DISTRIBUTION OF PHYTONEMATODES AND THEIR MANAGEMENT IN ORNAMENTAL CROPS IN THIRUVANANTHAPURAM DISTRICT

By

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THESIS

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DECLARATION

I here by declare that this thesis entitled **Distribution of phytonematodes and their management in ornamental crops in Thiruvananthapuram district** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of this or any other University or Society.

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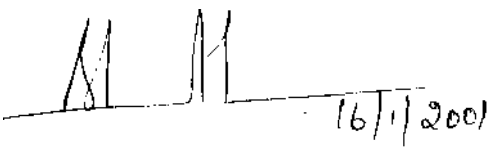
Dr. Arthur Jacob J. 

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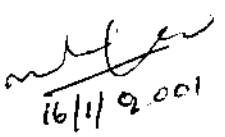
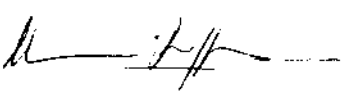
2. Dr.(Mrs) M. S. Sheela 

3. Dr.(Mrs) Sabina George T 

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INTRODUCTION

INTRODUCTION

Pests and diseases constitute a major threat to cultivated crops all over the world. Among the pests, phytophagous nematode too take a sizeable toll of numerous crops. The estimated loss due to this tiny organism is substantial in crops like potato (12.2 per cent), tomato (20.6 per cent) , egg plant (16.9 per cent) okra (20.4 per cent) and pepper (12.2 per cent) (Sasser and Freckman, 1986). This may be due to the prevalence of suitable environment (soil and climate) for its habitation and lack of awareness of the farming community about this unseen enemy.

Recently, there has been an increase in demand for cut flowers and ornamental foliages the world over. Keeping in stride with this global phenomenon, floriculture trade in India too has become an organized sector. Bestowed with natural advantages like favourable weather conditions, soil and cheap labour, India is emerging as one of the potential forces in the world flower trade. Various government agencies and co-operate giants are actively involved in the promotion of this sector, which is likely to contribute 100 crores of rupees of valuable foreign exchange to the country soon.

Intensive cropping of ornamental plants for greater returns has ushered in several problems in this sector hitherto unknown. The plant parasitic nematode too has contributed its share in this conglomerate of problems. The narcissus industry of Britain which was wiped out by the infestation of the nematode *Ditylenchus dipsaci* (Haque, 1972) is a major pointer to the devastation this microscopic animal can cause.Considerable growth reduction due to nematode infestation too has been reported on several plants like gladiolus (*Meloidogyne sp.*), chrysanthemum (*Aphelenchoides ritzemabosi*, *Belonolaimus longicaudatus* and *Trichodorus sp.*) and rose (*Xiphinema americanum* in USA and *X. diversicaudatum* in Western Europe (Haque, 1972) . The most important reason for this may be monoculturing of

the crop, which provides congenial atmosphere for population build up. Besides causing tremendous economic losses, indirectly the planting materials act as carrier of nematodes thus spreading it to newer areas.

The nematode has emerged as an economically important pest in major flower growing states like Karnataka, Tamil Nadu, West Bengal, Andhra Pradesh, Rajasthan and Maharasthra in India. A multitude of nematode fauna have been recorded from the rhizosphere of several priced ornamental plants. Incidence of *Meloidogyne sp.*, *Rotylenchulus reniformis* and *Helicotylenchus sp.* were recorded from the rhizosphere of jasmine from different locations in Karnataka (Singh *et al.*, 1979) . Bajaj (1989) reported the incidence of *Tylenchulus semipenetrans* in the rhizosphere of jasmine from Hariyana. Babu and Vadivelu (1988 b) reported *M. incognita, M. javanica,* and *M. arenaria* as major limiting factors in the successful cultivation of tuberose, *Polianthes tuberosa* in Tamil Nadu , *M. incognita* and *M. javanica* were identified as potential pests of this crop in Karnataka (Khan and Reddy, 1992) . The root-knot nematode is responsible for 25.62 per cent loss in number of flowers and 21.64 per cent loss in weight of flowers in crossandra (Khan and Reddy , 1992 a). Studies are under way in these states on different aspects of the nematode problem and management practices.

The status of nematode as a pest of ornamental crops is practically unexplored in Kerala. Apart from the report of K.A.U (1997) on the incidence of root-knot nematode *M.incognita* and burrowing nematode, *Radopholus similis* in anthurium and *M. incognita* in jasmine hardly any report is available on nematode association in ornamental crops. With the inclusion of the State in the intensive floricultural zone for orchid, anthurium and other ornamental plants with export potential by the government of India, it has become imperative to identify the

constraints in the cultivation of these crops. Identity of the prominent nematodes associated with the plants, the damage done and extent of infestation in the state need to be documented urgently.

The present investigation was taken up with a view to

- Survey and identify the plant parasitic nematodes associated with three groups of ornamental plants viz., cut flowers (anthurium and orchid), traditional flowers (jasmine and rose) and ornamental foliages (begonia and croton) in Thiruvananthapuram district

- Conduct histopathological studies to gather information on the mechanism of damage in plants identified as susceptible to root- knot nematode

- Conduct management studies for evolving suitable managemant strategies for root - knot nematode infesting the most susceptible and highly valued crop.

REVIEW OF LITERATURE

2 REVIEW OF LITERATURE

2.1 Nematodes associated with ornamental plants

2.1.1 Anthurium

Berg *et al.* (1993) described and figured *Criconemoides ornativulvatus* from the rhizosphere of *Anthurium ferrierense* in St.Joseph Martinque. Bala and Hosein (1996) reported the incidence of *Pratylenchus minutus, P. coffeae, M. incognita*, and *H. dihystera* in addition to *R. similis* in anthurium. Presence of *M. incognita* and *R. similis* in the root zone of anthurium was reported from Kerala (K.A.U.,1997).

2.1.2 Rose

Prasad and Dasgupta (1964) recorded fifteen nematode species from the rhizosphere of rose plants, of which *Hoplolaimus galeatus, X. diversicaudatum, H. nannus, T. dubius, P.pratensis, Hemicycliophora typica and M. incognita* were the most frequently encountered species. *M. javanica* was recorded in rose from Aligarh (Alam *et al.*, 1973). The population of *X. diversicaudatum* had a correlation with stunting of rose plants (Prasad and Dasgupta, 1964) . Muthukrishnan *et al.* (1975) considered *X. basiri* as the potential causative agent for unproductive flowers of *Rosa chinensis* . *P. zeae* and *Helicotylenchus sp.* were found associated with poor growth of rose plants (Babu and Vadivelu, 1988 a). Zarine and Maqbool (1991) reported the incidence of *H. verecundus* and *T. rosei* from the roots of rose plant.

2.1.3 Jasmine

M. incognita was pathogenic to *Jasminum sambac* and *J. flexile* (Rajendran and Rajendran, 1979). Singh *et al.* (1979) reported the incidence of *Meloidogyne sp., R. reniformis* and *Helicotylenchus sp.* in the rhizosphere of jasmine from different locations of Kerala and Karnataka. Bajaj (1989) observed the presence of *T. semipenetrans* in the rhizosphere of jasmine from Hariyana and correlated it with the poor growth of the plant . A new species of *Tylenchorhynchus* associated with jasmine in Udaipur, Rajasthan was identified as *T. vishwanathensis* (Pathak and Siddiqui 1996)

2.1.4 Croton

Pant *et al.* (1983) found that croton was highly susceptible to *M. incognita.* Pathak and Siddique (1977) reported a new species of *Tylenchorhynchus* associated with croton in Udaipur, Rajasthan and it was identified as *T. crotoni.*

2.1.5 Other ornamental plants

Edward *et al.*, (1969) observed the presence of *P. chrysanthus* associated with root rot of chrysanthemum. Incidence of *M. arenaria* and *M. javanica* were reported on chrysanthemum (Chandwani and Reddy 1967; Sen and Dasgupta 1977). Gill and Sharma (1976) observed the foliar nematode, *A. ritzemabosi* causing considerable damage to the foliages of this crop. *Meloidogyne sp, R. reniformis* and *Helicotylenchus sp* were seen infesting chrysanthemum in different locations in Kerala and Karnataka (Singh *et al.*, 1979). Siddique *et al.* (1991) reported the incidence of *Apratylenchoides homoglans* in the root zone of chrysanthemum from Karnataka and now it is widely distributed in major chrysanthemum growing areas of the state (Khan and Reddy, 1999).

Presence of *M.incognita* was reported from the rhizosphere of crossandra (Rajendran *et al.*, 1976). Incidence of *Longidorus africanus* and different species of *Meloidogyne, Pratylenchus,Helicotylenchus ,Hoplolaimus, Tylenchorhynchus* and *Rotylenchus* were also recorded from the root zone of crossandra (Rajendran *et al.*, 1976; Vadivelu and Muthukrishnan 1979; Muthukrishnan *et al.*, 1977).

The root-knot nematodes, *M. incognita* , *M.javanica* and *M.arenaria* were identified as a major limiting factor in successful cultivation of tuberose (*P. tuberosa*) in Tamil Nadu (Babu and Vadivelu, 1988 b) while *M.incognita* and *M.javanica* were potential pests of this crop in Karnataka (Khan and Reddy, 1992a).

Sen and Dasgupta (1975) found that balsam (*Impatiens balsamina*) and cocks comb(*Celosia cristata*) were the hosts of root - knot nematode. The foliar nematode, *A. ritzemabosi* was found to cause considerable damage to the foliage of zinnia, salvia, aster and dahlia (Varma *et al.*, 1986; Lamberti *et al.*,1987).

Zarine and Maqbool (1991) reported the incidence of *H. verecundus* and *T. rosei* from the root zone of Lily (*Pancratium verecundum*) . Besides *M.incognita,* presence of *R. reniformis* was also reported in the root zone of china aster (Rao 1994).

Nagesh and Reddy (1996 a) found that *M. incognita* was one of the serious limiting factors in commercial cultivation of carnation and gerbera under polyhouse condition. The nematode interacted with soil borne fungi such as *Fusarium sp.*and *Rhizoctonia solani* in causing wilt or rot complex in carnation and gerbera.

Studies conducted by Chandel *et al.*(1997) revealed root - knot nematode as

the most frequently occurring nematode in the rhizosphere of gladiolus followed by *H. dihystera, Macropothonia xenoplax* and *Pratylenchus sp.*

No flowering was recorded at higher level of nematode inoculum in *Antirrhinum majus* and dianthus (Goyal and Trivedi, 1999). Root galls were seen in secondary and fibrous roots .

2.2 Pathogenicity and Histopathology

The root-knot nematodes, *M. incognita* and *M. javanica* caused irregular and conspicuous galls on the roots of *P. tuberosa*. Consequently, yellowing of plants, drying of leaves, retarded growth and rotting of bulbs were observed (Jayaraman *et al.*, 1975)

P. coffeae, a potential pest of chrysanthemum caused heavy root damage which subsequently led to poor crop growth (Rashid and Khan, 1975). Stunting of plants with premature yellowing and drying of leaves were the common above ground symptoms. The flower size was also reduced. The nematode infection was confined to the cortical cells. Parenchymatous cells were completely destroyed due to nematode feeding.

