J. Cotton Res. Dev. **33** (2) 288-296 (July, 2019) **ISSN No. 0972-8619**

Relationship between soil properties and abundance of reniform nematode in cotton fields of Tamil Nadu

C. MATHIVATHANI*, K. POORNIMA AND P. KALAIARASAN

Department of Nematology, Tamil Nadu Agricultural University, Coimbatore - 641 003

E mail: mathichandh@gmail.com,

ABSTRACT : An investigation was taken up to survey six major cotton growing districts of Tamil Nadu *viz.,* Coimbatore, Tuticorin, Salem, Trichy, Perambalur and Madurai during 2017 – 2018 in 30 fields. Distribution of reniform nematode was determined by collecting random samples from the soil and cotton plant roots, extracting and counting the number of infective (J_4) juveniles, males/200 cc soil and females/5g of root. The relationship between nematode population and the factors of soil texture, organic carbon, Nitrogen (N), Phosphorus (P), Potassium (K) and pH were determined. Increase in nematode population was observed by increase in soil silt, sand, P, K and organic carbon, but by increase in total nitrogen and amount of clay in soil, the nematode population decreased. The most favourable soil pH for nematode activity was found to be seven while either an increase or decrease in pH resulted in decreased nematode population. The number of J_4 ranged from 45 to 418/200cc of soil while the females from 12 to 118 individuals/g of root, respectively. About 60 per cent of the studied fields were infested with *R. reniformis*. Pot studies on effect of soil type revealed that sandy loam and sandy soil favoured more nematode multiplication compared to black clay and red loamy soil.

Key words : Nematode multiplication, *R. reniformis*, soil type

Cotton (*Gossypium hirsutum*) is the major cash crop produced in India and plays a dominant role in industrial and agricultural economy of the country. India ranks first in area and second in total production where the total consumption during 2018-2019, as estimated by Cotton Association of India (CAI) is 198.80 lakh bales with a productivity of 568.29 kg lint/ha. Cotton is often grown in a monoculture system favouring the development of nematode community dominated by few parasitic species.

The severity of the infestation depends on the level of abundance of the pathogen that depends on the soil conditions for growth and survival of the organism (Abbott, 2013). Relationship between different properties of soil and nematodes were studied worldwide (Fajardo *et al.,* 2011).

Rotylenchulus reniformis is easily introduced into cotton fields through contaminated equipment and other means of soil transport. Once there, it can spread throughout the field by tillage and water flow (Monfort *et al.,* 2008; Moore *et al.,* 2011); however, in no-till systems, *R. reniformis* can spread independently both horizontally and vertically (Moore *et al.*, 2010).

Dropkin (1980) reported that nematodes live in the pores that are formed by the soil processes. They move in films of water clinging to soil particles. He stressed further that many nematode genera have particular soil and

climate requirements and that certain nematodes prefer clay or loamy soil. The prime objective of this study was to determine the soil nutrients, per cent of sand, silt and clay, textural class, pH and reproduction potential of *R. reniformis* in different soil types in major cotton growing districts of Tamil Nadu.

MATERIALS AND METHODS

Soil sampling : In total, 150 samplings were done from 30 cotton fields in major growing cotton growing areas of Tamil Nadu during 2017 – 2018 *viz.,* Perambalur, Trichy, Kovilpatti, Coimbatore, Salem and Madurai. The soil was categorized by feel method locally as sandy, black clay, red loam and sandy loam. Internationally accepted soil sampling technique was followed (Dufour*et al.*, 2003). Each soil type was divided into blocks (5 blocks/type). Composite soil samples consisting of 200 cc soil taken from rhizosphere were collected from each location at flowering stage of cotton. The collected samples were processed by Cobb's decanting and sieving method (Cobb, 1918) followed by a modified Baermann's funnel technique (Schindler, 1961). The population densities of nematode species in a sample were observed under a stereozoom microscope and tabulated. The root population were counted by staining the roots with cotton blue stain (Southey, 1986). The number of females were counted and expressed per gram of fresh root tissue.

Soil Properties : Soil type and texture for each sample were determined using USDA textural triangle. Soil pH was estimated by use of a 1:5 dilution of soil /water, taking pH measurements on the resulting solution with a laboratory pH meter (Page *et al.*, 1989). Walkley and Black's method (1934) was used for a determination of soil organic matter per cent. Total N content (µg/1) and available P contents (µg/1) of the samples (equivalent to 1g of oven dried soil) were determined by the Kjeldhal and Olson methods, respectively (Bremner, 1965). Soil potassium (µg/1) was determined through ammonium acetate (Page *et al.*, 1989). The tests were carried out in the Laboratory of Soil science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore.

