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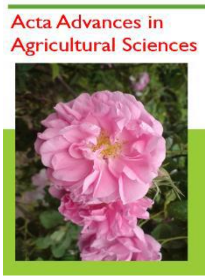

Research Article

Infectivity, development and reproduction of *Meloidogyne javanica* and *Rotylenchulus reniformis* as influenced by different water sources in Egypt

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ABSTRACT

The effects of different water sources (distilled water, drainage water, ground water, Nile water, sea water and tap water) on infectivity, development and reproduction of *Meloidogyne javanica* and *Rotylenchulus reniformis* were evaluated under greenhouse conditions. Sea water was very toxic death to both nematodes and tomato plants. Water source did not affect rate of penetration for *M. javanica* or *R. rotylenchulus*. Final population of root-knot was highest for Ground water and lowest for Drainage water. Final population of reniform nematode was highest with Nile water and lowest with Drainage water. Nematode reproduction was correlated with the concentration of some cations such as Na^{+}, Mg $^{++}$; and some anions i.e. Cl^{-} and SO_{4}^{--}. Root-knot nematode development and reproduction was higher with irrigation by ground water than the Nile water, distilled water or tap water treatments, however, the reniform nematode development and reproduction much higher when Nile water was used rather than the distilled water, tap water or ground water treatments. The root-knot nematode, *M. javanica* tolerated salinity of irrigation water more better than *R. reniformis*.

Introduction

Any water source contains some common dominant elements either anions such as chlorides, sulphates, bicarbonates and sometimes nitrate or cations i.e. calcium, sodium, magnesium and sometimes potassium. These elements can exist individually or in combination with others to form complex compounds. The impact of such compounds on nematodes egg hatch has become evident. The toxic effects of sodium chloride, boron, barium, iron and zinc on nematode egg hatch, infectivity, development and reproduction were reported by some researchers (Lal and Yadav, 1978, Prot, 1978 & 1979, Al Sayed *et al*., 1986, Korayem and El-Sisi, 1989 and Ahmed and Al Sayed, 1992). The infectivity and development of *M. incognita* on tomato plants was impaired by increasing Na Cl and Ca Cl_2 solutions (Edongalli and Ferris,1981 and Edongali *et al*., 1982).Also, they reported that development and egg production of entrant juveniles were inhibited by both salts and resulted in a population decrease.

Al Sayed *et al*. (1986) stated that $BaCl_2$, $CaCl_2$ and Na Cl suppressed *M. javanica* invasion, however, Mn Cl_2, and Mg Cl_2 enhanced the nematode invasion. The potential synergistic effects of both zinc and ferric sulphate on the nematicidal activity of oxamyl were evaluated under greenhouse conditions (Korayem and El-Sisi, 1989). They found that toxicity of oxamyl to *M. incognita* increased 11.3 times in combination with Fe_2 $(SO_4)_3$ and 4.1 times in combination with $ZnSo_4$ compared with toxicity in water alone. So, the objective of this research was determine the influence of different water sources on infectivity, development and reproduction of *M. javanica* and *R. reniformis* on tomato plants.

Materials and Methods

Six types of water sources i.e. distilled water, drainage water, ground water, Nile water, sea water and tap water were chemically analyzed (Table1) and used to evaluate their effect on penetration, development and reproduction of *Meloidogyne javanica* and *Rotylenchulus reniformis* on tomato plants, *Lycopersicon esculentum* (syn = *Solanum lycopersicon*) cv. Super strain B under greenhouse conditions 25± 5 °C. Fourteen days old tomato seedlings cultivated in 15 cm clay pots filled with clay and sandy soil (1:1) were inoculated with 2000 second-stage juveniles of *M. javanica* or fourth-stage juveniles as infective stages of *R. reniformis*. The nematodes were reared on eggplant cv. Pusa Purple Long in a greenhouse. All the pots were arranged in a completely randomized block design with seven replicates per treatment. Each treatment was watered individually with 100 ml of each water source two times a week. Roots of tomato plants were carefully uprooted after 2, 4 and 6 weeks from irrigation, gently washed with tap water to move the adhering soil and roots were stained in hot acid fuchsin - lactophenol , and then cleared with lactophenole to count the embedded stages i.e. the developmental stages and egg-masses (Taylor and Sasser,1978). The number of galls on the tomato roots were also counted. The juveniles were extracted from 1 g of roots for each treatment using the incubation (Southey, 1986), however, soil juveniles were extracted by using the sieving and decanting technique (Barker, 1985). The total number of juveniles in the soil and in the whole roots were recorded. Rate of nematode penetration as well as rate of nematode build-up were determined by the following equations:

Rate of penetration (R.P. %) = Total number of the embedded stages / inoculated level × 100.

