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Relationship between Soil Properties and Abundance of *Tylenchulus semipenetrans* in Citrus Orchards, Kohgilouyeh va Boyerahmad Province

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ABSTRACT

To understand the relationship between natural physicochemical properties of soil and abundance of citrus root nematode (*Tylenchulus semipenetrans*), a survey was conducted during 2009-2010 in some 37 citrus orchards, in Kohgilouyeh va Boyerahmad Province, Iran. Distribution of the citrus nematode was determined by collecting random samples from the soil and citrus plant roots, extracting and enumerating the number of second stage juveniles, males/100 g of soil and females/5 g of root. The relationships between nematode population, and the factors of: organic matter content, Nitrogen (N), Phosphorus (P), Potassium (K), organic carbon, Calcium Carbonate, soil texture, Electrical Conductivity (EC) and pH were determined. Increase in nematode population density was observed by increasing soil saturation percentage (up to 43%), and by an increase in soil silt, sand, P, K and organic carbon, but by an increase in soil salinity, Calcium Carbonate, total Nitrogen and the amount of clay in soil, the nematode population decreased. Maximum nematode population density was recorded in a loamy soil texture. The most suitable soil pH for nematode activity was found almost seven while either an increase or decrease in soil pH, resulted in a decrease in nematode population. The number of second stage juveniles ranged from 58 to 2,730/100 g of soil while females were present by 11 to 331 individuals/g of root respectively. About 62% of the studied orchards were infested with *T. semipenetrans*.

Keywords: Citrus nematode, Nematode population, Soil properties.

INTRODUCTION

Disease-causing organisms are among the natural components and the soil community. The soil organisms of the potential to be plant pathogens include: fungi, bacteria, viruses, nematodes and protozoa. Close and intimate interdisciplinary collaboration between and among such scientists as: plant pathologists, nematologists, agronomists, soil scientists, horticulturists, entomologists, weed scientists, soil ecologists, and microbiologists is necessary to broaden the application of soil ecosystem management (Wang and McSorley, 2005). The severity of plant disease depends on the level of abundance of the pathogen, itself being dependent upon the soil conditions for growth and survival of the organism (Abbott, 2013).

Relationships between and among different properties of soil and plant pathogens have been studied worldwide (Fajardo *et al*., 2011; Sharma, 2005; Van

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Den Boogert *et al*., 1999; Wang *et al*., 2004; Wang and McSorley, 2005). Among plant parasitic nematodes, citrus nematode, *Tylenchulus semipenetrans* Cobb 1913, is ubiquitous in all the citrus-producing regions. Maximum yield loss due to *T. semipenetrans* damage is estimated within the range of 10 to 30%, depending on the level of infection, degree of aggressiveness of the nematode population, soil characteristics, susceptibility of the rootstock, presence of other pathogens, as well as grove management practices (Duncan and Cohn, 1990). Sorribas *et al*. (2008) reported that the number of second-stage juveniles and of males of *T. semipenetrans* in soil were related to soil N and K content. The best extensive nematode population development has been reported to occur at pH 6.0–8.0; however, the nematode is pathogenic to citrus at low pHs too. *T. semipenetrans* is broadly adapted to most edaphic conditions, common to citricultures. The nematode survives in almost all types of soils of suitable texture for citrus, although, compared with most parasitic nematodes, its development in pot cultures is often less rapid than in sandy soils. Moderate levels of clay, silt and organic matter favor the infection, nematode activity and its development (Bello *et al.*, 1986).

The concept of soil ecosystem management is still at a developmental stage. While the model provides a general guideline toward maintaining a healthy soil ecosystem, much information must still be added to upgrade our understanding of soil health for ecosystem management (Abbott, 2013). The aim followed in the present study was: (i) to determine the distribution and population density of *T. Semipenetrans* in Kohgilouyeh va Boyerahmad Province, (ii) to find out the relationship between different soil properties and abundance of the citrus nematode in some citrus orchards in the aforesaid Province, Iran.

MATERIALS AND METHODS

Sampling and Nematode Abundance

In total, 222 samplings were done three times (March, June, and September) from the same trees of 37 citrus orchards in tropical regions of Kohgilouyeh va Boyerahmad Province, Iran, during 2009 and 2010. Simultaneously, at each sampling time, root and soil samples were collected together as one sample. Orchards were drip irrigated. They ranged from 3 to twenty years old. From one hectare area, ten citrus trees from the genera and species of: *Citrus sinensis* L., *Citrus aurantifolia* (Christm.) Swingle, and *Citrus limetta* L., grafted on sour orange rootstocks, were selected. About 1.5 kg samples of soil along with roots were collected, from 0 to 30 cm soil depth, by use of borer (auger). Soil along with roots were thoroughly mixed and a sample of about 250 cm^3 taken for nematode extraction and for determination of soil physicochemical properties. Roots were carefully washed free of soil and chopped. The extraction of J2 as well as its counting was done using modified Baermann funnel method (Timmer and Davis, 1982).

