CROP PROTECTION AND TILLAGE – FOCUSING MANAGEMENT TO BUILD SUSTAINABLE COTTON SYSTEMS

Tina Gray Teague
Steve Green
Jennifer Bouldin
Calvin Shumway
Arkansas State University, University of Arkansas Agricultural Experiment Station
Jonesboro, AR
Larry Fowler
University of Arkansas Division of Agriculture,
Judd Hill, AR

Abstract

A long term cotton systems study to assess agronomic, economic and environmental impacts of soil conservation and pest management was initiated in NE Arkansas at the Judd Hill Foundation Research Farm in fall 2007. This report summarizes results from component studies with pest control programs across three different tillage systems: conventional, no-till and a wheat/clover cover crop system. Pest control programs included automatic applications of insecticides for tarnished plant bug control, use of foliar fungicide applications during flowering as well as an integrated pest management (IPM) approach with intensive pest and crop monitoring.

Tillage systems significantly impacted lint yields in both years. Conventional tillage practices in 2008 resulted in highest yields, but by the second year, yields were highest when cotton was grown in the terminated wheat/clover cover crop system. Pest conditions were such that combinations of insecticide, miticide and fungicide programs offered no agronomic benefit in any of the three tillage systems in either year. Automatic insecticide applications resulted in secondary spider mite outbreaks in 2008. In neither year did the automatic applications of the fungicide, Headline, protect yield or quality.

A sustainable cotton system should incorporate an integrated pest management (IPM) strategy. An IPM approach endorses scouting, crop monitoring, and spraying pesticides only when needed. Chemical control and pesticides are important tools in an IPM strategy; however, overuse can result in unneeded additional expense, potential environmental contamination, and increased risks for secondary pest outbreaks as well as selection for pest populations resistant to pesticides. IPM is a key component in a sustainable cotton system.

Introduction

Conservation tillage has become a standard practice for many Midsouth cotton producers. Cover crops of wheat or rye often are used in these systems to reduce damage associated with wind and blowing sand. Cover crops also can enhance weed management. Interest in nitrogen-fixing legume cover crops has increased in response to high costs of fertilizer. One concern among producers and their crop advisors is the potential for outbreaks of pest insects such as thrips and plant bugs in low till systems because of increased availability of plant hosts in spring, and the "low spray" environments in the post-boll weevil era. As managers examine ways to reduce costs and increase use of their on-farm mechanization and technology investments, they may consider increasing use of preventative approaches for pest control to reduce the management intensive practices of scouting and crop monitoring required for an IPM strategy. In this report, we summarize results from years one and two of a planned multi-year study comparing crop protection practices across different tillage systems.

Materials and Methods

The experiment was carried out at the Judd Hill Plantation near Trumann, AR. It was arranged as a split-plot design with 3 tillage systems, 1) conventional, 2) no till, or 3) no till + legume/cereal cover crop (cover crop), considered main plots. The crop protection regimes were considered sub-plots. Treatment details are listed in Tables 1 & 2. Main plots were 16 rows wide and 450 ft long. Sub-plots were 16 rows wide, 75 ft long with 10 ft alleys. In October 2007, balansa clover (Kaprath Seeds, Inc., Manteca, CA) and wheat mixture was seeded at 10 lbs wheat and 8 lbs coated clover seed /acre. In the spring, the cover crop was terminated with glyphosate ca. 30 days before planting. Cruiser treated (thiamethoxam) Stoneville 4554 B2RF was planted on 6 May 2008 in the Dundee silt loam soil at 3 to 4 seeds/ft. Production practices were similar across all tillage treatments in-season with the following exceptions used only in conventional tillage main plots: disk bedders (hippers) used to re-form beds in early spring, tops of beds flattened just prior to planting with a DO-ALL fitted with incorporation baskets, row middles (water furrows) cleared with sweep plows prior to first furrow irrigation. No cultivations were made in any treatments. Similar methods were employed for the 2009 crop. Disk bedders were used to reshape beds in cover crop main plots in October 2008 after the 2008 harvest and prior to reseeding wheat and clover. In the conventional main plots, beds were reshaped on 17 April with disk bedders, and then flattened prior to planting with a DO-ALL. In 2009, spring rains delayed date of planting to 19 May.

The COTMAN crop monitoring system (Danforth and O'Leary 1998; Oosterhuis and Bourland 2008) was used to document differences in crop development among tillage and crop protection treatments from squaring until physiological cutout. Records of weekly damage assessments and crop response were collected for each crop protection input (pesticides). Extensive pest monitoring included direct and indirect sampling including use of pitfall traps, sweep nets, drop clots for insects, and late season plant mapping using the COTMAP procedure (Bourland and Watson 1990). Plots were harvested with a 2 row research cotton picker, and "grab" samples of seedcotton from each plot were pulled directly from the picker basket. These were ginned and submitted for fiber testing. All plant monitoring, yield and fiber quality data were analyzed using ANOVA with mean separation using protected LSD.

Table 1. Pesticide application descriptions including product, rate, and timings for the five pest control sub-plot treatments in 2008 JH trial.

