EVALUATION OF THE EFFECTS OF TELONE II ON NITROGEN MANAGEMENT AND YIELD IN LOUISIANA DELTA COTTON

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ABSTRACT

Research indicates that cotton yield on light soils within the alluvial flood plain of the Lower Mississippi delta may be increased by using chemical fumigation applications of Telone II and/or seed treatments to control infestations of plant parasitic nematodes. There is a documented interaction with fumigation and nitrogen and therefore a need to further understand the performance of site-specific treatment strategies for nitrogen (N) and fumigation treatments. In a small plot test conducted at the Northeast Research Station on Commerce silt loam soil, thrips population resurgence was significantly higher in plots treated with Avicta Complete PAK (ACP) Plus 120 lb N as compared to the non-treated plots Plus 120 lb N at 33 days after planting. Plant stand was significantly lower in the non-treated, and node of 1st square was significantly increased in plots treated with Telone II plus 80 lb N. GPS point data was interpolated using Inverse Distance Weighting (IDW) which made root mean square (RMS) values available as additional measures of yield variation. Root-knot nematode counts extracted from soil samples taken in June revealed that the highest level of control was with the Telone II fumigation treatment. Nematode populations were clumped and variable regardless of treatment and populations were higher in the non-treated. The high N strategy of 120 lb N plus ACP seed treatment out yielded Telone II plus ACP plus the low N strategy of 80 lb N. Yields were significantly better in both nematicide treatments as compared to the non-treated plus high N strategy. When treatment polygons were merged into a single field, histogram analysis indicated

yield ranged from 1029 – 1808 lbs lint. Yield for 74 of 96 data points was 1500 lbs or greater. When the yield features were linked in Arc GIS 9.1, it was observed that high yields corresponded to nematode treatments and low yields corresponded to the non-treated. RMS values were 61.3, 56.6 and 215.6 respectively, for the treatments.

In 2007 an embedded field trial was conducted on a 33 acre field consisting of Dundee silt loam and transitioning to Tensas clay, for the purpose of developing a variable- rate treatment prescription for that farm. Test treatments included three Nitrogen rates (80, 115, 135 lb actual N) applied with and without Telone II. The entire test area was treated with Avicta Complete PAK. Histogram analysis for the 39 acre test field indicated yield ranged from 480 – 1808 lb lint per acre, with an average for the field of 1316 lbs of lint per acre. Moran's I index was found to be 0.05 and Z score = 169.5 standard deviations, indicating significant spatial autocorrelation. After consolidation and processing of the data by the GIS specialist, the data were sent to the Department of Experimental Statistics at LSU for analysis. Linear mixed models analysis of covariance incorporating spatial components was used to analyze the data and make treatment comparisons within the various field management zones defined by EC_a zone, drainage area zone, nematode density zone, and elevation. The statistical models were developed using SAS® software. Once this was done, open source software developed by LSU's Department of Experimental Statistics was used to apply several potential producer preferences to the results of the statistical analysis, resulting in multiple prescription options suitable for site-specific treatments of Telone II and/or selected nitrogen (N) strategies. The treatment prescriptions were provided to the researchers and agricultural producer in graphical format for visual inspection, and in .csv file format for importing into variable-rate application equipment.

Keywords: Precision Agriculture, Root-knot Nematodes, Nitrogen strategies Mixed Model Analysis, Preference Specifications

INTRODUCTION

Seed treatments are conveniently popular but frequently require supplemental foliar treatments for insect pests or nematodes. Without adequate treatments for root-knot and reniform nematodes annual losses would increase (Overstreet and McGawley, 1999; Overstreet and McGawley, 2000; Overstreet and McGawley, 2001; Overstreet et al., 2001). In cotton, nematodes are known to cause additional losses due to interactions with soil borne diseases and early insects like thrips (Burris et al., 1989; Burris et al., 1990; Burris et al., 2006; Colyer et al., 1991; Micinski et al., 1992; Micinski et al, 1993).

In addition to the disease and insect complications caused by nematodes, recent research Burris et al., (2006) documents that cotton plants failed to adequately use nitrogen in the presence of high root-knot nematode population densities. There is scant data evaluating seed treatment and fumigant combinations with nitrogen rates. Telone II fumigation treatments are specific for nematode control and can be cost prohibitive when yields are not increased by the treatment. However, these test data suggest fumigation and seed treatment combinations may be helpful when attempting to remediate light soil infested with high to very high nematode populations (Fig. 1). The tests also suggest a need for continued work with nitrogen and nematicide combinations, especially when site-specific management is a goal.

