

ARTHROPOD MANAGEMENT & APPLIED ECOLOGY

Survey of Thrips Species Infesting Cotton Across the Southern U.S. Cotton Belt

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ABSTRACT

A survey investigating the composition of adult thrips species and the effect of preventive, at-plant insecticides on this composition was conducted at multiple locations across the U.S. Cotton Belt in 2009 and 2010. Small-plot experiments included insecticide seed treatments containing imidacloprid (Aeris[®]) or thiamethoxam (Avicta Complete Cotton[®]), in-furrow applications of the insecticide aldicarb (Temik[®]), and an untreated control (no at-planting insecticide). The species composition of adult thrips varied among all locations which included trials within Arkansas, Georgia, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, Texas and Virginia. As was the case

in previous studies, tobacco thrips (*Frankliniella fusca* [Hinds]) was the dominant species at most locations. This species comprised an even greater percentage of the species composition in cotton not treated with insecticide. Conversely, the percent composition of other species tended to increase in cotton treated with insecticide. These observations suggest that tobacco thrips are relatively more sensitive to these insecticides. Overall, aldicarb reduced populations of adults more than other treatments, particularly imidacloprid.

Thrips are typically the first insect pest growers will encounter during any given growing season. Additionally, while other pests of cotton tend to be regional in occurrence and distribution, thrips are widespread and can require treatment across the entire Cotton Belt. Species of thrips that commonly infest cotton seedlings in the U.S. include tobacco thrips, *Frankliniella fusca* (Hinds); flower thrips, *Frankliniella tritici* (Fitch); western flower thrips, *Frankliniella occidentalis* (Pergande); onion thrips, *Thrips tabaci* (Lindeman); and soybean thrips, *Neohydatothrips variabilis* (Beach) (Leigh et al. 1996, Albeldano et al. 2008). Significant delays in cotton maturity due to thrips injury have been observed (Gaines 1934, Dunham and Clark 1937, Bourland et al. 1992, Parker et al. 1992, Herbert 1998, Van Tol and Lentz 1999, Lentz and Van Tol 2000). Heavy infestations of thrips have delayed crop maturity to harvest for more than two weeks (Gaines 1934, Dunham and Clark 1937, Bourland et al. 1992, Parker et al. 1992). Additionally, delayed crop maturity can extend the period in which the crop is susceptible to injury from other insect pests, and can lead to higher production costs. By extending the crop growing period, cool temperatures causing further delayed maturation may be encountered before defoliation and harvest (Morris 1963, Gipson and Joham 1968).

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Several researchers have reported an increase in yields when seedling thrips were controlled (Cook et al. 2013, Davis et al. 1966, Davis and Cowan 1972, Burris et al. 1989, Herbert 1998, Van Tol and Lentz 1999, Lentz and Van Tol 2000). More consistent yield responses have been reported from Virginia where 220 insecticide treatments (including foliar, in-furrow, and seed applied) tested over a five-year period from 1997-2001 showed an average yield increase of 381 kg lint/ha over non-treated controls (Herbert 2002). More recently in North Carolina and Virginia, treatments with in-furrow applications of aldicarb and seed treatments with imidacloprid resulted in average increases of 483 and 614 kg lint/ha, respectively (Herbert et al. 2007). This is likely due to both higher thrips populations than elsewhere in the Cotton Belt as a result of a high number of thrips hosts relative to small field sizes (Herbert et al. 2012) and to the cooler environments in this region resulting in slower-growing seedlings (Bachelier, 2012), a scenario often conducive to magnified effects from thrips injury.

Control of thrips on cotton seedlings has been achieved with use of either in-furrow insecticides (e.g., aldicarb or acephate), seed-applied treatments such as acephate, imidacloprid, or thiamethoxam, and foliar-applied insecticides (Kerns et al. 2009, Kerns and Cattaneo 2009, Parker et al. 2009, Bachelier and Reisig 2010, Catchot et al. 2010, Greene 2010, Herbert 2010, Pollet et al. 2010, Reed et al. 2010b, Roberts et al. 2010, Stewart et al. 2010, Studebaker et al. 2010). The neonicotinoid seed treatments (i.e., imidacloprid and thiamethoxam) have been widely adopted by growers in several areas across the Cotton Belt. Although considered effective for thrips control, previous research has shown that at-planting insecticides may require supplemental foliar applications under high risk situations such as early planting on conventionally-tilled fields.

