Studies on certain aspects of pathogenicity of Pratylenchus thornei on mint and its control

ICAR Sponsored Ad-hoc Project  
(F.No. 2-5/88 pp dated 29.3.1989)

FINAL REPORT OF RESEARCH SCHEME  
28.3.1990 TO 27.3.1993

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PO: CIMAP CAMPUS  
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1. **Project Title**
   Studies on certain aspects of pathogenicity of *Pratylenchus thornei* on mint and its control.

2. **Sanction No.**
   File No. 2-5/88 PP dt. 29.3.1989

3. **Date of Start**
   28.3.1990

4. **Date of termination**
   27.3.1993

5. (a) **Name of the Institute:**
   Central Institute of Medicinal and Aromatic Plants (CIMAP-CSIR), P.O. CIMAP, Lucknow-226015. (India)

   (b) **Division/Section:**
   Plant Nematology Lab., Division of Plant Pathology.

   (c) **Location of Work:**
   CIMAP, Headquarters, Lucknow.

6. **Technical Personnel employed**

<table>
<thead>
<tr>
<th>Name with Designation</th>
<th>Date of Joining</th>
<th>Date of Leaving</th>
<th>Total No. of man month’s spent</th>
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<tr>
<td>Shri P.K. Shukla S.R.F.</td>
<td>28.3.1990</td>
<td>27.3.1993</td>
<td>36 man month’s</td>
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7. **Total outlay**
   Rs. 93,600/= (For three Years)
   Rs. 79000/= (Total grant received from ICAR, New Delhi.

8. **Total amount spent**
   Rs. 82 302/=

9. **Objective (as approved by:**
   Conducting field survey to cover the tarai area of western U.P. for nematode pests of mint as per following programme:

   (i) To study the effect of *Pratylenchus thornei* in sick plots on the growth of the plant and oil contents of three species of mint, *Mentha citrata Ehrh.*, *M. piperita L.* and *M. spicata L.* and to assess crop losses due to nematode infection.
(ii) To determine the seasonal fluctuations of the nematode in the field and the effect of different factors on nematode multiplication.

(iii) To study the effect of organic amendments with oil cakes and other waste products of medicinal and aromatic plants on nematode population and growth/yield of plants and oil contents.

**All the research work given in the objectives (as approved by the panel of ICAR, New Delhi was completed except the following:**

(i) To determine the influence of *P. thornei* on the growth, nematode multiplication and oil yield of *Mentha citrata*, *M. piperita* and *M. spicata* grown in different soil pH.

(ii) To control the *P. thornei* infesting *M. citrata* and *M. piperita* by using oil cakes, nematicides and waste material of medicinal and aromatic plants.

10. **Approved Technical Programme**

For the Year (28.3.1990 to 27.3.1991):

(i) Training of the staff member.

(ii) Survey of experimental beds at CIMAP, Headquarters, Lucknow and district Nainital to identify the plant parasitic nematodes associated with the diseased plants of various mints viz. *M. citrata*, *M. piperita* and *M. spicata*.

(iii) To determine the monthly population of plant parasitic nematodes associated with various mints viz. *M. citrata*, *M. piperita* and *M. spicata* grown in the experimental beds at CIMAP, Headquarters, Lucknow.
(iv) To determine the influence of different initial inoculum densities of *P. thornei* on the growth, nematode multiplication and total oil yield of *M. spicata*.

(v) Maintenance of pure culture of *P. thornei* in pot conditions for glass house studies.

(vi) Maintenance of culture beds of *M. citrata*, *M. piperita* and *M. spicata* in order to determine the monthly population of plant parasitic nematodes.

**For the Year (28.3.1991 to 27.3.1992):**

(i) Survey of mint growing areas of district Nainital and Rampur to identify the prevailing species of plant parasitic nematodes affecting the cultivation of various mints viz. *M. citrata*, *M. piperita* and *M. spicata*.

(ii) To determine the monthly population of plant parasitic nematodes in the rhizosphere of mint viz. *M. citrata*, *M. piperita* and *M. spicata* grown in the experimental beds at CIMAP Headquarters, Lucknow.

(iii) Recording of the data pertaining to the effect of different initial inoculum densities of *P. thornei* on the growth, nematode multiplication and total oil yield of *M. spicata*.

(iv) To determine the effect of various initial inoculum densities of *P. thornei* on the growth, nematode multiplication and oil yield of *M. piperita* and *M. spicata* grown in different soil types.

(v) Maintenance of pure culture of *P. thornei* in clay-pots for glass house experiments.
(vi) Maintenance of culture beds growing M. citrata, M. piperita and M. spicata at CIMAP Headquarters, Lucknow in order to determine the monthly population of plant parasitic nematodes.

For the Year (28.3.1992 to 27.3.1993):

(i) Monthly population of plant parasitic nematodes in the rhizosphere of various mints viz. M. citrata, M. piperita and M. spicata grown in the experimental beds at CIMAP Headquarters, Lucknow.

(ii) Survey of mint growing areas of district Nainital and other districts of Western Uttar Pradesh to identify the prevailing species of plant parasitic nematodes affecting the cultivation of various mints viz. M. citrata, M. piperita and M. spicata.

(iii) Recording of the data pertaining to the effect of various initial inoculum densities of P. thornei on the growth, nematode multiplication and total oil yield of M. spicata.

(iv) To determine the effect of different initial inoculum densities of P. thornei on the growth, multiplication of nematodes and total oil yield of M. piperita.

(v) Recording of the data pertaining to the effect of P. thornei on the growth, nematode multiplication and oil yield of M. piperita and M. spicata grown in different soil types.

(vi) To determine the influence of P. thornei on the growth, nematode multiplication and oil yield of M. citrata grown in different soil types.
11. Detailed Report:  

Introduction

Different mint species viz. Mentha arvensis L. sub sp. haplocalyx Briquet var. piperascens Holmes, M. cardiaca (S.F. Gray) Baker, M. citrata Ehrh, M. piperita L. and M. spicata Huds are important oil bearing plants which are cultivated on a large scale in tropical and subtropical countries of the world. The oils and their principal constituents of these mint species have great demand as they are valued in flavoring, perfumery, cosmetics and pharmaceutical applications. M. arvensis oil is being produced and traded in larger quantities than any other mint oil. About three decades ago, the entire requirements of Japanese mint oil and menthol in India were met through imports. Owing to the efforts made by CIMAP, Lucknow at present more than 800 tonnes oil and 400 tonnes menthol are produced annually with the result that the country has not only become self sufficient but foreign exchange to the extent of about Rs. 1200 lakhs per annum is also saved. Second in order is M. spicata oil, the current production being 80-100 tonnes valued at about Rs. 300 lakhs per annum. Annual production of M. piperita and M. citrata oils are 20 tonnes and 10 tonnes respectively. 

Plant parasitic nematodes are the pathogens in their own right and are capable of producing recognizable disease symptoms on a number of susceptible hosts. Most of the diseases caused by nematode are debilitating (Anon, 1968). Root lesion nematodes (Pratylenchus species) cause significant damage to various crops. They have world wide distribution, extensive host range and involvement with other organisms in disease complexes.

The amount of damage caused by them is governed by a number of factors such as the nematode species, the size of nematode population, susceptibility of host plant, environmental factors and presence of other organisms (Wallace, 1963,1969; Southey, 1970; Webster, 1972; Norton, 1978; Veech & Dickson, 1987).

Information on the nematode tolerance levels of the crop has great significance in the decision making programmes in agricultural production system now being increasingly applied in scientific agriculture. It is known that there is a positive correlation between

(vii) To control the *P. thornei* by using oil cakes and nematicides.

(viii) Maintenance of pure culture of *P. thornei* in clay pots for glass house experiments.

