INFLUENCE OF SOIL PROPERTIES ON NEMATODE COMMUNITIES IN THE MISSISSIPPI DELTA

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Abstract

A demonstration program was implemented in cotton fields in 2008. In 2009 the program was continued with 7 cotton fields selected in the Mississippi Delta. Fields were selected based on previous poor yield performance and in general fields were less than 20 hectares in size. Soil samples were removed based on a 0.40 hectare grid overlayed on each field map. Samples were returned to the soil and nematode laboratories in Starkville, MS to determine basic soil nutrients, soil textural components, and nematode analysis. Soil nutrients including calcium, magnesium, phosphorous, potassium, sodium, sulfur, and zinc, as well as the percent sand, silt, and clay from all samples were analyzed. In addition the CEC, organic matter, and pH were assessed. Samples from the nematode laboratory were assayed for the presence of reniform and root knot nematodes. Statistical analyses were conducted to determine specific correlations between soil characteristics and the number of nematodes using PROC CORR and stepwise regression. The analyses conducted determined that the presence of reniform nematodes was strongly correlated to the presence of root knot nematodes ($p > 0.0001$). A stepwise regression was conducted to determine specific differences between each of the variables and find the best coefficient of determination (R^2) for reniform and root knot nematodes. Four variables were determined to lead to the best R^2 for root knot nematodes (reniform, P, % sand, and Zn) while eleven variables fit the best model for reniform nematodes (Ca, K, Mg, Na, pH, root knot, S, % clay, sand, and silt, and Zn). Geostatistical analyses were conducted on the nematode data from two specific fields due to the size and shape of the field. Depending on the field location nematode communities at each location were either considered to be aggregated or random. This demonstration program will be continued in the future and expanded to include more locations as well as additional components to provide important production information for cotton farmers in the MS Delta.

Background and Justification

In 2008, employees of the Mississippi State University Extension Service, as well as several MSU researchers, started the Mississippi Cotton D.E.M.O. (Demonstration and Education of Management Opportunities) program to coordinate on-farm demonstration/verification trials. Essentially this is a verification program to implement best management practices with emphasis on pest management. This project was funded as part of a 3-year proposal through Cotton Incorporated. Some of the particular interests for demonstration involved variety selection, weed control, insect control, and nematode management. Fields were to be visited weekly by extension personnel and management decisions would be coordinated with the producer's consultant. With these objectives in mind, several fields with a prior history of a poor yield performance were chosen throughout Mississippi to be included in the program. In general, fields chosen were less than 50 acres in size and typically 6-8 field locations were chosen each season. All management suggestions were coordinated between D.E.M.O. personnel and the producer's consultant. For the purposes of this poster, data from the 7 fields that were chosen for demonstration in 2009 will be presented.

Soil Collection, Processing and Analysis

In 2009, seven cotton fields were chosen for inclusion into the program. Prior to planting, soil samples were collected from each of the fields based on grid sampling. Fields were sampled on a one-acre grid. 6 to 8 soil cores were collected from each one acre grid. Samples to be used for nutrient analysis were collected from a depth of 0 – 6" whereas samples used to quantify nematode populations were collected from a depth of 0 – 12". Soil samples were placed in individual, marked soil sample boxes and stored in coolers. Nematode samples were returned to the Mississippi State University nematode diagnostic laboratory to determine the number of root-knot (*Meloidogyne* sp.)

and reniform (*Rotylenchulus reniformis*) nematode numbers from each sample point. Soil samples were submitted to the soil test laboratory for texture analysis and to determine nutrient concentrations in the soil.

To determine the impact of soil chemical and textural variables on populations of reniform and root knot nematodes, descriptive statistical analyses were conducted using several correlative analysis methods including PROC CORR and Stepwise regression. In addition, to determine the impact of each nematode community (the population of nematodes in each particular field) geospatial analyses were conducted using GS+ (Version 7). Spatial maps of the nematode communities in each field (only 2 presented) were created using the inverse distance weighting procedure (IDW) in GS+. This particular procedure weighs the numbers of nematodes between locations with a known number of nematodes and compares it across distances to create a spatial representation of the nematodes across the field. A variogram was also created to provide a spatial, statistical representation of the community within the measured area. Contour maps are presented to represent the density and distribution of nematode communities within the fields.

