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Community analysis of plant parasitic nematodes infesting vegetable crops under polyhouse conditions

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Abstract
Polyhouse cultivation of fruits, vegetables and flowers is an emerging production technology as it overcomes biotic and abiotic stresses and breaks the seasonal barrier for round-the-year production. The present investigation was undertaken to analyze the different parameters of community analysis of important plant parasitic nematodes associated with the vegetable crops *viz*., tomato, cucumber and capsicum in the districts located at NCR region of Delhi *viz*. Alwar and Sonipat. Plant parasitic nematodes *viz*., *Meloidogyne incognita, Rotylenchulus reniformis, Pratylenchus* spp., *Hoplolaimus* spp., *Helicotylenchus* spp., *Tylenchorynchus* spp. etc. was found to be associated with these crops. It has been observed that *M. incognita* population was found to be maximum in all the three crops at both the districts of NCR region. The prominence value was found to be maximum for root knot nematode in all the vegetable crops *viz*. tomato, capsicum and cucumber having 592.9, 223.4 and 910.6 J2 per 200 cc respectively. The data also revealed that *M. incognita* absolute frequency in tomato and tomato + capsicum mixed cropping was 100% and in cucumber was 92.9%. From these studies it can be interpreted that *M. incognita* is most predominant nematode and cause damage substantially to all the vegetable crops grown in polyhouse conditions and also responsible for reduction in the yield of vegetable crops in protected cultivation.

Keywords: Absolute frequency, community analysis, *Meloidogyne incognita*, prominence, polyhouse

Introduction
India is bestowed with diverse agroclimatic conditions, which enables the farmers to grow all kinds if horticultural crops, almost throughout the year in one part of country or other. But sometimes the consistent production is not guaranteed as the crop is exposed to number of environmental factors that change frequently. In this context the most important technology is Controlled Environmental Agriculture (CEA), which is also known as Protected Cultivation Technology (PCT) such as greenhouses, polyhouses, net-houses and glasshouses. The technology of raising the vegetables and ornamental flower crops is gaining importance in protected cultivation as there is demand for high quality, export oriented horticultural products and need for the availability of horticultural crop produce round the year *i.e.*, in the off season. Due to this the farmers started cultivation of the horticultural crops under protected cultivation in most of the states of India like Rajasthan, Haryana, Himachal Pradesh, Karnataka, Maharashtra etc. In Rajasthan, estimated area under the protected cultivation is around 3,65,000 sq m and the major districts under this protected cultivation are Jaipur, Alwar, Chittorgadh, Udaipur, Kota and Sawai Madhopur. Haryana have different types of polyhouses including Hi-tech, WIT, AINSH, NVPH with covered area of 17,57,920 m^2 and also gained the vast scope for growing off season fruits and ornamentals under the ages of National Horticulture Mission (Anonymous, 2020) [1].

Maximum number of polyhouses has been adopted in Sonipat followed by Karnal, Bhiwani and Rohtak districts of Haryana (Kumar *et al*., 2018) [2]. This has given a good return to the farmers due to wide utilization of vertical area of the field, protection from insect pests and diseases and availability of controlled conditions. As a result of this continuous cultivation of the same crop and availability of high temperature and moisture, increased the problems of soil borne pest and diseases including plant parasitic nematodes. The proliferation rates of nematodes reached upto 10 to 30 folds more than in open field conditions. Within one or two year the population builds up very rapidly and reaches five to six times of thresholds levels. The degree of damage depends upon the population growth of nematodes which are influenced by the initial population (Udo and Ugwuoke, 2010 and Chandra et al., 2010) [3, 4].