(ix) Maintenance of culture beds growing *M. citrata*, *M. piperita* and *M. spicata* at CIMAP Headquarters, Lucknow in order to determine the monthly population of plant parasitic nematodes.
nematode population level and crop damage. Research in this area has been stimulated by the increasing concern about the overuse of pesticides and rising crop production costs. The equations describing the relationship between nematode numbers and crop response are utilized to determine nematode population threshold levels below which, a particular control method could be considered unnecessary (Ferris, 1978). Studies pertaining to such relationship have been conducted between several nematodes and crops (Lownsberry & Peters, 1955; Olthof & Potter, 1972; Haseeb et al. 1979, 1988, 1990, 1993; Haseeb & Pandey, 1989, 1990; Haseeb & Shukla, 1994 and Haseeb, 1994).

Plant parasitic nematodes and the microorganisms with which they interact, decrease crop yield (Webster, 1972), but the physiological processes which lead to this decreased yield are not adequately studied (Dropkin, 1980; Rouse, 1983). It has been reported that the nematode influences metabolic processes of plants such as water absorption, nutrient uptake, growth hormones synthesis, translocation and these changes in the plant system, directly or indirectly influence the host photosynthetic efficiency.

In India, no systematic work has been carried out on the losses due to Pratylenchus thornei in M. citrata, M. piperita and M. spicata, although indications are that nematodes cause considerable reduction in growth of plant and oil yield. The work pertaining to the present work will generate results on the losses done by nematodes; economic threshold, factors affecting population buildup and control of the nematodes by oil cakes and nematicides. As such studies related to the present project will be helpful in developing the agrotechnology for the cultivation of mint for higher production of menthol.

MATERIALS AND METHODS

I. PRODUCTION OF PLANTING MATERIAL:

Fifteen cm disease free aerial portion of Mentha citrata cv. Kiran, M. piperita cv. MPS-1 and M. spicata cv. MSS-5 were cut and planted singly in 30 cm clay pot containing steam sterilized soil and compost mixture. Pots were watered as and when required. Pots were kept in glass house for sprouting and establishment to individual plants. These plants were sprayed regularly with 0.01 per cent dimecron solution just to ensure that plants were free from insect attack.

II. MAINTENANCE OF CULTURE OF PRATYLENCHUS THORNEI:

Disease free cuttings of aerial portion of ornamental chrysanthemum were planted in 30 cm clay pot containing 7.5 Kg steam sterilized soil and compost mixture. After establishment of cuttings, surface sterilized 100 specimens of Pratylenchus thornei Sher & Allen were inoculated in each pot and kept in glass house for multiplication of the nematode. Soil of these pots were used as the source of inoculum of the nematode for various experiments.
III. SURVEY/SEASONAL FLUCTUATIONS OF PLANT PARASITIC NEMATODES:

A comprehensive survey of district Badaun (I. Rasulpur, II. Ghatpuri, IV. Sethal, V. Mamora, VI. Dataganj, VII. Vilsi, VIII Babrala), Lucknow (different sites of experimental farm of CIMAP), Moradabad (I. Amroha, II. Dhanoura, III. Gajasthal, IV. Shyampur, V. Sambhal, VI. Bachcharaun, VII. Gajaraula), Naintal (different sites of field Station Pantnagar CIMAP Site I. East, II. North, III. Centre, IV. West, V. South) and Rampur (I. Amir Khan ka Majra, II. Kalinagar, III. Khempur, IV. Parchaiee, V. Murseena, VI. Bagh Nazakat Ali Khan, VII. Tashkha, VIII. Chamarpur, IX. Somnagar, XI. Kaganagla, XII. Kameri, XIII. Bilaspur) of western Uttar Pradesh were carried out by taking soil and root samples from the rhizosphere of apparently diseased plants of M. citrata, M. piperita and M. spicata to identify the prevailing species of plant parasitic nematodes particularly root-lesion nematodes. Per cent occurrence of total plant parasitic nematodes/individual nematode species is based on average of 10 different sites of various villages/areas.

Studies pertaining to seasonal fluctuations of plant parasitic nematodes around the rhizosphere of various test species of mints were carried out in the experimental beds at CIMAP Headquarters, Lucknow.

(i) Symptomatology:

The above and below ground symptoms produced due to the infestation of nematode to different mint in fields were observed and details of symptoms were recorded.

(ii) Collection of root and Soil samples:

Soil samples:

During disease survey of various fields of mint, soil samples were collected with the help of khurpi from the rhizosphere of individual mint species separately from each field, 10 samples were taken. The sub-samples were mixed thoroughly and 500 g soil was taken into the polythene bags, tagged with relevant information and the polythene bags were tied with rubber band. The samples were brought to the laboratory and kept in fridge till the isolation of plant parasitic nematodes was made.

Root samples:

Root samples were also collected simultaneously from apparently diseased plants of mint separately as the manner described for soil samples. Root samples collected from individual species were kept in separate polythene bags, tagged with relevant information and polythene bags were tied with rubber band. Later on, the samples were brought to the laboratory and kept in fridge till the isolation of plant parasitic nematodes was done.
Isolation of Plant parasitic Nematodes

Soil from each bulk sample was thoroughly mixed and subsample of 250 g soil was made by using Cobb's sieving and decanting technique along with Baermann funnel (Southey, 1970). The nematode population in 5 g root sample was also determined by macerating the roots/suckers in Waring blender (Southey, 1970). Species of plant parasitic nematodes present in soil were identified and counted in 1 ml counting slide.

Effect of Different Initial Inoculum Densities of \( P. \) thornei on the Growth, Oil Yield and Physiological Changes in M. Citrata, M. Piperita and M. Spicata:

(i) Planting and Inoculation:

Five cm healthy suckers of M. citrata M. piperita and M. spica’ta Obtained from pots which were maintained in glass house for the purpose of planting material, were transplanted singly into 30 cm clay pots containing steam sterilized soil-sand-compost (7:2:1) mixture. Later on, pots were kept in glass-house for establishment. Pots were watered as and when required. At 4th leaf stage, plant of different test species of Mentha were inoculated separately with 250,500,2500, 5000, 10000, 15000, 30000 specimens of \( P. \) thornei obtained from pure culture.

For inoculation with nematodes, four holes, 5 cm deep around the plants within a radius of 1.5 cm from the plant were made and a calculated quantity of nematode suspension was transferred to the holes, using a sterilized pipette. The holes were then plugged by pressing the soil gently. For every test species of Mentha, five pots were left uninoculated which served as control. There were five replicates for each treatment.

(ii) Recording of data:

(a) Plant growth:

One hundred ten days after inoculation, plants were carefully uprooted from pot and the roots were washed in running tap water to remove the adhering soil particles. Excess water was removed with the help of blotting paper. Aerial portion of plants were cut and properly tagged. Plant length was measured by taking herb and root suckers length separately. Fresh weight of individual plant species was determined. For determining dry weight of herb and roots/suckers were dried in an hot air oven at 60°C for 48 hours. Later on herb and root portion of individual species were weighed separately. The per cent reduction in plant growth was also calculated.

(b) Nematode population:

At the end of each experiment, nematode population in 250 g soil and 5 g roots of different treatments were determined separately in the manner described earlier.

(c) Photosynthesis:
Initial measurement of CO₂ exchange rate showed that the third leaf from the apex of plant was physiologically most active and as such the third leaf was chosen. Measurements of net photosynthesis system model LI-6000 (LI-COR. Inc., Lincoln, U.S.A.) on third leaf. The leaf was enclosed in a polycarbonate chamber, in a closed system with the infra red gas analyser. The chamber contained sensors for humidity and temperature measurement. Measurements were made in natural light intensity of 800-1000 uE/ m²/Sec. The measurements were made 5h from beginning of light period.

