THE EFFECT OF SOIL WATER AVAILABILITY ON THE INTERACTION OF *ROTYLENCHULUS RENIFORMIS* AND COTTON IN MULTIPLE SOIL TYPES

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Abstract

A trial to determine the effect of water availability on the interaction of *Rotylenchulus reniformis* and early season cotton growth was conducted in 2011. The trial was a 6x3x2 factorial design with six different soils (clay, silt loam, loam, very fine sandy loam, fine sandy loam, sandy loam), three different soil moisture potentials (-0.33 bar, - 1.00 bar, - 3.00 bar), and *R. reniformis* present or absent. At 30 days after planting (DAP), each plot was evaluated for *R. reniformis* density per gram of root and plant growth parameters. Water availability affected both *R. reniformis* populations and plant growth; however, the effects were different dependent on soil type. The density of *R. reniformis* per gram of root was significantly higher ($P < 0.05$) at – 3 bar in the fine sandy loam soil compared to – 0.33 bar. Conversely, *R. reniformis* density per gram of root in the sandy loam soil was significantly lower at – 3 bar compared to the other soil moisture potentials. All other soils supported comparable *R. reniformis* populations at each of the three moisture potentials. Plant growth exhibited a general increase with increasing water availability, and plants free of *R. reniformis* were, on average, numerically taller and had higher weights compared to those with *R. reniformis.* Although there were no significant differences in plant growth between nematode present/absent plots, when compared to the nematode free control, all soils presented a general trend of decreasing plant growth with increasing moisture availability in the presence of *R. reniformis*.

Introduction

The reniform nematode, *Rotylenchulus reniformis*, is the most damaging nematode pathogen of cotton in Alabama. Currently, site-specific strategies are being explored for the economic management of this pathogen. One of the many factors to consider when creating management zones is the potential of water stress. Moore et al. (2011) reported that nematicides to control the reniform nematode resulted in a greater yield increase of cotton where the average seasonal volumetric water content of the soil was the lowest. The root-knot nematode (*Meloidogyne incognita*) can affect the maximum rate and cumulative amount of water flow within a cotton plant (Kirkpatrick et al., 1995) and the interaction of the root-knot nematode and water stress has been observed to negatively impact components of leaf water potential, leaf temperature, transpiration, and stomatal resistance of cotton (Kirkpatrick et al., 1991). Similarly, the interaction of root-knot nematodes and water stress was observed to negatively impact tobacco yields at both low and high water availability (Wheeler, et al., 1991). A study of the response of soybean in soybean cyst nematode (*Heterodera glycines*) infested soil at differing moisture potentials concluded that providing adequate moisture during the growing season may limit yield reductions caused by the soybean cyst nematode (Johnson, et al., 1994). The objective of this trial is to determine the effect on cotton by the reniform nematode at varying soil moisture potentials and how the effect may vary within a range of soil types.

Materials and Methods

A trial to determine the effects of soil moisture availability and *Rotylenchulus reniformis* on cotton in six different soil types was conducted in 2011 at the Auburn University Plant Science Research Center, Auburn, AL. The trial was arranged in a 6x3x2 factorial design (6 soils, 3 moisture potentials, with and without *R. reniformis*) with four replicates. The soil types used in the trials were Decatur silt loam (18-49-33 S-S-C, 1.0% OM, pH = 5.5), Hartsells fine sandy loam (66-21-13 S-S-C, 2.7% OM, pH = 5.4), Vaiden clay (9-53-38 S-S-C, 3.8% OM, pH = 6.1), Lloyd loam (38-35-27 S-S-C, 2.0% OM, pH = 5.5), Dothan sandy loam (82-11-7 S-S-C 0.6% OM, pH = 5.9), and Ruston very fine sandy loam (64-21-15 S-S-C, 1.6% OM, pH = 5.8). Soils were collected from the plow layer (top 6 in) of the soil in cultivated fields free of plant parasitic nematodes. Soils were analyzed for nutrient and pH levels and maintained according to standard recommendations set by the Alabama Cooperative Extension System. Three moisture potentials were determined for each soil type by creating a moisture release curve (Figure 1) and selecting the volumetric water content for each soil at matric potentials of -3.0, -1.0, and -0.33 bars (Table 1). Volumetric water content (VWC) for each pot was monitored throughout the trial with an EC-5 soil moisture sensor and logged with an EM-50 datalogger (Decagon Devices, Pullman, WA). Pots were maintained at the desired volumetric water content with a ¼ inch drip irrigation system controlled by a Rain Bird SST Series Automatic Sprinkler Timer (Rain Bird Corporation).

