# EFFECTS OF TILLAGE, IRRIGATION, AND THRIPS ON COTTON YIELD

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## Abstract

Thrips are a serious economic pest of southeastern US cotton production. A multifaceted management approach system is needed to ameliorate early-season thrips pressure since aldicarb is no longer available. This study sought to investigate the impact of tillage and irrigation on thrips populations and cotton injury. We hoped that by manipulating moisture, cotton could compensate for early season above and below ground tissue loss. Rye was planted as a cover crop on 6 December 2012; it was burned down prior to cotton planting on 3 May 2013. Small plots were created in a completely randomized factorial, with factors consisting of tillage (conventional, strip and reduced), insecticide treatment (treated and untreated), and irrigation (irrigated and dryland). We characterized populations of adult and immature thrips, visual plant injury ratings, plant height, plant maturity, plant populations, plant biomass, and yield. Total (adult and larval) thrips densities increased over time and varied among tillage type, insecticide regime, and irrigation. Adult thrips densities increased over time, but did not vary over tillage type, insecticide regime, and irrigation. Plant height increased over time and varied among tillage type, insecticide regime, and irrigation. Plant injury due to thrips increased over time and varied among tillage type, insecticide regime, and irrigation. Plant stand was significantly lower in plots with reduced tillage that were insecticide-treated compared to plant stand in plots that were strip-tilled without insecticide and conventionally-tilled with insecticide. Cotton plants with an insecticidal seed treatment and foliar overspray had roots that were nearly two times heavier than the weight of plant roots without insecticide. Yields were not significantly different among plots.

## Introduction

Thrips of the genus *Frankliniella* are widely recognized as serious economic pests of southeastern cotton production. Across the US, thrips infested 8.5 million acres in 2011 and claimed 167,428 bales of cotton (Williams 2012). Injury and damage symptoms can range from leaf curling to delays in crop maturity, reduced yield, and stand loss. Research in Virginia and North Carolina documented lint losses as high as 400 to 660 lb per acre, or 34 to 43% of total yield, respectively, when thrips were not controlled (Herbert et al. 2007). A single management tactic, insecticide application, has traditionally been the only economic option for southeastern cotton producers. Aldicarb was once the standard chemical for reducing densities of both thrips and nematodes to sub-economic levels. However, this chemical has not been produced since 2011. A multifaceted management approach system is needed to ameliorate early-season thrips pressure.

Conservation tillage is prevalent in North Carolina cotton production, partly due to genetically modified cotton and associated herbicide use (Young 2006), and partly due to the associated benefits of soil conservation. New consideration is being given to old tillage practices, however, with changes in the production system, including herbicide-resistant weeds, sustained drought, and the loss of many broad-spectrum insecticides. Numerous studies point to the correlation among thrips densities and tillage practices (All et al. 1992, Manley et al. 2002, Toews et al. 2010). In general, there are more thrips in conventionally tilled cotton compared with reduced-till cotton. For example, a recent study involved conventionally tilled and strip-tilled plots planted using a thiamethoxam seed treatment (Toews et al. 2010). Over two years, thrips populations exceeded Extension recommendations for foliar treatment on five out of a possible six sample dates in the conventionally tilled plots compared to only two out of six sample dates in strip-tilled plots.

Research in Georgia showed that early season thrips injury was correlated with decreased shoot growth (Roberts et al. 2009). Furthermore, reduced shoot biomass was highly correlated with decreases in root mass, effectively rendering these plants more vulnerable to future plant stresses like drought, nematodes, nutrient deficiencies, and plant pathogens. Plants are most susceptible to thrips injury from emergence through four true leaves (generally the first 28 days after planting). The modification of tillage and cover crop practices should have a direct bearing on cotton root growth, independent of thrips. Furthermore, it is known that no-till practices have a positive effect on soil moisture and aeration (Griffith et al. 1986) and a negative effect on certain weed species.