Numerous pesticide evaluation publications have reported efficacy against thrips but often do not refer to species composition related to treatments. The objectives of this study are to determine the composition of thrips species in cotton across the Cotton Belt and to investigate how at-planting insecticide treatments affect this composition.

MATERIALS AND METHODS

A survey of thrips species was conducted at 17 locations in 2009 and 2010 including trials at

Arkansas, Georgia, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, Texas, and Virginia. Thrips were collected from field tests of selected at-planting insecticide treatments. All seed contained a seed-applied fungicide. At-plant insecticide treatments included Aeri[®] seed treatment (imidacloprid at 0.375 mg AI/seed [insecticide] + thiodicarb at 0.375 mg AI/seed [nematicide], Bayer CropScience, Research Triangle Park, NC), Avicta Complete Cotton[®] seed treatment (thiamethoxam at 0.34 mg AI/seed [insecticide] + abamectin at 0.15 mg AI/seed [nematicide], Syngenta Crop Protection, Wilmington, DE), or Temik 15G[®] (aldicarb at 0.84 kg AI/ha [insecticide/nematicide], Bayer CropScience) applied in-furrow, and an untreated check. The Avicta Complete Cotton[®] treatment was only included at 10 locations in 2009 and 8 in 2010. Plots were four or eight rows wide, 10.7 - 15.2 m long and arranged in a randomized complete block design with four replications. Row spacing was 0.91 m, 0.97 m or 1.02 m. Varieties and planting dates were determined by the cooperator at each location, as were fertility, herbicides, and irrigation requirements, but were within Extension-recommended production practices in the region.

For each plot, plants were typically sampled three times: 14 days after emergence, the 1-2 leaf stage, and the 3-4 leaf stage. Individual samples consisted of five plants that were cut below the cotyledons or pulled from the ground, held in 475 ml (1 pint) glass jars or self-sealing plastic bags or dipped into 1.42 l (48 oz) containing 50% isopropyl alcohol. In the laboratory, thrips were washed from the plants or suctioned onto a filter paper or fine mesh screen as described by Burris et al. (1989). Adult thrips were then counted and identified to species (Reed et al. 2006).

Data were analyzed across years and sample dates to determine if insecticide treatment affected the species composition of adult thrips. Proc Mixed (SAS Institute Inc. 2010) was used for analysis with treatment as a fixed model effect and location and location*treatment as random effects. Treatment means were separated using the Tukey's option ($\alpha = 0.05$). Adjusted treatment means were converted to percentage values for presentation purposes.

RESULTS AND DISCUSSION

Mean numbers of adult thrips per sample summarized across treatments varied consider-

ably among locations within years and within some locations between years (Tables 1 and 2). Thrips species composition varied considerably among locations within years and within some locations between years. Tobacco thrips were by far the most common species present at most locations. In 2009 and 2010, respectively, tobacco thrips were identified from 15 and 16 locations, flower thrips were identified from 13 and 12 locations, western flower thrips and soybean thrips were found at 11 and 11 locations, onion thrips were found at 6 and 8 locations (Tables 1 and 2). A small number of other species were found at four locations each year. With few exceptions, only tobacco thrips exceeded a density of 1 adult per plant (i.e., 5 per 5 plants). There are several examples where species composition at one location changed considerably between years including the Lang Farm at the Tifton, GA location where tobacco thrips were the primary species in 2009, but western flower thrips were

dominant in 2010; and the Dimmitt, TX location where western flower thrips were most common in 2009, but onion thrips were the primary species present in 2010. It is unclear why these species shifts occurred, but the authors hypothesize that other crops or wild hosts in the vicinity could affect species composition.

Tobacco thrips are widely distributed across the mid-southern and southeastern cotton production regions. This species has previously been reported infesting cotton seedlings in Alabama (Cook et al. 2003), Arkansas (Cook et al. 2003), Georgia (Lambert 1985, Cook et al. 2003, Toews et al. 2010), Louisiana (Sharp and Eddy 1938, Newsom et al. 1953, Burris 1980, Graves et al. 1987, Cook et al. 2003), Mississippi (Dunham and Clark 1937, Cook et al. 2003), South Carolina (DuRant et al. 1994) and Tennessee (Cook et al. 2003), and is the primary pest species in Virginia and North Carolina (Bachelier 2012, Herbert 2002).

