USING VERIFICATION STRIPS TO DELINEATE TREATMENT ZONES

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Abstract

Site-specific_management strategies can aid in the management of root-knot and reniform nematodes which can cause significant damage to cotton. Root-knot nematodes are confined to sandier soils while reniform nematodes can live in soils with higher clay content. Location in the field and the species of nematodes present can be obtained from a routine soil sample. Crop rotation with corn for one to two years can help lower reniform nematode populations to manageable levels, but in the case of root-knot nematodes, corn serves as a host crop. Determining the areas of a field where economic returns can be gained from using nematicides is a more complicated process. A multi-state working group has determined that evaluation of fumigation treatments applied as strips across the different soil zones in a field, combined with yield monitor data, can help differentiate the potential nematicide treatment zones for a field. The use of strip tests and precision agriculture methodology to make sit-specific applications of nematicides has proven to show yield gains and economic returns to producers. In these tests when verification strips were used with aerial imagery, USDA soil type, Veris data, yield mapping and multiple year evaluations, a highly accurate evaluation of nematode damage in the Commerce-Bruin-Robinsonville soil association was made.

Introduction

Cotton tests conducted in California reveled by 1948 that fumigation of soils infested with the Fusarium wilt-root-knot nematode complex could increase yield (7). Multiple studies conducted at Louisiana State University (LSU) in 1954 - 1959 evaluated the effects of reniform nematode on yield and the relationship of nematodes to the development of Fusarium wilt in cotton (2,4, and 5). The LSU scientists recognized that wilt was more severe in the presence of reniform nematode and that fumigation could play a role in chemical treatment of wilt and nematode complexes. Several varieties evaluated produced variable results by variety and across years. Yield increases due to fumigation with Telone II ranged from 0 – 79.6%. Average response due to fumigation was 38% in 1956 when varieties were tested under ideal growing conditions.

Overstreet et al., (6) re-visited fumigation techniques for cotton using Telone II and reported positive yield responses for several on-farm tests; however yield increases were often inconsistent. Yield responses in tests conducted on the farm ranged from 0 - 500 lbs lint/A. Therefore, fumigation treatments did not always increase yield enough to justify the expense of treating whole fields. Evaluations of fumigation with Telone II in other mid-south states produced similar erratic yield results when whole fields were treated.

Killian (3) reported that site-specific techniques based on use of a Veris® cart and measurements of apparent soil electrical conductivity (Ec_a) could help offset the costs of nematicides when only selected portions of fields were treated using site-specific technique. Researchers in other regions soon adopted the new precision Ag techniques and found equally promising results.

In Louisiana, use of the Veris® cart has led to characterization of soil Ec_a zones that were either responsive or non-responsive (8). The practice of using USDA soils maps and/or Veris Ec_a data to separate field into zones, is now recommended when cotton fields located in the delta are infested with nematode/wilt problems.

This paper reports on the use of refined methods for evaluating site-specific technique and explores the use of verification strips to define soil treatment zones in fields that would be responsive to Telone II fumigation treatment. The general soil map for Tensas Parish, Louisiana lists the soils within this test field as the Commerce – Bruin – Robinsonville Association: They are Loamy soils originally formed on natural levees.

Materials and Methods

The field evaluated in these studies contains three soil types (Bruin silt loam, Commerce silt loam and a Commerce silty clay loam) and the Bruin and Commerce silt loam soils are deemed responsive to fumigation treatment while the mixed and heavy soils in the field are moderately and/or non-responsive to treatment. Strip test plots were used to prove our theory that use of Telone II treatments in a site-specific pest management strategy can be cost effective when applied only to the responsive zones of delta alluvial soil (Figure 1).

Figure 1. Application of Telone II.

In these tests, we use GIS/GPS procedures for on-farm tests in the Louisiana delta that were previously developed for evaluations of Telone II and/or fertilize test plots (8). The test was located near Waterproof, LA. A Veris® cart was used to collect Ec_a data and aerial images were used to capture NDVI data on June 15, 2009 (Figure 2).

