DEVELOPMENT OF A SYSTEM FOR SITE-SPECIFIC NEMATICIDE PLACEMENT IN COTTON

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ABSTRACT

Nematode distribution varies significantly in cotton fields. Population density throughout a field is highly correlated to soil texture. Field-wide application of a uniform nematicide rate results in the chemical being applied to areas without nematodes or where nematode densities are below an economic threshold, or the application of sub-effective levels in areas with high nematode densities. The investigators have developed a "Site- Specific Nematicide Placement" (SNP) system that is ready for commercial deployment and use by growers. The SNP system consists of the following components: I) Generating management zones based on inexpensive geo-referenced field soil texture map using a mobile soil electrical conductivity meter; II) The soil EC zones are then used to develop a nematode management map for each field based on targeted sampling for assay and quantification of nematode population densities; III) Geo-referenced nematicide application prescription maps are generated based on nematode assays; and IV) Nematicides are applied to the field site-specifically as appropriate for each management zone using GPS-guided equipment. This paper presents the results of efforts in South Carolina, Arkansas and Louisiana to further develop and refine this system for the effective delivery of nematicides in a site-specific, variable-rate manner in individual cotton fields.

Keywords: Precision agriculture, nematodes, cotton, site-specific management, management zones

INTRODUCTION

Cotton is one of the most important crops in the southern USA with an estimated annual production value of $6 billion (USDA-NASS 2006). The crop is produced on 13-14 million acres from California to the Carolinas. More than 440,000 jobs are directly associated with the cotton industry, generating revenues in excess of $120 billion (A.G. Jordan, 2004, National Cotton Council). Each year up to 10% of all USA cotton production is lost to nematodes (Blasingame and Patel, 2005; Koenning et al., 1999). Yield losses in individual fields may reach 50%.

Nematode management in cotton relies heavily on the use nematicides such as aldicarb (Temik 15G -- $ 22/acre) or 1,3-dichloropropene (Telone II -- $43/acre) (Starr et al., 2007; Koenning, 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 acreage 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. Collectively, three nematode species, the southern root-knot nematode (SRKN) *Meloidogyne incognita*, the reniform nematode (RN) *Rotylenchulus reniformis*, and the Columbia lance nematode (CLN) *Hoplolaimus columbus*, represent the single most costly disease threat in cotton production in the mid-South and southeastern portions of the country (Koenning et al., 2004).

Working both cooperatively and independently, three research groups have successfully developed cost-effective “site-specific nematicide placement” (SNP) systems for SRKN and CLN 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; Monfort et al. 2004a, 2004b, 2007 and 2008; Mueller et al. 2010, Overstreet et al., 2004a, 2004b, 2005, 2006a, 2006b, 2006c, 2007, 2008, 2009; Wolcott et al., 2008). A primary component of SNP is the generation of accurate, inexpensive geo-referenced, soil EC maps for each field to allow visualization of textural differences referred to as “management zones”. Once a map of management zones has been constructed for each field, the zones become the units for targeting nematode sampling. Appropriate nematicide applications are then focused only to management zones with nematode population densities that are greater than published economic threshold values. 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 chemical use, and enhancing farm profits on large-scale commercial cotton fields.

MATERIALS AND METHODS

The Clemson SNP system (Khalilian et al. 2003b) was redesigned to include the latest commercially-available variable-rate technology. The TASC-6500 and the onboard computer were replaced with the Mid-tech Legacy 6000 (Midwest Technologies, Inc., Springfield, IL), which is a complete system and can be used for controlling rates of Temik 15G and Telone II nematicide applications. Commercially available positive-displacement hoppers (Gandy: model-09P2PDA) with Lock & Load system were used for Temik 15G application. A self-contained nitrogen gas pressurized injection system was used to deliver Telone II nematicide.