The preliminary survey of some polyhouses has been carried out under the activity of AICRP (Nematodes), New Delhi in some of the villages (Table. 1) of Sonipat and Alwar districts. Alwar district has less incidence of *M. incognita* and other PPNs as compared to polyhouses of the Sonipat district. Keeping this in view a present investigation on the survey aspects has been carried out to map out the population status and dynamics of root-knot nematode and other parasitic nematodes associated on vegetable crops with the objective to assess the nematode community structure. Community analysis is an important criterion for assessment of the pathogenic potential region and identification of hotspots in particular areas. The abundance as well as distribution of plant parasitic nematodes is influenced by the soil texture, cropping pattern, control measure and anthropogenic factors (Chirchir *et al*., 2008, Patil *et al.*, 2020 and Patil *et al.*, 2021) [5, 6, 7]. Moreover, nobody till date has reported the community analysis of nematodes in polyhouses of Sonipat and Alwar districts, hence this will be the first recorded documentation.

Material and Methods

A nematode random survey was conducted to find out important plant parasitic nematodes associated with tomato, capsicum and cucumber in polyhouses located in NCR region of Delhi *i.e*. from Alwar, Rajasthan and Sonipat, Haryana. Twenty-three samples were collected from tomato, capsicum, tomato + capsicum (mixed cropping) and cucumber. These samples were collected from poorly growing plants which showed stunting and chlorosis symptoms on the foliage from a depth of 20-25cm. In this survey, to perform the community analysis the nematodes extraction was done by Cobb's sieving and decanting method (Cobb, 1918) [8] followed by modified Baermann's funnel technique (Schindler, 1961) [9] and the suspensions were collected. Genera of important plant parasitic nematodes in the suspension were identified and counted under the stereo binocular microscope. The population densities of the different nematode species in the sample were calculated using the formulae as given by Norton (1978) [10].

$$\text{Absolute frequency} = \frac{\text{No. of samples containing the species}}{\text{Total no of samples collected}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequencies of the species}}{\text{sum of frequencies of all the species}} \times 100$$

$$\text{Absolute density} = \frac{\text{No. of individuals of the species in the sample}}{\text{volume or units of sample}} \times 100$$

$$\text{Relative density} = \frac{\text{No. of individuals of the species in the sample}}{\text{total of the individuals of sample}} \times 100$$

$$\text{Prominence value} = \text{Absolute density } X \sqrt{\text{absolute frequency}}/\ 100$$

Also, the communities of the plant parasitic nematodes of both districts were compared with Bray and Curtis Similarity index (1957) [11].

S= 2W/A+B. where S is the similarity index ranging from 0 (no similarity) to 1.0 (complete similarity).

Results and Discussion

Distribution and community structure of plant parasitic nematodes on vegetable crops in polyhouse conditions: District wise nematode population found per 200 cc soil (Table 2) revealed that the presence of six important genera of plant parasitic nematodes *viz*., *Meloidogyne incognita*, *Rotylenchulus reniformis*, *Pratylenchus spp.*, *Hoplolaimus spp.*, *Helicotylenchus spp.*, and *Tylenchorynchus spp.* The maximum population of *M. incognita* (2942.5) was observed in Pinana village of Sonipat district of Haryana and minimum was found at Chauna village situated at Alwar district. Crop wise community structure was recorded in Table 3. The highest relative frequency was recorded for *M. incognita* and *Helicotylenchus* spp. (27.3%) followed by *Tylenchorynchus* spp. (18.2), *R. reniformis*, *Pratylenchus* spp. and *Hoplolaimuns indicus* recorded (9.1%) each on tomato crop. The highest relative density was recorded for *M. incognita* (62.6%) followed by *Pratylenchus* spp. (11.6%) *Tylenchgorynchus* spp. (10.9%), *Helicotylenchus* spp. (5.9%), *R. reniformis* (5.5%) and *Hoplolaimus* spp. (3.5%) on capsicum crop. Tomato and cucumber mixed cropping data results were found different, as maximum relative density is of *Tylenchorynchus* spp. (42.3%) followed by *M. incognita* (36.6%) and *R. reniformis* (21.1%). The relative frequency and relative density on cucumber crop of *M. incognita* (27.1, 67.5%) was recorded followed by *Tylenchorynchus* spp. (20.8 and 12.6%) and *Helicotylenchus* spp. (22.9 and 8.9%).