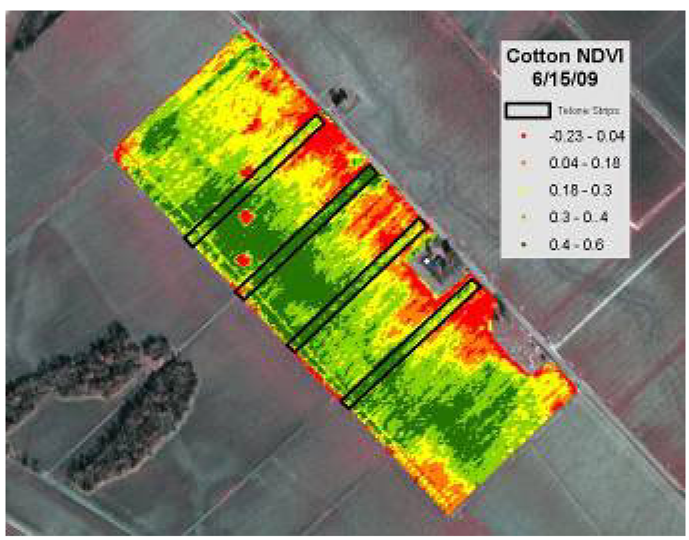

Figure 2. NDVI images taken in early June to define soils responsive to treatment with Telone II fumigation treatments.

Nematode soil samples were taken in-season and after harvest. Thirty sites were geo-referenced and samples were collected within a 15 ft. radius of the GPS point. Historical sample data taken across years 2007 – 2009 is now available for the test field. Novel analysis of yield data was conducted using Geo-da and Histogram analysis in ArcGis 9.2. Cotton yield was harvested using a John Deere picker equipped with a yield monitor. Yield data was collected from 24 row test strips and refined using ArcGis (Figure 3). The picker yield data was cleaned using yield editor and/or with manual cleaning in ArcGis. Since two pickers were used yields were normalized and then merged. Normalized yield was then converted back to lbs of lint/acre using the field average. The second picker was only used in the non-treated portion of the field and was not included in the replicated test strips.

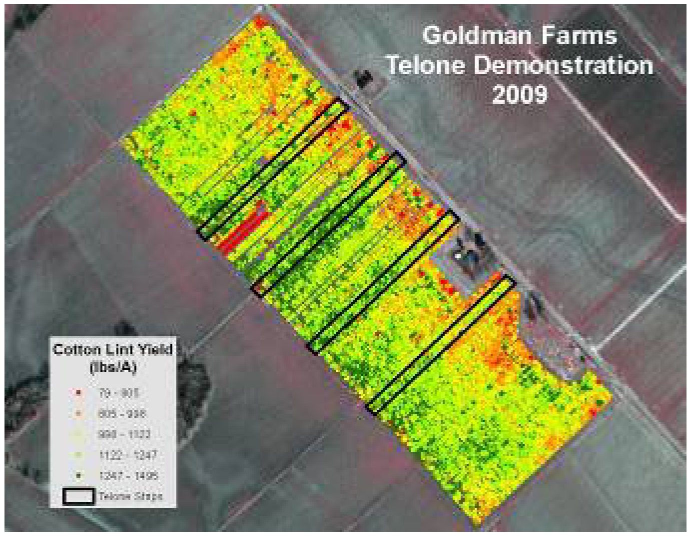

Figure 3. Cotton yield data from 2009.

Results

In the aerial image, replicated strips across the test field provide evidence of a visual response to fumigation and verify that site-specific treatments would be useful. NDVI values in the test field ranged from – 0.230 to + 0.600. The lowest NDVI values segregated portions of the field into zones, suggesting the field could be treated with site-specific treatments for nematode control. NDVI values in the areas with the most nematode damage were generally < 0.180 and were actually similar to bare earth values (Figure 2).

