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Population dynamics and community analysis of plant parasitic nematodes associated with carrot, potato and garlic in the Nilgiris district, Tamil Nadu

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Abstract
Assessment of the plant parasitic nematode population is an important tool for determining the damage caused by nematodes based on which suitable nematode management practices can be recommended. Analysis of distribution, frequency and population of plant parasitic nematode genera associated with the rhizosphere of major temperate vegetables *viz*., carrot, potato and garlic in The Nilgiris district was done. Composite soil samples were randomly collected, processed and nematode population was estimated as per standard protocol. Overall results revealed the presence of 13 genera belonging to 9 families of 2 orders of plant parasitic nematodes in The Nilgiris district. Nematode genera *viz.*, *Pratylenchus* spp, *Helicotylenchus* spp, *Hoplolaimus* spp, *Globodera* spp, *Meloidogyne* spp, *Tylenchorynchus* spp, *Tylenchus* spp, *Aphelenchus* spp, *Xiphinema* spp, *Longidorus* spp. and *Trichodorus* spp. were recorded in the rhizosphere region. The assessment of community structure of plant parasitic nematodes associated with carrot, potato and garlic in The Nilgiris revealed variation in their frequency, density and diversity. In carrot, *Meloidogyne* spp. was the more frequently occurring nematode having an absolute frequency of 96.64% and prominence value of 5.92. In potato, *Globodera* spp. was the more frequently occurring nematode having an absolute frequency of 95.7% and prominence value of 4.55. In garlic, *Pratylenchus* spp. was the more frequently occurring nematode having an absolute frequency of 94.43% and prominence value of 4.15.

Keywords: Plant parasitic nematode, community analysis, distribution and frequency

1. Introduction
The Nilgiris district is basically a horticultural district. Red lateritic is the soil type prevalent in the district. Major horticultural crops cultivated in this district are carrot, potato, cabbage, beans, peas, cauliflower, and Western vegetables like broccoli, leek, celery and lettuce. Due to intensive cultivation of vegetable crops in The Nilgiris, there is more possibility for an increase in nematode population as well as minor pests becoming major pests. There are several nematode species associated with vegetables, some of which cause significant yield loss, while others cause minor injuries. The major nematodes recorded in The Nilgiris are root-knot nematode in carrot and cyst nematode in potato. Northern root knot nematode, *Meloidogyne hapla* severely affects the carrot cultivation and causes 36% avoidable yield losses in The Nilgiris of Tamil Nadu (Anita and Selvaraj, 2011) [1]. The potato cyst nematodes, *Globodera rostochiensis* and *Globodera pallida* occurred at moderate to high densities in many potato-growing villages of Nilgiris hill regions. They cause 33.0-53.4% loss in tubers that may pose serious threat to potato cultivation (Seenivasan, 2017) [11]. In The Nilgiris hills, *M. hapla* was reported to affect the germination of seeds by 15% and carrot yield by 36% (Anita and Selvaraj, 2011; Seenivasan and Sundarababu, 2007) [1, 10]. With this background this study was conducted to assess the occurrence and general distribution pattern of plant parasitic nematodes in The Nilgiris district.

2. Materials and Methods
2.1 Soil sampling and processing
Fifty soil samples were collected at randomly from the rhizosphere of temperate vegetables *viz*., carrot (*Daucus carota*), potato (*Solanum tuberosum*) and garlic (*Allium sativum*), commonly grown in The Nilgiris district. The soil samples were mixed thoroughly and a representative sample of 250 cc was drawn along with root sample (5g).

The soil and root samples were placed in polythene bags and stored in a refrigerator at 5˚C to avoid drying of samples. The soil samples were processed by Cobb's decanting and sieving method (Cobb, 1918) [3], followed by modified Baermann's technique (Southey, 1986) [13] for extraction of nematodes. The roots were cut into pieces of 1 cm and macerated in a blender. The nematodes present in the residues were extracted by modified Baermann's technique (Southey, 1986) [13]. The nematodes collected were killed by heat and fixed by adding an equal volume of 4% formalin. Absolute frequency, relative frequency, Absolute density, relative density and prominence value were determined by using the following formulae (Beals, 1960) [2].