Crop wise maximum average frequency of *M. incognita* (100%) was recorded on tomato and tomato +capsicum followed by cucumber and capsicum. The prominence value of *M. incognita* (592.9%) was recorded maximum compared to other plant parasitic nematodes on tomato followed by cucumber, capsicum and tomato + capsicum. Hence it can be revealed the presence of root-knot nematode is the most predominant species having highest prominence value followed by *Helicotyelnchus* spp. causing damage substantially to all the vegetable crops grown in polyhouse conditions and responsible for reduction in the yield of vegetable crops. It has been also observed that the total number of plant parasitic nematodes associated with villages of Sonipat districts is more compared to samples collected from Alwar districts (Table. 2).

Differences in communities of plant parasitic nematodes among the villages of Sonipat and Alwar districts increased with increasing the distance between to regions. The high similarity was observed between Badwasini and Manauli villages (0.69) of Sonipat districts and between Chauna and Nangli villages (0.9) of Alwar districts having similar latitude and climatic conditions. The common genera of plant parasitic nematodes observed in this study where similar to nemic population dynamic studies under Hi tech cultivation of tomato, sweet pepper and cucumber under Indo Israel projects at IARI., where 20 and 45% damage in tomato and cucumber was observed respectively due to *M. incognita* predominantly. The population of root-knot nematode is comparatively less in capsicum (3160 J2/200 CC soil) compared to tomato and cucumber (5992 and 9448 J_2/200 CC soil). Root-knot nematode is a severe pest of tomato and sweet pepper is the least affected crop during the analysis of nematode problems in greenhouse cultivation in Himachal Pradesh (Sharma, et al., 2007) [12]. The results are also confirmed by Chandel et al, 2010 [13] who surveyed 214 greenhouses compromising of sweet pepper, carnation, cucurbits, tomato and cauliflower and found *M. incognita* to be predominant with a population range from 8-5604 J_2 in soil and 15-4288 individuals /5 g of roots.

It has been observed that in the NCR region tomato and cucumber grown under polyhouses in Gurugram, Sonipat and Alwar in Rajasthan were heavily infested with root-knot

nematode. The observation taken in this paper revealed that disease severity of root-knot nematode was reduced in Alwar villages because the polyhouse growers adopted soil solarization in the month of May- June which helped the maximum reduction of the root-knot nematode population.

Current investigations are related to the findings of Kumar et al. 2008 [2], Gautam et al. 2014 [14] and Patil et al. 2007 [15] where *M. incognita* was found to be most prevalent in cucumber crops sown in polyhouse conditions. Singh et al. (2016) [16] conducted the survey to determine the status of nematodes associated with French bean, cucurbits, tomato, crucifers and potato under polyhouse conditions and the results were again matched with our conclusions that *M. incognita* population was maximum with the population range of 28-20,000 J_2/200cc in tomato followed by 11-573 J_2/200cc in cucumber. Avoidable losses due to this nematode in greenhouse tomato were estimated to be 11.31 per cent during 2008-09 Sharma at al., 2009, Chandel at al. 2010 [17, 18]. This information on nematode occurrence on vegetable crops will be helpful for growers for planning and administering nematode management to reduce the nematode populations below their economic threshold levels.

