SITE-SPECIFIC NEMATODE MANAGEMENT - NUTRIENT AND TEXTURE DYNAMICS

M. Wolcott
LSU Agricultural Center, Department of Plant Pathology and Crop Physiology
Baton Rouge, LA
E. Burris
LSU AgCenter Northeast Research Station
St. Joseph, LA
Edward C. McGawley
Dept. of Plant Pathology and Crop Physiology
Baton Rouge, LA
C. Overstreet
LSU AgCenter
Baton Rouge, LA
Boyd Padgett
LSU AgCenter Northeast Region
Winnsboro, LA

Abstract

Replicated trials conducted from 2004 to 2006 in two commercial production cotton fields in the Mississippi River alluvial soil area of northeast LA with known histories of natural infestation of southern root-knot nematodes (*Meloidogyne incognita*) showed that the response of cotton yield to the application of Telone II (1,3-dichloropropene) nematicide differed across soil textural zones as delineated using bulk soil electrical conductivity (ECa). Yields were consistently higher in four soil zones studied, with an average yield increase in the responsive soils of 210 pounds of lint per acre. On the remaining soil zones studied, yield increases were not observed and optimum yields were achieved in spite of the presence of root-knot nematode populations considered to be potentially extremely damaging. Additional analysis of the vertical distribution of soil textural components to a depth of 24" indicated that the differences in cotton yield response were more related to soil textural differences through the soil profile than to nematode populations and soil texture in the surface soil alone. The responsive soil zones were those soils having higher sand content throughout the soil profile. Analysis of the vertical distribution of soil nutrients in the soil profile measured showed significantly higher potassium and zinc content for the soil profiles measured in the non-responsive soils compared to the responsive soils. Results from the analysis of phosphorus and sulfur content in the soil profile were inconclusive. An understanding of the nature of the soil profile texture, fertility and nematode population dynamics will be essential for the further development of site-specific nematode management strategies

Introduction

Plant-parasitic nematodes such as root-knot (*Meloidogyne incognita*) and reniform (*Rotylenchulus reniformis*) are a major factor limiting cotton production in the United States, costing producers millions of dollars annually (Overstreet and McGawley, 2001; Koenning et al., 1999). Current management strategies used to reduce losses due to nematode infestations include crop rotation and/or nematicide application (Overstreet and McGawley, 2000).

Generally, most cotton producers in the mid-South have adopted the use of in-furrow or seed treatment nematicides as the basis for a nematode management program, due to lower cost and ease of application. However, in recent years several field studies have shown substantial yield increases from the application of higher-cost fumigants such as Telone II (1,3-dichloropropene) in areas where the potential for nematode damage was high, as compared to in-furrow and seed applied materials (Wolcott et al, 2005, Overstreet et al 2005*).* With current advances in the application of geo-spatial technologies in production agriculture, or Precision Agriculture, the equipment currently exists to apply such nematicides to only those areas of production fields where potential yield response will produce economic benefits to the producer, if a an accurate prescription can be generated economically. Unfortunately, costs for labor, time, and laboratory assays related to intensive spatial or grid sampling to determine nematode population densities would typically be prohibitive. Alternative methods to accurately determine those areas of production fields in which plant parasitic nematodes have the potential to adversely affect crop yields are needed.

In the alluvial soil areas of Louisiana, soil texture can exhibit extreme variability within agricultural fields. Patterns of meandering alluvial deposition can result in soil texture variation from sandy loams to clays within each potential pass of application equipment. Soil type and texture have been shown to have a significant effect upon nematode population densities, as well as distribution of nematode species and impact on cotton yield (Khalilian et al., 2001; Koenning et al., 1996; Monfort, et al., 2007; Wolcott et al., 2004). Using this nematode / soil texture relationship in conjunction with new spatial technologies such as the geo-referenced mapping of bulk soil electrical conductivity (EC_a), as can be accomplished with instruments such as the Veris® 3100 Soil EC Mapping System (Veris Technologies, Salina, Kansas) or the EM38 (Geonics, Limited, Mississauga, Ontario, Canada), to create nematode management zones has shown promise in developing site-specific management programs (Khalilian et al., 2001, Overstreet et al., 2004; Wolcott et al., 2006).