Srinivasan and Muthukrishnan (1975) observed that association of *P. delattrei* with crossandra resulted in stunting, chlorosis of leaves and wilting. The leaves showed mottled appearance, which turned brown and became pinkish eventually. The root exhibited brown to black lesions. Heavily infested plants did not produce tertiary spikes and thereby flower yield was reduced.

Severe galling on roots of gladiolus was seen due to infestation by *M. incognita*. It resulted in yellowing of leaves which subsequently led to stunted growth. The nematode invaded roots, daughter corms, and cormels which developed after flowering and the nematode survived in the corm tissue in the soil as a source of inoculum for the subsequent season (Reddy *et al.*, 1979).

Pant *et al.* (1983) studied the susceptibility of different ornamental plants viz., tagetes, chrysanthemum, zinnia, cosmos, petunia, and croton to single egg mass population of *M. incognita* and found that these plants were highly susceptible to the nematode.

Babu and Vadivelu (1988 a) reported that rose plants infested with *P. zeae* and *Helicotylenchus sp.*showed chlorotic symptoms, stunted growth with necrotic lesions on the roots. *P.zeae* was responsible for 69.6, 36.4, 59.6 and 33.3 per cent reduction in shoot length , shoot weight, root length and root weight respectively. Incidence of *Pratylenchus sp.* and *Helicotylenchus sp.* were recorded from the rhizosphere of rose plants which caused poor growth of plants. Between the two, *P. zeae* was the most dominating species. Pathogenic potential of *P. zeae* on edward rose was established. Even at low inoculum level, the nematode caused 72 per cent reduction in weight.

Three species of root - knot nematode *M. incognita, M.javanica, M. arenaria* were predominant in Tamil Nadu and caused severe set back in the establishment of tuberose under field condition. Among the three species, *M. incognita* was the most predominent . At higher inoculum level, *M. incognita* caused 65 per cent reduction in top growth of plants (Babu and Vadivelu, 1988 b). Mohanty and Das (1994) conducted studies on the effect of *M. incognita* on tuberose var. single using inoculum levels of 0, 10, 100, 1000, 5000, 10000, 20000 nematodes per plant.

They recorded significant reduction in plant height, root length, shoot dry weight, root dry weight and number of leaves over control plant.

2.3 Nematode management

2.3.1 Cultural control

Application of farmyard manure reduced the population of lesion nematode in crossandra (Kolodge *et al.*, 1987). According to Khan and Reddy (1992 b), intercropping of crossandra with the enemy plant, marigold significantly reduced the population of root - knot and lesion nematode both in soil and root.

2.3.2 Biological control

The parasitic fungus, *Paecilomyces marguandi* grown on paddy seeds when applied at 2 g per kg soil gave efficient control of root-knot nematode infesting crossandra (Khan and Reddy, 1992 b).

2.3.3 Host resistance

Ohkawa and Saiguasa (1981) found that *R. indica* (major) and *R. multiflora* were resistant to *P. penetrans* and *P. vulnus* respectively, while Rosa var. Mavetti were resistant to *M. hapla*

2.3.4 Chemical control

2.3.4.1 Nursery treatment

Dipping of gladiolus corms in thionazin or fensulfothion solution (0.5g ai l^{-1}) gave reduced root - knot nematode infection (Overman, 1970). Similarly, dipping of bare root of rose in 0.1 per cent solution of fenamiphos for 30 minutes gave considerable reduction in root - knot infection (Dale, 1973).

Azam *et al.* (1978) found that application of DD mixture (1-3 dichloropropane and 1-2 dichloropropane) and Nemagon (1,2 dibromo 3- chloropropane) in ornamentals viz. cocks comb, zinnia, cosmos and tagetes reduced the population of *M. incognita, Helicotylenchus sp., Hoplolaimus sp.* and *Tylenchorhynchus sp.* in nursery beds as well as in the field to varying degrees.

Nursery treatment with granular formulations of phorate, aldicarb, fensulphothion and furadan each at 5 g per m^2 gave good and healthy crossandra seedlings free from *P. delattrei* (Vadivelu and Muthukrishnan, 1979).

2.3.4.2 Treatment in the main field

Application of vorlex (400 l ha^{-1}) resulted in better flower yield of gladiolus (Overman, 1967). Application of aldicarb 10 G at 1 kg per 100 m^2 was effective in reducing the population of *P. penetrans* in rose and increased the flower yield by 19 per cent (Johnson and Clanaham, 1974).

Vadivelu and Muthukrishnan (1979) found that carbofuran, phorate, fenamiphos, and disulfotan at 1 g per plant effectively controlled *P. delattrei* and increased flower yield of crossandra.

Gill (1981) reported that aldicarb and phorate each at 1.5 kg ha^{-1} was effective in controlling *A. ritzemabosi* on chrysathemum. Carbofuran 3G at 0.75 kg ai ha^{-1} applied 20 days after planting chrysanthemum was most effective in controlling *P. penetrans, M. incognita, R. reniformis* and *Helicotylenchus sp.* (Ramakrishnan and Vadivelu , 1995)

Fumigating with 1, 3 dichloropropene alone or in combination with methyl isothiocyanate or non volatile systemic nematicide such as aldicarb, carbofuran, fenamiphos, and thionazin was effective against root - knot nematode on ornamental plants in Italy (Lamberti *et al.*, 1987).

2.3.4.3 Foliar application of nematicide

Quinalphos, chlorpyriphos and methylparathion at 0.05 per cent when applied as foliar spray was effective in controlling the foliar nematode, *A. ritzemabosi* in zinnia and chrysanthemum (Gill,1981; Gill and Walia, 1980)

2.3.5 Integrated nematode management

Integrated management of root - knot nematode infecting crossandra was achieved by rational combination of a biocontrol agent (*Trichoderma harzianum* or *Verticillium chlamydosporium*) with a nematicide (aldicarb) or oil cake (neem cake) (Khan and Reddy 1992 b). Similarly, integration of neem, karanj and castor cakes with the AMF, *Glomus mosseae* significantly enhanced plant growth parameters, root colonization, and sporulation of the AMF and flower yield of crossandra. The above treatment also reduced root - knot nematode multiplication and root galling (Nagesh and Reddy, 1997).

Application of phorate at 4g ai per plant during May and September, pruning and incorporation of 20 kg farmyard manure per plant reduced the root - knot nematode population by 70 per cent and increased the yield of jasmine by 50 per cent (Babu,1992).

Integration of *Paecilomyces lilacinus* with 5 per cent neem leaf extract increased plant growth parameters and flower yield of tuberose .The above treatment also reduced root galling and increased egg parasitization by *P. lilacinus* (Nagesh *et al.*1996).

Integration of *P. lilacinus* or *Trichoderma harzianum* at 0.51 per m^2 (aqueous spore suspension containing 2 $X10^4$ spore per m) with neem cake at 0.5 kg per m^2 or fenamiphos at 2g ai per m^2 increased plant growth parameters and flower yield of carnation and gerbera. The above treatment also increased root - knot egg parasitisation by the parasitic fungi (Nagesh and Reddy, 1996).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1 Survey

The ornamental plants grown in Kerala were broadly classified into three groups viz., cut flowers, traditional flowers and ornamental foliages. A random survey was conducted in Thiruvananthapuram district to identify the plant parasitic nematodes associated with some of the commonly grown ornamental plants belonging to these groups like anthurium and orchid (cut flowers), rose and jasmine (traditional flowers) begonia and croton (ornamental foliages).

3.1.1Collection of soil and root sample

Samples of soil and root of each crop were collected from ten locations in Thiruvananthapuram district. Samples of soil were taken to a depth of 30 cm from the rhizosphere of 5 plants of each crop in a location. Soil samples thus collected were mixed thoroughly and 500g of the soil was transferred to a polythene bag. Similarly, root samples were taken from 5 plants of each crop in a location, pooled together and kept in a polythene bag.

3.1.2 Processing of soil sample

The soil samples (200 g) were processed by modified Cobb's sieving and decanting technique (Christie and Perry, 1951). The nematode suspension was drawn out after 48 hours.

3.1.3 Processing of root sample

Ten grams of root was weighed out from each sample and transferred to a plastic container .The roots were then gently cleaned off any soil particles adhering to them by holding them in a stream of water under a tap. The cleaned roots were then sliced into small bits of less than 1 cm length and placed on a wire gauze kept in a petridish containing water. Care was taken to see that the base of the wire gauze just touched the water in the petridish The nematode suspension was collected after 48 hours.

3.1.4 Estimation of nematodes in soil and root

The nematode suspension was transferred to a clean 250 ml beaker and allowed to settle for 3 hours. The total number of nematodes of each genera was counted separately. The nematode suspension was then preserved by adding an equal quantity of boiling 5 per cent formalin for further observation.

3.2 Histopathology

3.2.1 Preparation of denematized potting mixture

Sieved field soil, sand and well decomposed farm yard manure were mixed in the ratio 2:1:1 and the mixture was spread on the ground in the form of beds of 15 cm thickness. The beds were divided into blocks of one square metre . Each block was moistened and then drenched uniformly with 10 per cent formaldehyde solution. The beds were then covered with polythene sheet for denematisation. After two weeks the sheets were removed and the mixture was raked well and exposed. This

denematized potting mixture was used for maintaining pure culture of *M. incognita* and for further studies.

3.2.2 Raising of pure culture of *M. incognita*

Pure culture of *M. incognita* was raised from a single egg mass of the nematode collected from roots of ornamental coleus plants . Identity of the species was established by observing the perineal pattern of the female nematode. The culture of the nematode was maintained on ornamental coleus plants raised in sterilized soil. Sub culturing was done periodically to ensure availability of sufficient larval population for inoculation purposes. The culture so obtained was used in the experiment.

3.2.3 Inoculation of nematode

Viable egg masses of *M. incognita* were hand picked from infested roots of ornamental coleus plants and kept in cavity blocks containing sterile water. Newly hatched second stage larvae of *M. incognita* were inoculated to the root zone of the test plant @ 1 larva per g soil. Inoculation was done as per the method suggested by Venkitesan and Setty (1977). The required quantity of nematode suspension was pipetted out equally into the holes, which were closed immediately. The pots were irrigated daily to keep the soil moist.

3.2.4 Histopathology

The root-knot nematode susceptible plants , anthurium (monocotylendon) jasmine and begonia (dicotyledons) were selected for histopathological studies .The plants were raised in small pots containing denematized soil. One month after planting

the plants were inoculated with second stage juveniles of *M. incognita* as mentioned in para 3.2.3. Roots of plants were collected 35 days after inoculation and fixed in F A A (formaldehyde acetic acid, alcohol fixative). The fixed roots were then processed for microtomy as described by Johansen (1940) and observed under a microscope.

3.3 Management of root - knot nematode

A pot trial was conducted with a nematicide (cabofuran), an organic amendment (neem cake), and a beneficial fungus (*G. fasciculatum*) to evolve a suitable strategy for managing root - knot nematode in anthurium, a remunerative ornamental plant.

3.3.1 Raising pure culture of G. fasciculatum

Culture of *G. fasciculatum* obtained from the Department of Plant Pathology, College of Agriculture, Vellayani was maintained on guinea grass (*Panicum maximum*). Root segments of *P. maximum* colonised with the fungus and the chlamydospores in the soil-sand mixture on which the grass was grown were mixed thoroughly and it served as the mycorrhizal inoculum.