Results

In general, fields contained a greater number of reniform nematodes than root knot nematodes, on average 685 versus 5.6 for the two nematodes, respectively. The other soil characteristics, presented as the minimum, maximum, and average from each location, are included in Table 1 for each of the sampled locations.

Several different statistical analyses were conducted on this data set to attempt to understand the complex soil interactions that likely occur between soilborne nutrients and nematode communities. A general correlation analysis (PROC CORR) was conducted between the soil characteristics and the two nematode species. There were very few significant correlations between soil nutrients and nematodes, whether reniform or root knot, but especially when root knot nematodes were compared. However, two of the more interesting correlations occurred between root knot, reniform, and zinc as well as the correlation between the two different nematodes themselves. Zinc was positively correlated with root knot nematode and negatively correlated with reniform nematode. Only the correlation with root knot was significant (data not presented). The other interesting correlation occurred between the two nematodes themselves. A positive and significant correlation (r=0.4441; $p < 0.0001$) occurred between root knot and reniform nematodes from the 7 fields in the MS Delta.

In addition to a basic correlative analysis, a forward stepwise regression was conducted for both reniform and root knot nematodes (Table 2). In general this type of analysis adds only those variables to the regression model that improve the strength of the coefficient of determination (R^2). Based on the results of the stepwise regression, 11 variables created the best model fit ($R^2 = 0.4265$) for reniform nematodes. However, only 4 variables were entered into the model ($R^2 = 0.2376$) that best fit when root knot nematodes were in the model statement.

Geostatistical analyses were additionally conducted on the reniform and root knot communities from two locations to provide diagrammatic representations of nematode density and distribution (Figd. 1-4). For each figure the semivariogram as well as the contour map of the nematode community are included. A semivariogram of the data suggests whether or not the nematode communities are random (represented by a linear model) (Fig. 1B), aggregated (represented by a Gaussian model) (Fig. 2B), or discontinuous (represented by an exponential model). Data fit with a spherical model falls between aggregated and random (Fig. 3 & 4).

Conclusions

In the past, nematode communities within cotton fields have been determined to be aggregated, or present within one particular area within the field. In the two fields that were analyzed using geostatistics from 2009, nematode communities were determined to be random or aggregated and dependant on species.

Reniform and root knot nematode communities from the 7 sampled fields were judged to be correlated with one another and due to the high P-value this was not due to random chance.

A greater number of soil characteristics were significantly correlated to reniform nematode communties than root known nematode communities. However, this could have been due to the higher number of reniform nematodes in general from each location.

Table 1. Cumulative, descriptive soil properties, listed as a range (minimum-maximum) and average for each of the 7 locations where the D.E.M.O. program fields were assessed in 2009.

