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Effect of Sewage Water Deposits Retained at Different Depths of Soil Columns on Population Development of *Tylenchulus semipenetrans*

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Abstract. A Split-plot experiment was conducted in the growth chamber to determine the effect of sewage water deposits, retained at different depths of soil columns, on development of *Tylenchulus semipenetrans*. Sandy loam soil columns in PVC tubes were treated with a total of 7 l of tap water, 7 or 28 l. of sewage water in 14 days. Soils from different depths (0-7, 7-14 and 14-21cm) of columns were then emptied in plastic pots. To each pot, a lime seedling was transplanted and then inoculated with 5,000 second-stage juveniles of *T. semipenetrans*. Effects of the water treatments on nematode population development were not significantly different. However, population development was significantly higher on seedlings grown in soil collected from the lowest depth than from the upper depths of the soil columns.

Introduction

Irrigation with treated sewage water has become increasingly important as a possible source of additional irrigation water. El-Mashhady and El-Nennah [1] have studied the chemical quality of Riyadh sewage water and concluded that use of this water for irrigation is feasible and could be considered as a source of plant nutrients. They added that some precautions related to the concentration of trace elements especially boron seem to be necessary and accumulation of these elements in soil and plant should be followed for continuous use on all soils. Irrigation with sewage effluents for 25-45 years in loamy sand soils cultivated with citrus in Egypt has improved soil properties and increased both the exchange capacity (EC) and the content of organic matter in soil and caused an accumulation of Zn, Fe and Mn in these soils as compared with the same soils irrigated with artesian water [2]. In the same orchards El-Nennah *et al* [3] found a remarkable increase of available phosphorus and both total and soluble nitrogen as well as heavy metals. They also found that surface layers (0-25cm) contained higher amounts of elements than the subsurface ones (25-50cm).

Unfortunately, there is little published information on the effect of irrigation with treated sewage water as such on the population development of plant-parasitic nematodes. Yeates [4] has reported an increase in population of certain plant-parasitic (*Ditylenchus, Heterodera, Tylenchus*) and free-living nematode genera in pasture soil irrigated with dairy shed effluent compared to dryland pasture. *Pratylenchus* was not found at the dryland site but reached high level at the effluent-irrigated site. Recently Al-Yahya *et al.* [5] have found that population development of *T. semipenetrans* was significantly higher on lime seedlings irrigated with treated-sewage water than with tap water. Plant growth was not significantly affected.

The objective of the present study was to determine the effects of sewage water deposits retained at different depths of sandy loam soil columns on population development of the citrus nematode *Tylenchulus semipenetrans* Cobb on lime (*Citrus aurantifolia* L.) seedling in a growth chamber.

Materials and Methods

Preparation of soil columns

Sandy loam soil (78.5% sand, 7.0% silt and 14.5% clay) was used in this study. The soil physical and chemical properties were as follow: pH=7.43, EC=4.59 mmhos/cm, water holding capacity WHC=8.4%, organic matter=0.2%, CO_3=0.102 meg/l, HCO_3 1.34 meg/l, Cl=1.6 meg/l, Ca+Mg=22 meg/l, Na=15.86 meg/l, K=0.6 meg/l, and Sodium Adsorption Ratio (SAR)=4.78. The soil was air-dried for seven weeks. It was then ground and sieved through a 10-mesh (1.7 mm opening) sieve. Columns (12 cm diam. and 35 cm high) of polyvinyl chloride (P.V.C.) tubes were prepared. Each column was divided into five segments (cylinders), of 7 cm each. The segments of each column were fixed firmly together (Fig. 1) with vacuum grease and wrapped with an adhesive tape to prevent leakage. To support the soil in each column, a layer of cheesecloth was fixed firmly between the fourth and fifth segments. The three middle segments were filled with the soil at a rate of 1 kg soil per each segment. Thus, these three soil segments, represent soil depths of 0-7,7-14 and 14-21 cm. The first and the fifth segments were left for irrigation and water drainage, respectively.

Treatment of soil columns with sewage water

The secondary-treated sewage water was obtained from the Agricultural Experiment Station, King Saud University, at Riyadh where it has been used for irrigation. The chemical analysis of this water was determined [6] as follow: pH=7.12, E.C. =1.83 mmhos/cm, Ca=6.4 meg/l, Mg=4.6 meg/l, Na=14.56 meg/l, K=0.44 meg/l,

Fig. 1. Polyvinyl chlorid tubes (PVC) used for establishing soil columns with 5 segments.

