	Total S.S.	Treatment df = 6 S.S.	Treatment df = 6 M.S.	Error df = 35 S.S.	Error df = 35 M.S.	F
Number of leaves	115.82	55.70	9.28	60.12	1.72	5.4 **
Height of the plant	11444.01	1843.81	307.30	9600.21	274.29	1.12 N.S.
Number of fruits per plant	14.62	10.95	1.82	3.67	0.11	17.42 **
Weight of fruits per plant	409645.90	340968.90	56828.15	68677.00	1962.20	28.96 **
Shoot weight	44107.62	19356.95	3226.16	24750.67	707.16	4.56 **
Root weight	3583.09	501.63	83.60	3081.46	88.04	9.49 **
Total root knots per plant	6220.44	2684.73	447.46	3535.71	101.02	4.43 **
Galls per 10 cm roots at random	114.37	104.96	17.49	9.41	2.68	65.07 **
M. incognita population in 100 ml soil	937.68	917.15	152.86	20.53	5.87	260.61 **

NTROL OF ROOT-KNOT NEMATODES IN BRINJAL

BY

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ABSTRACT OF THE THESIS

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ABSTRACT

The egg plant (brinjal) which is one of the most common vegetable crops is highly susceptible to the root-knot nematode *Meloidogyne* spp. An effective control can often be achieved by the complete elimination of nematodes from transplants. Hence, the present study was undertaken with a view to find out the efficacy of nursery treatment with four nematicides viz. DBCP, aldicarb, carbofuran and metham sodium in control of the root-knot nematode *Meloidogyne incognita* in brinjal seedlings and their subsequent performance in the mainfield.

Seeds of brinjal local was sown in nematicide treated nursery beds. On 30th day after sowing seedlings were uprooted from each treatment and plant characters like number of leaves, height of the plants, galls per plant and weight of 25 seedlings were compared to study the effect of the treatment in the nursery. All these characters were found to be superior over the check.

These seedlings were transplanted in the corresponding plots for each treatment. Yield were recorded plant-wise. When the fruit setting was over and when no more fruits were available, the plants were uprooted for final observations like number of leaves, shoot weight, root weight,

number and weight of fruits, total root-knots per plant, root-knots per 10 cm roots at random from each plant and soil population of plant parasitic nematodes including *M.incognita*.

The number of leaves was increased over check by 101.8 per cent with carbofuran 0.4 g/m^2, 69.3 per cent with aldicarb 0.4 g/m^2 and 68.5 per cent with metham sodium 25 ml/m^2. There was an increase of 60.4 per cent shoot weight with carbofuran 0.4 g/m^2; 51.1 per cent with aldicarb 0.4 g/m^2 and 47.8 per cent with metham sodium 25 ml/m^2 over check. The root weight also significantly increased by 43.8 per cent in carbofuran 0.4 g/m^2; 40.4 perc cent in aldicarb 0.4 g/m^2 and 37.4 per cent in metham sodium 25 ml/m^2 over the root weight of the check plants.

Yield of fruits also increased in the plants raised from treated seedlings. The number of fruits and weight of fruits was increased by 84.0 per cent and 66.9 per cent with carbofuran 0.4 g/m^2; 63.9 per cent and 97.2 per cent with aldicarb 0.4 g/m^2; 69.5 per cent and 68.7 per cent with metham sodium 25 ml/m^2. The total number of galls present in each plant was reduced by 71.2 per cent in the case of carbofuran 0.4 g/m^2, 68.4 per cent with aldicarb 0.4 g/m^2 and 57.4 per cent with metham sodium 25 ml/m^2.

Soil population of plant parasitic nematodes including *M.incognita* was also reduced from 20.0 per cent to 50.1 per cent in nematicide treated plots over check. Thus the results presented above show that root-knot nematode free seedlings of brinjal could be produced by nursery treatments with carbofuran, aldicarb, methem sodium and DBCP. Maximum control with increased yield was obtained by the use of carbofuran 0.4 g/m^2 followed by aldicarb 0.4 g/m^2 and methem sodium 25 ml/m^2 in the main field.

The extent of damage on brinjal at different inoculum levels was studied in pot cultures under green house conditions. The treatments included the inoculation of one day old larvae of *M.incognita* at the rate of 0, 10, 100, 500, 1000, 5000 and 10,000 per pots of 30 cm diameter containing 12 kg of sterilized pot mixture. The yield was recorded during the experiment and when the fruit setting was over the plants were uprooted for final observations. It was found that the extent of damage caused to the crop progressively increased with the increased inoculum levels. The plant characteristics such as number of leaves, height of the plant, shoot weight, root weight, number of fruits and weight of fruits showed reductions of 14.8 to 64.6 per cent, 4.9 to 32.6 per cent, 5.9 to 61.2 per cent, 5.2 to 34.9 per cent, 20.9 to 82.1 per cent and 21.1 to 89.1 per cent respectively. In check plants, the total number of root-knots and population of *M.incognita* was completely absent. From the results obtained it can be seen that there is a steady increase of total number of root-knots and *M.incognita* population as the inoculum level increases from 10 to 10,000 larvae per plant.