Treatment Description	**Pesticide (rate/acre) application date**
Early, Mid, & Late season Insecticides[1]	Trimax (1.8oz) 18 June, 2 July; Centric (2 oz) + Diamond (9oz) 8 July; Leverage (3.75 oz) 22 July; Centric (2oz) 29 July; Bidrin (3.2 oz) 6 Aug.
Mid & Late season Insecticides	Centric (2 oz) + Diamond (9oz) 8 July; Leverage 2.7 SC (3.75 oz) 22 July; Bidrin 8EC (3.2 oz) 6 Aug
Mid & Late season Insecticides + Miticide[2]	Centric (2 oz) + Diamond (9oz) 8 July; Leverage (3.75 oz) 22 July, Zephyr (8oz) 29 July, Bidrin (3.2 oz) 6 Aug
Mid & Late season Insecticides + Fungicide[3]	Centric (2 oz) + Diamond (9oz) 8 July; Leverage (3.75 oz) 22 July Bidrin (3.2 oz) 6 Aug; Headline (17, 30 July); Bidrin (3.2 oz) 6 Aug
Untreated Check	

[1]Automatic insecticide applications were directed at preventing tarnished plant bug and stink bug infestations. All applications were made with a tractor mounted high clearance sprayer equipped with 8 row boom. Insecticides included were Trimax (imidacloprid), Leverage (imidacloprid/cyfluthrin), Bidrin (dicrotophos), Centric (thiamethoxam), and Diamond (novaluron).
[2]Zephyr (abamectin) miticide was applied to control spider mites.
[3]Headline fungicide (pyraclostrobin) was applied for prevention/control of foliar diseases and boll rot.

Table 2. Pesticide application descriptions including product, rate, and timings for the four pest control sub-plot treatments in 2009 JH trial.

Treatment Description	Pesticide (rate/acre) application date
Early, Mid, & Late season Insecticides[1]	Centric (2oz) 19 June; Trimax (1.5 oz) 26 June, 8 July; Centric (2oz) 20 July; Bidrin (6 oz), 10 Aug and Bidrin XP (10.6 oz) 18 Aug
Early, Mid & Late season Insecticides + Fungicide[2]	Centric (2oz) 19 June; Trimax (1.5 oz) 26 June, 8 July, Centric (2oz) 20 July; Headline (9 oz) 20 July, 10 Aug; Bidrin (6 oz), 10 Aug and Bidrin XP (10.6 oz) 18 Aug
Threshold Insecticide[3]	Centric (2oz) 20 July; Bidrin (6 oz), 10 Aug and Bidrin XP (10.6 oz) 18 Aug
Untreated Check	

[1]Automatic insecticide applications were directed at preventing tarnished plant bug and stink bug infestations. All applications were made with a tractor mounted high clearance sprayer equipped with 8 row boom. Insecticides included were Trimax (imidacloprid), Bidrin (dicrotophos), and Centric (thiamethoxam).

[2] Headline fungicide (pyraclostrobin) was applied for prevention/control of foliar diseases and boll rot..

[3]Insecticide was applied for tarnished plant bug control when the insects reached the UA MP144 recommended action threshold of a mean 3 bugs per drop cloth sample.

Results

Cool, wet spring weather affected planter efficiency and cotton seed germination in 2008, and plant stand density was significantly reduced in no till and the cover crop system compared to the conventional system (Fig 1). A conventional John Deere Max Emerge Air-Flow planter was used in 2008, and at times, closure of the seed furrow was not uniform, resulting in reduced seed-to-soil contact. In addition, seedbed preparations in conventional tillage resulted in higher soil temperatures which enhanced seedling growth (Teague et al 2009). A no-till planter was employed in 2009, and despite rain delayed planting, no differences in stand establishment were observed among tillage systems.

Squaring initiation was observed earlier in conventional system in both years (Fig 2). Pre-flower sympodial development as depicted in COTMAN growth curves varied among systems in 2008 but not 2009 (Fig 3, 4). There were no differences in first position square or boll retention among pesticide treatments or tillage. This measure is a sign that population densities of fruit feeding pests were at low levels in both years. Final end-of-season plant mapping results from COTMAP sampling showed no retention differences or differences in boll rot or hard lock associated with the fungicide treatment (data not shown); COTMAP results showed some plant structure differences among treatments (Table 3, 4). High rainfall accumulations were notable in 2009 (Table 5).

Significantly higher yields were associated with the conventional system compared to the no till and cover crop systems in 2008 (Fig. 5). In 2009, however, the cover crop system resulted in a significant increase in yield compared to the no till and conventional systems, which were not significantly different from one another (Fig 6).

Pest conditions were such that automatic pesticide programs offered no agronomic benefit in any of the three tillage systems in either year (Fig 7, 8, 9, 10). Automatic insecticide applications resulted in secondary spider mite outbreaks in 2008. A miticide application to control mites was efficacious, but mite numbers eventually collapsed across all treatments (data not shown). The fungicide, Headline, did not protect foliage or bolls such that a yield response was measurable in either year. Yield component and HVI lint quality analyses in 2008 showed no differences among tillage system or pest control inputs for lint quality parameters including % lint, micronaire, length, uniformity, strength, elongation, color, lint index, seed index, fibers per seed or fiber density (data not shown). Final results are not yet available for 2009.

Conclusions

Improvements in water and soil quality were associated with implementation of conservation tillage and cover crops in the first and second study years, but these are not included in this report. Concurrent improvements in yield were not observed in 2008, but in 2009, a cover crop system resulted in a significantly higher yield than either no till or conventional tillage. Yield differences in 2008 most likely were related to crop establishment and growth in the first 35 days after planting. Field preparation in the conventional tillage system resulted in a seedbed that was more favorable for germination and seedling establishment in the cool, wet May conditions compared to the stale seedbeds in the no till and cover crop treatments (Fig. 11). Changes in planter configuration in 2009 as well as delayed date of planting (because of rains) resulted in uniform stand among treatments and warmer soil conditions for early season plant development. The COTMAN growth curves show uniform plant growth among tillage systems in 2009. A possible explanation for the 2009 yield differences is unknown. On-going work to evaluate changes in soil physical and chemical properties for each of the tillage systems may provide some clues.

