EFFECTS OF PRECISION-APPLIED, IN-FURROW NEMATICIDE/INSECTICIDE (TEMIK™) AND SEED TREATMENTS (AERIS®, AVICTA®) ON POPULATIONS OF THRIPS AND NEMATODES IN COTTON

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Abstract

Thrips and nematodes can be serious early-season pests of cotton grown on the highly variable soil types common in the southeastern United States. We examined the effects of precision-applied Temik 15G™ and the seed treatments AERIS® and AVICTA Complete Pak® on populations dynamics of thrips and nematodes in management zones as defined by soil texture measured by soil electrical conductivity. Research plots were located within a field with variable soil types at the Clemson University Edisto Research and Education Center near Blackville, SC. Plots were mapped using a soil electrical conductivity (EC) meter. Soil texture was correlated with soil electrical conductivity, indicating that zone definition by soil EC is a practical management approach. Temik 15G™ was present in most treatments with the lowest numbers of thrips (tobacco thrips predominantly). There were higher numbers of thrips and nematodes (predominantly Columbia lance and Root-knot) in low EC or sandier areas of the field. More variability in yield occurred in the lowest EC zone (sandiest areas), where treatment combinations (seed treatment + Temik™) were more effective and profitable.

Introduction

Thrips are early-season pests of cotton in the southeastern United States that move into cotton fields from wild and cultivated vegetation (Layton and Reed 2002). Thrips feeding causes injury to seedling cotton plants, such as yellowing and crinkling of leaves, the silvering of the underside of leaves, reduced stands, stunting of growth, and plant decline (Davidson and Lyon 1987, Layton and Reed 2002, Roberts et al. 2009). Cotton is particularly susceptible to thrips injury. Thrips feed on the terminal bud of the plant as it develops slowly, depending on temperature, during the first seven to ten days after emergence. The terminal bud of the cotton plant contains tissues that will develop into the true leaves and fruiting parts (Layton and Reed 2002). Heavy infestations of thrips can cause damage to the terminal which results in branching and excessive vegetative growth. This damage can lead to delayed maturity and reduced yields (Greene et al. 2007, 2008, 2009). Out of an estimated loss of 461,500 bales of US cotton in 2008 due to arthropod pests, 50,465 bales (3.8%) were lost to thrips, with at least a 0.5% yield reduction in the South Carolina cotton crop (Adamczyk and Lorenz 2009, Williams 2009). Plant growth rate increases after three to four true leaves have developed. Therefore, the plant becomes less susceptible to thrips injury.

Populations of thrips can be affected by numerous abiotic conditions, including, but not limited to, temperature, rainfall, and soil type. Some studies have shown that soil texture does not affect densities of thrips (Sullivan et al. 2004). However, in a study conducted in 2008, higher thrips densities occurred in sandy areas of a field, defined by zones of low electrical conductivity that might be preferred by or potentially prosperous for thrips (Greene et al. 2009).

Nematodes can cause significant yield losses in cotton either alone or in combination with soil borne diseases or early season pests, such as thrips (Burris et al. 2008). Annual yield losses of $250 million are caused by plant-parasitic nematodes in US cotton (Khalilian et al. 2001, Wrather et al. 2002). The southern root-knot nematode, *Meloidogyne incognita*, and the Columbia lance nematode, *Hoplolaimus columbus*, are two of the three most damaging species of nematodes in the southeastern US cotton crop. Soil type has a significant effect on population density of nematodes. In addition to nematode densities, factors such as soil texture, nutrient availability, and pH affect potential damage to the cotton plant and yield (Khalilian et al. 2001, 2002; Overstreet et al. 2008). It has been shown that the greatest yield losses caused by nematodes in cotton occur in coarse textured, sandy soil. This is due to two factors. First, root-knot nematodes and *Fusarium* wilt are both more common in areas of a field with coarse-textured soils (Sullivan et al.2004, Overstreet et al. 2009). The second factor is that coarse textured soils do not retain moisture as well as finer textured soils or soil with higher clay, silt, and organic matter contents. Therefore, plants grown in coarse-textured soils are under more moisture and nutrient stress before they become infected with nematodes. More than 60% of cotton fields in South Carolina are infested with plant-parasitic nematodes. There currently are no resistant cotton cultivars available for the control of nematodes. Therefore, control or suppression of nematodes is reliant upon crop rotation or nematicides such as 1,3-dichloropropene (Telone II), aldicarb (Temik™), or seed treatments (Khalilian et al. 2001, 2002; Greene et al. 2007, 2008, 2009).