Standard recommendations for soil sampling for nematode population and soil fertility analysis call for replicated soil cores to a depth of 6 - 8 inches, and most management decisions are made from these results. It has been noted that measurement of a surface nematode population density for yield-loss prediction is meaningless if overwintering survival occurs at greater depths (Ferris, 1984). As cotton is a deep-rooted crop, capable of producing a tap root beyond these depths by the time the cotyledons unfurl, the potential impact of nematode populations as well as soil textural and chemical properties from deeper in the soil profile must be considered. An understanding of the nature of the soil profile texture, fertility and nematode population dynamics will be essential for the further development of site-specific nematode management strategies

The objective of this study was to characterize the vertical distribution of plant-parasitic nematode populations and the vertical distribution of soil texture and nutrient properties potentially influencing the impact of those populations on cotton yield on Mississippi River alluvial soils.

Materials and Methods

From 2004 to 2006, research was conducted in two commercial cotton fields in the Mississippi River alluvial soil area of northeast Louisiana located in Tensas Parish near St. Joseph, Louisiana. The first field, named the Levee field, consisted of 69.6 acres. The second field, named the Cemetery North field, consisted of 23.7 acres. Both fields had a long history of natural infestation with root knot nematode as well as natural variability in soil texture.

In 2003, the fields were mapped for EC_a utilizing the Veris® 3100 Soil EC Mapping System. The EC_a data obtained by the Veris® system measured EC_a from two approximate soil depths; 0-12”or shallow EC ($EC_{a\text{-}sh}$), and 0-36”or deep EC ($EC_{a\text{-}dp}$). The EC_a data was processed utilizing SSToolbox. The $EC_{a\text{-}sh}$ and $EC_{a\text{-}dp}$ point data was interpolated to a 20ft x 20 ft grid cell format using Kriging, and was classified into zones using unsupervised natural breaks. Based on the EC_a data, transect locations were selected for each field using GIS, representing the most predominate soil textural zones within the test area. These transects were used as a basis for further data collection and anaylsis. For the purpose of this study, 7 transects were selected for further investigation. Soil zones were designated by field (Cemetery North = CN, Levee =L) and number. Transects and sample locations are shown in relation to $EC_{a\text{-}dp}$ zones in Figure 1.