3.3.2 Raising of anthurium plants

Anthurium plants were raised in 15cm diameter pots containing 10 kg of sterilised planting substrate. The variety, Local pink (*Anthurium andreanum*) was selected for the study as it is commonly grown in house holds .The experiment was laid out in completely randomised block design with eight treatments and four replications. The treatment details were as follows.

T1 Carbofuran 2 kg ai ha^{-1}

T2 Neem cake 0.5 per cent w/w

T3 *G. fasciculatum* 200 spores per pot

T4 Carbofuran 1 kg ai ha^{-1} + Neem cake 0.25 per cent w/w

T5 Carbofuran 1kg ai ha^{-1}+ *G. fasciculatum* 200 spores per pot

T6 *G. fasciculatum* 200 spores per pot + Neem cake 0.25 per cent w/w

T7 Carbofuran 1 kg ai ha^{-1} + Neem cake 0.25 per cent w/w +*G. fasciculatum* 200 spores per pot.

T8 Check

Neem cake and culture of *G. fasciculatum* (20 g inoculum) were applied in the soil at the time of planting while carbofuran was applied one week after inoculation of the nematode.

3.3.3 Assessment of results

3.3.3.1 Plant characters

The number of leaves, number of flowers, plant height and root weight were recorded three months after inoculation of the nematode.

3.3.3.2 Gall index

The number of galls per root system were counted and the gall index was determined. The following scale was followed for calculating the gall index:

Gall number per plant	Gall index
0-5	1
6-10	2
11-15	3
16-20	4
21-25	5
>25	6

3.3.3.3 Nematode population in soil

Nematode population in soil was estimated as mentioned in para 3.1.2 and 3.1.4

3.3.3.4 Nematode population in root

Nematode population in root was estimated as mentioned in para 3.1.3 and 3.1.4

RESULTS

4 RESULTS

4.1 Survey

4.1.1 Anthurium

The root - knot nematode *M. incognita* was seen infesting anthurium in 8 locations out of the 10 locations surveyed in Thiruvananthapuram district (Table 1). The population of the nematode in the soil ranged from 0 -138 per 200 ml of soil , the average being 61 per 200 ml of soil. The population of the nematode in 5 g root ranged from 0- 42. The average number of nematode present in the root was 20 per 5 g root. Yellowing and stunting of plants were observed in areas where the nematode population was high. (more than 100 per 200 ml soil)

The burrowing nematode, *R. similis* occurred at a frequency of 60 per cent in Thiruvananthapurm district. The population in the soil ranged from 0-20 per 200 ml of soil and the average number of nematode recorded was 7 per 200 ml of soil. In the root, the population ranged from 0-8 per 5g of the root with a frequency distribution of 50 per cent. The average nematode population recorded was 2 per 5g root. Brown lesions were observed in the roots of infested plants.

The lance nematode, *Hoplolaimus spp.* was seen only in 4 locations in the district. The population of the nematode in the soil ranged from 0-10 per 200 ml of soil and the average number of nematode per 200 ml of soil was only 3.The nematode was seen only in root samples collected from 2 locations in the district. The population of the nematode in 5g root ranged from 0-3, the average being 1 per 5g root.

Table1:- Occurrence and distribution of nematodes in anthurium in Thiruvananthapuram district

	Soil 200 ml			Root 5 g		
Nematode	Range	Average	Frequency distribution (per cent)	Range	Average	Frequency distribution (per cent)
M. incognita	0-138	61	80	0- 42	20	80
R. similis	0-20	7	60	0-8	2	50
Hoplolaimus sp.	0-10	3	40	0-3	1	20
Helicotylenchus sp.	0-17	7	90	-	-	-

The spiral nematode *Helicotylenchus sp.* was seen in 9 locations .The population of the nematode ranged from 0-17 per 200 ml of soil with a frequency distribution of 90 per cent. The average nematode population recorded was 7 per 200 ml of soil. Other nematodes observed in the different locations were *Pratylenchus spp. and Criconemoides spp.*

4.1.2 Orchid

The root - knot nematode (*M. incognita*) was present in the soil in 50 per cent of the locations surveyed.The population of the nematode was very low in the soil and root. The number of nematode in 200 ml of soil ranged from 0-11 (Table 2).The average number of *M. incognita* was 5 per 200 ml of soil. The population in the root ranged from 0-2 per 5g root with a frequency distribution of 20 per cent. The average nematode population recorded was 1 per 5g root.

The population of the burrowing nematode (*R. similis*)in the different locations ranged from 0-3 per 200ml of soil, the frequency distribution being 30 per cent. The average number of nematode recorded from 200 ml of soil was only 1.No nematode was obtained from the root samples.

The population of lance nematode (*Hoplolaimus sp.*) in the soil ranged from 0-20 per 200 ml of soil with a frequency distribution of 70 per cent. The average number of nematode recorded was 9 per 200 ml of soil . The population of nematode in 5g root ranged from 0-12 with a frequency distribution of 40 per cent.The average number of nematode obtained from 5g root was 3.

The population of spiral nematode (*Helicotylenchus sp.*) ranged from 0-36

Table 2 :- Occurrence and distribution of nematodes in orchid in Thiruvananthapuram district

	Soil 200 ml			Root 5 g		
Nematode	Range	Average	Frequency distribution (per cent)	Range	Average	Frequency distribution (per cent)
M. incognita	0 -11	5	50	0 - 2	1	20
R. similis	0 -3	1	30	0	0	0
Hoplolaimus sp.	0 - 20	9	70	0 - 12	3	40
Helicotylenchus sp.	0 - 36	8	70	-	-	-

per 200 ml of soil. The average number of nematode recorded was 8 per 200 ml of soil, the frequency distribution being 70 per cent. *Pratylenchus spp.* was the only other nematode seen in the rhizosphere of orchid, in the different locations . The population of the nematode was negligible.

4.1.3 Rose

Of the 10 locations surveyed in Thiruvanthapuram district, *M.incognita* was seen infesting rose in 9 locations (Table 3). The population of the nematode in the soil ranged from 0-57 per 200 ml of soil. The average number of nematode recorded was 22 per 200 ml of soil . In the root, the population of nematode in 5g root ranged from 0-29 with a frequency distribution of 90 per cent and the average number of *M. incognita* recovered from 5g root was 8.

The population of burrowing nematode ranged from 0-2 per 200 ml of soil with a frequency distribution of 10 per cent. The average number of nematode recorded from 200 ml of soil was 1. The nematode could not be recovered from the roots.

The population of lance nematode in the soil ranged from 0-14 per 200 ml of soil with a frequency distribution of 60 per cent. The average number of nematode recorded was 7 per 200 ml of soil. The population of nematode in 5g root ranged from 0-5 with a frequency distribution of 20 per cent. The average number of nematode recorded was 1per 5g root. The population of spiral nematode ranged from 0 -19 per 200 ml of soil with a frequency distribution of 90 per cent. The average number of nematode recorded was 7 per 200 ml of soil .

Table 3 :- Occurrence and distribution of nematodes in rose in Thiruvananthapuram district

	Soil 200 ml			Root 5 g		
Nematode	Range	Average	Frequency distribution (per cent)	Range	Average	Frequency distribution (per cent)
M. incognita	0 - 57	22	90	0 - 29	8	90
R. similis	0 - 2	1	10	0	0	0
Hoplolaimus sp.	0 - 14	7	60	0 - 5	1	20
Helicotylenchus sp.	0 -19	7	90	-	-	-

Table 4 :- Occurrence and distribution of nematodes in jasmine in Thiruvananthapuram district

	Soil 200 ml			Root 5 g		
Nematode	Range	Average	Frequency distribution (per cent)	Range	Average	Frequency distribution (per cent)
M. incognita	18 - 81	42	100	5- 41	18	100
R. similis	0 - 8	4	70	0 - 4	1	20
Hoplolaimus sp.	0 - 20	11	90	0 - 3	1	20
Helicotylenchus sp.	0 -15	7	80	-	-	-

4.1.4 Jasmine

The root - knot nematode was seen infesting the plant in all the locations surveyed (Table 4). The average number of nematode in 200 ml soil was 42. The population ranged from 18-81 per 200 ml of soil . In the root the population ranged from 5- 41 per 5g root and average number of nematode recorded was 18.

The population of burrowing nematode in the soil ranged from 0-8 per 200 ml of soil , the frequency distribution being 70 per cent. Average number of nematode recorded from 200 ml of soil was 4. The population of nematode in 5g root ranged from 0- 4 with a frequency distribution of 20 per cent and an average of only one nematode was recovered from 5g root.

The population of lance nematode in the soil ranged from 0-20 with a frequency distribution of 90 per cent. The average number of nematode recovered from 200ml soil was 11. The population of nematode in 5g root ranged from 0-3 with a frequency distribution of 20 per cent. The average number of nematode recorded was only one.

The spiral nematode population in the soil ranged from 0-15 per 200 ml soil with a frequency distribution of 80 per cent and the average number of nematode recorded was 7 per 200 ml soil.

4.1.5 Begonia

The root-knot nematode population in the soil ranged from 20-42 per 200 ml soil (Table 5). The average number of nematode present in 200 ml soil was 32. The nematode population ranged from 7-22 per 5g root and the average number of *M. incognita* obtained from the root was 15 . Infestation of the nematode was seen in all the locations surveyed.

Table 5 :- Occurrence and distribution of nematodes in begonia in Thiruvananthapuram district

	Soil 200 ml			Root 5 g		
Nematode	Range	Average	Frequency distribution (per cent)	Range	Average	Frequency distribution (per cent)
M. incognita	20 - 42	32	100	7- 22	15	100
R. similis	0 - 8	2	40	0 - 2	1	10
Hoplolaimus sp.	0 - 18	10	80	0 - 8	2	20
Helicotylenchus sp.	0 - 24	8	80	-	-	-

The population of burrowing nematode in the soil ranged from 0 - 8 per 200 ml of soil and the infestation was seen only in 4 locations.The average number of nematode recorded from 200 ml of soil was 2. The population of nematode in 5g root ranged from 0-2 with a frequency distribution of 10 per cent and an average of only one nematode per 5g root .

The population of lance nematode in the rhizosphere soil ranged from 0-18 per 200 ml of soil with a frequency distribution of 80 per cent. The average number of nematode recorded was 10 . In the root, the population of nematode in 5g root ranged from 0-8 with a frequency distribution of 20 per cent. The average number of nematode recorded from root was 2.

The population of spiral nematode ranged from 0-24 per 200 ml of soil with a frequency distribution of 80 per cent. The average number of nematode recorded was 8 per 200 ml of soil.

4.1.6 Croton

The population of root-knot nematode in the soil ranged from 8-20 per 200 ml of soil with a frequency distribution of 100 per cent (Table 6). The average number of nematode recorded in soil was 14 per 200 ml soil. The population ranged from 1-8 per 5g root and an average of 5 nematode was recorded from the root, the frequency distribution being 100 per cent.

The population of burrowing nematode in soil ranged from 0-3 per 200 ml with a frequency distribution of 10 per cent. The average number of nematode recorded from soil was one.