Table 1. Mean number (percent) of adult thrips per five plants when averaged across treatments by species (2009).

Location	Tobacco Thrips	Flower Thrips	W. Flower Thrips	Soybean Thrips	Onion Thrips	Other ^Z
Keiser, AR	5.60 (93.4)	0.08 (1.4)	0.04 (0.7)	0.04 (0.7)	0.23 (3.8)	0.00 (0.0)
Marianna, AR	7.02 (97.1)	0.04 (0.6)	0.00 (0.0)	0.10 (1.4)	0.06 (0.9)	0.04 (0.6)
Rohwer, AR	1.02 (96.1)	0.02 (2.0)	0.00 (0.0)	0.02 (2.0)	0.00 (0.0)	0.02 (2.0)
Tifton, GA	1.02 (90.7)	0.02(1.9)	0.04 (3.7)	0.04 (3.7)	0.00 (0.0)	0.00 (0.0)
Tifton, GA (Lang Farm)	1.27 (26.1)	0.13 (2.6)	3.48 (71.4)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Winnsboro, LA	5.83 (88.1)	0.08 (1.3)	0.71 (10.7)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Bossier City, LA	3.61 (90.9)	0.14 (3.5)	0.17 (4.2)	0.06 (1.4)	0.00 (0.0)	0.06 (1.4)
Portageville, MO	1.13 (83.1)	0.15 (10.8)	0.04 (3.1)	0.04 (3.1)	0.00 (0.0)	0.00 (0.0)
Raymond, MS	1.83 (95.7)	0.00 (0.0)	0.00 (0.0)	0.08 (4.3)	0.00 (0.0)	0.00 (0.0)
Starkville, MS	1.15 (90.2)	0.13 (9.8)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Stoneville, MS	0.94 (93.8)	0.04 (4.2)	0.02 (2.1)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Rocky Mount, NC	7.08 (67.1)	0.53 (5.0)	1.25 (11.8)	0.11 (1.1)	1.58 (15.0)	0.03 (0.3)
Blackville, SC	1.33 (92.8)	0.00 (0.0)	0.00 (0.0)	0.10 (0.0)	0.00 (0.0)	0.00 (0.0)
Jackson, TN	2.06 (39.3)	0.13 (2.4)	0.00 (0.0)	2.44 (46.4)	0.63 (11.9)	0.00 (0.0)
Dimmitt, TX	0.00 (0.0)	0.00 (0.0)	10.25 (78.3)	0.00 (0.0)	2.83 (21.7)	0.00 (0.0)
Sunray, TX	0.00 (0.0)	0.00 (0.0)	0.50 (100.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Suffolk, VA	5.35 (70.4)	0.13 (1.6)	0.40 (5.2)	0.29 (3.8)	1.44 (18.9)	0.00 (0.0)
Locations found	15	13	11	11	6	4

^Z“Other” species collected in 2009 included *Frankliniella williamsi* Hood, *Scolothrips paladus* (Beach), *Microcephalothrips abdominalis* (D.L. Crawford), and *Thrips nigripilosus* Uzel.

Table 2. Mean number (percent) of adult thrips per five plants when averaged across treatments by species (2010).