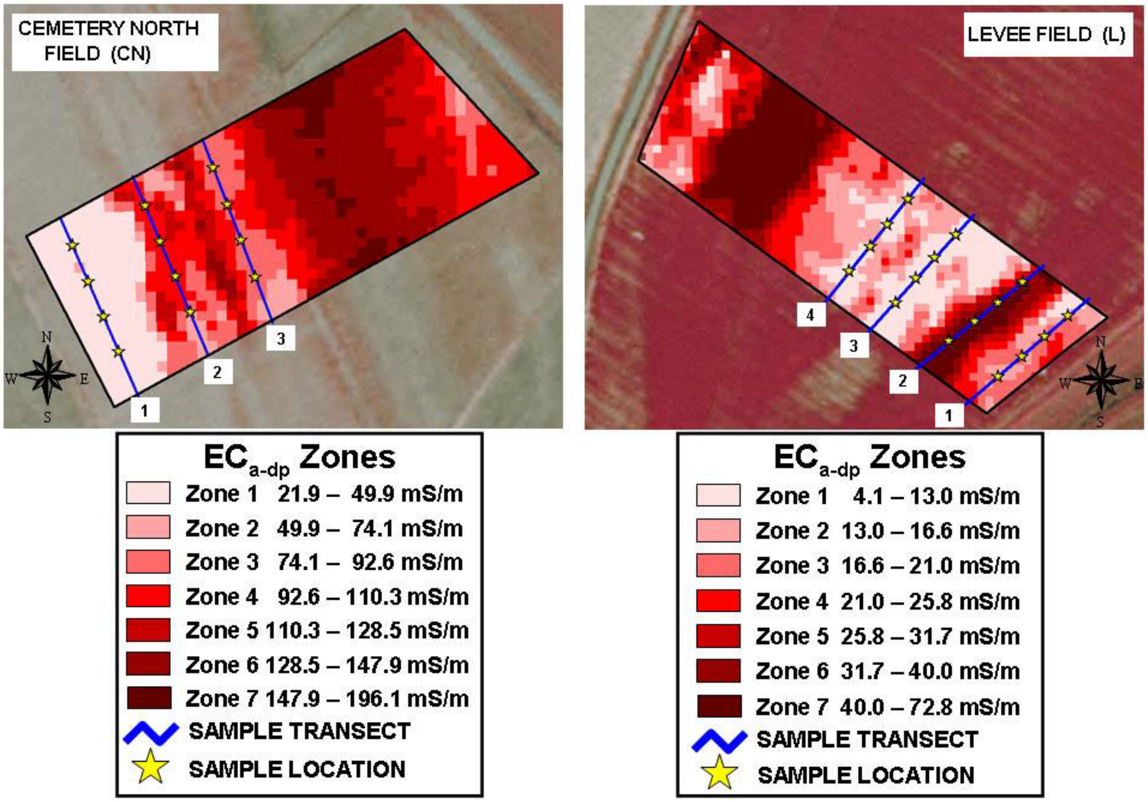

Figure 1. Location of data collection transects and sample locations in relation to $EC_{a\text{-}dp}$ zones for the test fields.

Each spring, Telone II was applied at a rate of 3.0 gallons of material per acre in five 12-row plots using a modified Yetter Avenger coulter applicator, operating at a depth of 12". An additional five 12-row plots were not treated. The fields were planted to Deltapine 555 using a 12 row John Deere Max-Emerge 2 planter. The test fields were managed following the standard production practices of the cooperator.

The fields were harvested using a six row John Deere cotton picker equipped with a John Deere cotton yield monitor using microwave sensor technology. The yield monitor data was cleaned using the Yield Editor software tool developed by USDA-ARS (Drummond and Sudduth, 2004). The yield monitor data and all other spatially referenced data were processed using SSToolbox GIS. Analysis of variance was performed using Statistix 8.0.

Soil samples were collected at a standard depth of 6" – 8" based on the sampling transects for the determination of nematode populations, primarily in the fall of 2005 and 2006. Additionally, each field was extensively sampled after the corn crop in 2007 in these same transects. Four replicated samples were obtained from the check plots of each representative soil zone. A tractor-mounted, hydraulic soil probe was utilized and two, two-inch diameter soil cores were collected to a depth of 24" at each sample location. The soil cores were divided into 4 partitions by depth; 0"-6", 6"-12", 12"-18", and 18"-24." The two soil cores representing each sample location and profile partition were composited.

A portion of the composited samples was analyzed to determine the vertical distribution of nematodes within the soil profile. Nematodes were extracted from the samples by elutriation (Byrd et al., 1976) and centrifugation (Jenkins, 1964). Nematodes were identified to species microscopically based on morphology, and population densities calculated using dilution techniques. Nematode populations were expressed as estimated population per 500 cubic centimeters of soil.

Upon completion of the nematode population analysis, the remaining soil portions were air dried and pulverized. The samples were submitted to the LSU AgCenter Soil Testing and Plant Analysis Laboratory for soil nutrient analysis, and to the LSU AgCenter's Coastal Wetlands Soils Characterization Lab for particle size analysis. Soil nutrient analysis was performed using the Mehlich 3 extraction. The determination of sand, silt, and clay content was performed using the pipette method. (Soil Survey Staff, 1996). Statistical analysis was performed using Statistix 8.

Results

For the purpose of this paper, results pertaining to the vertical distribution of nematode populations will not be included. The nematode population results can be found in a corresponding paper (Overstreet et al., 2008).