Conventional control of thrips and nematodes has involved the application of an in-furrow insecticide/nematicide, such as aldicarb (Temik 15G™), over an entire field. However, precisely placing the pesticide in the targeted zones with the seed at-planting can allow for the reduction of the amount of pesticide needed by at least one half (Lohmeyer et al. 2003). Aldicarb is formulated as an in-furrow, granular, systemic carbamate insecticide/nematicide (Temik™ 15G) that has been used to control and suppress thrips and nematodes for approximately forty years. This product will control thrips for up to approximately six weeks after planting (Faircloth et al. 2002). Aldicarb is very effective at controlling thrips (at 3.0+ lb/acre) and nematodes (at 5.0 lb/acre) in cotton but is hazardous and poses risks for environmental and human health if used incorrectly (Hayes 1982; Kemerait et al. 2004; Greene et al. 2007, 2008, 2009; Frye et al. 2009; Vandiver et al. 2009). Aldicarb can leach into groundwater and has been found in wells in twelve states in concentrations above the health advisory limit of 10 parts per billion (Howard 1991, Frye et al. 2009). Relatively new technologies, in the form of seed treatments, have become available for the control and suppression of thrips and nematodes (Greene et al. 2007, 2008, 2009). AVICTA Complete Pak® (ACP), introduced by Syngenta Crop Protection, Inc. in 2006, contains a nematicide (abamectin), an insecticide (thiamethoxam, trade name Cruiser™), and a fungicide (Dynasty) (Carter 2003). AERIS® is another nematicide/insecticide seed treatment and was introduced in 2007 by Bayer CropScience (Hall et al. 2007). It contains a combination of an insecticide/nematicide (thiodicarb, trade name Larvin™) and an insecticide (imidacloprid, trade name Gaucho Grande™) (Frye et al. 2009). This product is also offered with TRILEX™, an additional fungicidal seed treatment. Thiodicarb is a carbamate insecticide which acts on contact and systemically. Imidacloprid is a neonicotinoid insecticide which has systemic properties and controls thrips for approximately three weeks after planting (Faircloth et al. 2002, Riggs et al. 2007).

Avicta Complete Pak® and AERIS® have been evaluated in trials since 2007 in South Carolina; however, results from these trials are inconsistent and do not offer any data on precision placement of the various technologies in defined management zones (Greene et al. 2007, 2008, 2009). The objectives of this study were to determine the effects of precision-applied Temik™ and seed treatments, AERIS® and AVICTA Complete Pak®, on populations of thrips and nematodes in management zones defined by soil texture as measured by soil electrical conductivity and to examine the economic benefit or detriment of each management technique either alone or in combination in cotton.

Materials and Methods

Research plots, located in a field with variable soil types at the Clemson University Edisto Research and Education Center near Blackville, SC, were mapped for soil texture using a soil electrical conductivity (EC) meter (Veris 3100) to define management zones within the field. Research plots were arranged in a factorial, 3-way ANOVA design, with soil EC (low, medium, high), at-plant seed treatment (AERIS®, or AVICTA Complete Pak®), and Temik™ rate (0, 3, or 5 lb/acre) as factors. Plots consisted of eight rows forty-feet with 38-inch centers. Each treatment was replicated four times. Plots were planted on 6 May 2010. A Bollgard™ 2, Roundup Ready Flex™ cotton cultivar (DP 161 B2RF) from one seed lot was treated with both AVICTA® and AERIS® seed treatments.

Populations of thrips were sampled twice weekly from each plot until five weeks after planting. Thrips were sampled by submerging ten randomly selected seedling plants from rows two and seven in 1-quart jars 50% filled with 70% isopropyl alcohol to dislodge thrips. The jars were taken to the laboratory and the alcohol suctioned through filter paper where adult and immature thrips were separated and counted using dissecting scopes. The effects of thrips injury to seedling cotton plants were visually rated once a week on a scale of 0 to 10, where "0" described no damage and "10" described severe damage/dead plants (Greene et al. 2007, 2008, 2009).

Nematode samples were taken from each plot at planting, approximately seven weeks after planting, and at harvest to determine density of nematodes and the effects of nematodes on plant growth and vigor. These samples were taken from soil cores obtained by placing a conical probe eight inches deep into the furrow of the middle two rows five or six times until the probe was full. Nematode samples were extracted by a differential sieving and centrifugal flotation technique (Jenkins 1964). For this technique, 100 cc of soil were placed in a large beaker and water added until the beaker was about 75% full. The soil was stirred by hand to allow the nematodes to float out of the soil. Once the water in the beaker stopped swirling, the water was placed through two sieves (numbers 20 and 400). The soil and nematodes left in the bottom sieve were placed into centrifuge tubes and centrifuged for five minutes. Sugar solution was added to the centrifuge tubes and the pellets were stirred to loosen the soil and then centrifuged for one minute. The solution was placed through a number 400 sieve to capture the nematodes. The sugar solution was washed off of the nematodes, and then the nematodes were placed into vials for identification and counting (Jenkins 1964). Nematode gall ratings were taken approximately seven to eight weeks after planting. Gall ratings were taken by digging up the root systems of ten random plants from each plot. Galls were rated on a scale from 0 to 5, where "0" described no galls and "5" described severe galling on the entire root system (Caldwell et al. 2003). These roots were cut into small pieces and placed into cups for fresh weight measurement. Cups filled with root pieces were placed into a mist chamber for approximately five days, and then placed into a drying oven for 72 hours for dry weight measurement (Vrain 1977). Nematodes recovered from the mist chamber were identified to genera and counted.