Automatic applications of insecticides and fungicides did not improve yield in either year. Such an approach to cotton production in the 21st century is neither economically or environmentally sustainable. A sustainable cotton system incorporates an IPM strategy. Automatic, preventative foliar applications of pesticides result in unneeded additional expense and pose risks for environmental contamination. Automatic applications increase risk of pest resurgence and secondary pest outbreaks, and they can lead to selection of resistant pest populations. Crop monitoring, scouting, and applying chemical control options only when needed are a distinguishing characteristic of the cotton culture of Arkansas where IPM has a long and prominent history. IPM is a key component in a sustainable cotton system.

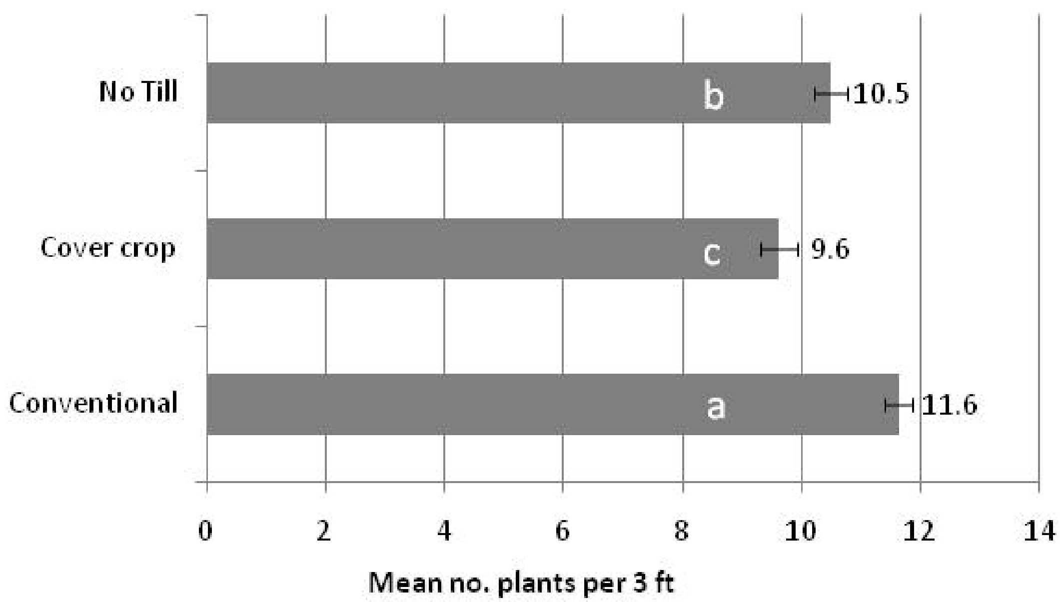

Figure 1. Plant stand density was affected by tillage in 2008 with greater mean no. plants (±SEM) per 3 ft at 24 DAP observed in the conventional system compared to the no till and cover crop treatments . Plant stand density was not impacted by tillage in 2009 with overall mean of 10.6 plants/3 ft (data not shown).