Soil type : Pot experiments to confirm the effect of soil type on *R. reniformis* were conducted. Cotton plants (Var. MCU 5) were raised in 500 g capacity sterile earthen pots holding five different soil types. Viz., Sandy, Sandy Loam, Red loam, Black clay and Pot mixture (Control) as treatments in the Glasshouse at Department of Nematology, Tamil Nadu Agricultural University, Coimbatore. After 15 -20 days of seedling establishment, 1000 $J_4$of *R. reniformis*were inoculated in the rhizosphere zone in each pot except pot mixture (Control). Each treatment was replicated quarterly in a completely randomized design.

Statistical analysis : All data were subjected to ANOVA using statistical software package AGRESS. Regression analysis was carried out to determine the effect of soil texture on population density of reniform nematode.

RESULTS AND DISCUSSION

The present study was undertaken to

investigate the effects of soil carbon, soil nutrients, pH and texture on population levels of reniform nematode in cotton.

Soil texture : In this study, three soil textural classes were identified viz., sandy loam, loamy and sandy clay loam. Sandy loam has shown highest mean population levels and higher proportion of infested samples. Probably, higher population levels of *R. reniformis* in sandy loam can be explained by nematode mobility. In contrast, the oxygen levels and pore size are lower in heavier soils and as a result, the mobility of *R. reniformis* in clay loam is lower. This is in consistent with other studies reported by Chosali (2015) that tea root lesion nematode in light textured soils was more active and had greater population. Similarly, the reniform nematode population behaviour in soil type experiment was more like *Pratylenchus brachyurus* that multiplied better in sandy loam and loam than in clay loam or sand (Endo, 1959).

Of all the soil characteristics, soil texture is significant and affects nematode population densities. It influences many other properties of greater importance to land use and management (Brown 1990). In this study, the maximum and minimum abundance of nematode population, in either roots or soil were observed in soils of sandy and clay textures respectively. Sandy soil with high levels of sand and silt content showed higher nematode population compared to soils with high clay content (Table 1).

Soil pH : The soil pH for nematode activity was found to be seven while either an increase or decrease in pH resulted in decreased nematode population (Table 1). Our findings are supported by Olabiyi *et al.*, (2009) who suggested that plant parasitic nematodes vary with soil texture and pH. And the most suitable soil pH

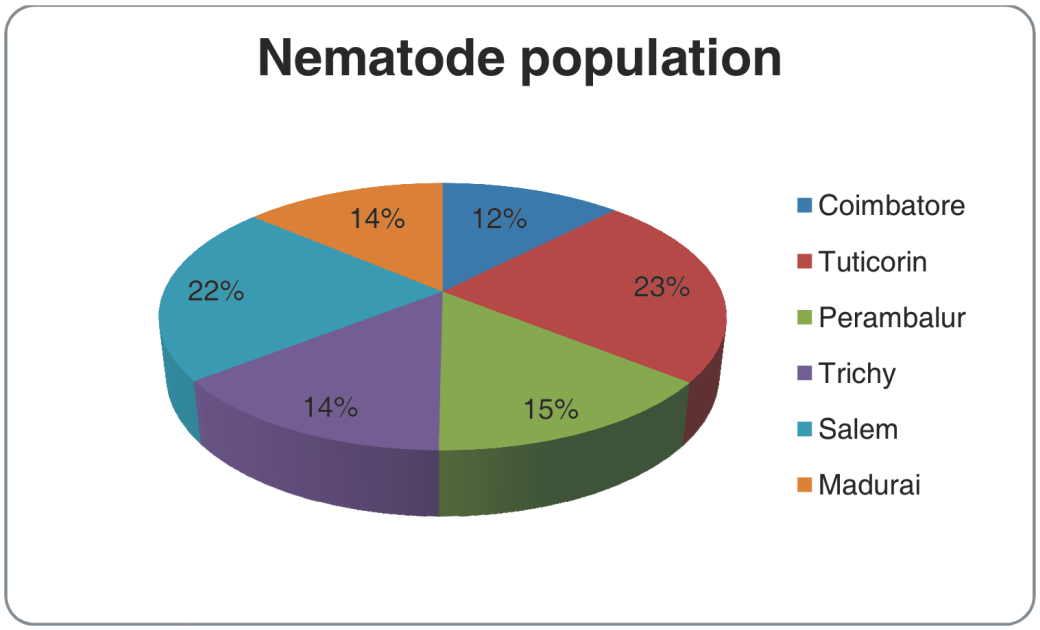

Fig. 1. Per cent infestation of reniform nematode in cotton growing districts of Tamil Nadu