Rate of reproduction or build-up (P_f / P_i) = Final population / Initial population × 100.

Statistical analysis:

All obtained data were subjected to statistical analysis by analysis of variance and using a F-test ($P< 0.05$) and the means were compared according to L.S.D. test (P=0.05 and 0.01) (Gomez and Gomez, 1984).

Results and Discussion

Influence of irrigation with different water sources on Meloidogyne javanica:

After irrigating pots for two weeks the ground and distilled water treatments had higher numbers of nematodes in the roots and more galls than from the other water sources (Table 2). Tap and drainage water sources resulted in the lowest numbers of nematodes in the roots, and use of Nile water resulted in the fewest galls than all other water sources except the drainage water. There was no effect of water source on rate of penetration. The sea water resulted in the death of all tomato plants and nematodes after four irrigation times.

Table 1. *Some chemical properties of water used to irrigate tomato infected with Meloidogynejavanica and Rotylenchulusreniformis.*

Type of water	Soluble cations (meq L $^{-1}$)				Soluble anions (meq L $^{-1}$)		
	Na^{+}	K^{+}	Ca^{++}	Mg^{++}	Cl^{-}	CO_3^{--}	SO_4^{--}
Distilled water	0.35	0.00	0.31	0.23	0.10	0.32	0.35
Drainage water	2.10	0.41	3.49	3.87	4.90	1.55	1.66
Ground water	2.89	0.55	4.10	2.15	4.65	1.86	2.35
Nile water	1.90	0.33	3.15	1.75	2.45	2.85	1.55
Sea water	610.00	4.90	25.10	140.55	534.10	2.66	166.20
Tap water	1.55	0.34	3.30	1.65	1.67	1.45	4.30

Four weeks after initiating irrigation treatments, tomato roots watered with the distilled water had the highest number of nematodes in the roots and drainage and ground water treatments had the lowest number of nematodes in the roots (Table 2). Gall numbers were lower for the drainage water treatment than for the tap, distilled and ground water treatments (Table 2). There were more egg masses for the ground water treatment than for the drainage water treatment (Table 2). There were no differences in penetration rates between water sources.

After six weeks of irrigation with different water sources, there was an increase in the number of galls and egg masses over that found at four weeks. There were no differences in root-knot nematode penetration rates between water sources. The number of nematodes in the roots was higher for the distilled water than all other water sources (Table 2). Gall numbers were lower for Nile water than for all treatments except drainage water (Table 2). The highest number of egg masses were associated with the Nile and tap water treatments. The highest population of root-knot nematode was associated with the ground water treatment and the lowest population density was associated with the drainage and distilled water treatments (Table 2).

The distilled water treatment was consistently associated with a higher number of galls and nematodes in the roots at 2, 4, and 6 weeks, but then had a low number of egg masses and a low final population density at the higher period. Irrigation with drainage water consistently had low numbers of galls, nematodes in the roots, and egg masses at all three sampling times and low final population density or root-knot nematode. This nematode species was negatively affected by drainage water. Irrigation with ground water resulted in high numbers of galls; however, there was an inconsistent relationship with numbers of nematodes in the roots; an intermediate number of egg masses, and a high final population density. Irrigation with Nile water resulted in low numbers of galls consistently, low number of nematodes in the roots, but relatively high number of egg masses and an intermediate final population density. Irrigation with tap water resulted in an inconsistent relationship with numbers of galls, low number of nematodes in the roots, relatively high egg masses, and intermediate final population density. There was some inconsistency among the measured nematode parameters for the different water sources. The most consistent responses across all measured parameters were with drainage water having a negative effect on root-knot nematode.

Influence of irrigation with different water sources Rotylenchulus reniformis:

After two weeks of irrigation, with different water sources tomato roots were invaded with low numbers of *R. reniformis* (average of 22 to 64 individual / root) that produce low numbers of egg-masses (average of 11 to 28 egg-mass/ root)

Table 2. *Penetration, development and reproduction of Meloidogyne javanica as influenced by different irrigation waters.*

Source of water	Two weeks			Four weeks				Six weeks							
	Galls	D.S.	R.P.	Galls	D.S.	Egg-masses	R.P.	Galls	D.S.	Egg-masses	Eggs/ eggmass	R.P.	Final population	Rate of build-up*
Distilled water(check)	185	310	15.5	350	540	230	38.5	575	285	310	25	29.8	8035	4.0
Drainage water	60	130	6.5	215	143	200	17.2	440	155	220	22	18.8	4995	2.5
Ground water	210	325	16.3	376	185	240	21.3	610	167	490	30	32.9	14867	7.4
Nile water	35	209	10.5	320	310	210	26.0	370	150	640	20	39.5	12950	6.5
Sea water	-**	-	-	-	-	-	-	-	-	-	-	-	-	-
Tap water	75	95	4.8	430	230	220	22.5	675	180	550	23	36.5	12830	6.4
LSD 0.05	25	55		109	111	35		203	49	110	8		1003	1.1
LSD 0.01	32	68		135	129	48		247	63	139	13		1243	1.7

D.S. = Developmental stages including 3rd and 4th juveniles stages. *Rate of build – up = Final population (P_f) / Initial population (P_i) **All plants died after four irrigation times.