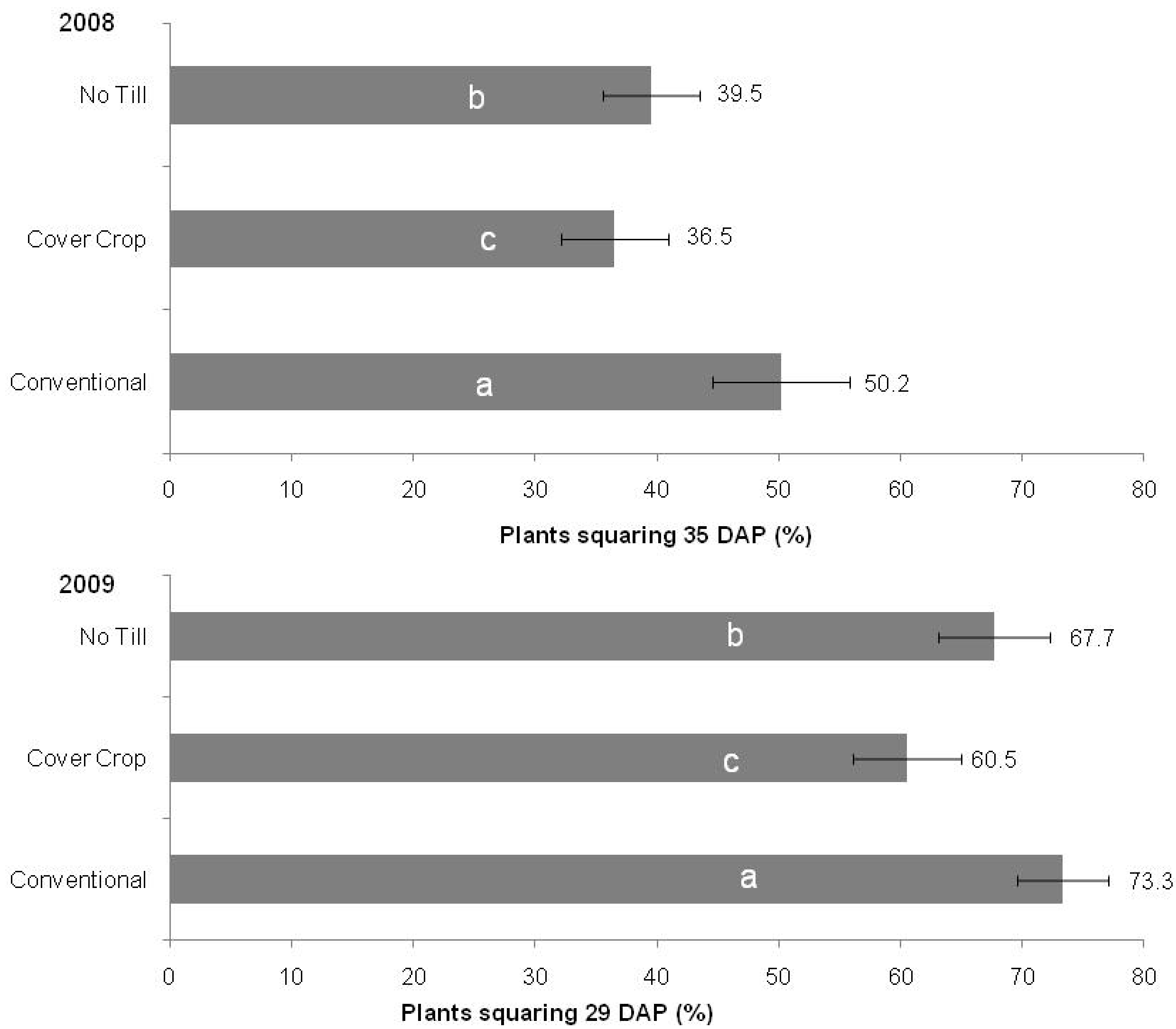

Figure 2. In both years, plants in the conventional tillage treatment had highest mean % of plants (±SEM) squaring early season compared to no till and cover crop treatments. Squaring levels were determined at 35 DAP in 2008 and 29 DAP in 2009.

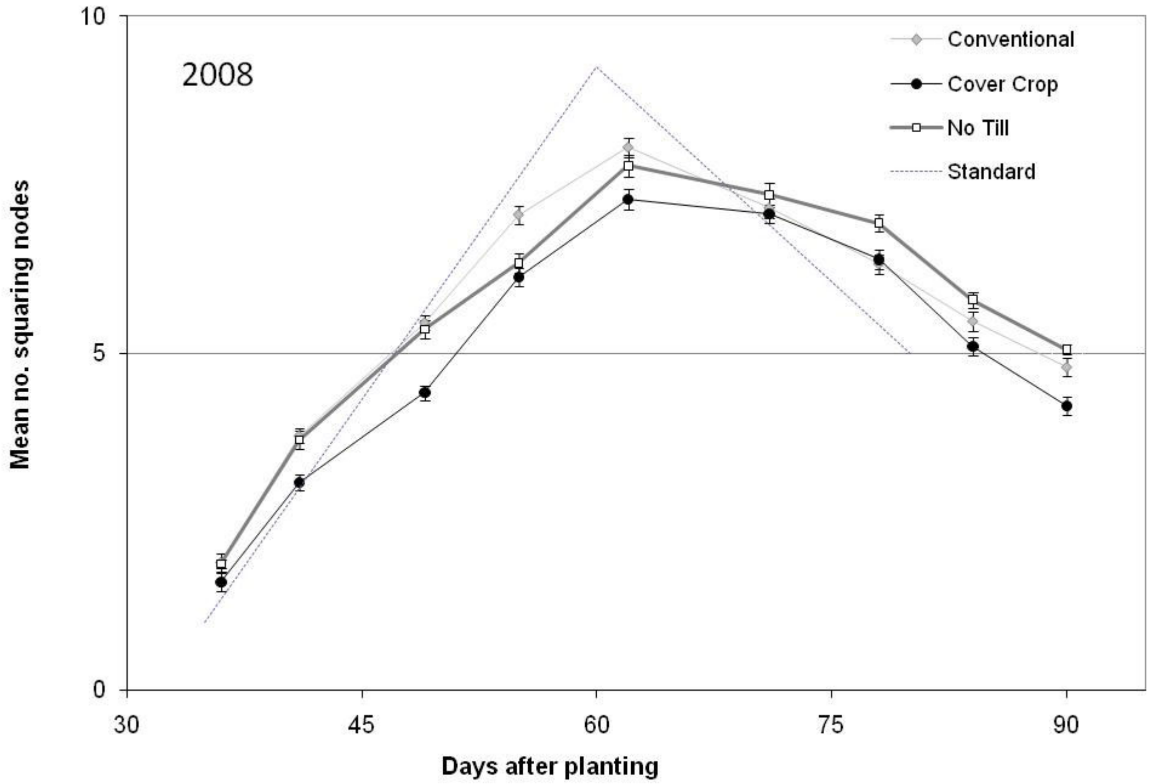

Figure 3. COTMAN growth curves for main plot tillage treatments in 2008 show that fewer mean no. squaring nodes (±SEM) were produced pre-flower in the cover crop system compared to no till and conventional systems. Both cover crop and no till treatments had fewer main-stem sympodia than conventional by 58 DAP (P=0.01). Date of planting was 3 May in 2008.