(d) Estimation of chlorophyll:

Chlorophyll (a, b and total) content of the third leaf was estimated according to the method of Arnon (1949). Fresh leaves (0.2 g) sample was ground in a pestle and mortar. Leaf tissue was homogenized in 80% acetone and the homogenate was filtered through Whatmann filter paper No. 1 into a volumetric flask. Calcium carbonate was added to the sample during grinding to avoid loss of chlorophyll. The process was repeated thrice. Extra solvent was evaporated to make the final volume (V) of extract to 25 ml. The absorbance (A) of extract was recorded at 645 and 663 mm using Bausch and Lomb spectronic-21 and the total chlorophyll, chl a and chl b were calculated by the following formula:

Total Chl=(20.2 x A 645)+(8.02xA663) factor

Chl a = (12.3xA663)-(0.86xA645)x factor

Chl b = (19.3xA645)-(3.60xA663)x factor

Factor = Volume (V)/ 1000 x leaf weight (g)

(e) Extraction of oil:

The essential oil content was determined by hydrodistillation of fresh herb with the help of Clevenger apparatus (Clevenger, 1928). Hundred gram chopped fresh herb was filled into round bottom flask of the apparatus with sufficient amount of water. The flask was kept on a heating mentel running at 85°C. As the water started boiling, oil from herb evaporated through the condensor and started to drop on to the water filled in measuring tube of the apparatus. The process was run for two hours and the volume of oil was measured in ml and per cent oil recovery was calculated on fresh herb basis.

(V) EFFECT OF DIFFERENT SOIL TYPES ON NEMATODE MULTIPLICATION, PLANT GROWTH AND OIL YIELD OF M. CITRATA, M. PIPERITA AND M. SPICATA:

In order to determine the effect of different soil types on the plant growth and multiplication of P. thornei, following procedure was undertaken.

Collection and mechanical analysis of Soil:

Collection of soil was done from different experimental fields at CIMAP and various cultivated lands around Lucknow. Mechanical analysis of these soils was done by the Internation Pippette Method (Piper, 1950). After the analysis, three major soil types viz. loamy sand (81.05% sand, 6.95% silt, 12.00% clay, and 41.00% W.H.C.), sandy loam (66.10% sand, 14.40 silt, 19.50% clay and 43.00% W.H.C) and sandy-clay-
A: Healthy plant of Mentha citrata (left) and plant infected with Pratylenchus thornei (right).

3: Healthy sucker (left) and suckers infected with P. thornei showing necrosis with reduced root hairs/rootlets (right).

FIG. 1
loam (53.60% sand, 22.40% silt, 24.00% clay and 49.00% W.H.C.) were selected for studies.

Planting, inoculation and recording of data was done in the manner described earlier.

(VI) CONTROL OF P. THORNEI INFESTING VARIOUS MINT BY USING OIL CAKES AND NEMATICIDES:

Autoclaved soil treated with linseed (Linum usitatissimum L.), mustard (Brassica comapastris L.), neem (Azadirachta indica Juss.) cakes @ 1g N/kg soil, and aldicarb, carbofuran and ethoprop @ 3 kg a.i./ha. two weeks prior to transplantation of suckers. Ten pots were left untreated, out of which five pots were left uninoculated which served as control. Planting of suckers, inoculation and recording of data was done in the manner as described earlier.

EXPERIMENTAL RESULTS

I. TRAINING OF THE RESEARCH FELLOW IN NEMATOLOGICAL TECHNIQUES:

Soon after joining of Shri Prabhat Kumar Shukla (Sr. Research Fellow) on 28.3.1990, the research fellow was given thorough training on the various theoretical and practical aspects of plant nematological research particularly the aspects related to the objectives of the present project.

II. SURVEY OF PLANT PARASITIC NEMATODES INFESTING VARIOUS MINTS, VIZ. MENTHA CITRATA, M. PIPERITA AND M. SPICATA AT CIMAP HEADQUARTERS, LUCKNOW AND OTHER DISTRICTS OF WESTERN UTTAR PRADESH:

Symptoms:

Studies pertaining to disease survey revealed that in field, initial symptoms were occasional yellowing of leaves and within two to three months time a large portion of the foliage become completely affected. Growth seemed to cease soon after yellowing. Brown to black lesions of various sizes were observed on the suckers. Root hairs and root lets were significantly reduced in comparison to suckers of healthy plants (Fig.1).

Important Plant Parasitic Nematodes:

In general, plant parasitic nematodes viz. Tylenchus sp., Tylenchorhynchus vulgaris, Hoplolaimus sp. Helicotylenchus sp., Pratylenchus thornei, Pratylenchus sp., Rotylenchulus reniformis, Hirschmanniella sp., larvae of Meloidogyne species, Longidorus pisi and Xiphinema sp. were consistently isolated and identified from the rhizosphere of M. citrata, M. piperita and M. spicata. P. thornei and Pratylenchus sp. was predominant nematode species harbouring various mints. Helicotylenchus sp. and T. vulgaris were next to the root-lesion nematode. However, the population of total tylenchid nematodes varies from area to area and among the species of Mentha.
FIG. 2

LOCATIONS

PERCENT OCCURRENCE

PLAN트 PARASITE NEMATODES INFESTED ON MENTHA 01TRATA AT OFFER

LOCALITIES OF PANTIN 14R

10 ROY
6 HOE
8 TIL
7 XP
6 MEL
5 TRH
4 HRL
3 HIL
2 PRTL
1 TOTAL

1340N
1060L
740N
840N
Results pertaining to the occurrence of various plant parasitic nematodes infesting M. citrata, M. piperita and M. spicata grown in five different sites at field station, Pantnagar of district Nainital revealed that the population of total nematode species was highest at site II on M. citrata and M. piperita and lowest at site V on M. citrata and at site I on M. piperita. Whereas, the population of total plant parasitic nematodes was highest on M. spicata at site IV and the lowest at site II. In general, Pratylenchus thornei/Pratylenchus sp. was predominant nematode species. However, the occurrence of Helicotylenchus sp. and T. vulgaris were substantially high, irrespective of plant species (Fig.2-4).

M. citrata:

Highest occurrence of P. thornei (56.99%) was obtained at site I on M. citrata followed by Xiphinema sp. (8.34%), T. vulgaris/Tylenchus (6.95%), Hirschmanniella sp./larvae of Meloidogyne sp./Hoplolaimus sp. (5.56%) and Helicotylenchus sp. (4.17%) respectively. However, R. reniformis was absent at this site. At site II, population of P. thornei (53.75%) was highest on M. citrata followed by Helicotylenchus sp. (3.75%), T. vulgaris (6.25%), Xiphinema sp./Tylenchus sp./R. reniformis (5.00) and Hirschmanniella sp./larvae of Meloidogyne sp./Hoplolaimus sp. (3.75%) respectively. At site III, P. thornei was present 63.45% followed by Hoplolaimus sp./T. vulgaris/Tylenchus sp. (6.75) and R. reniformis (1.35%) respectively. However, Hirschmanniella sp., larvae of Meloidogyne sp., Xiphinema sp. and R. reniformis were absent at this site.

At site IV, P. thornei was present 50.69% followed by Helicotylenchus sp./Tylenchus sp. (10.96%), T. vulgaris (8.22%), Xiphinema sp. (6.85%) and Hirschmanniella sp./larvae of Meloidogyne sp./R. reniformis (4.11%) respectively. However, Hoplolaimus sp. was absent at this site (Fig.2).

P. thornei was 53.64% at site V followed by larvae of Meloidogyne sp. (13.41%), Helicotylenchus sp. (1043%), T. vulgaris/Xiphinema sp. (7.45%), Tylenchus sp. (5.96) and Hirschmanniella sp. (1.49) respectively. However, Hoplolaimus sp. and R. reniformis were absent at this site.

M. piperita:

Population of P. thornei was highest (53.13%) at site I followed by Xiphinema sp. (16.12%), Hirschmanniella sp. (14.49%), Helicotylenchus sp. (6.44%), larvae of Meloidogyne sp. (4.83%), T. vulgaris (3.22%) and Hoplolaimus (1.62%) respectively. No specimens of Tylenchus sp. and R. reniformis were recovered from site I (Fig.3).
For allure at Pan Nagar.