Table 6 :- Occurrence and distribution of nematodes in croton in Thiruvananthapuram district

	Soil 200 ml			Root 5 g		
Nematode	Range	Average	Frequency distribution (per cent)	Range	Average	Frequency distribution (per cent)
M. incognita	8 - 20	14	100	1 - 8	5	100
R. similis	0 - 3	1	10	0	0	0
Hoplolaimus sp.	0 - 12	5	50	0 -4	1	20
Helicotylenchus sp.	0 - 37	8	80	-	-	-

The population of lance nematode ranged from 0-12 per 200 ml soil with a frequency distribution of 50 per cent. The average number of nematode in 200 ml of soil was 5. The population of nematode in the root ranged from 0 - 4 per 5g root, with a frequency distribution of 20 per cent.

Population of spiral nematode in soil ranged from 0-37 per 200 ml of soil with a frequency distribution of 80 per cent . The average number of nematode recorded was 8 per 200 ml of soil. The only other nematode observed in the rhizosphere of croton was *Pratylenchus sp.*

4.2 Histopathology

Anatomical features of the roots of nematode susceptible plants viz., anthurium, a monocotyledonous plant, begonia and jasmine, two dicotyledonous plants were observed.

4.2.1 Anthurium

Other than slight yellowing of the plants, no remarkable change could be detected in the growth of the plants when observed five weeks after inoculation of the nematode. Small terminal galls were seen in the root system (Plate I) . No mature females could be seen during this period. Marked cellular changes were detected only five weeks after inoculation.

The microphotograph of healthy and infested root sections of anthurium is given in (Plate II). All the tissues in the healthy root were found to be arranged symmetrically. The stele was compact with well-developed pith. The pith had thick walled sclerenchymatous cells centrally. Numerous xylem and phloem bundles were arranged in an alternate manner radially close to the pericycle.

Plate : I

Terminal galls of *Anthurium andreanum*

Plate : II

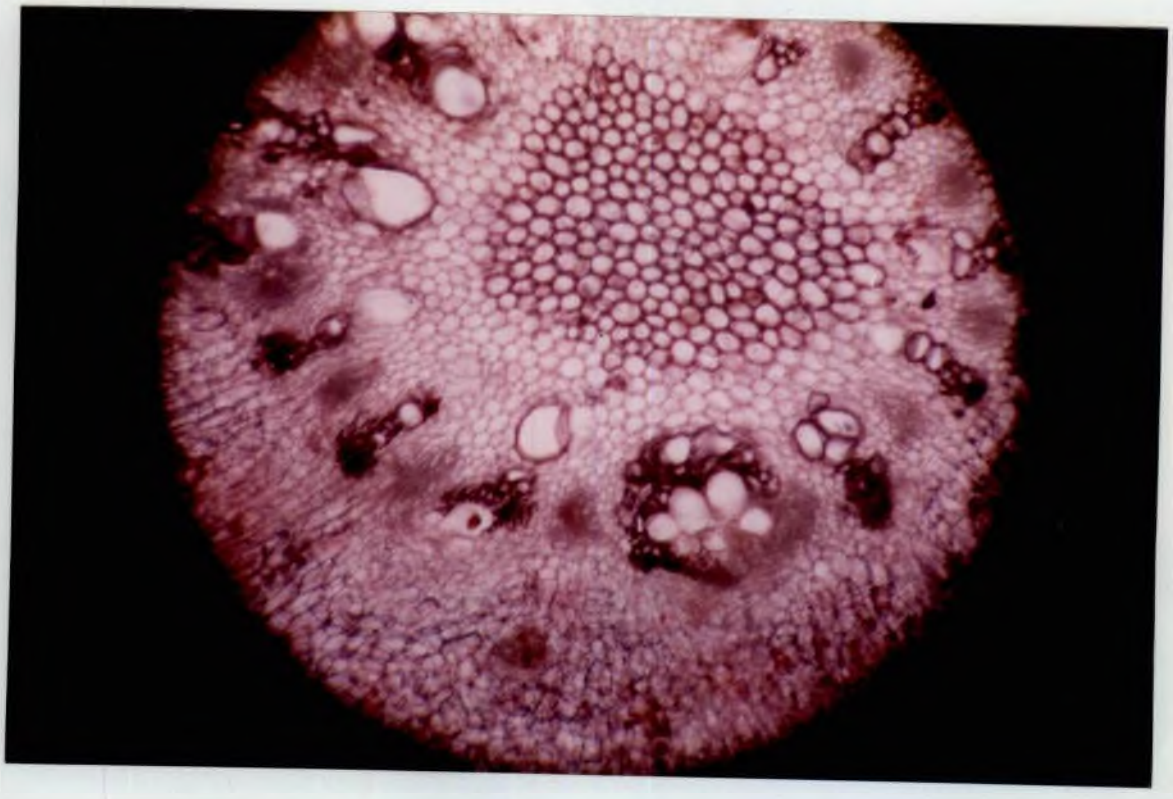
Transverse section of healthy and *M. incognita* infested anthurium root

a) **Healthy (10 X)**

b) **Infested (20 X)**

a

b



Not much distortion could be distinguished in the stelar region in the root section of infected plant. Giant cells were seen close to the meta xylem of the xylem bundles, whereby the flow of food materials to the various part of the plant was supressed affecting the normal growth of the plant. No visible difference could be detected between the pholem vessels in healthy and infested roots indicating that the pholem vessels were not affected by the nematode.

4.2.2 Jasmine

Though small galls were seen throughout the root system, significant above ground symptoms was not manifested in the plants when observed four weeks after inoculation. However marked cellular changes were detected including clear giant cell formation during this period.

The microphotograph of healthy and infested root sections are given in (Plate III) . The stele was intact with six xylem and six pholem arranged radially in healthy plants. Pith was absent and the central portion of stele was filled with metaxylem.

Root section of the infested plants showed signs of secondary growth. The inner most layer of cortex was well developed. Inner to that secondary phloem could be seen without damage or distortion . But the primary and secondary xylem was completely destroyed and the central portion were completely occupied by a few giant cells. The cortex was also seen slightly distorted.

