Effect of Soil Water on Infectivity and Development of Rotylenchulus reniformis on Soybean, Glycine max[1]

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Abstract: The effect of soil water content on *Rotylenchulus reniformis* infectivity of 'Lee' soybean roots was investigated in an autoclaved sandy clay loam. Nematodes were introduced into soil masses maintained at constant soil water levels ranging from 3.4 to 19% by weight. Seedling growth and the soil water content-water potential relationships of the soil were determined. Nematode infectivity was greatest when the soil water content was maintained just below field capacity in the 7.2 (-1/3 bar) to 13.0% (-1/7 bar) ranges. Nematode invasion of roots was reduced in the wetter 15.5 (-1/10 bar) to 19.0% (-1/20 bar) soil moisture ranges and in the dryer 3.4 (-15 bar) to 5.8% (-3/4 bar) soil moisture ranges. *Key Words:* plant growth, transpiration, nematode, water potential.

Soil water is an important environmental factor which affects movement and behavior of nematodes in soil. Verma and Prasad (6) found the lowest of three soil-water regimes investigated to be conducive to rapid increase of reniform nematode (*Rotylenchulus reniformis* Linford and Oliveira 1940) population on castor beans. My work was conducted to determine the effect of soil moisture on parasitism and development of *R. reniformis* on soybean.

A preliminary report has been published (2).

MATERIALS AND METHODS

Soybean seeds, *Glycine max* L. Merr. 'Lee', were surface sterilized for 30 sec in 95% ethanol followed by a 15-min dip in a commercial 5.25% sodium hypochlorite solution and water (1:4, v/v) and then transferred directly to sterile potato-dextrose agar and incubated for 4 days at 27 C. Uncontaminated seedlings were weighed and planted (one per cup) in 150 g (dry wt) of an autoclaved [15 min at 1.05 kg-force/cm^2 (15 psi)] sandy clay loam in a weighed plastic cup (165-ml capacity). Each container (Fig. 1) represented one replication. All treatments were randomized and replicated 5 and 6 times in tests 1 and 2, respectively. The sandy clay loam used in these tests contained approximately 63% sand, 21% clay, and 16% silt. It had a soil pH of 6.4, and a cation exchange capacity of 10-11 meq/100 g. The soil water content-water potential relationship was determined by the pressure plate method (4).

Immediately after the seedlings were planted, the soil water was brought to 20% by weight with sterile demineralized water, and then allowed to evaporate to the desired percent (w/w). A 0.5-ml fraction of surface-cleaned nematodes (3) (approximately 400 and 800 nematodes in tests 1 and 2, respectively) was injected (5 and 15 days after planting in tests 1 and 2, respectively) into the center of the soil mass in each container. To minimize evaporation from the soil surface to the air, container tops were covered with a thin polyethylene film held in place with masking tape, leaving only the plant shoots exposed. To determine evaporation losses through the polyethylene, cups without plants and containing 15, 8 or 4% moisture by weight, were set up under similar conditions and weighed periodically. The polyethylene was covered with aluminum foil (Fig. 1) for insulation and to prevent localized condensation of water by maintaining uniform temperatures throughout the plastic containers. For optimum nematode development, the soil temperature was maintained at 29.5 ± 1 C in greenhouse water baths (3).

The average percent soil water, deviations therefrom, and corresponding average soil-water potential (in bars) maintained for each treatment in tests 1 and 2 are listed in Table 1. Soil water levels were maintained by injecting sterile demineralized water through the plastic covering at several points along the sides of the cup with a hypodermic needle two or three times daily. To maintain the desired percent soil moisture, the gross weight of each container and its contents was adjusted