Cover crops provide many of the same benefits as conservation tillage, including positive effects on soil moisture and aeration and a reduction in weed abundances (Clark 2007). Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) has been confirmed in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee (Culpepper et al. 2008, Price et al. 2011). The level of resistance in these weed populations is so high that even a 3x rate of glyphosate gave only 17% control (Culpepper et al. 2006). There is currently increased interest in use of rolled high residue cover crop systems that can suppress weed germination and growth though mulching and allelopathic affects. A recent Georgia study demonstrated that heavy rye residue alone decreased glyphosate-resistant Palmer amaranth by 94% in the row middle and 50% in the rows (Culpepper et al. 2010). Weed suppression by residue has been previously associated with biomass amount (Price et al. 2005). In addition, the benefits extend beyond direct effects on the plant. Thrips larvae densities can be reduced on cotton seedlings by two to eight times when planting into a cover crop compared with cotton planted without a cover crop (Olson et al. 2006). Hence, both tillage and cover should be investigated as possible management strategies to combat thrips.

A loss of biomass of cotton from thrips early in the season may or may not translate into yield differences at the end of the season. Cotton plants, at times, may be able to compensate for these early-season losses. For example, thrips injury can delay the onset of flowering and boll set. In some seasons, this can be an advantage because the water and nutrient demands of the delayed plants are more synchronized with favorable conditions. Because there is an excellent relationship between above and below ground biomass, thrips injury above ground should translate into reduced growth below ground. Furthermore, potential stress from a lack of moisture might be eliminated by modifying tillage practices and irrigation. This study sought to investigate the impact of tillage and irrigation on thrips populations and cotton injury. We hoped that by manipulating moisture, cotton could compensate for early season above and below ground tissue loss.

## Materials and Methods

Rye (variety not specified) was planted on 6 December 2012 in Plymouth, NC to provide a cover crop. The design was a completely randomized factorial, with factors consisting of tillage, insecticide treatment, and irrigation. Before cotton was planted in 2013, the rye was burned down using glyphosate and the land was prepped with conventional tillage and strip tillage, while some was left untilled (reduced till). All plots were planted on 3 May 2013 with PHY367 cotton seed. Treatments were further split into insecticide-treated seed (Aeris + Trilex Advanced), with a foliar spray of acephate (Orthene at 8 oz/A) at the second true leaf, and seed treated only with Trilex Advanced with no foliar overspray. The final treatment was irrigation, with some plots receiving drip irrigation and other plots not receiving irrigation. Irrigation management followed the University of Georgia recommendations. Because of a wet spring, plots were only irrigated twice. However, the times the cotton required the irrigation was at peak water requirement for the crop (2nd and 4th week of bloom- 1.5 inches of water on 23 July and 0.5 inches of water on 7 August, respectively).

We characterized populations of adult and immature thrips, visual plant ratings, plant height, plant maturity, plant populations, and plant biomass. Starting 7 days after 90% plant emergence and weekly until cotton was at the 5 leaf stage (4 sample dates- 21 May, 28 May, 4 June, 11 June 2013), we estimated populations of immature and adult thrips by inverting 5 randomly selected plants per plot into jars partially filled with 70% ethyl alcohol (or soapy water). On those same sample dates we recorded visual injury ratings, plant height, and plant maturity. Visual injury ratings were rated on a per plot basis on a scale of 0 to 5 (no damage to dead plants) with 3 being designated as acceptable thrips control for commercial growers. Injury ratings were not taken on 11 June. Plant height was estimated by measuring the total height from ground level to the tip of the growth terminal on 5 plants per plot. Plant maturity was estimated by recording the number of true leaves (expanded to the size of a quarter) on those same 5 plants. Plant stand and biomass production was estimated at 42 days after planting. Plant stand was estimated by counting the total number of plants in one entire row, while above and below ground plant biomass was estimated by digging 5 random plants per plot when the soil was moist and carefully removing the entire plants, including the roots. Plants were separated into above and below ground by cutting them at the plant level and pooling the shoots and roots into labeled paper bags. Soil was rinsed from the roots with a hose. The samples were dried in a forced air oven at 140 degrees F for 48 h and then weighed. Yield data were collected at the end of the season using a mechanical picker.