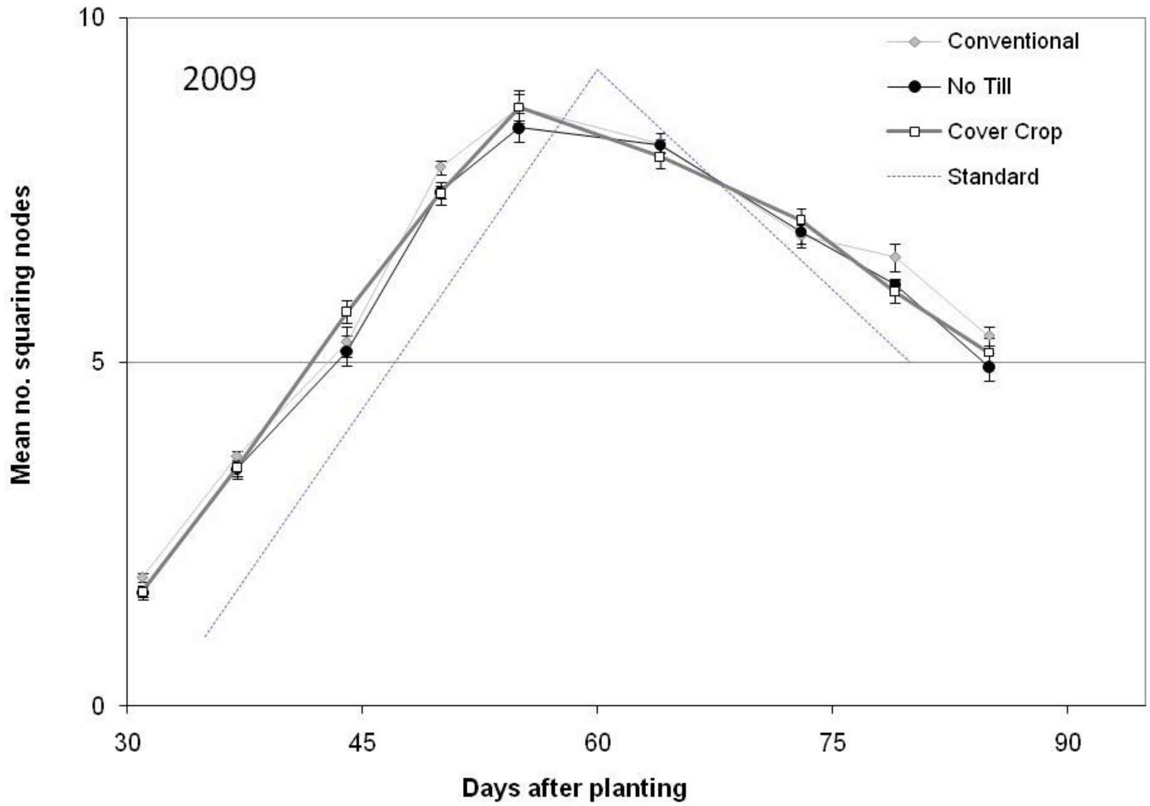

Figure 4. In 2009, COTMAN growth curves for main plot tillage treatments show that pace of crop development was advanced related to the standard curve with squaring initiated prior to 35 DAP. Warmer soil temperature associated with the rain delayed date of planting (19 May) increased the rate of development of main stem squaring nodes which were similar among tillage main effects season-long.

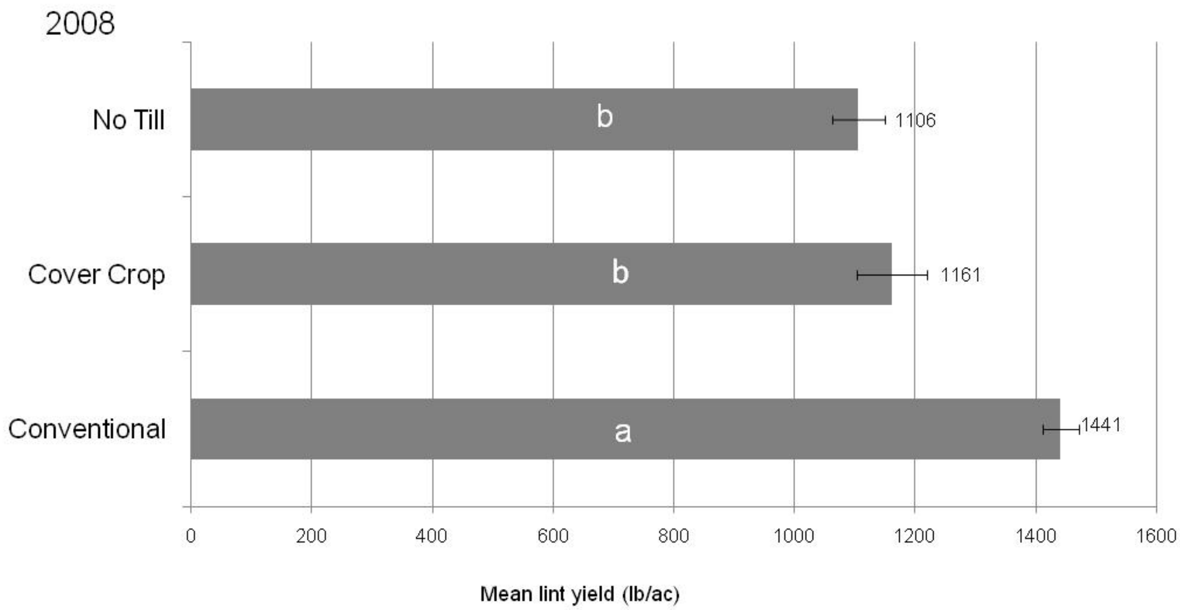

Figure 5. Mean lint yield (±SEM) for 2008 main plot tillage treatments; conventional management resulted in significantly higher yields compared to the no till and cover crop systems ($P<0.01$; LSD_{05} =183).

