AN UPDATE ON SITE-SPECIFIC NEMATICIDE PLACEMENT (SNP) SYSTEM IN COTTON

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Abstract

Every year, about 10% of U.S. cotton production is lost to nematodes. Yield losses in individual fields may reach 50%. Nematode distribution varies significantly within cotton fields and is highly correlated to soil texture. Field-wide application of a uniform nematicide rate results in applications to areas where nematodes are not present or are below the economic threshold. Uniform applications also result in application of sub-effective levels in areas with high nematode densities. The investigators have developed "Site-Specific Nematicide Placement" (SNP) systems that are currently being used by some growers in South Carolina, Arkansas, Georgia and Louisiana. The objective of this work was to conduct on-farm research in South Carolina to further develop and refine the SNP system and to evaluate the performance and effectiveness of the SNP technology compared to current nematode management practices. The results showed that site-specific nematicide applications either improved or maintained yields comparable to field-wide nematicide application but required 40 to 80% less nematicides. Nematicide application significantly increased cotton lint yield in management zones which had lighter soil textures. There were no differences in cotton yield due to nematicide application in management zones with heaver soils. Nematode densities were highly correlated to soil texture and there was a strong positive correlation between increasing incidence of Southern root-knot and Columbia lance nematodes with increasing sand content. Aldicarb concentrations in the effluent in the uniform-rate application plots were significantly higher than the site-specific treatment plots in the top 18 inches of the soil.

Introduction

Nematode management in cotton relies heavily on the use nematicides such as Temik 15G® ($15/acre) or Telone II® ($39/acre) (Starr et al., 2007; Koenning et al., 2004). When a nematode problem is suspected, farmers usually apply a uniform rate of one of these nematicides across the entire field or in some cases across the entire farm (Mueller et al., 2010). However, nematodes are not uniformly distributed within fields, and there may be substantial acreages in most fields where nematodes either are not present, or are not above the economic threshold. Therefore applying a nematicide at one rate over the entire field can be both costly and environmentally questionable.

Clemson University has successfully developed cost-effective "site-specific nematicide placement" (SNP) systems that are now being adapted by some cotton growers in South Carolina, Arkansas and Louisiana (Mueller et al., 2001; Khalilian et al. 2001, 2003a, 2003b, and 2004; Mueller et al. 2010). A primary component of the SNP system (Figure 1) is the generation of accurate, inexpensive and geo-referenced soil EC maps for each field to allow visualization of textural differences referred to as "management zones" (A). Once a map of management zones has been constructed for each field, the zones become the units for targeting nematode sampling (B). Appropriate nematicide application rates are then focused only to management zones with nematode population densities that are greater than published economic threshold values (C & D).

Figure 1: Primary components of the SNP System: A: Generating management zones; B: Management zones for nematode sampling; C: Nematicide application prescription map; D: Variable-rate application equipment.

The objectives of this study were: 1) to refine the SNP system for use by growers; and 2) to document the effectiveness of the SNP systems in controlling nematodes, reducing nematicide use, and enhancing farm profits on large-scale commercial cotton fields.

Materials and Methods

Equipment:

GPS-based equipment for controlling the rates of Telone II® and Temik 15G® to match the spatial distribution of nematodes was developed. The Clemson SNP system (Khalilian et al. 2003b) was redesigned to include the latest commercially-available variable-rate technology. The Mid-Tech TASC-6300 and the onboard computer were replaced with the Mid-Tech Legacy 6000 (Figure 2 - A), which is a complete system and can be used for controlling rates of Temik 15G® and Telone II® applications. Prescription application maps, based on nematode population densities in the soil EC management zones, can be loaded on the Legacy 6000. Commercially available positive-displacement hoppers (Gandy: model-09P2PDA) equipped with the Lock & Load system and gear-type metering device were used for variable-rate applications of Temik 15G® (Figure 2 - B). The hopper is powered by a 12V-DC variable-speed electric motor with rotational speed ranging from 0 to 50 rpm. The motor was controlled by the Legacy 6000 system and one hopper was used for every two rows of cotton.