Several recent publications address statistical issues that arise in the analysis of data from embedded field trials. Milliken (2003) and Willers, et al. (2004, 2008) provide a detailed discussion of the conceptual framework and statistical methodology used in designing and analyzing data from embedded field trials. Schabenberger and Pierce (2002) include a chapter on analyzing spatially correlated data. Milliken and Johnson (2002) provide a thorough treatment of analysis of covariance. Littell, et al. (2006) provide coverage of mixed model analysis, and also include chapters on analysis of covariance and the analysis of spatial data.

Numerous on-farm tests conducted since 2001, support the use of apparent electrical conductivity zones (EC_a) and soil sampling for nematodes as key methodology for obtaining optimum yield from site-specific applications of Telone II fumigation treatments (Burris et al., 2006; Overstreet, 2004; Overstreet, 2005;Wolcott et al., 2005). Use of EC_a, elevation, yield monitor data and imagery themes with procedures developed for defining and analyzing site-specific experiments in commercial cotton fields (Willers et al., 2004; Willers et al., 2008), present new opportunities to evaluate nitrogen applications in the presence of high nematodes counts. Milliken (2003) provides a discussion on the analysis of multilevel designs that relates to the topological experimental design process applied to analyze a VRN experiment (and indirectly as well, effects of nematodes) that was initially planned as a traditional randomized, complete block design. This spatial, general linear mixed model approach in the final stages of development through the support of the USDA-ARS laboratory in Starkville, Mississippi is briefly compared to another analysis process that aggregated the cotton yield monitor points by the N management zones established according to EC_a data.

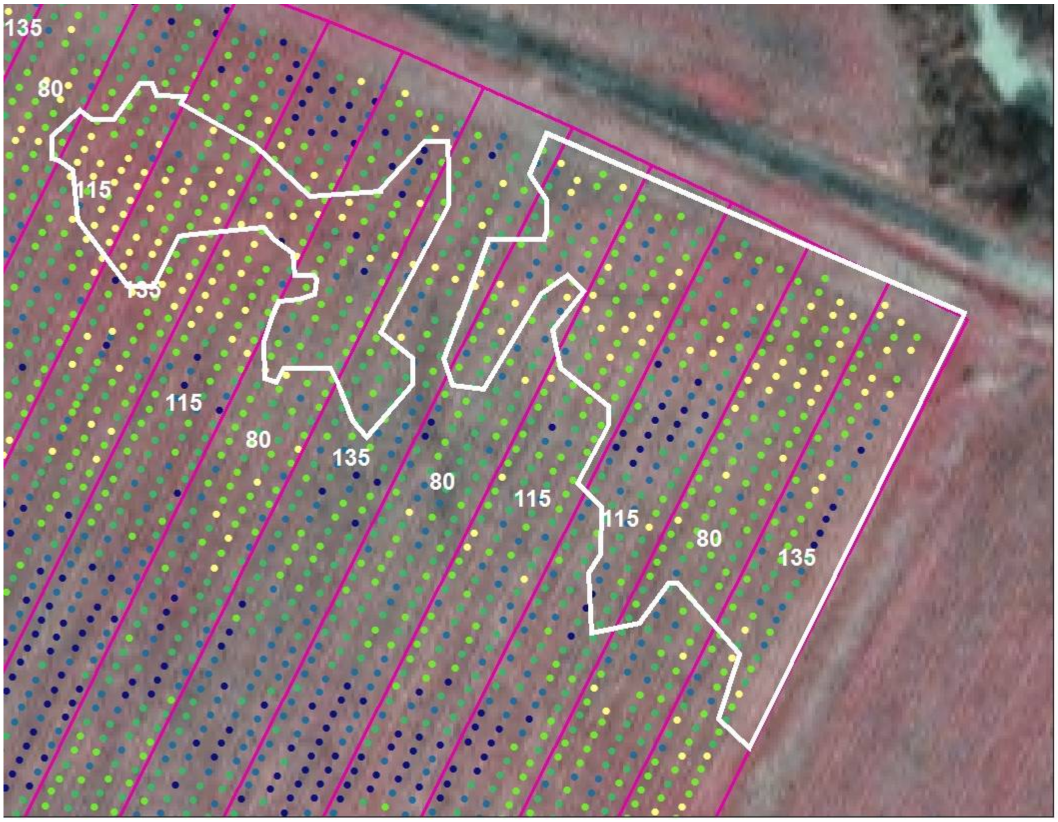


Fig. 1. Nitrogen test strips with and without Telone II and isolated low ECa regions of an on-farm test. Contrasts in yield monitor data points are evident due to treatment influences. Mixed linear analysis of the test results was used to generate prescription options.