Plant parasitic nematodes infecting Mentha spicata at different...
At site II, *P. thornei* was present 50.22% followed by *Helicotylenchus/T. vulgaris* (11.16%), *R. reniformis* (8.37%), larvae of *Meloidogyne* sp. (5.58%), *Hirschmanniella* sp. (4.65%), *Xiphinema sp./Tylunchus* sp. (3.72%) and *Hoplolaimus* sp. (0.93%) respectively.

At site III, population of *P. thornei* was maximum (71.44%) followed by *Helicotylenchus* sp. (10.64%), larvae of *Meloidogyne* sp. (7.60%), *Tylunchus sp./Hoplolaimus* sp. (4.56%) and *Hirschmanniella* sp. (1.52%) respectively. However, *T. vulgaris*, *Xiphinema* sp. and *R. reniformis* were present at this site on *M. piperita*.

At site IV, population of *P. thornei* was 47.30% followed by *Helicotylenchus sp./larvae of Meloidogyne sp./R. reniformis* (8.80%), *Hirschmanniella sp./T. vulgaris/Tylunchus* sp. (7.70%), *Xiphinema* sp. (2.20%) and *Hoplolaimus* sp. (1.10%) respectively.

At site V, population of *P. thornei* was highest (59.39%) followed by *Helicotylenchus sp.* (13.44%), larvae of *Meloidogyne* sp. (10.08%), *T. vulgaris/Tylunchus* sp. (5.60%), *Xiphinema* sp. (4.48%) and *Hirschmanniella sp. (1.12%) respectively. However, *Hoplolaimus* sp. and *R. reniformis* were absent at this site (Fig.3).

**M. spicata:**

At site I, population of *P. thornei* was maximum (46.40%) on *M. spicata* followed by *Xiphinema* sp. (11.60%), *Hirschmanniella* sp. (10.15%), *T. vulgaris* (8.70%), *Helicotylenchus sp./Tylunchus* sp. (5.80%), *Hoplolaimus* sp./*R. reniformis* (4.35%) and larvae of *Meloidogyne* sp. (2.90%) respectively (Fig.4).

At site II, *P. thornei* was present 54.72% followed by *T. vulgaris/Helicotylenchus* sp. (10.64%), *Tylunchus* sp. (7.60%), *Hirschmanniella sp./Xiphinema* sp. (6.08%), *Hoplolaimus* sp. (3.04%) and *R. reniformis* (1.52%) respectively. However, no specimen of larvae of *Meloidogyne* sp. was recovered from this site.

At site III, population of *P. thornei* was highest (73.01%) followed by *Helicotylenchus* sp. (8.94%), *Xiphinema* sp. (7.45%), *T. vulgaris/Hoplolaimus* sp. (4.47%) and *R. reniformis* (1.49%) respectively. However, larvae of *Meloidogyne* sp., *Tylunchus* sp. and *Hirschmanniella* sp. were not recovered at all.

At site IV, highest population of *P. thornei* was 51.51% followed by *T. vulgaris/R. reniformis* (9.09%), larvae of *Meloidogyne* sp. (8.08%), *Helicotylenchus* sp. (7.07%), *Hirschmanniella sp./Xiphinema* sp. (6.06%) and *Tylunchus* sp. (3.03%) respectively. However, *Hoplolaimus* sp. was not found at this locality.

At site V, population of *P. thornei* was highest (49.30%) followed by *Helicotylenchus* sp. (13.05%), *Hirschmanniella* sp. (10.15%), *T. vulgaris* (8.70%), larvae of *Meloidogyne* sp. (7.25%) and *Xiphinema sp./Tylunchus* sp. (5.80%) respectively. However, *Hoplolaimus* sp. and *R. reniformis* were absent at this site on *M. spicata*. 

13
PLANT PARASITIC NEMATODES INFESTING MENTHA CITRATA IN DIFFERENT LOCALITIES OF RAMPUR DISTRICT

![Graph showing nematode infestation in different localities]
RAMPUR:

Survey studies conducted at 13 different villages of district Rampur revealed that several important plant parasitic nematodes were encountered on M. citrata, M. piperita and M. spicata. Population of total individual nematode species infesting mint varies from village to village and species of mint. Highest population (1540 nema./250 g soil) of total plant parasitic nematodes was encountered in Chamarpur on M. citrata/M. piperita and lowest at village Kaga nagla (720 nema./250 g soil) on M. citrata. P. thornei/Pratylenchus sp. was the most predominant nematode species infesting different mints (Fig.5-7).

M. citrata:

Out of thirteen villages, M. citrata has been cultivated in nine areas. Highest population of total plant parasitic nematodes was found at Chamarpur area and the lowest population encountered at Kaga nagla (Fig.5).

Per cent occurrence of P. thornei was highest (73.32) of Shorn nagar followed by Murseena (50.96%), Chamarpur (48.10), Khempur (45.22), Mominpur (44.16), Parchaiee (43.20), Kameri (40.00), Kaga nagla (38.92) and Taskha (21.84) respectively.

Highest occurrence of Helicotylenchus sp. (22.24%) was found at Kaga nagla followed by Chamarpur (22.10%), Khempur (19.04%), Parchaiee (18.90%), Mominpur (11.52%), Taskha (10.92%), Kameri (10.00%), Shom nagar (8.46%) and Murseena (5.46%) respectively.

Per cent occurrence of T. vulgaris was highest (12.00) at Kameri (12.00) followed by Parchaiee (10.80), Kaga nagla (8.34), Chamarpur (7.80), Khempur (7.14), Mominpur (5.76) and Murseena/Taskha (5.46) respectively. This nematode was absent in Shom nagar area.

Highest occurrence of Hirschmanniella sp. was found at Khempur Village (14.28%) followed by Parchaiee (8.10%), Kameri (8.00%), Mominpur (7.68%) Shom nagar (5.64%), Chamarpur (3.90%) and Taskha (3.64%) respectively. However, this nematode was not found at Murseena and Kaga nagla.

Variation in the occurrence of other plant pathogenic nematodes were observed between the range of 1.30%-20.2%. Highest population of Meloidogyne sp., Xiphinema sp., L. pisi, Tylrenchus sp., Hoplolaimus sp. and R. reniformis was found at Taskha (20.02%), Parchaiee (8.10%), Taskha (12.74%), Khempur (11.90%), Mominpur (17.28%) and Taskha (7.28%) respectively. Criconemoides sp. was found only 4.00% at Kameri.

M. piperita:

Out of thirteen villages surveyed, M. piperita was not cultivated in four villages. Highest population of total plant parasitic nematodes per 250 g soil basis was found at Chamarpur (1540) followed by Bilaspur (1440), Mominpur (1400), Kameri (1220), Murseena (1080), Taskha (1020), Amin Ka Majara (980), Parchaiee (840) and Kaga nagla (780) respectively (Fig.6).
P. thornei/Pratylenchus fep. was the most predominant nematode species found at all the villages. However, it varies between the range of 25.48%-51.80%. Highest population of this nematode was found at Murseena and the lowest at Taskha village.

Per cent occurrence of other plant parasitic nematodes on this crop varies between the range of 1.30-30.72. Highest population of Helicotylenchus sp. was found at Amir Khan Ka Majra (24.48%), Hirschmanniella sp. at Mominpur (14.28%), T. vulgaris at Amir Khan ka majra (14.28%), larvae of Meloidogyne sp. at Kaga nagla (30.72%), Xiphinema sp. at Parchaiee (16.66%), L. pisi at Parchaiee (11.90%), Tylenchus sp. at Amir Khan ka Majra (6.12%), Hoplolaimus at Mominpur (10.10%) and R. reniformis at Taskha (7.84%) respectively. Criconemoides sp. was present only at Kameri (4.92%) and Bilaspur (1.39%) (Fig.6).

M. spicata:

Similarly, M. spicata has been cultivated only in 8 villages, out of 13 localities surveyed. Highest population of total plant parasitic nematodes (1820) per 250 g soil basis was found at Bilaspur followed by Chamarpur (1520), Kali nagar (1400), Mominpur (1280), Bagh Nazakat Ali Khan (1220), Amir Khan Ka Majra (1000), Kaga nagla (860) and Khempur (840) respectively (Fig.7).