Female nematodes were extracted from roots that had already been carefully washed free of soil and then chopped. A 5 g root subsample from each main sample was boiled (in lactophenol containing 0.1% acid fuchsin) for 3 minutes. The roots were placed in a food blender jar, and macerated at a maximum speed for two successive 15-second intervals (Southey, 1986). The suspension of nematodes was sieved through a 74-μm screen to remove the root debris. The numbers of females were counted and expressed per gram of fresh root tissue.

Soil Properties

Soil mineral particle sizes and textures were determined through hydrometer method. Soil particle sizes were classified as: 0-2 μm; clay, 2-50 µm; silt and 50-2000 µm; sand (Bouyoucos, 1962).

Soil electrical conductivity (dS m^{-1}) was determined as follows (Rayment and Higginson, 1992):

1. A 1:5 soil/water suspension was prepared by weighing 10 g air-dry soil (< 2 mm) into a bottle and adding 50 ml of deionized water, then mechanically shaking the mixture at 15 rpm for 1 hour to dissolve the soluble salts.

2. Calibrated the conductivity meter according to the manufacturer's instructions using the KCl reference solution to obtain the cell constant.

3. Rinsed the cell thoroughly. Then measuring the electrical conductivity of the 0.01M KCl at the same temperature as the soil suspensions.

4. Rinsed the conductivity cell with the soil suspension. Refilled the conductivity cell without disturbing the settled soil. Recorded the value indicated on the conductivity meter. The cell was thoroughly rinsed with deionized water between measurements.

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).

The soil saturation percentage was estimated by the method in which a 1:5 soil/water suspension was prepared by weighing a 100 g air-dry soil (< 2 mm) into a bottle and adding 500 ml of deionized water. The soil suspension was incubated in an electrical oven at 105°C for 24 hours. Soil saturation percentage was determined by dividing the weight of water by the weight of dried soil multiplied by 100. (Rayment and Higginson, 1992).

Walkley and Black's method (1934) was employed for a determination of the percentage of soil organic matter.

Total N content (µg l^{-1}) and available P contents (µg l^{-1}), of the samples (equivalent to 1 g of oven-dried soil) were determined by the Kjeldhal and Olson methods, respectively (Bremner, 1965; Olsen *et al*., 1945).

Calcium carbonate was determined through weight loss method, using HCl to have CO_2 evolved from carbonate in the sample, the weight loss being recorded using a top-pan balance. A correction factor (for evaporation weight loss) was applied to allow for the loss of water vapor and HCl (Blakemore *et al*., 1987).

Soil potassium (µg l^{-1}) was determined through Ammonium acetate (Page *et al*., 1989).

The tests were carried out in the Laboratory of Soil Research, Agriculture and Natural Resources Research Center of Kohgilouyeh va Boyerahmad Province.

Statistical Analysis

Data were analysed by use of SPSS software version 15. Average data for each orchard has been considered for analysis. Data taken from the surveyed orchards were analyzed to determine the relationship between each physicochemical property item of the soil and the population density of second stage juveniles and as well the females of the citrus nematode.

The models employed for analyses were Linear, Logarithmic, Inverse, Quadratic and Cubic. Relationships between the experimental parameters and nematode population in soil and in root were duly established.

RESULTS

Soil Physicochemical Properties

Soil Saturation Percentages

Within cubic and quadratic models, increase in soil saturation up to 43% led to an increase of nematode population in soil and in citrus root samples. A maximum nematode population was detected at 43% of soil saturation. In soils of more than 43% of saturation, the number of nematode was decreased. However, using other models (Linear, Logarithmic, and Inverse) resulted in a decreasing of nematode population with increase in soil saturation (Figure 1-A).

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Results coming from the cubic model are supported by a high level of r-square in the mentioned model (0.018 and 0.019 in soil, while 0.007 and 0.009 in root).

Soil Electrical Conductivity (EC)

The observed points are so close to cubic model (Figure 1-B) showing that this model is the fittest for this factor, however other models lead to different results. When soil *EC* was increased to 3 dS m^{-1}, the nematode population decreased, but it increased at *EC* 8. The nematode population increased to its maximum level at *EC* 23 and then decreased continuously, the trend being similar to population in root. Other models present a decrease of nematode population with increase in *EC*. High r-square for cubic model confirms results obtained through this model (Figure 1-C).

