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Central Institute of Medicinal and Aromatic Plants (CIMAP-CSIR), P.O. CIMAP, Lucknow- 226 015, India

EFFECT OF *PRATYLENCHUS THORNEI* AND *MELOIDOGYNE INCOGNITA*, ALONE AND IN COMBINATIONS, ON THE GROWTH AND OIL YIELD OF *MENTHA ARVENSIS*

by

A. HASEEB[1] and P. K. SHUKLA

Summary. Pathogenicity of *Pratylenchus thornei* at various initial population densities (Pi) and its interaction with *Meloidogyne incognita*, in concomitant and sequential inoculations, were studied on *Mentha arvensis* cv. HY77 in a glasshouse pot experiment. Influence of all the Pi of *P. thornei* and *M. incognita* on the growth and oil yield of *M. arvensis* was inversely proportional and highly significant ($P \leq 0.01$). The influence of *M. incognita* on plant growth was more severe ($P \leq 0.05$) than *P. thornei* at equal Pi. In concomitant and sequential inoculations the greatest reduction in growth of *M. arvensis* was observed in *M. incognita* prior + *P. thornei* post followed by *M. incognita* + *P. thornei* simultaneous, and *P. thornei* + *M. incognita* post, respectively. Final nematode population (Pf) of *P. thornei* and *M. incognita* increased with the increase of Pi and the reproduction factor (Rf) decreased with the increase of Pi. The influence of all Pi on Pf and Rf of both the nematodes was significant ($P \leq 0.05$). *M. incognita* generally produced higher populations ($P \leq 0.05$) than *P. thornei* at equal Pi. In concomitant and sequential inoculations of the two nematodes, their sum Pf was less than that of the 5000 *P. thornei* or *M. incognita* alone. Twenty days prior inoculations of both the nematodes resulted in higher Pf followed by simultaneous and post inoculations respectively. Root-galling index was significantly ($P \leq 0.01$) higher (3.8) at 5000 J2 per pot followed by 2500 *M. incognita* alone (2.8), 2500 *M. incognita* prior (2), simultaneous (1.8) and post (1.3), respectively.

Menthol mint, *Mentha arvensis* (family Labiatae) is the best source of menthol (80-88% in oil) and has been in increasing demand for the flavoring, cosmetic and pharmaceutical industries. In India, cultivation of *M. arvensis* has increased tremendously in the last decade (Bhattacharya, 1998) and as a result, it is now among the leading mint oil exporting countries (George, 1994; Bhattacharya, 1998). Monoculture has increased nematode problems in this crop and has reduced crop production. Root-knot nematodes, *Meloidogyne incognita*, *M. javanica* and the root lesion nematode, *Pratylenchus thornei* are major constraints in the cultivation of menthol mint (Haseeb, 1994) often in concomitant infestations. Therefore, an experiment was conducted to investigate the pathogenicity of *P. thornei* and *M. incognita* at various initial population densities (Pi) and the effect of concomitant and sequential inoculations of *P. thornei* Sher *et* Allen and *M. incognita* (Kofoid *et* White) Chitw. on their reproduction and on the growth of *M. arvensis* L. in glasshouse.

[1] Present Address: Department of Plant Protection, Rafi Ahmad Kidwai Institute of Agricultural Sciences, Aligarh Muslim University, Aligarh - 202 002, India

Materials and methods

Five-cm-long suckers of *M. arvensis* cv. HY77 were transplanted singly into 7.5 kg soil capacity clay pots containing a mixture (9:1) of autoclaved soil (76% sand, 8% silt, 16% clay, pH 7.7) and composted farm cattle manure. Suckers at the fourth leaf stage were inoculated with *P. thornei* and/or *M. incognita* as indicated in Table I. Nematodes were obtained from pure cultures maintained on ornamental *Chrysanthemum* sp. (*P. thornei*) and *Solanum melongena* L. (*M. incognita*). Egg masses of *M. incognita* were picked from roots, allowed to hatch, and then juveniles (J2) separated into a Baermann tray. Populations of *P. thornei* were obtained by isolating from soil using Cobb's decanting and sieving technique followed by Baermann funnel.