Nodes above white flower counts, stand counts, and fresh and dry weights of shoot and root systems were measured to determine plant vigor and maturity. Yields were determined by machine-harvesting the 4 center rows of each plot. Data were analyzed using 3-way Analysis of Variance and means were separated using Least Significant Difference with soil EC (low, medium, high), at-plant seed treatment (AERIS®, or AVICTA Complete Pak®), and Temik™ rate (0, 3, or 5 lb/acre) as factors.

Results and Discussion

Soil electrical conductivity (EC) was associated with soil texture (% sand or clay) (Figures 1 and 2). In all EC zones, numbers of thrips were highest in plots with no Temik 15G™ and seed treatments, AERIS® and AVICTA®, applied alone (Figure 3). Thrips numbers were lowest where Temik 15G™ was common in the treatments. Density of thrips increased as EC decreased (i.e. more thrips were found as % sand increased) (Figure 4). Numbers of Columbia lance nematodes were lowest in the high EC zone at 8-weeks-after planting (Figure 5) but followed similar trends for thrips numbers in the medium EC zone where lowest numbers were found with Temik 15G™ in common (Figure 6). Gall ratings were low (Figure 7), indicating low pressure from root-knot nematodes in this test area during 2010. There was more variability in yield as soil EC decreased, and combinations of treatments were more effective in the lower EC or sandier areas of the field (Figure 8). As expected, yields increased as soil EC increased (Figure 9). Economic returns for at-plant systems used alone or in combination were variable, but combinations of Temik 15G™ and seed treatments were more profitable as soil EC decreased.

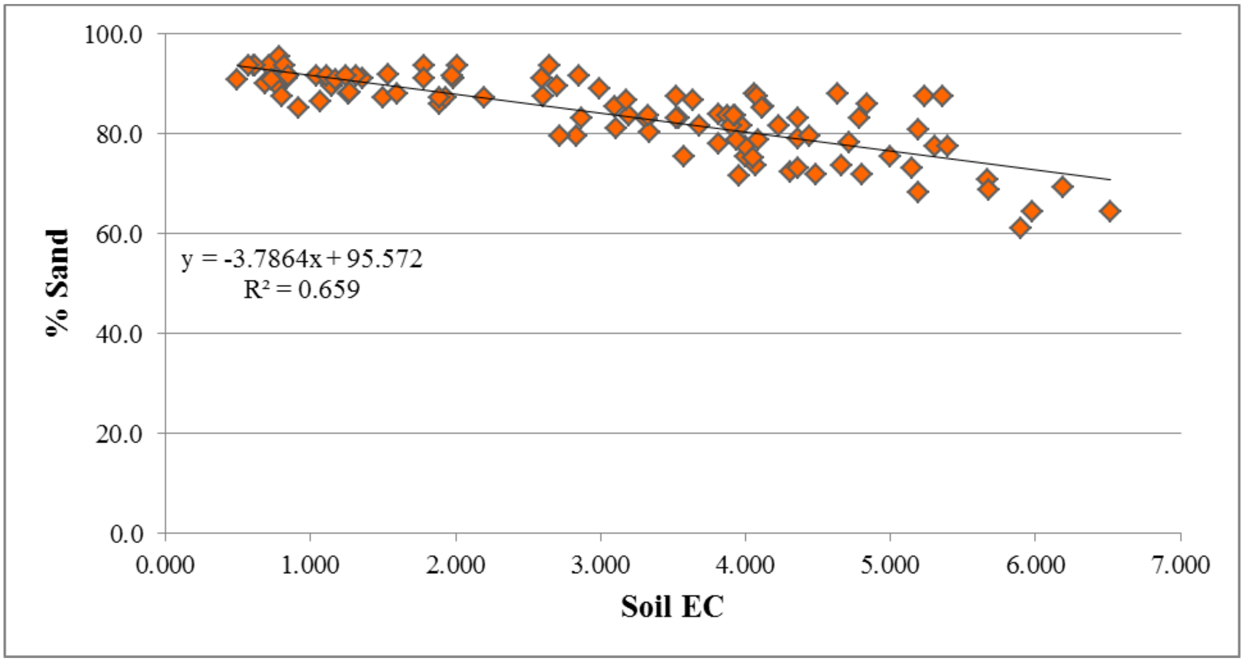

Figure 1. Association between electrical conductivity of soil and soil texture (% sand) during 2010 near Blackville, SC.