Plate : III

Transverse section of healthy and *M. incognita* infested jasmine root

a) **Healthy (10 X)**

b) **Infested (10 X)**

a

b

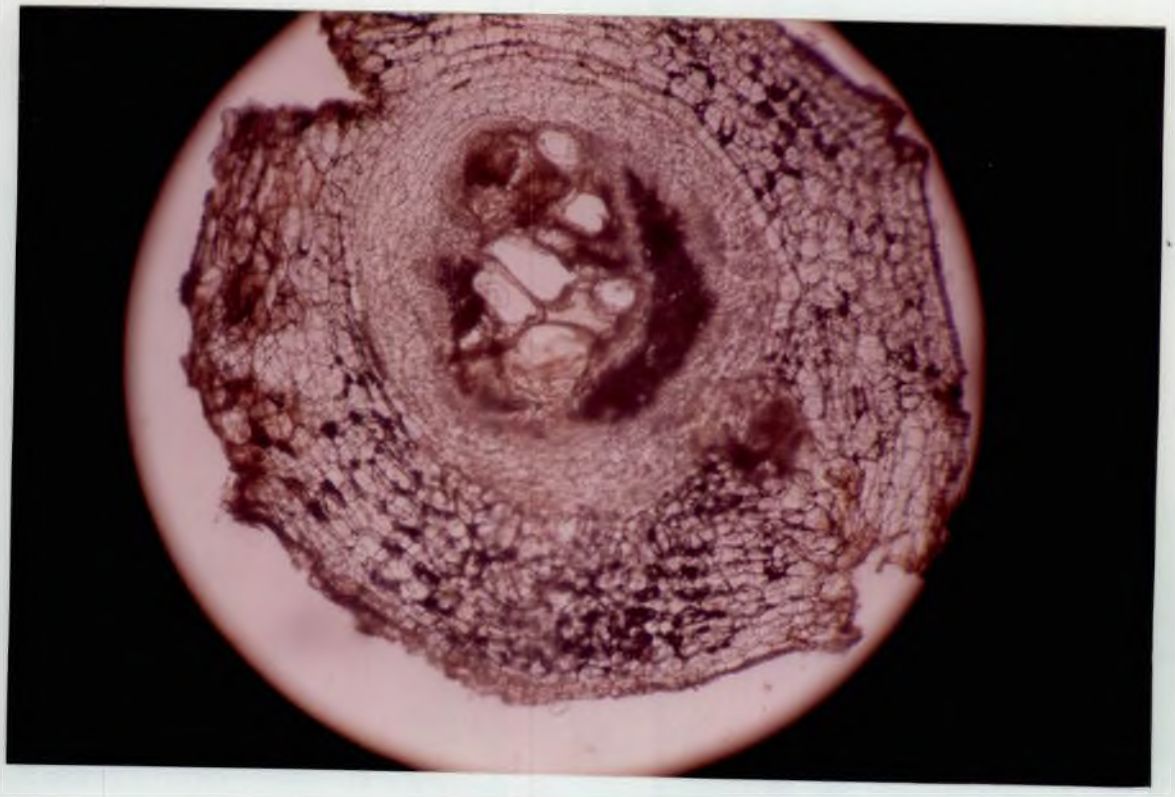


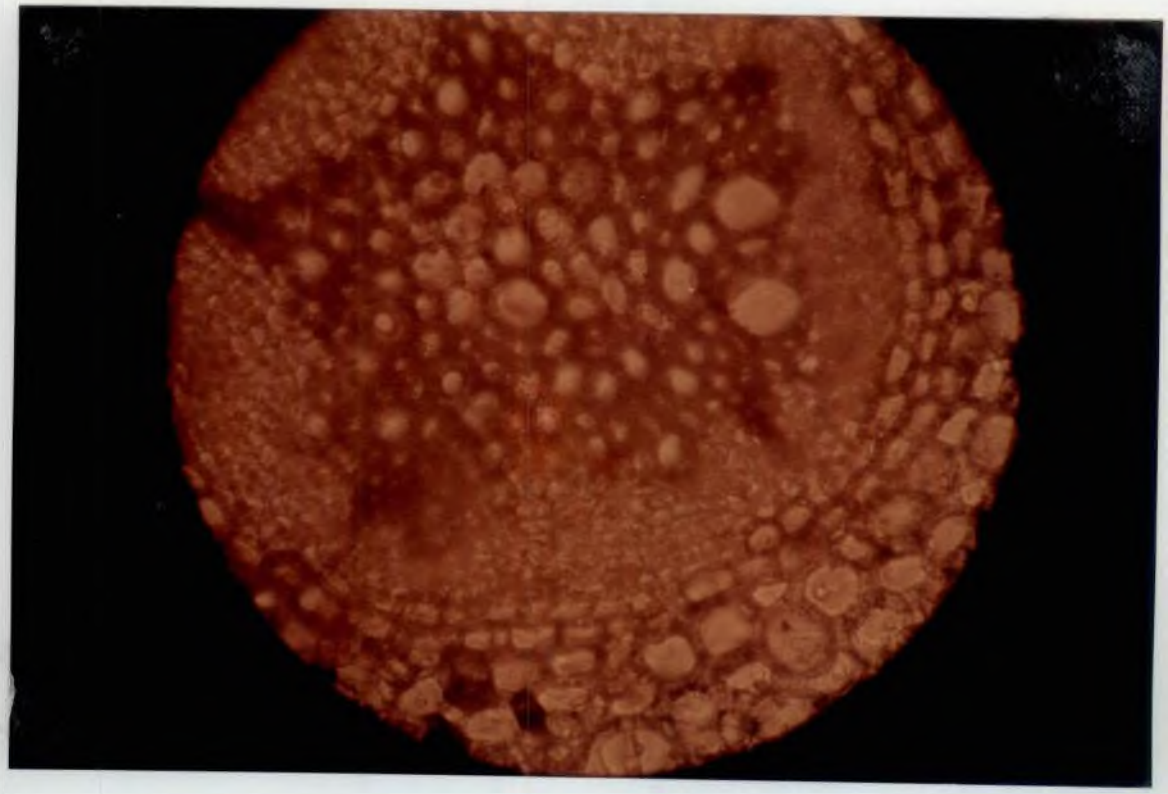
Plate : IV

Transverse section of healthy and *M.incognita* infested begonia root

a) **Healthy (20 X)**

b) **Infested (10 X)**

a



b

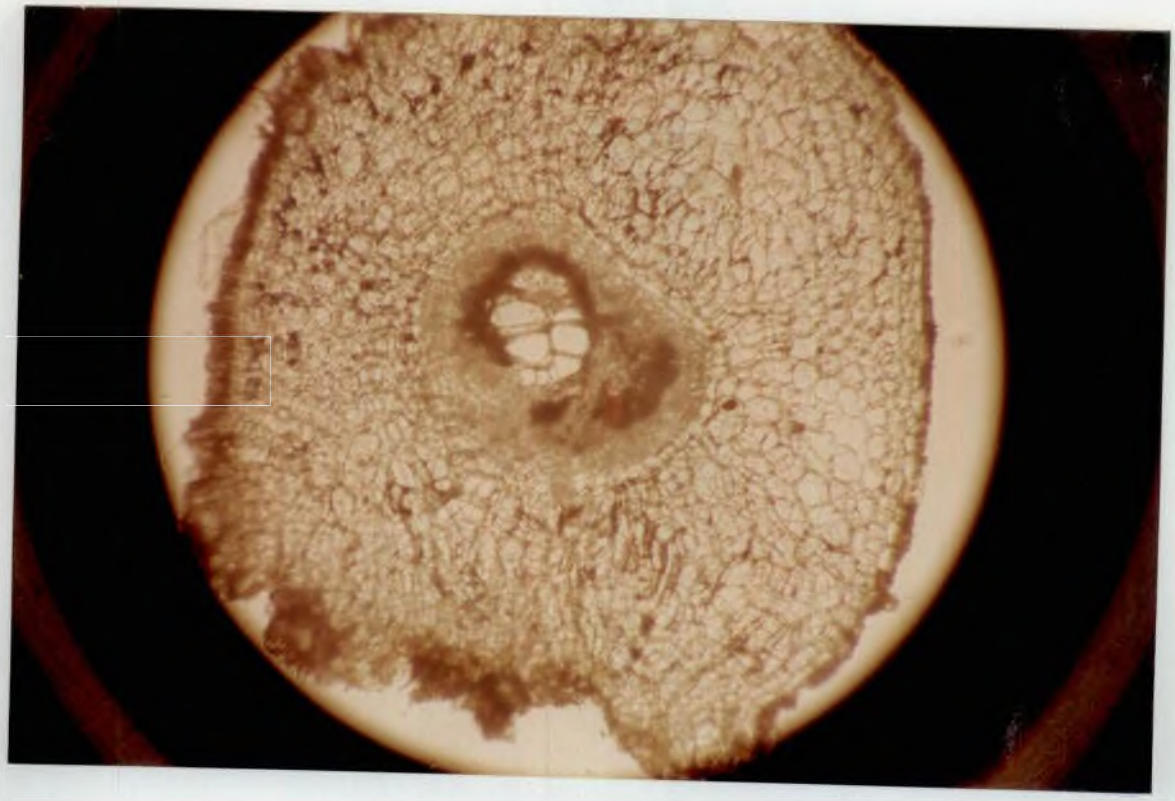
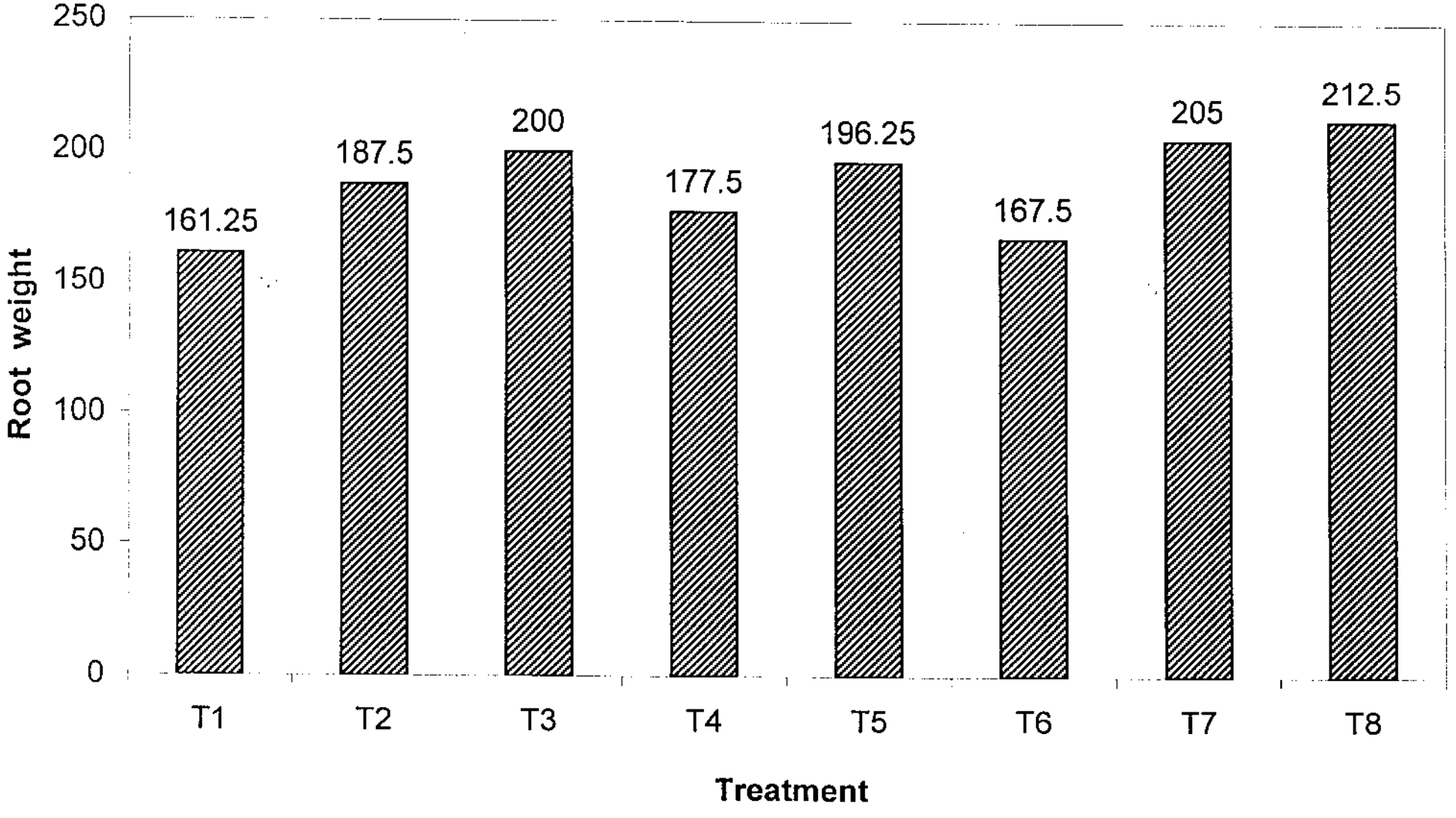


Fig. 1 **Effect of different treatments on root weight of *A. andreanum***



4.2.3 Begonia

Stunted growth of the plants was observed four weeks after inoculation. Both primary and secondary galls were seen in the root system.

The micro photograph of healthy and infested root sections are shown in (Plate IV). An intact stelar region was seen with five xylem and five phloem bundles arranged alternately and radially inner to the pericycle in the uninfested plants. Pith was absent and the inner region was filled with metaxylem.

However, the stelar region was completely distorted in nematode infested plants. The xylem bundles were unidentifiable, completely destroyed and were replaced by giant cells. Giant cell formation was observed from the third week after inoculation of the nematode while dissolution of the cell walls was seen from the fourth week onwards. The phloem vessels were not affected and the cortex was also much distorted.

4.3 Management of root - knot nematode

4.3.1 Effect on plant characters

Among the plant characters studied, no significant difference was observed in the height of plant , number of leaves , and number of flowers due to the treatments. However, the root weight of plants in different treatments showed a significant reduction. (Fig.1). While the root weight of nematode infested plants (control) was 212.5g, it ranged from 161.25g to 205g in the different treatments. Maximum reduction in the root weight was observed in plants treated with carbofuran @2kg ai ha^{-1}

Table 7 :- Effect of carbofuran, neem cake and *G. fasciculatum* alone and in combination on population of root-knot nematode in soil and root three months after treatment (mean of four replications)

Treatments	Nematode population		Gall index
	Soil (200g)	Root (5g)	
Carbofuran 2 kg ai ha^{-1}	63 (7.9)*	35.75 (5.9)	1.25
Neem cake 0.5 per cent w/w	78.5 (8.8)	49.5 (7.3)	2.0
G. fasciculatum 200 spores per pot	100.5 (10.02)	62 (7.8)	2.25
Carbofuran 1 kg ai ha^{-1} + neem cake 0.25 per cent w/w	63.25 (7.9)	38.75 (6.2)	1.25
Carbofuran1kg ai ha^{-1}+ *G. fasciculatum* 200 spores per pot	95 (9.7)	54.5 (7.3)	1.75
G. fasciculatum 200 spores per pot + neem cake 0.25 per cent w/w	85 (9.2)	40 (6.32)	1.5
Carbofuran 1 kg ai ha^{-1} + Neem cake 0.25 per cent w/w + *G. fasciculatum* 200 spores per pot	65.25 (8.07)	33.75 (58)	1.5
Check	272.5 (16.5)	102.75 (10.12)	3.25
CD	16.89	8.57	

*Figures in the parenthesis are values after √x transformation.

(161.25g) and it was on par with the root weight of plants treated with carbofuran @1kg ai ha^{-1} + neem cake 0.25 per cent w/w (167.5g). The root weight of plants treated with carbofuran @1kg ai ha^{-1} + *G. fasciculatum* 200 spores per pot was 196.25 g and it was on par with the root weight of plants treated with *G. fasciculatum* 200 spores per pot alone (200 g) and *G. fasciculatum* 200 spores per pot + neem cake 0.25 per cent w/w (205 g). Application of carbofuran @1kg ai ha^{-1} + *G. fasciculatum* 200 spores per pot + neem cake 0.5 per cent w/w resulted in still lower weight of roots(177.5 g) and it was on par with application of neem cake 0.5 per cent w/w alone (187.5 g) and carbofuran 1 kg ai ha^{-1} + neem cake 0.25 per cent w/w (167.5 g). There was no significant reduction in the root weight of plants treated with *G. fasciculatum* 200 spores per pot+ neem cake 0.25 per cent w/w (205 g) . It was on par with untreated plants.