Location	Tobacco Thrips	Flower Thrips	W. Flower Thrips	Soybean Thrips	Onion Thrips	Other ^Z
Keiser, AR	8.67 (97.5)	0.08 (0.9)	0.05 (0.6)	0.07 (0.8)	0.00 (0.0)	0.02 (0.2)
Marianna, AR	14.02 (95.9)	0.08 (0.3)	0.00 (0.0)	0.07 (3.7)	0.00 (0.0)	0.00 (0.0)
Rohwer, AR	19.44 (84.4)	3.64 (15.6)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Tifton, GA	4.61 (53.5)	2.67 (13.7)	3.58 (31.4)	0.17(1.4)	0.00 (0.0)	0.00 (0.0)
Tifton, GA (Lang Farm)	1.50 (85.7)	0.20 (9.7)	0.09 (4.6)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Winnsboro, LA	1.00 (84.6)	0.00 (0.0)	0.17 (15.4)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Bossier City, LA	18.92 (98.4)	0.17 (0.9)	0.00 (0.0)	0.14 (0.7)	0.00 (0.0)	0.00 (0.0)
St. Joseph, LA	7.80 (82.6)	0.50 (4.4)	0.69 (9.1)	0.20 (3.8)	0.04(0.1)	0.03 (0.1)
Clarkton, MO	0.71 (52.6)	0.08 (5.9)	0.31 (22.9)	0.18 (13.3)	0.07 (5.3)	0.00 (0.0)
Stoneville, MS	5.90 (98.5)	0.03 (0.5)	0.04 (0.6)	0.00 (0.0)	0.00 (0.0)	0.02 (0.3)
Pantego, NC	5.93 (86.6)	0.66 (9.3)	0.11 (0.8)	0.27 (2.9)	0.06 (0.4)	0.00 (0.0)
Rocky Mount, NC	4.54 (55.8)	0.23 (1.4)	1.74 (22.4)	2.55 (2.2)	0.27 (2.2)	0.00 (0.0)
Blackville, SC	3.83 (91.5)	0.06 (2.3)	0.00 (0.0)	0.22 (6.2)	0.00 (0.0)	0.00 (0.0)
Jackson, TN	5.79 (69.8)	0.00 (0.0)	0.00 (0.0)	2.36 (28.2)	0.13(2.0)	0.00 (0.0)
Dimmitt, TX	0.00 (0.0)	0.00 (0.0)	1.36 (28.2)	0.00 (0.0)	3.45 (71.8)	0.00 (0.0)
Sunray, TX	0.02 (0.2)	0.00 (0.0)	2.20 (23.8)	0.00 (0.0)	6.98 (75.6)	0.03 (0.3)
Suffolk, VA	3.64 (89.0)	0.00 (0.0)	0.00 (0.0)	0.21 (5.1)	0.24 (5.9)	0.00 (0.0)
Locations found	16	12	11	11	8	4

^Z“Other” species collected in 2010 included *Frankliniella* sp., *Stomatothrips* sp., *Scirtothrips* sp., and *Thrips quinciensis*.

Although tobacco thrips have always been a relatively ubiquitous pest in upland cotton, western flower thrips have previously been observed infesting cotton seedlings in Alabama (Cook et al. 2003), Arkansas (Cook et al. 2003), California (Bailey 1938), Georgia (Cook et al. 2003, Toews et al. 2010), Louisiana (Cook et al. 2003), Mississippi (Reed 1988, Cook et al. 2003), New Mexico (Race 1961), Oklahoma (Karner and Cole 1992), South Carolina (DuRant et al. 1994), Tennessee (Cook et al. 2003), Texas (Gaines 1965), and North Carolina and Virginia (Reed et al. 2010a). Flower thrips have been reported infesting cotton seedlings in Alabama (Cook et al. 2003), Arkansas (Cook et al. 2003), Georgia (Lambert 1985, Cook et al. 2003), Louisiana (Sharp and Eddy 1938, Cook et al. 2003), Mississippi (Dunham and Clark 1937, Cook et al. 2003), Tennessee (Cook et al. 2003), Texas (Gaines 1934), South Carolina (Watts 1937, DuRant et al. 1994), and North Carolina and Virginia (Reed et al. 2010a). Several authors have reported soybean thrips infesting cotton seedlings in Alabama (Cook et al. 2003), Arkansas (Cook et al. 2003), Louisiana (Burris 1980, Cook et al. 2003), Mississippi (Dunham and Clark 1937, Cook et al. 2003), South Carolina (Watts 1937) and Tennessee (Cook et al. 2003). Sharp

and Eddy (1937) reported onion thrips infesting cotton seedlings in Louisiana and Watts (1937) observed infestations in South Carolina.

Across all locations and treatments, tobacco thrips composed 67-78% of all adult thrips that were collected (Table 3). Western flower thrips and onion thrips were the next most common species encountered. Adult tobacco thrips were relatively less common in cotton that received an at-planting insecticide treatment ($P < 0.0001$, Table 3). Other species, and flower thrips and western flower thrips in particular, tended to be relatively more abundant when at-planting insecticides were used. However, when considered individually, the percent composition of these other species was not significantly affected by insecticide treatment (Table 3). These data suggest that tobacco thrips are more sensitive to at-planting insecticide treatments than are other thrips species commonly found in cotton. However, it is also possible that at-planting treatments are relatively repellent to tobacco thrips compared with other species. Although not evident in these studies, other tests suggest that western flower thrips are more sensitive to thiamethoxam and aldicarb than imidacloprid (Vandiver et al. 2009).