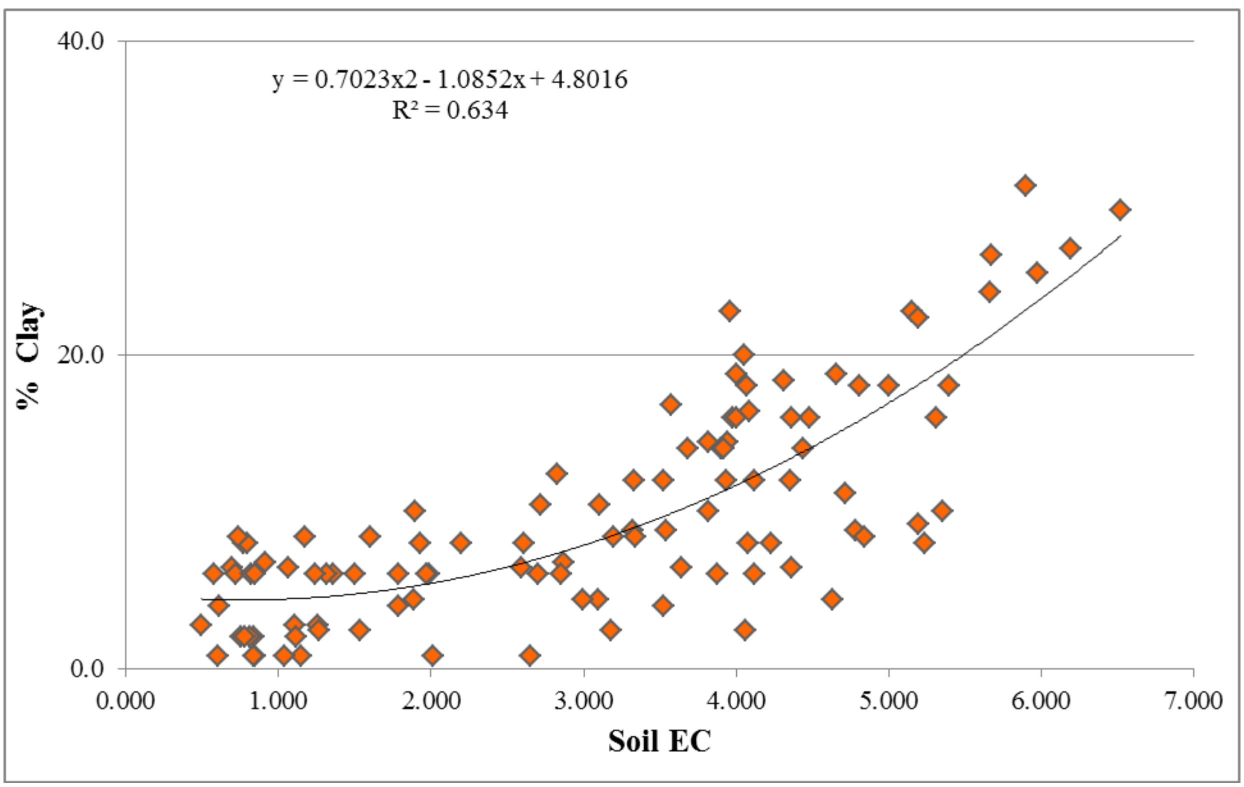

Figure 2. Association between electrical conductivity of soil and soil Texture (% clay) during 2010 near Blackville, SC.

