CONTROL OF ROOT KNOT NEMATODE (*Meloidogyne incognita*) BY USE OF NEMATICIDES IN TUBEROSE (*Polyanthes tuberosa* L.)

A
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THE ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY,
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MASTER OF SCIENCE IN AGRICULTURE
(NEMATOLOGY)

By

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2010

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Dedicated

To

My Beloved Parents

DEPARTMENT OF NEMATOLOGY, COLLEGE OF AGRICULTURE,
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Dr. A. ACHARYA, Ph.D, FNSI
Professor

CERTIFICATE - I

This is to certify that this research work recorded in this thesis entitled **"CONTROL OF ROOT KNOT NEMATODE (*Meloidogyne incognita*) BY USE OF NEMATICIDES IN TUBEROSE (*Polyanthes tuberosa* L.)"** submitted in partial fulfillment of the requirements towards award of degree of **MASTER OF SCIENCE (AGRICULTURE)** in **NEMATOLOGY** to the Orissa University of Agriculture and Technology Bhubaneswar, is an authentic record of bonafide research work carried out by **Sri Chandra Kanta Nag** under my close guidance and supervision.

The research work is original and no part of it has been submitted for any other degree or diploma or published / sent for publication in any form. The help and information received during the course of investigation has been duly acknowledged by him.

I wish all success in life

Bhubaneswar
Date : 15-09-2010

(Dr. A. ACHARYA)
Chairman
Advisory Committee

CERTIFICATE - II

This is to certify that the thesis entitled **"CONTROL OF ROOT KNOT NEMATODE (*Meloidogyne incognita*) BY USE OF NEMATICIDES IN TUBEROSE (*Polyanthes tuberosa* L.)"** submitted by **CHANDRA KANTA NAG** to the Orissa University of Agriculture and Technology, Bhubaneswar, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **NEMATOLOGY,** has been approved by the Student's Advisory Committee after an oral examination on the same in collaboration with the External Examiner.

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BHUBANESWAR
Dated the, 15th September 2010

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ABSTRACT

Results of a replicated pot culture experiment consisting of twelve treatments(two individual nematicides/insecticides as soil application, three nematicides as foliar spray and six combined treatments with the above nematicides/insecticides with one suitable untreated control) with three replications showed significant enhancement in the plant growth parameters and reduction in the infectivity of the tuberose plants against *Meloidogyne incognita*. The results also further revealed that Furadan3g(1Kg a.i/ha) as soil application, Carbosulfan(0.2%)as foliar spray & combined treatment of Furadan(1kg a.i/ha)with Carbosulfan (0.2%) was proved to be the most suitable & effective treatment against *Meloidogyne incognita* for enhancing the growth parameters & reducing the disease incidence in tuberosa(*Polyanthes tuberosa* L).

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INTRODUCTION

INTRODUCTION

The tuberose, a native of mexico, belongs to family amaryllis and is commonly known as lily. It has long being cherished for aromatic oils extracted from its fragrant white flowers.

It is a popular cut flower not only for use in arrangements but also for individual florets that can provide fragrance to bouquets and boutonnieres. Among flowers it occupies a selective position because of its beauty, elegance and sweet pleasant fragrance.

It has gained considerable importance among growers of tropical regions of south-east Asia. It is now a days being commercially grown in large areas. It has great economic potential in the cut flower market and in essential oil industries. It grows in elongated spikes that produce cluster of white flowers that are 5-6cm long and have a characteristic bending. The flower spikes are upto 2 feet in height. Tuberose flowers blooms from the bottom towards the top of the spike.

Mainly tuberose are of two types i.e single budded and double budded. These are grown mostly in sandy loam to loamy soil which requires cool weather condition and high atmospheric humidity. As the ornamental crops are grown in the same land year after year, it provides a congenial environment for more than one plant parasitic nematodes, for population build up if such high population of plant parasitic nematodes are not checked properly it may reach an alarming level and wipe out the whole crop. Apart from this high level of population even a low level of their population may make the planting stocks unmarketable.

The infested planting materials may also serve as carrier of some nematode genera of quarantine concern. Root knot nematode, *M.incognita, M.javanica* and *M. arenaria* has been reported as the major limiting factor in successful tuberose cultivation.

The affected tuberose plants exhibits stunting, yellowing, drying up of leaves and rotting of bulbs as reported by Jayaraman *et. al* (1975). *M. incognita* alone was responsible for13.25%,9.87%,14.30%,13.78% and 28.58% reduction in plant weight , number of flowers, spike length ,spike weight, number of bulblets respectively as reported by Khan and Parvath Reddy (1992).

Although attempts have been made to combat this noxious nematode pathogen by chemical, physical, biological or cultural measures but none of the single control measures have been found successful in reducing the disease because of several limitations of each measures.

Considering the economic importance of tuberose crop and seriousness of the root knot disease a pot culture experiment was conducted using different chemicals (nematicides) by both soil application and foliar spray.

Quite often it is experienced that initial nematode population will multiply many times if the nematicidal treatments are not taken properly and timely. Since very less work have been carried out to manage this nematode disease it was felt imperative to attempt a sound and suitable management strategy through chemical (Nematicide) method. Thus the present investigation undertaken is the best suitable management strategy through the chemical (Nematicide) means by soil application & foliar spray for effective control of nematode infecting tuberose.

Chapter II

REVIEW OF LITERATURE

Shepherd (1986) evaluated the effect of aldicarb on yield of flue-cured tobacco and root knot nematode control in Zimbabwe. Aldicarb at 2.2, 4.5, 6.7 or 9 kg/ha or ethylene dibromide at 1.8 g/plant was applied to tobacco in fields infested with *Meloidogyne javanica* in Zimbabwe. Both treatments produced highly significant increases in yield and reductions in gall damage. However even at 9kg/ha, aldicarb was not as effective as ethylene dibromide.

Teran *et al.* (1987) reported chemical control of *Meloidogyne incognita* in tobacco in Cuba. Different nematicides were applied to the soil at transplanting time, including fenamiphos, carbofuran and fensulfothion, applied at 10 kg a.i./ha as granulars. Only fenamiphos showed a high efficiency (81.3%). The same nematicide applied as a leaf spray was not effective in controlling M. incognita on tobacco. The low efficacy of carbofuran which failed to control more than 50% of the nematodes is discussed.

Morale and Kurundkar (1989) evaluated the effect of some pesticides on root-knot of brinjal caused by *Meloidogyne incognita*. Out of 10 pesticides tested for control of *M. incognita* on aubergines in a pot experiment, phorate was the most effective followed by oxycarboxin, benfuracarb and carbofuran.

Ahuja (1990) reported the effect of nematicide treatments on infestation of okra (*Abelmoschus esculentus* L.) by *Meloidogyne incognita* in field, Carbofuran, aldicarb, fenamiphos, fensulfothion of disulfoton were applied to okras in the field for control of *M. incognita.* There was no significant difference in the root-knot indices of different treatments although greatest yields were obtained with carbofuran at 5 g/plant.

Bhagawati and Phukan (1990) suggested the chemical control of *Meloidogyne incognita* on pea. Carbofuran, diazinon, Ekalux [quinalphos] and phorate at 1, 2 or 3% were tested for the control of *M. incognita* on peas under laboratory and experimental field conditions in India. All chemicals reduced galls and egg masses in roots and increased pea yields even at the lowest concentration. Carbofuran at 3% was the most effective.

Borah and Phukan (1990) evaluated the efficacy of certain chemicals as seed treatment for the control of *Meloidogyne incognita* on green gram. Carbofuran, ethoprophos, phorate or diazinon at 1, 2 or 3% i.e. were tested as seed dressings for control of *M. incognita* on Vigna radiata in pot trials. Carbofuran at 3% was the most effective in reducing root galls, egg masses and increasing yield of V. radiata, followed by ethoprophos, diazinon and phorate at the same concentration.

Chand and Jain (1990) suggested the chemical control of root-knot nematode (*Meloidogyne incognita*) through seed dressing in cotton (*Gossypium hirsutum*). Cotton seeds dressed with carbofuran, isofenphos or benfuracarb at 1, 2 or 4% a.i. were grown in pots containing *M. incognita.* Carbofuran treated seeds had minimum number of galls. No galls occurred at the highest concentration of all 3 treatments.

Cuadra *et al.* (1990) reported the control of *Meloidogyne incognita* with the nematicides DD and heterofos. In field experiments, heterophos at 400 and 600 kg. a.i./ha was 71.4 and 79.6% effective, while 1,3-dichloropropene-1,2-dichloropropane at 200 and 400 t/ha was 91.5 and 100% effective against M. incognita on tomato and kenaf (*Hibiscus cannabinus*) resp. Macrophomina phaseolina increased its pathogenic effect in the presence of *M. incognita*.

Gogoi and Phukan (1990) evaluated the efficacy of certain chemicals as seed treatment against *Meloidogyne incognita* on lentil. Seed treatment of lentils by carbofuran, phorate, diazinon or Ekalux [quinalphos] at 1.0 and 2.0% was tested for control of *M. incognita* under pot and field experimental conditions in India. All chemicals at 2% were effective in reducing number of galls and egg masses and increasing yield, with diazinon and quinalphos giving best results in the pot and field experiments, respectively.

Kaul and Chhabra (1990) evaluated efficacy of granular nematicides as spot applications on root-knot nematode infesting brinjal. Phorate or carbofuran were applied as spot applications either at 1.5 g/plant at the site of transplant or in 2 split doses of 0.75 g/plant at the time of transplanting and 30 days after as basal dressing to fields of aubergines infected with *Meloidogyne incognita* in India. There was a significant increase in yield of aubergines with all nematicidal applications with split applications having a greater effect. Carbofuran was more effective than phorate in reducing yield losses. Nematode populations were also lower in roots and soil having split doses.

Meher (1990) suggested the effect of sebuphos on invasion of *Meloidogyne incognita* in brinjal. Second-stage juveniles of *meloidogyne incognita* were exposed to 0.0005, 0.0050 or 0.0500 µg/ml sebufos for 24 and 48 h and then inoculated into aubergine cv. Pusa Bheraw seedlings. Invasion of nematodes was significantly reduced at all concentrations irrespective of the exposure period. The reduction remained effective up to 15 days.

Nayak *et al.* (1990) studied on chemical control of root-knot nematode *Meloidogyne incognita* infesting papaya. A survey carried out in the major papaya growing districts of Karnataka revealed *Meloidogyne incognita* [paw paw] to be the major nematode parasite. Five popular cultivars of paw paw: Coorg Honey

Dew, CO-2, CO-3, Solo and Washington were screened for their reactions against M. incognita. All the cultivars were relatively susceptible to the nematode and the growth and development of their seedlings were affected. Carbofuran, aldicarb and Ethoprophos were tested for their effectiveness on hatching and survival of the nematode. Aldicarb at 20 p.p.m. was found to be most effective followed by carbofuran and Ethoprophos. In pot culture studies aldicarb at 10 kg (a.i.)/ha was found to affect growth of Solo seedlings. Ethoprophos was phytotoxic even at 6 kg (a.i.)/ha. Carbofuran at 6 kg (a.i.)/ha was found to be most effective in checking development and reproduction of M. incognita in the roots of paw seedlings.

Pal and Das (1990) reported the effect of weedicides on growth and flowering of tuberose. Field trials were conducted with 3-4 kg/ha Saturn [thiobencarb], 3-4 litres/hr Gramoxone [paraquat dichloride] and Basagram [bentazone] and 2-3 litres Glycel [glyphosate] applied 7 d prior to planting or 3 times(at intervals of 40 d) after planting tuberose [*polyanthus tuberosa*] cv. Single in Mar. 1987. Gramoxone reduced weed biomass from weedy control values of 55-57.5 g DW/0.25 g, where as all other treatments resulted in 37-52 g weeds. The following tuberose growth parameters were increased by herbicide treatments: height (from 27-27.5 to 27.5-41 cm), the number of leaves/plant (from 6.5 to 6.7-13), the number of bulbs/plant (from 72-73 to 73-94 cm), the number flower spikes/plot (from 90-95 to 100-180) and the flower yield/plot (from 1-1.2 to 1.3-4.2 kg). Gramoxone at 4 litres Glycel generally had the least effect.

Johnston *et al.* (1991) evaluated fumigants and nematicides for control of root-knot nematodes on carrot in field trials in New Jersey, Telone [1, 3-dichloropropene] preplant, Vapam [metam] preplant, or Vydate [oxamyl] preplant incorporated or foliar, were evaluated for control of *Meloidogyne hapla* on carrot. All treatments significantly reduced nematode populations compared with controls within 2 months after treatment. However, at harvest, only those treatments where Vydate was applied as a foliar spray to fumigated soil or where foliar applications began 6 weeks after soil application significantly reduced *Meloidogyne* soil populations.

Mishra and Gupta (1991) studied the chemical control of *Meloidogyne incognita* (Kofoid and White, 1919) Chitwood, 1949 associated with soybean. Thiride [thiram], Dithan M-45 [mancozeb], Bavistin [carbendazim], Aldrin 30 EC, monocrotophos, Thimet 10G [phorate], carbofuran, phorate, ziram and Saturn [thiobencarb] were evaluated for control of *M. incognita* on soyabean in pot experiments. All chemicals except Bavistin and Ziram were effective in reducing the nematode larval population. Carbofuran and phorate gave the best results by increasing plant growth, nodule number and nodule weight.

Mian *et al.* (1991) reported the efficacy of Furadan for control of root-knot in potato. Furadan 3G (carbofuran) was evaluated in pot experiments for the control of *Meloidogyne incognita* in potato grown from true potato seeds (TPS) and seed tubers using nematode infested soil. The soil was treated with the nematicide at 0, 1.0, 1.5, 2.0 and 2.5 mg a.i./kg. soil just before planting. At the end of the growing period, plants from TPS (60 days) and from seed tubers (80 days) were used to collect data on growth parameters and gall development. Carbofuran enhanced plant growth, and decreased development of nematode and severity of root-knot. Better plant growth and nematode control corresponded to the higher rate of chemical applied to the soil ranging from 1.0 to 2.5 mg a.i./kg soil.

Patel *et al.* (1991) assessed the efficacy of different seed treatment nematicides against root-knot nematode *Meloidogyne incognita* infecting cowpea. Cowpea seeds were treated in a pot experiment with aldicarb, phorate, carbofuran, fenamiphos or aldicarb sulphone [aldoxycarb] at 1, 2 or 3% a.i. for control of *M. incognita.* Greatest nematode control occurred in the highest fenamiphos treatment although plant growth was not the best with this treatment.