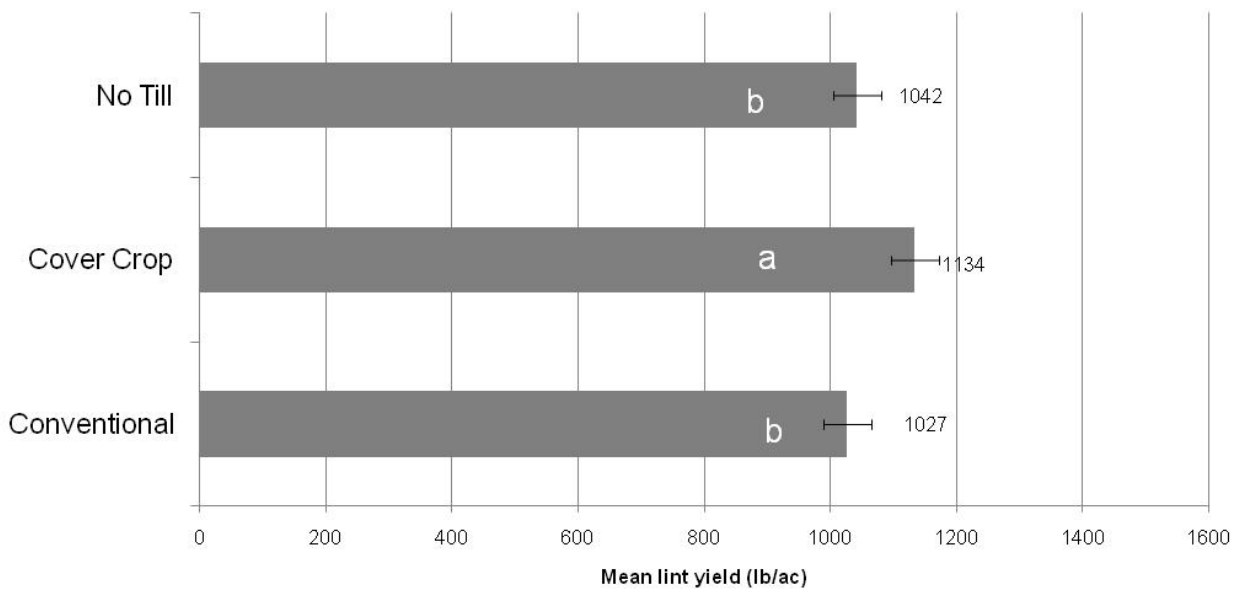

Figure 6. Mean lint yield (±SEM) for 2009 main plot tillage treatments; highest yields were harvested in the cover crop system compared to conventional and no-till ($P=0.01$; LSD_{05} =38).

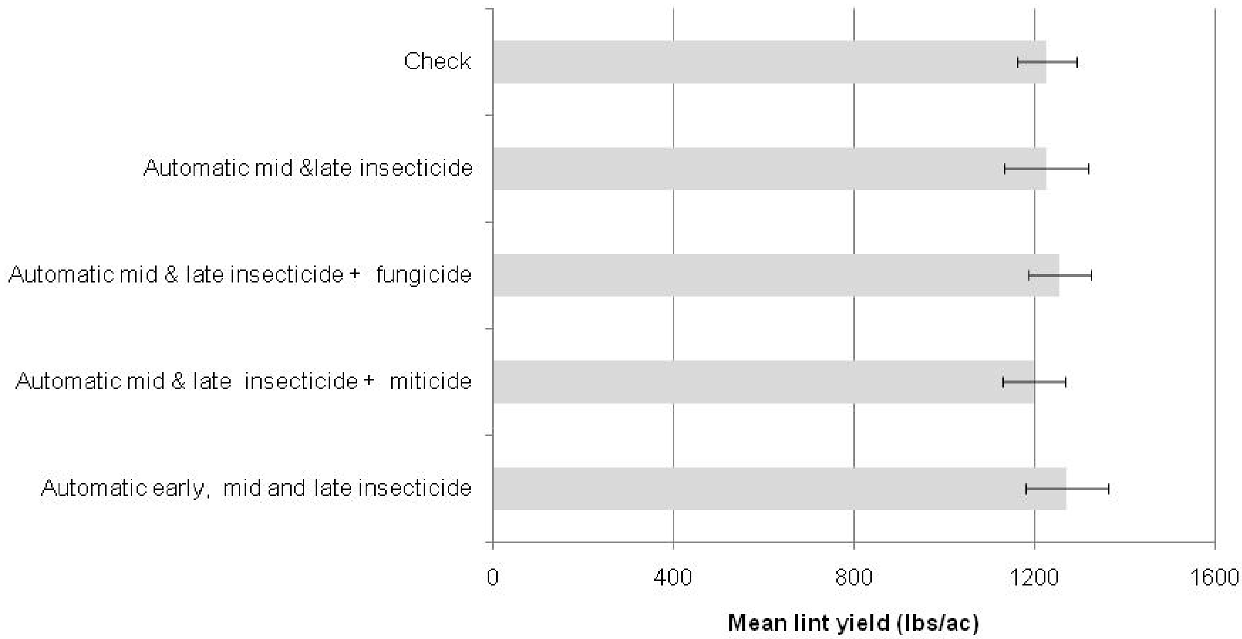

Figure 7. Pesticide treatments had no significant effects on yield in 2008 (P=0.68), and there were no significant pesticide * tillage interactions.