Cotton yield response to the application of Telone II across soil textural zones for 2004 – 2006 is summarized in Figure 2. Yield response to the application of Telone II differed across soil textural zones as delineated using EC_a. Telone II application resulted in consistent yield responses compared to the control treatments in four of the soil zones, with an average yield increase across the responsive soils of 210 pounds of lint per acre. The yield increases were obtained in the lower EC_a, lighter textured soils. Significant yield increases were not obtained in the remaining soil zones in spite of the presence of root-knot nematode populations considered to be potentially extremely damaging. This data shows that the three non-responsive soil zones produced average yields of 1600+, 1100+, and 1200+ pounds of lint per acre during the three-year period, indicating that the use of nematode populations alone for the development of nematicide prescription maps could result in the unnecessary and uneconomical application of these pesticides.

For the purpose of this discussion, those soil zones showing no yield response to the application of Telone II will be described as "non-responsive soils." These include Zone 2 in the Levee field (L2), and Zones 2 and 3 in the Cemetery North field (CN2 and CN3). Those soil zones showing consistent yield responses to the application of Telone II will be described as "responsive soils." These include Zones 1, 3, and 4 in the Levee field (L1, L3, and L4), and Zone 1 in the Cemetery North field (CN1).

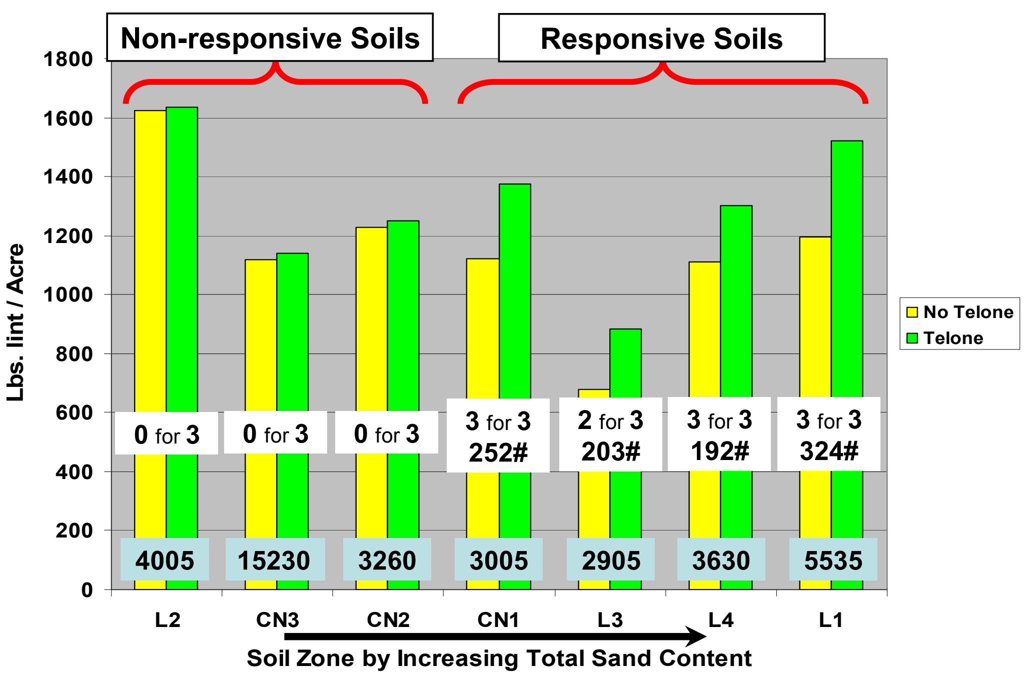

Figure 2. Three-year summary (2004 - 2006) of cotton yield response by soil zone to the application of Telone II for the Levee (L) and Cemetery North (CN) fields in Tensas Parish, Louisiana. Data shown in white text boxes for each

column pair indicates the number of years that a statistically significant yield response was obtained, with the average yield response for the soil zone for those years. Data at the base of each column pair indicates the 2005 mean post-harvest root-knot nematode population per pint of soil for each soil zone.

Results of the soil texture particle size analysis showing the vertical distribution of the soil components sand, silt, and clay are shown in Table 1. The texture results for the 0” – 6” soil depth show no consistent relationships with the responsive and non-responsive soils. Within this depth, soil zones showing no significant differences in component content were observed in both the responsive and non-responsive classifications for all 3 soil components.