Sekhar and Gill (1991) evaluated the efficacy of *Pasteuria penetrans* alone and in combination with carbofuran in controlling *Meloidogyne incognita.* Application of *P.penetrans* and carbofuran individually at 2.5 g/kg soil and 3 kg/ha, respectively, or in combination at half their individual doses, significantly reduced gall formation by *M. incognita* and improved growth of tomato cv. Pusa Ruby in a pot experiment. Maximum increase in plant growth characters and maximum reduction in galling occurred when *P. penetrans* was applied alone.

Amin *et al.* (1992) assessed the effect of trifluralin and certain pesticides for managements of *Meloidogyne incognita* on tomato. Trifluralin at 3.5 litres/ha, aldicarb, oxamyl, carbofuran, diazinon each at 30 kg or sulphur at 40 kg were applied to tomatoes in the greenhouse for control of *M. incognita.* Aldicarb gave the greatest reduction in root populations of *M. incognita* followed by oxamyl, sulphur and trifluralin. With carbofuran and diazinon root populations increased. Tomato yields were also highest with aldicarb.

Amarantha and Krishnappa (1992) studied certain pesticides for the management of *Meloidogyne incognita* infesting sunflower. Carbofuran, ethoprophos or phorate at 2 or 4 kg/ha were applied to sunflower one week before or one wek after inoculation with *M. incognita* in a pot experiment. Ethoprophos at 4 kg applied 7 days before nematode inoculation gave the greatest reduction in nematode development and reproduction. Sunflower growth was highest with phorate at 6 kg applied 7 days before nematode inoculation.

Mahanta and Phukan (1992) assessed the efficacy of certain chemicals as seed treatments for the control of *Meloidogyne incognita* on blackgram. Carbofuran, phorate, ethoprophos or diazinon at 1, 2 and 3% w/w were applied to seeds of *Vigna mungo* for control of *M. incognita* in a pot experiment. All chemical at the two higher concentrations were effective in reducing galls and egg masses on roots and increasing seed yield of crops, with ethoprophos at 3% giving best control.

Patel *et al.* (1992) evaluated bioefficacy of six nematicides for management of root-knot nematodes in tomato nursery. Prophos [ethoprophos], phorate, sebufos, HOE 388 and benfuracarb at 3 or 6 kg/ha were compared with carbofuran at 3 kg for control of *Meloidogyne incognita* infested tomato nurseries. Sebufos at both concentrations recorded significantly lower root knot indices with the lower rate also giving maximum seed germination.

Pankaj and Siyanand (1992) reported the efficacy of chemicals as seed dresser against *Meloidogyne incognita* on bitter gourd and round melon. Seeds of Momordica charantia and Paracitrullus fistulosus were treated with carbofuran, carbosulfuron or fenamiphos at 1, 2 or 3% w/w and then grown in pots inoculated with *M. incognita*. All chemicals inhibited larval penetrations and the development of females on roots and increased plant growth. Fenamiphos or carbofuran at the lowest concentration were sufficient to give initial protection against *M. incognita* on both crops.

Rao and Reddy (1992) studied the comparative efficacy of certain plant leaves and carbofuran in the management of *Meloidogyne incognita* on tomato. The efficacy of the incorporation of leaves of *Brassica compestris, Catharanthus roseus, Pedilanthus tithymaloides, Bougainvillea spectabilis. Azadirachta indica,* *Pongamia glabra [P. pinnata], Calotropis procera* and *Ricinus communis* at 80 g/kg soil was compared with carbofuran application at 2 kg a.i./ha for control of *M. incognita* on tomato. *B. compestris, P. tithymaloides, R. communis, A. indica* and *C. procera* were as effective as carbofuran for control.

Zahid (1992) studied nematicides to control root-knot of brinjal. Basamid at 300, 400 and 500 kg/ha : Sunfuran 3G at 30, 40 and 50 kg/ha ; Smite at 50, 75, 100 kg/ha, and Furadan 5G [carbofuran] at 30 kg/ha were tested to control *Meloidogyne incognita* on brinjal [aubergine] under pot house conditions. All nematicides were effective in reducing the severity of the disease and reduced the number of galls and larvae and females in roots. Sunfuran 3G at 50 kg/ha appeared to be the best treatment in reducing the severity of root gall and improving plant growth.

Aboul Eid and Youssef (1993) evaluated the effect of systemic nematicides on tomato plants infested with the root-knot nematode *Meloidogyne incognita* in the nursery and open field. Tomato plants were grown in nursery plots naturally infested with *M. incognita.* Plots were then treated with fenamiphos at 2.1 kg/feddan or ethoprophos at 3.15 kg. 15 d after transplanting seedlings were retreated with oxamyl as one foliar spray at 0.72 litres. Nursery treatments with ethoprophos or fenamiphos alone or with oxamyl showed a significant decrease in the number of nematode egg-masses and second-stage juveniles, and an increase in the number and weight of tomato fruits compared to oxamyl alone or untreated plots.

Aboul Eid and Youssef (1993) assessed the effect of certain nematicides on tomato plants infested with the root-knot nematode *Meloidogyne incognita* in the nursery and open fields. Soil application of either ethoprophos or fenamiphos in tomato cv. Supermarmand nursery, with or without oxamyl foliar sprays in the main field (Giza, Egypt), significantly reduced number of egg masses and soil second stage larvae of *Meloidogyne incognita* at both vegetative and flowering but not at the fruiting stages. The number and weight of tomato fruits significantly increased due to the two nursery treatments over the untreated checks. The development of root galls was not significantly suppressed in all the different tested nematicidal treatments. No significant influences were detected for the oxamyl foliar sprays in the main field whether it was applied without or after the nursery treatments. The significantly effective nursery treatments are cheaper in cost inputs and less pollutant to tomato fields due to the limited quantity and area of applications.

Ahmed *et al.* (1993) studied the efficacy of certain chemicals in controlling *Meloidogyne incognita* infecting cucumber (*Cucumis sativus* L.). Studies on the efficacy of carbofuran, Metasystox-R [oxydemeton-methyl] and Dimecron [phosphmidon] revealed that pre-aplication of oxydemeton-methyl was the most effective in controlling *Meloidogyne incognita* and increasing plant vigour.

Basile (1993) studied the efficacy of broadcast, band and seeding site applications of fenamiphos for the control of the root-knot nematode *Meloidogyne incognita* on tomato. The effect of fenamiphos on the control of *Meloidogyne incognita* on tomato was investigated in two field trials at Castellaneta (TA) in 1988 and 1989. Preplanting broadcast applications of 5-20 kg a.i./ha, band applications of 2.5-20 kg/ha before planting or 0.5-20 kg/ha 30 days after transplanting, and seeding site applications at 0.025-0.3 g a.i. site, were compared with fumigations with 150 litres 1,3D/ha and a non treated control. In 1988 significant yield increases were obtained, fumigating with 1, 3 D or with applications of fenamiphos in bands at 10-20 kg/ha before planting or 7.5-10 kg/ha transplanting, or in seeding sites at 0.075-0.3 g/site. In 1989 yield increases were also observed with band application of fenamiphos at lower rates. All treatments suppressed nematode root infestation, although better nematode control was observed in the plots fumigated with 1, 3 D or treated with the largest doses of fenamiphos.

Ganguly *et al.* (1993) reported the new disease complex of tuberose (*Polyanthes tuberosa*) involving root-knot nematode, *Meloidogyne incognita* and a mite species. *M. incognita* was found associated with *Tyrophagus putrescentiae* on *Polyanthes tuberosa* in New Delhi. This is the first report of a disease complex involving *Meloidogyne* and a mite species on this plant.

Govindaiah *et al.* (1993) studied the efficacy of different doses of carbofuran on *Meloidogyne incognita*, infecting mulberry. The use of carbofuran at 4 kg a.i./ha per year in 4 equal split doses for the control of *Meloidogyne incognita* on mulberry is suggested.

Johnston *et al.* (1993) suggested the evaluation of fumigants and nematicides for the control of root-knot nematodes on carrot. ASC 66824 900 EC, ethoprophos, 1, 3-dichloropropene, metam-sodium or oxamyl were evaluated for control of *Meloidogyne hapla* on carrot in field trials in New Jersey. Best control was obtained with ASC 66824 900 EC, while there was no control with foliar applications of oxamyl.

Kalita and Phukan (1993) evaluated the efficacy of four chemicals as seed treatment for the control of *Meloidogyne incognita* on blackgram. Carbofuran, phorate, diazinon or Posse 25 STD [carbosulfan] were applied at 0.25, 0.50 and

1.00% w/w as seed treatment to *Vigna mungo* in field trials in Assam, India. Increasing the concentration of all 4 chemicals decreased gall index due to *M. incognita* and increased *V. mungo* yield with best results obtained with carbofuran at 1% w/w.

Meena and Mishra (1993) suggested the nematicidal efficacy of chemicals as soil and seed treatment against *Meloidogyne incognita* infecting soybean. The efficacy of Oncol [benfuracarb], Marshall [carbosulfan] and HOE-388 as soil treatment at 1, 2 and 3 kg/ha, seed soaking at 50, 100 and 200 p.p.m. on the development of *M. incognita* and growth of soyabean cv. Pusa-24, was evaluated in a pot experiment. Greatest suppression of nematode numbers occurred at the highest doses, with Oncol being better as a soil treatment and HOE-338 and Marshall better as seed coating and seed soaking respectively. The highest dose of chemicals applied as soil treatment did not give better plant growth due to a phytotoxic effect.

Siddique *et al.* (1993) evaluated seed treatment with some chemicals for the control of the root-knot nematode on bottle gourd and bitter gourd. Seeds of *Lagenaria siceraria* and *Meloidogyne incognita* were treated with carbofuran, fenamiphos or phorate at 3 and 6% w/w and then grown in a field having moderate infestation of *Meloidogyne incognita*. Root-knot development was reduced and yields increased in all treatments, with the highest rate of fenamiphos having the greatest effect.

Barman, and Das,(1994) studied foliar spraying of nematicide for the control of root knot nematode *Meloidogyne incognita* on green gram. Seeds of *Vigna radiata* were treated with carbosulfan alone at 3% w/w or combined with carbosulfan, triazophos, monocrotophos or Zolone [phosalone] as a foliar spray at 40 or 70 days after sowing in greenhouse trials, for control of *M. incognita.* Seed dressing followed by a single or double spray with carbosulfan or triazohos were most effective in reducing root galls (61.23-63.59%), egg masses (71.89-75.11%) and final population of *M. incognita* (63.43-67.10%) and also increasing plant growth characters and number of pods/plant by 128-156% compared to controls.

Hong, *et al.* (1994) studied on the chemical control of root-knot nematodes on Chinese catalpa. Applying 0.8 g of 15% Temik (aldicarb])or 40% isofenphos-methyl [isofenfos] per Catalpa tree reduced root galls of *Meloidogyne* by 92.9 and 91.8% respectively in field and laboratory experiments.

Johnson, and Young (1994) evaluated efficacy of fenamiphos formulations applied through irrigation for control of *Meloidogyne incognita* on squash. Management of *Meloidogyne incognita* by chemigation with fenamiphos was studied in an infested field planted to *M. incognita*-susceptible yellow summer squash (*Cucurbita pepo*) cv. Dixie Hybrid. Fenamiphos (VL 73.1% a.i. manufacturing concentrate in propylene gloycol) was mixed with Unitol DSR-90 or used as fenamiphos 3 SC (spray concentrate). Both formulations, applied with 63.5 kl irrigation water hectare, decreased numbers of *M.incognita* second-stage juveniles in the soil and root-gall indices, and increased yield of squash compared with the untreated control. There was no benefit achieved by mixing the fenamiphos concentrate with Unitol DSR-90 over the use of fenamiphos 3 SC formulation. Fenamiphos application rates between 3.36 and 6.72 kg a.i./ha could provide control of *M. incognita* comparable to that obtained with 6.72 kg a.i./ha. Reduced rates of fenamiphos applied with irrigation water used to control plant-parasitic nematodes could reduce the potential for groundwater pollution as well as cost to the grower.

Melton (1994) studied evaluation of nematicde combinations for the control of root-knot nematode. 1, 3-dichloropropene, chloropicrin, terr-o-gas [methyl bromide], fenamiphos alone or + chloropicrin, aldicarb, chlorpyrifos or chlorpyrifos + aldicarb, aldicarb alone or ethoprophos + aldicarb were evaluated for control of *Meloidogyne* spp. in tobacco in field trials in North Carolina, 1, 3-dichloropropene at 10.5 gal/acre gave the greatest percent control of nematode eggs and juveniles. Highest yields were obtained with terr-o-gas at 6 gal.

Oduor Owino and Waudo (1994) evaluated comparative efficacy of nematicides and nematicidal plants or root-knot nematodes. Ethylene dibromide and aldicarb were compared to *Tagetes minuta* and *Datura stramonium* for control of *Meloidogyne* javanica on tornate in pot experiments. Ethylene fibroid gave the most effective reduction of galling and the poorest shoot growth and fruit yield, though its effects were reduced under field conditions. Aldicarb gave the highest shoot growth and fruit yields. It also reduced the galling intensity significantly more than *T minuta* or *D. stramonium. D. stramomium* had significantly greater suppressive effects on gall formation than did *T. minuta.* The two nematicidal plants stimulated tomato growth significantly more than the control, the methods used in this test may be ideal for comparing the relative efficacies of 2 or more nematicides with nematicidal plants or root knot nematodes. The economic implications of these methods and results obtained on the management of root-knot nematodes are discussed.

Osman *et al.* (1994) studied the compatibility and efficacy of certain nematicide-fungicide mixtures against root-knot nematode and leaf spot disease of peanut in Egypt. Field studies In Egypt during 1992 indicated that oxamyl-sulfur and oxamyl-Dithane-M45 [mancozeb] mixtures were compatible. Efficacy of oxamyl against *Meloidogyne incognita* on peanut [groundnut] was better when it was combined with sulfur or Dithane than when applied alone. Efficacy of sulfur against leaf spot disease [*Mycosphaerella berkeleyi*] decreased when it was applied alone or in combination with oxamyl. Oxamyl alone was not effective against leaf spot disease. Also fungicides applied alone were not effective against nematodes.

Sharma and Sharma(1995) reported management of root-knot nematodes (*Meloidogyne incognita* and *M.Javanica*) in tomato by bare root dip treatment. Management of *M. incognita* and *M.Javanica* by using nematicides as a soil and bare root dip application in tomato crop, revealed that 1000 p.p.m. root dip treatment of carbosulfan, phosphamidon and triazophos gave significantly higher yield over control. Among soil treatments 2.0 kg a.i./ha dose of carbofuran and phorate gave the highest yield and reduced root knot galling indices over control.