4.3. 2 Effect on nematode infestation

4.3.2.1 Population of nematode in soil

Statistical analysis of the data on population of nematode in soil three months after treatment showed that all the treatments were significantly effective in reducing nematode population in soil (Table 7). Treatment of soil with carbofuran @ 2 kg ai ha^{-1}gave maximum reduction of nematode population in soil (63 per 200g soil). This was followed by application of carbofuran @1 kg ai ha^{-1} +neem cake 0.25 per cent (63.25 per 200 g soil) and carbofuran @1kg ai ha^{-1} + *G. fasciculatum* 200 spores per pot + neem cake 0.25 per cent w/w (65.25 per 200 g soil). Statistically these treatments were on par with neem cake 0.5 per cent w/w alone which was on par with treatment of soil with neem cake 0.25 per cent w/w + *G. fasciculatum* 200 spores per pot and *G. fasciculatum* 200 spores per pot + carbofuran @1kg ai ha^{-1} the nematode population

in 200 g soil being 78.5, 85 and 95 respectively in these treaments. Treatment of soil with *G. fasciculatum* 200 spores per pot alone (100.50 per 200 g soil) was on par with its combined application with carbofuran @1kg ai ha^{-1} (95 per 200 g soil) and neem cake 0.25 per cent w/w (85 per 200 g soil).

4.3.2.2. Population of nematode in root

Infestation of root-knot nematode in anthurium was effectively checked by various treatments as evidenced by the nematode population in the root. While the population of *M. incognita* in the roots of untreated plants was 102.75 per 5 g root, it ranged from 33.75 to 62 per 5 g root in the different treatments (Table 7). Effective control was achieved by treating soil with carbofuran @1 kg ai ha^{-1} + *G. fasciculatum* 200 spores per pot + neem cake 0.25 per cent w/w (33.75 per 5 g root). The treatment was on par with treatment of soil with carbofuran @ 2kg ai ha^{-1} (35.75 per 5 g root), carbofuran @ 1kg ai ha^{-1} + neem cake 0.25 per cent w/w (38.75per 5g root) and *G. fasciculatum* 200 spores per pot + neem cake 0.25 per cent w/w (40 per 5 g root). Treatment of soil with neem cake 0.5per cent w/w alone (49.5 g per 5 g root) and carbofuran @1 kg ai ha^{-1} + *G. fasciculatum* 200 spores per pot (54.4 per 5 g root) were on par in their effect in reducing nematode population in the root. Though a higher population of nematode was observed in the root of plants treated with *G. fasciculatum* 200 spores per pot alone (62 per 5g root), the treatment was significantly superior when compared to untreated plants (102.75 per 5g root).

4.3.2.3 Gall index

Untreated plants, had a gall index of 3.25. Significantly low gall index was observed in the plants receiving various treatments (Table 7). A low index of 1.25

was observed in plants treated with carbofuran @ 2kg ai ha^{-1} and carbofuran @1kg ai ha^{-1} +neem cake 0.25 per cent w/w.These treatments were on par with *G. fasciculatum* 200spores per pot + neem cake 0.25 per cent w/w (1.5), carbofuran @1kg ai ha^{-1} +neem cake 0.25 per cent w/w + *G. fasciculatum* 200 spores per pot (1.5), carbofuran @1kg ai ha^{-1} + *G. fasciculatum* 200 spores per pot (1.75) and neem cake 0.5 per cent w/w alone (2.0).Comparatively, plants treated with *G. fasciculatum* 200 spores per pot alone showed a higher gall index (2.25).

DISCUSSION

5 DISCUSSION

The destructive potential of plant parasitic nematodes in crop production is well established. Most of these nematodes damage the roots leading to poor utilization of available moisture and nutrient in the soil resulting in reduced metabolism. This deleterious effect results in reduced yield and poor quality of crops. Ornamental plants too are vulnerable to nematode infestation. However, due to low acreage, nematode pests of ornamental plants did not receive due attention till recently. Increasing demand for cut flowers, live plants, cut foliages, seeds and fruits has now invigorated the otherwise neglected ornamental sector. Several nematodes have been listed as major pests of valuable ornamental plants causing economic loss. Considering the income per unit area which is much higher in this crop than in any other agricultural product, it has become imperative to maximize production. Naturally, the thrust now is on identifying the constraints in its cultivation. So identification of the major nematode problems, the nature of infestation and formulation of suitable management strategies is needed.

5.1 Nematodes associated with ornamental plants

The random survey conducted in Thiruvananthapuram district showed the preponderance of the ubiquitous root - knot nematode *M. incognita* on the ornamental plants selected for survey . The finding agrees with the observations of Haider and Khan (1986) who reported that most of the ornamental plants suffered great loss due to root - knot nematode infestation. This noxious pest was seen in the rhizosphere of all the ornamental plants surveyed, viz. anthurium and orchid (cut flowers), rose and jasmine (traditional flowers), begonia and croton (ornamental foliages). Several workers have reported the association of the nematode with the plants selected for

the present study viz. anthurium (Berg ,1993; K.A.U., 1997), rose (Prasad and Dasgupta, 1964), jasmine (Rajendran and Rajendran, 1979) and croton (Pant *et al.*, 1983) . Few reports are available on the association of root- knot nematode in orchid and practically no report on begonia. Random surveys conducted by different workers in different parts of the country have revealed the nematodes attacking other ornamental plants (Chandwani and Reddy, 1967 and Jayaraman *et al.*, 1975). Among the plants surveyed, anthurium, jasmine and begonia were found to be more susceptible to the nematode than the other plants as indicated by the nematode population in the root. Yellowing and stunting of plants were seen in locations where high population of the nematode was encountered.

The other important plant parasitic nematode seen infesting the ornamental plants was the burrowing nematode, *R. similis*. This nematode was seen in more than 50 per cent of the location surveyed in anthurium (60 per cent) and jasmine (70 per cent).Roots of infested anthurium plants showed brown necrotic lesions. However, no such lesions were seen on roots of jasmine. Besides , the number of nematodes obtained from the roots was too low to consider it as a pest of the crop. The frequency of occurrence of the nematode in the other plants was low. The population of the nematode in the soil and root of rose,croton and orchid was very low. This indicated the probable non preference of the plants to the nematode. So it may be presumed that anthurium was more susceptible to the nematode than the other plants. Presence of burrowing nematode in the root zone of anthurium was reported from Spain (Bala and Hosein, 1996) and Kerala (K.A.U., 1997). Khan and Reddy (1989) recorded high population of *R. similis* from *J. pubescens* in Bangalore.

Besides the two nematodes, the spiral nematode *Helicotylenchus spp.* and lance nematode *Hoplolaimus spp.* were also seen in the soil samples collected from

the ornamental plants. The frequency of distribution of these nematodes was higher when compared to root-knot nematode. However, the presence of these nematodes does not permit any conclusive inference since no specific symptoms of damage could be associated with the nematodes in any of the ornamental plants surveyed. Occurrence of the nematodes *H. galeates* and *H. nannus* was reported by Prasad and Dasgupta (1964) from the root zone of rose plants. *Helicotylenchus spp.* was found associated with poor growth of rose plants (Babu and Vadivelu 1988 a). Similarly *Helicotylenchus spp.*was reported from rhizosphere of jasmine from different locations of Kerala and Karnataka (Bajaj, 1989).

From the survey, it could be concluded that among the plants selected as representative of the three groups of ornamental plants, anthurium (cut flowers), jasmine (traditional flowers) and begonia (ornamental foliage plant) were susceptible to root - knot nematode and the pest is a menace to their cultivation in the state.Considering the other nematodes, detailed extensive survey need to be conducted for conclusive results. Orchid was definitely not preferred by the nematodes.

5.2 Histopathology

The below ground symptom of root - knot nematode infestation is obviously the formation of galls. The size of the galls depends on the characteristics of the plant, as the gall is the product of reaction of the host to the parasite. In the present study small terminal galls were observed in anthurium, while larger galls spread throughout the root system were seen in begonia .

Among the plant parasitic nematodes, the root-knot nematode *Meloidogyne spp.* is unique in its capability to induce giant cells as well as causing

extensive pericycle hyperplasia and cortical hypertrophy resulting in galls. The second stage juveniles penetrate the root, travel through the cortex and establish feeding sites on vascular parenchyma. The cell contents are liquified and semi digested extra corporeally with the help of hydrolytic enzymes secreted by esophageal gland, eventually resulting in a group of multinucleate giant cells (feeding site). The cortical parenchymatous cells around the giant cells undergo hyperplasia giving rise to primary galls on the roots. This relationship in the nematode is so balanced that continued existence of both the parasite as well as giant cells is necessary for the development and maintenance of the two antagonistic entities. Giant cells induced by the nematode characteristically have transfer cell like wall ingrowth getting into cytoplasm and these are localized in specific region of giant cell wall which are adjacent to vascular tissues.

The present study indicated that there was no significant difference in the mechanism of root - knot nematode infestation in the ornamental plants. The study revealed that xylem vessels were highly damaged by the root-knot nematode . The impairment of the xylem vessels led to the pathogenesis observed in the plant. The flow of water and minerals to the different parts of the plants was suppressed leading to expression of the above ground symptoms. The pholem vessels of healthy and diseased roots did not show any significant difference. Hence it may be presumed that the pholem vessels were not affected by the root - knot nematode in anthurium, begonia and jasmine.The finding is in agreement with the observations made in pepper by Jacob (1977), ginger by Charles (1978), and in kacholam by Rajani (1997).Controversial reports are there regarding the conducting vessels (xylem and pholem) attacked by the nematodes. Siddique (1974) recorded that pholem and infrafascicular region of the root were affected by larvae of *M. incognita*. Shetty and Rudramaniyappa (1992) also reported that the largest site of infection of root - knot nematode was the pholem and ray parenchyma cell in mulberry roots.

5.3 Nematode management

Once nematodes are established in a field its eradication is difficult. Hence maintenance of population of noxious nematodes below economic threshold levels is necessary for economical crop production. The direct and indirect benefits of nematode control include increased quality and quantity of produce, improved health of plants leading to increased ability to withstand adverse growing conditions and better utilization of nutrients and moisture. Several methods applied singly or in combinations, help to reduce the nematode population. . Though the widely adopted practice for nematode control is the application of nematicides, in view of the high cost and hazards associated with this method of control, combined application of different methods is more effective and economical in suppressing nematode population. The tactics to be integrated varies according to the nature and requirement of the nematode problem. In highly remunerative crops like anthurium, the aesthetic value, export potential and conditions under which the crop is grown has to be taken into consideration before adopting control measure for nematode management.