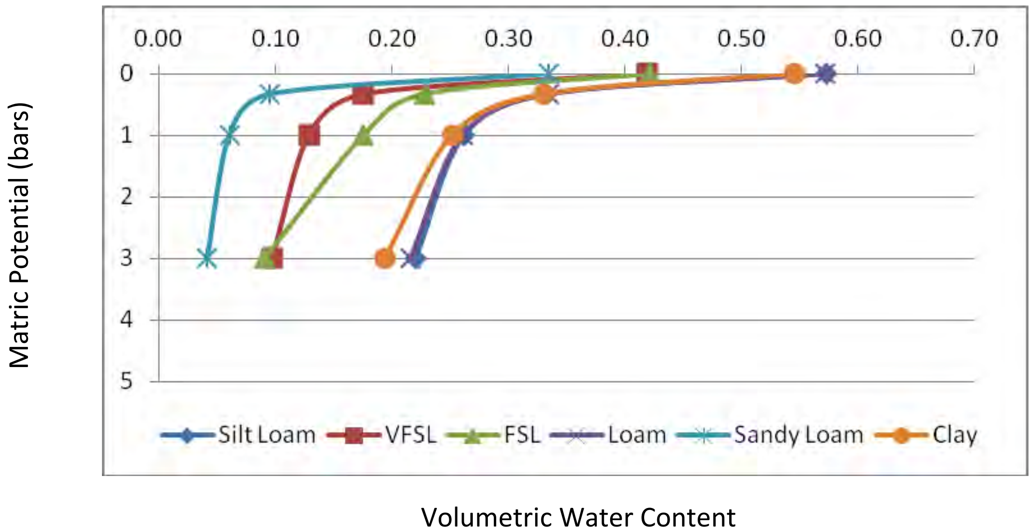

Figure 1. Soil moisture release curves for each soil type (silt loam, very fine sandy loam, fine sandy loam, loam, sandy loam, and clay).

Table 1. Volumetric water content for each soil at each of the three matric potentials.

	Clay	Silt Loam	Loam	Very Fine Sandy Loam	Fine Sandy Loam "	Sandy Loam
Matric	Volumetric Water Content "					
- 0.33	0.33	0.33	0.33	0.18	0.23	0.1
- 1.00	0.25	0.26	0.26	0.13	0.18	0.06
- 3.00	0.19	0.22	0.22	0.10	0.09	0.04

One thousand cubic centimeter polystyrene pots were planted with DP161B2RF cotton and 10,000 vermiform life stages of *R. reniformis* were added to the designated pots in 5 mL of water. Cotton plants were evaluated at 30 days after planting (DAP) for height, shoot fresh weight and root fresh weight. Populations of *R. reniformis* were evaluated at 30 DAP by combined gravity screening/sucrose centrifugation and enumerated. Eggs were extracted by agitating the root system on an orbital shaker at 150 rpm for 4 minutes in a 0.6% sodium hypochlorite (NaOCl) solution and collected on a 25 µm screen.

Data were analyzed using analysis of variance (ANOVA) within the GLIMMIX procedure of SAS, version 9.2 (SAS Institute, Cary, NC). Treatment means were determined from the PDIFF option with LSMEANS, were $P \leq 0.05$ was required to be significant. There was a significant effect of soil type and as such each soil type was analyzed separately. Treatment means (with or without nematodes) for plant parameters were compared directly within each matric potential for each soil type. Mean numbers of *R. reniformis* per gram of root were compared between matric potentials within each soil type.

Results

Differences in water availability of the six soil types had little overall impact on nematode numbers within this trial. No significant differences in the numbers of *R. reniformis* per gram of root were observed in the clay, silt loam, loam or very fine sandy loam at any of the three matric potentials (Table 2). Density of *R. reniformis* per gram of root was significantly higher at the -3.0 bar matric compared to the -0.33 bar matric in the fine sandy loam soil, however were significantly lower at -3.0 bar matric compared to the other two in the sandy loam soil.

Plant parameters exhibited a noticeable difference between soils due to the effects of soil moisture and nematode presence. The difference in average plant height between nematode present/absent pots was affected very little by water availability in the clay, silt loam, loam and very fine sandy loam. At each of the three matric potentials, -3.0, -1.0, and -0.33 bar, the nematode absent pots produced 18, 17 and 20% taller plants in the clay soil compared to the nematode present pots, 13, 15 and 17% taller in the silt loam, 25, 25, and 25% taller in the loam, and 6, 11, and 10% taller in the very fine sandy loam. Conversely, in the fine sandy loam and sandy loam soils, plants at the -3.0 bar moisture potential were taller in the nematode present pots by 1 and 13%, respectively. As more water became available at the -1.0 and -0.33 bar matric potentials, the nematode absent pots had increased plant heights by 12 and 14% in the fine sandy loam and 2 and 26% in the sandy loam.

Differences in average shoot fresh weight were higher in the nematode absent pots at all matric potentials in the clay, silt loam, and loam soils by an average of nearly 27%. However, in the very fine sandy loam, the fine sandy loam, and the sandy loam soils, the nematode present pots had increased average shoot fresh weight at the -3.0 matric potential by 7, 14 and 48%, respectively. As with the plant heights, as more water became available at the -1.0 and -0.33 matric potentials, the nematode absent pots had increased shoot fresh weight compared with the nematode present pots.

Table 2: Average cotton plant height, shoot fresh weight, root fresh weight, and numbers of *R. reniformis* per gram of cotton root f
potential.