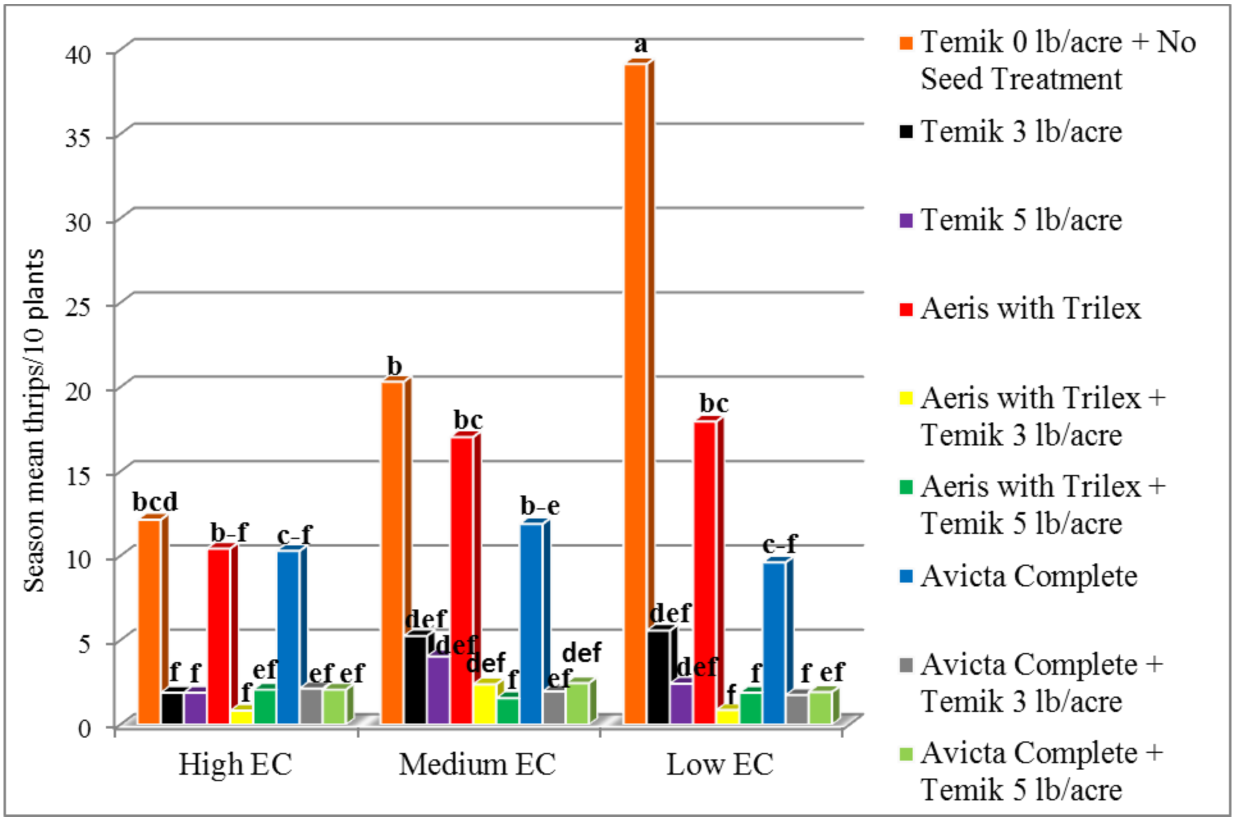

Figure 3. Density of thrips from cotton seedlings across soil electrical conductivity zones (EC) and following various at-plant, preventative options during 2010 near Blackville, SC.

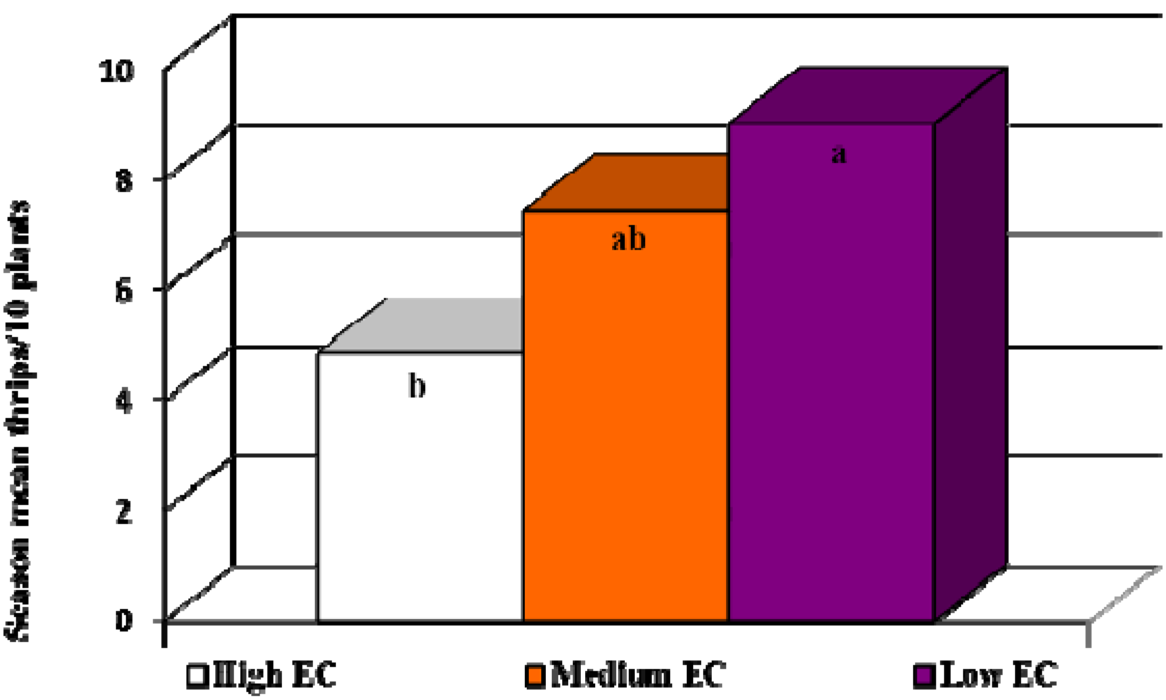

Figure 4. Density of thrips from cotton seedlings from soil electrical conductivity zones (EC) during 2010 near Blackville, SC.