Methods

Geographical Information Systems (GIS) and Global Positioning Systems (GPS) were used in the analysis of data collected from small plots on the experiment station as follows: Cotton seed were planted on 23 Apr. The test area received fall-applied soil amendments which included 1 ton of lime, 100 lb of a complete fertilizer (0-0-60), and 45 lb of K-Mag (22% sulfur) per acre. A John Blue VR-2455 applicator was used to apply a sidedress application of a mixed liquid fertilizer (30-0-0-2) on 1 Jun. Telone II plus the Avicta Complete PAC (ACP) seed treatment plot was sidedressed with 24 gallons of fertilizer to supply 80 lb of actual nitrogen (N) and 5.34 lb of sulfur, and was considered a low N strategy. The ACP seed treatment and the non-treated plots were sidedressed with 37.2 gallons of fertilizer to supply 120 lb of actual N plus 8.0 lb of sulfur, and was a high N strategy. Plot size was thirty two rows (centered on 40 inches) by 50 feet. Thirty-two GPS sample points (replicates) were recorded per block and identified with bicycle flags placed 12 ft from the ends and between the fourth and fifth row of each eight row set, providing a total of 96 sample locations for the 3 treatments. Yield was harvested on 11-30-07 using a John Deere picker equipped for small plot harvest.

In the on farm test, yield was harvested on 10-27-07 using a John Deere six row picker equipped with a yield monitor. Lint yield was cleaned prior to analysis. Generally, GIS and statistical filtering steps of the yield records were completed as previously described by (Willers et al., 2004) before analyses.

A statistical model of lint yield was developed using the observed field characteristics and the applied treatments as explanatory variables. SAS® PROC GLIMMIX (2005) was used to build the model using a linear mixed models analysis of covariance.

The applied treatments are nitrogen rate (NRATE) and nematicide (TELONE). The observed field characteristics consist of three classification variables and one continuous covariate. The classification variables are EC_a zone (EC_ZONE), an indicator variable identifying areas in the field with drainage problems (LOW_YLD_DR), and an indicator variable identifying areas with high nematode infestation (RESP_SOIL). The variable ELEVATION was included in the model as a continuous covariate. There are 12 possible combinations of the values taken on by the variables EC_ZONE, LOW_YLD_DR, and RESP_SOIL. However, the area with drainage problems and the area with high nematode infestation are relatively small localized areas in the field, and so not all combinations of these field characteristic variables actually existed in the data. The combinations of these variables that exist in the data, along with the values taken on by ELEVATION (rounded to 0.1 foot), define the field management zones within which the combinations of the applied treatments NRATE and TELONE must be compared in order to create a treatment prescription. To simplify the model statements and the interpretation of the resulting output, a classification variable (FLD_ZONE) was defined with levels for each combination of the field characteristic variables EC_ZONE, LOW_YLD_DR, and RESP_SOIL. The variable FLD_ZONE was then used in the model in place of the three constituent variables. Note that each combination of NRATE and TELONE occurred within each of the field management zones existing in the field. Hence all of the applied treatment combinations can be compared within each level of FLD_ZONE.

Results

In a small plot test conducted on Commerce silt loam soil, Telone II significantly improved stand and the node of 1st fruit. Yields in the low N Telone II treatment, ACP seed treatment and non-treated were 1652, 1671 and 1372 lbs lint respectively. Both nematicide treatments significantly improved yield compared to the non-treated. Using ArcGis 9.1 and GeoStatistical Analyst the RMS values were calculated as 61.3, 56.6 and 215.6 respectively, for the treatments (Table 1).

Table 1. Telone II and Avicta Complete PAC; results of a small plot test conducted on Commerce silt loam soil infested with root-knot nematodes.