Soil pH

Within all the infected root and soil samples collected from different regions of the province, a maximum number of the nematode was observed when soil pH was at seven. Either increase or decrease in soil pH from seven, resulted in decreasing of the nematode population. The slope of population reduction with regard to pH change was slow as compared with that in *EC*. Cubic and quadratic models, especially cubic model, were the fittest among the other used models for showing the relationship between pH and nematode population (Figure 1-C).

Soil Nutrients

Maximum nematode population was seen in soil when soil total nitrogen was between 0.1 and 0.17 percent. High nematode activities were noted when the levels of available phosphorus and potassium ranged from 5 to 15 and from 150 to 300 ppm respectively. Increase in phosphorus past

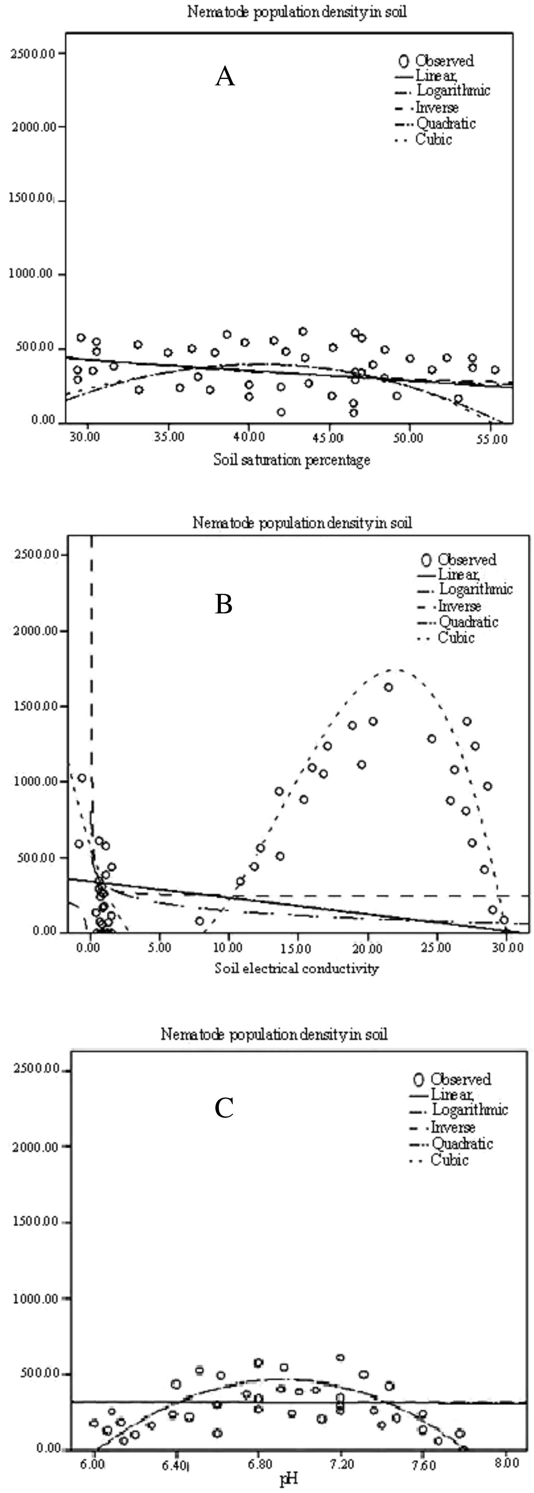

Figure 1. Relationship between nematode population in soil and (A) soil saturation percentage (B) soil Electrical Conductivity (EC), (C) soil pH.

this level did not exert any further effect on nematode population, but further increase in potassium level showed reduction in nematode population (Figure 2).

Soil Texture

Maximum and minimum abundances of nematode population, in either roots or soil were seen in soils of loamy and clay textures respectively. In soils containing high levels of silt and sand, the nematode population was increased, but a high clay content resulted in low numbers of nematode in soil and in citrus roots. A high nematode population level was recorded, when percentages of sand, silt, and clay in soil were 48, 35 and 17 respectively (Figure 3).

Organic Carbon

A low nematode population was recorded in the soil and as well in citrus roots when the level of organic carbon was either below 0.5% or higher than 1.7%. A maximum population of the nematode was seen in soils with 1.5% of organic carbon (Figure 4).

Total Neutralizing Value (TNV)

TNV, which is an indicator of the level of calcium carbonate in the soil, was in a direct relationship with nematode population in soil and as well in citrus roots. Maximum nematode population was recorded in surveyed citrus orchards with TNV values of 45 to 55 percent. In soils of more than 55% of TNV, the nematode population was decreased.