Plant stand, plant biomass, and yield data were analyzed using a general linear mixed models analysis of variance. Fixed factors included tillage type, insecticide regime, irrigation, and their interaction. Replication was included as a random factor. Thrips abundance, plant height, and plant injury data were analyzed using a repeated measured general linear mixed models analysis of variance. Assumptions of the model were addressed using transformations and the repeated/ group= option in SAS (SAS 2008), when necessary, and Tukey's honestly significant difference procedure was used for mean separations.

## Results

Total (adult and larval) thrips densities increased over time ($F = 127.8$, d.f. = 3, 144, $P < 0.0001$) and varied among tillage type, insecticide regime, and irrigation (Figure 1, $F = 7.60$, d.f. = 2, 144, $P = 0.0007$). Adult thrips densities increased over time ($F = 289.07$, d.f. = 3, 144, $P < 0.0001$), but did not vary over tillage type, insecticide regime, and irrigation. Plant height increased over time ($F = 320.59$, d.f. = 2, 55.1, $P < 0.0001$), and varied among tillage type, insecticide regime, and irrigation (Figure 2, $F = 4.60$, d.f. = 2, 39, $P = 0.0161$). Plant injury due to thrips increased over time ($F = 99.96$, d.f. = 2, 87.3, $P < 0.0001$), and varied among tillage type, insecticide regime, and irrigation (Figure 3, $F = 5.07$, d.f. = 2, 60.2, $P = 0.0092$).

