PREDICTING COTTON NEMATODES DISTRIBUTION UTILIZING SOIL ELECTRICAL CONDUCTIVITY

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Abstract

The overall objective of this work is to develop and test concepts and technologies for site-specific detection and control of plant-parasitic nematodes with the aim of optimizing farm profit while minimizing the effect of production practices on the environment. Nematodes cause over $250 million in yield losses to cotton in the United States each year. Farmers usually apply one rate of a nematicide across an entire field to protect their crop from these nematodes. However, nematodes are not uniformly distributed within fields, and there may be substantial acreage in most fields where nematodes are either not present, or are not an economic concern. Applying a nematicide at one rate over the entire field can be both costly and inefficient.

Using soil electrical conductivity to predict the distribution of soil textures and nematodes within a field is achievable in a sandy or loamy sand soil type. This will allow placement of nematicides in portions of the field with soil textures that have the highest probability of containing significant levels of specific nematode species, which are being targeted for control.

There was a strong positive correlation between increasing incidence of Columbia lance nematode with increased sand content both at planting and at harvest. An increase of nine percent in clay content of the sandy loam soil resulted in a 57% reduction in nematode population density. Ring nematodes were recovered in significant numbers both at planting and at harvest only from plots with the highest levels of sand.

Introduction

Cotton is the most important agronomic crop in the southern U.S.A. Approximately 18 million bales of cotton are produced annually with an estimated production value of $6 billion. Nematode-induced yield losses in cotton were estimated at 4.24% or approximately $250 million across the U.S. Cotton Belt for the 1999 growing season (Blasingame & Patel, 2000). Yield losses in individual fields may reach 30-50%. Collectively, three nematode species, the southern root-knot nematode (*Meloidogyne incognita*), the reniform nematode (*Rotylenchulus reniformis*), and the Columbia lance nematode (*Hoplolaimus columbus*) represent the single most costly disease in cotton production in the mid-South and southeastern portions of the country.

Control options for nematodes in cotton are limited. There is no known resistance to either reniform or Columbia lance nematodes in *Gossypium hirsutum* (Mueller, 1993; Robinson & Percival, 1997). Crop rotation using non-host or resistant crops has been somewhat successful in suppressing nematode population densities and improving cotton yields. Unfortunately, many of the crops that are useful in lowering nematode population densities are not economically profitable, or allotments for crops like peanut are limited in certain states.

Nematode management in the southern U.S. relies heavily on the use of nematicides, such as aldicarb (Temik 15G), applied at-planting at a cost of approximately $16.00 per acre or preplant soil fumigation with 1,3-dichloropropene (Telone II) at a cost of $33.00/acre. The standard procedure for nematicide use in cotton is to apply a uniform rate of one of these nematicides across an entire field or even farm.

Field-wide application of a uniform rate of a nematicide may not provide maximum economic efficacy. Application to the entire field generally results in considerable pesticide being applied to areas with no nematodes or where the population densities are well below the damage threshold. Site-specific identification of zones or areas within fields where nematodes actually pose an economic threat to profitable production would allow these nematicides to be placed only where needed at appropriate rates. In Missouri, grid sampling for nematodes indicated that 69% of a test field had a root-knot nematode population density below the damage threshold, therefore no aldicarb was used (Wrather et al., 2000). The rest of field required a nematicide rate 57% less than the conventional uniform rate. Cotton yields were similar between areas treated with either the uniform or variable nematicide rate. Unfortunately, the investment in labor, time, and laboratory fees for nematode assays for entire-field grid sampling would be a major impediment to widespread acceptance by farmers.

In the southern U.S. soil types vary significantly, and soil type and texture have a great effect upon distribution of nematode species and on nematode population densities. In field microplots, reproduction of the root-knot nematode (*M. incognita)* was greater in coarse-textured than in fine-textured soils, and population densities were inversely related to the percentages of silt and clay (Koenning et al., 1996). In the same study, the reniform nematode (*R. reniformis)* reproduced best in loamy sand with a silt plus clay content of approximately 28%. Similarly, soil texture also may affect nematicide efficacy and movement in the soil, or effects may be indirectly expressed through influences on plant growth.

Recently, new technologies have become available that allow the development effective field management systems which optimize profits and reduce environmental impact by accounting for variability in soil types. In recent years, major advancements have been made in the technologies required to implement precision farming practices. The foundation of a site-specific nematode management program of this type will be based on our ability to develop an effective nematode distribution map without the need for annual grid sampling and nematode assays from all grids in every field.