Table 3. Mean percent composition of adult thrips species and the mean number (\pm standard error) of thrips per sample for each at-planting insecticide treatment averaged across all locations.

Treatment	Tobacco thrips	Flower thrips	Western flower thrips	Soybean thrips	Onion thrips	Other	No. thrips per sample
Imidacloprid	67.4 b	4.3 a	11.9 a	6.3 a	9.9 a	0.13 a	6.0 \pm 0.9 b
Thiamethoxam	72.3 b	4.7 a	13.5 a	2.7 a	6.5 a	0.25 a	5.3 \pm 1.0 bc
Aldicarb	68.3 b	5.6 a	14.4 a	5.8 a	5.9 a	0.00 a	4.6 \pm 0.9 c
Untreated	78.2 a	3.1 a	9.0 a	2.7 a	6.9 a	0.10 a	7.5 \pm 0.9 a
<i>F</i>	10.64	0.21	0.06	2.33	1.97	1.08	12.84
<i>DF*</i>	3, 78.8	3, 1551	3, 25.6	3, 51.2	3, 56	3, 1171	3, 65.1
<i>P > F</i>	< 0.0001	0.8921	0.8921	0.0853	0.1295	0.3556	< 0.0001

Means, within columns, not followed by a common letter are significantly different ($P < 0.05$).

*Denominator degrees of freedom as defined by Proc Mixed, type 3 tests of fixed model effects (SAS Institute Inc., 2010).

At-planting insecticide treatments need to target tobacco thrips because it is the most common species encountered across the upland Cotton Belt. Across these 34 experiments, all insecticide treatments significantly reduced the average number of adult thrips (Table 3). Compared with cotton not treated with insecticide, aldicarb caused the greatest reduction in thrips populations across the complex of species observed in these tests. Thrips numbers in the aldicarb (Temik[®]) treatment were significantly lower than in the imidacloprid (Aeris[®]) treatment. However, the numbers presented do not include immatures which often compose the majority of the total thrips populations. Future analyses of this data set will address the efficacy of at-planting insecticide treatments on total thrips populations in cotton, including immature stages, and the effects on plant growth and yield. Preliminary results have already been reported elsewhere (Akin et al. 2010, 2011, 2012).

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REFERENCES

- Akin, D. S., J. E. Howard, G. M. Lorenz, G. Studebaker, S. D. Stewart, D. Cook, J. Gore, A. L. Catchot, B. R. Leonard, S. Micinski, K. Tindall, A. Herbert, D. L. Kerns, R. E. Jackson, M. Toews, P. Roberts, J. Bachelier, D. Reising and J. Greene. 2012. Evaluation of automatic insecticide applications following preventative insecticides for thrips. p. 1102-1106. *In Proc. Beltwide Cotton Conf., Orlando, FL. 3-6 Jan. Natl. Cotton. Counc. Am., Memphis, TN.*
- Akin, D. S., G. M. Lorenz, G. E. Studebaker, S. D. Stewart, B. R. Leonard, S. Micinski, J. Greene, R. E. Jackson, K. C. Allen, A. L. Catchot, J. Reed, J. Gore, D. Cook, C. Daves, K. Tindall, D. L. Kerns, P. Roberts, M. Toews, A. Herbert, and J. Bachelier. 2010. Evaluation of automatic insecticide applications following preventative insecticides for thrips: preliminary results from a regional project. p. 1119-1121. *In Proc. Beltwide Cotton Conf., New Orleans, LA. 4-7 Jan. Natl. Cotton. Counc. Am., Memphis, TN.*
- Akin, D., M. Toews, P. Roberts, J. Bachelier, A. L. Catchot, J. Reed, D. Cook, J. Gore, J. Greene, A. Herbert, R. E. Jackson, K. C. Allen, D. L. Kerns, B. R. Leonard, G. M. Lorenz, S. Micinski, D. Reising, S. D. Stewart, G. E. Studebaker, and K. Tindall. 2011. Evaluation of automatic insecticide applications following preventative insecticides for thrips. p. 1086-1093. *In Proc. Beltwide Cotton Conf., Atlanta, GA. 4-7 Jan. Natl. Cotton. Counc. Am., Memphis, TN.*
- Albeldano, W. A., J. E. Slosser and M. N. Parajulee. 2008. Identification of thrips species on cotton on the Texas Rolling Plains, *Southwest Entomol.* 33: 43-51.
- Bailey, S. F. 1938. Thrips of economic importance in California. California Agricultural Experiment Station Circular 346. University of California, Berkeley, CA.
- Bachelier, J.S. 2012. Managing Insects on Cotton. p. 124-146. *In K. Edmisten (ed.), 2012 Cotton Information. College of Agriculture and Life Sciences, North Carolina State University.*
- Bachelier, J. S. and D. D. Reising. 2010. Insect control in cotton. p. 83-88. *In 2010 North Carolina Agricultural Chemicals Manual. College of Agriculture and Life Sciences, North Carolina State University.*
- Bourland, F. M., D. M. Oosterhuis, and N. P. Tugwell. 1992. Concept for monitoring the growth and development of cotton plants using main-stem node counts. *J. Prod. Agric.* 5: 532-538.