R.P. (Rate of penetration) = Total embedded stages / Inoculation level × 100.

Table 3. *Penetration, development and reproduction of Rotylenchulus reniformis as influenced by different irrigation waters.*

Source of water	Two weeks			Four weeks					
	D.S.	Eggmasses	R.P.	D.S.	Eggmasses	Eggs / Eggmass	R.P.	Final population	Rate of build-up*
Distilled water(check)	35	23	2.9	45	133	38	8.9	5099	2.6
Drainage water	64	11	3.8	85	155	15	12.0	2410	1.2
Ground water	34	28	3.1	25	160	20	9.3	3225	1.6
Nile water	22	23	2.3	31	186	30	10.9	5611	2.8
Sea water	-**	-	-	-	-	-	-	-	-
Tap water	23	25	2.4	26	135	33	8.1	4481	2.2
LSD 0.05	10	8		23	7	6		603	0.6
LSD 0.01	21	12		30	11	9		745	0.9

D.S. = Developmental stages including 2nd and 3rd juveniles stages. *Rate of build – up = Final population (P_f) / Initial population (P_i) **All plants died after four irrigation times.

R.P. (Rate of penetration) = Total embedded stages / Inoculation level × 100 containing few eggs The fewest number of nematodes in the roots were associated with the Nile and tap water sources while the most nematodes in the roots were associated with the drainage water source (Table 3). Irrigation with the drainage water had fewer egg masses than all other water sources (Table 3). Penetration rate was similar between all water sources.

After four weeks of irrigation with different water sources, the drainage water treatment again had the highest number of nematodes in the roots (Table 3). However, irrigation with the Nile water had the highest number of egg masses and the distilled and tap water treatments had the lowest number of egg masses (Table 3). The final population density was highest for the Nile water and distilled water treatments and lowest for the drainage and ground water sources (Table 3).

Irrigation with distilled water had an intermediate number of nematodes in the roots, and was inconsistent with egg mass number between sampling dates, though there was a high final nematode density. Drainage water had a high number of nematodes in the roots, an intermediate number of egg masses, and a low final population density. Irrigation with ground water resulted in a low number of nematodes in the roots, inconsistentcy over time with the number of egg masses and a low final population density. Irrigation with Nile water resulted in a low number of nematodes in the roots, high number of egg masses, and high final population density. Irrigation with tap water resulted in a low number of nematodes in the roots, inconsistent relationship with egg masses at the two sampling times, and an intermediate final nematode population density. There was not good agreement between nematode parameters for a single water source, though for most of the parameters, ground water resulted in poorer conditions for nematode population increase. All the other water sources had such inconsistency between measured parameters that it is difficult to determine whether they had a negative impact on the reniform nematode population development.

Our findings may be explained as reference with the chemical components of the evaluated types of water (Table 1). At application the sea water comparatively with the rest treatments, its was very toxic to either the tested nematode (*M. javanica* and *R. reniformis*) or tomato plants, may be due to the high concentration of some cations and anions (Table 1).The concentrations of Na^{+}, Mg^{++} and Cl^{-} elements caused positive relationship between suppression of nematode infectivity, development and reproduction and these values of elements. So, the values of some salts especially in drainage water decrease the nematode development and reduces the number of eggs produced / female (Edongali *et al*., 1982).Moreover, Ahmed and El-Sayed (1992) found that the root-knot nematode, *M. incognita* tolerated salinity level better than the reniform nematode, *R. reniformis* did. The role of salinity level which play not only on the nematode species, different stages (free or embedded) but also to the salinity stress on plant vigorous resulting in weak growth (Edongali *et al*., 1982).These effects may be attributed to a) direct toxicity of both cations and anions components to the nematode juveniles before their penetration the host roots; b) indirectly effect to pH, osmotic pressure as well as prolonged the exposure time to the treatments (Al-Sayed *et al*., 1986). Also, the copper sulphate monohydrate formulations are suitable candidates for field application as toxic agent against the rice-root nematode, *Hirschmanniella oryzae*, besides the other pests and pathogens living in rice field water (Korayem and Helaly,1988). Finally, using of irrigation water by tap water or Nile water seemed to have stimulated effect on the nematode infectivity, development and multiplication as compared with the rest water sources. This could be due to nematode adaption to the type of water under the traditional conditions.

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