Table 1: Agro climatic conditions between two districts of Alwar and Sonipat

	Alwar district	**Sonipat District**
Soil type	Alluvial Soils, red sandy soils	Fine loamy soils
Altitude	250 msl	224 msl
Latitude	27.5530° N	28.98°N
Longitude	76.6346° E	77.02°E
Average Rainfall	637mm	653 mm
Average Annual temperature	25.4 C	24.9
Soil pH	7.4 to 9	7.3 to 9.7
Villages surveyed	Gujjuki, Pothi, Tilwaad and Nangli, Chauna	Badwasini, Pinana, Manauli

Table 2: District wise distribution of plant parasitic nematodes (J_2 per 200 cc soil) recorded at different villages of Sonipat and Alwar

	Pinana, Sonipat	**Badwasini, Sonipat**	**Manauli, Sonipat**	**Gujjuki, Alwar**	**Pothi, Alwar**	**Chauna, Alwar**	**Tilwaad, Alawar**	**Nangli, Alwar**
Meloidogyne incognita	2942.5	1446.1	790	19	227.3	9	81.6	11
Rotylenchulus reniformis	0	47.8	68.7	9	69.3	0	64	0
Pratylenchus spp.	35	60.8	146.2	0	0	0	0	0
Hoplolaimus spp.	55	109.1	43.7	0	6.3	0	0	0
Helicotylenchus spp.	125	165.3	75	21	178.8	0	0	0
Tylenchorhynchus spp.	100	200	125	84.66	16	0	120	0
Free Living Nematode	860	1461.6	688.7	160	842.3	108	271	254.5

Table 3: Population frequency, density and prominence value of major plant parasitic nematodes (J_2 per 200 cc soil) associated with different vegetable crops of Alwar and Sonipat districts

	Nematode species	***Meloidogyne incognita***	***Rotylenchulus reniformis***	***Pratylenchus spp.***	***Hoplolaimus spp.***	***Helicotylenchus spp.***	***Tylenchorynchus spp.***
Tomato	TS	3	3	3	3	3	3
	SS	3	1	1	1	3	2
	TC	5992	44	70	110	294	200
	AF	100	33.3	33.3	33.3	100	66.7
	RF	27.3	9.1	9.1	9.1	27.3	18.2
	AD	5929	4	70	110	294	200
	RD	89.2	0.7	1.1	1.7	4.4	3
	PV	592.9	2.5	4	6.3	29.4	16.3
capsicum	TS	4	4	4	4	4	4
	SS	2	1	4	2	1	3
	TC	3160	275	585	175	300	550
	AF	50	25	100	50	25	75
	RF	15.04	7.7	30.8	15.4	7.7	23.1
	AD	3160	275	585	175	300	550
	RD	62.6	5.5	11.6	3.5	5.9	10.9
	PV	223.4	13.8	58.5	12.4	15	47.6
Tomato + Capsicum	TS	2	2	2	2	2	2
	SS	2	1	0	0	0	1
	TC	104	60	0	0	0	120
	AF	100	50	0	0	0	50
	RF	50	25	0	0	0	25
	AD	104	60	0	0	0	120
	RD	36.6	21.1	0	0	0	42.3
	PV	10.4	4.2	0	0	0	8.5
Cucumber	TS	14	14	14	14	14	14
	SS	13	13	6	3	5	11
	TC	9448	491	370	674	1252	1756
	AF	92.9	42.9	21.4	35.7	78.6	71.4
	RF	27.1	12.5	6.2	10.4	22.9	20.8
	AD	9448	491	370	674	1252	1756

	RD	67.5	3.5	2.6	4.8	8.9	12.6
	PV	910.6	32.2	17.1	40.3	111	148.4

TS = Total No. of Samples Collected SS = Total No. of Samples Containing Species
TC = Total Species Count AF = Absolute Frequency
RF = Relative Frequency AD = Absolute Density
RD = Relative Density PV = Prominence Value

Table 4: Bray and Curtis similarity index of plant parasitic nematodes among the villages of Sonipat and Alwar districts

	Pinana	**Badwasini**	**Manauli**	**Gujjuki**	**Pothi**	**Chauna**	**Tilwaad**	**Nangli**
Pinana		0.667	0.463	0.073	0.199	0.006	0.103	0.007
Badwasini			0.696	0.123	0.365	0.009	0.217	0.011
Manauli				0.193	0.450	0.014	0.352	0.017
Gujjuki					0.207	0.127	0.561	0.153
Pothi						0.036	0.425	0.043
Chauna							0.065	0.900
Tilwaad								0.079
Nangli								