Soil electrical conductivity correlates strongly to soil particle size and texture (William and Hoey, 1987). Sands have a low conductivity, silts have a medium conductivity, and clays have a high conductivity. In addition to texture, electric conductivity has been proven to relate closely to other soil properties, such as organic carbon, CEC, and depth of topsoil (Kitchen and Sudduth, 1996; Doolittle et al. 1994; and McBride et al. 1990). Equipment is now available through Veris Technologies for rapid and accurate determination of various soil physical properties within fields. This equipment, the Veris 3100, resembles a small disk and measures soil electrical conductivity continuously across a field. The implement can be operated at speeds from 8-12 mph, and can measure a 40-60 ft-wide swath in most fields. This equipment would allow a 20-40 acre field to be mapped for soil type in a few hours, rather than the several days that would be required for manual grid sampling and standard laboratory texture analyses.

Objectives

The objectives of this project were:

1. Determine the relationship between soil electrical conductivity and soil texture.
2. Determine the potential for predicting nematode distribution and density using soil electrical conductivity.

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Methods and Materials

Tests were conducted in a 10-acre field, naturally infested with Columbia lance nematodes, near Elko, SC. A commercially available system to measure soil electrical conductivity, the Veris Technologies 3100, was used to identify variations in soil texture across the field. The mapping system consists of the sensor cart on which three pairs of straight-blade disk coulters are mounted (Figure 1). These coulters serve as electrodes from which EC measurements are made as the sensor cart is pulled through the field. This unit can map the soil electric conductivity in either the top 12 or 36 inches of soil. A soil texture map was developed using GPS and geographic information systems (Figure 2). The accuracy of the map was verified by taking soil samples from the grids and analyzing for soil texture using the hydrometer method. Results were compared with results obtained using the Veris system.

The soil texture map was used to designate four possible soil types. A minimum of 12 replications of 16-row plots 50-feet long on 38-inch row centers were established in each of the four soil types (EC = 1,2,3, or 4). Each 16-row plot was divided into 4, 4-row plots. These were treated with either 0.0, 2.0, 4.0, or 6.0 lbs/acre of Temik 15G applied in-furrow at planting. There were 48 plots of each of the four treatments. This large number of replications for each treatment allowed us to make observations on naturally occurring combinations of nematode densities and soil types.

Land was prepared using “conventional” production practices. The field was disked, and then 300 lbs of 6-18-36 were applied. Treflan was applied at 2 pints per acre prior to bedding the rows. The field was planted to Deltapine ‘458’ cotton. Plots were sprayed twice with Round Up Ultra and cultivated once. Two applications of 30 units of nitrogen each were applied post-emergence.

Each plot was identified using a GPS system so that we could return to identical sites in two consecutive growing seasons. At the initiation of the study, sufficient soil cores (1.0-inch diameter by 8 inches deep) were collected to allow nematode assay as well as texture analyses and determination of bulk density. Nematodes were extracted from soil using a combination of wet sieving and centrifugal sugar flotation (Jenkins, 1964). Nematodes were identified to species microscopically based on morphology, and population densities calculated using dilution techniques. Nematode samples were also collected at harvest. Yield was recorded using cotton yield monitors mounted on a John Deere picker.

Results and Discussion

Use of soil electrical conductivity to predict soil texture was very successful as was the subsequent use of soil texture to predict the distribution of Columbia lance, spiral, and ring nematodes in a field. The Veris model 3100 Electrical Conductivity Mapping System provided readings from 0.31 to 3.90 mS/M in a ten-acre loamy sand field in Barnwell County, South Carolina. These ratings were able to predict percentage clay in a soil sample with a linear model having a correlation coefficient of 0.915 (Figure 3) and predict percentage sand in a soil sample with a correlation coefficient of 0.912. When broken down into four electrical conductivity ranges (0.0 to 1.0; 1.1 to 2.0; 2.1 to 3.0; and 3.1 to 4.0) they showed distinct distribution patterns for Columbia lance, spiral, and ring nematodes. Recovery at planting and at harvest of Columbia lance nematode decreased as soil electrical conductivity increased, i.e. as clay content of the soil increased and sand content of the soil decreased (Figures 4 and 5). Recovery of spiral nematodes was greater at planting and at harvest from soil types with an EC reading of 2, 3 or 4 than from a soil type with an EC of 1. Recovery of ring nematodes was severely restricted by soil type. No ring nematodes were recovered at planting or harvest from soil types with an EC of 3 or 4, and ring nematode recovery from soils with an EC of 2 were very low. Recovery of ring nematodes from soil types with an EC of 1 were very high, 25 per 100 cm^3 of soil. Nematode distributions are affected by soil particle size. Large nematodes such as sting and Columbia lance cannot move well through soils containing small particle sizes or high percentages of clay. However, the degree of difference observed between Columbia lance and spiral nematode distributions was somewhat surprising since these nematodes are relatively similar in size. Soil particle size may have indirect as well as direct effects on nematodes species and their distribution. Plant root growth is less in sandy soils and Columbia lance nematodes may simply out compete other nematode species for the limited number of infection sites on the root. Like wise, where cotton root growth is limited by soil type or feeding by Columbia lance nematodes no canopy closure occurs in the cotton crop and weed species such as yellow nutsedge which are excellent hosts for ring nematodes, will proliferate.