Sobita Devi (1995) assessed evaluation of carbofuran as a seed and soil treatment against *Meloidogyne incognita* on gram. Seed treatment with carbofuran at 2 g a.i./kg of seed and soil treatment at 2 kg a.i./ha was effective against *Meloidogyne incognita,* and increased chickpea yield.

Zaki and Maqbool (1995) assessed efficacy of nematicides in the control of root knot nematode on tomato. Use of Rugby [cadusafos], Tenekil(petroleum hydrocarbon) and Furadon[carbofuran] significantly reduced *meloidogyne* infection on tomato plants. Maximum reduction in gall formation was produced where cadusafos was used at 0.03 g/kg followed by ebufos at 0.02 g/kg, Tenekil at 0.018 g/litre and carbofuran at 0.12 g/kg soil. Greater increase in fresh weight of shoot was observed where cadusafos was used at 0.03 or 0.02 g/kg soil.

Mohanty and Das (1996) investigated the pathogenicity of *Meloidogyne incognita* with inoculum levels of 0, 10, 100, 1000, 5000, 10000 and 20,000 nematodes under semi sterile pot culture condition. There was a progressive reduction in plant height, root length and number of leaves with the increased inoculum levels over the control. The rate of reproduction was maximum in plants inoculated with 10 nematodes and minimum in plants treated with 20,000 nematode.

Subramaniyan (1996) assessed evaluation of insecticides as seed soaking treatment for the control of *Meloidogyne incognita* in bhendi and cowpea. Eight insecticides viz., methyl demeton, dimethoate, monocrotophos, phosphamidon, thiometon, formothion, carbosulfan and triazophos each at 0.1 % were tested as seed soaking treatment for 12 hours for the control of *M. incognita* in bhendi [okra] and cowpea under pot culture conditions. All the chemicals significantly increased the plant growth and reduced host infestation as well as multiplication of the nematode in both the crops. Monocrotophos and phosphamidon in okra, and phosphamidon and methyl demeton in cowpea were highly effective. Seed soaking treatment with insecticides can be effectively employed to reduce the severity of root-knot nematode infestation in okra and cowpea.

Bharali and Phukan (1997) studied efficacy of certain chemicals as seed soaking treatment against *Meloidogyne incognita* on cucumber. Seed soaking with carbosulfan 25 EC, Hostathion 40 EC [triazophos] and quinalphos 25 EC at 0.1 and 0.2 % a.i. (V/V) for 1 and 2 h was found to be effective in reducing galls, egg masses and eggs per egg mass of *M. incognita.* There was also improvement in the plant growth characters of cucumber.

Chakraborty *et al.* (1997) assessed the efficacy of neem (*Azadirachta indica*) and garlic (*Alium sativum*) against floral malady of P. tuberose var. single caused by *Aphelinchoids besseyi* and *Meloidogyne incognita* was tested on field experiment. A combined treatment of bulb dipping either in neem seed kenel extract or in garlic clove extract along with neem cake as an organic amendment significantly controlled the disease.

Deka and Phukan (1997) studied efficacy of certain chemicals as root dip treatment against *Meloidogyne incognita* on tomato. The efficacy of carbosulfan, methovip, quinolvip and triazophos at 0.05 and 0.1%(v/v) by root dipping of tomato seedlings for 0.5, 1, 2 and 3 h against *M incognita* was determined. All these nematicides were effective in reducing gall, egg mass and nematode populations in soil. However, carbosulfan and triazophos at 0.1 % with 1.2 and 3 h dipping periods, and methovip and quinolvip at 0.1 % with 2 and 3 h dipping periods were the most effective treatments.

Nagesh *et.al* (1997) studies integrated management of *Meloidogyne incognita* on tuberose. A fiend experiment was conducted for the management of *M. incognita* infecting *Polianthes tuberosa,* by integrating the use of the antagonistic fungus, *Paecilomyces lilacinus,* with 5% leaf extracts of castor [*Ricinus communis*] and neem [*Azadirachta indica*] as bulb treatments and soil drenches. Combination of *P. lilacinus* (at 2 x 104 spores/ml) with 5% neem leaf extract resulted in significantly higher fresh plant weight and flower yield. Root gall index was least under *p. lilacinus* plus neem leaf extract (5%) combination followed by P. lilacinus plus castor leaf extract (5%) treatment. Although the per cent egg and egg mass parasitization by *P. lilacinus* was higher when integrated with the leaf extracts, neem leaf extracts, neem leaf extract improved the parasitization by *P. lilacinus* more than that with castor leaf extract.

Oyedunmade (1997) studied the effects of phorate (Thimet) on the root knot nematode *(Meloidogyne incognita)* (Kofoid and White) Chitwood infesting soyabean (*Goycine* max L. Merrill) and resultant effects on some biochemical components of seeds. Soyabean cultivar TGm 80 treated with phorate at 1000 and 1500 ug a.i./ml recorded more than double the seed weight of the control plants. Significantly lower gall indices and nematode populations (P=0.05) were recorded for treated plants when compared with the controls. Biochemical analysis of seeds from treated plants showed significantly (P=0.05) higher crude fibre, fat/oil and phosphorus content but lower protein and free fatty acids content.

Reddy *et al.*(1997) studied seedling bare root dip with chemical for the management of root knot nematode in brinjal.The highest yield increase of brinjal [aubergine] was obtained with carbosulfan at 0.1% followed by Triazophos 0.05% in nursery plots.the reduction in gall index of *M.incognita* race I was also lowest with these two treatments.

Negesh *et al.* (1998) studied management of *Meloidogyne incognita* on *Polyanthes tuberosa* using parasitic fungus. *Paecilomyces lilacinus in* combination with oil cakes. A field experiment was carried out to evaluate the efficacy of the parasitic fungus. *P. lilacinus(* @ 50 g paddy grain containing 18 X 108 spores/g) and oil cakes of castor, neem and pongamia at 2 kg/m^2 either singly or in combination (at half the dosages) for the management of root-knot nematodes infecting tuberose. The fungus and oil cakes were tried as both single application (at planting) and split application (at planting and 45 days after planting). The results revealed that split application of *P. lilacinus* in combination with oil cakes (at planting and 45 days later) significantly reduced root-gall index, root and soil populations of *M. incognita* and its multiplication rate, compared to the single application of *P. lilacinus,* oil cakes and their combinations at planting. Further, integration of *P. lilacinus* with oil cakes not only promoted better establishment of *P. lilacinus* in the rhizosphere but also promoted its rate of multiplication.

Novaretti *et al.* (1998) evaluated chemical control of *Meloidogyne incognita* and *Pratylenchus zeae* on sugarcane through carbofuran or terbufos application. The efficiency of carbofuran and terbufos, at different formulations and doses, on the population levels of *M. incognita* and *P. zeae* were evaluated on sugarcane under field conditions. Seven trials were carried out in naturally infested areas, with the predominance of *M. Incognita* and/or *P. zeae* previously assessed, with the objective to compare the efficacy of soil treatment with carbofuran (Furadan 350 CS) at the rate of 8.5 and 10 litres c.p./ha, carbofuran (Furadan 50 G) at 60 kg c.p./ha, terbufos (Counter 50 G) at 50 and 60 kg c.p./ha, and a non-treated control. Evaluations were based upon nematode population data (number of nematodes per 50g of roots) collected 6 months after planting and crop performance (tonne of cane per ha). The results showed that the control of *M.incognita* and/or *P.zeae* through soil application of carbofuran and terbufos under the conditions used is technically and economically viable; and that the efficacy of the chemical control, expressed in terms of reduction of nematode population level and the consequent increase of cane production, was dependent on the nematicide doses and the target nematode species occurring in the experimental area.

Pareek *et al.* (1998) evaluated management of root-knot nematode. *Meloidogyne incognita* on gram (*Cicer arietinum* L.) by different nematicides. Monocrotophos 35 EC followed by carbosulfan 25 EC and triazophos 40 EC (each at 0.05 and 0.1%) were effective in controlling *M. incognita* through seed soaking of chickpea in pot experiments. Similarly, soil application of carbofuran at 2kg a.i./ha was better in improving plant growth characters and reducing nematode populations in comparison to sebufos and phorate.

Siddiqui and Mehta (1998) studied root-knot and reniform nematodes management by bare root dip treatments with some pesticides on tomato and egg plants. The effect of bare root dip treatment of tomato, and egg plant [aubergine] with nematicides to control *Meloidogyne incognita* and *Rotylenchulus reniformis* was studied in pot experiments. Triazophos, carbosulfan and ebufos caused significant inhibition in the root penetration of second stage juveniles *M. incognita* and the subsequent root galling, and also the population building up of *R. reniformis* on tomato cv. Pusa Ruby and aubergine cv. Pusa Purple Long. The bare root dip treatment significantly masked the nematode damage to the plants and consequently the plant growth improved. The root-knot development and the population of the reniform nematodes were gradually decreased with an increase in the concentration of the test chemicals and the duration of the root dip treatment.

Ranganatha (1998) studied field performance of brinjal seedlings treated in nursery against root-knot nematode, *Meloidogyne incognita*. Nursery bed studies were conducted on the integrated management of *Meloidogyne incognita* on brinjal [aubergine] using Neemark 0.03% EC [neem extract] (at 2% at 1.25 litres/m^2). Carbofuran 3G (13.33 g/m^2), *Pasteuria penetrans* (625 g/m2) and *Glomus fasciculatum* (500 g/m^2). There was a significant increase in the plant growth characters of aubergine cv. Erengere ,as well as a reduction in the nematode population.

Siddiqui (1998) assessed Evaluation of root dip treatments with nematicides on development of root gall and yield (*Meloidogyne incognita)* in tomato and aubergine. The greatest increase in yield of both tomato and aubergine was observed in seedlings treated with fenamiphos at 0.3 g a.i./100 ml. The root gall formation on tomato was significantly reduced when seedlings were treated with both carbofuran and fenamiphos at the above rate.

Vats *et al.* (1998) studied efficacy of a few chemicals as seed-dip treatment against root-knot nematode in cotton. Seeds of cotton (cv. H-777) were soaked for two hours each in dichlorvos, monocrotophos, benfuracarb, carbosulfan and triazophos at two concentrations i.e. 1000 (0.1%) and 2000 ppm (0.2%), and sown in pots (15 cm) containing steam sterilized sandy soil. Untreaed check (water soaking) was also maintained. Upon germination each plant was inoculated with freshly hatched juveniles of *Meloidogyne incognita* @ one J2/g soil. Observations recorded (60 days after germination) revealed that all the nematicides resulted in significantly better growth parameters (plant height, number of leaves, fresh shoot and root weights) than the check. However, monocrotophos was the most effective in improving growth parameters. All the nematicides reduced number of galls, egg masses per plant, eggs per egg mass and final nematode population significantly in comparison to the untreated check. However, maximum reduction in nematode infection and multiplication was observed at the higher dose of monocrotophos.

Javed and Ahmad (1999) studied chemical control of root-knot nematode *Meloidogyne incognita* on muskmelon.Metasystox [oxydemeton methyl]. Advantage [carbosulfan] and Furadan [carbofuran] were each applied at 1482 ml/ha, 1235 ml/ha and 24.7 kg/ha on susceptible muskmelon cv.Ravi. Carbofuran was the most effective nematicide, both in pre-and post-plant treatment, in reducing *M. incognita* and increasing the plant vigour.

Khan *et al.* (1999) studied effect of nematicides on the control of root knot nematode disease on tomato. Three nematicides. Tenekil [polychlorinated petroleum hydrocarbon], Furadan [carbofuran] and Advantage [carbosulfan] were compared for their effectiveness against *Meloidogyne incognita* on tomato (cv. Moneymaker). Tenekil was the most effective in reducing root knot disease and increasing plant vigour, followed by Furadan and Advantage.

Narayana and Prasad (1999) studied effect of seed soaking in carbosulfan and triazophos on plant growth of sunflower infected with *Meloidogyne incognita* race 1. The effect of seed soaking with carbosulfan 25 STD and triazophos 40 EC on plant growth of sunflower in *M. incognita* race-1 infected soil was studied in 20 cm dia earthen pots. Observations on plant growth parameters were recorded 60 days after inoculation. In general, all concentrations (50, 100, 200 and 400 ug/ml) of both the nematicides decreased root-knot incidence and increased the plant growth. The maximum plant growth and minimum nematode galling was recorded at 400 ug/ml of both the chemicals. Carbosulfan proved to be more effective as seed soak than triazophos. Even lower concentrations of either nematicide were sufficient to cause significant improvement in growth of sunflower.

Vadhera *et al.* (1999) studied management of *Meloidogyne incognita* on okra by chemical seed dressing and seed soaking. A trial on seed dressing of okra was carried out in a field naturally infested with *M. incognita,* in Jabalpur, Madhya Pradesh, India. Seed dressing with carbosulfan, benfuracarb (as Oncol) and triazophos reduced the gall index and increased the yield of okra. Maximum yield was obtained with carbosulfan at 3%. Seed soaking in carbosulfan, triazophos, monocrotophos and zolone [phosalone] reduced the number of galls and egg-masses. Carbosulfan also reduced the invasion of larvae.

Basile *et al.* (2000) evaluated use of phenamiphos to control *Meloidogyne incognita* on cucumber: nematicidal activity and toxic residues accumulation in cucumber fruits. A chemical control trial, conducted in Castellaneta, Italy, against *M. incognita* infesting cucumber , confirmed the efficiency of fenamiphos even at 200 kg/ha application of the commercial product (5% a.i.). The concentration of toxic residues in cucumber fruits differed with varying application rates used, and ranged from 0.001 to 0.15 mg/kg fresh weight when applied at 500 kg/ha. The concentration of fenamiphos and toxic metabolites (sulfone and sulfoxide), when fenamiphos was applied at 200 and 300 kg/ha, were lower than the limit of 0.1 mg/kg established by the Italian Health Ministry for other agricultural products such as tomato, beans, aubergine, melon, onion, potato and sugar beet.

Baird *et al.* (2000) studied management of *Meloidogyne incognita* in cotton with nematicides. Four field trials were conducted in Georgia, USA over two years to compare rates of 1, 3-dichloroproprene (1, 3-D), aldicarb and their combinations on the growth of cotton in producer fields infested with *Meloidogyne incognita*. 1, 3-D was injected 30-cm-deep with a single in-row chisel two weeks prior to planting. Three rates of aldicarb were applied in-furrow during the planting operation. In three of the test, an additional side dressing application of aldicarb was placed into the soil at 2.5-cm-deep and 15 cm on either side of the cotton plants at 24 to 28 days after planting. Cotton lint yields varied by location and year but were improved with 1, 3-D (32 kg a.i./ha) + aldicarb (0.59 kg a.i. /ha), aldicarb (1.17 kg a.i./ha) and aldicarb (0.87 kg a.i./ha) + aldicarb side dress (1.17 kg a.i./ha). The 1,3-D (32 kg a.i./ha) + aldicarb (0.59 kg a.i./ha) treatment provided the most consistent and greatest yield improvement over controls, while relative cotton yield in specific aldicarb treatments varied among test. Plant stands, plant height, and root-knot nematode numbers generally did not differ among treatments. Based on data from these tests, 1, 3-D and aldicarb, alone or in combination: can be recommended for management of *M. incognita* in Georgia cotton production systems.