Average yield increased by soil type as determined by use of the official USDA Soil Survey was 102 lbs lint/A for the Bruin (BaA) Silt Loam soil, 71 lbs lint/A for the Commerce Silt Loam Soil (CmA) and 55 lbs lint/A for the Commerce Silty Clay Loam (CnA) soil type. The range of yield increased for BaA was 56 – 134 lbs lint/A, 12 – 71 lbs lint/A for the CmA, and 0 – 83 lbs lint/A for the CnA soil type. The above comparisons of Ec_a values and soil type indicate that either technique could be used to establish treatment zones for prescriptions and/or application of site-specific treatments. Equipment is now available to make site-specific Telone II applications based on use of soil and Ec_a .shp file data similar to that generated in these tests.

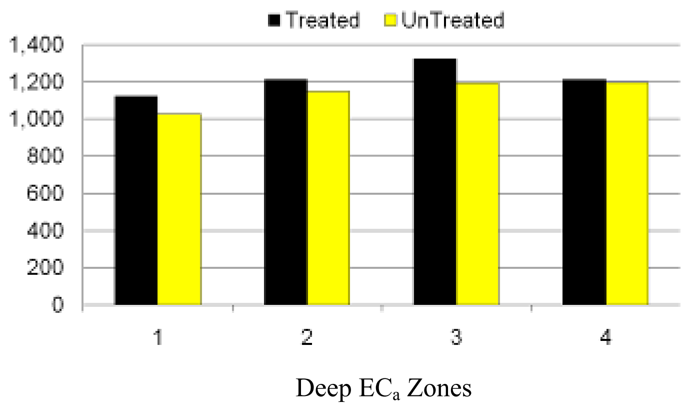

Figure 4. Yield Response x EC_a zone. Lint yield in the Telone II fumigation treatment was increased 94, 63 131, 16 lbs/A in EC_a zones 1 - 4.

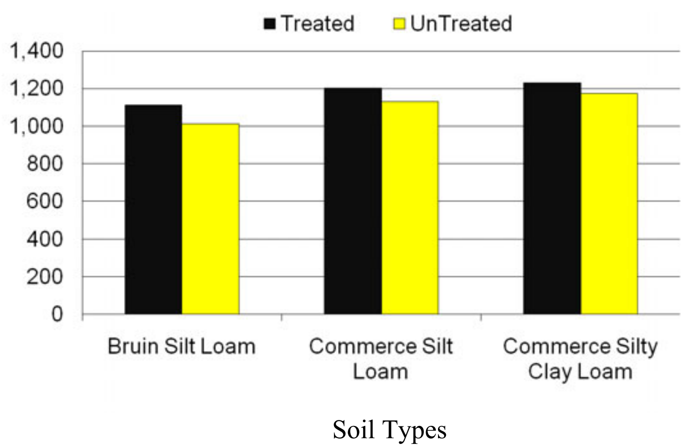

Figure 5. Yield Response x Soil Types. Lint yield was increased 102 lbs for the Bruin Silt Loam, 71 lbs for the Commerce Silt Loam and 55 lbs for the Commerce Silty Clay Loam soil types.

In 2007, breakeven analysis of cotton lint yield for a 78-acre test field indicated economic losses occurred on 13 acres, which correlated to the lowest Ec_a zones, and sustained the most nematode damage (Figure 6). The analysis further revealed that 22 acres of cotton yield above economic breakeven cost was required to compensate for the 13 acres of low yield. Therefore, profit was derived from only 43 acres of the 78-acre field. Cotton lint yield in the field ranged from 49 – 2190 lbs lint. Root-knot nematode counts ranged from 0 – 2560 and reniform nematode counts ranged from 0 – 98,240 per cc of soil. In the mixed soil (CnA) the high reniform counts did not equal high yield loss and root-knot nematode population densities were very low.