2.2 Statistical analysis

Parameters for community analysis of various nematode genera were calculated using formulae by Norton (1978) [8].

$$\text{Absolute Frequency} = \frac{\text{Number of samples containing species}}{\text{Number of samples collected}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Sum of frequencies of all species}} \times 100$$

$$\text{Relative Density} = \frac{\text{Number of individuals of a species in a sample}}{\text{Total of all individuals in a sample}} \times 100$$

$$\text{Absolute Density} = \frac{\text{Number of individuals of a species in a sample}}{\text{Volume or Mass or Unit of the sample}} \times 100$$

$$\text{Prominence value} = \frac{\text{Absolute density}\sqrt{\text{Absolute frequency}}}{100}$$

3. Results and Discussion

The predominant plant parasitic nematodes and other nematode species occurring in temperate vegetables in The Nilgiris district of Tamil Nadu are shown in Table 1.

3.1 Community structure of nematodes associated with carrot

An analysis of nematode communities (Table 2) revealed the presence of 7 genera of plant parasitic nematodes associated with carrot. *Meloidogyne* spp. was the more frequently occurring nematode having an absolute frequency of 96.64%, *Pratylenchus* spp. of (86.64%). These were followed by *Helicotylenchus* spp. 82.74%, *Hoplolaimus* spp. (81.64%), *Tylenchorynchus* spp. (74.96%), *Globodera* spp. (73.31%). *Tylenchus* spp. was least frequently occurring species of 62.18% in carrot. *Meloidogyne* spp. (60.24%) had the highest absolute densities, followed by *Helicotylenchus* spp. (28.60%) and *Pratylenchus* spp. (26.76%). These were followed by *Tylenchorynchus* spp. (21.93%) *Tylenchus* spp. (20.78%) and *Hoplolaimus* spp. (20.34%). *Globodera* spp. had the least absolute density of 12.53%. Likewise, the highest relative density was recorded for *Meloidogyne* spp. (24.73%), *Helicotylenchus* spp. (18.92%), *Pratylenchus* spp. (17.08%) followed by *Hoplolaimus* spp. (13.33%) and *Tylenchorhynchus* spp. (13.26%). The least relative density was observed in *Tylenchus* spp. (7.2%). Considering both frequencies and densities, the prominence value was higher in *Meloidogyne* spp. (5.92), *Pratylenchus* spp. (2.62) followed by *Helicotylenchus* spp. (2.56), *Tylenchorynchus* spp. (1.95), *Hoplolaimus* spp. (1.84) and *Tylenchus* spp. (1.82). The least prominence value was recorded in *Globodera* spp. (1.02).

3.2 Community structure of nematodes associated with potato

An analysis of nematode communities associated with potato (Table 3) revealed the presence of 6 genera of plant parasitic nematodes associated with potato. *Globodera* spp. was the more frequently occurring nematode having an absolute frequency of 95.7%, *Pratylenchus* spp. 90.82% and *Tylenchus* spp. 78.32%. These were followed by *Helicotylenchus* spp. (73.31%) and *Hoplolaimus* spp. (59.98%). *Meloidogyne* spp. was least frequently occurring species of (54.15%) in potato. The cyst nematode *Globodera* spp. had the highest absolute densities of 46.56%, *Pratylenchus* spp. (44.0%), *Tylenchus* spp. (25.40%). These were followed by *Helicotylenchus* spp. (17.66%). Lance nematode, *Hoplolaimus* spp. (10.05%) and root knot nematode, *Meloidogyne* spp. had the least absolute density of 10.00%. Likewise, the highest relative density was recorded for *Globodera* spp. (34.65%), followed by *Pratylenchus* spp. (31.57%). These were followed by *Tylenchus* spp. (21.3%), *Helicotylenchus* spp. (14.82%) and *Hoplolaimus* spp. (8.46%). The least relative density was observed in *Meloidogyne* spp. (8.35%). Considering frequencies and densities, the prominence value was higher (4.45) in *Globodera* spp. followed by *Pratylenchus* spp. (4.19), *Tylenchus* spp. (2.4), *Helicotylenchus* spp. (1.52) and *Meloidogyne* spp. (0.9). The least prominence value was recorded in and *Hoplolaimus* spp. (0.75).