Nematode Abundance

Out of 37 citrus orchards surveyed, 23 (62.2%) were infested by the *T. semipenetrans*. Based on observations in the surveyed regions, 66.7, 62.1, and 57.2% of citrus orchards were infested by the nematode in Bahmaei, Gachsaran and Kohgyloyeh districts respectively. The number of second stage juveniles ranged from 58 to 2,730/100 g of soil while female numbers ranged from 11 to 331/g of root. The models employed for analyses were Linear, Logarithmic, Inverse, Quadratic and Cubic. Relationships between the parameters and nematode populations in soil and in root were established, and presented in Table 1.

Relationship between Roots and Soil Population of Nematodes

Nematode population increase inside roots well corresponded with the population increase in soil and this always occurred as a fact. However, nematode population in soil was much higher as compared with that in the infected roots. Correlation analyses confirm this result too (Figure 5). Considering nematode population in soil and in root as two main components in correlation, one can present direct correlation between nematode populations in soil and in infected roots as regards the studied factors.

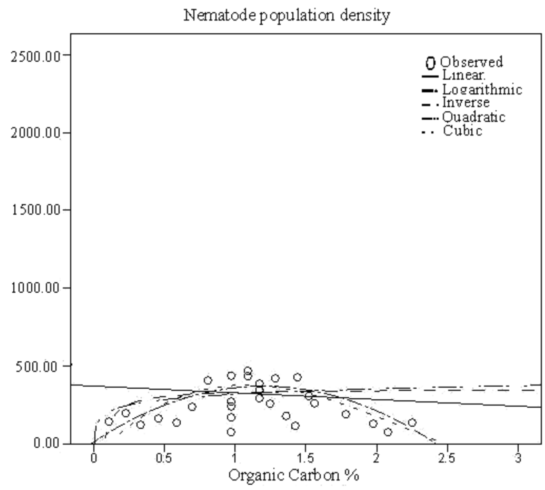

Figure 4. Relationship between soil nematode population and soil organic carbon.

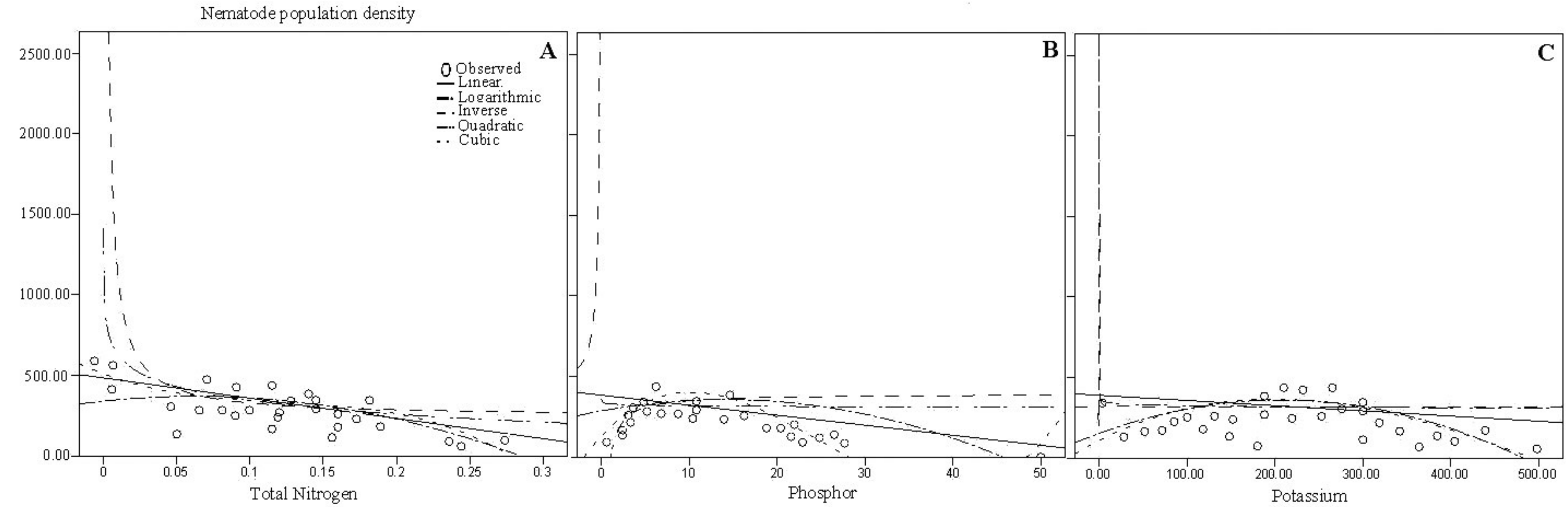

Figure 2. Relationship between soil nematode population and soil nutrients: (A) Total nitrogen; (B) Phosphorus, and (C) Potassium.