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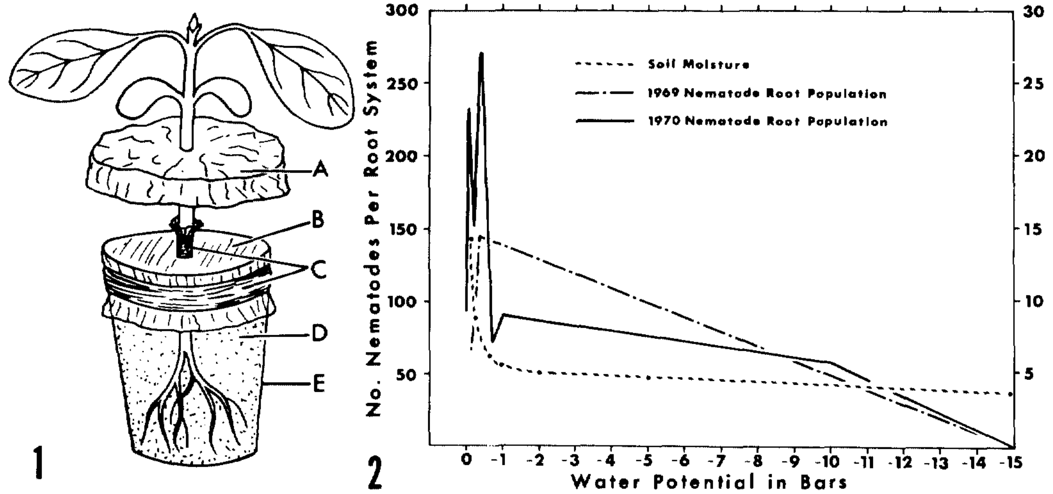

FIG. 1-2. **1.** Diagram of the apparatus used to grow plants at various soil-water levels. Aluminum foil cover, **A**; thin plastic wrap, **B**; masking tape, **C**; soil, **D**; and plastic cup, **E**. **2.** The soil water content-water potential relationship (soil-moisture characteristics) curve for sandy clay loam and the effects on *Rotylenchulus reniformis* infectivity of 'Lee' soybean roots in tests 1 and 2 (1969 and 1970, respectively).

TABLE 1. Effect of soil-water content on infectivity and development of *Rotylenchulus reniformis* on 'Lee' soybean. Figures represent the mean of five replications in test 1 and six replications in test 2.

	Avg. % soil-water (w/w)	Avg. water potential (bars)[1]	No. of nematodes in soil[2]	No. of mature females[3] per root system	No. of mature females[3] per gram of root	Total no. of females per root system	Total no. of females per gram of root	Total no. of nematodes recovered/ rep.	No. of eggs/ female
Test 1	15.5 ± 1.5	-1/10	51.8 b	33.0 b	44.7 b	47.6 b	65.3 b	99.4 b	34.0 a
	8.1 ± 1.6	-1/3	42.6 b	82.0 a	60.7 a	112.0 a	87.8 a	154.6 a	50.9 a
	3.7 ± 0.5	-15	148.4 a	0.0 b	0.0 c	1.4 c	2.8 c	149.8 ab	0.0 b
	LSD, $P = 0.05$		45.4	38.7	14.2	36.4	15.7	51.9	21.9
Test 2	19.0 ± 2.3	-1/20	63.8 c	15.1 b	16.1 b	95.3 bc	105.9 bc	158.3 c	
	13.0 ± 2.1	-1/7	85.5 bc	65.2 a	93.7 a	234.9 a	333.2 a	320.4 ab	
	8.8 ± 2.1	-1/5	111.0 bc	18.8 ab	22.9 b	154.5 ab	146.2 bc	265.5 abc	
	7.2 ± 1.2	-1/3	99.5 bc	46.1 ab	32.6 b	248.9 a	233.5 ab	348.4 ab	
	5.8 ± 1.0	-3/4	145.3 bc	8.0 b	6.1 b	72.2 bc	90.8 bc	217.5 ab	
	5.0 ± 1.0	-1	227.3 b	10.0 b	4.8 b	91.2 bc	126.1 bc	318.5 ab	
	4.5 ± 1.2	-10	184.3 bc	6.2 b	6.4 b	59.9 bc	76.4 c	244.2 bc	
	3.4 ± 0.5	-15	410.2 a	0.0 b	0.0 b	0.2 c	1.6 c	410.4 a	
	LSD, $P = 0.05$		123.6	46.5	57.9	93.0	130.3	135.4	

[1] Bar = 1 megadyne/cm^2 or approximately 1 atmosphere of pressure.
[2] Column figures for any one test followed by different letters are significantly different from one another at the 5% level, Duncan's multiple range test.
[3] Mature females = females that have an egg matrix.

periodically to compensate for seedling growth. At 15 and 10 days after inoculation in tests 1 and 2, respectively, plants were removed from the cups, roots and tops weighed and the roots fixed and stained with lactophenol-acid fuchsin to facilitate counting of nematodes and eggs. Nematodes were extracted from the entire soil mass by the elutriation method (5).