A yield map for the test field was developed (Figure 6) and the average yield for each plot was determined using geographic information systems. A yield response was obtained from the 2 lb, but not the 4 or 6 lb rates of Temik 15G (Table 1 and Figure 7). This may be due to delayed maturity on a late-planted crop caused by the nematode control obtained with the 2 higher rates. Columbia lance nematodes were able to increase over the growing season for all rates of Temik 15G (Figure 8). In fact, the increase was greater on the higher rates where more root tissue was available for infection.

Summary

Using soil electrical conductivity to predict the distribution of soil textures and nematodes within a field is achievable in a sandy or loamy sand soil type. This will allow placement of nematicides in portions of the field with soil textures that have the highest probability of containing significant levels of specific nematode species, which are being targeted for control.

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Acknowledgments

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Table 1. Effects of Temik 15G and nematode density on seed cotton yield.

Soil type	Temik (lbs/acre)	At Planting Lance	At Harvest Lance	Yield (lbs/acre)
Mean	0	11	16	998
Mean	2	10	17	1048
Mean	4	13	27	925
Mean	6	11	22	958

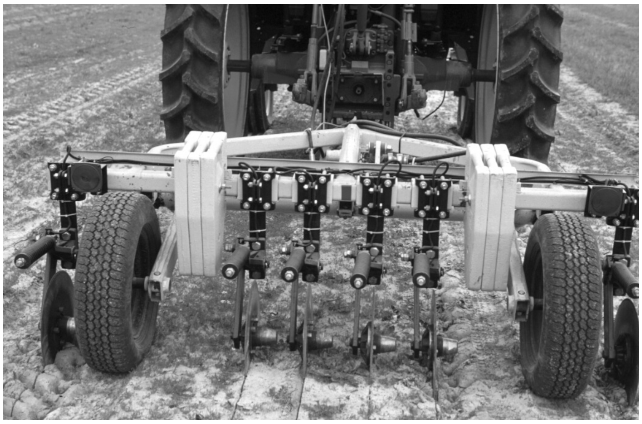

Figure 1. Veris Model 3100 Electrical Conductivity Mapping System.

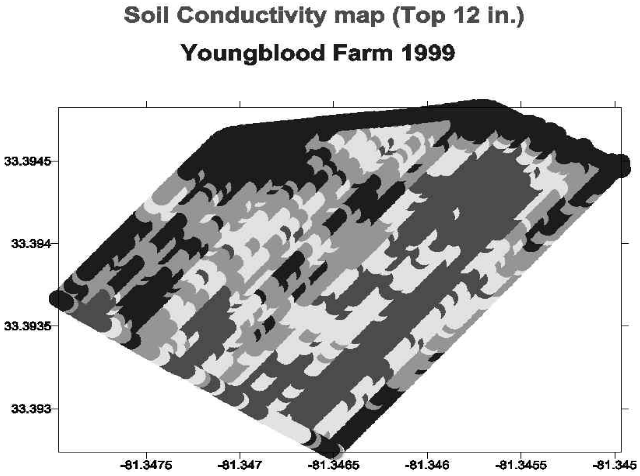

Figure 2. Test field map illustrating the variability in spatial distribution of soil electrical conductivity (EC).

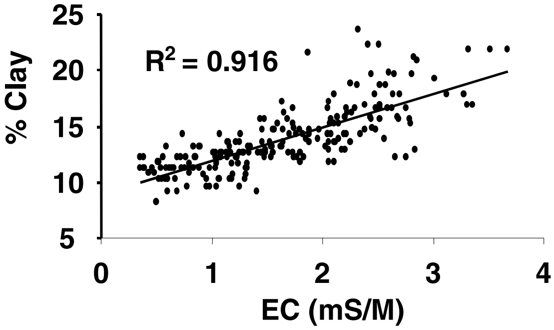

Figure 3. Effects of soil texture (% clay) on soil electrical conductivity (EC).