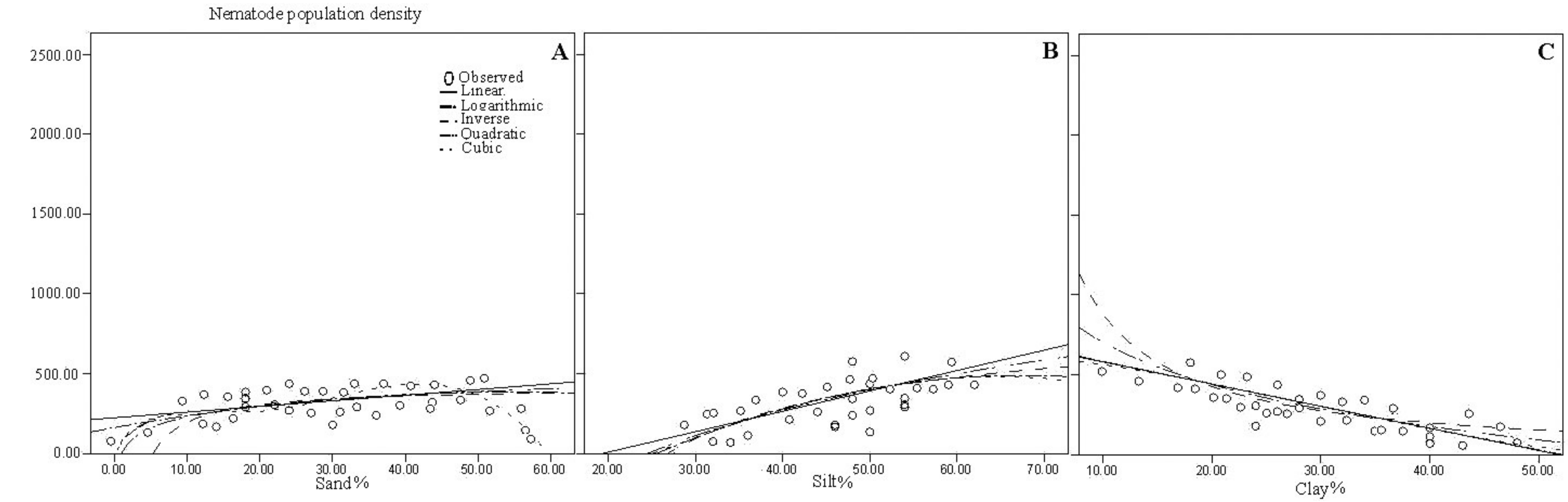

Figure 3. Relationship between soil nematode population and soil texture: (A) Sandy; (B) Silt, and (C) Clay.

Table1. Physicochemical properties of soils and abundance of citrus nematode in Kohgylouyeh region