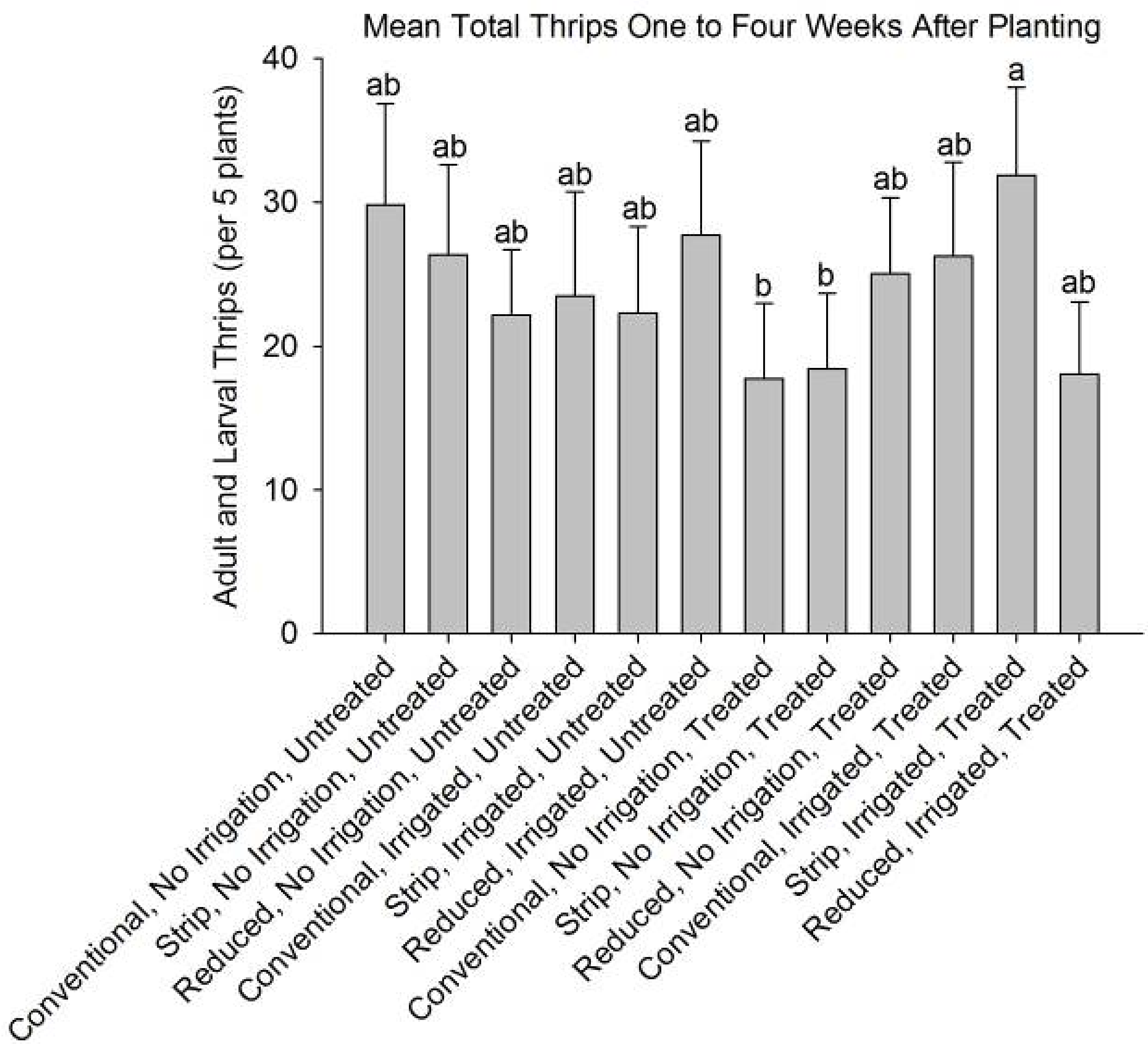


Figure 1. Total mean total thrips (adult + larval) densities one to four weeks after planting.