3.3 Community structure of nematodes associated with garlic

An analysis of nematode communities (Table 4) revealed the presence of 5 genera of plant parasitic nematodes associated with garlic. *Pratylenchus* spp. was the more frequently occurring nematode having an absolute frequency of 94.43%, *Helicotylenchus* spp. (79.15%), *Tylenchorynchus* spp. (74.96%) and *Hoplolaimus* spp. (65.28%). *Tylenchus* spp. was least frequently occurring species of 54.13% in garlic. *Pratylenchus* spp. 42.03% had the highest absolute density, *Helicotylenchus* spp. (29.23%). These were followed by *Hoplolaimus* spp. (18.51%), *Tylenchorynchus* spp. (15.16%) and *Tylenchus* spp. with the least absolute density of 10.04%. Likewise, the highest relative density was recorded for *Pratylenchus* spp. (36.34%), *Helicotylenchus* spp. (26.0%). These were followed by *Hoplolaimus* spp. (15.87%), *Tylenchorynchus* spp. (13.29%). The least relative density

was observed in *Tylenchus* spp. (8.46%). Considering both frequencies and densities of plant parasitic nematodes associated with garlic, the prominence value was high in *Pratylenchus* spp. (4.15), *Helicotylenchus* spp. (2.86). These were followed by *Hoplolaimus* sp. (1.54), *Tylenchorynchus* sp. (1.29) and *Tylenchus* spp. had the least prominence value of 0.76.

Soil nematodes are ubiquitous and important soil inhabitants. The assessment of community structure of plant parasitic nematodes associated with carrot, potato and garlic in Nilgiris revealed variation in their frequency, density and diversity which may be due to ecological and edaphic factors as reported by Khatoon *et al*. (2001) [5]

Plant-parasitic nematodes are a major cause of carrot disease as they can cause stunting or forking of carrot roots, reduce water and nutrient uptake efficiency, and decrease crop growth (Greco and Brandonisio 1980 [4]; Vrain and Belair, 1981) [14]. In the present study the major nematode associated with carrot was root knot nematode which is in confirmation with the previous reports by Seenivasan, (2017) [12].

The present survey results revealed cyst nematodes, *Globodera* spp. and *Pratylenchus* spp. to be more predominant in the potato growing regions in The Nilgiris. Ramakrishnan *et al*. (2015) [9] have reported that there was considerable increase in PCN incidence as per Grainger's test throughout the potato growing areas of The Nilgiris district in spite of the use of chemical and nonchemical management strategies to contain the PCN. However, there is not much information on the association of *Pratylenchus* spp. in potato in The Nilgiris district.

Root lesion nematode *Pratylenchus* spp. has been reported to be associated with garlic in Oman (Mani *et al*. 1997) [6] and in Yemen (Mohamed 2015) [7], Similarly in the present study *Pratylenchus* spp. was the predominant species recorded for the first time in garlic in The Nilgiris.

Based on the study conducted it is concluded that plant parasitic nematodes both endo and ectoparsites are distributed in the rhizosphere of temperate vegetable crops grown in The Nigiris. Though root knot nematodes and cyst nematodes are the major plant parasites associated, it was also observed that the lesion nematode *Pratylenchus* spp. to be predominantly associated with potato, carrot and garlic. This nematode being a migratory enodparasite can also cause damage to the crop. The damage potential of *Pratylenchus* spp. on temperate vegetable crops like potato, carrot and garlic needs to be further investigated for reducing crop loss.