Table 1.Physicochemical properties of soils and abundance of *Rotylenchulus reniformis* in cotton growing areas of Tamil Nadu

S. No	Location	Co ordinates Latitudes (°E)	Co ordinates Longitudes (°N)	Soil texture	Sand (%)	Silt (%)	Clay (%)	K (%)	P (ppm)	Total (ppm)	pH N (%)	Organic Carbon	Nematode Population 200 cc Soil	Nematode Population 5g roots
1.	Nariampalli	11.235237	77.109524	L	46	14	40	318	10.80	0.185	7.2	1.61	173.00	38.00
2.	TNAU	11.020124	76.928728	L	48	32	20	258	15.60	0.128	7.3	1.17	213.00	44.00
3.	Sengalipalayam	11.109558	76.952122	Cl- L	14	36	50	143	10.80	0.164	7.8	0.74	243.00	42.00
4.	Thondamuthur	10.978777	76.842402	L	46	32	22	315	14.60	0.199	7.3	1.36	196.00	29.00
5.	Avinashi	11.191301	77.268069	Si - L	28	54	18	168	6.20	0.16	7.4	1.95	86.00	12.00
6.	Kovilpatti	9.189364	77.881272	Cl	18	28	54	118	18.40	0.155	7.7	1.39	345.00	102.00
7.	Srivaikundam	8.629643	77.915960	L	66	26	8	148	12.50	0.283	7.8	1.42	418.00	118.00
8.	Ottapidaram	9.027741	77.990810	L	46	36	18	138	15.60	0.214	7.6	1.36	312.00	96.00
9.	Thonugal	9.165859	77.810414	Cl- Si	18	40	42	342	10.40	0.158	7	1.97	299.00	94.00
10.	Sattankulam	8.438505	77.910767	Si - L	30	42	28	300	8.00	0.115	7.2	1.68	208.00	54.00
11.	Veppanthattai	11.351173	78.803504	L	46	30	24	268	11.50	0.143	7.3	1.76	193.00	29.00
12.	Padaloor	11.091891	78.826835	L	42	29	29	138	7.30	0.123	7.3	0.97	211.00	53.00
13.	Lalgudi	10.876235	78.826788	L	48	32	20	118	3.07	0.065	7.7	0.15	146.00	36.00
14.	T. palur	11.092428	79.373341	L	54	28	18	148	13.60	0.183	7.8	1.75	320.00	96.00
15.	Chettikulam	11.129436	78.772101	L	40	34	26	120	14.50	0.123	7.6	2.59	159.00	22.00
16.	M. Kurichi	10.836764	78.645699	Si - L	24	54	22	300	13.10	0.153	7.6	0.96	89.00	22.00
17.	Thiruvallarai	10.959107	78.672642	Si - L	18	32	50	135	10.50	0.065	7.8	0.38	155.00	21.00
18.	Thuraiyur	11.138220	78.603425	Si - Cl	24	50	26	224	6.70	0.149	7.4	1.68	200.00	47.00
19.	Kulumani	10.845961	78.586322	Si - L	38	42	20	295	6.90	0.198	7.3	1.46	168.00	36.00
20.	Manikandam	10.739906	78.636659	Si - Cl	18	54	28	230	15.30	0.175	7.4	1.42	288.00	22.00
21.	Ariyanur	11.607289	78.092372	Si - Cl	14	46	40	208	9.60	0.213	7.5	1.49	296.00	93.00
22.	Athanur	11.495188	78.124184	Cl	16	36	48	246	13.50	0.139	7.3	1.8	399.00	98.00
23.	Thalaivasal	11.598439	78.749769	L	40	34	26	163	12.50	0.199	7	1.43	410.00	112.00
24.	Idapadi	11.581207	77.844242	Cl	22	34	44	96	3.50	0.187	7.7	0.42	89.00	39.00
25.	Viraganur	11.482286	78.734721	L	36	46	18	150	11.60	0.156	7.7	1.89	305.00	63.00
26.	Melur	9.955232	78.183910	Cl	20	32	48	132	5.90	0.12	7.6	0.63	155.00	21.00
27.	Othakadai	10.316278	77.948118	Si - Cl	18	52	30	260	40.00	0.146	7.4	1.42	299.00	82.00
28.	Vellodu	10.302288	77.951900	L	36	48	16	294	11.60	0.187	7.8	0.58	334.00	66.00
29.	Ambathurai	10.253393	77.911880	Cl	22	44	34	196	15.80	0.19	7.2	0.97	120.00	46.00
30.	Toppampatti	10.265769	77.919426	Si- Cl	8	66	26	92	14.60	0.12	7.3	1.813	45.00	36.00