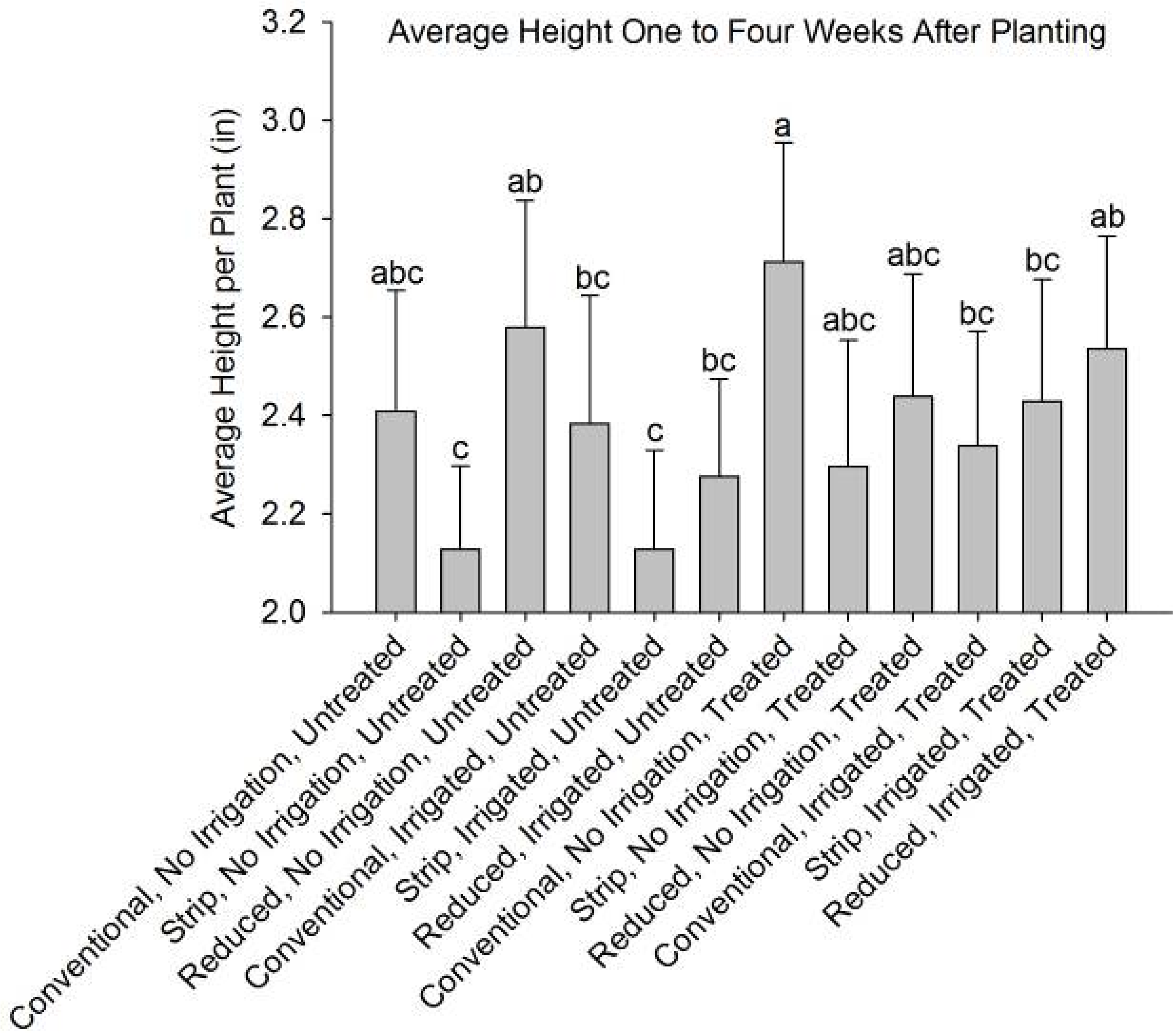


Figure 2. Total average plant height (inches) one to four weeks after planting.