John *et al.* (2000) studied bare-root dip of brinjal seedlings in phytochemicals for the management of root knot nematode *(Meloidogyne incognita*). Aqueous neem leaf extract, neem oil and marotti oil (from

Hydnocarpus laurifolia) [H.*pentandrus*] at different concentrations ere tested as bare-root dip treatments for their efficacy in controlling root-knot nematode (*M. incognita)* infestation in aubergine. Roots of plants dipped in neem leaf extract for 1 h showed significantly better height and number of leaves compared to plants treated with neem and marotti oil. Among the different concentrations of neem leaf extract tested, 6.25 and 25% extracts proved more effective. Significant reduction in gall index was also seen in neem leaf extract treated plants. Higher concentrations of the extract (50 and 25%) significantly reduced the number of egg masses produced. But none of the phytochemicals had any adverse effect on the hatching of the egg masses. All three phytochemicals, irrespective of the doeses, reduced population of the nematode in the soil. An overall assessment of the result established the superiority of neem leaf extract (25%) among the different phytochemicals in checking nematode infestation.

Kumar (2000) reported the effect of *M. incognita* on the growth of *polyanthes tuberosa*. Freshly hatched second stage juvenile (J_2) of *M. incognita* at 0.01, 1.00 and 10.00 juveniles/g soil were inoculated to the soil 15 days after sowing the *Polyanthes tuberosa bulbs.* Plant growth was significantly reduced when *M. incognita* was inoculated at 1 or 10- J_2/g soil. The flower yield was significantly reduced with 10 J_2/g soil.

Lamberti *et al.* (2000) studied chemical control of root-knot nematodes. Trials of chemical nematode control were carried out in 1998 against *Meloidogyne incognita* on cantaloupe and tobacco in southern Italy. Pre-plant soil fumigation with metham potassium, metham sodium [metam] or 1, 3 dichloropropene (1, 3-D 97) were the most effective treatments. Pre-plant application of granular or microencapsulated liquid fenamiphos gave very good results on cantaloupe.

However, all treatments significantly increased yields and decreased root gall indices to different extents. Significant increases in yields of tobacco were obtained only by soil fumigation with 1, 3-D 97 or with pre-plant application of aldicarb ; the root gall index on this crop was reduced only slightly to moderately by the different treatments. Post-plant treatments were effective on neither crop.

Prasad and Narayana (2000) reported effect of carbosulfan and triazophos the penetration and development of *Meloidogyne incognita* on sunflower. Effect of soil drench with carbosulfan 25 STD and triazophos on penetration and development of *Meloidogyne incognita* race 1 on sunflower (cv. EC 68414) was studied in pots. Development of root knot nematodes at lower concentration (50 μg/ml) of nematicides was found to be quicker than at higher concentrations (400 μg/ml). On the 7^{th} day of observation both the chemicals were found to be quite effective in reducing the total penetration and subsequent development. This, in turn also affected the fecundity of the nematodes.

Vadhera *et al.* (2000) reported field evaluation chemical management of root knot nematode in tomato. Nursery treatment and seedling root dip were evaluated for their efficacy for the management of root knot nematode (*Meloidogyne incognita*) on tomato (cv. Pusa Ruby) under field conditions at the Department of Horticulture Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, Madhya Pradesh, India. Carbofuran @ 0.6 g a.i ./m^2 in a nursery bed treatment improved seed germination and seedling vigour, significantly reduced the gall index from 5.0 to 3.6, and increased the yield of tomatoes by 36.9%. Seedling root dip for 6 h in carbosulfan (25 ST) and triazophos (40 EC) @0.1% increased the yield by 43 and 42% respectively, and reduced the tall index to 3.5 and 3.8, respectively compared with 5.0 for the control.

Vats *et al.* (2000) assessed management of root-knot nematode (*Meloidogyne incognita)* in cotton through seed dressing with chemicals. An experiment was conducted to evaluate the efficacy of seed dressing against *M. incognita.* Seeds of cotton (*Gossypium hirsutum* cv. H-777) were dressed with carbosulfan (Posse 25 ST) or benfuracarb (Oncol 40 ST), at 3 or 6% a.i. (w/w) and sown in pots which were later inoculated with 1 J2 M. indica/g soil. Two control treatments were also maintained: untreated seeds inoculated with *M. incognita* (control I) and untreated and uninoculated seeds (control II). Fresh shoot weights were significantly higher in the 3% carbosulfan and benfuracarb treatments, compared to control I (18.7 g), but the greatest fresh shoot weight was recorded in control II (258.8g). The lowest values for number of galls per plant, egg masses per root, and eggs per egg mass were obtained at higher concentrations of benfuracarb and carbosulfan. Carbosulfan at 6% produced lower values than benfuracarb. The lowest soil population of *M. incognita* (86.0 juveniles/100 ml soil) was obtained with 6% carbusulfan.

Ahmad *et al.* (2001) studied seed treatment effect of soybean on the penetration and soil population of root knot nematode. *Meloidogyne incognita.* The efficacy of carbofuran (1 and 2%) and monocrotophos (0.5 and 1%) as seed dressing in controlling *Meloidogyne incognita* infesting soyabean cv. "Bragg" was determined. All treatments resulted in lower number of galls per plant and nematode population in the soil and roots compared to the control, with seed soaking in 25 carbofuran resulting in the lowest number of galls per plant (13.99), and nematode population in soil (162.03) and roots (2662.56).

Ahmad *et al.* (2001) assessed the pre-sowing nematicidal treatment for the management of root-knot nematode, *M. incognita* on soybean crop.

Ahmad *et al.* (2001) evaluated effect of seed treatment of soybean with the nematicides on the penetration and soil population of root knot nematode, *Meloidogyne incognita*. Soyabean (*Glycine max* cv. Bragg) seeds were treated with carbofuran flowable at 1 and 2%, and monocrotophos at 0.5 and 15 before sowing in soil-sand mixture in paper cups. *Meloidogyne incognita* juveniles were inoculated after 1 week of culture. Results revealed that seed treatment with carbofuran at 2% was the most effective treatment for reducing gall formation on the roots and nematode population.

Ahmad *et al.* (2001) examined seed treatment effect of soybean on the penetration and soil population of root knot nematode, *Meloidogyne incognita*. The efficacy of carbofuran (1 and 2%) and monocrotophos (0.5 and 1%) as seed dressing in controlling *Meloidogyne incognita* infesting soyabean cv. Bragg was determined. All treatments resulted in lower number of galls per plant and nematode population in the soil and roots compared to the control, with seed soaking in 2% carbofuran resulting in the lowest number of galls per plant (13.99), and nematode population in soil (162.03) and roots (2662.56).

Ahmad *et al.* (2001) evaluated carbofuran as seed and soil treatment against root-knot nematode *M. incognita* on soybean. Experiments were conducted in Jhansi, Uttar Pradesh, India [date not given] to evaluate the efficacy of carbofuran, as seed and soil treatments, against the root-knot nematode *Meloidogyne incognita*. The local soyabean cultivar Bragga was treated with carbofuran at 2 g a.i. /kg seed (as seed treatment) and 2 kg a.i./ha (as soil treatment). The experimental area was naturally infested with *M. incognita,* with populations ranging from 315 to 430 per 500 g of soil. Both treatments significantly reduced the number of galls and *M. incognita* larvae and significantly increased soyabean yield as compared to the untreated control.

Faruk *et al.* (2001) studied management of root-knot nematode (*Meloidogyne*) of tomato with two organic amendments and a nematicide. Two separate experiments were conducted in Bangladesh to evaluate the efficacy of pre-plant soil treatment with poultry refuse, neem leaf powder, and Furadan 5G [carbofuran] for the management of root-knot nematodes (*Meloidogyne* spp.) of tomato. Under net house conditions, soil inoculated with root-knot nematodes were treated with poultry refuse at 200 g and neem (Azadirachta indica) leaf powder, at 10 g and Furadan 5G at 2 g per pot containing 5 kg soil. In a field experiment in 1998-99, pit soils were treated with Furadan 5G at 2 g/pit, poultry manure at 10 t/ha, and neem leaf powder at 0.5 t/ha. In both experiments, poultry manure, neem leaf powder and its combination with Furadan 5g gave considerable reduction of root-knot disease. The treatments also improved plant growth (weight and length of shoot and weight of root) and, in the field, significantly increased the yield of tomato. Among the treatments, poultry refuse alone and mixed with Furadan 5G reduced root-knot disease and improved the growth and fruit yield of tomato.

Kumar and Lingaraju (2001) reported the pathogenicity of the nematode to the tuberose crop. Single plants are inoculated with 10, 100, 1000 or 5000 freshly hatched *M. arenaria* shows that the decrease in shoot or root length with increase in inoculum density.

Khan *et al.* (2001) reported the effect of organic amendments and carbofuran on *Meloidogyne incognita* population and yield in tomato. The effect of available organic amendments, along with carbofuran, on root-knot nematode infesting tomato cv. Pusa Ruby was investigated in a field experiment conducted during 1997 and 1998, in Solan, Himachal Pradesh, India. The treatments comprised carbofuran 3 G at 2 kg a.i. /ha, neem cake at 25 q/ha, mustard cake at

25 l/ha, cotton seed cake at 25 g/ha and untreated control. All the treatments improved plant growth and yield in comparison to the untreated control. Nematode population also declined in the different treatments. Although the soil amendments were significantly effective over untreated control still these did not match well with carbofuran treatment. Amongst the organic amendments, neem cake was the best. The trends were similar in both years.

Meher (2001) examined nematicidal efficacy of cadusafos and carbosulfan against *Meloidogyne incognita* on tomato. Field experiments were conducted in New Delhi, India, in November of 1999 and 1999 to evaluate the efficacy of cadusafos at 0.5 and 1 kg a.i./ha and carbosulfan at 1 and 2 kg a.i./ha in controlling *M. incognita* on tomato cultivars Pusa Ruby and Azad-T2. Both chemicals controlled the final population of the nematode. The reduction in population level was higher in cadusafos (0.5 kg a.i. /ha) compared carbosulfan.

Sharma *et al.* (2001) studied management of *Meloidogyne incognita* on groundnut through nematicides. Experiments with groundnut were conducted to control root-knot nematode, *Meloidogyne incognita*. Carbofuran, phorate and sebufos [cadusafos] at 2.0kg/ha were applied to the infested soil in pots. Three seeds of groundnut were sown in each pot, and after 5 days of germination, plants were thinned to one plant per pot. After 40 days, plants were uprooted from each pot and root length and fresh weight of shoot and roots were recorded. In another experiment, seeds of groundnut were soaked in carbofuran 25 EC at 1% and benfurocarb 50 SP at 2% for 12 h and then sown in infested pots. Seeds soaked in tap water served as the control. Similar observations were recorded after 40 days of inoculation in the case of soil application treatment. Results indicated that all treatments were significantly superior to the untreated control with respect to plant growth. Carbofuran treatment was the best, followed by sebufos and phorate. A similar trend was recorded with regard to nematode reproduction.

Shafiq and Khan (2001) reported seedlings bare root-dip treatment with chemicals for the management of root-knot nematode (*Meloidogyne incognita*) on brinjal. A study was conducted to determine the most efficient treatment for *M. incognita* on aubergine cv. Pusa Purple Long. Treatments comprised: 1000 or 2000 µg/ml of benfuracarb, carbofuran, endosulfan, Malathion, methyl parathion [parathion-methyl] or phorate. Malathion at 2000 µg/ml exhibited the greatest protection to aubergine against root-knot nematode followed by phorate, carbofuran, endosulfan, methyl parathion and benfuracarb. The highest improvement in plant growth and suppression of nematode multiplication and root galling were recorded in plants treated with phorate at 1000 µg/ml concentration followed by carbofuran, malathion, endosulfan, methyl parathion and benfuracarb.

Chawla *et al.* (2002) studied different combinations of neem cake and carbofuran against *Meloidogyne incognita* on *Vigna radiata.* The combined application of neem cake and carbofuran in various proportions was studied for their effect on *Meloidogyne incognita* on mung bean cv. Pusa Baisaki. For comparison, the sole application of neem cake and carbofuran was conducted at 1% w/w and 2 kg a.i. /ha, respectively. The increase in the rate of carbofuran resulted in the decrease in the quantity of neem cake. The combined application of neem cake and carbofuran at half the rate of sole application resulted in plant growth equivalent to that obtained with neem cake alone and nematode control at par with the sole carbofuran treatment. Studies indicate that the combined use of neem cake and carbofuran for nematode management provides an effective alternative for harnessing the advantages of both while augmenting the limitation of the bulk quantity required for neem cake.

Rao and Naik (2003) reported the pochonia chlamydosporis (V. chlamydosporium, 20 or 40 g at 106 cfu/g) and t. harzianum alone or in combination were applied as neem based formulation show significant decrease of nematode and fungi (causing wilt disease) that increases the no. of florets/spike and spike/plot in tuberose. Higher application rates of biological control agents appeared simultaneously were more effective than the lower rates in reducing pest and disease incidence.

Danlei and Shengfu (2004) reported the root knot disease in Yuanjiang country, Yunnar, China. The infected plant showed symptoms of dwarfing, yellowing and withering. There were many galls on diseased roots. The severely infected plants had thin floral axis, few severely infected plants were dead. The nematode was identified as *Meloidogyne incognita* based on female morphological characteristics. The circumstance and control are also mentioned.

Rao and Reddy (2004) reported the efficacy of a formulation of the biocontrol fungus pochonia chlomydosporia zare *et al. for the management of Meloidogyne incognita*. Application of 100 g of the formulation per plot (m_{2*} m_2) reduced the population of nematode significantly and floral character in this crop.

The efficacy of carbofuran (1.0 and 2.0%) and monocrotophos (0.5 and 1.0%) against *Meloidogyne incognita* on soyabean was investigated in Jhansi, Uttar Pradesh, India [date not given]. Both nematicides were applied before sowing of soyabean cv. Bragga seeds. After one week of germination, 500 freshly hatched larvae the nematodes were inoculated around the growing seedlings. After 45 days of germination, data were recorded for germination, plant growth, bacterial nodulation and number of nematode galls. The results showed that both nematicides can be used at rates of 2 to 3 kg a.i./ha to obtain maximum nematode control with no adverse effect on the soyabean crop.