	Extractable nutrient levels (lbs/Acre)										%				# nematodes/pint of soil	
Field Location (# samples)	Ca	K	Mg	Na	P	S	Zn	CEC	OM	pH	sand	silt	clay	General texture	Reniform	Root knot
Dublin, MS (51)	2,694-6,676	213-656	347-968	70-185	41-255	76-186	0.6-22.9	10.8-24.6	0.5-1.3	5.4-6.9	5-45	47-82	5-15	Silt loam	0-33,110	0-1,540
	Avg. 4,144	Avg. 414.5	Avg. 598.3	Avg. 111.1	Avg. 84.9	Avg. 127.5	Avg. 2.7	Avg. 16.4	Avg. 0.9	Avg. 6.0	Avg. 23.7	Avg. 68.0	Avg. 8.7		Avg. 8,907.8	Avg. 143.4
Glendora, MS (35)	1,143-4,091	210-648	145-620	74-180	29-97	65-226	0.4-2.9	5.4-15.9	0.4-1.6	5.6-6.9	23-66	26-66	5-15	Loam	8-3,477	0-378
	Avg. 2,462.8	Avg. 462.4	Avg. 334.2	Avg. 101.7	Avg. 52.8	Avg. 124.0	Avg. 1.3	Avg. 9.6	Avg. 0.9	Avg. 6.5	Avg. 50.1	Avg. 41.5	Avg. 8.4		Avg. 739.0	Avg. 14.8
Heathman, MS (42)	1,189-2,507	275-583	181-363	85-173	43-145	68-120	0.8-3.5	6.0-9.7	0.5-0.8	5.7-6.8	6-64	28-90	2-8	Silt loam	55-2,814	0
	Avg. 1,837.6	Avg. 410.6	Avg. 290.7	Avg. 99.8	Avg. 68.8	Avg. 93.6	Avg. 1.7	Avg. 7.7	Avg. 0.6	Avg. 6.2	Avg. 16.0	Avg. 78.8	Avg. 5.2		Avg. 642.2	
James, MS (55)	2,552-8,780	174-853	495-2,112	90-169	58-219	48-289	1.1-5.1	10.5-35.0	0.3-2.0	5.5-6.8	3-66	28-82	5-25	Silt loam	0-11,682	0-47
	Avg. 5,509.0	Avg. 473.5	Avg. 1,204.0	Avg. 118.9	Avg. 116.9	Avg. 149.9	Avg. 2.7	Avg. 22.1	Avg. 1.0	Avg. 6.3	Avg. 20.8	Avg. 65.4	Avg. 13.8		Avg. 895.5	Avg. 0.8
Indianola, MS (22)	1,736-4,677	220-559	204-728	86-203	37-157	79-305	0.3-2.8	8.9-18.6	0.5-2.1	4.9-6.7	15-50	41-78	2-10	Silt loam	0-363	0-8
	Avg. 3,031	Avg. 346.4	Avg. 407.9	Avg. 103.9	Avg. 70.9	Avg. 159.8	Avg. 1.2	Avg. 12.9	Avg. 1.1	Avg. 5.9	Avg. 32.8	Avg. 60.6	Avg. 6.6		Avg. 43.1	Avg. 0.4
Itta Bena, MS (26)	1,877-4,475	332-710	296-761	76-135	35-106	86-215	0.4-2.9	9.1-18.4	0.6-1.5	5.5-6.4	7-62	31-80	3-13	Silt loam	0-10,340	0-126
	Avg. 2,815.3	Avg. 553.8	Avg. 444.8	Avg. 97.4	Avg. 70.7	Avg. 145.3	Avg. 1.2	Avg. 12.0	Avg. 1.0	Avg. 6.0	Avg. 33.5	Avg. 58.4	Avg. 8.0		Avg. 2,234.8	Avg. 14.2
Sledge, MS (58)	763-4,566	286-815	65-165	69-168	52-298	60-189	1.8-31.3	4.7-12.4	0.4-1.3	5.3-8.1	2-34	64-95	1-3	Silt	0-32	0-197
	Avg. 1,570.7	Avg. 423.3	Avg. 108.9	Avg. 89.8	Avg. 88.6	Avg. 106.0	Avg. 4.6	Avg. 6.5	Avg. 0.7	Avg. 6.4	Avg. 10.4	Avg. 87.3	Avg. 2.3		Avg. 1.8	Avg. 3.4

Table 2. Results from forward stepwise regressions conducted on each nematode type (either root knot or reniform) of 13 soil variables each of which are listed in Table 1.

Root knot nematode

	R^2		
Variable	partial	model	*P*
Reniform/pint	0.1973	0.1973	<0.0001
Zn	0.0342	0.2315	0.0004
P	0.0044	0.2359	0.2013
% Sand	0.0018	0.2376	0.4180

Reniform nematode

	R^2		
Variable	partial	model	*P*
Root knot/pint	0.1973	0.1973	<0.0001
Ca	0.0252	0.2225	0.0025
Mg	0.0759	0.2984	<0.0001
Zn	0.0515	0.3499	<0.0001
pH	0.0246	0.3744	0.0010
S	0.0200	0.3945	0.0025
Na	0.0092	0.4036	0.0385
K	0.0082	0.4118	0.0494
% Clay	0.0066	0.4184	0.0759
% Silt	0.0071	0.4255	0.0651
% Sand	0.0010	0.4265	0.4981

Figure 1. **A,** semivariogram plot indicative of a linear relationship (R^2 = 0.63) and **B** corresponding contour map of the reniform nematode community from a cotton field in Glendora, MS.