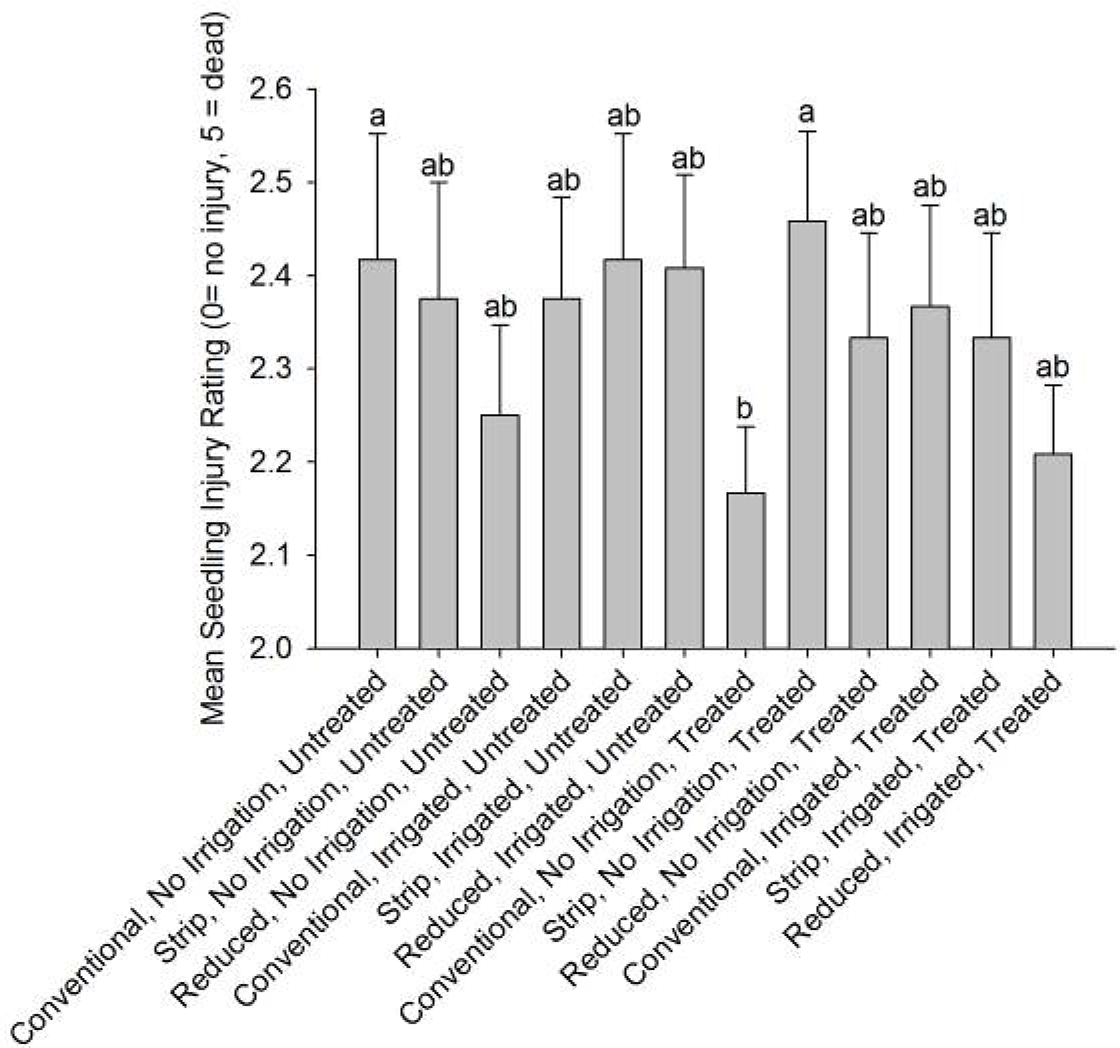


Figure 3. Total average plant injury one to four weeks after planting.

At 42 days after planting, plant stand was significantly lower (3.2 plants per row-foot) in plots with reduced tillage that were insecticide-treated compared to plant stand in plots that were strip-tilled without insecticide and conventionally-tilled with insecticide (3.7 plants per row-foot; F = 5.46, d.f. = 2, 18.2, P = 0.0139). At 42 days after planting, above-ground biomass varied among tillage type, insecticide regime, and irrigation (F = 4.86, d.f. = 2, 33, P = 0.0141), but mean separations were not significant by Tukey's honestly significant difference procedure. Hence, data are not presented here. Cotton plants with an insecticidal seed treatment and foliar overspray had roots that were nearly two times heavier (0.0046 oz/plant) than the weight of plant roots without an insecticidal seed treatment and foliar overspray (0.0024 oz/plant; F = 12.86, d.f. = 1, 29.9, P = 0.0012). Yields were not significantly different among plots.

## Discussion

There were not consistent trends for impacts of tillage, insecticide regime and irrigation on thrips densities, plant height, and plant injury. The presence of a singificant three-way interaction for these factors was unexpected since irrigation was not applied until six weeks following the last thrips rating and data collection point. Drip irrigation tape was placed in the plots almost immediately following cotton planting. The drip tape did not influence adult colonization, since adult numbers were consistent across treatments. Thus, its influence impacted larval densities either directly or indirectly, by impacting plant growth.

Plots under reduced till tended to be of intermediate height. This was unexpected, since we hypothesized that plots under reduced till would have the lowest height. However, experimental results may have been different under other environmental conditions, including soil type, weather, and a true "no-till" scenario. This highlights the importance for more year/location data to explain results. Finally, thrips caused a significant reduction in the root mass, but this effect was not as strong when above-ground biomass was assessed.

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## References

All, J. N., B. H. Tanner, and P. M. Tanner. 1992. Influence of no tillage practices on tobacco thrips infestations in cotton, pp. 77-78. *In* M. D. Mullen and B. N Duck (eds.) Proc. 1992 Southern Conservation Tillage Conference. Jackson and Milan, TN. 21-23 July 1992. Tennessee Agric. Exp. Sta. Special Publication 92-01. Univ. of Tennessee, Knoxville, TN.