RESULTS AND DISCUSSION

Except under near-flooding conditions, it is impossible to have uniform soil-water potential throughout a soil mass in which plants are removing water for growth and transpiration. The water added per replication per day (Table 2) was lost mostly via transpiration, except for 0.2 - 0.5 g, which evaporated directly from the

TABLE 2. Effect of soil-water content on soybean plant growth and water uptake. Figures represent the mean of five replications in test 1 and six replications in test 2.

	Avg. % soil water (w/w)	Fresh wt of plant		plant top (g)	Total fresh wt of plant (g)	Water added/ replication/day (g)[2]
		roots (g)[1]	tops (g)			
Test 1	15.5 ± 1.5	0.74 b	1.28	0.16 ab	2.02 ab	3.70 ab
	8.1 ± 1.6	1.30 a	1.08	0.21 a	2.38 a	4.82 a
	3.7 ± 0.5	0.86 ab	0.70	0.13 b	1.56 b	1.77 b
	LSD, P = 0.05	0.55	0.64	0.06	0.68	1.84
Test 2	19.0 ± 2.3	0.98 ab	1.37 a	0.26 a	2.35 a	6.07 a
	13.0 ± 2.1	0.89 ab	1.34 a	0.24 a	2.29 a	6.46 a
	8.8 ± 2.1	1.16 a	1.20 ab	0.25 a	2.59 a	5.90 abc
	7.2 ± 1.2	1.07 ab	1.17 ab	0.21 ab	2.23 a	4.68 abc
	5.8 ± 1.0	0.99 ab	1.15 ab	0.24 a	2.14 ab	4.08 bc
	5.0 ± 1.0	0.90 ab	0.94 bc	0.18 b	1.84 bc	2.93 cd
	4.5 ± 1.2	0.77 ab	0.72 c	0.21 ab	1.75 bc	2.93 cd
	3.4 ± 0.5	0.59 c	0.68 c	0.15 b	1.28 c	1.49 d
	LSD, P = 0.05	0.39	0.32	0.07	0.62	1.90

[1] Column figures for any one test followed by different letters are significantly different from one another at the 5% level, Duncan's multiple range test.
[2] All but 0.2 to 0.5 g of the water added was taken up by the plant.

soil, as determined from unplanted controls. Direct evaporation from the soil was not significantly different at the various soil-water levels, but plant transpiration was. The main variables reducing transpiration in these experiments, appeared to be increased soil-water stress and reduced plant size (1). The greatest variation in average soil-water potentials occurred in the −1 bar or lower range, where small changes in percent soil moisture caused large changes in soil-water potential (Fig. 2).

The results of both tests (Table 1) indicate that moderate soil-water stresses of −1/7 to −1/3 bar are favorable, while wetter or dryer soil conditions were less favorable for *R. reniformis* invasion and development on soybean roots in the soil studied. These data generally agree with observations on other phytoparasitic nematodes (7, 8).

The total number of nematodes per root system and per gram of root were used as a criterion for measuring the invasion rate, since the postinoculation periods of 15 days in test 1 and 10 days in test 2 were too short for significant second-generation hatch and invasion of roots (3). The numbers of mature females per root, mature females per gram of root, and eggs per egg matrix served as indicators of nematode development rates.

The greatest root-infection rate occurred just below field capacity (≃1/10 bar), which is usually associated with the region of downward deflection in the soil-moisture characteristics curve (Fig. 2). This part of the curve corresponds closely to the hypothesized zone of optimum soil water for maximum nematode activity (7).

All plants appeared healthy, but growth was severely retarded by high water-stress conditions (Table 2). Based on plant growth, nematode infectivity, and nematode development, it appears that soil-water contents that favored maximum host-root growth also favored nematode parasitism and development (Tables 1 and 2). This host-parasite relationship, however, may not be entirely direct. In the wettest treatments for each test, reduced oxygen-diffusion rates (7, 8), accumulation of carbon dioxide (7), and/or increase of toxins (8) could all contribute in some way to the decreased nematode survival, root-invasion, and development rate. Low soil-oxygen levels can also reduce root growth and water uptake (1). Under adverse dry conditions, adaptability to survival and reduced motility of the nematodes are the most likely contributors to poor root penetration and high soil populations (7, 8).

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