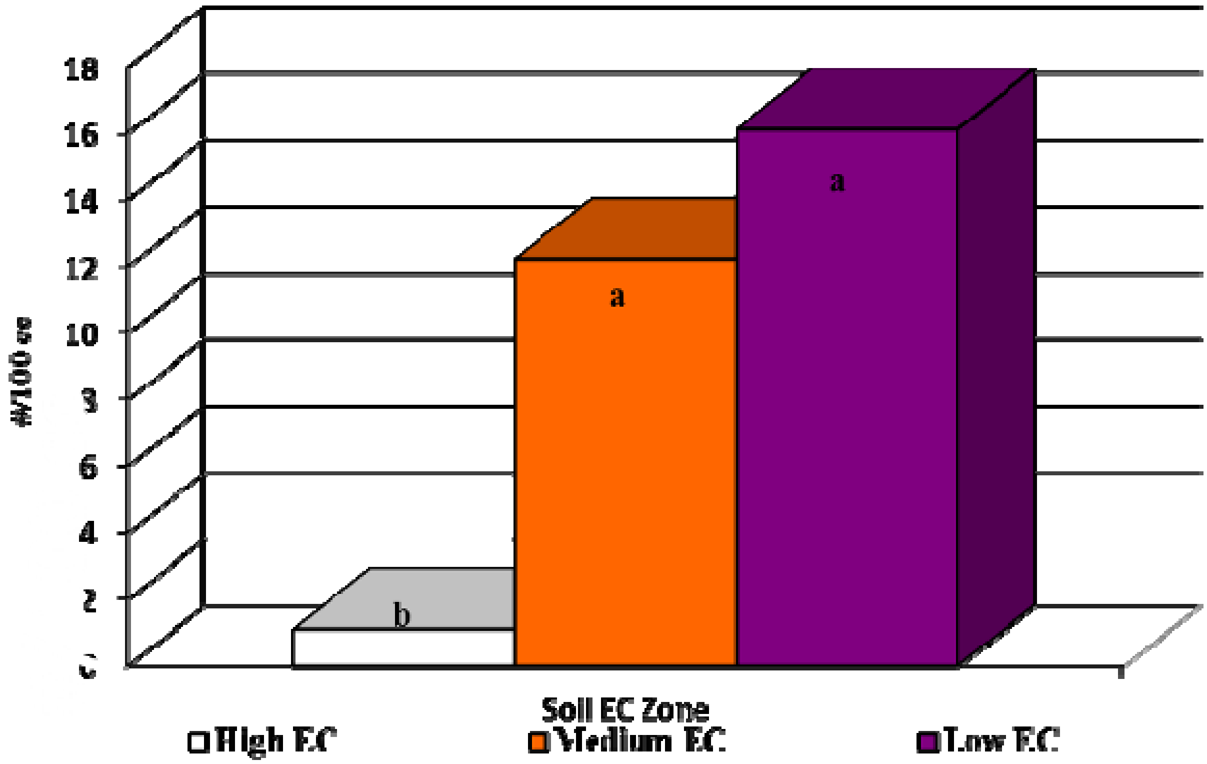

Figure 5. Density of Columbia lance nematodes in soil at 8-weeks-after planting by soil electrical conductivity zones (EC) in cotton during 2010 near Blackville, SC.

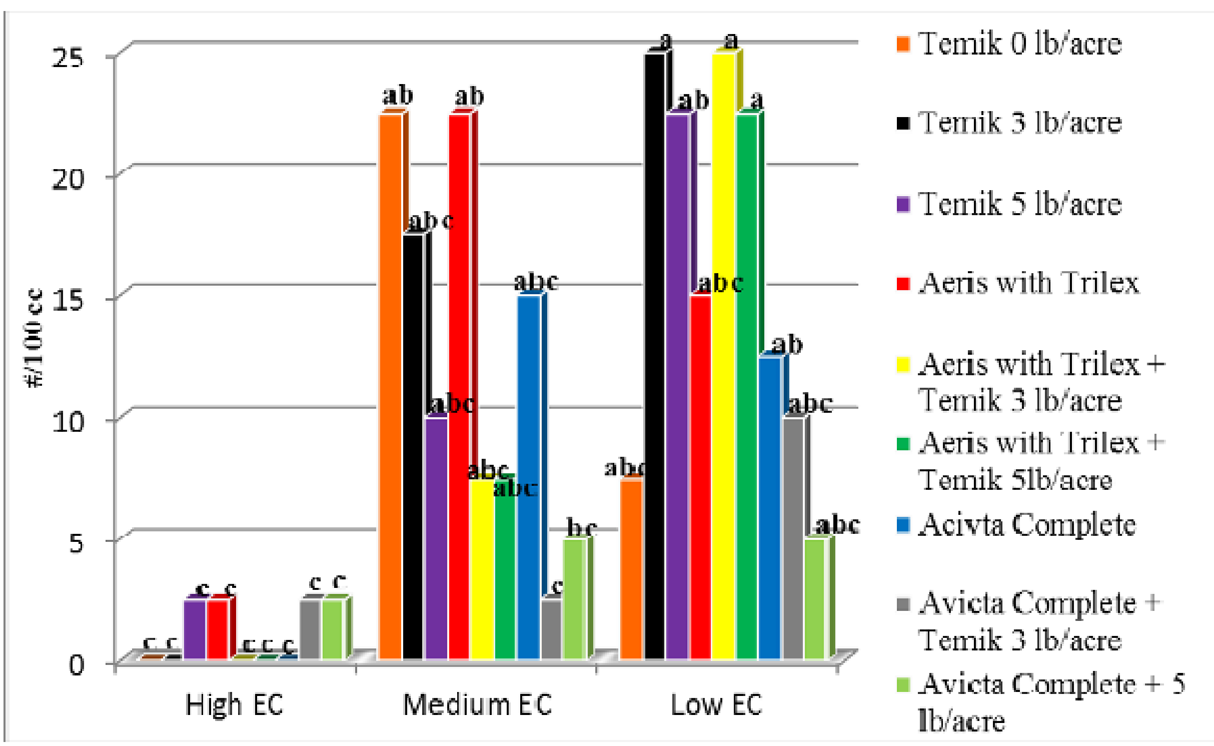

Figure 6. Density of Columbia lance nematodes in soil at 8-weeks-after planting across soil electrical conductivity zones (EC) in cotton during 2010 near Blackville, SC