Per cent occurrence of P. thornei/Pratylenchus sp. on this crop has always been high. It ranges between 28.00%-50.00%. Population build up of P. thornei was highest at Kali nagar (50.00%) followed by Chamarpur (47.52%), Mominpur (45.24%), Bilaspur (41.80%), Bagh Nazakat Ali Khan (39.36%), Kaga nagla (34.95%), Khempur (28.56%) and Amir Khan ka Majra (28.0%) respectively.

Per cent occurrence of other plant parasitic nematodes varies as in case of M. citrata and M. piperita. It varies between the range of 1.10%-23.30%. Highest population of Helicotylenchus sp. was found at Khempur (19.04%), Hirschmanniella at Khempur (14.28%), T. vulgaris at Amir Khan Majra (22.00%), larvae of Meloidogyne sp. at Mominpur (9.36%), L. pisi at Bagh Nazakat Ali Khan (9.84%), Tylenchus sp. at Khempur (11.90%), Hoplolaimus sp. at Mominpur (10.92%) and R. reniformis at Kaga nagla (11.65%) respectively. Criconemoides sp. was found only 2.20% at Bilaspur (Fig.7).

BADAUN:

Survey studies carried out in eight localities in Badaun district indicate that several species of plant parasitic nematodes were found to be associated with M. citrata, M. piperita and M. spicata. Population of total/individual nematode species infesting mint varies from locality to locality and species of mint. Highest population of total tylenchid nematodes was 1940 nema/250 g soil found at Dataganj on M. citrata. Pratylenchus species/P. thornei was the most predominant nematode species infesting all the three species of mint (Fig.8-10).
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PLANT PARASITIC NEMATODES INFesting MENTHA PIPERITA IN DIFFERENT LOCALITIES AT BADAUN DISTRICT

Figure 9
M. citrata:

At Badaun, out of eight localities surveyed, M. citrata was grown consistently only at four localities. Highest population (1220 nema/250 g soil) of total plant parasitic nematodes was found at Babrala and lowest (780 nema/250 g soil) at Dataganj (Fig.8).

Population of P. thornei was highest (69.86%) at Babrala followed by Sethal (47.92%), Ghatpuri (42.18%) and Dataganj (38.00%) respectively. Whereas, highest occurrence of Helicotylenchus sp. (19.46%) was found at Sethal followed by Dataganj (19.12%), Babrala (8.32%) and Ghatpuri (6.21%) respectively.

Occurrence of Hirschmanniella sp. was highest (6.21%) at Ghatpuri followed by Sethal (3.26%), and Dataganj (1.88%) respectively. Highest occurrence of T. vulgaris (31.42%) was found at Dataganj followed by Ghatpuri (24.10%), Sethal (16.24%) and Babrala (14.43%) respectively.

Per cent occurrence of larvae of Meloidogyne sp. was highest (6.21) at Ghatpuri followed by 4.96 at Dataganj. However, this nematode was not found at Sethal and Babrala on this crop.

Occurrence of L. pisi was highest (10.10%) at Ghatpuri followed by Sethal (7.80%) and Dataganj (1.88%) respectively. However, this nematode was absent at Babrala.

Occurrence of other plant parasitic nematodes was found less than 5 per cent. Highest population of Xiphinema sp., Tylenchus sp. and Hoplolaimus sp. was found at Dataganj (4.96%), Ghatpuri (1.46%) and Sethal (3.26%) respectively. However, R. remiformis was absent at all on M. citrata in all the localities of Badaun district.

M. piperita:

Out of eight localities surveyed, M. piperita was cultivated only in three localities. Highest population (per 250 g soil basis) of plant parasitic nematodes (1560) was found at Alapur followed by Vilsi (1440), Dataganj (1260), Rasulpur (1120) and Sethal (880) respectively (Fig.9).

P. thornei/Pratylenchus sp. was the most predominant nematode species found at all the localities. However, population of this nematode varies between the range of 28.46%-46.89%. Highest population of this nematode was encountered at Sethal and the lowest at Vilsi.

Per cent occurrence of other plant parasitic nematode on this crop varies between the range of 1.02-25.80. Highest population of Tylenchus sp. was found at Alapur (6.52%), T. vulgaris at Alapur (25.86%) Helicotylenchus sp. at Rasulpur (18.21%), Hoplolaimus sp. at Dataganj (5.37%), Hirschmanniella sp. at Vilsi (9.65%), Xiphinema sp. at Dataganj (10.89%), L. pisi at Alapur (6.52%), R. raniformis at Rasulpur (18.21%) and larvae of Meloidogyne sp. at Sethal (5.42%) respectively (Fig.9).
PLANT PARASITIC NEMATODES INFESTING MENTHA SPICATA IN DIFFERENT LOCALITIES AT MORADABAD DISTRICT

Fig. 10
PLANT PARASITIC NEMATODES INFESTING MENTHA CITRATA IN DIFFERENT LOCALITIES AT MORADABAD DISTRICT

FIG. 11
M. spicata:

At Badaun, M. spicata was found to be cultivated at all the localities surveyed. Highest population of total plant parasitic nematodes (per 250 g soil basis) was 1940 found at Ghatpuri followed by Rasulpur (1800), Mamora (1620), Babrala (1520), Dataganj (1400), Alapur (1320), Vils (1180) and Sethal (940) respectively (Fig.10).

Per cent occurrence of P. thornei/Pratylenchus sp. on this crop has always been high. It ranges between 30.86% - 44.28%. The population build up of P. thornei was highest at Mamora (44.28%) followed by Alapur (41.16%), Vils (39.23%), Rasulpur (38.63%), Ghatpuri (35.48%), Sethal (31.88%), Dataganj (31.23%) and Babrala (30.96%) respectively.

Per cent occurrence of other plant parasitic nematodes varies as in the case of M. citrata and M. piperita. It varies between the range of 1.05% - 30.82%. At some places, some species of nematodes were not recovered at all. Highest population of Tylenchus sp. was found at Alapur (5.04%), T. vulgaris at Sethal (27.75%), Hirschmanniella sp. at Sethal (8.26%), Hoplolaimus sp. at Mamora (4.97%), R. reniformis at Alapur (1.26%), larvae of Meloidogyne sp. at Rasulpur (7.42%), Xiphinema sp. at Dataganj (12.82%) and L. pisi at Babrala (7.12%) (Fig.10).

MORADABAD:

Survey conducted at seven different localities in Moradabad district for the association of plant parasitic nematodes infesting various mints revealed that several important plant parasitic nematodes were encountered on M. citrata, M. piperita and M. spicata. Population nematodes of total / individual nematodes species infesting mint varies from locality to locality and species of mint. Highest population (per 250 g basis) of total plant parasitic nematodes (1460) was encountered at Gajraula on M. piperita and lowest at Shyampur (920) on M. citrata (fig.11-13).

M. citrata:

Out of seven localities surveyed, M. citrata has been cultivated at six places. Highest population of total plant parasitic nematodes was found at Bachcharaun and lowest population encountered at Shyampur (Fig.11).

Per cent occurrence of P. thornei was highest (40.67) at Shyampur followed by Dhanoura (38.67), Gajasthal (37.92), Amroha (34.76), Bachcharaun (33.25) and Sambhal (30.82) respectively.

Per cent occurrence of other plant parasitic nematodes on this crop varies between the range of 1.38-28.47. Highest population of Helicotylenchus sp. was found at Bachcharaun (28.47%), Hirschmanniella sp. at Amroha (11.48%), T. vulgaris at Amroha (28.14%), larvae of Meloidogyne sp. at Sambhal (5.53%), Xiphinema sp. at Sambhal (5.62%), Tylenchus sp. at Dhanoura (7.88%), Hoplolaimus sp. at Gajasthal (2.04%), L. pisi at Gajasthal (4.48%) and R. reniformis at Shyampur (7.36%).
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In different localities at Moradabad District, the plant Paraagilo nematode infestation Mentha piperita was studied.
PLANT PARASITIC NEMATODES INFESTING MENTHA SPICATA IN DIFFERENT LOCALITIES AT MORADABAD DISTRICT

FIG. 13
M. piperita:

Out of seven localities surveyed, M. piperita was not cultivated at two localities. Highest population of total plant parasitic nematodes per 250 g soil basis was found at Gajaraula (1460) followed by Dhanoura (128), Amroha (1160), Shayampur (1120) and Gajasthal (1040) respectively (Fig. -12).