No.	Locality	Soil texture	Clay (%)	Silt (%)	Sand (%)	K (Ava.) (ppm)	P (Ava.) (ppm)	total N (%)	OC (%)	TNV (%)	pH	EC10^3	Soil saturation (%)	No. of female/gr root	No. of J2 and male/100 gr. soil
1	Zargham abad	Cl-L	34[a]	46	22	284	16.8	0.177	1.61	19.25	7.3	1.08	48	284	1367
2	Choram	Si-Cl-L	18	48	34	316	4.8	0.128	1.17	52.5	7.4	1.08	47	109	576
3	soogh	Si- L	26	66	8	132	2	0.06	0.643	56.75	7.2	1.13	39.5	0	0
4	Choram	Cl-L	28	42	30	310	4.2	0.117	0.072	48.75	7.8	0.70	43.53	0	0
5	Kalachoo	Si- L	24	60	16	174	5.2	0.074	0.741	53	7.3	0.85	40	298	1639
6	Cheshmeh Belghais	Si-CL-L	34	48	18	3.6	4.8	0.128	1.17	52.5	7.4	10.8	47	42	342
7	Kohbord	L	18	32	50	208	15.6	0.214	1.95	51.25	7.7	30	39	0	0
8	Shahrak-e-Sepah	Si-CL	43	43	15	498	12.5	0.176	1.76	22.5	7.7	0.82	50	13	58
9	Sabte Ahval	L	25	44	31	253	3.07	0.16	1.56	52.5	7.6	0.91	40	31	260
10	Avale Kandideh	L	21	46	33	94	3.83	0.065	0.39	57	7.9	0.79	34	0	0
11	Marin	L	24	32	44	200	>40	0.285	2.593	56.75	7.2	0.96	52	0	0
12	Moleh Barfi	Cl	40	36	24	300	15.6	0.156	1.423	54.25	7.3	1.48	-	60	114
13	Emamzadeh Zamen	L	22	44	34	188	4.4	0.058	0.741	58	7.5	0.67	44.9	130	881
14	Bidzard	Si- L	24	54	22	276	3.6	0.046	1.521	56.75	7.3	0.80	48.4	112	306
15	Cham-e-Bolbol	L	40	34	26	364	2.2	0.128	1.17	55	7	1.27	46.50	43	70
16	Cham-e-Bolbol	L	40	36	24	160	2.8	0.150	1.365	50	7.5	1.16	39.75	0	0
17	Anbarshahi	L	48	32	20	180	18.4	0.116	0.97	35.25	7.5	0.670.	42.00	11	75
18	Anbarshahi	Si-Cl-L	14	50	36	148	2.4	0.05	0.585	43.75	7.8	0.37	46.49	32	135
19	Chahar Bisheh	L	42	40	18	188	14.6	0.140	1.17	40.5	7.5	1.08	31.6	104	385
20	Ghoorak-e-Sofla	L	32	46	22	138	5.8	0.117	0.97	65.5	7.9	0.420	43.6	0	0
21	Ghoorak-e-Sofla	Si- L	26	50	24	188	6.8	0.120	0.97	50.75	7.4	0.750	43.7	52	270
22	Kalaghneshin	L	36	48	16	152	10.4	0.119	0.97	47	7.8	0.700	35.7	0	0
23	Booston	Si- L	24	50	26	210	6.2	0.115	0.97	49.5	7.2	1.50	50	0	0
24	Abkhan	L	30	46	24	118	14	0.160	1.36	50.75	7	0.960	40.3	0	0
25	Pol-e-Padook	L	18	36	46	166	8	0.145	1.32	58	7.5	0.81	38	331	2067
26	Lirkak	Sa-L	18	28	54	268	40	0.199	1.813	59	7.4	1.25	41	0	0
27	Sepahi Koshteh	L	16	48	36	152	10.4	0.119	0.97	47	7.8	0.7	35.7	159	1000
28	Mahoor-e-Basht	Si-CL-L	28	54	18	300	10.8	0.145	1.17	52	7.6	0.59	46.6	144	610
29	Petrol pomp of Basht	Si- L	26	50	24	210	6.2	0.115	0.97	49.5	7.2	1.50	50	48	437
30	Mahoor-e-Basht	L	28	54	18	300	10.8	0.145	1.17	52	7.6	0.59	46.6	51	346
31	Pakooh-e-Basht	Si- L	28	54	18	300	10.8	0.145	1.17	52	7.6	0.59	46.6	31	292
32	Kalaghneshin	L	16	48	36	152	10.4	0.119	0.97	47	7.8	0.7	35.7	47	240
33	Abkhan	L	24	46	30	118	14	0.160	1.36	50.75	7	0.96	40	24	179
34	Bidestan	Si-CL-L	40	46	14	342	2.40	0.115	0.97	26.5	7.7	0.87	53	41	168
35	Emamzadeh Jaafar	L	20	38	42	138	5.6	0.12	0.97	48	7.3	0.77	34.6	0	0
36	Pol-e-Berim	CL	40	36	24	300	15.6	0.156	1.423	54	7.3	1.48	40	0	0
37	Shoosh	Si-CL-L	40	28.54	18	300	10.8	0.115	0.97	49.5	7.2	1.5	50	0	0

[a] Data presented in the table are means of 6 replications for each place (3 replications in 2009 and 3 replications in 2010).