Ravishankar and Singh (2005) conducted experiment to evaluate the effect of carbosulfan (25 STD) and Neem Seed Kernel Powder (NSKP) as corm dressing on growth of gladiolus var shweta infested with root-knot hematode *M. incognita*. Carbosolfan (25 STD) at 3% (w/w) and neem seed Kernel powder at 10% (w/w) resulted in increased plan growth parameters and less galls of *M. incognita* compared to their corresponding lower concentrations.

Radwan *et al.* (2006) studied the effect of controlled release of Carbofuran formulations against root-knot nematode *M. incognita* in two soil types. The results revealed that all the applied formulations in both soils significantly reduced root galling as compared to the untreated check. Among starch-based formulations, starch area borate (SUB). In case of PVC based formulations, foamed plastic (FP) exerted the highest reduction followed by expanded plastic (EP) and non-expanded plastic (NEP). However the nematicidal efficiency of (FP) was significantly at par with either EP or NEP particularly in the case of clay loam soil. Addition of saw dust at 20% in the composition of PVC formulations, significantly increased the efficacy for controlling *M. incognita* especially in case of FP and NEP when applied in sandy clay loam, rather than clay laom soil. All the formulations at the selected conc. (10 mg ai/kg soil) had no phytotoxic effect on tomato plants. FP and FP+20% SD of carbofuran formulations have shown to be more effective than its convertional formulation (10 G) against *M. incognita* in clay loam soil on the other hand SUB and FP + 20% SD formulations were higher in their effectiveness than the traditional one in sandy clay loam soil.

Srivastava and Lal (2007) conducted one green house experiment which showed that cadusafos soil application (a 1 kg ai/ha when applied either at the time of sowing or in the split dose was most effective than carbofuran. In enhancing plant growth parameters at maize C.V. Daccan 103 and reducing final population at maize cyst nematode, *Heterodera zeae*. The results further indicated that spilt dose of either of the chemicals given 21 days after nematode inoculation was comparatively less effective compared to their single doses. The fecundity of the nematode (egg and J_2 per cyst) was reduced maximum when codusafos was applied @ 1 kg ai/ha at the time of sowing as compared to all other treatments of carbofuran.

Rajvanshi *et al.* (2008) conducted one experiment for the management of root-knot nematode in round melon by using varied applications (soil application seed sowing and foliar spray) of chemicals i.e. carbofiron 3G and carbosulfan. The combination of seed sowing + foliar spray @ 1000 ppm% with half recommended dose of carbofuran 3G (1.0 kg ai/ha) gave highest crop yield (84.44 g/ha) and reduced the no. of galls per plant (9.67) and final nematode population of soil (125.20), followed by carbofuran 3G @ 2 kg ai/ha (treated check) with yield 71.67 q/ha, number of galls /plant (12.80) and final nematode population of soil (135.50). All the treatments showed higher crop yield, reduced number of galls/plant and final nematode population of soil as compared to untreated control.

Jolly *et al.* (2008) studied the nematicidal activity of 1-phenylethy lidenemalononitrite Derivateves. Seven 1-phenyle thylidenemalononitrile derivates (la. VIIa) were screened for nematicidal potential against *Caenorbabditis aureus* and *Ditylenchus myceliophagus* by aqueous in vitro technique at various conc. Compound 11a inflicted absolute mortality against both the test nemotodes whereas, compound 1a, va induced absolute morality against. *S. aureus* and *D. myceliophagus* respectively at 200 ppm after 96 h. exposure. The compound 11 a has also been found to be quite effective against the test nematode of lower concentrations.

Dhavan and Singh (2009) evaluated the effect of antagonistic fungus, *Pochonia Chlamydosporia* a parasite of nematode eggs, neem cake and carbofuran alone and in combination, in micro plots infested with *M. incognita* on okra under net house condition plant growth parameters fruit yield, root galling, egg production and final nematode population densities were determined after 90 days of germination. Heavy galling in the nematode alone treatment was observed resulted in highest root wt. as compared to treated ones and healthy. All the treatments receiving any of the management component showed enhancement in plant growth and suppression of nem. Multiplication. The effect of *P. Chlamydosporia* (BCA) was recorded better than neem cake and at par with tested nematicide. The compined application of BCA with neem cake and/or carbofuran at reduced doses gave better recovery in comparision to either of the single application in terms of shoot length, shoot wt, root length, fruit yield and significantly (P< 0.05) suppressed *M. incognita* in terms of galling, egg production, soil population. The trio combination of *P. Chlamydosporia,* carbofuran, neem cake yielded significantly not only higher fresh fruit but also recovered shoot wt.

Chapter III

MATERIALS AND METHODS

MATERIALS AND METHOD

1) Preparation of Soils & Pots

Well pulverized sandy loam soil from Central Farm, OUAT was collected, roots and debrishes were separated and clods were broken. The soil was heaped on cemented floor to which farm yard manure was added in 3:1 proportion and mixed thoroughly. The soil mixture was added with adequate 1.5% formal dehyde solution followed by and again mixed thoroughly and covered with wet gunny bags. Three days after the treatment, gunny bags were removed and soil was spread in thin layer.

Thirty six numbers of 20 cm diameter earthen pots were choosen and surface sterilized by rinsing in hot water. About 1.5 kg. of sterilized soil mixture was filled in each pot up to the brim. The pots were arranged in 12 rows and 3 pots in each row and kept inside the net house of dept. of Nematology.

2) Collection of planting materials

Planting materials were collected from the tuberose nursery of Horticulture Department., OUAT, Bhubaneswar.

3) Treatment assignment and experimental Design

T_1 Padan 4G (1Kg a.i./ha) soil application
T_2 Furadan 3G(1Kg a.i./ha) soil application
T_3 Carbosulfan (0.2%)foliar spray
T_4 Hostathion (0.2%) foliar spray
T_5 Monocil (0.2%)foliar spray
T_6 Padan (1Kg a.i./ha) soil application + Carbosulfan (0.2%) foliar spray
T_7 Padan (1Kg a.i./ha) soil application + Hostathion (0.2%) foliar spray
T_8 Padan (1Kg a.i./ha) soil application + Monocil (0.2%) foliar spray
T_9 Furadan (1Kg a.i./ha) soil application + Carbosulfan (0.2%) foliar spray
T_{10} Furadan (1Kg a.i./ha) soil application + Hostathion (0.2%) foliar spray
T_{11} Furadan (1Kg a.i./ha) soil application + Monocil (0.2%) foliar spray
T_{12} Control : without any nematicide application

To above treatments were arranged in a completely randomized Design with three replications each.

In case of control no nematicide treatment was carried out.

4) Inoculation of nematode

Egg mass were collected from pure culture of brinjal plants grown in pots and placed in tissue paper ware gauge assembly fitted over a petridish and allowed to hatch in distilled water. Freshly hatched 2^{nd} stage juveniles were collected and counted for population estimation. One thousand and five hundred freshly hatched juveniles were inoculated to the soil in each pot of 20 days old tuberose plant by making three small radial holes made around the plants and placing nematode suspension and closed by pressing with finger tips. The pots were watered regularly and checked daily for any visible symptoms of the plant.

5) Soil treatment of Nematicides

For soil treatment of nematicides first surface area of pot is calculated. Diameter of pot is 20 cm.

So area πr^2 (where $\pi = \frac{22}{7}, r = Radius$)

So area $\frac{22}{7} \times \frac{20}{2} \times \frac{20}{2}$ cm^2

As our treatments are given in the doses per acre basis, we have to convert it to the doses per surface area of the pot. So different nematicides are weighed according to their concentration of treatments and available active ingredient. These nematicides were applied 40 days after inoculation of nematodes. These nematicides were applied in small holes in that soil of required pot and watered properly under constant supervision.

Recording of observation

Plants in different treatments were harvested 100 days after inoculation. Observation on different growth characters such as Shoot length, Root length Shoot weight (Dry),Root weight(Dry),&disease incidence parameters such as Root knot index, Root nematode population, soil nematode population were recorded.

Root and shoot were placed in an oven at a temperature of 80°C for 48 hour and dry weight was recorded. The height of the plant was recorded with the help of a meter scale, the weight was taken in a physical balance.

Root knot index of each treatment was calculated by following the method according to AICRP on plant parasitic nematodes (ICAR Project)

Class I (HR)	→	No infection, No visible gall
Class II (R)	→	1-10 galls/egg masses per plant
Class III (MR)	→	11-30 galls/egg masses per plant
Class IV (S)	→	31-100 galls/egg masses per plant
Class V(HS)	→	>100 galls/egg masses per plant

HR : Highly Resistant, R : Resistant, MR : Moderately Resistant
S : Susceptible HS : Highly Susceptible

One gram sampled root from each treatment was taken, fixed and stained in lactophenol acid fuchsin (0.01%) and cleared in plant lactophenol. Population estimation of different stages of nematode including number of egg masses in root was carried out by pressing the stained roots between two glass slides with small amount of lactophenol and observing under a binocular stereoscopic microscope. Further final soil populations in the pots were estimated by cobb's sieving and decantation technique and the number of nematodes in replicated aliquot were counted.

Statistical Analysis and Formula

C.F (correction factor) = $\dfrac{(Grand\ sum\ total)^2}{Total\ no.\ of\ observations}$

T.S.S (Total sum of square) = Sum of square of individual observations-C.F.

Tr.S.S (Treatment sum of square)

$$= \frac{(Sum\ of\ square\ of\ replication\ over\ treatment)}{number\ of\ treatments} - C.F$$

Er. S. S (Error sum of square) = T.S.S –Tr. S. S

Error mean sum of square (EMS) & treatment mean Sum of square (Tr.S.S) were calculated by dividing with Error degree of freedom & treatment degree of freedom respectively

Calculated f = $\dfrac{TrMS}{EMS}$

The calculated 'F' value was greater than the table 'F', it was found significant.

CD(critical difference)$_{(0.05)}$=t.SE(d)

Where SE(d) = $\sqrt{\dfrac{2EMS}{r}}$

The difference between the two treatment mean was greater than the CD value, indicates the significant difference between the treatments.

In this way, comparison between the treatments were made.

Chapter IV

RESULT AND DISCUSSION

RESULT AND DISCUSSION

A replicated pot culture experiment was conducted to study the effect of different nematicides, that are applied both by soil application and foliar spray method on host crop tuberose (*polyanthes tuberosa.* L) to control the noxious root knot nematode (*M. incognita*).

The results of the investigation have been presented on the basis of (a) different growth parameters like shoot length, root length, shoot dry weight, root dry weight and (b) Root knot infestation such as root nematode population, soil nematode population and root knot index in Table No-1 and 2 respectively & statistically analysed in figure I to VII.

Shoot length :-

As shoot length is one of the most important growth parameter, the relative efficacy of different treatments in enhancing the shoot length was studied in Table-1 and illustrated is fig. I. Percentage increase of shoot length in each treatment was calculated over untreated control & mentioned in Table 1.

On the basis of the tabulated data it was observed that there was increase in shoot length in all the treatments as compared to the untreated control.

Among the different soil application nematicides maximum plant growth was observed (111.33 cm) in the treatment furadan 3G (1 Kg a.i/ha) with an increase of 10.96% over untreated control followed by the treatment padan 4G (1 Kg a.i/ha) being (110 cm) with an increase of 9.63% over control. Out of the foliar spray of different nematicides such as carbosulfan (0.2%), Hostathion (0.2%) and monocil (0.2%), carbosulfan has been proved to be most effective treatment with highest shoot length (102 cm) followed by Hostathion being (101.66 cm),& monocil with (100.66 cm) with an increase of 1.66%, 1.32% & 0.32% respectively over control.

Among the different combined treatments of soil application as well as foliar spray application of nematicides furadan3G (1 Kg a.i/ha) with carbosulfan (0.2%) resulted in maximum shoot length i.e (114.33 cm) followed by padan4G (1 Kg ai/ha) with carbosulfan (0.2%) being next highest shoot length of (113.33 cm) and furadan(1kg a.i/ha) with Hostathion(0.2%)resulted in shoot length of(108.33cm) with an increase of 13.95%, 12.95% & 7.97% over control respectively.

Statistically analysed data revealed that growth response of host plant tuberose, with respect to shoot-length was significantly higher than the control in case of all treatments of soil application, foliar spray and combined treatments of both. Out of different soil application treatments Furadan gave the best result with maximum shoot length of 111.33 cm, similarly among the different foliar spray application, maximum shoot length was recorded in the treatment of carbosulfan (0.2%) i.e. 102 cm.

Out of the different combined treatments Furadan (1Kg a.i/ha) with carbosulfan (0.2%) resulted in the highest shoot length i.e. (114.33 cm) which was also statistically superior than all other treatments including control.

The results of the present investigation are in conformity with the above works of Rajvanshi *et.al* (2008). They studied the chemical control of root knot nematode associated with round melon and concluded that the combined application of Furadan 3G soil application and carbosulfan (0.2%) foliar spray, proved to be the most effective treatment against disease incidence of root knot nematode and showed enhanced plant growth. Which was also in conformity with the present investigated findings.

Root length :-

As root length was one of the most important growth parameter. Relative efficiency of different treatments on this growth character was also studied and represented in Table-1 & illustrated in Fig. II. Percentage increase of root length of each treatment was calculated over the untreated control and shown in table 1.

On the basis of the tabulated data, it was observed that there was increase in root length in all treatments as compared to control.

Among the different soil application treatments maximum root length was observed (22.66 cm) in treatment, treated with Furadan 3 G (1 kg a.i/ha) with an increase of 94.33% over control followed by the treatment padan 4G (1 kg a.i/ha) having root length (20.66 cm) with an increase of 77.18% over control.

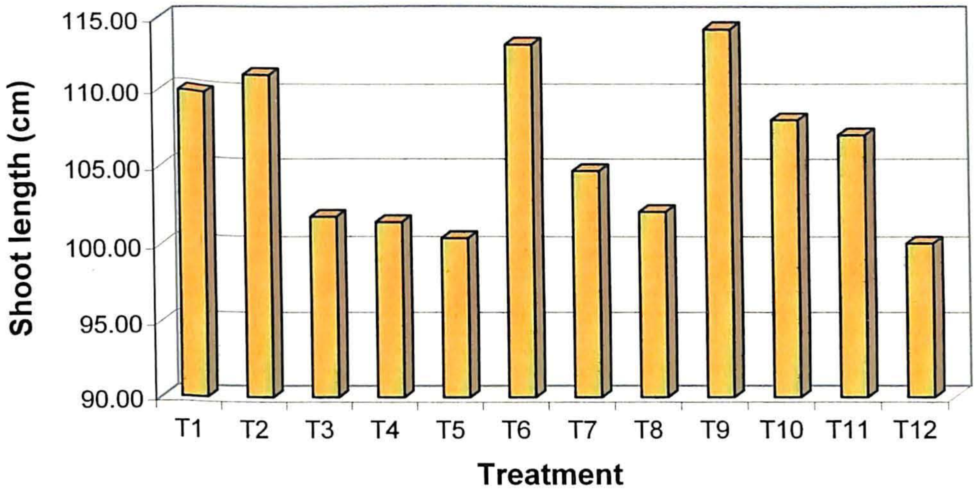
Out of the foliar spray of different nematicides such as carbosulfan (0.2%), Hostathion (0.2%), monocil (0.2%), carbosulfan gave the highest root length i.e. (13.33 cm) followed by Hostathion (0.2%) being (12.66 cm) and monocil (12 cm) with an increase of 14.32%, 8.57% and 2.91% respectively over control.