Application of carbofuran 2kg ai ha^{-1} undoubtedly gave good control of the nematode both in soil and root. The result conformed to the findings of Mahajan (1978), Bhagavathy and Phukan (1990), and Mohan and Mishra (1993) .Carbofuran a systemic nematicide, might have protected the plant both by killing the nematode larvae in soil before invading the root by contact action and after invasion by systemic action (Hugh and Thomason, 1975; Volvos and Lamberti, 1976).This accounted for the reduction in the population of nematode in soil as well as in the root in carbofuran treated pots. Application of neem cake alone @ 0.5 per cent w/w and combined application of carbofuran + neem cake at half the dose and carbofuran +neem cake *G. fasciculatum* were also on par with carbofuran treatment alone.

The significant reduction in population of nematodes on addition of neem products have been reported by many workers (Alam ,1990;Bhattacharya and Goswami , 1990). The increase in microbial activity in soil amended with neem product lead to the release of a wide variety of substances which may be directly toxic to the larva penetrating the root system. In the combined treatment involving lower doses of carbofuran and neem cake, initially the nematode population in soil might have been reduced by neem cake and subsequently the residual population of nematode might have been decreased by carbofuran.

Though application of *G. fasciculatum* alone at 200 spores per pot did not prove to be as effective as other treatments for reducing nematode population, integration of *G. fasciculatum* 200 spores per pot with neem cake significantly reduced nematode population in the root. Similar observations were made by Nagesh and Reddy (1997) . Khan and Reddy (1992 a) reported the effectiveness of integration of *G. fasciculatum* with neemcake for reducing root - knot nematode multiplication in crossandra and tuberose . Neem cake acts as an excellent food base for multiplication of *G. fasciculatum* (Channabasappa *et al.*, 1995; Nagesh and Reddy, 1997) aiding in better colonization of the mycorrhizal fungi on the target roots. Consequently, the damage caused by nematodes is offset by improved plant nutrition or altered biochemical constituents. (Cooper and Grandison 1986 , 1987)

While nematode infested plants had a higher root weight, a marked reduction in root weight was observed due to different treatments . Application of carbofuran @ 2kg ai ha^{-1} to nematode infested anthurium plants reduced the root weight significantly (161. 25g). Both decrease in root weight (Dhawan and Sethi 1976; Shetty and Reddy 1985) and increase in root weight (Dhruj and Vaishnav 1981; Thakar *et al.* 1986) as a result of root - knot nematode infestation have been

reported . The increase in weight was attributed to enlargement and fast multiplication of cells, multiple galls, and increased water content.

Results of the study indicated that application of neem cake alone at 0.5 per cent w/w or combined application of lower doses of carbofuran @ 1kg ha $^{-1}$+ neem cake (0. 25 per cent w/w) were equally good as application of carbofuran @ 2 kg ai ha^{-1} for reducing root - knot infestation in anthurium. So under situations where infestation of the nematode is moderately high, application of neem cake, an ecofriendly component at 0.5 per cent w/w alone can be resorted to . When infestation is severe application of carbofuran @ 1kg ha $^{-1}$+ neem cake 0.25 per cent w/w can be done.

The present study indicates the debilitative effect the nematode have on priced ornamental plants. Nematological investigations on ornamental plants have received practically no attention in Kerala. Intensive and systematic surveys of ornamental plants should be conducted in the state with the dual objectives of determining the incidence, prevalence and severity of the pest and the geographical distribution of the nematodes involved. This would go a long way in developing an advisory diagnostic service. Adequate emphasis need to be given to studies on the biology and host parasite relationship of major nematode pests which may lead to formulation of cheap and sound control methods.

SUMMARY

SUMMARY

High cash returns from several ornamental plants has led to their intensive cultivation, bringing in its wake a series of problems. The damage nematodes can cause to highly priced ornamental plants is well established. Rapid development of floriculture in Kerala has necessitated identification of the constraints in its cultivation. Considering the importantce of nematode pests, a survey was conducted in ten locations in Thiruvananthapuram district to identify the major nematode pests of cut flowers (anthurium and orchid), traditional flowers (rose and jasmine) and ornamental foliages (begonia and croton). Histopathological studies were conducted to gain an insight into the mechanism of infestation caused by root - knot nematode in the susceptible plants. Management studies were also done to identify suitable practices for resolving the pest problem.

The important findings of the investigations are summarised below:-

- The root - knot nematode *M.incognita* was the major pest associated with the cut flowers (anthurium and orchid), traditional flowers (jasmine and rose) and ornamental foliages (begonia and croton) in Thiruvananthapuram district. Yellowing and stunting of the plants where noticed in locations where the population of the nematode was high. Infested anthurium plants had small terminal galls while large sized galls spread throughout the root system were seen in begonia and jasmine

- Orchid was least preferred by *M.incognita*

- The burrowing nematode *R.similis* was also found infesting anthurium. Brown necrotic lesions were observed on the roots of the affected plants

- High population of the lance nematode *Hoplolaimus spp.*, spiral nematode *Helicotylenchus spp.* were observed in the rhizosphere of all the ornamental plants surveyed. However no specific damage due to these nematodes could be identified in the plants. The other nematodes observed in the rhizosphere of the plants were *Criconemoides spp.*, and *Pratylenchus spp.*

- Histopathological studies done on the root - knot nematode susceptible plants viz. anthurium, jasmine, begonia showed damaged xylem vessels which affected the translocation of nutrients and water.

- Application of carbofuran 2kg ai ha^{-1}, neem cake 0.5 per cent w/w and carbofuran 1kg ai ha^{-1} + neem cake 0.25 per cent w/w, were found effective for controlling root - knot nematode in anthurium.

REFERENCES

REFERENCES

Alam, M.M. 1990.Control of plant parasitic nematodes with organic amendments and nematicides in nurseries of annual plants. *J. Bangladesh Acad. Sci.*, **14**: 107-113

Alam, M.M., Khan, A.M. and Saxena, S.K. 1973. Some new host records of root - knot nematode *Meloidogyne incognita* (Kofoid and White,1919) Chitwood 1949. *Indian J. Nematol.*, **3**: 159-160

Azam, M. F., Khan, A.M. and Saxena, S. K. 1978. Population of plant parasitic nematode as influenced by certain nematicides around some ornamentals. *Indian J.Nematol.*, **8**: 69-73

Babu, R.S. 1992. Nematodes in jasmine. *Tamil Nadu Agri Univ. Newsl.* **21**:2

Babu, R.S and Vadivelu S. 1988 a .Studies on the nematodes associated with rose . *Indian J. Nematol.*, **18** :139

Babu, R.S. and Vadivelu, S. 1988 b. Pathogenicity of *Meloidogyne sp.* to tube rose (*Polianthes tuberosa* L.) . *Indian J. Nematol.*, **18** : 146-148

Bala,G. and Hosein, F. 1996.Plant parasitic nematode associated with anthurium and other tropical ornamentals. *Nematropica* , **26** : 9-4

Bajaj, H. K. 1989. Phyto and soil inhabiting Nema fauna of Haryana, Publication of Department of Nematology, Haryana Agricultural University. Hissar

Berg – E- Van- den, Quenchcrve, P. and Van-den- Berg, E. 1993. *Criconemoides ornativulvatus sp.* from Martinique. Fundamental and Applied Nematology. **16 : 6** 539-542 .

Bhagawathi,B and Phukan. 1990. Chemical control of *M.incognita* on Pea. *Indian J. Nematol.* **20** : 79-83

Bhattacharya, D and Goswami, B.K. 1990. Effect of different dosages of neem and ground nut oil cake on plant growth characters and population of root-knot nematode, *M. incognita* in tomato. *Indian J. Nematol.*, **18** : 125-127

Chandwani, G.H. and Reddy, T.S.N. 1967. The host range of root-knot nematode *M. javanica* in tobacco nurseries at Rajahmundry, Andrapradesh. *Indian Phytopath.*, **20**: 383-384

Chandel, S.S., Khana, A.S. and Khan, M.L. 1997. Faunistic studies on nematodes associated with Gladiolus L. *Annuals of Agricultural Research.*, **18** : 44 - 47

Channabasappa, B.S., Krishnappa,K.and Reddy,B.M.R.1995. Utilisation of ecofriendly biological agent and bio-components in the integrated management of *R. similis* on banana. National symposium on nematode problems of India- An

appraisal of the nematode management with ecofriendly approaches and bio-components- Abstr. p.42

Charles, J.S. 1978. Studies on the nematode diseases of Ginger (*Zingiber officinale* Rosc) M.Sc (Ag.) thesis, Kerala Agricultural University, Vellayani

Christie, J.R.and Perry,V.G.1951.Removing nematodes from soil. *Proc. Helminth. Soc. Washington.*, **18**:106-108

Cooper, K.M. and Grandison,G.S. 1986. Interaction of vesicular- arbuscular fungi with root-knot nematode on cultivars of tomato and white clover susceptible to *Meloidogyne hapla. Ann. Appt. Biol.*, **108** : 1-11

Cooper, K. M. and Grandison, G.S. 1987. Effect of vesicular- arbuscular mycorrhizal fungi on infection of tomarillo *(Cyphomandra betaces)* by *M. incognita* in fumigated soil. pl.Dis., **71:** 1101-1106

Dale, P.S. 1973. Elimination of root-knot nematode from roses by chemical bare root dips. *New Zealand J. of Exptl. Agric.* **1**: 121-122

Dhawan, S.C. and Sethi C.L.1976. Observation on the pathogenicity of *Meloidogyne incognita* to egg plant and on relative susceptibility of some varieties to the nematode. *Indian J. Nematol.* **6**: 39-46

Dhruj, I. and Vaishnav,M.U. 1981. Pathogenicity of root-knot nematode on

groundnut . *Indian J. Nematol.* **11**: 217 - 218

Edward, J. C., Mishra, S. L., Rai, S. B. and Peter, E.1969. Association of *Pratylenchus chrysanthus* sp. with chrysanthemum root rot. *The Allahabad Farmer* **43**: 175- 272

Gill, J.S. 1981. Fighting the foliar nematode of chrysanthemum. *Indian Hort.* **25** : 2

Gill, J. S. and Sharma. 1976. Additional host range of the foliar nematode. *Aphelenchoides ritzemabosi* from India. *Indian J. Nematol.* **6**: 169-171

Gill, J.S. and Wallia, R. K. 1980. Control of chrysanthamum foliar nematode *A. ritzemabosi* on *Zinnia elegans. Indian J. Nematol.* **10**: 86-88

Goyal, S. and Trivedi, P. C. 1999 . Pathogenicity of *Meloidogyne incognita* on winter ornamentals (*Antirrhinum majus* and *Dianthus barbatus*) . *Indian J. Nematol.* **29** : 85-87

Haider,S. R. and Khan, M. W. 1986. Int. Nematol. Netw. Newsl. **3**:17-18.