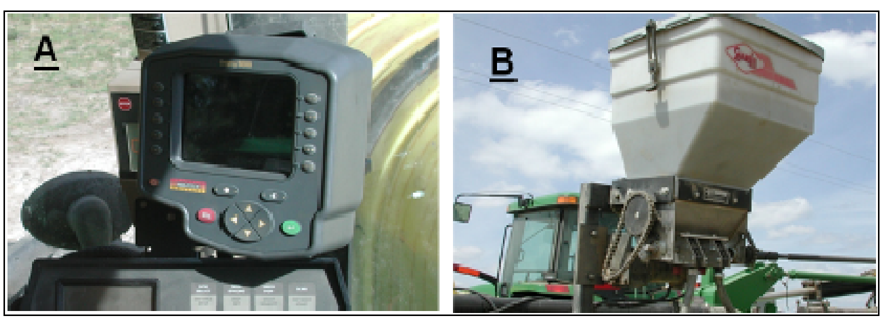

Figure 2: The Mid-Tech Legacy 6000 rate controller (A) and the positive-displacement Gandy hopper (B).

A self-contained nitrogen gas pressurized injection system was used to deliver Telone II® (Figure 3). The Legacy 6000 monitors the signals from a flow meter (Mirusso Enterprises, Inc., Model # 110375) and regulates output voltages to a throttle-type flow control valve (Tee Jet 35-04070) to adjust chemical application rates.

Figure 3: A 4-row SNP system for fumigant nematicide application.

To date, the SNP system for applying Telone II® has relied on two rates, either nematicide application or no application (as opposed to a true variable-rate application prescription). Consequently, growers will not need expensive equipment for applying varied rates of the fumigant nematicide; they only need "on" and "off". In response to these requests, we have developed a map-based switch (MBS) which applies either zero or 3 gal/acre of Telone II® at a significantly lower equipment cost than the true variable-rate SNP system (Figure 4). The MBS system replaces the manual on-off switch for applying Telone II® and can communicate with Farm Site Mate (Farm Works Software LTD) for map-based application of the fumigant. A typical motor for running the Telone II® pump on growers' existing equipment, usually draws about 50A of current, therefore, a single Solid State Relay (SSR) could not handle the inductive transient voltage from the motor. The MBS system was designed using a 2-stage solution with a DC power solenoid (Grainger #6C028) and a small SSR (Grainger #5Z950) to drive the power solenoid (Figure 4).

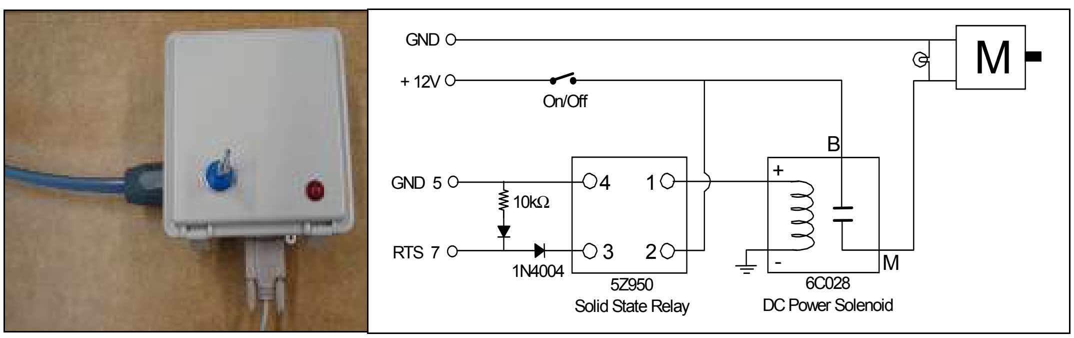

Figure 4: The map-based switch (MBS) for fumigant nematicide application and its schematic diagram.

Field tests:

The components of the SNP system were assembled and installed on four growers' existing equipment (planters and subsoilers) at geographically diverse locations in South Carolina. Field sizes ranged from 30 to 140 acres. Replicated tests were conducted on each of these farms to evaluate the performance and effectiveness of the SNP technology compared to current nematode management practices utilizing uniform rate applications of nematicides.

At the initiation of the tests, all fields were mapped for soil EC using a mobile soil conductivity measurement system (Veris Technologies), and three management zones were established based on variations in soil EC. In each zone, the following treatments were arranged in a randomized complete block design and were replicated 3 to 6 times depending on the field size: 1) typical treatment (uniform-application), 2) optimized treatment (site-specific), and 3) no treatment (control). Either Temik 15G® or Telone II® was used depending on each grower's standard practice.

Geo-referenced nematode samples were collected throughout the season from plots of each management zone. In each location, cotton was harvested at crop maturity using a spindle picker equipped with an AgLeader yield monitor and GPS unit to map changes in lint yield within and among treatments.