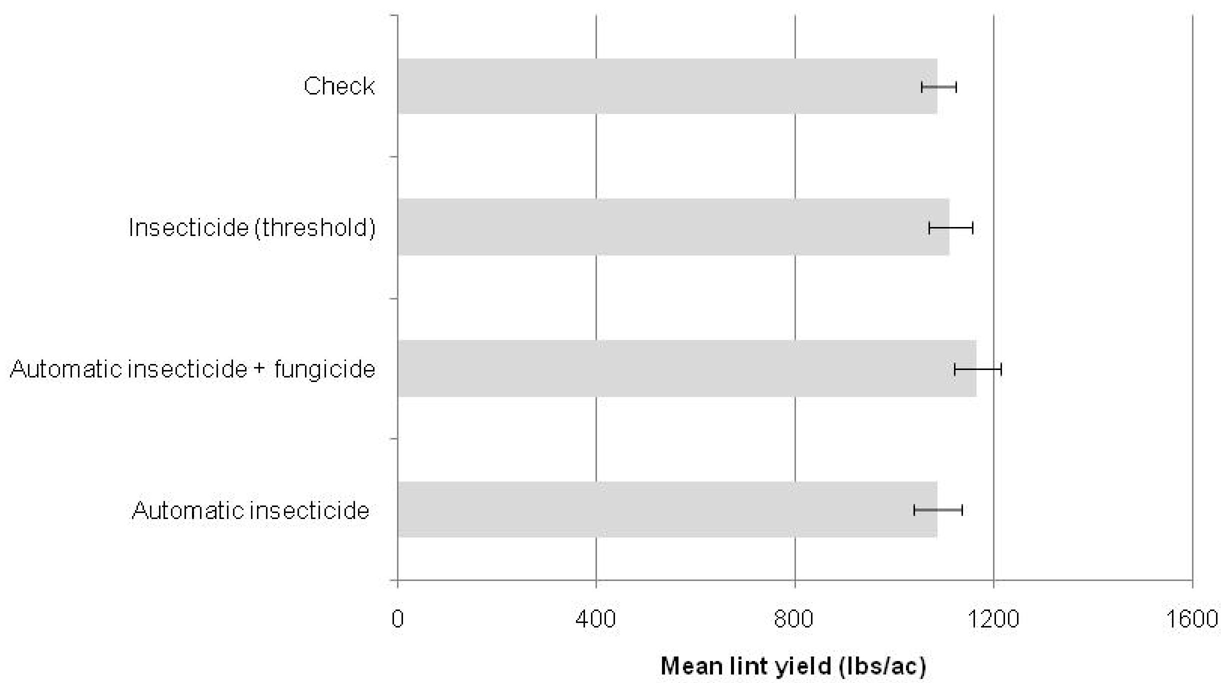

Figure 8. Pesticide treatments had no significant effects on yield in 2009 (P=0.48) , and there were no significant pesticide * tillage interactions.

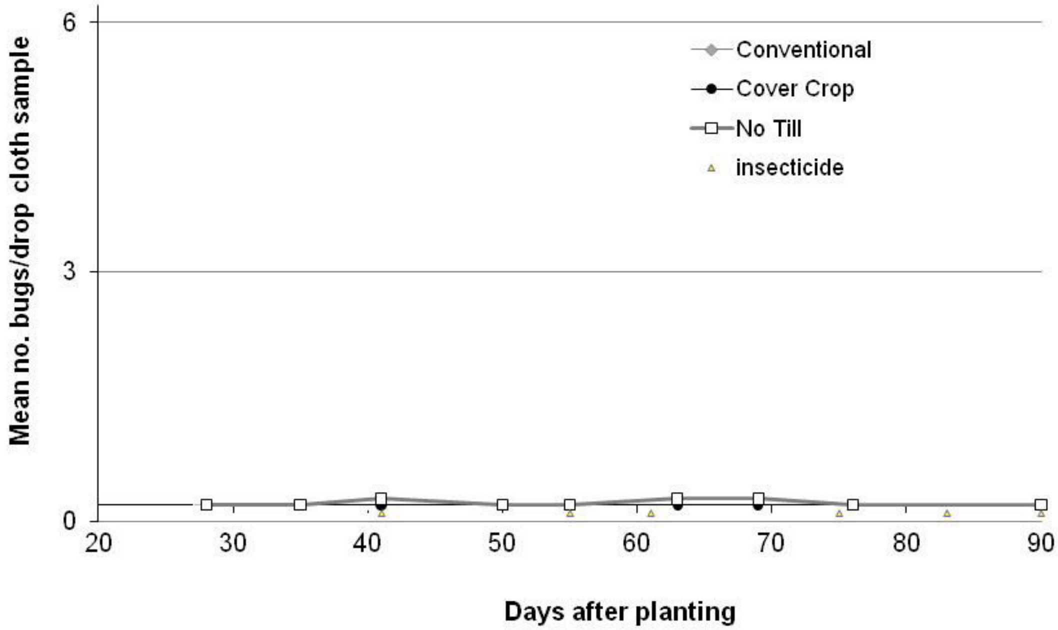

Figure 9. Tarnished plant bug numbers were very low through the 2008 season with mean numbers of nymphs and adults never exceeding the action levels set at 3 bugs per drop cloth sample. Shown above are mean no. of plant bugs observed per week across tillage treatments.