Treatment	Stand	Root-Knot	1st sq.	Lint Yield
Telone + Avicta + 24 GPA 30-0-0-2	69.2a	141.8b	6.0b	1652
Avicta + 37.2 GPA 30-0-0-2	61.3b	320.6b	6.6a	1671
Non-treated + 37.2 GPA 30-0-0-2	40.1c	816.8a	6.4a	1370
P>F	0.00001	0.0006	0.0013	

• Stand was taken on 29 May, Nematodes sampled 11 June and square data recorded on 15 June. Harvest was on Oct. 30. Root Mean Square (RMS) values for lint were **63.7, 64.0 and 195.93 for the treatments**

In the small plot study, root-knot nematode counts extracted from soil samples taken in June revealed that the highest level of control was with the Telone II fumigation treatment. However, a high N strategy + ACP seed treatment out yielded Telone II + ACP + a low N strategy. Nematode populations were clumped and variable regardless of treatment and populations were higher in the non-treated. When treatment polygons were merged, histogram analysis of yield indicated ranges from 1029 to 1808 lbs lint. Yield for 74 of 96 data points was 1500 lbs or greater. Linking features indicated the high yields corresponded to nematode treatments and selection of low yielding areas of the plots corresponded to the non-treated. RMS value for yield provided a measure of variability that may be helpful for researchers attempting to associate wilt damage interactions with nematode hot-spots.

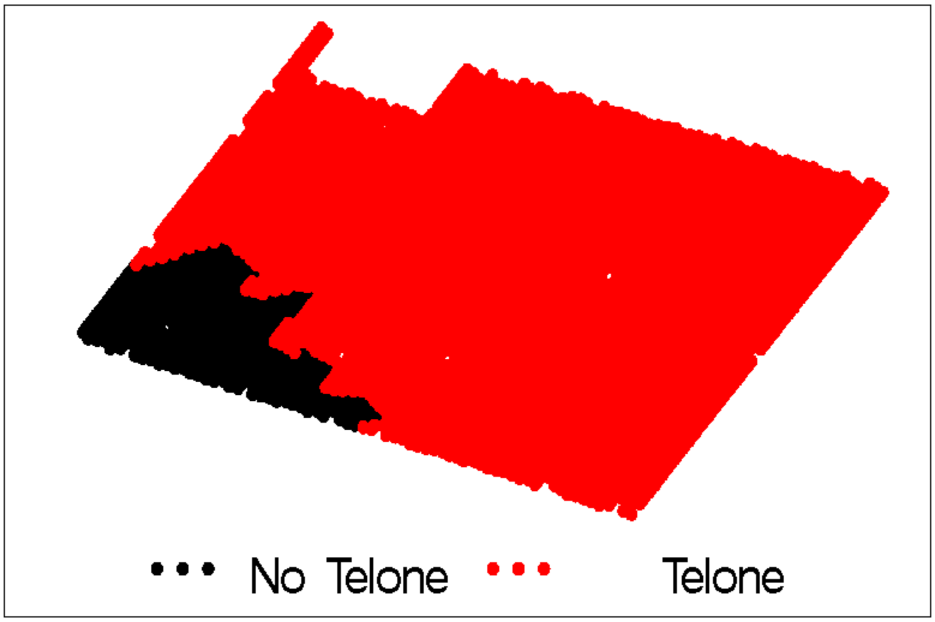
Two treatment prescription options were developed using the data from the on-farm embedded field trial described above by applying two potential producer preferences to the results of the statistical analysis described above. The software used to do this is described and illustrated in McCarter et al. (2007). The first such preference specification we consider can be thought of as the Top Performer preference, which selects the combination of NRATE and TELONE that has the highest predicted yield within each field management zone. We refer to this preference as Preference Specification A. The resulting prescriptions for Telone II and nitrogen are found in Figure 2. Telone II is prescribed for all but the southwest corner of the field. Recall that the southwest corner of the field has poor drainage and as a result has lower yields. The prescription for nitrogen consists of 135 pounds per acre in the northernmost and southernmost portions of the field, and 115 pounds per acre across the center of the field from west to east. In the southwest corner of the field, the lowest rate of 80 pounds of nitrogen per acre is prescribed. Averaged over the entire field, this prescription applies an average of 121 pounds of nitrogen and 0.88 gallons of Telone II per acre, yielding an estimated 1,360 pounds of cotton lint per acre.

We also construct treatment prescriptions by considering a producer preference limits the amount of nitrogen applied and the amount of Telone applied. Under this producer preference, lower Nitrogen levels are preferred to higher levels, and not using Telone II is preferred to the use of Telone II.