To document the effectiveness of the SNP systems in reducing nematicide usage and their potential adverse impacts on ground water one field was selected for soil and water monitoring. Soil cores were taken to depths of 4 ft on 6 dates: 3-, 5-, 7-, 14-, 21- and 28-days following application. Cores were separated into 4 depth zones and aldicarb and the two active oxidation products, aldicarb sulfoxide and aldicarb sulfone were extracted from the samples.

Results and Discussion

Figure 5 shows the effects of soil texture (as measured by soil EC) on Southern root-knot nematode (SRKN) from the Brubaker Farm, near Bamberg, SC in 2007. There was a strong positive correlation between increasing incidence of SRKN with increasing sand content at planting. This field had been divided into three zones based on soil EC data. The average EC values for zones one, two and three, were 0.45, 2.32, and 5.64 mS/m, respectively. Population density of SRKN was three times greater in zone one than in zone two and 12 times greater in zone two than in zone three. Figure 6 shows the effects of nematicide rate and management zones on cotton lint yield for the Brubaker Farm. In zone one, which had the highest SRKN population, nematicide application significantly increased cotton lint yields. In zone two, there were no differences in lint yields between 3 and 5 lb/acre Temik 15G®, however, both rates significantly increased yields compared to no nematicide treatment. There were no differences in cotton lint yield due to nematicide application in zone three.

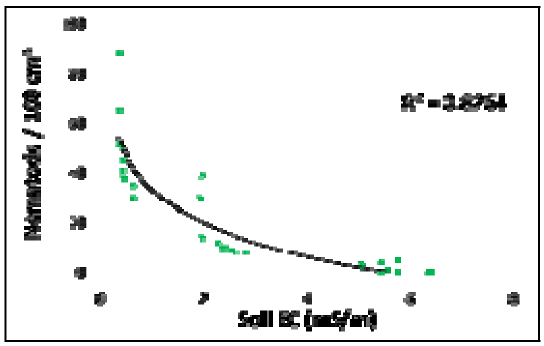

Figure 5: Effects of soil texture on SRKN juveniles (Brubaker Farm-2007).

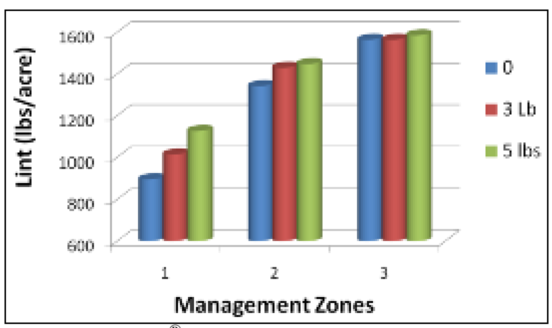

Figure 6: Effects of nematicide rate (Temik 15G®) and management zones on cotton lint yields.

Figure 7 shows the effects of soil texture as measured by soil EC and Temik 15G® application method on lint yields. Both methods (site-specific and uniform-rate) increased the cotton lint yield compared to non-treated check plots in the sandier areas of the field. In areas which contained less sand and more clay (a higher EC reading) neither nematicide application method was able to significantly increase yields. Site-specific Temik 15G® applications required 47% less nematicide compared to the single rate application. However, there were no significant differences in lint yields between these two treatments.

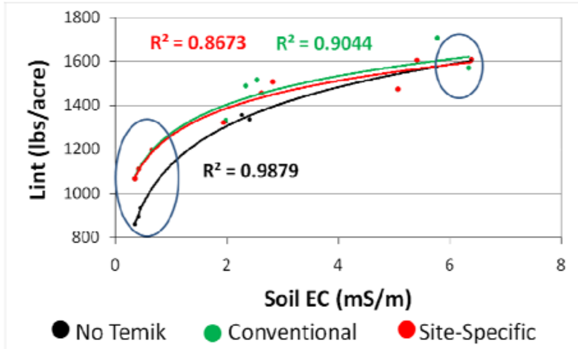

Figure 7: Effects of nematicide application methods and soil EC on cotton lint yields (Brubaker Farm).

Figure 8 shows the effects of nematicide rate and management zones on cotton lint yield for a field at Magnolia Farms near Springfield, SC. This grower usually applies a uniform rate of 7 lbs/acre Temik 15G® to control nematodes on his farm. In zone one, which had the highest Columbia lance nematode (CLN) population, application of 3, 5, or 7 lbs/acre Temik 15G significantly increased cotton lint yield compared to the non-treated check. Application of 7 lbs/acre Temik 15G® in zone one did not increase lint yields above those of the 5 lbs/acre treatment. In zone two, there were no differences in lint yields among the 3, 5, and 7 lbs/acre rates of Temik 15G®, however, all rates significantly increased yields compared to the non-treated check. There were no differences in cotton lint yield due to nematicide application in management zone three.