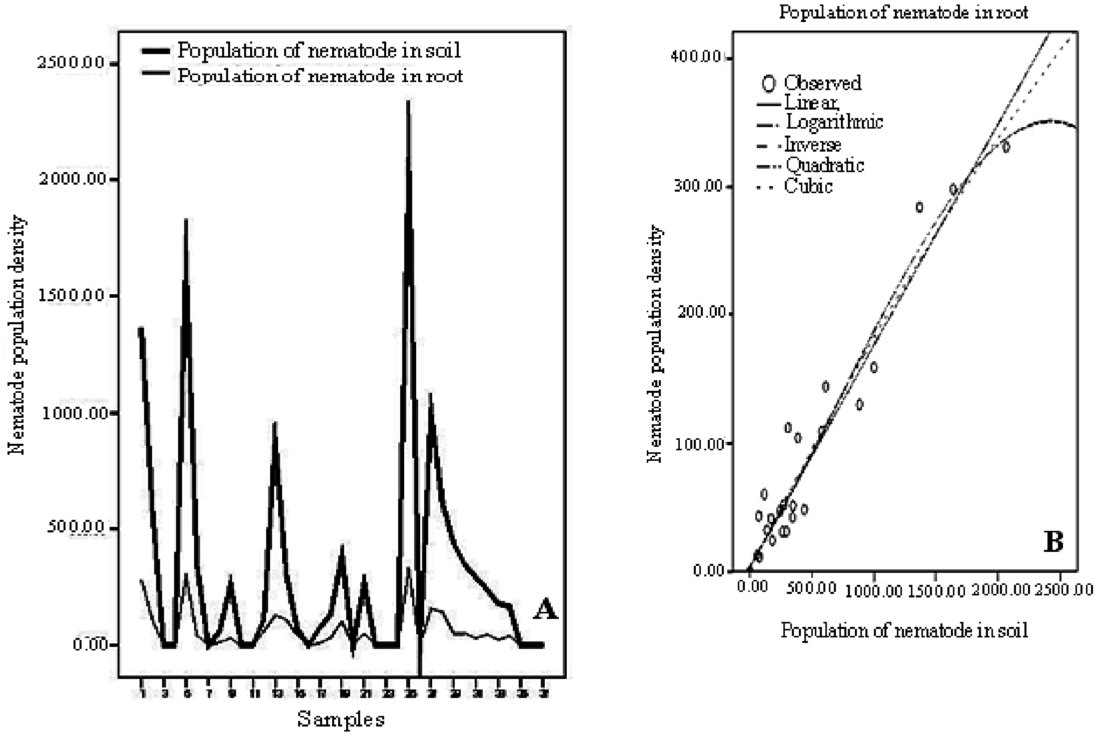

Figure 5. Relationship between nematode population in soil and in root. (A) Nematode population density in different orchards /100 g of soil and /g of the root, (B) Relationship between soil and root population of citrus nematode.

DISCUSSION

Tylenchulus semipenetrans is considered as a major plant-parasitic nematode of citrus, because of the fact that it can cause 10-30% yield losses (Verdejo-Lucas *et al.*, 2004). According to the obtained results, a maximum abundance of *T. semipentrans* was observed in soils at a saturation point of 43%, *EC* of 23 dS m^{-1}, pH of 7, total nitrogen between 0.1 and 0.17 percent, available phosphorus between 5 and 15 ppm, 150 to 300 ppm of potassium, with percentages of sand, silt, and clay of 48, 35 and 17 respectively, 1.5% of organic carbon content and 45 to 55 percent of TNV.

The study revealed that the number of second stage juveniles of the nematode ranged from 58 to 2,730/100 g of soil and while the number of females varing from 11 to 151/g of plant's root. In the present study, citrus decline which is reported as one of the symptoms of infested citrus trees by *T. semipentrans* (Verdejo-Lucas *et al.*, 2004), was seen in some infested and as well in non infected trees. However, this symptom was not seen in some infested citrus trees which could be due to the low number of the nematode in soil and within the infected roots. Nematicide treatments are recommended at various nematode populations, ranging from 100-400 females/g root and 2,000-4,000 juveniles/100 ml of soil (Timmer and Davis, 1982; Westerdahl, 2000; Le Roux *et al.*, 2000; Stapleton *et al.*, 2000). However, the age and vigor of the citrus trees, the nematode population densities in the soil, the aggressiveness of the nematode, soil characteristics, and other environmental factors can influence the level of infestation inflicted by the nematode.

Within the present study, an increase of soil moisture up to saturation point decreased the citrus nematode population in

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soil and as well in plant root. Maintenance soil moisture under saturation conditions would lead to inadequate living conditions for the nematode, bringing about a dramatic reduction in their populations. Browning, *et al*. (1999) demonstrated suppression of *Tylenchorhynchus* spp. and *Hoplolaimus galeatus* populations at saturation soil conditions for seven days, the average reduction of *Tylenchorhynchus* spp. population was 81% as compared with unsaturated soil. Reduction of the population densities of *Tylenchorhynchus martini* in flooded rice soil was attributed to a production of organic acids by anaerobic bacteria, rather than a lack of oxygen (Johnston, 1959). Norton *et al*. (1971) reported different soil factors affecting plant parasitic nematodes with nematode population density being higher in a wet rather than in a dry year. The highest numbers of nematodes were usually found in the lighter soils, except in the loamy sand where moisture was probably a limiting factor. In general, soil moisture levels below 20% saturation were probably limiting for most nematodes studied, except for the Dorylaims which survived in large numbers in soils with less than 20% saturation (Browning *et al*., 1999).