A different relationship is observed when the soil texture vertical distribution for the complete soil profile tested is compared. All soil zones in the responsive soils had significantly different component content for all soil texture components when compared to the non-responsive soils. The responsive soil zones were those soils having higher sand content (lighter texture) throughout the soil profile, while the non-responsive soil zones had higher clay content below the 6” depth, indicating that the differences in cotton yield response were more related to soil textural differences through the soil profile than to nematode populations and soil texture in the surface soil alone.

Results of the soil nutrient analysis showing the vertical distribution of potassium, sulfur, zinc, and phosphorus are shown in Table 2. Based on the statistical analysis, there were no consistent relationships with the responsive and nonresponsive soils for sulfur or phosphorus for either the 0” – 6” depth or the total soil profile.

There was a potential relationship with the responsive and non-responsive soils for potassium and zinc. Although the potassium content for one non-responsive soil zone (CN2) at the 0” – 6” depth was not statistically different from those of the responsive soils, there was a trend that the non-responsive soil zones contained higher potassium levels at that depth. When looking at the total potassium measured in the entire soil profile, all soil zones in the non-responsive soils contained potassium levels that were significantly higher than in the responsive soils. For the soil zinc content, all of the non-responsive soils contained zinc levels that were significantly higher than in the responsive soils, in both the 0” – 6” depth and for the total soil profile.

Table 1. Soil texture vertical distribution for Telone II responsive and non-responsive soil zones for the Levee (L) and Cemetery North (CN) fields

Zone	Description	Soil Depth 0"-6"	6"-12"	12"-18"	18"-20"	Total
		Sand Content				
L2	Non_Responsive	24.2 d	17.7 c	6.0 b	2.6 b	50.5 b
CN3	Non_Responsive	32.3 d	21.6 c	12.0 b	2.3 b	68.1 b
CN2	Non_Responsive	49.4 bc	14.5 c	10.5 b	4.2 b	78.6 b
CN1	Responsive	58.1 ab	47.3 ab	45.4 a	45.3 a	196.0 a
L3	Responsive	43.3 c	43.0 b	57.9 a	63.9 a	208.2 a
L4	Responsive	48.0 bc	50.3 ab	63.9 a	63.8 a	225.9 a
L1	Responsive	65.2 a	59.9 a	58.0 a	46.7 a	229.8 a
		Silt Content				
L2	Non_Responsive	64.8 a	66.0 a	64.3 a	57.9 abc	253.0 a
CN3	Non_Responsive	56.5 a	62.4 ab	64.4 a	60.6 ab	243.9 a
CN2	Non_Responsive	36.3 cd	54.7 b	59.8 a	62.0 a	212.8 a
CN1	Responsive	31.9 d	38.2 cd	40.3 b	41.1 cd	151.4 b
L3	Responsive	46.0 b	44.6 c	31.9 b	28.1 d	150.5 b
L4	Responsive	43.3 bc	39.1 cd	28.7 b	29.0 d	140.2 b
L1	Responsive	29.8 d	32.3 d	33.7 b	42.8 bcd	138.6 b
		Clay Content				
L2	Non_Responsive	11.0 b	16.3 b	29.7 a	39.5 a	96.5 ab
CN3	Non_Responsive	11.2 b	16.0 b	23.6 a	37.1 a	88.0 b
CN2	Non_Responsive	14.3 a	30.8 a	29.8 a	33.8 a	108.7 a
CN1	Responsive	10.0 b	14.6 bc	14.4 b	13.6 b	52.5 c
L3	Responsive	10.7 b	12.4 bcd	10.3 b	8.1 bc	41.5 cd
L4	Responsive	8.7 b	10.6 cd	7.4 b	7.2 c	33.9 d
L1	Responsive	5.0 c	7.8 d	8.3 b	10.6 bc	31.6 d

Data are expressed as pounds per 100 pounds of dry soil for each soil component. For each soil component and soil depth, data in columns followed by the same letter does not differ (P<0.05) by analysis of variance and LSD test.