CO_3=Nil, HCO_3=1.98 meg/l, Cl=15.2 meg/l, SO_4 =9 meg/l, total soluble salts (TSS)=1173.12 ppm and SAR=6.2. Chemical analysis of tap water, however, was determined as follow: pH=7.37, E.C.=0.78 mmohs/cm, Ca=4.97 meg/l, Mg=0.84 meg/l, Na=1.68 meg/l, K=1.97 meg/l, CO_3=Nil, HCO_3=1.97 meg/l, Cl=2.38 meg/l, SO_4=3.41 meg/l, TSS=502.5 ppm, and SAR=0.99 [6].

Three treatments were established as follows: 1) soil columns received a total of 7 l of tap water at the rate of one liter every other day for 14 days (control); 2) soil columns received a total of 7 l of sewage water at the rate of one liter every other day for 14 days; and 3) soil columns received a total of 28 l of sewage water at the rate of 4 l every other day for 14 days. Each treatment was replicated three times, and thus a total of nine soil columns were used. Soil columns wee kept during the water treatment in a randomized complete block design on a bench at room temperature. After 14 days, each segment with its own soil was carefully separated. Chemical analysis of each soil obtained from the different column segments was performed [6, p. 106].

Nematode population development test

Soil from each segment, in each replicate, of the previous water treatment was transferred to a plastic pot (10 cm diam) in order to be used for the nematode population development test. A total of twenty seven pots, each containing a soil from a single segment (1 kg soil/pot), were used. To each pot, a lime seedling (five-month-old) was transplanted. A week later, each seedling was inoculated with 5000 second stage juveniles of the citrus nematode, *T. semipenetrans*, extracted from infested soil using a combination of Baermann trays with sieving [7,P. 553]. Thus, a split-plot experiment was established. The three main plot treatments were the previously treated soils (in the columns) with the three water treatments, and the three sub-plot treatments were the soil depths (segments) of the soil columns (0-7, 7-14, and 14-21 cm). The nine soil treatments, each replicated three times, were arranged in a randomized complete block design in a growth chamber at 27°C with a 12 h. photoperiod of 30×10^3 lux. All pots were irrigated with tap water, and a special care was made to avoid leaching of deposited materials from soil with a special method of irrigation: each pot was placed in a saucer and the tap water was added, whenever needed, to the saucer instead of directly onto pots.

Two months after nematode inoculation, the test was terminated. Nematode developmental stages attached to lime roots were extracted with 0.5% sodium hypochlorite [8] for 7 min. Nematodes in soil of pots were also extracted using a combination of Baermann trays with sieving [7,p. 553]. Data were transformed to $\sqrt{x+0.5}$ before statistical analysis.

Results

Effects of the different water treatments and depths on the tested chemical parameters of the soil segments are not significantly different (Table 1).

The population develoment of *T. semipenetrans* on lime seedlings grown in soils collected from the different soil segments (Water treatments of tap 7l, sewage 7 and 28l) showed no significant differences in nematode final population whether attached to roots or free in soil (Table 2). However, the subplot treatments (soil depths in columns) showed significant differences in nematode final counts. Juveniles, females, eggs and total counts (including males) attached to roots as well as those free in soil were all significantly ($p=0.05$) higher on seedlings grown in soil collected from the lowest depth (14-21 cm) than in soils from the upper depths (0-14cm). No differences were found between the two upper depths except in juvenile counts which were higher in the upper depth (0-7 cm) than in the midlle one (7-14cm).

Table 1. Analysis of soil as influenced by treatment with tap or sewage water, for 14 days, and by depth of soil column.

Treatment	pH	EC (mmhos/cm)	Cations (meq/l) Ca+Mg	Na	K	Anions (meq/l) CO_3	HCO_3	Cl	SAR*
Water									
Tap 7l	8.0	1.4	7.6	38.1	0.8	0.24	2.8	3.2	19.6
Sewage 7l	8.0	1.9	9.5	53.0	1.3	0.08	3.4	4.6	24.3
Sewage 28l	7.4	2.0	8.7	48.0	1.2	0.16	2.9	5.0	23.0
Depth (cm)									
0-7	7.7	1.6	8.2	44.8	0.9	0.13	2.8	4.5	22.1
7-14	7.8	1.9	8.5	49.3	1.0	0.15	3.0	3.9	23.9
14-21	7.8	1.7	9.1	45.1	1.3	0.20	3.3	4.3	21.1