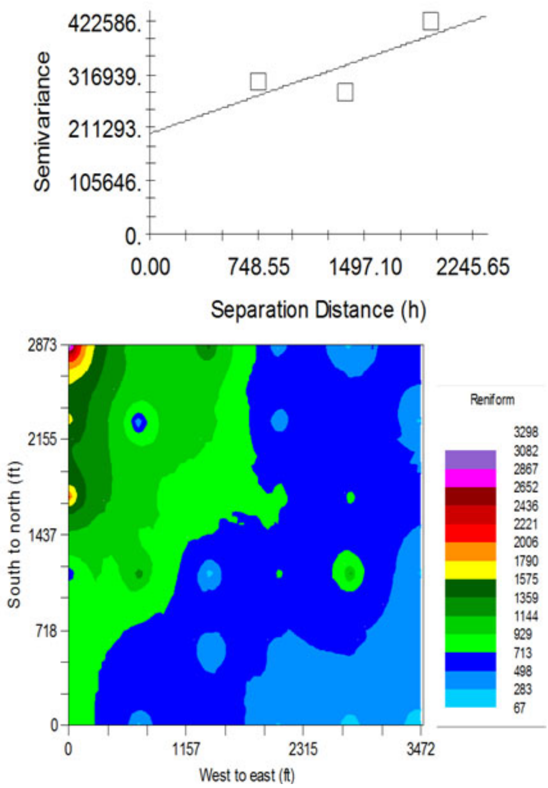

Figure 2. **A,** semivariogram plot indicative of a Gaussian relationship (R^2 = 0.99) and **B** corresponding contour map of the root knot nematode community from a cotton field in Glendora, MS.

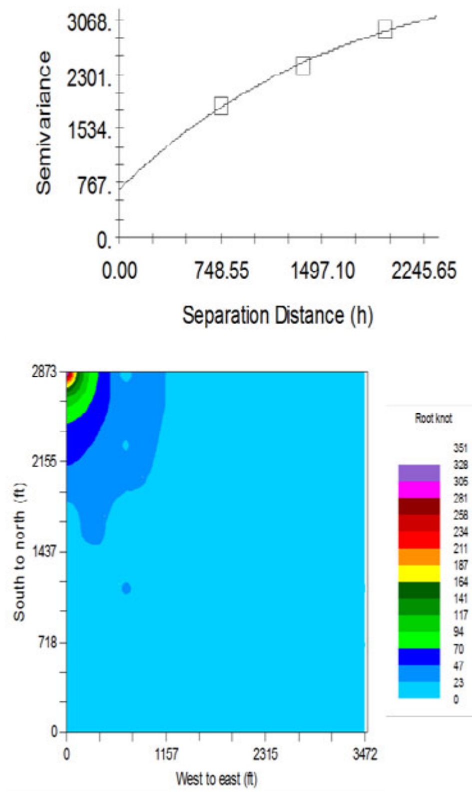

Figure 3. **A**, semivariogram plot indicative of a spherical relationship (R^2 = 0.65) and **B** corresponding contour map of the reniform nematode community from a cotton field in Indianola, MS.

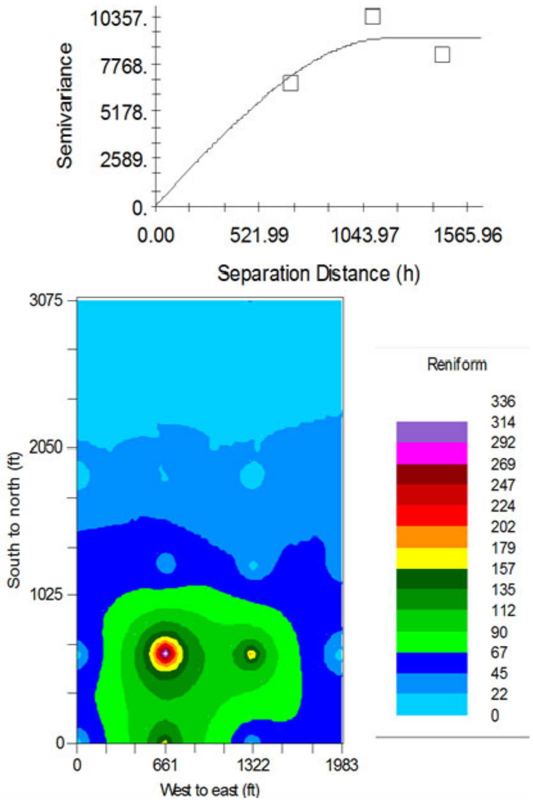

Figure 4. **A**, semivariogram plot indicative of a spherical relationship (R^2 = 0.12) and **B** corresponding contour map of the root knot nematode community from a cotton in field Indianola, MS.