Table 2. Vertical distribution of selected soil nutrients for Telone II responsive and non-responsive soil zones for the Levee (L) and Cemetery North (CN) fields

Zone	Description	Soil Depth 0"-6"	6"-12"	12"-18"	18"-20"	Total
		Potassium Content				
L2	Non_Responsive	220.6 ab	191.7 a	210.9 a	256.2 a	879.4 a
CN3	Non_Responsive	256.7 a	150.1 b	190.9 a	259.3 a	857.1 a
CN2	Non_Responsive	181.3 bc	216.4 a	211.0 a	245.9 a	854.5 a
CN1	Responsive	132.6 c	117.1 bc	130.7 b	109.3 b	489.7 b
L3	Responsive	128.9 c	91.1 cd	78.1 c	55.6 c	353.7 c
L4	Responsive	151.8 c	81.8 d	74.8 c	64.8 c	373.3 bc
L1	Responsive	133.5 c	106.4 cd	79.2 c	82.8 bc	401.8 bc
		Sulfur Content				
L2	Non_Responsive	7.2 a	5.2 a	4.9 a	5.5 a	23.0 a
CN3	Non_Responsive	5.3 b	4.2 ab	4.0 ab	4.1 b	17.6 b
CN2	Non_Responsive	3.5 d	3.6 bc	3.7 ab	4.5 ab	15.4 bc
CN1	Responsive	3.2 d	2.6 c	2.7 b	2.5 d	11.0 d
L3	Responsive	4.8 bc	3.2 bc	2.9 b	2.5 d	13.5 cd
L4	Responsive	3.7 cd	3.1 c	2.8 b	2.7 cd	12.2 cd
L1	Responsive	4.4 bcd	3.4 bc	3.3 b	3.8 bc	14.9 bc
		Zinc Content				
L2	Non_Responsive	1.6 a	2.0 a	3.3 a	4.0 a	10.9 a
CN3	Non_Responsive	1.2 b	1.5 b	2.2 b	3.1 b	7.9 b
CN2	Non_Responsive	1.3 b	2.1 a	2.0 b	2.2 c	7.6 b
CN1	Responsive	0.9 c	1.1 bc	1.2 c	1.1 d	4.3 c
L3	Responsive	0.8 c	1.3 bc	1.2 c	1.1 d	4.5 c
L4	Responsive	0.9 c	1.3 bc	1.1 c	1.2 d	4.6 c
L1	Responsive	0.8 c	0.9 c	1.3 c	1.4 d	4.4 c
		Phosphorus Content				
L2	Non_Responsive	59.1 a	31.0 a	26.9 a	19.0 b	136.0 a
CN3	Non_Responsive	37.1 ab	19.5 b	28.4 a	47.4 a	132.4 ab
CN2	Non_Responsive	16.1 b	7.5 c	11.8 b	11.3 b	46.8 e
CN1	Responsive	28.1 b	11.7 c	19.5 ab	12.4 b	71.7 cde
L3	Responsive	55.6 a	13.5 bc	13.1 b	13.4 b	95.6 cd
L4	Responsive	27.2 b	10.1 c	13.5 b	12.0 b	62.8 de
L1	Responsive	54.3 a	19.5 b	12.8 b	13.6 b	100.2 bc

Data are expressed as ppm for each soil nutrient, based on Mehlich 3 extractant. For each soil nutrient and soil depth, data in columns followed by the same letter does not differ ($P<0.05$) by analysis of variance and LSD test.

Conclusions

The results of this study indicate that the development of site-specific nematode management plans for Mississippi River alluvial must consider factors other than nematode population alone. Soil texture, including soil texture through the soil profile, and limiting soil fertility factors must all be considered. Due to the potential influence of soil texture through the soil profile on yield reductions due to root-knot nematodes, the use of ECa-dp may prove to be feasible in developing site-specific nematode management plans.

Disclaimer

The interpretation of data presented may change with additional experimentation. Information is not to be construed as a recommendation for use or as an endorsement of a specific product by the LSU AgCenter.

Acknowledgments

The authors acknowledge the support and cooperation of Panola Planting Company in making this project possible.