* SAR = sodium adsorption ratio= $\frac{Na}{\sqrt{\frac{Ca+Mg}{2}}}$

Table 2. Numbers of *Tylenchulus semipenetrans* on lime seedlings grown in soils collected from different depths of soil columns previously treated, for 14 days, with tap or sewage water.*

Factor	Number of nematode stages/root system Juveniles	Females	Eggs	Males	Total	Nema/kg soil
Water treatment (Main-plot treatment)						
Tap 7l. (control)	267 a	104 a	424 a	135 a	930 a	386 a
Sewage 7l.	279 a	51 a	406 a	242 a	978 a	243 a
Sewage 28l.	174 a	46 a	671 a	121 a	1012 a	286 a
Soil depth (cm) (Sub-plot treatment)						
0-7	137 a**	41 a	338 a	134 a	686 a	259 a
7-14	118 b	71 ab	276 a	121 a	586 a	238 a
14-21	428 c	90 b	888 b	242 a	1648 b	415 b

* Values are means of three replicates. Data were transformed to $\sqrt{X + 0.5}$ before analysis.

** For each factor (water or soil depth), means in a column followed by the same letters are not significantly different at $p=0.05$.

Discussion

It appears that stimulation of nematode development in the lowest soil segments might be due to the effects of the sewage water deposits which passed through the two upper soil segments (0-14 cm) and then retained, partially or compeletely, in the lowest segment (14-21 cm). It might be, however, that some of these materials have even passed through this section with the draining water. No attempt was made to use soil depth more than 21 cm. It has been found that the surface layers (0-25 cm) of a loamy sand soil irrigated with sewage water for many years contained higher amounts of elements than the subsurface (25-50 cm) layers [3]. However, it should be noted that soil analysis was not complete with respect to all possible chemicals that might influence the nematode population development. El-Mashhady and El-Nennah [1] have found that use of Riyadh sewage water in irrigating recreation areas for about three years increased the contents of P and micronutrients Cu, Mn and Zn in plant and soil as compared to samples irrigated with tap water. They concluded that use of Riyadh sewage water could be considered as a source of plant nutrients. This would suggest that increase of root system and subsequently increase of the infection sites, by the additional plant nutrients provided by the sewage deposits, could be one of the indirect mechanisms involved in the stimulation of the citrus nematode population development.

Stimulation of the citrus nematode population development by the sewage water deposits might be due to some chemicals, other than plant nutrients, which have been adsorbed by even the low organic matter and fine soil particles present in the tested soil. Al-Yahya *et al.* [5] have found that juveniles, eggs and total counts of *T. semipenetrans* per gram of lime roots were all significantly higher in sewage water treatment than in tap water. Plant growth was not significantly affected. The Stimulating chemicals might act directly or indirectly on nematode, host, or both, or on the rhizosphere ecosystem. Complete and detailed investigations of this area of research are needed. Biological components of the sewage water, in particular, should not be excluded. In a different study [9], the fungi *Paecilomyces variotii* Bainier and *Mucor hiemalis* Wehmer were isolated from the sewage water and significantly increased the citrus nematode population development on lime seedlings.

In conclusion, stimulation of *T. semipenetrans* development was significantly higher in soils collected from the lowest depth (14-21 cm) than from the upper depths (0-14 cm) of soil columns treated with sewage water. Possible mechanisms involved were of chemical and/or biological nature. Complete and detailed investigation of these mechanisms are needed.

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دراسة تأثير مكونات مياه الصرف الصحي المترسبة على أعماق مختلفة من أعمدة تربة على تطور نيماتودا الموالح

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ملخص البحث. تم ري تربة سلتية رملية موضوعة في أعمدة بلاستيكية من مادة الـ PVC بـ ٧ لترات مياه صنبور، ٧ لترات من مياه الصرف الصحي أو ٢٨ لترًا من مياه الصرف الصحي خلال مدة ١٤ يوما. بعد ذلك تم تقسيم التربة في العمود الواحد إلى ثلاثة أقسام تبعا للأعماق التالية: صفر - ٧، ٧ - ١٤، ١٤ - ٢١ سم ونقلت تلك الترب إلى أصص بلاستيكية. تم تشتيل بادرات ليمون بنزهير في الأصص ثم لقحت بعد ذلك بمعدل ٥٠٠٠ يرقة من يرقات نيماتودا الموالح لكل بادرة. أظهرت النتائج أن تأثير المعاملات المائية المختلفة على تكاثر نيماتودا الموالح كان متشابها إلا أن تطور النيماتودا كان أعلى معنويا على جذور بادرات الليمون البنزهير المنزرعة في الترب المأخوذة من أي من العمقين الأول والثاني.