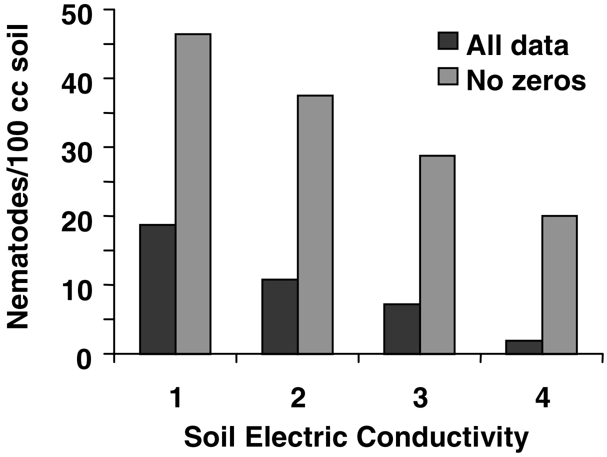

Figure 4. Effects of soil texture on Columbia lance nematode at planting.

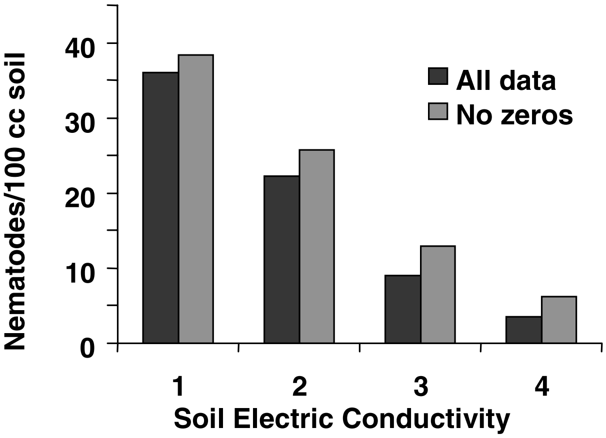

Figure 5. Effects of soil texture on Columbia lance nematode at harvest.

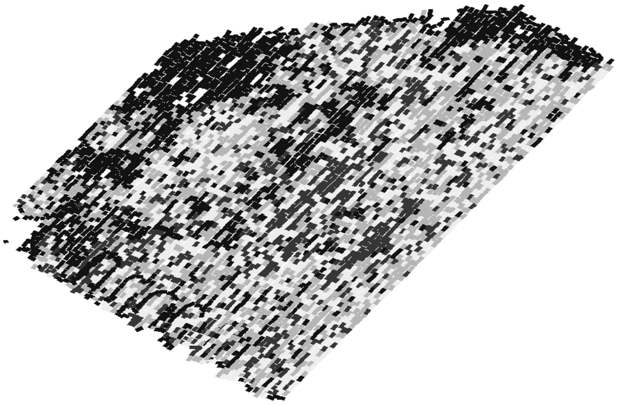

Figure 6. Seed cotton yield map, Youngblood Farm.

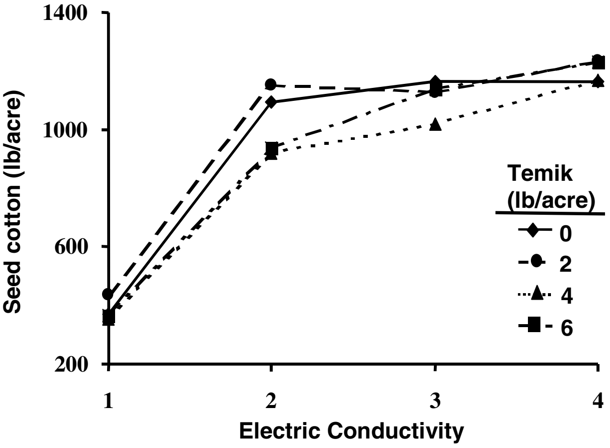

Figure 7. Effects of Temik 15-G and soil texture on cotton yield.

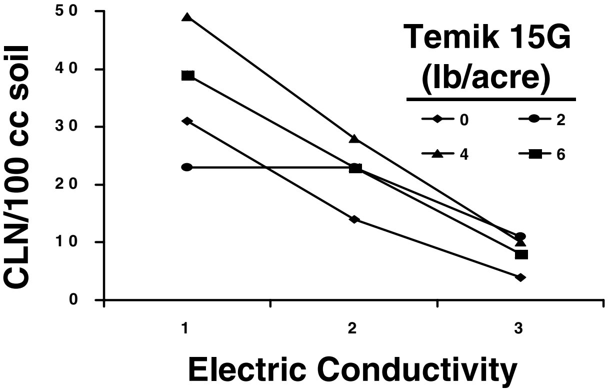

Figure 8. Recovery of Columbia lance nematode at harvest.