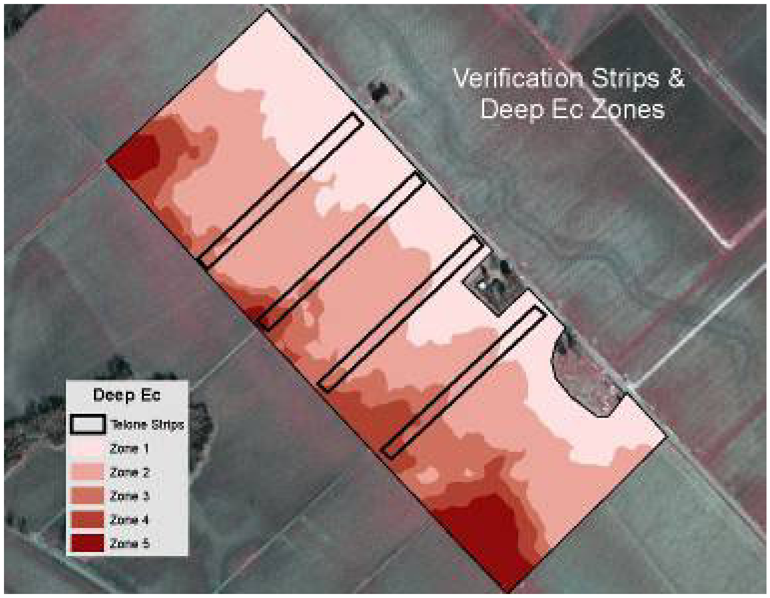

Figure 6. Veris Deep EC_a Zones.

The nematode data collected in 2009 was influenced by weather adversities and rotation to corn during 2008. However, nematode levels remained high. Root-know population densities after harvest were 0 – 7,040 and reniform levels were 0 – 65,920. Cotton lint yield was increased by the Telone II treatments in Ec_a zones 1 – 3, and not enough yields was obtained to justify treatments across zones 4 – 5. Analysis of yield monitor data across verification strips indicated Morans I was highly significant which supports spatial autocorrelation in the field and the probability that site-specific treatments for soil issues and/or pests could be used.

Collection of soil samples for nematodes, use of NDVI aerial images and evaluation of cotton and corn yield monitor data over a three year period allowed researchers to determine that root-knot nematodes were a major cause of yield loss in the field. In historical hot spots, root-knot nematode infestations measured in 2007, 2008 and 2009 remained higher than economic threshold levels despite one-year rotation with corn and reniform population densities were just slightly lowered due to rotation from cotton to corn. In 2009, complex variation in plant biomass growth was captured in aerial images taken in early July. Higher NDVI in the Telone II treatments was evident but the verification strips also indicated limited response on the mixed soil type.

Histogram analysis of lint yield for the 78 acre test field indicated there were 24,340 data points. The minimum yield was 507 lbs lint/A, the maximum was 1400 lbs lint/A, the mean was 1092 lbs lint/A and the standard deviation was 107.44. Skewness was 0.59436. The net increase in yield analyzed across verification strips 1 - 4 as compared to the whole field average was 29, 120, 232 and 121 lbs lint/A. Lint yield analyzed using ordinary least squares analysis of variance in GeoDa 0.9 indicated there was a highly significant ($P = < 0.0001$) response to Telone II treatment.

Conclusions

Verification strips are a valuable aide for developing site-specific treatment programs. When verification strips were used with aerial imagery, USDA soil type (Figure 7), Veris Ec_a data, yield mapping and multiple year evaluations, a highly accurate evaluation of soils in the Commerce – Bruin – Robinsonville Association was made. These Loamy soils, formed on natural levees, are capable of supporting high population densities of Fusarium wilt-root-knot nematode complexes and the problems may be increasing; such that soil fumigation strategies applied on a site-specific basis are required to increase yield to full capacity for the infested zones within fields that would respond to treatment.

Figure 7. USDA Soil Type Map of the test field and also the choice for development of the prescription for site-specific application of Telone II by zones in the 2010 cotton production year.

The accurate record of nematode damage and assessment of the population dynamics for multiple species of nematodes by soils and Ec_a zones should enhance the farmer's ability to make accurate decisions about strategies for nematode pest management for this field and others with similar problems. A prescription was developed for this purpose and will be used in 2010 (Figure 8).

Figure 8. Prescription Application Map for Telone II for 2010.

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