- Burris, E. 1980. Observations on tobacco thrips (*Frankliniella fusca*) and soybean thrips (*Sericothrips variabilis*) damage to and control in cotton. p. 204-206. Northeast Louisiana Agricultural Experiment Station Progress Report. LSU AgCenter, Baton Rouge, LA.
- Burris E., K. J. Ratchford, A. M. Pavloff, D. J. Boquet, B. R. Williams, and R. L. Rogers. 1989. Thrips on seedling cotton: related problems and control. Louisiana Agricultural Experiment Station Bulletin 811. LSU AgCenter, Baton Rouge, LA.
- Catchot, A. L., G. Andrews, B. Burdine, D. Cook, C. Daves, D. Dodds, J. Gore, R. Jackson, T. Koger, E. Larson, F. Musser, P. McKibben, J. Reed, J. Robbins, J. Smith, and S. Winters. 2010. Cotton insect management. p. 2-21. *In* Insect Control Guide for Agronomic Crops 2010. Mississippi State University Extension Service, Mississippi State University.
- Cook, D. R., C. T. Allen, E. Burris, B. L. Freeman, G. A. Herzog, G. L. Lentz, B. R. Leonard, and J. T. Reed. 2003. A survey of thrips (Thysanoptera) species infesting cotton seedlings in Alabama, Arkansas, Georgia, Louisiana, Mississippi, and Tennessee. *J. Entomol. Sci.* 38: 669-681.
- Cook, D. R., B. R. Leonard, E. Burris, and J. Gore. 2013. Impact of thrips infesting cotton seedlings on cotton yield distribution and maturity. *J. Cot. Sci.* 17: 23-33.
- Davis, J. W., W. C. Watkins, Jr., C. B. Cowan, Jr., R. L. Ridgway, and D. A. Lindquist. 1966. Control of several cotton pests with systemic insecticides. *J. Econ. Entomol.* 59: 159-162.
- Davis, J. W., and C. B. Cowan, Jr. 1972. Field evaluation of three formulations of aldicarb for control of cotton insects. *J. Econ. Entomol.* 65: 231-232.
- DuRant, J. A., M. E. Roof, and C. L. Cole. 1994. Early season incidence of thrips (Thysanoptera) on wheat, cotton, and three wild host plant species in South Carolina. *J. Agric. Entomol.* 11: 61-71.
- Dunham, E. W., and J. C. Clark. 1937. Thrips damage to cotton. *J. Econ. Entomol.* 30: 855-857.
- Gaines, J. C. 1934. A preliminary study of thrips on seedling cotton with special reference to the population, migration, and injury. *J. Econ. Entomol.* 27: 740-743.
- Gaines, J. C. 1965. Cotton insects. Texas Agricultural Experiment Station Serial Bulletin 933. Texas A&M University, College Station, TX.
- Gipson, J. R., and H. E. Joham. 1968. Influence of night temperature on growth and development of cotton *Gossypium hirsutum* (L.) II. Fiber properties. *Agron. J.* 60: 296-298.
- Graves, J. B., J. D. Powell, M. E. Farris, S. Micinski, and R. K. Story. 1987. Western flower thrips, a new cotton pest in Louisiana. *Louis. Agric.* 30: 4-5,8.