Table 1: Predominant plant parasitic nematodes present in temperate vegetable crops in The Nilgiris district

S. NO	Crops	Predominant Nematodes	Other nematode species
1	Carrot	*Meloidogyne* spp. *Pratylenchus* spp. *Helicotylenchus* spp. *Hoplolaimus* spp. *Tylenchorynchus* spp.	*Tylenchus* spp. *Trichodorus* spp. *Xiphinima* spp.
2	Potato	*Globodera* spp. *Meloidogyne* spp. *Pratylenchus* spp. *Helicotylenchus dihystera,*	*Hoplolaimus* spp. *Tylenchorynchus* spp. *Tylenchus* spp.
3	Garlic	*Pratylenchus* spp. *Helicotylenchus multicinctus, Hoplolaimus* spp.	*Tylenchorynchus* spp. *Tylenchus* spp. *Aphelenchoides* spp.

Table 2: Population structure, frequency, density and prominence value of soil inhabiting plant parasitic nematodes of carrot crop in The Nilgiris district

Nematodes	Population (250cc soil)	Frequency		Density		Prominence value
		Absolute	Relative	Absolute	Relative	
Pratylenchus spp.	66.92 (3.33-107.5)	86.64	15.96	26.76	17.08	2.62
Helicotylenchus spp.	71.46 (34.6-110.0)	82.74	15.26	28.60	18.92	2.56
Hoplolaimus spp.	50.63 (20.83-68.33)	81.64	14.90	20.34	13.33	1.84
Tylenchorynchus spp.	50.22 (9.16-111.6)	74.96	13.67	21.93	13.26	1.95
Tylenchus spp.	47.96 (6.66-93.33)	62.18	12.47	20.78	12.69	1.82
Meloidogyne spp.	150.6 (22.8-250.8)	96.64	13.28	60.24	24.73	5.92
Globodera spp.	64.99 (12.3-63.1)	73.31	13.56	12.53	7.20	1.02

Table 3: Population structure, frequency, density and prominence value of soil inhabiting plant parasitic nematodes of potato crop in The Nilgiris district

Nematodes	Potato					
	Population (250cc soil)	Frequency		Density		Prominence value
		Absolute	Relative	Absolute	Relative	
Pratylenchus spp.	110.0 (44.7-150.3)	90.82	21.08	44.0	31.57	4.19
Helicotylenchus spp.	44.15 (21.66-67.5)	73.31	18.20	17.66	14.82	1.527
Hoplolaimus spp.	25.14 (16.4-37.1)	59.98	13	10.05	8.46	0.75
Tylenchus spp.	63.52 (44.3-100.2)	78.32	18.16	25.40	21.3	2.4
Globodera spp.	116.4 (74.6-162.3)	95.7	26.11	46.56	34.65	4.55
Meloidogyne spp.	25(14.6-40.1)	54.15	11.68	10	8.35	0.9

Table 4: Population structure, frequency, density and prominence value of soil inhabiting plant parasitic nematodes of garlic crop in The Nilgiris district

Nematodes	Garlic					
	Population (250cc soil)	Frequency		Density		Prominence value
		Absolute	Relative	Absolute	Relative	
Pratylenchus spp.	105.1 (38.33-168.75)	94.43	25.03	42.03	36.34	4.15
Helicotylenchus spp.	73.88 (45-101.6)	79.15	25.43	29.23	26	2.86
Hoplolaimus spp.	46.28 (20-78.33)	65.28	17.22	18.51	15.87	1.54

Tylenchorynchus spp.	37.91 (14.1-48.1)	74.96	19.69	15.16	13.29	1.29
Tylenchus spp.	25.1 (10-48.75)	54.13	14.27	10.04	8.46	0.76

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