Under this preference, which we will call preference specification B, controlling the level of nitrogen takes precedence over controlling the Telone II level. Treatment combinations are ranked by nitrogen level first (80, 115, 135). Within each nitrogen level, the treatment combination with NO TELONE is preferred over the combination with TELONE. The most preferred treatment combination that is not significantly different than the Top Performer is then selected as the prescribed treatment within each field management zone.

The resulting treatment prescription can be found in Figure 3. From the map we see that Telone II is prescribed in a strip across the center of the field as well as in the northwest corner. In the areas where Telone is to be applied, the prescription calls for 115 pounds per acre of nitrogen. On the rest of the field the prescription calls for 80 pounds of nitrogen per acre and no Telone. Averaged over the entire field, this prescription applies an average of 96 pounds of nitrogen and 0.45 gallons of Telone II per acre, and yields an estimated 1,343 pounds of cotton lint per acre.

Telone Prescription



Nitrogen Prescription

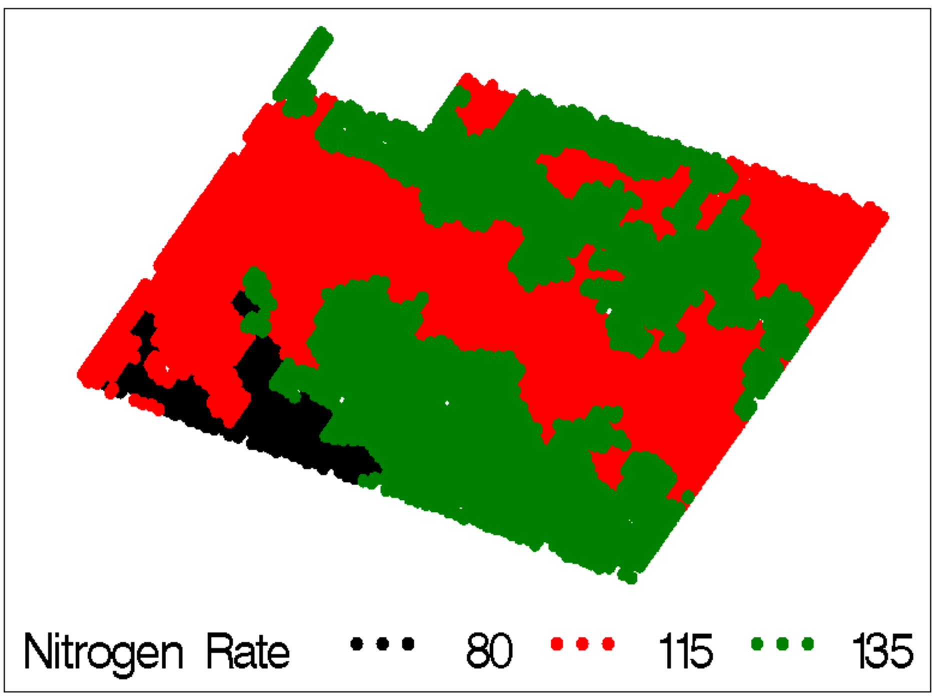
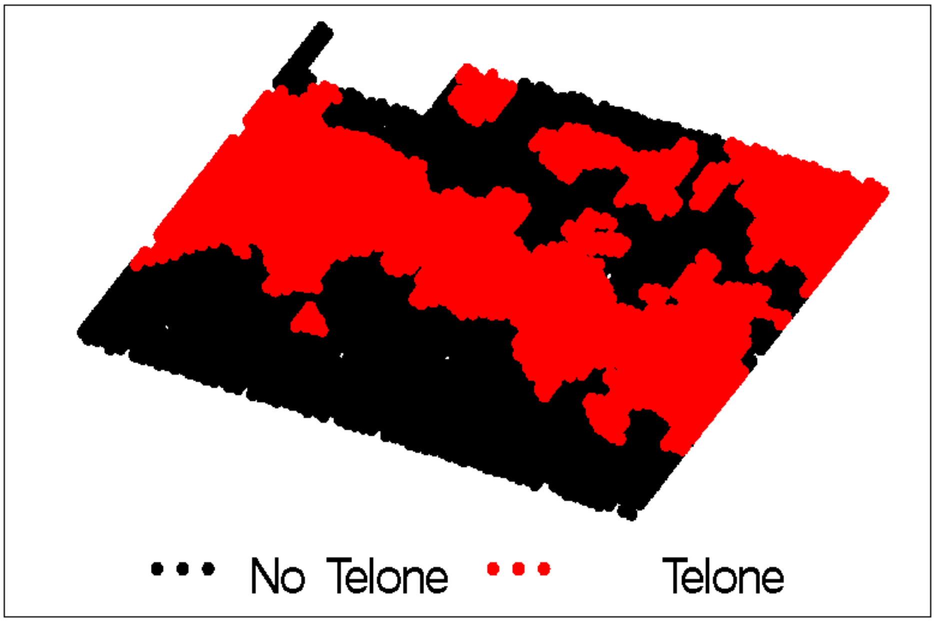