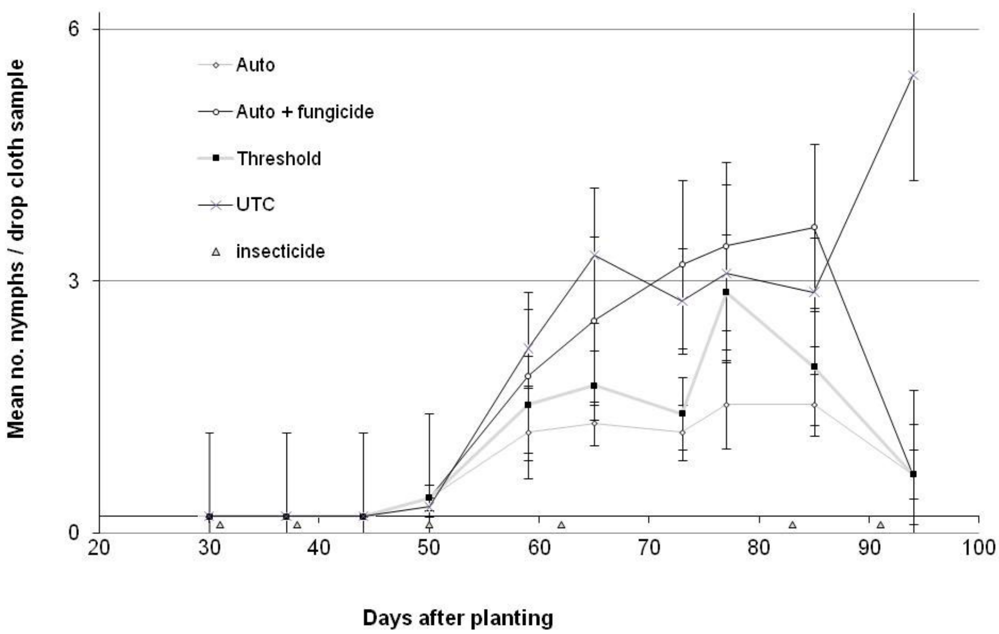

Figure 10. Plant bug infestation levels increased after flowers in 2009. Insecticide application dates are indicated on the x-axis. Numbers were maintained below threshold in sprayed treatments; in the unsprayed check, mean bugs/drop exceeded action levels in late season. First position retention levels remained above 85% through 75 DAP (data not shown), and were similar among treatments season-long.

Table 3. Results from final end-of-season plant mapping using COTMAP for tillage main plot effects- 2008[1].

Category	Mean per plant for management treatment				
	Conventional	Cover Crop	No Till	*P>F*	*LSD_{05}*
1st Sympodial Node	6.9	7.3	6.5	*0.11*	
No. Monopodia	2.7	2.7	2.2	*0.08*	
Highest Sympodia with 2 nodes	11.0	8.4	10.2	*0.17*	
Plant Height (inches)	45.4	36.2	40.0	*0.05*	*6.9*
No. Effective Sympodia	10.8	9.6	10.3	*0.17*	
No. Sympodia	15.7	12.8	14.5	*0.05*	*2.4*
No. Symp. with 1st Position Bolls	5.3	4.5	5.3	*0.36*	
No. Symp. with 2nd Position Bolls	1.2	1.3	1.2	*0.87*	
No. Symp. with 1st & 2nd Bolls	1.6	0.9	1.2	*0.33*	
Total Bolls/Plant	10.3	9.2	9.6	*0.66*	
% Total Bolls in 1st Position	67.5	59.4	67.5	*0.46*	
% Total Bolls in 2nd Position	26.6	23.4	25.0	*0.71*	
% Total Bolls in Outer Position	2.7	3.8	1.0	*0.32*	
% Total Bolls on Monopodia	2.8	12.8	6.5	*0.06*	
% Total Bolls on Extra – Axillary	0.3	0.6	0.0	*0.23*	
% Boll Retention - 1st Position	43.4	41.9	44.6	*0.59*	
% Boll Retention - 2nd Position	25.9	25.7	24.1	*0.96*	
% Early Boll Retention	49.0	45.7	53.7	*0.59*	
Total Nodes/Plant	21.6	19.2	20.0	*0.06*	
Internode Length (inches)	2.1	1.9	2.0	*0.14*	

[1] means of 10 plants per plot.

Table 4. Results from final end-of-season plant mapping using COTMAP for tillage main plot effects- 2009[1].

Category	Mean per plant for management treatment				
	Conventional	Cover Crop	No Till	*P>F*	*LSD_{05}*
1st Sympodial Node	7.1	7.2	6.8	*0.13*	
No. Monopodia	2.0	2.1	1.9	*0.49*	
Highest Sympodia with 2 nodes	11.6	10.9	11.0	*0.25*	
Plant Height (inches)	43.0	42.1	42.6	*0.86*	
No. Effective Sympodia	10.1	9.6	9.6	*0.12*	
No. Sympodia	15.0	14.4	14.3	*0.26*	
No. Symp. with 1st Position Bolls	4.9	5.2	4.8	*0.29*	
No. Symp. with 2nd Position Bolls	1.3	1.4	1.2	*0.51*	
No. Symp. with 1st & 2nd Bolls	1.2	0.8	0.9	*0.28*	
Total Bolls/Plant	10.1	9.2	8.6	*0.16*	
% Total Bolls in 1st Position	61.6	65.4	67.4	*0.05*	*4.56*
% Total Bolls in 2nd Position	24.5	22.9	23.6	*0.70*	
% Total Bolls in Outer Position	6.1	3.7	3.7	*0.01*	*1.25*
% Total Bolls on Monopodia	7.6	8.0	5.3	*0.10*	
% Total Bolls on Extra – Axillary	0.1	0.0	0.0	*0.44*	
% Boll Retention - 1st Position	41.1	41.2	39.7	*0.65*	
% Boll Retention - 2nd Position	21.4	19.3	18.7	*0.42*	
% Early Boll Retention	44.3	40.7	38.7	*0.13*	
Total Nodes/Plant	21.1	20.6	20.2	*0.22*	
Internode Length (inches)	2.0	2.1	2.1	*0.34*	

[1] means of 10 plants per plot.

Table 5. Monthly rainfall totals (inches) at the Judd Hill Plantation for the 2008 and 2009 cotton production seasons.

Month	2008	2009
January	1.63	2.31
February	3.21	2.95
March	9.15	5.09
April	5.71	9.51
May	4.04	9.82
June	0.95	4.62
July	1.76	8.25
August	0.61	3.83
September	3.17	4.75
October	2.86	12.38

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Figure 11. Photographs of the 2008 tillage system plots showing seedbed of the conventional plots at planting (far left) compared to no-till and cover crops at 9 days after planting (center and right).