Plants were maintained in a glasshouse until the experiment was terminated 100 days after inoculation. Plant growth was determined by considering root length, shoot height, and fresh and dry weight of root and shoot (only dry weight data shown in Table I). Main shoot was cut at the soil surface. Thereafter, the roots were carefully removed from the pots and washed in running tap water. Root and shoot dry weights were determined after drying in a hot air oven at 60 °C. Essential oil content was determined by hydro-distillation of fresh shoot using Clevenger (1928) apparatus. Root-knot index was rated on a 0-5 scale (Taylor and Sasser, 1978). The final nematode population (Pf) in 250 g soil from each replicate for each Pi was determined by sieving with final separation in a Baermann funnel. Nematode numbers in roots were determined by comminuting 5 g fresh root tissue in a warring blender. Final volume of each of the samples was made up to 50 ml and nematode numbers were counted in a one-ml capacity counting slide under stereoscopic binocular microscope. Nematode population in total roots or total soil was calculated. Reproduction factor (Rf) was calculated by the formula, Rf=Pf/Pi.

TABLE I - *Effect of* Pratylenchus thornei *and* Meloidogyne incognita, *alone and in combination, on the growth and oil yield (ml/100 g fresh herb) of* Mentha arvensis.

Initial population densities	Root dry weight (g)	Shoot dry weight (g)	Per cent oil content in fresh herb
0	31.8	51.8	0.82
625 *P. thornei*	29.0 (8.8)	47.5 (8.3)	0.66 (17.1)
1250 *P. thornei*	26.8 (15.7)	44.2 (14.6)	0.65 (20.7)
2500 *P. thornei*	23.7 (25.5)	38.8 (25.1)	0.60 (26.8)
5000 *P. thornei*	20.9 (34.3)	35.1 (32.2)	0.55 (32.9)
10000 *P. thornei*	18.5 (41.8)	31.5 (39.2)	0.45 (45.1)
20000 *P. thornei*	16.8 (47.2)	28.4 (45.2)	0.38 (53.7)
2500 *M. incognita*	23.2 (27.0)	37.6 (27.4)	0.57 (30.5)
5000 *M. incognita*	19.2 (40.3)	31.8 (38.6)	0.46 (43.9)
2500 *M. incognita* + 2500 *P. thornei* simultaneously	20.4 (35.8)	33.5 (35.3)	0.50 (39.0)
2500 *M. incognita* + 2500 *P. thornei* (20 days later)	19.0 (40.3)	32.7 (36.9)	0.48 (41.5)
2500 *P. thornei* + 2500 *M. incognita* (20 days later)	21.9 (31.1)	36.4 (29.7)	0.54 (34.1)
$LSD_{0.05}$	0.69	1.27	0.008
$LSD_{0.01}$	0.93	1.69	0.011

Figures in parenthesis are per cent reduction over uninoculated control.

The experiment was a completely randomized block design with five replicates of each treatment. Five pots were left uninoculated as controls. The data were statistically analyzed by analysis of variance (Cochran and Cox, 1957) and statistically significant differences between the treatments and control were analyzed by least significant difference (LSD).

Results

Data presented in Table I show the significant ($P \leq 0.05$) effect of various initial population densities of *P. thornei* on plant growth and oil yield of *M. arvensis*. An inverse proportional relationship between Pi of *P. thornei* and the above mentioned growth parameters was observed. Reduction in growth and oil yield of *M. arvensis* due to *M. incognita* inoculation was higher than *P. thornei* at equal Pi. At 5000 Pi of *P. thornei*, *M. incognita* or *P. thornei* + *M. incognita*, reduction in root and shoot dry weights and oil yield of *M. arvensis* was highest ($P \leq 0.05$) in plants inoculated with *M. incognita* alone followed by *M. incognita* prior + *P. thornei* post, *M. incognita* + *P. thornei* simultaneously, *P. thornei* alone, and *P. thornei* prior + *M. incognita* post, respectively (Table I). Influence of all the Pi of *P. thornei* or *M. incognita* alone on growth parameters of *M. arvensis* was significant ($P \leq 0.01$) but when compared to concomitant and sequential inoculations of *P. thornei* and *M. incognita* a few non-significant differences were observed. Shoot dry weight between *P. thornei* + *M. incognita* concomitant and *M. incognita* prior + *P. thornei* post, and between *P. thornei* prior + *M. incognita* post and 2500 *M. incognita* alone inoculations were equal ($P \leq 0.05$). Similarly, root dry weight between *P. thornei* + *M. incognita* simultaneous and 5000 *P. thornei* alone and between 2500 *P. thornei* or *M. incognita* alone inoculations were almost ($P \leq 0.05$) equal. However, influence of all the treatments on oil yield was significantly different ($P \leq 0.05$) from each other (Table I).