Figure 2: Treatment Prescription Maps Based on Analysis of YIELD under Preference Specification A (Top Performer) for a on-farm test.

Telone Prescription



Nitrogen Prescription

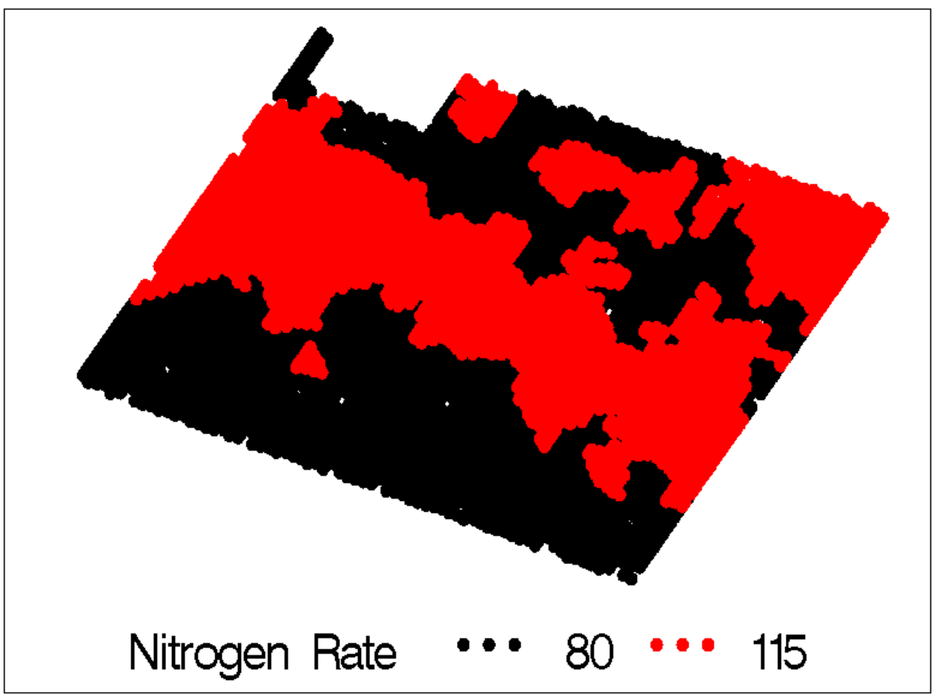


Figure 3.: Treatment Prescription Maps Based on Analysis of YIELD under Preference Specification B for a on-farm test.

Conclusion

In the small plot study, root-knot nematode counts extracted from soil samples taken in June revealed that the highest level of control was with the Telone II fumigation treatment. However, a high N strategy + ACP seed treatment out yielded Telone II + ACP + a low N strategy. A possible interaction with *fusarium* wilt may have been the cause for weaker performance in the low N Telone II plots. Nematode populations were clumped and variable regardless of treatment and populations were higher in the non-treated. When treatment polygons were merged, histogram analysis of yield indicated ranges from 1029 to 1808 lbs lint. Yield for 74 of 96 data points was 1500 lbs or greater. Linking features indicated the high yields corresponded to nematode treatments and selection of low yielding areas of the plots corresponded to the non-treated. RMS value for yield provided a measure of variability that may be helpful for researchers attempting to associate wilt damage interactions with nematode hot-spots.

Treatment prescriptions for applications of Telone II with the appropriate nitrogen strategy for a 33 acres field were developed using the expertise and efforts of a multidisciplinary team that included the agriculture producer, agricultural researchers, data management and GIS specialists, and statisticians. An embedded field trial provided yield data for Telone II and nitrogen, from which tailored treatment prescriptions were developed. Treatment prescription A was termed preference specifications for Top Performer and treatment prescriptions B was a lower environmental impact prescription. SAS analysis using a mixed linear model of yield monitor data resulted in two treatment prescription options suitable for site-specific treatments of Telone II + nitrogen.

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