References

Byrd, D.W., Jr., K. R. Barker, H. Ferris, C. J. Nusbaum, W.E. Griffin, R. H. Small, and C. H. Stone. 1976. Two semi-automatic elutriators for extracting nematodes and certain fungi from soil. Journal of Nematology 8:206-212.

Drummond, S. T., and K. A. Sudduth. 2004. Analysis of errors affecting yield map accuracy. *In* Proc 7th Intl. Conf. on Precision Agriculture. ASA/CSSA/SSSA, Madison, WI.

Ferris, H. 1984. Nematode damage functions: The problems of experimental and sampling error. Journal of Nematology 16:1-9.

Jenkins, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Disease Reporter 48:692.

Khalilian, A., J. D. Mueller, Y. J. Han, and F. J. Wolak. 2001. Predicting Cotton Nematodes Distribution Utilizing Soil Electrical Conductivity, pp. 146-149. *In* Proceedings 2001 Beltwide Cotton Conference. National Cotton Council, Memphis TN.

Koenning, S. R., S. A. Walters, and K. R. Barker. 1996. Impact of soil texture on the reproductive and damage potentials of *Rotylenchulus reniformis* and *Meloidogyne incognita* on cotton. Journal of Nematology 28:527-536.

Koenning, S.R., C. Overstreet, J.W. Noling, P.A. Donald, J.O. Becker and B.A. Fortnum. 1999. Survey of crop losses in response to phytoparasitic nematodes in the United States for 1994. Journal of Nematology 31: 458-618.

Monfort, W.S., T. L. Kirkpatrick, C. S. Rothrock, and A. Mauromoustakos. 2007. Potential for site-specific management of *Meloidogyne incognita* in cotton using soil textural zones. Journal of Nematology 39:1-8.

Overstreet, C. and E.C. McGawley. 2000. Management options for reniform nematode in cotton production for Louisiana. Nematropica 30:142-143.

Overstreet, C. and E.C. McGawley. 2001. Introduction to cotton nematodes. Pp. 38-40. In T.L. Kirkpatrick and C.S. Rothrock (eds.) Compendium of Cotton Diseases, 2nd edition. Published by the American Phytopathological Society Press, St. Paul, Minnesota.

Overstreet, C., M. Wolcott, G. B. Padgett, E. Burris, E.C. McGawley, and D. Sullivan. 2004. Developing management zones for root-knot nematode in cotton in Mississippi Alluvial soils. Journal of Nematology 36:339-340.

Overstreet, C., M. Wolcott, G. Burris, D. R. Cook, D. Sullivan, G. B. Padgett, and R. Goodson. 2005. Telone application against root-knot nematode in Tensas Parish, Louisiana, during 2004, pp. 171-176. *In* Proceedings 2005 Beltwide Cotton Conferences. National Cotton Council, Memphis TN.

Overstreet, C., E. Burris, E. C. McGawley, G. B. Padgett, and M. Wolcott. 2008. Site-specific nematode management – population dynamics. *In* Proceedings 2008 Beltwide Cotton Conferences. National Cotton Council, Memphis TN., in print.

Soil Survey Staff, 1996. Soil survey laboratory methods manual: U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE, Soil Survey Investigations Report No. 42, Version 3, 693 p.

Wolcott, M., C. Overstreet, B. Padgett, and E. Burris. 2004. Using soil electrical conductivity to denote potential nematode management zones, pp 349-353. *In* Proceedings 2004 Beltwide Cotton Conferences. National Cotton Council, Memphis TN.

Wolcott, M., C. Overstreet, E. Burris, D. Cook, D. Sullivan, B. Padgett, and R. Goodson. 2005. Evaluating cotton nematicide response across soil electrical conductivity zones using remote sensing, pp 215- 220. *In* Proceedings 2005 Beltwide Cotton Conferences. National Cotton Council, Memphis TN.

Wolcott, M., C. Overstreet, E. Burris, B. Padgett, D. Burns, and D. Cook. 2006. Site-specific nematode management for cotton in the Mississippi River alluvial soils of Louisiana. *In* Proc 8th Intl. Conf. on Precision Agriculture. ASA/CSSA/SSSA, Madison, WI., In Press.