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Study of fluctuations in the population of *Citrus* nematode (*Tylenchulus semipenetrans*) in the North Bihar

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Abstract
The study of the population fluctuation of *Citrus* nematode (*Tylenchulus semipenetrans*) in production area is necessary to find the damaging potential of *Citrus* nematode, identify key factor that influence *Citrus* population densities and find effective management strategies. In present study, I studied seasonal population fluctuations in two infected *Citrus* orchards during 2023. I evaluated the effect of soil temperature on the population of the nematode. Then I observed the nematode population is differ at both the soil depth. The nematode populations and female per gm roots are higher at 30 cm soil depth than 20 cm throughout the year at both orchards. The nematode population in soil and female in roots are the higher during May to June and August to September throughout the year. The regression analysis between number of nematodes and temperature in soil and females in roots show highly significant results at both orchards. I observed maximum nematode and female populations at a temperature between 25 to 29 degrees Celsius at a soil depth of 20 cm and 30 cm. Minimum nematode and female populations at a temperature between 9 to 12 degrees Celsius at a soil depth of 20 cm and 30 cm. I concluded from present study that the management of *Citrus* nematode to apply some chemical materials that protect the new roots from the nematode infections.

Keywords: Fluctuations, roots, population dynamics, management

Introduction
Citrus fruit is most common fruit of the world as well as India and Bihar also. *Citrus* belongs to the order spindales and the family rutaceae. There are so many types of *Citrus*es such as oranges, lemons, key lime, grapefruit, pomelos. *Citrus* is native to South Asia, East Asia, Southeast Asia and Australia. *Citrus* plants are evergreen trees or shrubs with glossy oval shaped and thorny leaves.
Citrus fruits are good source of vitamin C that strengthens the immune system. *Citrus* fruits also have good amounts of other vitamins and minerals. It is good source of fiber. These fibers have several health benefits, that improving digestive health and help weight loss. *Citrus* fruit help to low the risk of kidney stones. *Citrus* fruits and juices may help boost brain and heart health.
Citrus fruits are known for their fragrance due to flavonoids and limonoids.
Citrus is affected by nematodes, bacteria, viruses, viroids, insect pests and fungus. *Citrus* nematodes cause slow decline of *Citrus* and an estimated 8% loss of productions. Affected trees show reduced terminal growth, chlorosis and dieback of branches reduction in number and size of fruits.
The study of the population dynamics of *Citrus* nematode in a production area

Materials and Methods
I studied the fluctuations in the populations of *Citrus* nematode in soil and roots in two naturally infested *Citrus* orchards in North Bihar. The orchards located at the Muzaffarpur Agriculture University of Samastipur which are about 80 kilometers away from each other. The orchards are under cultivation for the last 10 years. I took root and soil samples from these two *Citrus* orchards at 15 days interval from January 2022 to December 2022 as described by Iqbal *et al*. (2014a). I collected samples from five randomly selected plants from each orchard, each weighing about 1 kg with the help of soil sampler at the depths of 20 and 30 cm from root zone. The samples from each tree I placed in polyethylene bags separately. I also taken Samples of feeder roots. I recorded soil temperature at the time of sampling. I took samples at a distance of 120 cm from the tree trunks.

The samples are immediately brought to the laboratory and processed for further evaluation.

I extracted juveniles of *T. semipenetrans* from the soil samples by modified Whitehead and Hemming tray method. I took out one gram of fresh feeder roots from each sample and carefully washed under gentle stream of water to remove soil particles, stained in acid fuchsin lactophenol. It macerated the stained roots in a blender for 30 seconds. The root suspensions are sieved through 100 and 275 mesh sieves into beakers. The materials are then centrifuged to concentrate the females in a volume of 10 ml. The suspensions from each sample are placed in counting dishes and I counted females under stereomicroscope and expressed as number of females per gram of roots.

Table 1: Population dynamics of *Citrus* nematode (*Tylenchulus semipenetrans*) during the year 2022 at Site 1 (Muzaffarpur)

Date of sampling	Nematodes at soil of depth		Females at soil of depth	
	20 cm	30 cm	20 cm	30 cm
1st January	189	278	6	7
16th January	180	300	8	11
1st February	265	380	9	13
16th February	409	604	10	14
1st March	449	643	13	19
16th March	479	885	17	20
1st April	789	1295	26	38
16th April	801	1327	30	42
1st May	950	1556	35	58
16th May	1172	1802	38	57
1st June	1031	1701	31	54
16th June	1001	1461	30	53
1st July	921	1411	21	56
16th July	851	1302	26	49
1st August	828	1318	22	57
16th August	794	1184	32	48
1st September	1089	1449	32	45
16th September	1133	2103	36	58
1st October	511	1931	16	27
16th October	386	1418	11	17
1st November	254	694	10	15
16th November	296	310	13	18
1st December	184	272	10	6
16th December	168	252	3	4