Haque, N.G.G. 1972. Nematode disease of flower bulbs, glass house crops and ornamentals. In: Economic nematology (Ed) Webster, J. M., Academic Press Inc. , London. p. 565

Hough, A.and Thomason, I.J. 1975 Effect of aldicarb on the behaviour of *Heterodera sahachtii* and *Meloidogyne javanica* . *J. Nematol* . 7: 221- 222

Jacob,A. 1977.Studies on root-knot nematode of pepper (Piper nigrum L.) M.Sc. (Ag.) thesis. Kerala Agricultural University, Vellayani

Jayaraman, V., Rajendran, G. and Muthukrishnan, T, S. 1975.Occurrence of root - knot nematode in *Polianthes tuberosa L.* in Tamil Nadu. *Indian J. Nematol.* **5**: 101-102

Johansen, D. A. 1940. Plant Microtechnique. Mc. Graw Hill, New York. p.523

Johnson, P.W. and Mc Clanaham, R. J. 1974. Nematode control and effect of soil treatment on green house rose beds with aldicarb and oxamyl. *Pl. Dis. Reptr.* **58**: 730-732

K.A.U. 1997. Biennial report of AICRP on plant parasitic nematode with integrated approach for their control, Vellayani centre p.32

Khan, R.M., and Reddy, P.P. 1989. *Jasminum pubescens* hitherto unrecorded host of *Radopholus similis* from India. *Int. Nematol. Network Newsl.* **6**:19-20

Khan, R.M. and Reddy, P.P. 1992 a . Nematode pest of ornamentals crops. In : Nematode pest of crops (Ed) Bhatti, D. S. and Wallia, R. K., C.B.S. Publishers and Distributors, Delhi p.381

Khan, R. M. and Reddy, P. P. 1992 b. Nematode problem of ornamental crops and their management. *Proc. Nat. Seminar on Commercial Floriculture in India,* Bangalore p.47

Khan,R.M. and Reddy, P.P. 1999. Nematodes associated with chrysanthemum and other crops in Kerala and Karnataka with special reference to *Apratylenchoides homoglans* . *Pest management in Horticultural ecosystem.* **5** : 113-117

Kolodge, C., Radewald, J. D. and Shibaya, F. 1987. Revised host range and studies on the life cycle of *Longidorus africanus*. *J. Nematol.* **19**: 77-81

Lamberti, F., Tacconi, R.,Marinari, A., Errico, F. P., Basile, M. and Errico, F., P.1987. *Difesa-delle- piantc* **10**:1, 77-84

Mahajan, R. 1978. Efficiency of carbofuran for the control of M. incognita on okra. *Indian J. Nematol* **8** : 91-92

Mohan, S. and Mishra 1993 . Management of *M. incognita* infecting french bean through seed coating with chemicals. *Indian J. Nematol.* **23** : 92-94

Mohanty, L. and Das, S. N. 1994. Effect of different inoculum level of *M. incognita* on tuberose *Polianthes tuberosa* L. 0,10, 100, 1000, 5000,10000, 20000, per plant. *Indian J. Nematol.* **24** :249

Muthukrishnan, T.S.,Chandrasekaran, J., Lakshmanan, P.L. and Chinnarajan, A.M.1975. Occurrence of the nematode, *Hemicycliophora labiata*, on roses. *South Indian Hort.* **23:** 75-76

Muthukrishnan, T.S., Vadivelu, S. and Rajendran, G. 1977. *Longidorus africanus* and its pathogenic effect on *Crossandra undulaefolia. Indian J. Nematol.*, 7 : 69-72

Nagesh, M. and Reddy, P.P. 1996 . Management of *M. incognita* on carnation and gerbera in commercial poly house. *Second Intl. Crop Sci. Congress,* New Delhi. P. 349

Nagesh, M., Reddy,P.P. and Rao, M.S. 1996. Integrated management of *M. incognita* on tube rose using *Paecilomyces liliacinus* in combination with plant extract. *Nematol. Medit.* **25**:3-6

Nagesh, M. and Reddy, P.P. 1997. Management of *M. incognita* on *Crossandra undulaefolia* using vesicular arbuscular mycorrhiza, *Glomus mosseae* and oil cake. *Mycorrhiza news* **9** : 12-14

Ohkawa and Saiquasa, T. 1981. Resistance of rose root stalk to *M. incognita, Pratylenchus penetrans* and *P. vulnus. Hort. Sci.* **16**: 559-560

Overman, A. J. 1967. In row and broadcast application of soil fumigant for gladiolus flower production . *Proc. Fla. St. Hort. Soc.* **79**: 481- 484

Overman, A. J. 1970. Gladiolus dip for root-knot nematode control. *Proc. Fla. St. Hort. Soc.* **82**:363-366

Pant,V., Hahim,S., Sing, S.P., and Saxena, S.K. 1983. Susceptibility of different ornamental plants to root - knot nematode and morphometrics of females of *M. incognita*. *Indian J. Nematol.* **13**: 217- 222

Pathak, M. and Siddiqui, A.V. 1996. A new species of *Tylenchorhynchus* found associated with jasmine (*Jasminum grandiflorum*). *Indian J. Nematol.* **26** :274- 277

Pathak, M. and Siddiqui, A.V. 1977.One new and four known species of *Tylenchorhynchus* Cobb 1913 from ornamental crops in Udaipur region of Rajasthan. Indian J. Nematol. **27** : 99-103

Prasad, S.K. and Dasgupta, D. R. 1964. Plant parasitic nematodes associated with roses in Delhi. *Indian J. Ent.* **26:** 120 -122

Rajani, T.S.1998. Bioecology and management of root-knot nematode *M.incognita* (Kofoid and White) in Kacholam (*Kaemperia galanga* Linn). M.Sc. (Ag). thesis Kerala Agricultural University, Vellayani

Rajendran, B. and Rajendran, G. 1979. Report of *Meloidogyne incognita* in *Jasminum sambac* and *J. flexile*. *South Indian Hort.*, **27**:70

Rajendran, G., Vadivelu, S. and Muthukrishnan, T.S. 1976. Pathogenicity of

M. incognita on crossandra. *Indian J. Nematol.* **6:** 115-116

Ramakrishnan, S and Vadivelu S. 1995. Nematodes associated with chrysanthemum and their management. *South Indian Horticulture* **43**: 5-6

Rao, M.S., Janakiraman, T., Rao, T. M. and Pankaj. 1994. Reaction of some cultivar or lines of china aster against *M. incognita. Indian J. Nematol.* **24** : 227-257

Rashid, A.and Khan, A.M. 1975. Studies on the lesion nematode, *Pratylenchus coffeae* associated with chrysanthemum. *Indian J. Phytopath* **28**: 22-28

Reddy, P.P., Singh, D.B. and Rao, V.R.1979 .The root-knot nemetode on gladiolus from India. *Curr. Sci.* **48**:82

Sasser, J.N. and Freckman, D.W. 1986. Economic importance of plant parasitic nematodes. In:A textbook of plant nematology. Ed. Upadhyay,K.D. and Dwivedi,K.Aman publishing house, Meerut. p.148

Sen,K. and Dasgupta, M.K. 1975. Further report on the occurence of *Meloidogynes sp.* on some plants in West Bengal including a few host records from India. *Indian J. Nematol.* **5**:128-129

Sen, K. and Dasgupta, M. K. 1977. Additional host of the root- knot nematode, *Meloidogyne sp.* from India. *Indian J. Nematol.* 7:74

Shetty , K.D. and Reddy, D.D.R. 1985. Pathogencity of *Meloidygne incognita* on *Solanum khasianum* . *Indian J. Nematol.* **15**:185- 186

Shetty, P.S, and Rudramaniyappa, C.K. 1992. Histochemical study on root-knot nematode of mulberry. *Indian Phytopathol.* **45**:361-363

Singh, D.B., Rao, V.R. and Reddy, P.P. 1979. Plant parasitic nematode associated with Horticultural crops in S.India. *Indian J. Nematol.* 9:183- 186

Siddiqui, Z A, Rahid, A, Yunus. M. and Ghouse, A.K.M. 1974. Studies on the reaction-xylem development due to *M.incognita* in the root of *Lagenaria leucantha. Indian J. Nematol* . **4**: 46-52

Siddiqui, M.R., Khan, R.M. and Reddy, P.P. 1991. *Apratylenchoides homoglans* (*Nematoda: Tylenchina*) parasitic on roots of chrysanthemum at Bangalore, India. *Afro- Asian J. Nematol.* **1:** 1- 4

Srinivasan, A. and Muthukrishnan, T.S. 1975. A note on nematode fungal complex in crossandra (*Crossandra undulaefolia*) in Coimbatore. *Curr. Sci.* **44**: 743- 444

Thakar, N.A., Patel, H.R.and Patel, C.C 1986. Comparative pathogencity of root-knot nematode , *M. incognita* on susceptible and resistant varieties of cowpea. *Madras Agric.* J. **72**:288-291

Vadivelu, S. and Muthukrishnan, T.S.1979. Control of root lesion nematode *Pratylenchus delattrei* on crossandra. *Indian J. Nematol.* **9**: 86

Varma, A.C., Yadav, B.S. and Bhargava,S. 1986. First record of the foliar nematode *Aphelenchoides spp.* on chrysanthemum in Rajastan. *Indian J. of Mycol. and pl. Pathol.* **16**: 82-83

Venkitesan, T.S. and Setty, K.G.H. 1977. Pathogencity of *Radopholus similis* to black pepper (*Piper nigrum.* L). *Indian J. Nematol.*, 7: 17-26

Vovlas,N, and Lamberti, F. 1976 Studies on the systemic action of some chemicals in the control of root-knot nematode. *Nematol. Medit.* 4 : 111-113

Zarine,B. and Maqbool, M.A.1991. Description of *Helicotylenchus varecundus sp.* and *Tylenchorhynchus rosei* from Pakistan. *Pakistan J. nematol.* **9:2**, 79-86

ABSTRACT

DISTRIBUTION OF PHYTONEMATODES AND THEIR MANAGEMENT IN ORNAMENTAL CROPS IN THIRUVANANTHAPURAM DISTRICT

By

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ABSTRACT OF A THESIS

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ABSTRACT

A random survey was conducted in Thiruvananthapuram district to gather information about the nematodes associated with cut flowers(anthurium and orchid), traditional flowers(rose and jasmine) and ornamental foliage plants (begonia and croton).

The root - knot nematode *M. incognita* and burrowing nematode, *R. similis* were found associated with these plants. Other nematodes observed were the lance nematode *Hoplolaimus spp.*,spiral nematode *Helicotylenchus spp.* and ring nematode *Criconemoides sp.* Among the cut flowers, anthurium was found to be highly susceptible to root - knot nematode. In ornamental foliage, begonia and traditional flowers, jasmine were found susceptible to the nematode. Small terminal galls were seen in anthurium whereas comparatively large sized galls spread throughout the root system were seen in begonia and croton . Histopathological studies were conducted in anthurium, jasmine and begonia .The xylem vessels were highly damaged in these crops due to nematode attack affecting translocation of nutrients and water.

Studies on nematode management conducted in anthurium revealed no significant difference in the biometric characters of the plant. Significant reduction in root weight was observed in plants receiving different treatments. Treatment of soil with carbofuran 2 kg ai ha^{-1} gave maximum reduction of nematode population in soil. Neem cake 0.5 per cent w/w , carbofuran 1kg ai ha+ neem cake 0.25 per cent w/w and carbofuran 1 kg ai ha^{-1}+neem cake 0.25 per cent w/w +*G. fasciculatum* 200 spores per pot were equally effective in reducing population of nematode in the soil. *G. fasciculatum* 200 spores per pot +neem cake 0.25 per cent w/w gave maximum reduction of nematode in root. A low gall index of 1.25 was observed in plants treated with carbofuran @ 2 kg ai ha^{-1} and carbofuran @ 1 kg ai ha^{-1}+neem cake 0.25 per cent w/w.