Among the different combined treatments of both soil application and foliar spray application of nematicides. Combined treatments of Furadan 3G (1 kg a.i/ha) with carbosulfan (0.2%) resulted in highest root length of (25.66 cm) with an increase of 120% over control followed by Padan 4G (1 kg a.i/ha) with carbosulfan (0.2%) being (24.33 cm) and Furadan (1 kg ai/ha) + Hostathion (0.2%) being (19 cm) with an increase of 108.66% and 62.90% respectively over control. Statistically analysed data showed that growth response of tuberose plant with respect to root length in all the treatments were significantly higher than the control.

Photograph showing effect of different treatments on tuberose plant
T1-Padan 4G , T2-Furadan 3G, T3-Carbosulfan, T4-Hostathion, T5-Monocil, T6-(Padan+Carbosulfan)

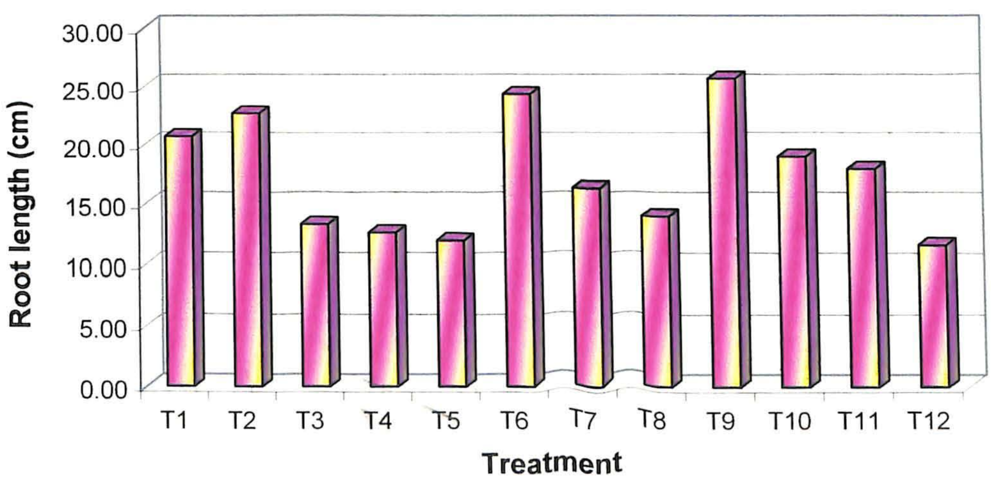
Photograph showing effect of different treatments on tuberose plant
T7-Padan+ Hostathion,T8-Padan+Monocil, T9-Furadan+Carbosulfan, T10-Furadan+Hostathion, T11-Furadan+Monocil, T12-Control

Fig.I Shoot length (cm)



T_1-Padan 4G , T_2-Furadan 3G, T_3-Carbosulfan, T_4-Hostathion, T_5-Monocil, T_6-(Padan+Carbosulfan) + T_7-Padan+ Hostathion,T_8-Padan+Monocil, T_9-Furadan+Carbosulfan, T_{10}-Furadan+Hostathion, T_{11}-Furadan+Monocil, T_{12}-Control

Fig. II Root length (cm)



T_1-Padan 4G , T_2-Furadan 3G, T_3-Carbosulfan, T_4-Hostathion, T_5-Monocil, T_6-(Padan+Carbosulfan) + T_7-Padan+ Hostathion,T_8-Padan+Monocil, T_9-Furadan+Carbosulfan, T_{10}-Furadan+Hostathion, T_{11}-Furadan+Monocil, T_{12}-Control

Out of different soil application treatments maximum root length was recorded in Furadan 3G (1 kg a.i/ha) being (22.66 cm) which was higher as compared to soil application treatment with padan 4G.

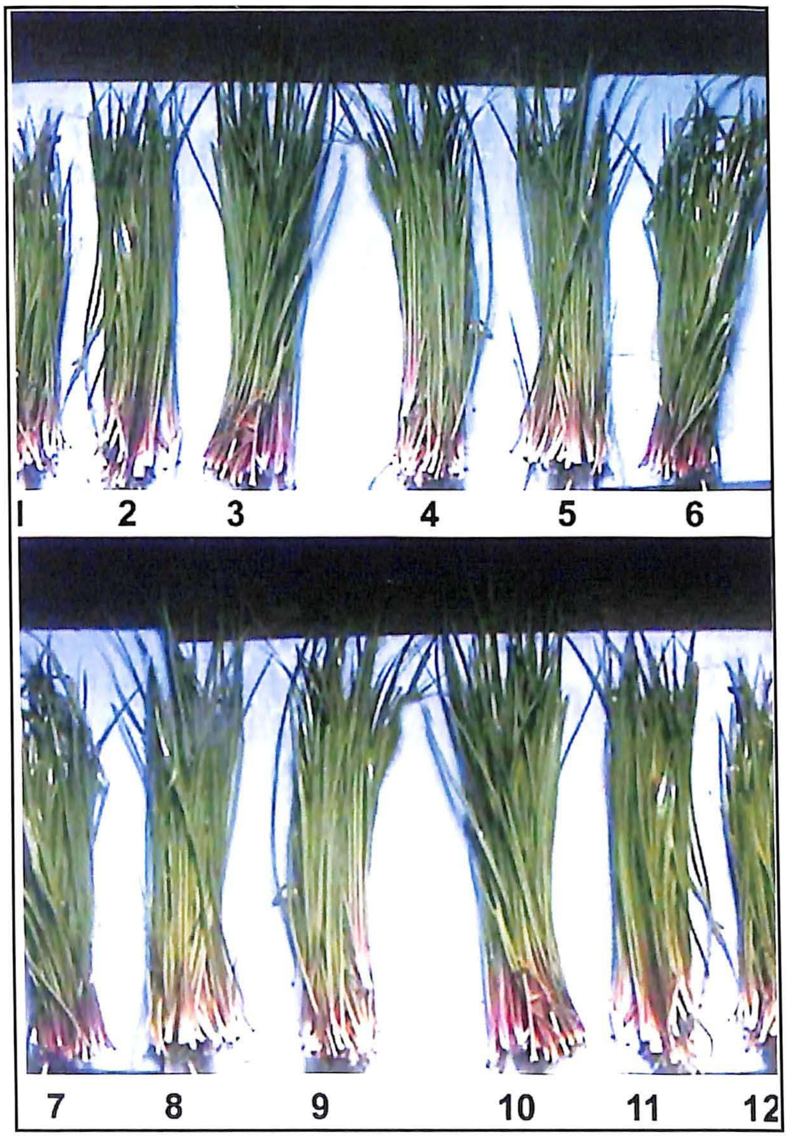
Similarly among foliar application treatments maximum root length was recorded in case of carbosulfan (0.2%) i.e (13.33 cm) which was also higher than other foliar spray treatments.

Among the different combined treatments Furadan (1 kg ai/ha) with carbosulfan (0.2%) resulted in the highest root length i.e.(25.66 cm) which was also significantly superior than all other treatments including untreated control.

The results of above investigations are in conformity with the works of Mian *et al.* (1991) who reported the efficacy of Furadan for control of root knot nematode in potato. Furadan 3G was evaluated in pot culture experiments for control of M. incognita in potato grown from true potato seeds (TPS) and seed tubers using nematode infested soil. The soil was treated with nematicides at 0, 1, 1.5, 2, 2.5 mg ai/kg soil just before planting. At the end of the growing period plants from (TPS) 60 days and from seed tubers (80 days) were used to collect data on growth parameters & gall developments. Furadan enhanced the plant growth and decreased the development of nematode & severity of root knot.

Shoot Dry Weight :-

Dry shoot weight was another important aspect of plant growth character. The relative efficacy of different treatments on the aspects was also studied and presented is Table-1 and illustrated in Fig.-III. The percentage of increase of shoot dry weight of each treatment was calculated over untreated control and mentioned in Table 1. it was observed on the basis of tabulated data that all the treatments were superior with respect to increase in shoot dry weight as compared to controlled check.



Photograph showing effect of different treatments on shoot length of tuberose plant
T1-Padan 4G , T2-Furadan 3G, T3-Carbosulfan, T4-Hostathion, T5-Monocil, T6-(Padan+Carbosulfan) + T7-Padan+ Hostathion,T8-Padan+Monocil, T9-Furadan+Carbosulfan, T10-Furadan+Hostathion, T11-Furadan+Monocil, T12-Control

Among the two different soil application treatments maximum dry shoot weight was observed incase of Furadan 3G (1 kg a.i/ha) i.e(31g) with an increase of 82.35% over control followed by the treatment Padan 4G (1 kg a.i./ha) being(29 g) with an increase of 70.58% over control.

Out of the three foliar spray of different nematicides carbosulfan (0.2%) gave the highest shoot dry weight of (21 g) with an increaseof 23.52% over control followed by Hostathion (0.2%) being(19.33 g) and monocil (0.2%) being (18.33 g) with an increase of 13.70% and 7.82% respectively over control.

Similarly out of combined treatments, Furadan(1 kg a.i/ha) with carbosulfan (0.2%) resulted the highest dry weight of (33.33 g)with an increase of 96.05% over control followed by padan 4G (1 kg a.i/ha) with carbosulfan (0.2%) being (32.33g) and Furadan with Hostathion (0.2%) being(27.66 g) with an increase of 90.17% and 62.70% respectively over control.

Statistically analysed data exhibited that growth response of tuberose plant with respect to dry shoot weight was significantly higher than the control in case of all the treatments. So far soil application treatment i.e furadan 3G(1kg a.i/ha) is concerned the results of above investigation was in conformity with the findings of Sharma *et al.*(2001) who studied the management of *M incognita* on groundnut, through nematicides. Experiments with groundnut were conducted to control root-knot nematode, *M. incognita*.

Furadan, phorate and sebufos at (2 kg a.i/ha) were applied to the infested soil in pots. Three seeds of groundnut were sown in each pot and after 5 days of germination, plants were thinned to one plant per pot. After 40 days, plants were uprooted from each pot and root length and fresh weight of shoot & roots were recorded.

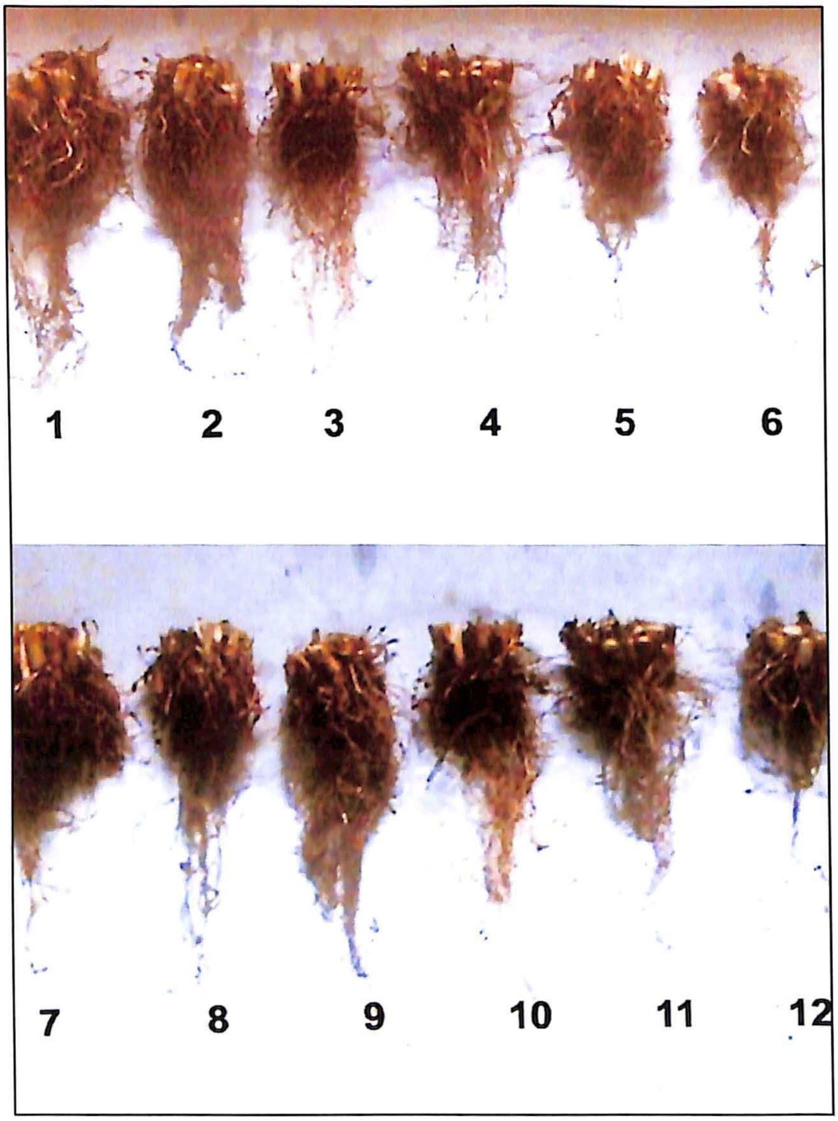
In another experiment, seeds of groundnut were soaked in carbofuran 25EC at 1% and benfurocarb 50 SP at 2% for 12 hr. and then sown in infested pots. Seed soaked in tap water served as control. Similar observations were recorded after 40 days of inoculation in the case of soil application treatments. The results indicated that all treatments were significantly superior to the untreated control with respect to plant growth. Furadan treatment was found to be the best followed by sebufose and phorate which corroborates the present investigation findings.

Root Dry weight:-

Root dry weight was another important component of plant growth parameter. The data relating to dry root weight have been recorded and presented in Table 1 and shown in fig. IV. Mean data on dry root weight recorded in table-1 indicated that it was greater in all the treatments over the control.