P. thornei / Pratylenchus species was the most predominant nematode species found at all the localities. However, it varies between the range of 40.36% -53.21%. Highest population of this nematode was found at Gajasthal and the lowest at Shyampur.

Per cent occurrence of other plant parasitic nematodes on this crop varies between the range of 1.23-28.54. Highest population of Helicotylenchus sp. was found at Shyampur (20.46%), Hirschmanniella sp. at Dhanoura (4.23%), T. vulgaris at Gajaraula (28.92%), larvae of Meloidogyne sp. at Dhanoura (4.23%), Xiphinema sp. at Amroha (7.07%), Tylencehs sp. at Gajasthal (8.48%), Hoploaimus sp. at Shyampur (1.70%), L. pisi and R. reniformis at Gajasthal (5.30%).

M. spicata:

Similarly, M. spicata has been cultivated in five localities out of seven localities surveyed. Highest population of total plant parasitic nematodes (1360) per 250 g soil basis was found at Gajaraula followed by Gajasthal (1300), Sambhal (1260), Amroha (1160) and Bachcharaun (1080) respectively (Fig.13).

Per cent occurrence of P. thornei / Pratylenchus sp. on this crop has always been high. It ranges between 32.48-44.23%. Population buildup of P. thornei was highest at Gajasthal (44.23%) followed by Bachcharaun (40.80%), Amroha (39.08%), Sambhal (36.82%) and Gajaraula (32.48%) respectively.

Per cent occurrence of other plant parasitic nematodes varies as in case of M. citrata and M. piperita. It varies between the range of 1.22-27.68%. Highest population of Helicotylenchus sp. was found at Gajaraula (26.34%), Hirschmanniella sp. at Amroha (8.43%), T. vulgaris at Sambhal (27.55%), larvae of Meloidogyne sp. at Gajasthal (5.92%), Xiphinema sp. at Sambhal (5.51), Tylencehs sp. at Bachcharaun (7.42%), Hoploaimus sp. at Bachcharaun (3.71%), L. pisi and R. reniformis at Gajastha (6.58%) respectively (Fig.13).

III. SEASONAL FLUCTUATIONS OF PLANT PARASITIC NEMATODES AROUND THE RHIZOSPHERE OF M. CITRATA, M. PIPERITA AND M. SPICATA AT LUCKNOW:

Studies conducted during 1990 to 1992 pertaining to seasonal fluctuation of plant parasitic nematodes associated with M. citrata, M. piperita and M. spicata, revealed that several important genera of plant parasitic nematodes viz. Tylencehs sp., Tylenchorhynchus vulgaris, Helicotylenchus sp., Pratylenchus thornei / Pratylenchus sp., larvae of Meloidogyne Sp., Xiphinema sp. and Longidorus pisi were consistently isolated from rhizopheric soil. However, the population of different nematodes varies with eonth to month and species of mint. In general, P. thornei was most dominant nematode species. Population of T. vulgaris,
SEASONAL FLUCTUATIONS OF PLANT PARASITIC NEMATODES ON
MENTHA CITRATA

FIG. 14
SEASONAL FLUCTUATION OF PLANT PARASITIC NEMATODES ON MENTHA PIPERITA

![Graph showing nematode population fluctuations throughout the year.](image)

- PRAT
- O HEL
- + HIR
- X TRH
- ▲ MEL
- △ LONG
- ● XIP
- O TYP

**FIG. 15**
SEASONAL FLUCTUATIONS OF PLANT PARASITIC NEMATODES ON MENTHA SPICATA

FIG. 16
Helicotylenchus sp. and Hirschmanniella sp. were also present in high numbers. Maximum population of total plant parasitic nematodes was found during March in all the test species of mint. Whereas, lowest population was encountered during August (Fig.14-16).

**M. citrata**

Population of *P. thornei* fluctuate between 200-640 nema./250 g soil. Population of this nematode was highest during February (640 nema./250 g soil) which gradually decreased with the season and it reached at lowest population (200 nema./250 g soil) in the month of August.

Population of *Helicotylenchus* sp. did not fluctuate much during most of the months. Nematode population fluctuate between 120-2.20 nema./250 g soil. Highest population of this nematode was obtained during January and the lowest in June.

Similarly, highest population (per 250 g soil basis) of *Tylenchus* sp. (160) was found during March, *T. vulgaris* (260) during May-June, *Hirschmanniella* sp. (220) during March, larvae of *Meloidogyne* sp. (160) during March-April, *Xiphinema* sp. (220) during March and *L. pisi* (140) during March respectively (Fig. 14).

**M. piperita**

*P. thornei* was predominant nematode species through out the year and the population ranges between 260-620 nema./250 g soil. Highest population of this nematode was found in the month of February and lowest in August. Occurrence of *P. thornei* among the total isolated plant parasitic nematodes was 40.30 per cent found during August.

Highest population (260 nema./250 g soil) of *Helicotylenchus* sp. was found in the month of November and the lowest (40 nema./250 g soil) in the month of July.

Highest population (per 250 g soil) of *Hirschmanniella* sp. (240) was found during February, *T. vulgaris* (260) during May, larvae of *Meloidogyne* sp. (200) during March, *L. pisi* (120) during March, *Xiphinema* sp. (180) during March and *Tylenchus* sp. (140) during March respectively (Fig.15).

**M. spicata**

As in case of *M. citrata* and *M. piperita*, *P. thornei* was predominant nematode species in all the months on *M. spicata*. However, the nematode population fluctuates between 320-700 nema./250 g soil. Population of total plant parasitic nematodes was highest during February and lowest in the month of August.

Highest population of *Helicotylenchus* sp. was found during March-April and lowest in July August.
EFFECT OF PRATYLENCHUS THORNEI ON MENTHA CITRATA

FIG. 18

ES3 PLANT LENGTH

- - - - PLANT FRESH WEIGHT

- - - - PLANT DRY WEIGHT

- - - - OIL YIELD

- - - - REPRODUCTION FACTOR

PERCENT REDUCTION

NUMBER OF NEMATODES PER POT

0 250 500 2500 5000 10000 15000 30000

0 10 20 30 40 50 60 70 80 90 100

0 250 500 750 1000 1250 1500 1750 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000 8500 9000 9500 10000

0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000
FIG. 20

NUMBER OF NEMATODES PER POT

PERCENT REDUCTION

REPRODUCTION FACTOR

OIL YIELD

PLANT FRESH WEIGHT

PLANT LENGTH

EFFECT OF PRATYLENCHUS THOREI ON MENTHA PIPERITA
EFFECT OF PRATYLENCHUS THORNEI ON MENTHA SPICATA

FIG. 22

- PLANT LENGTH
- PLANT FRESH WEIGHT
- PLANT DRY WEIGHT
- OIL YIELD
- REPRODUCTION FACTOR

NUMBER OF NEMATODES PER POT

PERCENT REDUCTION
Like M. citrata and M. piperita, population of all other plant par-sitic nematodes varies between 20-260 nema./250 g soil and the population fluctuates with the season as shown in Fig. 16.

IV. TO DETERMINE THE INFLUENCE OF DIFFERENT INITIAL INOCULUM DENSITIES OF *PRATYLENCHUS THORNEI* ON THE GROWTH, OIL YIELD AND PHYSIOLOGICAL CHANGES IN MENTHA CITRATA, M. PIPERITA AND M. SPICATA.