Soil	Matric	Nematodes	Plant Height (cm)	95% Confidence Interval	Shoot Fresh Weight (g)	95% Confidence Interval	*R.renifor* gram ro
Clay	-3.00	Yes	9.8 a*	(7.8, 11.8)	3.2 a*	(1.9, 5.1)	4257 a
		No	12.0 a	(10.0, 14.0)	4.3 a	(2.4, 7.2)	NA
	-1.00	Yes	13.3 a	(9.0, 17.7)	5.1 a	(3.0, 7.2)	3783 a
		No	16.1 a	(12.3, 19.8)	6.0 a	(3.9, 8.1)	NA
	-0.33	Yes	14.5 a	(10.8, 18.2)	5.8 a	(2.8, 8.7)	7994 a
		No	18.2 a	(14.5, 21.9)	8.2 a	(5.2, 11.2)	NA
Silt Loam	-3.00	Yes	15.1 a	(11.5, 18.5)	5.0 a	(2.3, 7.6)	21772 a
		No	17.3 a	(13.4, 21.2)	7.4 a	(4.5, 10.4)	NA
	-1.00	Yes	17.6 a	(11.4, 23.8)	6.5 a	(1.4, 11.6)	18275 a
		No	20.6 a	(14.4, 26.8)	9.2 a	(4.1, 14.3)	NA
	-0.33	Yes	17.7 a	(11.0, 24.4)	5.6 a	(1.9, 9.3)	15992 a
		No	21.4 a	(14.8, 28.1)	7.4 a	(3.7, 11.2)	NA
Loam	-3.00	Yes	7.0 a	(6.0, 8.0)	1.1 a	(0.83, 1.33)	20906 a
		No	9.3 a	(7.9, 10.3)	1.4 a	(1.15, 1.65)	NA
	-1.00	Yes	7.1 a	(4.4, 9.7)	1.2 a	(0.6, 1.7)	20821 a
		No	9.5 a	(8.4, 13.7)	1.7 a	(1.1, 2.2)	NA
	-0.33	Yes	7.1 a	(5.0, 9.1)	1.2 a	(0.6, 1.8)	22071 a
		No	9.5 a	(6.5, 10.5)	1.8 a	(1.2, 2.4)	NA
Very Fine Sandy Loam	-3.00	Yes	11.8 a	(8.4, 15.1)	4.2 a	(2.5, 5.9)	5619 a
		No	12.6 a	(9.2, 15.9)	4.0 a	(2.3, 5.7)	NA
	-1.00	Yes	15.8 a	(12.6, 19.0)	5.7 a	(3.6, 7.8)	4268 a
		No	17.8 a	(14.6, 21.0)	5.6 a	(3.5, 7.7)	NA
	-0.33	Yes	18.1 a	(14.9, 21.3)	7.2 a	(5.3, 9.0)	3941 a
		No	20.1 a	(16.9, 23.3)	8.7 a	(6.9, 10.6)	NA
Fine Sandy Loam	-3.00	Yes	16.2 a	(10.9, 21.5)	9.1 a	(3.0, 15.2)	4755 a
		No	16.1 a	(10.8, 21.4)	8.0 a	(1.9, 14.1)	NA
	-1.00	Yes	27.4 a	(20.6, 34.2)	19.8 a	(13.4, 25.9)	4113 a
		No	31.3 a	(24.4, 38.1)	22.5 a	(16.2, 28.7)	NA
	-0.33	Yes	26.8 a	(22.8, 30.8)	19.6 a	(14.6, 24.5)	2384 b
		No	31.1 a	(27.2, 35.1)	25.6 a	(20.6, 30.6)	NA

Soil	Matric	Nematodes	Plant Height (cm)	95% Confidence Interval	Shoot Fresh Weight (g)	95% Confidence Interval	*R.renifor* gram ro
Sandy Loam	-3.00	Yes	9.4 a	(5.9, 12.8)	3.1 a	(1.8, 4.4)	4371 b
		No	8.3 a	(4.8, 11.7)	2.1 a	(0.8, 3.4)	NA
	-1.00	Yes	11.4 a	(6.7, 16.0)	3.6 a	(1.6, 5.7)	9939 a
		No	11.6 a	(6.9, 16.2)	3.7 a	(1.6, 5.7)	NA
	-0.33	Yes	12.1 a	(8.3, 15.9)	4.4 a	(3.1, 5.7)	14256 a
		No	16.4 a	(12.6, 20.2)	6.5 a	(5.2, 7.8)	NA

*Means for plant parameters are compared directly within each matric potential within each soil type and means followed by the s
significantly.

** Means for *R. reniformis* populations are compared between matric potentials within each soil type and means followed by the s
significantly. "

Summary

The presence of *R. reniformis* within this trial caused early season cotton growth to exhibit a slight decline in overall plant growth as water became more available. However, the differences observed between soils suggests that water available to the plant may not have as much of an effect on *R. reniformis* as volumetric water content of a soil. For example, VWC at -3.0 bar for the silt loam was 0.33 while for the sandy loam was 0.04. Although the plant available water is the same, the amount of water within the soil pores or the continuity of the water particles within the soil is not necessarily equal. Further study on the season-long effects of soil moisture availability is needed to determine the how these differences will affect cotton yields.

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