Locality 1-5 Coimbatore, 6- 10 Tuticorin, 11-15 Perambalur, 16-20 Trichy, 21-15 Salem, 26 – 30 Madurai

Si – Silt, Cl – Clay , L - loam

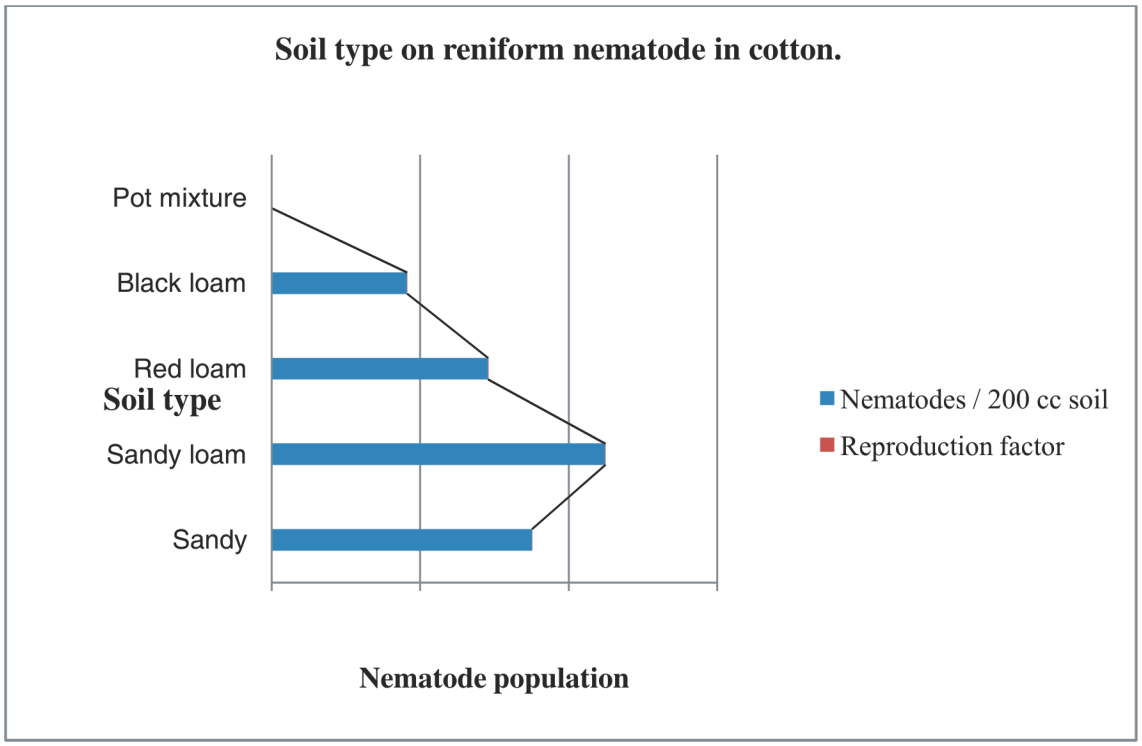

Fig. 2. Effect of soil type on reniform nematode population in cotton – Pot experiment

for nematode activity was found almost seven while either an increase or decrease in soil pH, resulted in a decrease in nematode population (Salahi Ardakani, 2014).

Organic carbon : A low nematode population was observed in the soil and roots of cotton when the level of organic carbon was either below 0.5 per cent or higher than 1.8 per cent. Maximum nematode population was seen in soils with 1.4 per cent organic carbon (Table 1). According to Thoden *et al.*, (2012) low nematode population was observed in the soil and roots of cotton when the level of organic carbon was either below 0.5 per cent or higher than 1.8 per cent. These findings are similar to previously made observations that increase in population number was higher in soil of higher organic matter. The highest mean soils as well as root population numbers of *M. graminicola*were observed in loamy sand with organic matter contents of 4% as compared to sandy loam and clay loam in rice (Vinodhkumar *et al.*, 2017).

Soil nutrients : The present results revealed that the maximum nematode population was seen in soil when soil total nitrogen was 0.1 and 0.15 per cent. High nematode activity was observed when the level of available phosphorus and potassium ranged from 5 to 15 and 150 to 300 ppm, respectively. Increase in phosphorus than this level has no effect on nematode population, but further increase in potassium levels showed reduction in nematode population. This is in agreement with other reports except for the nitrogen. Sorribas *et al.* (2008) reported citrus nematode population in soil as negatively related to N

concentration and positively related to K concentration in soil (Table 1).