The components of the SNP system were assembled and installed on eight growers' existing equipment (planters and subsoilers) at geographically diverse locations in South Carolina and Arkansas. All systems were calibrated and checked for accuracy in applying variable-rate nematicides, and growers and their farm managers were trained to generate application maps and operate the SNP equipment. Figure 1 shows an example of Temik 15G applicator (left) and Telone II injection system (right). The field size ranged from 30 to 320 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.

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 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 nematicide was used depending on each grower's standard practice.

To document the effectiveness of the SNP systems in reducing chemical use 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.

Geo-referenced nematode samples were collected through the season from

Figure 1. An 8-row SNP system for granular nematicide application (left) and a 4-row SNP system for fumigant nematicide application (right).

plots of each management zone using GPS technology. 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 date, the SNP system for applying Telone-II nematicide 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 system which applies either zero or 3 gallon/acre of Telone II at significantly lower equipment cost ($250) than the true variable-rate SNP system (Figure 2). These new technologies have already been installed on two farmers' equipment in South Carolina and its efficacy and cost-effectiveness was tested.

Figure 2: the Telone II Controller system

Results and Discussion

Figure 3 shows the effects of soil texture (as measured by soil EC) on root- knot nematode from the Brubaker Farm, in South Carolina. There was a strong positive correlation between increasing incidence of the root-knot nematode with increased sand content at planting. This field had been divided into

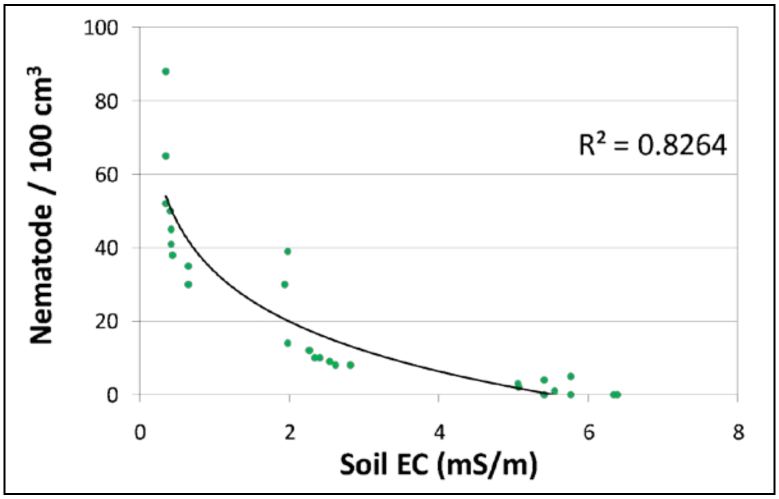

Figure 3. Effects of soil texture on root- knot nematode (Brubaker Farm).

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. The majority of the root-knot nematodes (74%) were in zone one followed by 24% in zone two and only 2% in zone three. In addition, 92% of the ring nematodes were distributed in zone one. Similar results were obtained from other fields in South Carolina.

Figure 4 shows the effects of nematicide rate and management zones on cotton lint for the Brubaker Farm. In zone one, which had the highest root-knot population, nematicide application significantly increased cotton lint. In zone two, there were no differences in lint yields between 3 and 5 lbs/acre Temik 15G, however, both rates significantly increased yields compared to no-nematicide treatment. There were no differences in cotton yield due to nematicide application in zone three.