- Greene, J. K. 2010. Cotton Insect Management. p. 90-107. *In* R. G. Bellinger (ed.), 2010 Pest Management Handbook for Field Crops. Clemson Cooperative Extension Service. Clemson University.
- Herbert, D. A., Jr. 1998. Evaluation of thrips damage on maturity and yield of Virginia cotton, p. 1177-1180. *In* Proc. Beltwide Cotton Conf., San Diego, CA. 5-9 Jan. Natl. Cotton. Counc. Am., Memphis, TN.
- Herbert, D. A., Jr. 2002. Yield protection strategies for thrips in Virginia cotton. *In* Proc. Beltwide Cotton Conf., Atlanta, GA. 8-13 Jan. Natl. Cotton. Counc. Am., Memphis, TN.
- Herbert, D. A., Jr., J. Bacheler, S. Malone, and D. Mott. 2007. Thrips control options in Virginia/North Carolina: overviews, insights and updates. p. 1649-1653. *In* Proc. Beltwide Cotton Conf., New Orleans, LA. 9-12 Jan. Natl. Cotton. Counc. Am., Memphis, TN.
- Herbert, D. A., Jr. 2010. Insect Control. p. 20-45. *In* 2010 Virginia Cotton Production Guide. Virginia Cooperative Extension Service. Virginia Polytechnic Institute and State University.
- Herbert, D. A., S. Malone, J. Samler, J. Bacheler, D. Reisig and D. Mott. 2012. Thrips wars: challenges from the Northeast Region. p. 942-952. *In* Proc. Beltwide Cotton Conf., Orlando, FL. 3-6 Jan. Natl. Cotton. Counc. Am., Memphis, TN.
- Karner, M. A., and C. L. Cole. 1992. Species composition of thrips inhabiting cotton in Oklahoma. p. 820. *In* Proc. Beltwide Cotton Conf., Nashville, TN. 6-10 Jan. Natl. Cotton. Counc. Am., Memphis, TN.
- Kerns, D. L., and M. G. Cattaneo. 2009. Suggested insecticides for managing cotton insects in the Lower Rio Grande Valley 2009. Texas AgriLife Extension Service, Texas A&M.
- Kerns, D. L., C. G. Sansone, K. T. Siders, and B. A. Baugh. 2009. Suggested insecticides for managing cotton insects in the High Plains, Rolling Plains, and Trans Pecos areas of Texas 2009. Texas AgriLife Extension Service, Texas A&M.
- Lambert, W. R. 1985. The thrips problem. p. 130-131. *In* Proc. Beltwide Cotton Prod. Res. Conf., New Orleans, LA. 6-11 Jan. Natl. Cotton. Counc. Am., Memphis, TN.
- Leigh, T. F., S. H. Roach, and T. F. Watson. 1996. Biology and ecology of important insect and mite pests of cotton. p. 17-86. *In* E. King, J. Phillips and R. Coleman (eds.), Cotton insect and mites: characterization and management. The Cotton Foundation, Memphis, TN.
- Lentz, G. L. and N. B. Van Tol. 2000. Early-season insect control: Adage™ vs. recommended standards. p. 1113-1115. *In* Proc. Beltwide Cotton Conf., San Antonio, TX. 4-8 Jan. Natl. Cotton. Counc. Am., Memphis, TN.