Results as shown in Fig. 17-22 indicates that the various initial inoculum densities (Pi) of P. thornei showed its pathogenic potential on M. citrata, M. piperita and M. spicata in terms of reduction in suckers/herb length (cm), fresh/dry sucker and herb weight (g), chlorophyll content in leaf (mg/g fresh weight), photosynthetic rate (mg CO₂/dm²/hour) and oil yield (ml/100 g fresh herb). In general, with the increase in initial inoculum densities, there was a corresponding decrease in all the growth parameters. Reverse was the trend for nematode multiplication (Rf).

**M. citrata:**

Highest reduction in plant length, fresh and dry plant weight, oil yield, total chlorophyll content and photosynthetic rate was 69.44, 70.10, 70.42, 65.00, 54.55 and 60.05 per cent respectively as against uninoculated control. Highest reproduction factor (Rf=72.00) was obtained in plant inoculated with lowest Pi (250 nema./pot). Whereas, lowest reproduction factor (Rf=2.89) was found at highest Pi (30000 nema./pot) (Fig. 17-18).

**M. piperita:**

Highest reduction in plant length, fresh and dry weight of plant, oil yield, total chlorophyll content and photosynthetic rate was 65.54, 62.19, 65.95, 66.66, 56.25 and 55.22 per cent respectively as against uninoculated control. Highest reproduction factor (Rf=68.40) was obtained in plants inoculated with lowest Pi (250 nema./pot). Whereas, lowest reproduction factor (Rf=3.94) was found at highest Pi (30000 nema./pot) (Fig. 19-20).

**M. spicata:**

Highest reduction in plant length, fresh/dry plant weight oil yield, total chlorophyll content and photosynthetic rate was 66.52, 58.40, 61.06, 61.53, 56.76 and 60.39 per cent respectively in plants inoculated with 30000 nema./pot as compared to uninoculated control. Highest reproduction factor (Rf=66.00) was obtained in plants inoculated with lowest Pi (250 nema./pot). whereas, the lowest reproduction factor (Rf=4.50) was found at highest Pi of 30000 nema./pot (Fig. 21-22).

V. TO DETERMINE THE INFLUENCE OF *P. THORNEI* ON THE GROWTH, OIL YIELD, PHYSIOLOGICAL CHANGES IN M. CITRATA, M. PIPERITA AND M. SPICATA GROWN IN DIFFERENT SOIL TYPES:

Results as shown in Fig. 23-25 clearly indicate that the plant length, fresh/dry weight of plant, oil yield, chlorophyll content and photosynthetic rate was significantly reduced in inoculated plants grown
EFFECT OF DIFFERENT SOIL TYPES ON YIELD OF MENTHA CITRATA AND NEMATODE MULTIPLICATION

NUMERICAL VALUES = TOTAL YIELD

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<th>PLANT DRY WEIGHT (g)</th>
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FIG. 23
EFFECT OF DIFFERENT SOIL TYPES ON YIELD OF *MENTHA PIPERITA* AND NEMATODE MULTIPLICATION

**NUMERICAL VALUES = TOTAL YIELD**

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**FIG. 24**
EFFECT OF DIFFERENT SOIL TYPES ON YIELD OF MENTHA SPICATA AND NEMATODE MULTIPLICATION

NUMERICAL VALUES = TOTAL YIELD

- PLANT LENGTH (cm)
- PLANT FRESH WEIGHT (g)
- PLANT DRY WEIGHT (g)
- OIL YIELD (ml/100 gfw t)
- REPRODUCTION FACTOR

FIG. 25

SOIL TYPES
in sandy-loam, loamy sand and sandy-clay-loam soil types. Per cent reduction in all the growth parameters was very distinct among each other. Similarly, the nematode reproduced well on all the test species of mint. However, reproduction rate varies significantly with the soil type.

**M. citrata:**

Highest reduction in plant length, fresh/dry weight, oil yield, total chlorophyll content and photosynthetic rate was 62.00, 69.54, 68.33, 66.67, 57.92 and 65.36 per cent respectively in plants inoculated with 30,000 nema./pot grown in sandy-clay-loam as against uninoculated control followed by 60.04, 66.14, 64.22, 61.67, 50.86 and 60.26 per cent respectively in loam-sand and 58.30, 63.02, 63.18, 58.46, 47.94 and 57.18 per cent respectively in sandy-loam (Fig. 23).

Similar was the trend in Rf in inoculated plants grown in all the test soil type.

Highest reproduction factor (Rf=2.92) was found in plants inoculated with 30,000 nema./pot grown in sandy-clay-loam followed by 2.63 in loamy-sand and 2.52 in sandy-loam soil respectively.

**M. piperita:**

Highest reduction in plant length, fresh/dry weight, oil yield, total chlorophyll content and photosynthetic rate was 68.01, 67.39, 68.27, 61.67, 55.96 and 60.02 per cent respectively in plants inoculated with 30,000 nema./pot grown in sandy-clay-loam as against uninoculated control followed by 65.73, 64.53, 65.21, 56.00, 54.51 and 56.06 per cent respectively in loamy-sand and 60.77, 61.04, 61.49, 50.00, 51.67 and 53.98 per cent respectively in sandy-loam (Fig. 24)

Reverse was the trend in nematode multiplication in inoculated plants grown in all the three soil types.

Highest reproduction factor was 4.20 in plants inoculated with 30,000 nematodes/pot grown in sandy-loam soil followed by 3.64 in loamy-sand and 3.42 in sandy-clay-loam soil respectively (Fig. 25).

**M. spicata:**

Highest reduction in plant length, fresh/dry weight, oil yield, total chlorophyll content and photosynthetic rate was 65.35, 59.24, 57.17, 58.33, 48.45 and 52.39 per cent respectively in plants inoculated with 30,000 nema./pot grown sandy-clay-loam as against uninoculated control followed by 61.30, 57.78, 55.08, 54.55, 43.59 and 47.73 per cent respectively in loamy-sand and 58.60, 51.20, 47.88, 40.00, 39.57 and 44.56 per cent respectively in sandy-loam soil. Whereas, highest rate of nematode multiplication was 3.76 in plants inoculated with 30000 nematodes/pot grown in sandy-loam followed by 3.56 in loamy-sand and 2.99 in sandy-clay-loam soil respectively.
EFFECT OF DIFFERENT NEMATICIDES AND OIL SEED CAKES ON YIELD OF MENTHA SPICATA AND NEMATODE MULTIPLICATION

FIG. 26
VI. TO CONTROL **P. THORNEI** INFESTING **M. SPICATA** BY USING OIL CAKES AND NEMATICIDES:

Per cent increase (+) or decrease (-) in plant length fresh / dry weight and oil yield of M. spicata in plants inoculated and treated with aldicarb, carbofuran, ethoprop, linseed, mustard and neem cakes was + 9.86, 4.84, + 5.86, - 9.17, + 2.55, + 14.78 respectively; + 9.75, - 6.98, + 2.01, - 8.86, + 1.03, _11.67 respectively; + 9.07, 7.48, + 1.58, 9.98, - 0.91, + 9.75 respectively and + 3.33, - 5.00, + 1.67, - 8.33, 0.00, + 6.67 respectively as compared to untreated uninoculated controls. In the above treatments final nematode population (pf) was 2372, 6152, 3414, 9487, 6820 and 3570 respectively (Fig-26).

12. SUMMARY:

Different mint species viz. Mentha arvensis L. sub sp. Haplocalyx Briquet var. piperascens Holmes, M. cardiaca (S.F. Gray) Barker, M. citrata Ehrh, M. piperita L. and M. spicata Huds are important essential oil bearing plants which are being cultivated on a large scale in tropical and sub-tropical countries of the world. The oil and their principal constituents of these mint species have great demand as they are valued in flavouring, perfumery, cosmetics and pharmaceutical applications.

Beside, other plant pathogens, plant parasitic nematodes are one of the most important pest which causes considerable damage to mint cultivation. In India, no systematic attempt has been made on the losses caused by Pratylenchus thornei on M. citrata, M. piperita and M. spicata, although indication are that nematode causes significant reduction in plant growth and oil yield.