The present results revealed that standard critical (minimum) levels of N, P, and K for the growth of citrus were those also appropriate for nematode activities. Increase in the level of these elements in soil resulted in a similar increase in nematode population. This result is in agreement with other reports', except for the case of nitrogen. Sorribas *et al*. (2008) reported citrus nematode population densities in soil as negatively related to N concentration, and positively related to K content in soil. Other studies also shown ammonia to have a nematicidal effect (Rodriguez-Kábana, 1986) that is enhanced when ammonia releasing fertilizers are combined with alkaline amendments (Oka *et al*., 2006). Application of urea at the rate of 160 kg ha^{-1} prevented *T. semipenetrans* infection and development on rough lemon in a pot test (Mangat and Sharman, 1981). Potassium content of the soil was positively related to densities of J2 and males in soil, a relationship known to occur in other crops (Pettigrew *et al*., 2005; Sharma *et al*., 2005).

Van Gundy and Martin (1962) observed *T. semipenetrans* on citrus increased four-fold in a neutral (pH 7.0) loam soil, as compared with acid (pH 5.0) loam or acidic sandy loam. *T. semipenetrans* reproduces well in sandy clay loam at pH 6.0-6.6 (Davide and Delarosa, 1971). These results indicate that soil pH and texture are closely related in their impacts on citrus nematode. However, the present study's results showed that a maximum number of the nematode was observed when soil pH was seven. An increase or decrease in soil pH from seven, resulted in a decrease of nematode population. In the case of other plant parasitic nematodes, population densities of *Meloidogyne incognita* and *Radopholus similis* were in general reduced in either extremely acidic or alkaline soil, but *R. similis* was more tolerant than *M. incognita* to extreme acidic soil (Davide, 1980).

High nematode population was observed in the present study when percentages of sand, silt, and clay of soils amounted to 48, 35 and 17 respectively, the soil being classified as medium loam as based upon soil textural triangle (www. css.cornell.edu/soil test). Van Gundy *et al.* (1964) observed *Tylenchulus semipenetrans* reproduced well in soil containing 10-15% clay. *T. semipenetrans* can be found in any texture, but the greatest damage occurs in shallow, poorly drained soils with organic matter contents ranging from 2 to 3% (O'Bannon and Essar, 1985). However, the present results showed a maximum population of the nematode in soils with 1.5% of organic carbon.

Different models used in the analyses benefit from different algorithms and results and they likely differ from each other. Thus use of different models seems to be indispensable. From among all the models, the cubic and quadratic models, especially cubic model showed the most acceptable

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results as evident from the high *r*-square values. However, some results of the other models could be considered, such as inverse model as related to soil saturation percentage and organic carbon cases. The relationship between the observed points and graphs are also indicative of this fact. Fajardo *et al*. (2011) proposed the use of Stepwise regression, as a useful tool when using multiple soil factors for elaborating on a single biological variable.

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ارتباط بین صفات فیزیکوشیمیایی خاک و فراوانی نماتد مرکبات (*Tylenchulus semipenetrans*) در باغ های مرکبات استان کهگیلویه و بویراحمد

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چکیده

به منظور درک ارتباط بین صفات فیزیکوشیمیایی خاک در شرایط طبیعی و فراوانی نماتد مرکبات (***Tylenchulus semipenetrans***) ، طی تحقیقی در سال های ۱۳۸۸ و ۱۳۸۹، تعداد ۳۷ باغ مرکبات در استان کهگیلویه و بویراحمد مورد بازدید قرار گرفت. نمونه برداری از خاک و ریشه درختان مرکبات به صورت تصادفی انجام و فراوانی نماتد بر اساس جداسازی و شمارش لارو سن دوم نماتد در ۱۰۰ گرم خاک و ریشه گیاه تعیین گردید. ضمن تعیین میزان مواد آلی، نیروژن، فسفر، پتاسیم، کربن آلی، کربنات کلسیم، بافت خاک، هدایت الکتریکی و میزان اسیدیته در نمونه های خاک، تاثیر این عوامل روی فراوانی جمعیت نماتد مورد بررسی و مطالعه قرار گرفت. نتایج نشان داد که با افزایش درصد رطوبت خاک (تا ۴۳ درصد)، سیلت، ماسه، فسفر، پتاسیم و کربن آلی خاک، جمعیت نماتد نیز در خاک افزایش می یابد در حالی که با افزایش میزان نمک، کربنات کلسیم، نیتروژن کل و رس در خاک، جمعیت نماتد کاهش می یابد. بالاترین جمعیت نماتد در خاک های با بافت لومی به ثبت رسید. در خاک های با اسیدیته ۷، بیشترین فعالییت نماتد ثبت گردید اما با افزایش یا کاهش در این مقدار، جمعیت نماتد کاهش یافت. تعداد لارو سن دوم نماتد در هر گرم خاک از ۵۸ تا ۲۷۳۰ عدد و تعداد نماتد ماده در هر گرم ریشه از ۱۱ تا ۳۳۱ عدد متغیر بود. در حدود ۶۲ درصد از باغ های مورد بررسی به نماتد مرکبات آلوده بودند.

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