- Morris, D. A. 1963. Variation in the boll maturation period of cotton. *Empire Cotton Grow. Rev.* 40: 114-123.
- Newsom, L. D., J. S. Roussel, and C. E. Smith. 1953. The tobacco thrips, its seasonal history and status as a cotton pest. Louisiana Agricultural Experiment Station Technical Bulletin 474. Louisiana State University, Baton Rouge, LA.
- Parker, R. D., M. J. Jungman, S. P. Biles, and D. L. Kerns. 2009. Suggested insecticides for managing cotton insects in the Southern, Eastern, and Blackland areas of Texas 2009. Texas AgriLife Extension Service, Texas A&M.
- Parker, R. D., S. D. Livingston, R. L. Huffman, and D. A. Dromgoole. 1992. Evaluation on cotton of Orthene applied in-furrow at-planting with and without starter fertilizer in the Texas coastal bend. p. 818-819. *In Proc. Beltwide Cotton Conf.*, Nashville, TN. 6-10 Jan. Natl. Cotton. Counc. Am., Memphis, TN.
- Pollet, D. K. (ed.), J. L. Baldwin, L. D. Foil, M. L. Grodner, A. Hammond, G. Henderson, N. Humel, S. Johnson, R. Leonard, A. Morgan, J. Pyzner, T. E. Reagan, D. Reed, D. Ring, R. N. Story, and M. Stout. 2010. Louisiana recommendations for control of cotton insects. p. 121-126. *In 2010 Louisiana Insect Pest Management Guide.* Louisiana Cooperative Extension Service. LSU AgCenter.
- Race, S. R. 1961. Early-season thrips control on cotton in New Mexico. *J. Econ. Entomol.* 54: 974-976.
- Reed, J. T. 1988. Western flower thrips in Mississippi cotton: identification, damage, and control. Mississippi Agriculture & Forestry. Experiment Station Information Sheet 1320. Mississippi State University, Mississippi State, MS.
- Reed, J. T., R. Bagwell, C. Allen, E. Burris, D. Cook, B. Freeman, R. Leonard, and G. Lentz. 2006. A key to the thrips (Thysanoptera: Thripidae) on seedling cotton in the Mid-Southern United States, Mississippi Agricultural & Forestry Experiment Station, Information Bulletin 1156.
- Reed, J. T., A. Catchot, S. Akin, G. Lorenz, G. Stuebaker, A. Herbert, C. Daves, K. Tindall, J. Greene, M. Toews, R. Leonard, S. Stewart, D. Cook, J. Gore, D. Kerns, J. Bachelier, P. Roberts, and S. Micinski. 2010b. Regional thrips trial, 2009: thrips species composition. p. 906-912. *In Proc. Beltwide Cotton Conf.*, New Orleans, LA. 4-7 Jan. Natl. Cotton. Counc. Am., Memphis, TN.
- Reed, T., R. H. Smith, and B. Freeman. 2010a. Cotton: Insect, disease, nematode, and weed control recommendations for 2010. Alabama Cooperative Extension System publication IPM-0415. Alabama Cooperative Extension System. Alabama A&M University and Auburn University.
- Roberts, P. M., J. Ruberson, M. Toews. 2010. Cotton insect control. p. 125-131. *In P. Guillebeau (ed.), 2010 Georgia Pest Management Handbook Commercial Edition.* University of Georgia Cooperative Extension. University of Georgia.
- SAS Institute Inc. 2010. SAS Enterprise Guide, version 4.3. Cary, NC.
- Sharp, S. S., and C. O. Eddy. 1938. Thrips in Louisiana. Entomological progress, Louisiana Bulletin 298. Louisiana State University, Baton Rouge, LA.
- Stewart, S. D., R. Patrick, and A. McClure. 2010. 2010 Cotton insect control recommendations. p. 3-16. *In 2010 Insect Control Recommendations for Field Crops, Cotton, Soybeans, Field Corn, Sorghum, Wheat, and Pasture.* PB 1768, University of Tennessee Extension.
- Stuebaker, G., S. Akin, J. L. Bernhardt, J. Carson, J. D. Hopkins, D. T. Johnson, T. J. Kring, K. Loftin, G. Lorenz, P. J. McLeod, M. V. Meisch, P. Spradley, D. C. Steinkraus, R. N. Wiedenmann, and J. Zawislak. 2010. Cotton insect control. p. 65-74. *In 2010 Insecticide Recommendations for Arkansas.* Division of Agriculture, University of Arkansas.
- 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 Man. Sci.* 66: 1089-1095.
- Vandiver, M., D. L. Kerns, and M. G. Cattaneo. 2009. Thrips management options in irrigated cotton on the Texas High Plains. p. 721-933. *In Proc. Beltwide Cotton Conf.*, San Antonio, TX. 5-8 Jan. Natl. Cotton Counc. Am., Memphis, TN.
- Van Tol, N. B., and G. L. Lentz. 1999. Evaluation of Adage 5FS™ for early-season insect control. p. 1098-1101. *In Proc. Beltwide Cotton Conf.*, Orlando, FL. 3-7 Jan. Natl. Cotton. Counc. Am., Memphis, TN.
- Watts, J. G. 1937. Species of thrips found on cotton in South Carolina. *J. Econ. Entomol.* 6: 857-860.