Nematode population : Out of 30 cotton fields surveyed, 28 fields showed population over 100 numbers of *R. reniformis.* Based on the observations in the surveyed regions, the number of infective juveniles ranged from 45 to 418/200cc of soil while the females ranged from 12 to 118 individuals/g of root and presented in Table 1.

The Tuticorin district showed the maximum population of 2046 (23%) followed by Salem (22%) with the population of 1904. The central part of Tamil Nadu comprising Perambalur (15%) and Trichy (14%) with black and sandy loam recovered the population of about 1265 and 1248 respectively. In Madurai (14 %) and Coimbatore (12%) with loamy soil had the minimum population per cent compared to other districts (Fig. 1). Results showed that the districts with sandy loam and sandy soil have shown more nematode population. Similarly soils in Tamil Nadu had varying textural classes and could be classified into different series based on parent material formation (Smyth and Montgomery, 1962).

Pot experiment : Nematode population in different soil types was assessed (Fig. 2). The multiplication rate of *R. reniformis* were observed in five soil types showed that maximum population was found in sandy loam and minimum in black clay loam. The roots of inoculated plants in all the soil types were infested with egg-laying females. The final population (both female and juvenile stages) was higher with 2247 nematodes in sandy loam followed by 1753 nematodes in sandy soil. Red loam and black loam supported comparatively less population of 1457 and 912 nematodes, respectively. The reproduction factor of *R. reniformis* was higher (2.24) in sandy loam followed by sandy soil (1.75) compared to other soil types. Similarly, the loamy and clay soil tends to have high moisture retaining capacity, fluctuations in moisture levels were not rapid. Whereas sandy soil due to poor moisture holding capacity, shows more soil moisture fluctuations and hence showed lower multiplication of nematode. This nematode has the ability to reproduce at higher levels than *M. incognita* in various soil types on cotton, implies greater parasitic fitness (Shaner *et al.*, 1992).

It is evident from the data (Table 2) that control and red loam soil were on par with each other for shoot length and weight. Significant

Table 2. Growth of cotton plants as influenced by soil texture and *R. reniformis,* 120 days after inoculation of 1000 nematodes

S. No	Treatment	Nematode population		Plant weight (g)				Reproduction factor(Rf)
		200 cc soil	5g roots	Shoot	Root	Shoot	Root	
1.	Sandy	1423.00^{b}	49.0^{b}	52.90^{b}	7.87^{d}	22.02^{d}	11.50^{b}	2.94
2.	Sandy loam	2504.00^{a}	61.0^{a}	56.40^{b}	11.10^{cd}	27.50^{b}	13.70^{b}	5.13
3.	Red loam	960.00^{c}	35.0^{c}	85.90^{a}	14.95^{b}	39.30^{a}	24.85^{a}	1.99
4.	Black loam	442.00^{d}	13.0^{d}	77.80^{a}	16.80^{bc}	45.57^{c}	25.32^{a}	0.19
5.	Pot mixture(Control)	0^{e}	0^{e}	87.60^{a}	22.27^{a}	51.15^{c}	30.50^{a}	0
	SEd	146.70	3.93	6.541	2.238	6.391	3.579	
	C.D (p=0.05)	312.69	8.38	13.944	4.770	13.620	7.620	

decrease in shoot length at sandy and sandy loam was 60.77 and 67.50 cm, respectively. The shoots of the plants grown in sandy soil exhibited poor growth as in the case of Shoot and root weight, significant differences were observed in sandy and sandy loam soil with maximum reduction in plant weight of 33.52 and 41.20cm, respectively. According to Moore *et al.* (2013) *R. reniformis* will reach higher population densities in soils with smaller medium soil particle size however, the reduction in yield or plant growth very well may be no greater than in a soil that is less preferential to the nematode.

Relation between roots and soil population of nematodes : The increase in nematode population in soil always corresponds with the population increase inside the roots and is a universal truth. However, soil nematode population was higher as compared with that of the infested roots. Considering nematode population in roots and soil which are two main components in correlation, one can directly correlate the nematode population in soil and in infested roots as regards the studies factors.

CONCLUSION

R. reniformis is widely adapted to cotton growing areas and causes economic damage; our results suggest that *R. reniformis* would cause comparable yield loss in a wide range of soil types. Using soil texture to create management zones within a field is useful for *R. reniformis* site specific management. But, the soil properties, yield potential, water stress and initial population must be considered to develop an economic threshold and management for each zone.

ACKNOWLEDGEMENT

We thank the Department of Soil science and Agricultural Chemistry, TNAU, Coimbatore for helping me to carry out the soil analysis and Department of Nematology, TNAU, Coimbatore for supporting me throughout this topic.

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Received for publication : February 11, 2019
Accepted for publication : April, 19, 2019