Influence of various Pi of *P. thornei* and *M. incognita* on Pf in total root, and 7.5 kg of soil, and Rf was highly significant ($P \leq 0.01$) in the single inoculations. Pf increased and Rf decreased with the increase of Pi of *P. thornei* and *M. incognita*. Reproduction of *M. incognita* was significantly higher than *P. thornei* at equal Pi. Pf and Rf of both the nematodes were significantly ($P \leq 0.01$) suppressed in all the combinations as compared to single inoculations at equal Pi. Highest suppression ($P \leq 0.01$) of *P. thornei* was observed in plants inoculated with *M. incognita* prior followed by simultaneous inoculation and *P. thornei* prior, respectively. Similarly highest reduction ($P \leq 0.01$) in reproduction of *M. incognita* was observed in *P. thornei* prior, simultaneous and *P. thornei* post inoculations. Similarly, root galling was significantly ($P \leq 0.01$) influenced by various treatments. Highest root-knot index (3.8) was observed at Pi of 5000 J2/pot followed by 2500 *M. incognita* alone (2.8), *M. incognita* post (1.8), respectively (Table II).

Discussion

Results confirm the high damage potential of *P. thornei* and *M. incognita* on *M. arvensis*. Reduction in growth and oil yield of *M. arvensis* in plants inoculated with *M. incognita* was higher than that from *P. thornei* at equal Pi. These results confirm the high degree of virulence of *M. incognita* as compared to *P. thornei*. Reduction in growth parameters of *M. arvensis* was higher in plants inoculated with *M. incognita* prior to *P. thornei*, which may have provided a better opportunity for parasitism. Contrary to this, when *P. thornei* was inoculated first, the reduction in growth of *M. arvensis* was less due to decreased opportunity of parasitism by *M. incognita*. Host suitability might also have played an important role. *M. arvensis* is a good host of both the nematodes but when *P. thornei* was inoculated first, its faster penetration and migratory habit left fewer feeding sites for *M. incognita* or when *M. incognita* was inoculated first, it changed the physiology of the plant making it less suitable for parasitism by *P. thornei* (Eisenback and Griffin, 1987).

The relationship between growth reduction and Pi and/or Pf was directly proportional in single inoculations with *P. thornei* or *M. incognita* but in simultaneous and sequential inocu-

TABLE II - *Reproduction of* P. thornei *and* M. incognita, *alone and in combination, on* M. arvensis.

Initial population densities (Pi)	*P. thornei*			*M. incognita*			
	Final population		Reproduction factor	Final population		Reproduction factor	Root-knot index
	Total root	7.5 kg soil		Total root	7.5 kg soil		
0	–	–	–	–	–	–	–
625 *P. thornei*	21196	16200	55.0	–	–	–	–
1250 *P. thornei*	30348	26400	45.4	–	–	–	–
2500 *P. thornei*	41496	38400	32.0	–	–	–	–
5000 *P. thornei*	52920	49200	20.4	–	–	–	–
10000 *P. thornei*	58080	60600	11.9	–	–	–	–
20000 *P. thornei*	63216	65400	6.4	–	–	–	–
2500 *M. incognita*	–	–	–	46028	44400	36.2	2.8
5000 *M. incognita*	–	–	–	58032	50600	21.7	3.8
2500 *M. incognita* + 2500 *P. thornei* simultaneously	9224	21000	16.1	27768	25800	21.4	1.8
2500 *M. incognita* + 2500 *P. thornei* (20 days later)	2312	15600	11.2	30780	29400	24.1	2.0
2500 *P. thornei* + 2500 *M. incognita* (20 days later)	29952	32400	24.9	20736	20400	16.5	1.3
$LSD_{0.05}$	1666.2	1241.4	0.95	1796.0	1310.3	1.11	0.07
$LSD_{0.01}$	2243.9	1671.9	1.28	2474.6	1805.4	1.53	0.09

lations the relationship varied. This might be the result of differences in the degree of pathogenicity/reproduction damage potential of *P. thornei* and *M. incognita*, nature of parasitism (Eisenback and Griffin, 1987), time of inoculation (Gay and Bird, 1973), host suitability (Gay and Bird, 1973), mutual inhibition (Estores and Chen, 1972), etc.

In conclusion the results indicate that both the nematode species, alone and in combination, may cause severe yield losses to *M. arvensis*. Therefore, precautionary control measures should be adopted before transplanting *M. arvensis* in fields where high populations of *P. thornei* and/or *M. incognita* are present. Since both the nematodes are endoparasitic, healthiness of planting material should also be confirmed.

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