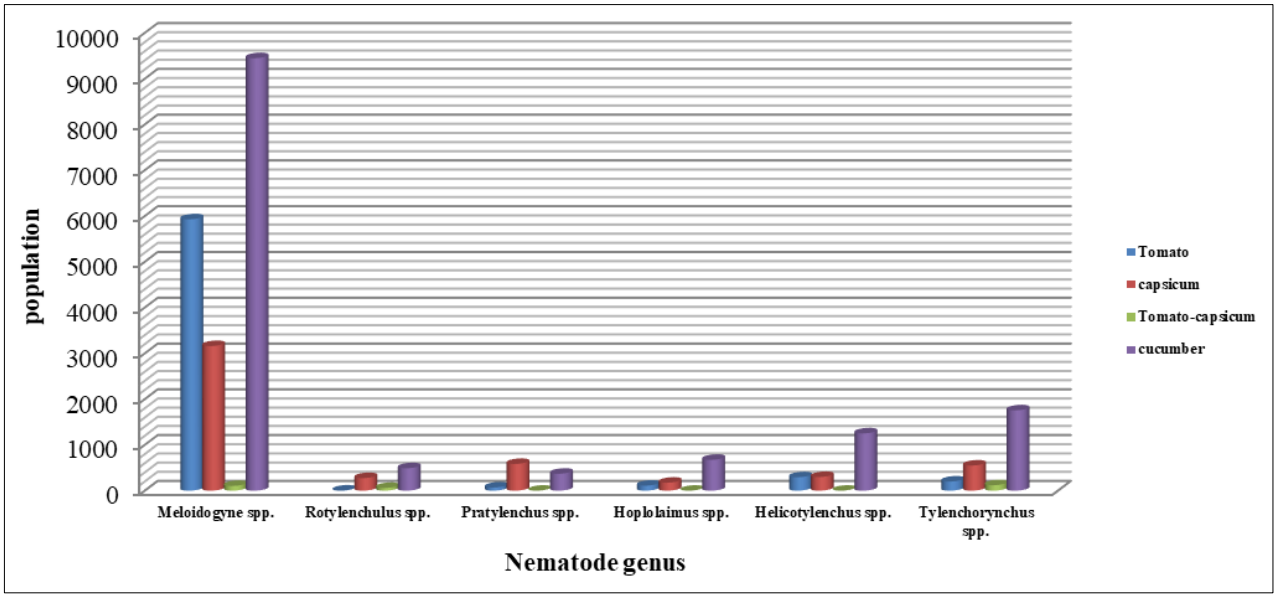

Fig 1: Absolute density of important plant parasitic nematodes associated with vegetable crops