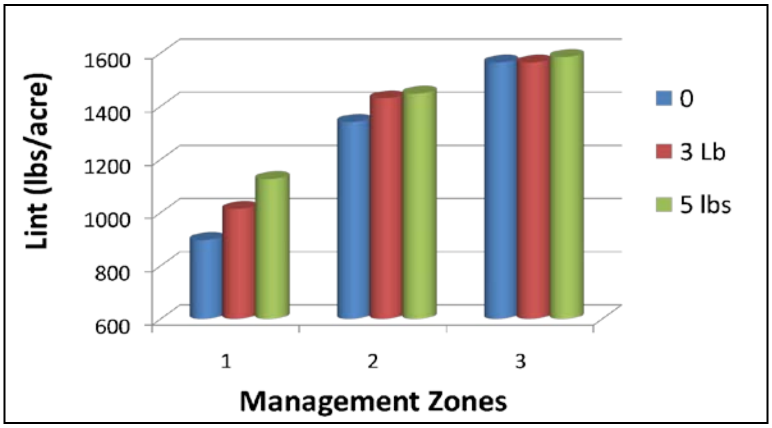

Figure 4. Effects of nematicide rate and management zones on cotton lint.

Figure 5 shows the effects of soil electrical conductivity and nematicide application method on lint yields. Both nematicide treatments (site-specific and uniform-rate) increased the cotton yield compared to no-nematicide plots. The yield increase in the sandy portion of the field was significantly higher than the clay areas, likely because there were more nematodes in the sandy part of the

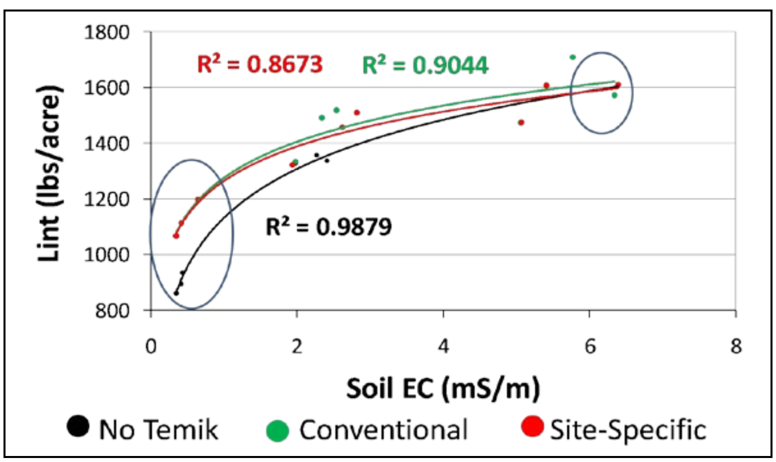

Figure 5. Effects of nematicide application methods and soil EC on cotton lint (Brubaker Farm).

field. Site-specific Temik 15G applications required 47% less nematicide compared to single rate application. However, there were no significant differences in lint yields between these two treatments. Similar results were obtained with Telone II system from other fields in South Carolina. Variable-rate Telone II resulted in 5% higher yield and 78% lower nematicide usage compared to the conventional single rate.

The results from the Philips Farm (South Carolina) showed that the uniform-rate nematicide application required 50% more chemicals than the site-specific application system. Likewise, 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 9 inches and 9-18 inches of the soil, respectively. Consequently, the SNP system lowers any potential environmental and human health risks from pesticide exposure.

Figure 6 shows EC zones from a production field in Panola Plantation (Louisiana). This field was infested with high levels of root-knot nematode especially in areas with lighter soil texture. The test field was divided into six management zones and was treated with "verification strips" (check rows and Telone II at 3 gal/acre side-by-side through the various soil zones) to determine where the response areas occurred in the field.