Again both Temik 15G® treatments (site-specific and uniform-rate) increased the cotton lint yield compared to the non-treated check in the sandy portion of the field, The uniform-rate nematicide application required 50% more nematicide than the site-specific application system. However, there were no significant differences in lint yields between these two treatments. The results from Magnolia Farms also showed that aldicarb concentrations in the effluent (principally as sulfoxide) in the uniform-rate application plots were 13% and 35% higher than the site-specific treatment plots in the top 25 cm and 25-50 cm of the soil, respectively. Consequently, the SNP system lowers any potential environmental and human health risks from pesticide exposure.

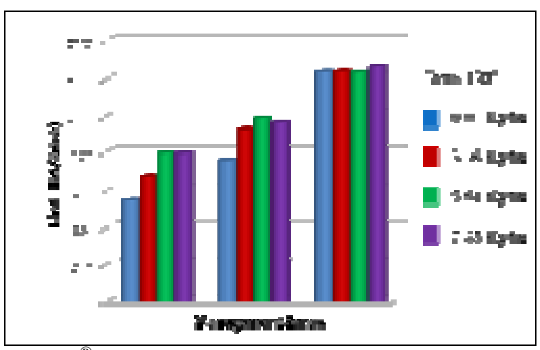
Figure 8: Effects of Temik 15G® rate and management zones on cotton lint (Magnolia Farms).

Table 1 shows the 2010 on-farm test results from a second field at the Brubaker Farm in Bamberg County, South Carolina. Like the 2007 Brubaker field and the Magnolia Farms field, Temik 15G®application significantly increased cotton lint yield in the sandiest zone (zone one, EC = 1.93 mS/m), which also had the lightest soil texture and the highest SRKN population. In zone two (EC = 6.16 mS/m), there were no differences in lint yields between 3 and 5 lbs/acre Temik 15G®, however, both rates significantly increased yields compared to the non-treated check. There were no differences in cotton lint yield due to nematicide application in zone three (EC = 16.24 mS/m).

Table 1: Effects of management zones and Temik 15G® rate on cotton lint yields at the Brubaker farm field in 2010.

Management Zone	Temik 15G® (lbs/acre)	Lint Yield (lbs/acre) *
1	0.0	1229 c
1	3.0	1300 b
1	5.0	1401 a
2	0.0	1304 b
2	3.0	1440 a
2	5.0	1448 a
3	0.0	1487 a
3	3.0	1537 a
3	5.0	1539 a

* Values within a management zone with a letter in common are not significantly different (LSD, $\alpha = 0.05$).

Both nematicide application methods (site-specific and uniform-rate) increased cotton lint yields compared to the non-treated check plots in the sandiest areas of the field. There was no yield increase associated with nematicide applications of any rate or type in the areas with less sand and more clay. Site-specific Temik 15G® applications required 40% less nematicide compared to single rate application. However, there were no significant differences in lint yields between these two treatments.

The map-based switch (MBS) for Telone II® application was tested on the Bowers & Son Farms in Hampton County, SC during the 2009 and 2010 growing seasons. The results showed significant reductions in soil fumigant nematicide use compared to uniform-rate applications while still enhancing farm profits and minimizing environmental impacts. The reductions in Telone II® application rates were 40% and 52% for 2009 and 2010, respectively (data not shown).

Summary

Replicated tests were conducted in production fields in South Carolina to evaluate the performance and effectiveness of the SNP technology compared to current nematode management practices. The results showed that:

- It is possible to accurately match nematicide rate with the spatial distribution of nematodes to reduce chemical inputs and expenditures.
- A soil electrical conductivity meter can be used successfully to measure soil texture and predict the distribution of nematode species at a fraction of the costs associated with conventional soil sampling methods currently used by farmers.
- Site-specific nematicide applications either improved or maintained yields comparable to field-wide nematicide application but required between 40 to 80% less nematicide.
- Nematicide application significantly increased cotton lint in zones which had lighter soil textures and lower EC values. There were no differences in cotton yield due to nematicide application in heaver soils with higher EC values.
- Nematode densities were highly correlated to soil texture and there was a strong positive correlation between increasing incidence of either SRKN or CLN and increasing sand content.

Acknowledgements

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