Studies covered in the present project generate the information related to the survey of mint growing areas of western Uttar Pradesh for the association of plant parasitic nematodes infesting different mint, seasonal fluctuation of plant parasitic nematodes associated with various mint, determination of economic threshold of *P. thornei*, factors affecting population build up and control of root-lesion nematode etc.

Studies pertaining to disease survey revealed that generally in fields, the leaves of M. citrata, M. piperita and M. spicata were smaller and plants were stunted. Upon uprooting of such plants, brown to black lesions of various sizes were seen on the suckers and root system was very much reduced. Survey studies also indicate that several important plant parasitic nematodes were isolated from the rhizosphere of apparently diseased plants of all the three species of mint. Pratylenchus thornei/Pratylenchus sp. was the most dominant nematode species to this crop. However, population of *Tylenthorhynchus* sp., Hirschmanniella sp. and Xiphinema sp. were substantially high.

Highest population of total plant parasitic nematodes (per 250 g soil basis) was 1600 on M. citrata, 2140 on M. piperita and 1960 on M. spicata, encountered at Pantnagar of district Nainital. Whereas, the lowest population (per 250 g soil basis) was 720 on M. citrata, 780 on M. piperita and 840 on M. spicata at Rampur district. However, the per cent occurrence of *Pratylenchus* sp./ *P. thornei* was highest on M. citrata.
At Rampur followed by M. spicata (73.01) and M. piperita (71.44) at Pantnagar. Whereas, lowest per cent occurrence of P. thornei was 30.82 on M. piperita at Badaun and 28.00 on M. spicata at Rampur.

Studies pertaining to seasonal fluctuation of plant parasite nematodes associated with M. citrata, M. piperita and M. spicata clearly indicate that nematode population was influenced by seasonal changes, growing period of mint and the species of mint. Highest population of total plant parasitic nematodes was found during March and lowest in August in all the test species of mint. P. thornei was the most dominant nematodes genera followed by Helicotylenchus sp., T. vulgaris, Hirschmanniella sp., larvae of Meloidogyne sp., Tylenceh sp., Xiphinema sp. and L. pisi, respectively. Highest population (700 nema/250 g soil) of P. thornei was encountered on M. spicata in the Month of February. whereas, lowest population (200 nema/250 g soil) was found on M. citrata during August. Highest (per 250 g soil basis) of Helicotylenchus sp. (280) on M. citrata, Hirschmanniella sp. (240) on M. piperita, larvae of Meloidogyne sp. (260) on M. spicata, Longidorus sp. (220), Tylenceh sp. (160) on M. citrata.

Pathogenicity experiment of P. thornei on different mints indicate that inoculation with various initial inoculum densities (Pi) of P. thornei showed its pathogenic potential on M. citrata, M. piperita and M. spicata in terms of reduction in length, fresh/dry weight of plants, oil yield and physiological changes in all the test species of mint. In general, with the increase in initial inoculum level, there was a corresponding decrease in all the growth parameters. Highest reduction in all the growth parameters was obtained in plants inoculated with 30,000 P. thornei/pot. Reverse was the trend for nematode multiplication. Highest reduction in plant length, fresh/dry weight, oil yield, chlorophyll content and photosynthetic rate was 69.44, 70.10, 70.42, 65.00, 54.55 and 60.05 per cent respectively in M. citrata plants inoculated with highest Pi of 30,000 P. thornei/pot. Whereas, lowest reduction in all the above growth parameters was 11.22, 10.5, 11.06, 15.38, 10.14 and 8.71 per cent respectively in M. spicata plants inoculated with lowest (250) initial inoculum density of P. thornei.

Generally, highest reproduction factor was found in plants inoculated with lowest Pi irrespective of mint species. However, highest Rf was 72.00 in M. citrata in plants inoculated with 250 nema./pot. Whereas, lowest Rf (2.89) was also found in M. citrata at Pi of 30,000 P. thornei/pot.

Studies pertaining to the influence of P. thornei on the growth, oil yield and physiological changes in M. citrata, M. piperita and M. spicata plants grown in three different soil types indicate that the significant reduction in plant length, fresh/dry weight, oil yield, chlorophyll content and photosynthetic rate were obtained in inoculated plants grown in different soil types. there was a clear distinction in per cent reduction in the growth of M. citrata, M. piperita and M. spicata between the different soil types i.e. loamy-sand, sandy-loam and sandy-clay-loam. similarly, nematode reproduction was also influenced by soil type. Highest reduction in plant length, fresh/dry weight, oil yield, total chlorophyll content and photosynthetic rate was 62.00,
69.54, 68.33, 66.67, 57.92 and 65.36 per cent respectively in M. citrata plants inoculated with 30000 \( P. \) thornei/pot grown in sandy-clay-loam as against uninoculated control, whereas, lowest reduction in above growth parameters was found 58.60, 51.20, 47.88, 40.00, 39.57 and 44.56 per cent respectively in M. spicata inoculated with 30000 P. thornei/pot grown in sandy-loam soil. Highest reproduction rate (Rf = 4.20) was found in M. piperita inoculated with 30000 P. thornei/pot grown in sandy clay loam soil. Whereas, lowest nematode multiplication (Rf = 2.52) was found in M. citrata inoculated with 30000 P. thornei grown in sandy-loam soil.

Studies pertaining to the control of P. thornei infesting M. spicata by the use of various nematicides (aldicarb, carbofuran, ethoprop) and oil cakes (linseed, mustard, neem) indicate that in general all the treatments were able to increase plant growth and decrease nematode multiplication. However, treatment with neem cake and aldicarb were best for the control of P. thornei followed by ethoprop, mustard cake, carbofuran and linseed cake respectively. Highest increase in plant length, fresh/dry weight and oil yield was 114.78, 111.67, 109.75 and 106.67 per cent respectively obtained in neem cake treated plants as compared to untreated uninoculated control. All the treatments were effective in reducing the nematode population in root and soil.

13. RESULTS WHICH CAN BE EXPLOITED IN PILOT OR FIELD SCALE:

Findings of present project is of basic in nature i.e. to study the disease, quantification of losses and the development of appropriate control measures. Since such studies are feed back to applied research for commercial exploitation, certainly the present studies will be helpful in developing the agrotechnology for the cultivation of mint for higher production of menthol.

14. Papers/Articles prepared/published:

Papers published:


Abstracts published:


15. Suggestions for future lines of research

Area of cultivation of various mint species are being increased day by day because of utility of its oil in flavouring, perfumery, cosmetics and pharmaceutical industries and this crop is also being considered as a foreign exchange earner. However, with the increase in the cultivation, the crop production has declined considerably due to the infestation of important plant parasitic nematodes particularly root-lesion nematode. The present project covers studies pertaining to the survey, seasonal fluctuation of plant parasitic nematodes associated with various mint, economic threshold of Pratylenchus thornei; factors affecting population build up and control of root lesion nematode. However, most of the studies were carried out only in pot conditions.

Keeping in mind with regards to the damage caused by plant parasitic nematodes particularly root-lesion nematodes, studies pertaining to extensive survey of mint growing areas for the nematodes;
crop loss assessment; factors affecting in disease development, screening of germplasm of various mint for disease resistance and control of nematode in field conditions should be taken up. Since, soil borne fungi, bacteria limits the production of mint, studies should also be made to study nematode-fungus/bacteria complex on various mint.

16. Acknowledgements:

I am extremely grateful to Dr. Sushil Kumar, Director, Central Institute of Medicinal and Aromatic Plants, Lucknow for providing the necessary facilities, encouragement and critical suggestions during the course of these investigations. I thank the Indian Council of Agricultural Research (ICAR), New Delhi for financial assistance for carrying out the present work under the project (F. No. 2-5/88-PP).

I also wish to record a special word of thanks to my colleagues for their cooperation.

17. Signature:

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