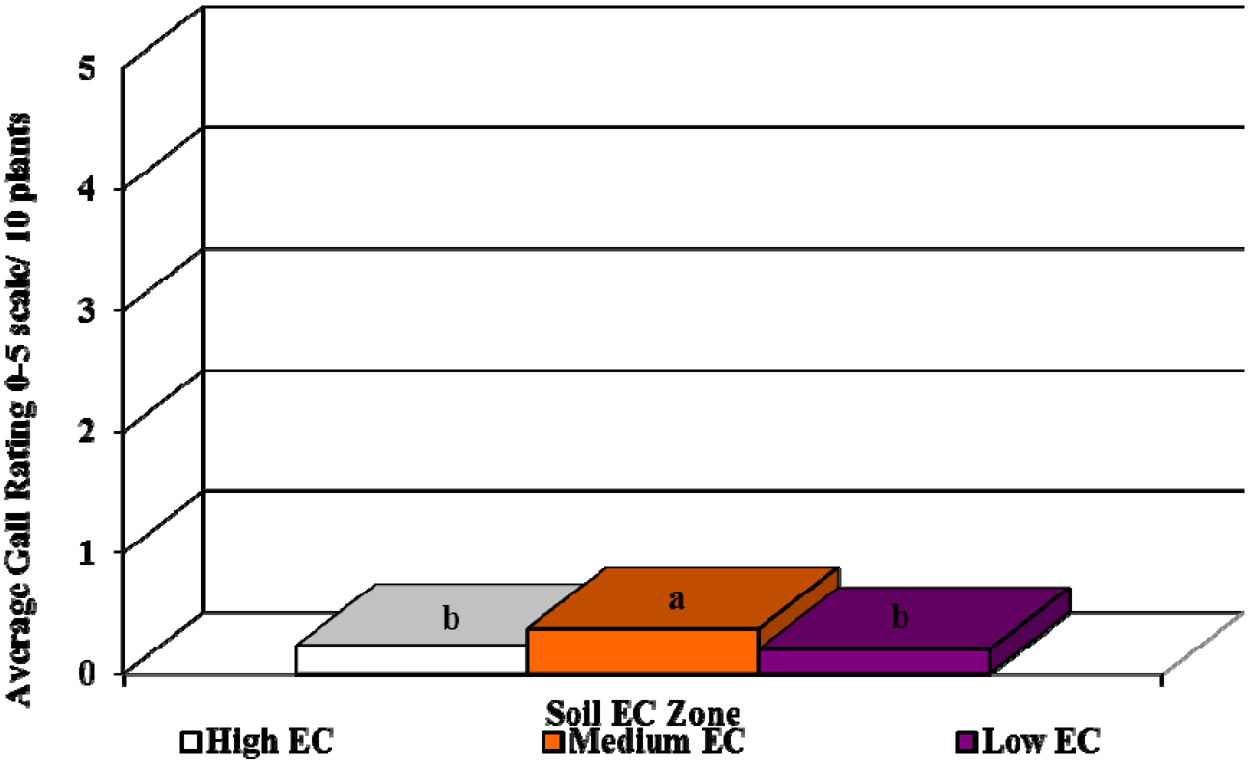

Figure 7. Root galling ratings at 7 weeks after planting from cotton plants by soil electrical conductivity zones (EC) during 2010 near Blackville, SC.