Clark, A. (ed.) 2007. Managing cover crops profitably. Handbook Series Book 9. Sustainable Agriculture Network, Beltsville, MD.

Culpepper, A.S., J. Kichler, L. Sosnoskie, A. York, D. Sammons, and R. Nichols. 2010. Integrating cover crop residue and moldboard plowing into glyphosate-resistant Palmer amaranth management programs, 1531. Proceedings of Beltwide Cotton Conference. Jan 4-7 New Orleans, LA.

Culpepper, A. S., A. C. York. A. W. MacRae, and J. R. Whitaker. 2008. Distribution of glyphosate-resistant Palmer amaranth (Amaranthus palmeri) in Georgia and North Carolina during 2005 and 2006. Journal of Cotton Sci. 12: 306-310.

Culpepper, A. S., A. C. York, S. M. Brown, W. W. Hanna, J. W. Davis, W. K. Vencill, T. L. Grey, T. M. Webster, and J. M. Kichler. 2006. Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) confirmed in Georgia. Weed Sci. 54: 620-626.

Griffith, D. R., J. V. Mannering, and J. E. Box. 1986. Soil and moisture management with reduced tillage, p. 19-55. *In* M.A. Sprague and G.B. Triplett (ed.). No-tillage and surface-tillage agriculture. Wiley, New York.

Herbert, D. A., Jr., J. Bacheler, S. Malone, and D. Mott. 2007. *In* Proceedings of the Beltwide Cotton Conferences, pp. 1649-1653, January 9-12, New Orleans, LA. National Cotton Council of America, Memphis, T.N.

Manley, D. G., J. A. DuRant, P. J. Bauer and J. R. Frederick. 2002. Rye cover crop, surface tillage, crop rotation, and soil insecticide impact on thrips numbers in cotton in the Southeastern coastal plain. J. Agric. Urban Entomol. 19: 217-226.

Olson, D.M., R.F. Davis, S.L. Brown, P. Roberts and S.C. Phatak. 2006. Cover crop, rye residue and in-furrow treatment effects on thrips. J. Appl. Entomol. 130: 302–308.

Price, A. J., K. S. Balkcom, and F. J. Arriaga. 2005. Rye biomass amount affect weed suppression levels in conservation-tillage cotton, 2921-2923. Proceedings of the Beltwide Cotton Conference. Jan 4-7, New Orleans, LA.

Price, A. J., R. L. Nichols, H. Schomberg, J. A. Kelton, K. S. Baldom, and S. A. Culpepper. 2011. Glyphosate-resistant Palmer amaranth: a threat to conservation tillage. J. Soil Water Cons. 66: 265-275.

Roberts, P. M., M. Toews, and B. Kemerait. 2009. Impact of early season thrips control on root development and nematode management, pp.1140. *In* Proceedings of the Beltwide Cotton Conferences, January 5-8, San Antonio, TX. National Cotton Council of America, Memphis, TN.

SAS Institute. 2008. SAS/STAT 9.2 user's guide, 2$^{nd}$ ed. SAS Institute, Cary, NC.

Toews, M. D., R. S. Tubbs, D. Q. Wann, and D. Sullivan. 2010. Thrips (Thysanoptera: Thripidae) mitigation in seedling cotton using strip tillage and winter cover crops. Pest. Manag. Sci. 66: 1089-1095.

Williams, M. R. 2012. Cotton insect losses 2011, pp. 1001-1012. *In* Proceedings of the Beltwide Cotton Conferences, January 3-6, Orlando, FL. National Cotton Council of America, Memphis, TN.

Young, B. 2006. Changes in herbicide use patterns and production practices resulting from glyphosate-resistant crops. Weed Tech. 20: 301-307.