Table 2: Population dynamics of *Citrus* nematode (*Tylenchulus semipenetrans*) during the year 2023 at Site 2 (Samastipur)

Date of sampling	Nematodes at soil of depth		Females at soil of depth	
	20 cm	30 cm	20 cm	30 cm
1st January	336	300	8	13
16th January	380	378	13	8
1st February	516	526	17	11
16th February	532	538	18	11
1st March	770	760	26	16
16th March	858	855	30	19
1st April	950	1448	32	50
16th April	880	1370	41	61
1st May	1164	1868	42	62
16th May	1160	1925	43	63
1st June	1216	1906	47	66
16th June	1148	1852	30	60
1st July	960	1500	36	48
16th July	992	1488	34	46
1st August	1032	1622	36	53
16th August	1050	1647	37	54
1st September	1122	1831	43	62
16th September	1242	1948	45	64
1st October	562	870	21	41
16th October	550	808	19	49
1st November	508	575	12	20
16th November	388	620	15	12
1st December	276	456	9	15
16th December	184	276	6	9

Results

The nematode populations differed significantly at both the soil depths. The populations are significantly lower at a depth of 30 cm and higher at 30 cm throughout the year at both the orchards. Similarly, females per gram of roots also followed the same pattern. The number of nematodes in the soil and females in the roots are the higher during the months of April to June and August, September showing two peaks throughout the year.

The regression analysis between temperature and number of nematodes in the soil and females in the roots show highly significant results at both the orchards. I observed direct relationship between nematode populations and temperature. I observed maximum nematode and female populations at a temperature ranging between 25 °C to 29 °C at a soil depth of 20 cm. On the other hand, minimum population is recorded at a temperature range of 9 °C to 12 °C. Similar trends are observed at the soil depth of 30 cm shown.

Discussion

Citrus nematode is widespread in the world. Since its first report in roots of *Citrus* trees in California in 1912, its occurrence has been reported from all over the major *Citrus* growing regions of the world. The population density of *T. semipenetrans* has been reported to fluctuate throughout the year and often exhibits two distinct periods of growth.

Van Gundy (1958) found that organic debris created a thin protective cover over *Citrus* roots that enhanced nematode infectivity. Soil type apparently has little influence on *Citrus* nematode migration. Baines (1974) and Tarjan (1971) found that nematode mobility in various soils was limited.

O'Bannon *et al*. (1972) found that peak populations developed during corresponding periods of increased root growth that occurred in April-May and November-December. Infection and subsequent population cycles are restricted to primary roots because *Citrus* nematodes feed only in the cortex of primary roots.

Al-Hinai and Mani (1998) studied the population of *T. semipenetrans* in soil and roots, which steadily increased from September and reached high levels during January-March than sharply declined during summer from May-August. Significant negative correlations were observed between maximum air and soil temperatures and nematode populations and roots. Anju and Sharma (2000) studied the optimum basal and upper threshold temperature requirement of *T. semipenetrans* and other important nematodes and concluded that the mean soil temperature is important for distribution of the nematodes and their potential for damage to the plants.

Pandey *et al*. (2004) observed fluctuation of *T. semipenetrans* populations at different soil pH levels. Maximum population of male is recorded at pH 7.5-7.6. Female population is the maximum at pH 7.8, and the larval population increased at pH 7.6. Maximum total population of the nematode is observed at pH 7.5-7.8; optimum pH for maximum population (male, female, larva, and tota total) is 7.6.

Ahmed *et al*. (2009) recorded the seasonal population dynamics of *T. semipenetrans* in *Citrus* orchards of Islamabad, Pakistan. The population level was increased with the optimum temperature range of 23.5- 30 °C. It was maximum during October-November. It was maximum during October-November, 2006 and April-May, 2007 while the minimum population was recorded in rest of the sampling periods with negative correlation of temperature. With the increase of temperature to the higher level of 37 °C during June 2007 decrease of temperature at lower level (5 °C) during December, 2006, the trend of population of *T. semipenetrans* showed a decline *Citrus* nematode occurs over a wide range of soil conditions throughout the world. Certain soil factors readily influence infection and reproduction. Van Gundy *et al*. (1964) found that growth and reproduction of *Citrus* nematodes occurred on *Citrus* seedlings in soils containing 50% clay. The rate of reproduction, however, is significantly lower in soils of 50% clay than in soils containing 5, 15 or 30% clay. Generally, *Citrus* nematode invasion and reproduction is slower in very sandy, coarse-textured soils than in other soil. Soils containing organic matter up to 10% favored infection and rapid increase in nematodes that resulted in early damage.

Conclusions

It is concluded from the present study that population of *Citrus* nematode showed wide variations throughout the season. The number of nematodes in the soil and females in the roots are the higher during the months of April to June and August to September showing two peaks throughout the year corresponding to the appearance of new flushes. This means that the control of nematode including application of some chemical should started in the spring season, just prior to the first root flush, and continue during the growing season to protect the new roots from nematode infection.

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