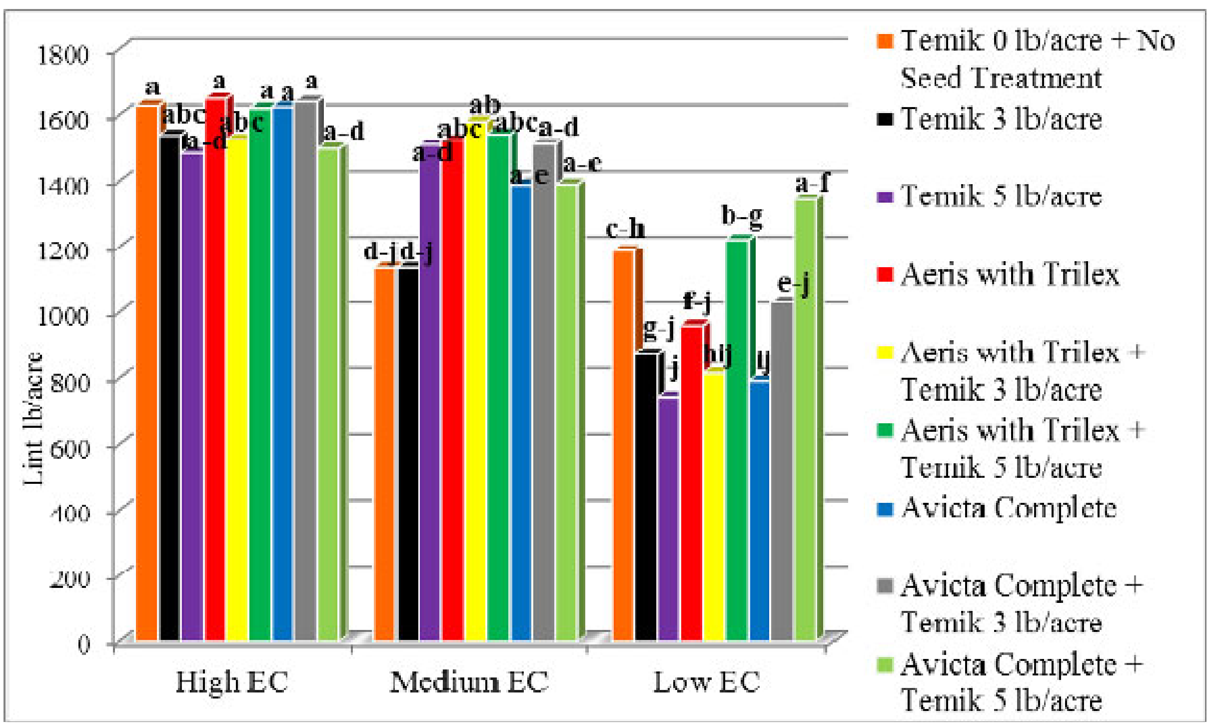

Figure 8. Lint yield (lb/acre) from cotton planted across soil electrical conductivity zones and with at-plant, preventative pesticides for thrips and nematodes alone or in combination during 2010 near Blackville, SC.

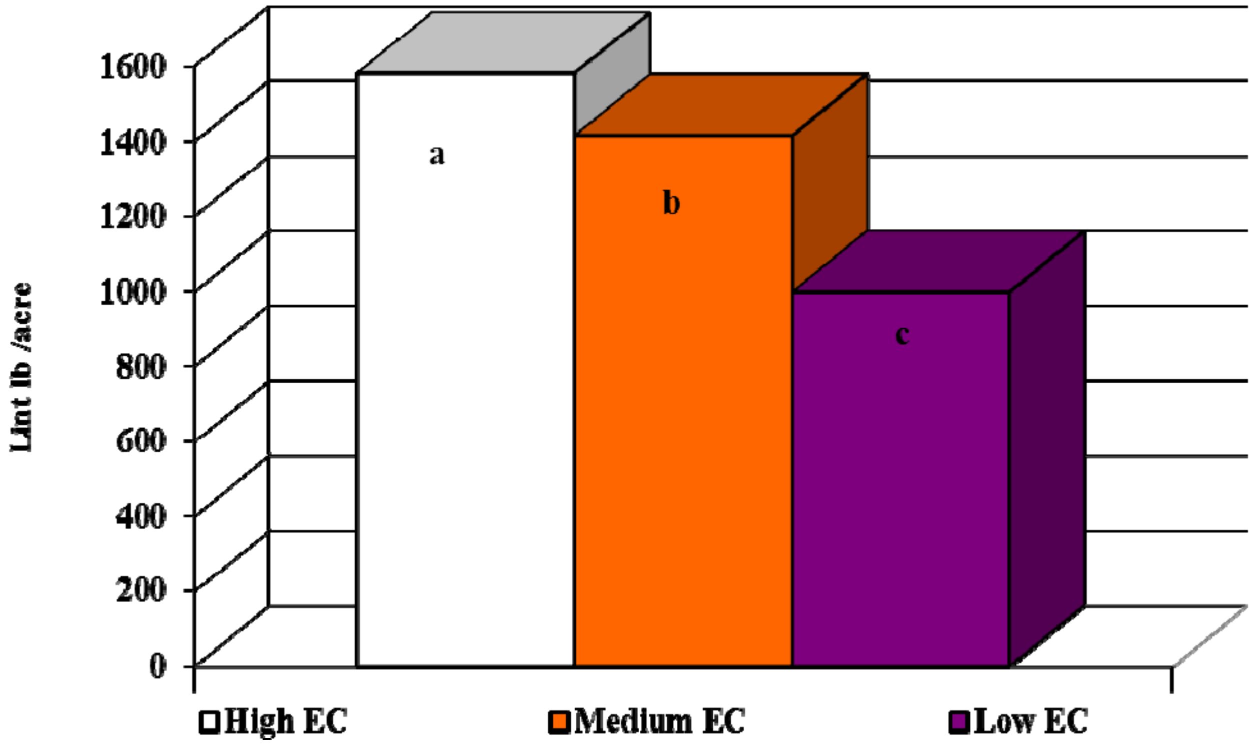

Figure 9. Lint yield (lb/acre) from cotton planted across soil electrical conductivity zones during 2010 near Blackville, SC.

Conclusions

Overall, low numbers of thrips (90% tobacco thrips) and nematodes (predominantly Columbia lance and root-knot) were experienced during the first year of this study. This study will be repeated again during the 2011 season in fields identified with more pressure from nematodes, and planting date will be modified (planted earlier) for optimal pressure from thrips. Temik 15G™ was common in treatments with the lowest numbers of thrips. There were higher numbers of thrips and nematodes in zones of low soil electrical conductivity (EC) or sandier areas of the field. Because soil texture was correlated with EC, zone definition by EC can be used as a practical management approach for thrips and nematodes. More variability in yield occurred in the lowest EC zone (sandiest areas), where treatment combinations (seed treatment + Temik 15G™) were more effective and profitable.

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