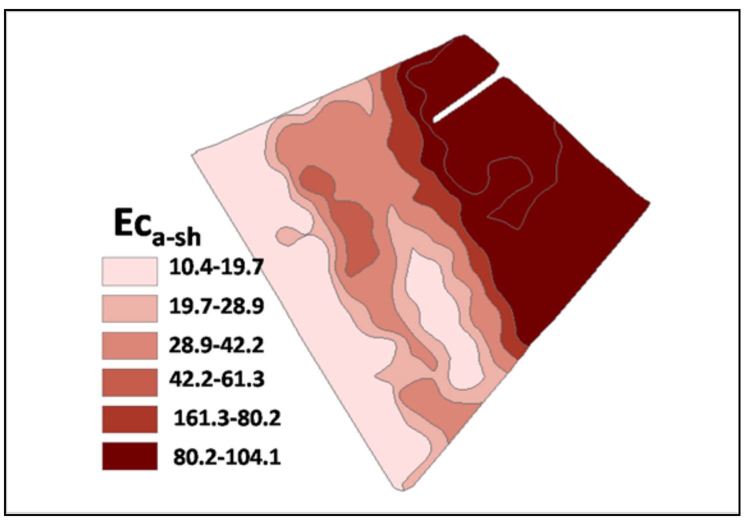

Figure 6. Soil EC management zones from Panola Plantation (Louisiana).

The results showed that except for zone one, there were no differences in lint yield between two treatments (Figure 7). There were no nematodes in zones five and six. Although, nematode population densities were extremely high (3000/ 100 cm^3 soil) in zones one to four, only zone one (sandy soil) showed response to Telone II application. Similar results were obtained in Arkansas where site specific nematicide placement resulted in a 42% and a 37% reduction in nematicide applied in two fields in northeastern and southeastern Arkansas, respectively that were infested by SRKN (data not shown). Additional studies demonstrated that the damage threshold for the SRKN varies according to soil texture. In these studies, the damage threshold in a soil with 40% sand was considerably higher (2000 nematodes/500 cm^3 soil) than in a soil with 60% sand (200 nematodes/500 cm^3 soil) (Monfort et al., 2004). Interestingly, although

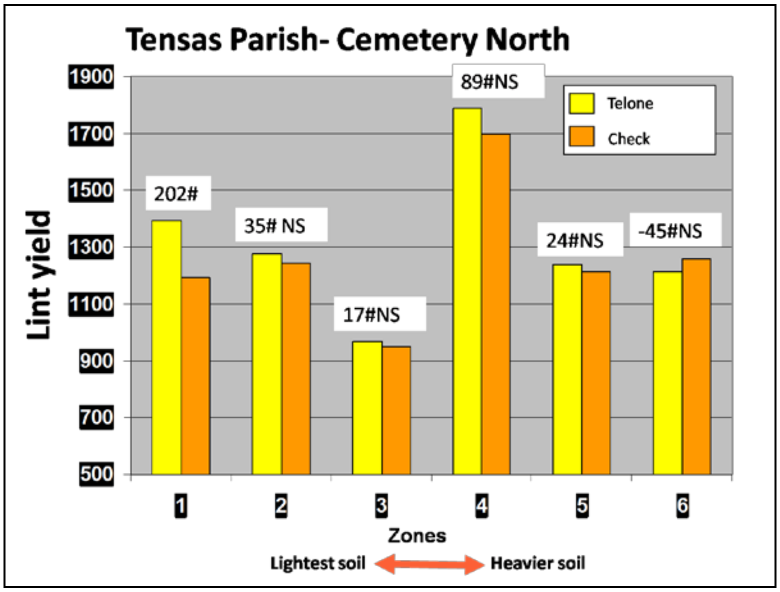

Figure 7. Effects of nematicide application methods and soil EC zones on cotton lint (Panola Plantation, Louisiana).

population densities declined at higher sand contents, the damage potential of the nematode continued to increase as sand content increased. In Panola Plantation, application of Telone II increased lint by 18% in zone one compared to no nematicide application. This translates into 80% reduction in chemical use compared to uniform Telone applications.

SUMMARY

Replicated tests were conducted in eight production fields in South Carolina, Arkansas, and Louisiana to evaluate the performance and effectiveness of the SNP technology compared to current nematode management practices. The results showed that 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. The SNP technology can lead to substantial reductions in nematicide use and subsequent adverse impacts on ground and surface water quality while maintaining yields comparable to field-wide nematicide application. Nematode densities were highly correlated to soil texture and there was a strong positive correlation between increasing incidence of the root-knot and Columbia lance nematodes with increased sand content.

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