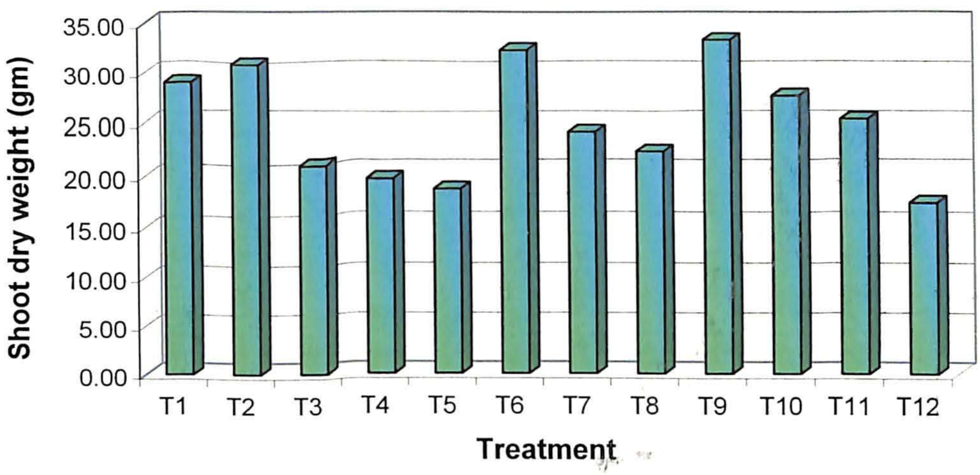
Among the different soil application nematicides, maximum root dry weight was observed i.e (2.19g) in case of Furadan 3G (1 kg a.i/ha) with an increase of 184.41% over control followed by the treatment Padan 4G (1 kg a.i/ha) being (1.89 g) with an increase of 145.45% over control. Out of the three foliar spray treatments of different nematicides carbosulfan (0.2%) gave the highest root dry weight of (1.02g) with an increase of 32.46% over control followed by Hostathion (0.2%) i.e (0.91g) and monocil (0.2%) (0.85g) with an increase of 18.18% & 10.38% respectively over control.

Similarly in case of the six combined treatments. Furadan (1 kg a.i/ha) with carbosulfan (0.2%) resulted the maximum root dry weight i.e. (2.30g) with an increase of 198.70% over control followed by Padan (1 kg a.i/ha) with carbosulfan (0.2%) with (2.28g) and Furadan (1 kg a.i/ha) + Hostathion (0.2%) being(1.78 g) with an increase of 196% and 131.16 % respectively over control.



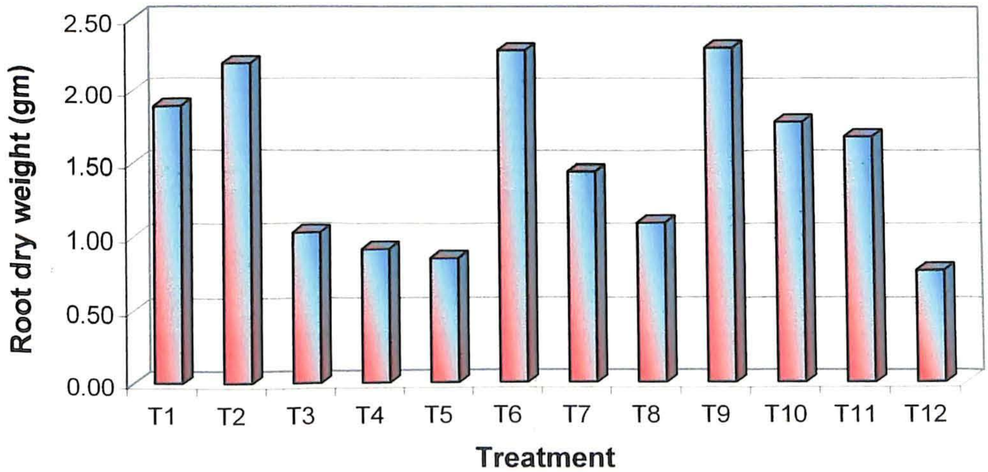
Photograph showing effect of different treatments on root length of tuberose plant
T1-Padan 4G , T2-Furadan 3G, T3-Carbosulfan, T4-Hostathion, T5-Monocil, T6-(Padan+Carbosulfan) + T7-Padan+ Hostathion,T8-Padan+Monocil, T9-Furadan+Carbosulfan, T10-Furadan+Hostathion, T11-Furadan+Monocil, T12-Control

Fig.III Shoot dry weight (gm)



T_1-Padan 4G , T_2-Furadan 3G, T_3-Carbosulfan, T_4-Hostathion, T_5-Monocil, T_6-(Padan+Carbosulfan) + T_7-Padan+ Hostathion,T_8-Padan+Monocil, T_9-Furadan+Carbosulfan, T_{10}-Furadan+Hostathion, T_{11}-Furadan+Monocil, T_{12}-Control

Fig.IV Root dry weight (gm)



T_1-Padan 4G , T_2-Furadan 3G, T_3-Carbosulfan, T_4-Hostathion, T_5-Monocil, T_6-(Padan+Carbosulfan) + T_7-Padan+ Hostathion,T_8-Padan+Monocil, T_9-Furadan+Carbosulfan, T_{10}-Furadan+Hostathion, T_{11}-Furadan+Monocil, T_{12}-Control

Statistically analysed data showed that greater dry root weight was observed in all treatments over control. Among the different combined treatments. Furadan 3G (1 kg a.i/ha) + carbosulfan (0.2%) resulted in maximum root dry weight i.e (2.30g) as compared to all other treatments including control.

However there was no. significant difference in root dry weight. in case of the combined treatments i.e Furadan with Hostathion and Furadan with monocil. So far soil application was concerned the above results of the present investigation are in conformity with findings of Javed & Ahmad (1999) who studied chemical control of root-knot nematode *M. incognita* on muskmelon, metasystox, carbosulfan, furadan were each applied at 1482 ml/ha, 1235 ml/ha and 24.7 kg/ha on muskmelon C.V. Ravi, out of which Furadan was the most effective nematicide, both in pre and post plant treatment in reducing *M. incognita* & increasing the plant vigour.

Soil nematode population:-

The final soil nematode population density of second stage Juveniles (J_2) in pots (1.5 kg soil) at the time of harvest was presented in Table-2 and illustrated in fig V. Soil Nematode population was found to be maximum in case of untreated control i.e. (3014/pot) against the minimum (315.66/pot) incase of the combined treatment of Furadan 3G (1 kg a.i/ha) with carbosulfan (0.2%) with 89.52% decrease over control. Out of the two soil application treatments of nematicides in tuberose minimum soil nematode population i.e (512 /pot) was found incase of furadan3G,as compared to Padan 4G,having nematode population of(706.33/pot) with decrease of 83.01% and 76.56% over the control respectively.

Among the three foliar spray nematicides, carbosulfan (0.2%) resulted in the minimum no of nematode population i.e(2056.33/pot) with decrease of

31.77% over control, followed by Hostathion (0.2%) being (2324.33/pot) and monocil (0.2%) being(2503.66/pot) with decrease of 22.88% and 16.93% respectively over control.

Among the different combined treatments, Furadan (1kg a.i/ha) with carbosulfan (0.2%) resulted in minimum population of (315.66/pot) followed by (422.66/pot) as in case of combined treatment of Padan 4G (1 kg a.i/ha) with carbosulfan (0.2%), and Furadan 3G (1kg a.i/ha) with Hostathion (0.2%) being 791.33/pot having population decrease of 89.52%, 85.97% and 73.74% respectively over control. Statistical analysis of the observation with regards to soil nematode population showed that there was significant decline of nematode population in all treatments as compared to control.

The finding of Deka, phukan (1997) in which they have studied the efficacy of certain chemicals like root dipping chemicals in tomato such as furadan quinalphos & Hostathion at different concentrations found that all these nematicides were effective in reducing gall, egg mass and nematode population in soil and carbosulfan at 0.1% was found to be most effective along with other nematicides ,our results were also quite agreeable with the above findings.

Novaretti *et al* (1998) evaluated chemical control of M. incognita on sugarcane through furadan. The results showed that soil application of Furadan resulted in reduction of nematode population level and consequent increase of cane production. Our results of furadan treatment in reducing the soil nematode population is quite matchable with above findings.

Table – 1
Effect of Nematicides on plant growth parameter on Tuberose infected by *M. incognita*

Treatment	Concentration	Shoot length(cm)	% increase over control	Root length (cm)	% increase over control	Shoot dry weight (g)	%increase over control	Root dry wt. (g)	%increase over control
T_1 Padan 4G	1 kg a.i./ha	110	9.63	20.66	77.18	29	70.58	1.89	145.45
T_2 Furadan 3G	1 kg a.i./ha	111.33	10.96	22.66	94.33	31	82.35	2.19	184.41
T_3 Carbosulfan	0.2%	102	1.66	13.33	14.32	21	23.52	1.02	32.46
T_4 Hostathion	0.2%	101.66	1.32	12.66	8.57	19.33	13.70	0.91	18.18
T_5 Monocil	0.2%	100.66	0.32	12	2.91	18.33	7.82	0.85	10.38
T_6 Padan + Carbosulfan	1 kg a.i./ha + 0.2%	113.33	12.95	24.33	108.66	32.33	90.17	2.28	196
T_7 Padan + Hostathion	1 kg a.i./ha + 0.2%	105	4.65	16.33	40.05	24	41.17	1.44	87
T_8 Padan + Monocil	1 kg a.i./ha + 0.2%	102.33	1.99	14	20.06	22	29.41	1.09	41.55
T_9 Furadan + Carbosulfan	1 kg a.i./ha + 0.2%	114.33	13.95	25.66	120	33.33	96.05	2.30	198.70
T_{10} Furadan + Hostathion	1 kg a.i./ha + 0.2%	108.33	7.97	19	62.9	27.66	62.70	1.78	131.16
T_{11} Furadan + Monocil	1 kg a.i./ha + 0.2%	107.33	6.97	18	54.37	25.33	49	1.68	118.18
T_{12} Control		100.33		11.66		17		0.77	
SE (ed)		0.38		0.45		0.27		0.02	
CD (0.05)		1.20		1.29		0.78		0.06	

Table – 2

***Effect of Nematicides* on disease incidence of *M. incognita* on Tuberose**

Treatment	Concentration	Root nematode population/g root weight	%Decrease over control	Soil nematodes population/pot	% Decrease over control	Root knot Index	% Decrease over control
T_1 Padan 4G	1 kg a.i./ha	23(1.36)	76.76	706.33(2.84)	76.56	1.66	58.50%
T_2 Furadan 3G	1 kg a.i./ha	20.66(1.31)	79.13	512(2.70)	83.01	1.33	66.75%
T_3 Carbosulfan	0.2%	53.66(1.72)	45.79	2056.33(3.31)	31.77	3	25%
T_4 Hostathion	0.2%	63.66(1.80)	35.69	2324.33(3.36)	22.88	3.33	16.75%
T_5 Monocil	0.2%	82(1.91)	17.17	2503.66(3.39)	16.93	3.66	8.50%
T_6 Padan + Carbosulfan	1 kg a.i./ha + 0.2%	20(1.30)	79.79	422.66(2.62)	85.97	1.33	66.75%
T_7 Padan + Hostathion	1 kg a.i./ha + 0.2%	40(1.60)	59.59	1003.33(3.00)	66.71	2.33	41.75%
T_8 Padan + Monocil	1 kg a.i./ha + 0.2%	50.33(1.70)	49.16	1511.33(3.17)	49.85	2.66	33.50%
T_9 Furadan + Carbosulfan	1 kg a.i./ha + 0.2%	16(1.20)	83.83	315.66(2.49)	89.52	1	75%
T_{10} Furadan + Hostathion	1 kg a.i./ha + 0.2%	29.66(1.47)	70.04	791.33(2.89)	73.74	2	50%
T_{11} Furadan + Monocil	1 kg a.i./ha + 0.2%	31.66(1.50)	68.02	928.33(2.96)	69.20	2.33	41.75%
T_{12} Control		99(1.99)		3014(3.47)		4	
SE (ed)		0.37		1.27		0.15	
CD (0.05)		1.06		3.65		0.45	

( ) Figures in parenthesis indicates Logarithmic values

Root Nematode Population :-

The final root population per gram root weight was mentioned in Table-2 and illustrated in fig. VI, indicated that incidence of root nematode population was less in all the treatments as compared to control. It was observed on the basis of tabulated data that there was decrease of root nematode population in all the treatments as compared to control.

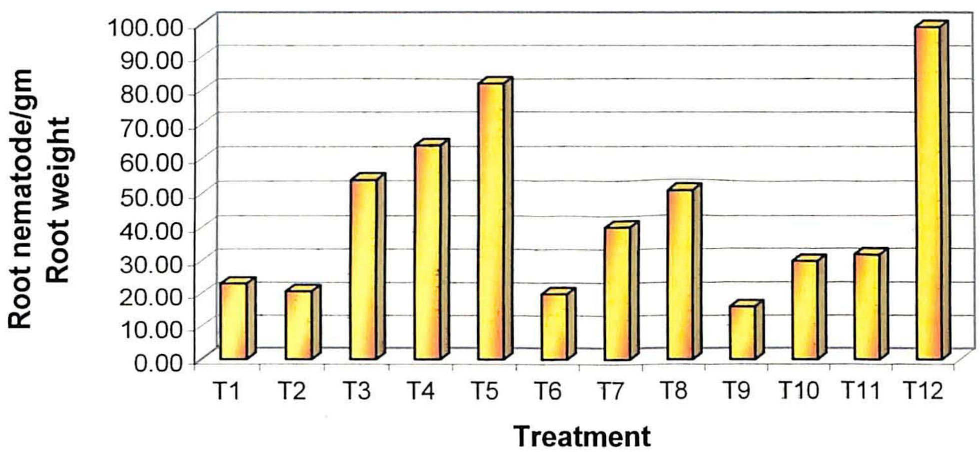
Among the different soil application nematicides minimum root population of nematode was found in case of Furadan 3G (1kg a.i/ha) i.e. (20.66/g root) with decrease of 79.13% over control followed by Padan 4G (1 kg a.i/ha) i.e. (23/g root) with decrease of 76.76% over control.

Out of the three foliar spray nematicides carbosulfan (0.2%) resulted in minimum no of population i.e.(53.66/ g) root with decrease of 45.79% over control followed by Hostathion (0.2%) being(63.66/g) root and monocil (0.2%) i.e. (82/g root)with decrease of 35.69 % and 17.17% respectively over control.