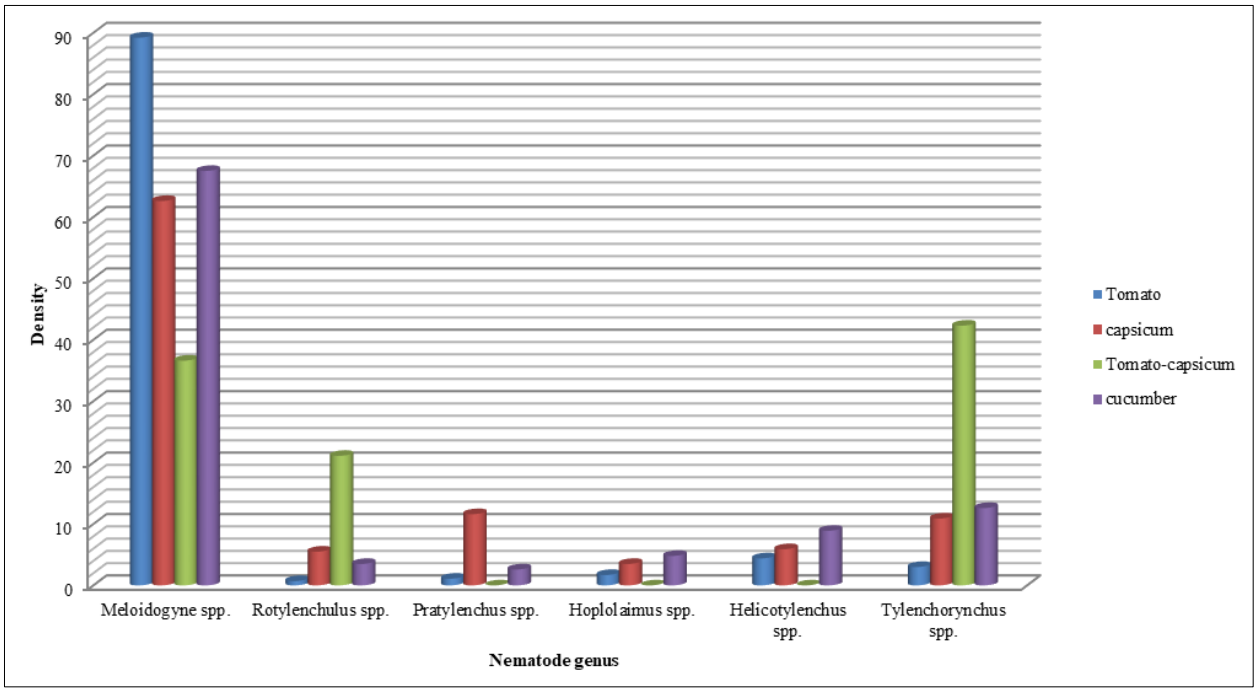

Fig 2: Relative density of important plant parasitic nematodes associated with vegetable crops

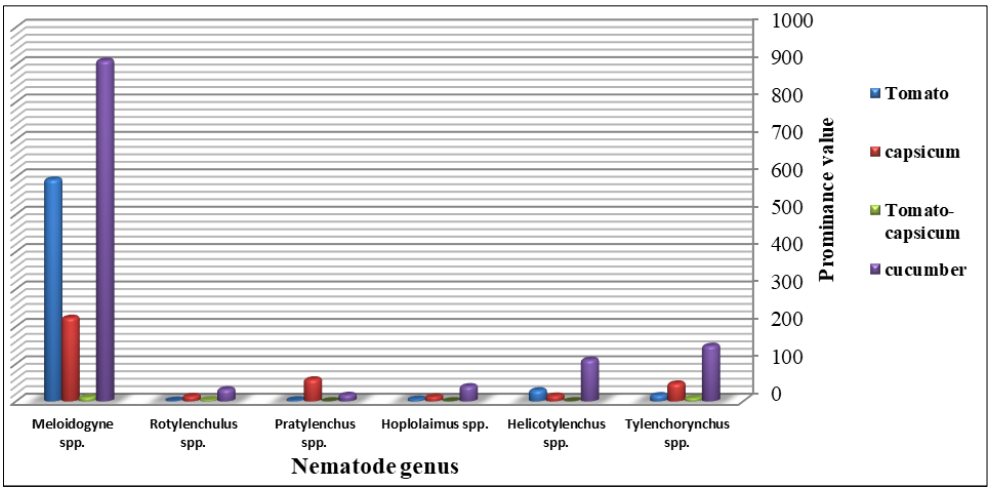

Fig 3: Prominence value of important plant parasitic nematodes associated with vegetable crops

Conclusion

The survey has played an essential role in developing effective management practices to reduce initial inoculum and prevent the buildup of phytonematodes population in polyhouse crops. Soils should be tested prior to the erection of polyhouses and successive testing in each season should be a regular management activity in the polyhouse crops.

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