Similarly among the different combined treatments, Furadan (1 kg a.i/ha) with carbosulfan (0.2%) resulted in the minimum root population i.e. (16/g root) followed by Padan 4G (1 kg a.i/ha) with carbosulfan (0.2%) being (20/ g root), and Furadan (1 kg a.i/ha) with Hostathion (0.2%) being (29.66/g root) against percentage decrease of 83.83%, 79.79% and 70.04% respectively.

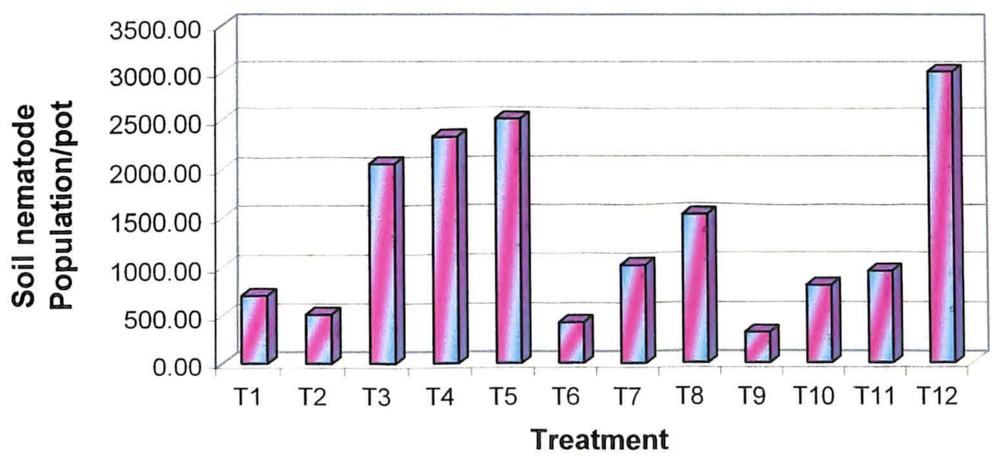
Statistical analysis of the observed data with regards to root nematode population exhibited that there was significant decrease in root nematode population in case of all the treatments as compared to control.

Fig. V Root nematode population/gm root weight

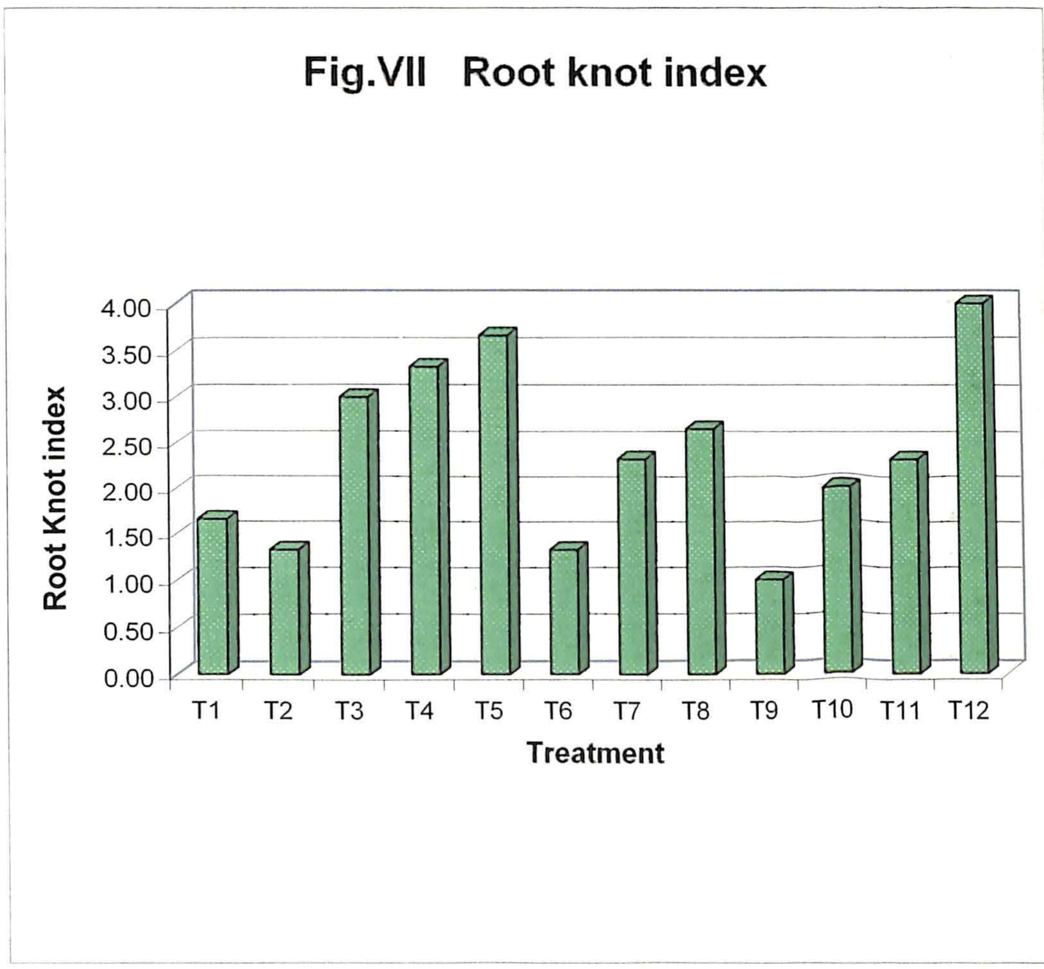


T_1-Padan 4G , T_2-Furadan 3G, T_3-Carbosulfan, T_4-Hostathion, T_5-Monocil, T_6-(Padan+Carbosulfan) + T_7-Padan+ Hostathion,T_8-Padan+Monocil, T_9-Furadan+Carbosulfan, T_{10}-Furadan+Hostathion, T_{11}-Furadan+Monocil, T_{12}-Control

Fig.VI Soil nematode population/pot



T_1-Padan 4G , T_2-Furadan 3G, T_3-Carbosulfan, T_4-Hostathion, T_5-Monocil, T_6-(Padan+Carbosulfan) + T_7-Padan+ Hostathion,T_8-Padan+Monocil, T_9-Furadan+Carbosulfan, T_{10}-Furadan+Hostathion, T_{11}-Furadan+Monocil, T_{12}-Control



T_1-Padan 4G , T_2-Furadan 3G, T_3-Carbosulfan, T_4-Hostathion, T_5-Monocil, T_6-(Padan+Carbosulfan) + T_7-Padan+ Hostathion,T_8-Padan+Monocil, T_9-Furadan+Carbosulfan, T_{10}-Furadan+Hostathion, T_{11}-Furadan+Monocil, T_{12}-Control

Maximum reduction in root nematode population was found in case of combined treatment of Furadan (1 kg a.i/ha) with carbosulfan (0.2%) being (16 /groot) with 83.83% decrease over control. Out of foliar spray treatments carbosulfan is found to be the best over Hostathion and monocil.

The results of our findings were in conformity with pareek et al. (1998) they evaluated the management of Root knot nematode M. incognita on gram (*cicer arieatinum* L.) by different nematicides. Monocil 35 EC followed by carbosulfan 25EC and Hostathion 40 EC (each at 0.05, 0.1%) were effective in controlling *M. incognita* through seed soaking of chickpea in pot experiments. Similarly, soil application Furadan @ 2 kg ai/ha was better in improving plant growth characters and reducing nematode populations in comparison to sebufos, phorate.

Root Knot Index:-

Infectivity of root knot nematode (*M. incognita*) in different treatments (Table-2) on tuberose plants revealed a declined trend in root knot index over control. Root knot index was found to be maximum is the treatment of untreated control check. Out of the different soil application treatments, root knot index was found to be minimum in case of Furadan 3G (1 kg a.i/ha) i.e (1.33) with decrease of 66.75% over control, followed by Padan 4G (1 kg a.i/ha) being (1.66) with 58.50% decrease over the control.

Similarly in case of foliar spray treatments, carbosulfan (0.2%) was proved to be most effective having the minimum root knot index value of(3) followed by Hostathion (0.2%) with index value of (3.33) & monocil (3.66), with decrease of 25%, 16.75% and 8.5% respectively over the control .Out of the 3 combined treatments Furadan (3G) (1 kg a.i/ha) with carbosulfan (0.2%) was proved to be statistically superior treatment with regards to root knot index with index value of (1), followed by Padan 4 G (1 kg a.i/ha) with carbosulfan (0.2%) with index value of (1.33) followed by Furadan 3G (1 kg a.i/ha) with Hostathion (0.2%) being(2) with decrease of 75%, 66.75% and 50% respectively over control, out of all the treatments combined treatment of Furadan with carbosulfan was proved to be the best treatment.

The above results were in conformity with the findings of Ahuja (1990) on Okra, Bhagwati, Phukan (1990) on pea, Borah & Phukan (1990) on green gram Chand, Jain (1990) on cotton, main *et al.* (1991) on potato Zhid (1992) on Brinjal, Kalita, Phukan (1990) on blackgram, siddique *et al.* (1993) on bitter gourd, Reddy *et al.* (1997) on brinjal respectively. Also the works of Ahmad *et al.* (2001), corroborates our findings who evaluated the use of Furadan as seed and soil treatment against root-knot nematode. *M. incognita* on Soyabean. Experiments were conducted in Jhansi UP of India to evaluate the efficacy of Furadan, as seed and soil treatments against the root-knot nematode *M. incognita*. The local soyabean Cultivar "Bragga" was treated with Furadan at 2 g a.i/kg seed (as seed treatment) and 2 kg a.i/ha as soil treatment. The experimental area was naturally infested with M. incognita, with populations ranging from 315 to 340 per 500g of soil. Both treatments significantly reduced the number of galls and *M. incognita* larvae and significantly increase soyabean yield compared to untreated control.

Chapter V

SUMMARY AND CONCLUSION

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The present investigation was undertaken to study the control of root knot nematode *M. incognita* by use of nematicides in Tuberose (*Polyanthes tuberosa* L.).

A replicated pot culture experiment was laid out in Completely Randomized Design (C.R.D), with 12 treatments and 3 replications each. The different nematicides were applied as soil application, foliar spray and as combination of both soil application and foliar spray application. Nematicides like Furadan 3G (1 kg ai/ha) and Padan 4G (1 kg ai/ha) were used as soil application treatment, and carbosulfan (0.2%), Hastathion (0.2%) and Monocil (0.2%) as foliar spray treatment and combination of both soil application and foliar spray were taken in case of the combined treatments along with this a suitable inoculated check without application of any treatment, was taken to make a comparision study.

The effect of the treatments were assessed by measuring different growth parameters such as shoot length, root length, shoot dry weight and root dry weight & disease incidence , such as soil nematode population, root nematode population and root knot index & have been presented in Table No-1 and 2 respectively and analysed & illustrated in figure I to VII.

All the treatments exhibited improved plant growth parameters over the untreated control when applied in their respective doses. Also all the treatments showed improved plant growth parameters in combined forms of both soil and foliar application as compared to their respective treatments alone.

Plants were harvested 100 days after inoculation, the data were tabulated, analysed and discussed. The salient features of the present investigations are as follows :-

Among the soil application nematicides, Furadan 3G (1 kg a.i/ha) recorded the maximum shoot length (111.33 m). Where as in case of foliar spray treatments carbosulfan (0.2%) recorded maximum shoot length ,(102 cm) whereas out of the combined treatments Furadan 3G (1 kg a.i/ha) with carbosulfan (0.2%) showed the highest plant growth with (114.33 cm).

Root length is one of the most important growth parameter. The maximum root length (22.66 cm) was achieved in case of Furadan (1 kg a.i/ha) as soil application treatment. Similarly out of the foliar spray treatments carbosulfan (0.2) resulted in (13.33 cm) and in case of combined treatments. Furadan 3G (1 kg a.i/ha) with carbosulfan (0.2%) resulted maximum root length of (25.66cm) which showed similar trend as that of shoot length parameter results.

Shoot dry weight is another important aspects of plant growth character. so far the soil application treatment is concerned the highest shoot dry weight was recorded in case of Furadan 3G (1 kg a.i/ha) i.e. (31g). In case of foliar treatments, carbosulfan (0.2%) resulted in highest shoot dry weight of (21g). similarly incase of combined treatments Furadan 3G (1kg a.i/ha) with carbosulfan (0.2%) resulted maximum shoot dry wt. of (33.33g) which was significantly higher over all other treatments along with control check.

So far dry root weight was concerned, when compared with untreated control, dry root weight of all the treatments were significantly higher. However incomparision to Furadan 3G and Padan 4G, Furadan 3G (1 kg a.i/ha) exhibited maximum dry root weight of (2.19g) when applied in the soil..

Similarly in case of foliar application treatments, carbosulfan resulted in maximum dry root weight of (1.0 2g) which was significantly higher then other foliar spray nematicides.

Among the combined treatments of different nematides. Furadan (1 kg a.i/ha) with carbosulfan (0.2%) with dry root weight of(2.30g) was proved to be the best treatment including control . It was significantly superior than all other treatments including control.

The data on root nematode population in tuberose plant indicated that minimum root nematode population was achieved i.e. (16/g root) weight incase of combined treatment of Furadan 3G (1 kg/ ai/ha) with carbosulfan (0.2%). Among foliar spray treatments carbosulfan (0.2%) was found to be best with nematode population of(53.66/g)root as against (99/g root) incase of control.

The final soil nematode population density was recorded highest incase of control i.e. (3014/pot) as against lowest (315.66/pot), as incase of combined treatment of Furadan 3G (1kg a.i/ha) with carbosulfan (0.2%). Among soil application treatments, Furadan showed less population i.e. (512/pot) as compared to Padan 4G (1 kg a.i/ha) which has nematode population of (706.33/pot). Also out of the foliar spray treatment carbosulfan showed better result, with a soil population of (2056.33/pot) as compared to, Hostathion & monocil. Being(2324.33/pot) and(2503.66/pot) respectively.

The root knot index was found to be maximum i.e (4) in case of untreated control and minimum was recorded incase of combined treatment of Furadan 3G (1 kg a.i/ha) with carbosulfan (0.2%) with an index value of (1). Among the soil application treatment Furadan was found to be superior with index value of (1.33) as compared to Padan 4 G (1 kg a.i/ha) with a index value of (1.66)

In case of foliar spray treatments carbosulfan showed index value of (3) and was superior as compared to Hostathion & monocil with value of (3.33) and (3.66) respectively.

Thus from the results of present investigation it can be concluded that Furadan 3G (1 kg ai/ha) as soil application, carbosulfan (0.2%) as foliar spray and combined treatments of Furadan (1 kg a.i/ha) with carbosulfan (0.2%) was proved to be most suitable & effective treatment in enhancing the growth parameters and reducing the disease incidence. Which may be recommended to farming community to over come the root knot nematode problems in a commercially grown cash crop like Tuberose.

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